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# MEDARE

Proceedings of the International Workshop  
on Rescue and Digitization of Climate  
Records in the Mediterranean Basin





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Records in the Mediterranean Basin

(Edited by Manola Brunet and Franz G. Kuglitsch)

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## Foreword

The Mediterranean basin is considered the pivot of a major branch of human history, since numerous civilizations have flourished around this “sea in the middle of lands” which mankind has sailed for thousands of years. In 2000, the total population of the Mediterranean coastal countries was almost 430 millions, which compared with the 280 millions registered in 1970 represents an increase above 50 per cent in just thirty years. Current predictions for the year 2025 are estimating the future number of inhabitants of the Mediterranean basin at 520 million. On the coastal regions of the Mediterranean Sea there are now more than 100 major cities, each with a population in excess of 100.000. According to the Fourth Assessment Report of the WMO co-sponsored Intergovernmental Panel on Climate Change (IPCC), this already highly climate-sensitive region is projected to face increased risks in terms of drought, heatwaves and extreme rainfall events; with corresponding negative impacts such as reduced water availability, decline in hydropower potential, stressed tourism, increased health risks, a larger frequency of wildfires and generally reduced crop productivity.

The region experienced several heatwaves during the first seven years of this century, with major episodes in Western Europe during 2003 extending towards the northern and central countries and, in 2007, in South Eastern Europe, where temperatures broke new records by reaching 45°C in some areas. Flooding also produced considerable damage in many areas, including the northern and southern banks of the Mediterranean basin. Considering the current climate situation and the projected scenarios, research on the Mediterranean climate is by no means a mere intellectual or scientific exercise; rather, it is a necessity to face the various climate and environmental challenges being experienced in relation to sustainable development and economic growth. Therefore, adapting to climate change impacts in the Mediterranean basin will demand sustained efforts and the development of innovative approaches to encompass various needs in terms of

observations, research, monitoring, prediction and extreme weather forecasting.

A backbone of these vital efforts is the ensemble of accurate, high-resolution, high-quality, real-time and historical long-term climate records, which require quality control, homogeneity and appropriate management. However, this effort will not be sufficient unless the relevant climate data are also made widely available to the user community. Accordingly, data sharing will be an essential component of any collaborative regional data gathering enterprise, in order to achieve common goals. Under these key principles, WMO promotes collaboration among the National Meteorological and Hydrological Services of its Members and with other climate-competent institutions at the global, regional and national levels, in particular through a wide framework for data sharing covering all the relevant technical, programmatic and policy issues.

The International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin fits well within this context by setting up the framework for a sustained MEDiterranean climate DATA REScue (MEDARE) project initiative. The success of this initiative will be a shared responsibility among the WMO Members concerned and the international climate community. Based on this new initiative and with the benefits ensured by fully proven WMO standards and guidelines, the countries of the Mediterranean basin are encouraged to take joint actions to preserve any data set at risk of loss or deterioration by appropriately digitizing their current and past data sets in standard computer compatible format.

I wish to assure you that WMO will continue to do its share in facilitating and coordinating the MEDARE initiative and in promoting the necessary synergies among the Members concerned in Africa and in Europe.



(M. Jarraud)  
Secretary - General

## Statements during the opening ceremony of the International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin

BY DR. BURUHANI NYENZI (WORLD METEOROLOGICAL ORGANIZATION):

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Mr Antonio Conesa (Instituto Nacional de Meteorología, Spain), Prof. Xavier Grau (University of Rovira i Virgili Chancellor, Tarragona, Spain), Dr. Pierre Bessemoulin (President, Commission for Climatology), dear Workshop Participants, Ladies and Gentlemen

It is my great pleasure to be with you on this occasion of the opening of this International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin. On behalf of the World Meteorological Organisation (WMO) and that of my own and my colleague Mr Omar Baddour, I wish to express my sincere appreciation to the Government of Spain and the University Rovira I Virgili for hosting this important workshop. This is a testimony of the commitment of the Government of Spain and its institutions in supporting the optimum climate activities of WMO that contribute to the sustainable development in the region as a whole.

I would like to take this opportunity to thank Prof. Xavier Grau and Dr. Manola Brunet, from this University for the kind hospitality and warm welcome that has been extended to all of us since our arrival. I wish to commend the entire International and Local organising committees of the Workshop for the excellent arrangements they have made, which will no doubt contribute to the successful conclusion of the meeting. I would also like to thank the various CCI experts and lecturers from countries that are not part of this region who have taken their time to prepare and come to lecture at this workshop. Their contribution is highly appreciated.

*Ladies and Gentlemen*

Climate change is one of the most complex, multifaceted and serious threats the world faces. The Fourth Assessment Report of the International Panel on Climate Change (IPCC) has confirmed that anthropogenic greenhouse gas emissions are having

significant and negative impacts on climate change, emphasized the dangers of rising global mean temperatures and provided an assessment of the means and costs for combating climate change. It calls that action to stop climate change must begin immediately and be fundamental if irreversible damage is to be avoided. The High Level Event on Climate Change, convened by the United Nations Secretary-General on 24 September 2007, saw the unequivocal commitment of world leaders to tackle climate change through concerted action and their agreement that the only forum in which this issue can be decided upon is the United Nations Framework Convention on Climate Change (UNFCCC). It also sent a signal of political commitment to initiate negotiations for a future climate change regime at the Bali conference and affirmed a need for shared commitment to action. This calls for all countries to understand the impacts of climate change and take the necessary preventive measures.

In order to better understand, detect, predict and respond to global climate variability and change long-term, high-quality and reliable climate instrumental time series are key information. These help in carrying out regional climate studies and predictions, calibration of satellite data, and generation of climate quality re-analyses data. They are also essential tool in translating climate proxy evidence into instrumental terms. The Mediterranean region has a very long and rich history in monitoring the atmosphere, going back in time to the 19<sup>th</sup> century. However, despite of the efforts undertaken by some National Meteorological and Hydrological Services (NMHSs) in the region in Data Rescue (DARE) activities accessible digital climate data is still limited. This has resulted in preventing the region from developing more accurate assessments of climate variability and change. This workshop is being organized in order to address some of these issues which will, among others, include: (i) discussions on techniques and procedures on data and metadata recovery, digitization, composing,

formatting, archiving and disseminating long-term climate records (ii) Establishing an Inventory based on countries of the currently available long-term climate records in digital form (temperature, precipitation, air pressure) and the longest and key climate records to be recovered and (iii) Identification of opportunities for resource mobilization at the national and regional scales.

A number of NMHSs and other institutions from the region have been invited to participate in this workshop. I believe that at the end of this workshop we will come up with some good recommendations to make the rescued time series accessible to the international scientific community; decision makers and other end users. WMO looks forward to receiving the recommendations of this workshop and I assure you that we shall take the necessary appropriate follow-up actions as soon as we receive the report of the workshop.

In concluding I would like to thank the University Rovira i Virgili of Tarragona for playing a major technically and scientifically role in supporting the CCI work. I would particularly wish to express our gratitude to Dr. Manola Brunet for facilitating this role as CCI-OPAG2 Co-chair

Thanks

**BY MR. ANTONIO CONESA (INSTITUTO NACIONAL DE METEOROLOGÍA, SPAIN):**

Dear Vice-Chancellor of the University Rovira i Virgili of Tarragona, Director of the World Climate Programme at World Meteorological Organization (WMO), distinguished participants, ladies and gentlemen.

I would like to give a warm welcome to all of you on behalf of the National Institute of Meteorology, the National Weather Service in Spain. Mr Francisco Cadarso the Director of the Institute and Permanent Representative of Spain within the WMO regrets

very much not being able to join us at the opening of this important International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin with presence of scientists and experts from the Mediterranean countries and other parts of the world.

Data Rescue activities aimed at transferring historical long-term climate records into accessible climate data sets is an important contribution for climate studies and the National Institute of Meteorology as well as the Ministry of Environment of Spain, to which the INM belongs, is very glad to have contributed to the organization of this workshop.

The Spanish Institute, like most of the National Meteorological Services in the world, has been involved in climate research activities since its foundation one hundred and twenty years ago now. Understanding the Earth climate and its evolution has always been a key point in the missions of the weather services and important work has been dedicated to observing, compiling and studying the climate.

Everybody knows that the issue has acquired crucial importance nowadays and understanding, detecting, predicting and preparing responses to global climate variability and change is a priority now for decision makers, in order to protect the world society against new climate scenarios and preserve the planet for sustainable living.

The role of the Meteorological Services in this task was underlined, for instance, in the statement issued by the International Conference on 'Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services' organized by the WMO which took place in Madrid (Spain) in March this year, and I am sure that it will also be highlighted during the World Conference on Climate to be held next year.

However the Meteorological Institutes do not work alone on climate research. Traditionally many

scientific institutions, public and private, universities and research centres have made important effort in climate research activities and frequently with higher dedication and success than the Weather Services themselves. This is necessary and this is welcome. Without the joint effort of many people and many institutions throughout the world the climate studies would not have reached the level they have today.

Co-operation between them and participation of different players and disciplines related to climate is a fundamental asset for the progress in understanding and predicting the climate. The World Climate Research Programme, The Global Climate Observing Systems and the Intergovernmental Panel on Climate Change represent very good examples of the collaboration and integration of different communities with interest in climate.

The Spanish Meteorological Institute has always been keen to facilitate the work on climate activities to other national institutions and co-operating with them as much as possible. The role of university departments on climate research in Spain has been quite important on this regard and let me mention particularly the dedication and work of our host, the University Rovira i Virgili of Tarragona.

I also would like to pay a tribute to Dr Manola Brunet and her department. Dr. Brunet is now Co-chair of the Open area Programme Group for Monitoring and Analysis of Climate Variability and Change in the Commission of Climatology of WMO. The World Meteorological Organization is the natural environment for the collaboration of National Meteorological Services but the members of WMO are the world countries not just the weather services. We are proud that Dr Brunet has reached that significant position in the Commission for Climatology. It is a deserved recognition to her brilliant job in the Commission activities which we hope she will continue for long time.

This Workshop will provide an international opportunity for those interested in recovering,

processing and using long-term climate records for the benefit of climate studies. The availability of homogeneous data set for studying and characterizing the variability of climate is also a priority in the scientific plans of the National Institute of Meteorology and we look forward to a successful outcome of this workshop.

I would like to express the appreciation of our Institute for the presence of experts coming from many countries gathered today in Tarragona and our special thanks to the University Rovira i Virgili and Dr Manola Brunet for the local organization. Let me again give you a warm welcome to Tarragona, to Catalonia and to Spain wishing you a happy time here and a most fruitful workshop.

Many thanks.

**BY DR. JOSEP MANEL RICART (UNIVERSITY ROVIRA I VIRGILI, SPAIN):**

Dr. Buruhami Nyenzi, Director of the World Climate Programme of the World Meteorological Organization; Mr. Antonio Conesa, Director of the Territorial centre in Catalonia of the National Institute of Meteorology; researchers, ladies and gentlemen

On behalf of the Rector of the University Rovira i Virgili, it is an honour to welcome you to Tarragona, to our university, and to the opening ceremony of the International Workshop on Rescue and Digitalization of Climate Records in the Mediterranean Basin.

Although I'm not an expert, I have read the recent Fourth Assessment Report from the Intergovernmental Panel of Climate Change (IPCC), to whom I congratulate for the effort, the service to the planet, and of course for the Nobel price. As a scientist I believe in the main conclusions of this report.

The warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures,

# Summary Report of the WMO/WCP/WCDMP MEDARE International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin

By Phil Jones

widespread melting of snow and ice, and rising of the global average sea level.

Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, and most particularly temperature increases.

Global atmospheric concentrations of CO<sub>2</sub>, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values.

Continued greenhouse emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century.

Thus, we leave in a planet in danger, climate changes and what is also important, we are polluting the planet and wasting its natural resources. We need more than one planet (the number is not important) to satisfy the present needs of only a part of the humanity.

It is still possible to mitigate climate change impacts... We need a strategic plan to save the planet.

Thus, it is extremely important that all the scientist work together in order to convince governments and people. For that it is necessary to know meteorological data as much as possible.

In particular, the climate of the Mediterranean basin is very rich, with natural fluctuations and the period of observations is short. All the work to increase our knowledge of this area will be of great interest.

The universities have to be committed to work against global warming, because they have to serve the society. Our University is just now implementing a new environmental policy to save water and energy. We are promoting a center of research in sustainable chemistry and a new Catalan research institute of renewable energy that will have two sites, one in Barcelona and another one in Tarragona. The

research lines in Tarragona will investigate biofuels, solar cells, and marine eolic power generators. Perhaps it is not far the creation of a reactor that removes CO<sub>2</sub> from the air to produce biofuels by means of micro-waterweed.

With respect to the knowledge of the climate we are proud of the work done by group of Dr. Brunet and Dr. Bonillo, who since 1995 are devoted to the study of long-term climate variability and change on a regional basis. They are also dedicated to the organisation of workshops, meetings and conferences, both at the international and national levels, establishing a firm basis of international scientific cooperation. With their collaboration, the university is now promoting a new research institute for the observation of the climate change. It will be located in Tortosa near of the one of the most important Deltas in the Mediterranean, the Ebro delta.

I thank the World Meteorological Organization for having chosen Tarragona and our University for this workshop as well as the Instituto Nacional de Metereologia and the Servei Meterològic de Catalunya who have made this event possible.

I wish you fruitful discussions. I'm sure that this meeting will contribute, and it is indeed very necessary to the knowledge of global warming and climate change.

Thank you very much.

## INTRODUCTION:

The first meeting of the MEDARE initiative group was held at University Rovira i Virgili (Tarragona, Spain) on November 28-30, 2007 with 45 attendees. The long-term goal of the project is to develop a high quality Mediterranean climate dataset, and the meeting laid out the initial plans for this undertaking. The first two days were given over to presentations – on the first day a number of invited experts spoke about dataset development, data rescue activities, data digitization efforts and homogeneity assessment of various digitized time series. The second day saw presentations by most of the National Meteorological and Hydrological Services (NMHSs) that encompass the Greater Mediterranean Region (GMR). The final day saw discussions about the best way to achieve the ambitious goal of the project. This summary report briefly discusses some of the common threads evident through the two sets of presentations, and lays out the decisions taken on the final day of the meeting.

The extended versions of all the papers presented will be in the proceedings of the workshop, which will be hung off of the MEDARE web portal. The presentations as given during the meeting can be downloaded from the MEDARE web portal (<http://www.omm.urv.cat/MEDARE-workshop-outcomes/index.html>)

## SUMMARY OF THE PRESENTATIONS FROM DAY 1 FROM THE INVITED EXPERTS:

Each expert was asked to talk on a specific aspect of data rescue. These aspects included, the need for data rescue and digitization, the apparent lack of digitized data in some parts of the GMR in international databases (e.g. the European Climate Assessment and Dataset, ECA&D and the Global Historical Climatology Network, GHCN and the latter's daily version, GDCN), scanning options, possible ways of improving the efficiency of

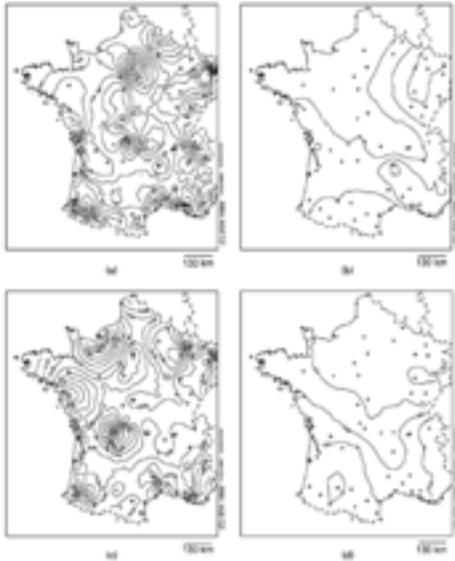
digitization and the best techniques for homogenizing the resulting long climatic series. The best illustration of the need for the complete set of procedures was illustrated by Olivier Mestre's figure for France, which showed the spatial pattern of temperature trends for the 1901-2000 period before and after homogenization. Without the final homogeneity step, the digitization efforts in France would not have produced a coherent picture of the temperature increase. We show this figure as it is an ideal for all countries to aspire to (Figure 1, from Caussinus and Mestre, 2004). An example of what can be achieved for a single station was shown for Gibraltar (Dennis Wheeler), which is possibly the longest site in the southern part of the GMR. Additionally, a number of speakers discussed the MEDARE efforts in the context of wider international efforts, such as those envisaged by ACRE (Atmospheric Circulation Reconstructions over the Earth: <http://brohan.org/hadobs/acre/acre.html>), RECLAIM (Recovery of Logbooks and International Marine Data: <http://icoads.noaa.gov/reclaim/index.html>), GDCN (<http://www.ncdc.noaa.gov/oa/climate/research/gdcn/gdcn.html>) and IEDRO (International Environmental Data Rescue Organization: <http://www.iedro.com>).

## SUMMARY OF THE PRESENTATIONS FROM DAY 2 FOR NMHS REPRESENTATIVES:

Most countries from the GMR region gave summary presentations on data rescue and recovery projects in their respective countries. There were a number of common recurring themes in many of the presentations:

- *Costs/access of the data:* Each country has different policies with respect to this, ranging between free data access to reduced prices for non-commercial purposes like climate research. The general opinion was that historical climate data should be freely accessible for climate

research, but commercial use is still an issue in many GMR countries.



*Figure 1: Maps showing smoothed contour plots of station temperature trends for 1901-2000 for a) minimum temperature as measured, b) as a) but after homogenization, c) as a) but for maximum temperature and d) as c) but after homogenization.*

- *Availability/access to the data:* In each country it is important to easily know what data have been digitized and how the national and international climate community can gain access. For each country there should be a contact person for assistance with access to the data. It is recommended that a list be made with e-mail addresses of NMHS contact persons, together with a list of other more European and Global sources of data (e.g. ECA&D, GHCN, etc.).
- *Resources for digitization:* It is clear that few NMHSs in the GMR have resources available to make much progress in achieving the goals of MEDARE. Some are routinely digitizing current observations, so can get some digitizing done (albeit slowly) through this process. The resource issue will be discussed later in the MEDARE Implementation Plan.
- *Digitizing data and metadata in NHMS and national archives:* It is recommended that with the digitized data not only the common metadata should be made available, but also articles or reports dealing with the climatological time series be made available (via pdfs). Standards need to be adopted for content of both the metadata and the data themselves. NMHSs should use their existing data formats when digitizing early data and adapt if necessary. For metadata, there is a WMO/CCI publication with a number of possibilities ([http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp\\_series/documents/WCDMP-53.pdf](http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp_series/documents/WCDMP-53.pdf))
- *Digital and paper/printed-archival sources:* Regional problems with data rescue were also discussed. Many of the concerns raised cross current political borders. There are also problems with “colonial” data rescue and digitization - where are the data and how do we gain access to them? A modern day political border issue for many of the new Balkan states is: How does an NMHS gain access to historical station data that are currently held by a different national NHMS? What type of agreements may need to be set up to streamline this process? Related to this, for some countries, images of early instrumental data are available on the internet. Examples of this are the images made by the NOAA Central Library Climate Data Imaging Project using publicly available meteorological yearbooks for these countries. It is recommended that countries check the website of this project ([http://docs.lib.noaa.gov/rescue/data\\_rescue\\_home.html](http://docs.lib.noaa.gov/rescue/data_rescue_home.html)) to see if digital images of their data (under previous colonial and current national administrations) are available there before making images themselves.

- *Assistance in digitizing data:* The EU-CIRCE project (<http://www.circeproject.eu/>) has 60Keuros available for digitization of historical data. Olivier Mestre (Meteo-France) is coordinating this to digitize historical climate data from some of the present GMR. Tom Ross indicated that the Climate Database Modernization Program (CDMP) of the National Climatic Data Center (NCDC) (<http://www.ncdc.noaa.gov/oa/climate/cdmp/cdmp.html>) in the US can be approached to digitise important data sets for MEDARE
- *Working with data rescue, imaging and digitisation activities of existing projects and initiatives.* The representatives of a number of existing regional to international initiatives at the MEDARE workshop, such as ACRE, CIRCE, ECA&D, IEDRO, MedCLIVAR and RECLAIM, all indicated a keenness to work with the MEDARE NMHS's to rescue, recover, image and digitise historical to contemporary data series for the GMR.

*Quality control of the digitized data and homogeneity assessment of the long time series:* Existing NMHS standards and software should suffice for quality control. Some NHMSs have experience of different homogeneity software packages, but more need to be aware of developments in this area.

#### PREAMBLE TO THE IMPLEMENTATION PLAN:

The common thread from most of the NMHS presentations was that more resources (both financial and personnel) would be needed before significant progress could be made. It is also extremely unlikely that potential funding agencies would consider a proposal just for data rescue and digitization activities. It is necessary, therefore, to emphasize all the potential uses for which the instrumental dataset will be essential.

These include:

- Placing extreme events in a long context
- Enhancing knowledge about instrumental climate variability and change, and the possible factors causing these changes across the region
- Contributing to further advancement in climate change detection and attribution studies
- Enhancing inputs for defining/adopting the best strategies to mitigate climate change over the GMR
- Improving adaptation to climate change impacts, by developing longer series for assessing impact sector models
- Developing climate change scenarios by combining observational climate measurements with projections from Regional Climate Model simulations
- Enhancing the ability for contribution to the climate component of large field experiments/programmes
- Providing input to extended historical reanalysis (i.e. reanalyses prior to 1948)
- Calibrating natural/documentary proxies, for potential further extension of the climatic history of a country/region
- Calibrating satellite estimates of surface variables
- Providing better observation data for the validation of climate model outputs (both RCMs and GCMs)
- Performing more robust analysis of climate and applied climatological studies

All of these are discussed further in the papers at the Proceedings.

#### POTENTIAL FUNDING SOURCES:

The group discussed numerous potential funding sources, from the regional (e.g. the European Union, the World Bank, the African Development Bank) to the national (e.g. National Governments and Research Councils) and the Private Sector (e.g. Google World). The basic limitation of all is that scanning and digitization efforts are not considered high-profile science, even though the requirement for credible climate data is strongly emphasised by various international organizations and fora (i.e. G8 2005; GCOS 2003, 2004, 2006; GEO 2005, etc.). In addition, we all consider such efforts as essential requirements forming the backbone of our discipline. Essential components are endorsement of the needs of these activities by the GMR as whole, and by WMO and other relevant intergovernmental bodies.

#### IMPLEMENTATION PLAN:

##### *Date Rescue Activities*

All NMHSs have digitized most of their recent records, with many having most of the period from the 1950s digitized. All NMHSs, however, have many old and original paper records, together with much non-digitized material in the old year books. This plan seeks to both preserve this material and digitize as much of the useful non-digitized material available to extend climatologically important time series.

Undertaking Data Rescue (DARE) activities involves rescuing both the data and metadata. The first step is to locate the original records and ensure their preservation for future studies. In many countries, old paper records need copying. The ideal is to not only scan the original material but also achieve long-term preservation by producing poly-acetate films. The latter is expensive, and will only be required where there is a serious risk of the records disintegrating or being destroyed. Storing for the future as paper records is adequate, provided recommendations for preservation from, for example, the European Commission Preservation

and Access (EPCA) are followed. Digitizing of the material is the second and more important phase of any DARE project. This can proceed from either the original paper or year-book material or from scanned images. It is also possible that in some countries, the private sector may be able to help with the scanning and filming. Climatological insight is necessary in deciding what needs to be scanned, but much of the work could be achieved through the use of students and well-motivated private individuals (e.g. recent retirees). All DARE activities should be considered long-term, so there is a need to prioritize efforts, as well as continuing to look for sources of older material, looking particularly for measurements made prior to the founding of the NMHS.

Within the GMR there are many countries which have only become independent during the last 50 years. It is important, therefore, to consult the MEDARE community concerning archives held by other nations during colonial periods. Throughout the GMR, it should be possible to develop a few series for every country back at least into the mid to late-19<sup>th</sup> century. More extensive and spatially complete series will be available for later decades of the 20<sup>th</sup> century.

##### *Variables*

The ideal would be to digitize all material, but resources will always be limited. The recommendation from the meeting is to emphasize the Essential Climate Variables (ECVs) for the surface given in numerous Global Climate Observing System (GCOS) publications (see e.g. the GCOS Implementation Plan). These are, in priority order:

- Air temperature at 1.5-2m – including mean, maximum and minimum values
- Precipitation amounts
- Atmospheric Pressure – corrected to mean sea level

- Surface humidity – ideally vapour pressure, but also dewpoints, specific humidity and relative humidity
- Wind speed and direction
- Surface radiation – ideally measurements from radiometers, but sunshine records can be converted to the above with simple algorithms

##### *Temporal Resolution*

Again the ideal would be to develop a database down to the shortest temporal scale, but the minimum recommendation would be the daily timescale. Series should also be aggregated up to the monthly timescale as well.

##### *Digitizing*

This aspect is potentially the most time consuming and expensive part of the work, as it requires the development of digitizing software and climatological experience and input at all stages. In almost all countries such software and expertise has been developed for local needs, but it generally requires more resources to cater for the potential volumes of material involved. Manual digitizing is the only approach for hand-written material, but Optical Character Recognition (OCR) techniques should be investigated for all printed material (e.g. in early year books). There is a lot of experience of OCR across the GMR and also in many countries in Northern Europe. In addition, work is also progressing on electronic means of digitising strip charts, such as thermohygrograph or barograph traces. In many NMHSs the use of well-supervised students has been found to be a very cost-effective way of achieving the best results – in terms of the amount of data digitized.

##### *Quality Control*

Every NMHS has quality control (QC) procedures for assessing current data entering national NMHS digital archives. Once digitized, the extended series

should be passed through these procedures taking advantage of the experience of trained staff.

##### *Homogenization*

Over the last 20 years, a number of software packages have been developed to assess the long-term homogeneity of climatic time series. At present, there isn't a best method, but interactions with the COST Action HOME (<http://www.homogenisation.org/>), which will run over the next four years, is highly recommended. However, MEDARE will not be able to rely entirely on links to activities such as HOME, so funding for a MEDARE training workshop, where participants can come with data and learn about experiences across the GMR with some of the more well-used approaches is recommended. In support of such activities, MEDARE should also look to interact with the CCI/CLIVAR/JCOMM Expert Team on Climate Change and Indices (ETCCDI) in association with WMO, NMHSs, and other co-sponsors such as GCOS, IPCC, START, who are organising roving regional workshops on Climate Data Homogenization and Climate Change Indices (<http://www.clivar.org/organization/etccdi/activities.php>). The ETCCDI has accomplished a [series of regional workshops](#), covering SE Asia (Nov 07), Africa (central April 07), southern Asia (Feb 05), Central America (Nov 04), SW Asia (Oct 04), South America (Aug 04) and southern Africa (May 04). These workshops have promoted regional climate change detection activities and filled in gaps in global climate data sets.

##### *Development of Data Inventory*

Mindful of the time such a project will take, and the variety of rates of achievement of the aims across the GMR, the group proposed a data inventory to enable some progress to be made within the first few months. Here, the MEDARE community would develop lists for their country of the longest times series data for the ECVs. The lists would not include the data, but give sufficient details on what metadata

## Introduction to the MEDARE workshop proceedings

By Manola Brunet

are available and what part of the record is digitally available (from whom), what part still needs recovering and digitizing and what homogeneity assessments have been carried out on the series. The national lists would be combined into a GMR inventory of source availability of the long and potentially long records (> 50 years).

### *Development of the Web Portal*

The University Rovira i Virgili in Tarragona agreed to host the site, where information on goals, people, contact lists, working groups, documentation, inventory of the longest climate records, and other MEDARE activities will be provided. It will include restricted areas for the MEDARE community and its working groups.

Set up a number of email accounts for contacting working groups with specific questions and general advice:

- Where might early colonial material be held?
- What are the best scanners to purchase?
- Which is the best OCR software for printed material?
- Which homogenization software is best for specific variables?

*Next meeting: Greece!*

Phil Jones

December 2007

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This proceedings is the result of a cooperative effort made by the MEDARE Community (<http://www.omm.urv.cat/MEDARE/index.html>), which brings together scientists from universities, research centres, international institutions and projects and climatologists from the National Meteorological and Hydrological Services (NMHSs) in the Greater Mediterranean Region (GMR). It is based on the contributions presented at the International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin held at the University Rovira i Virgili (Tarragona, Spain, 28-30 November 2007), which was organised by the World Meteorological Organization / World Climate Data and Monitoring Programme (WMO/WCDMP), the Agencia Española de Meteorología (AEMET: Spanish Meteorological Office) and the University Rovira i Virgili.

The workshop was impelled by WMO/WCDMP, in order to give a decided impulse to data rescue activities over the GMR through involving data producers and data analysts in the common enterprise of developing high-quality/long-term climate datasets and, then, to enhance climate data availability, which can be more confidently used in the assessments of regional climate change detection and modelling, their related impacts over the Mediterranean socio-ecosystem and to define the best strategies to adapt the countries to the current and future climate change challenges.

The proceedings provides, for the very first time, a comprehensive overview on the needs and benefits of undertaking Data Rescue (DARE) activities, on existing international and regional DARE projects and programs and reviews long-term climate data availability and potential for fostering DARE missions at the sub-regional and national scales across the GMR. It has been organised in three main sections preceded by a foreword from Mr. Michel Jarraud, Secretary-General of WMO, the statements in the opening ceremony, the summary of the workshop, and followed by the reference and abbreviation lists.

The first section is devoted to emphasise needs and expectable benefits, both scientific and socio-economic, of undertaking DARE activities. It is open by an assessment on the key importance of climate data and information to face development challenges. Scientific benefits of bringing old instrumental climate records into the 21st century are discussed in the second chapter. Climate data availability for monitoring and research purposes is explored in the third chapter, with a special emphasis put in the Mediterranean region. The needs for a historical climate data and metadata bases for the Mediterranean are discussed next. The activities and procedures for recovering one of the longest climate records in the Mediterranean, the Gibraltar record, are described in the fifth chapter. A review on currently available homogenisation procedures, together with the need of developing long-term homogeneous climate records, is assessed in the penultimate chapter. Finally, tips and tricks in data rescue and digitization learned from the Dutch experience are discussed in the last chapter of the section.

The second section is dedicated to review existing regional initiatives and climate datasets, with a special focus over the Mediterranean. First, the global project "Atmospheric Circulation Reconstruction over the Earth", aimed at facilitating the recovery, extension and consolidation of global historical terrestrial and marine instrumental daily to sub-daily surface observations covering the last 100-2050 years is presented. The Italian experience on enhancing availability and quality of secular climate records is exposed in the second chapter. The NOAA's Climate Database Modernization Program is described in the third chapter. Status, deficiencies and strategies for fostering DARE missions over eastern Mediterranean and the Balkans sub-regions are presented in the following two chapters. Finally, the section is closed by a contribution on the need of counting with the collaboration of non-profit/non-governmental organisations in data rescue and digitisation activities.

The third section is focused on reviewing national climate data rescue projects across the Mediterranean. Experiences gained from Portugal on recovering, digitising, quality controlling, homogenising and making available the longest Portuguese climate records are exposed in the first chapter. Availability and management of long climate records over Spain is assessed next. DARE activities and the development of climate databases over Andorra and Catalonia are discussed on the third and fourth chapters. The efforts dedicated by Météo-France to the recovery of French and oversees long climate records at different temporal scales are described in the following chapter. From chapter sixth to chapter tenth, current climate data availability, the DARE activities carried out by Slovenian, Croatian, Montenegro and Bulgarian NMHSs and the prospects for improving climate data coverage over this sub-region are discussed. The chapter tenth provides an overview of data rescue operations of historic meteorological data at Hellenic National Meteorological Service in Greece. Constraints for processing climatological data and developing long-term climate records over Georgia are assessed in the eleventh chapter. Rescue and digitisation efforts at the Climatological Service of the Lebanese Meteorological Department are described next. Availability and potential of developing long meteorological records over Israel are discussed in the thirteenth chapter, while the fourteen is focused on exploring these issues over Cyprus. Finally, the last two chapters are devoted to give details on the meteorological networks of Tunisia and Algeria and on the DARE activities and the difficulties found for undertaking DARE activities over these North-African Mediterranean countries.

The proceedings ends with a reference and abbreviation lists.

Several national funding agencies have made possible the production of this proceedings. The AEMET (Spanish Meteorological Office), the Servei Meteorològic de Catalunya (Catalonian

Meteorological Service), the Spanish Ministry of Science and Education and University Rovira i Virgili have provided the funds needed for the publication of the proceedings, to which the MEDARE Community is especially grateful.

Manola Brunet

Tarragona, May 2008

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## SECTION I: EMPHASIZING NEEDS FOR DARE PROJECTS

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## I.1. Climate data and development challenges

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### ABSTRACT:

A brief review of the notion of climate variability and climate change is given to introduce the general scope of this paper which is the use of climate data in taking up some development challenges. The inter-annual variability of the climate system is not independent from the impact of the global warming and associated climate change which is taking place. Changes in the frequency and intensity of climate extremes constitute the manifestation of this linkage between both notions. Two illustrating examples of the observed modern climate change are provided to reflect the sea level rise and the Arctic sea ice decline, which bring two major concerns posed by the impact of global warming.

Understanding climate change, its impact and the various projected scenarios need reliable, high resolution, high quality instrumental climate records. In addition these data are needed for day to day and long term planning decision making in all social and economic sectors. The WMO Data Rescue and Digitization of old Climate Records in the Mediterranean (MEDARE) is a response towards taking up development challenges in the Basin. In fact it fits well with the Madrid Statement and Action Plan (MSAP) which was adopted by the international conference on secure and sustainable living: Social and economic benefit of weather, climate and water related information and services, Madrid, Spain 19-22 March 2007 (MSAP, 2007). The paper provides at the end the objective and outcomes of the workshop on rescue and digitization of climate records which set up the MEDARE initiative.

### INTRODUCTION:

Climate is varying and changing at various space-time scales. Climate fluctuations such as those occurring at time scale less than a decade tend to

not affect the long term state of the climate. Fluctuations occurring at longer time scale are widely known to constitute climate change, in which the climate system moves to a different state. These changes can be caused by internal processes, external forces, or, more recently, human activities and they have been always the source of many societal implications. Societies had learnt how to adapt to slow climatic shifts in the past, however, the recent observed changes in the climate which have been occurring since the industrial period, particularly since the mid of the 20<sup>th</sup> century are more rapid, as a consequence making the adaptation more challenging than previous climatic variations. A key question about the climate system and its implications on humankind is: *what changes are laying ahead considering our understanding of present and past changes in the climate system?*; responding to this question needs efforts on various fronts including the scientific one, where the need in narrowing uncertainties, particularly in the determination of the rate of climate change, the regional and local impacts, the occurrence of extremes, the decline of arctic ice and the sea level rise is of high priority. In this regard, long-term, high-quality and reliable climate instrumental data are key information required in undertaking robust and consistent assessments.

Developing countries are especially vulnerable to climate change because of their geographic exposure, low incomes, and their greater reliance on climate sensitive sectors such water resources and agriculture. A single climate extreme event in some countries can cause setbacks equivalent to decade's worth of economic growth (ref. Stern review report). Therefore achieving the United Nations Millennium Development goals will be possible only if climate variability and change are managed effectively.

Climate change and its impacts as one of the most serious problems facing global sustainable development have been addressed by several global, regional and national organizations and

institutions. In this framework, WMO strategies have been designed and adapted to respond to a number of challenges related to weather, climate and water. The WMO MEDARE workshop comes into the main stream of scientific actions dealing with data needs for climate studies and focuses on one of the most climate sensitive regions in the world which is expected to deal with negative climate change impacts. The Mediterranean countries have shown their great interest in attending the workshop; their representatives defined realistic and feasible actions to be taken including rescuing climate data records and making them discoverable and exchangeable through a dedicated regional portal.

#### CLIMATE VARIABILITY AND CHANGE:

##### *What is the difference?*

Climate change refers to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to internal processes and/or external forcing; some external influences, such as changes in solar radiation and volcanism, occur naturally and contribute to the total natural variability of the climate system, while others such as the change in the composition of the atmosphere that began with the industrial revolution, are the result of human activity (<http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter9.pdf>).

As part of the natural variability of the climate system, the El Niño/Southern Oscillation (ENSO) phenomenon has been well documented and explained in several research papers; it constitutes the most prominent feature of the coupled Ocean-Atmosphere climate variability. Monitoring ENSO includes sea surface temperature anomaly measurements in the central tropical Pacific. ENSO has been used extensively as a key information source in producing seasonal to inter-annual climate

prediction information. Many other natural climate variability features have been also explored in research studies including the well known North Atlantic Oscillation, the Atlantic dipole and the recently studied Indian Ocean dipole.

##### *Climate extremes in recent years*

In the recent decade 1998-2007, WMO recorded an important number of climate and weather extremes. Most reminding ones include the global average temperature record in 1998, the heat wave in Europe in 2003 which caused several thousands casualties, the busy hurricane season in 2005 which killed near 3000 in southern states of the United States, prolonged droughts in the greater horn of Africa, Australia and parts of North America, and devastating flooding in Africa, the Caribbean states, south Asia and China.

On annual basis the year 2007 was one of the busiest years in terms of climate and weather extremes.

In 2007 extreme summer heat waves affected south-eastern Europe, southern United States, Japan and Australia, leading to record temperature breaking and forest fires in many locations. For example the thermometer indication rose up to 45°C (113°F) in Bulgaria and dozens of people died in Australia, while conditions were not as severely dry as in 2006, long term drought meant water resources remained extremely low in many areas, leading to extensive fires.

Oppositely, unusual monsoon season caused flooding in areas such as in South Asia, Africa and Mexico where torrential rains caused severe flash floods. For example some 1.5 million people were affected and hundreds of thousands homes destroyed in west, central and east Africa during the northern summer monsoon in 2007. Tropical cyclone *Sidr* which made landfall in Bangladesh in August 2007 killed over 3000 and destroyed or damaging nearly 1.5 million homes.

Although it is not possible to make direct link between individual extreme events to the global warming on yearly basis, however their magnitude, extend and intensity fit well with the current understanding of climate change impacts. Therefore it is not possible to rout out the linkage between these events and the effect of the global warming and the induced climate change.

#### MODERN OBSERVED CHANGES AND PROJECTED CLIMATE CHANGE EFFECTS:

##### *The role of instrumental climate observations*

Understanding the changes that occurred in the past back to several thousands years becomes crucial when addressing the relation of climate change with human activities. The knowledge should include a reliable assessment of the magnitude and rate of the changes which affected in particular the fundamental elements of the climate system such as temperature, precipitation, snow and ice cover as well as the changes in the sea level. In this deem, the challenge has been always the availability of and accessibility to past climate records. Climate proxy data, such as those provided by ice core samples and tree rings, are very useful in extending time series several thousand years back in the past; it provides useful evidences on how climate varied in the past centuries and millennia and at which rate.

However, modern Instrumental climate records which started in the mid of the eighteenth centuries are needed for translating climate proxy evidences into instrumental terms, and constitute fundamental input for climate model simulations and calibrations. High quality, high resolution instrumental climate records are therefore necessary for understanding and comparing past and present climate on common scientific basis and providing objective simulations and projections for future climate in relation with various anthropogenic forcing.

##### *Detecting climate change*

International efforts in prospecting simple indices reflecting climate change have led to the definition of several indices useful for detecting climate change. The international coordination of these efforts is being undertaken by the Joint CCI/CLIVAR/JCOMM Expert team on Climate Change Detection and Indices (ETCCDI). A total of 27 indices summarizing temperature and precipitation extremes have been defined using daily climatological data. Leading experts developed software allowing quality control and homogeneity test and adjustment for large data sets as well as the computation of climate extremes. Several workshops were organized in various parts of the world to cover as much as possible the existing gaps in developing countries. These workshops provided an optimal opportunity to produce peer-reviewed papers, thus contributing to the IPCC studies. An action plan for future work was established in November 2006 by ETCCDI (ref WCDMP No 64, WMO-TD No 1042)

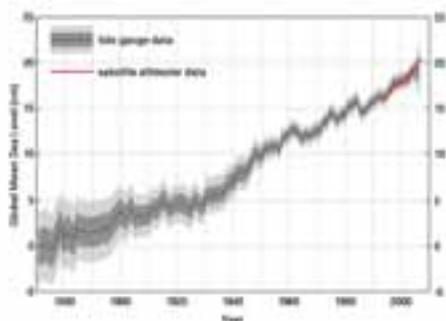
##### *Recent changes detected in the global climate system*

The IPCC fourth Assessment Report (4AR, IPCC, 2007) indicates that since the beginning of the twentieth century, the global average surface temperature has risen by 0.74 °C and that the warming trend over the past 50 years (0.13 °C per decade) is nearly twice that of the past 100 years. Eleven of the past twelve years (1995-2006) are amongst the 12 warmest years on records, depicting further acceleration in the observed warming trend in the most recent years. Average ocean temperature increased to depths of at least 3000 m. Ocean has absorbed 80% of heat added leading to sea water expansion and sea-level rise (IPCC 4AR) .

##### *Sea level rise*

Modern satellite measurements reveal also that since 1993, sea-level has been rising at an average rate of about 3 mm per year, substantially faster than the average for the 20th century of about 1.7 mm per

year, estimated from coastal sea-level measurements (John Church, WCRP News)

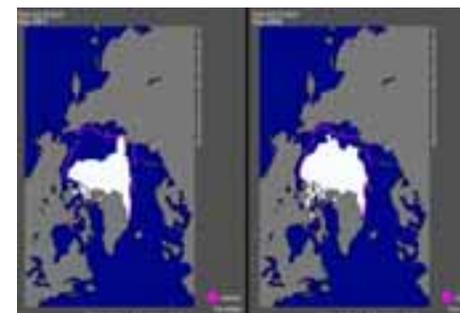


*Figure 1: Global averaged sea level determined from coastal sea level measurements (solid line with one and two standard deviation error estimates, from 1970 to 2006) and from satellite altimeter data (red, from 1993 to November 2007). [Figure provided by CSIRO Marine and Atmospheric Research based on coastal tide-gauge data from the Permanent Service for Mean Sea Level (PSMSL) and altimeter data from NASA and CNES.]*

The impacts of sea-level rise will be felt through both an increase in mean sea level and through an increase in the frequency of extreme sea-level events (e.g. storm surges) of a given level. Impacts include increased flooding (both severity and frequency) of low-lying areas, erosion of beaches, and damage to infrastructure and the environment, including wetlands, inter-tidal zones and mangroves, with significant impacts on biodiversity and ecosystem function. Millions of people in low-lying nations such as Bangladesh, the Mekong and other deltas, and Pacific islands such as Tuvalu, will have to respond to rising sea levels during the 21st century and beyond ([http://wcrp.wmo.int/AP\\_SeaLevel.html](http://wcrp.wmo.int/AP_SeaLevel.html))

#### Arctic sea ice extent shrinking

The average sea ice extent for the month of September 2007 was 4.28 million square kilometres, the lowest September value on record. At the end of the melt season, the Arctic sea ice extent was 39 percent below the long-term average from 1979 to 2000 and 23 percent below the previous record set in 2005. The disappearance of ice across parts of the Arctic opened the Canadian Northwest Passage for about five weeks starting 11 August. Nearly 100 voyages in normally ice-blocked waters sailed without the threat of ice. The September rate of sea ice decline since 1979 is now approximately 10% per decade, or 72,000 square kilometres per year, (WMO statement on the climate in 2007). The changes in the Arctic sea ice feedbacks through various processes into the chain of variations affecting the climate system. In fact its melting in response to rising temperature creates a positive feedback loop by reducing the reflectance power of the Arctic (decreasing albedo), thus allowing more heat absorption by the underlying ocean waters as a consequence the ocean heats up and Arctic temperature rise further and hence more ice melts away (WMO statement on the climate in 2006, WMO TD1016). Sea ice also affects ocean circulation through salinity mechanism which helps maintaining the large scale ocean circulation. The loss of sea ice has the potential of changing climate patterns and accelerating observed trends in global climate change.



*Figure 2: Sea ice extent for September 2007 (left) and September 2005 (right); the magenta line indicates the long-term median from 1979 to 2000. September 2007 sea ice extent was 4.28 million square kilometers (1.65 million square miles), compared to 5.57 million square kilometers (2.14 million square miles) in September 2005. This image is from the NSIDC Sea Ice Index (Source: National Snow and Ice Data Center, United States)*

#### CLIMATE CHANGE PROJECTED IMPACTS (IPCC 4AR):

IPCC Fourth Assessment Report (4AR) illustrates various potential regional climate changes and their effects on natural and human environments. Such information is now available across a wide range of systems and sectors concerning the nature of future impacts. Projected impacts are expected to affect water resources at first instance. In fact by mid-century, annual average river runoff and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas, and decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics, some of which are presently water stressed areas. Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk. In the course of the century, water supplies stored in glaciers and snow cover are projected to decline, reducing water availability in regions supplied by melt-water from

major mountain ranges, where more than one-sixth of the world population currently lives.

#### CLIMATE DATA AND DEVELOPMENT CHALLENGES:

##### *Climate Data, a resource for development*

In addition to their great importance in developing the knowledge and science about climate change, historical climate data provide key information to development stakeholders in various socio-economic sectors; at various levels of decision making, from day to day operation to long term planning and strategies. Water resource management is a sector having strong direct linkage with the current and future development challenges, it provides a clear evidence on how climate information is important in all aspects of management. This include water supply and demand projection for improved resource allocation and facility management; flood volume, inundation area and timing projection for flood hazard mitigation, including biological and health impacts; reservoir and river/estuarine water quality projection for ecological and health objectives. (Ward et al., 2005)

In managing a reservoir over the coming several months, key information is the risk of each month's inflow being less than specified thresholds, translated into risks of failure to meet specified user requirements. This risk can be estimated based on historical climatology, drawing on information contained in long historical records combined with physical understanding of the regional climate.

This kind of risk management approach based on historical information is also valid in many other climate sensitive sectors, such as agriculture, food security, health, energy, and tourism (Nyenzi et al., 2005). All constitute key development sectors particularly in developing countries.

##### *Alerting on climate extremes, climate watches*

A climate watch is an advisory on foreseen and/or evolving climate anomalies with possible impacts

leading to extreme weather and climate events. Its preparation is based on climate monitoring products and long range forecast on one hand, on the other hand, on the existing information on socio-economic impacts of various global and regional climate patterns and anomalies. Therefore a "Climate Watch" can serve as a mechanism to heighten awareness in the user community that a significant climate anomaly exists or might develop and that preparedness measures should be initiated. Historical climate data provide references on which the development and issuing of climate watches are based.

Given the advances in climate monitoring and long range forecast during the last two decades, it is now feasible that National Meteorological and Hydrological Services (NMHSs) issue climate watches and help reduce socio-economic vulnerability by improving preparedness procedures for adverse climatic conditions (Zhai *et al.*, 2007). Based on this development, WMO Congress-XV reviewed Climate System Monitoring and Climate Watches and issued a resolution on future priorities which include "To enhance climate monitoring capabilities for the generation of higher quality and new types of products and services", including assistance for the countries in need: Developing Countries (DCs), Least Developed Countries (LDCs) and Small Island Developing States (SIDSs).

#### *Madrid Statement and Action Plan (MSAP)*

Recognizing the importance of climate data, information and services in addressing the various opportunities and challenges in relation with development and risk management, WMO organized several conferences and regional workshops. In this regards and following two international conferences on understanding the role of NMHSs in creating social and economic benefits, a third conference entitled "Secure and sustainable living; social and economic benefits of weather, climate and water services", focusing on users and decision-makers,

was held 19-22 March 2007 in Madrid, Spain. The International Conference unanimously adopted the Madrid conference statement and action plan. The overall objective of the plan is "to achieve, within five years, a major enhancement of the value to society of weather, climate and water information and services in response to the critical challenges represented by rapid urbanization, economic globalization, environmental degradation, natural hazards and the threats from climate change".

The Mediterranean Data Rescue initiative MEDARE, sits well in the Madrid action plan under action 12 which aims at encouraging the free and unrestricted exchange of meteorological, hydrological and related data to support research and improve operational services. This action includes activities such as the preparation of the needed infrastructure, tools and databases in NMHSs, promoting the exchange of historical data for climate change assessment and climate extreme analysis, capacity building and training workshops on climate data management systems as well as data rescue and digitization of historical climate records.

#### THE INTERNATIONAL WORKSHOP ON RESCUE AND DIGITIZATION OF CLIMATE RECORDS IN THE MEDITERRANEAN BASIN:

##### *Objectives*

Under the auspices of the WMO, NMHSs and several universities from the Mediterranean countries and elsewhere gather together in Tarragona, Spain, 28-30 November 2007 to foster their collaboration in establishing a basin wide climate Data Rescue and inventory initiative. The workshop was co-organized by the WMO, the Spanish *Instituto Nacional de Meteorología (INM)* and the university of Rovira *i Virgili* in Tarragona, Spain. Around 50 experts from the countries in the basin and from other regions discussed how to go about preserving and digitizing the numerous and un-valuable old climate records that exist in the

region, but still not exploitable under digital form. These records, if made available in a suitable electronic format, will provide very useful information for advancing the scientific knowledge of the Mediterranean climate and reducing uncertainties in climate change studies. The workshop was built on existing WMO programs and international projects including the Global Climate Observing System (GCOS) Regional Action Plans (GCOS, 2006). The workshop assigned the following objectives:

- Inform on and discuss techniques and procedures on data and metadata recovery, digitization, composing, formatting, archiving and disseminating long-term climate records,
- Establish an inventory on country basis of the currently available long-term climate records in digital form (temperature, precipitation, air pressure) and the longest and key climate records to be recovered at NMHSs and other the potential sources,
- Identify opportunities and resources to be mobilized at the national and regional scales, and beneficiaries of implementing Mediterranean climate data rescue projects,
- Set up a portal for inventorying the current available climate data and the potential data to be recovered on a national basis and actions to be undertaken for developing national and regional Data Rescue Activities (DARE).
- Discuss and issue recommendations to make accessible the rescued time series for the international scientific community; decision makers and other users.

##### *Outcomes*

##### Requirements for Data Rescue

Long-term, high-quality and reliable climate instrumental time series are key information required in undertaking robust and consistent assessments to better understand, detect, predict

and respond to global climate variability and change. The benefit areas include regional climate studies and predictions, calibration of satellite data, generation of climate quality reanalyses data, besides being a formidable and essential tool in translating climate proxy evidence into instrumental terms. Participant agreed that MEDARE activities should focus on GCOS Essential Climate Variables (ref. GCOS), as well adding other parameters such as Marine and Hydrology.

##### Existing Regional and National Initiatives and Datasets

Data rescue activities have been undertaken in the region for many years. The current status shows that despite efforts undertaken by various NMHSs in (DARE) activities aiming at transferring historical long-term climate records from fragile media (paper forms) to new electronic media, accessible digital climate data are still mostly restricted to the second half of the 20<sup>th</sup> century, hence preventing the region from developing more accurate assessments of climate variability and change. Individual country presentations show different stages of data rescue and digitization. On this aspect, participants noted that a collaborative and multi-country approach is required to recover data held in various places which are dating from the old colonial periods. In addition, some countries are well advanced in designing and implementing data rescue projects, therefore are providing an interesting starting point for multi-country data rescue implementation.

##### Resource Mobilization

The workshop identified many institutions and projects that have the potential to provide support to DARE activities on both technical and financial aspects. These include in particular:

- The Framework of EU FP7, the World Bank, Development/Cooperation agencies such as DFID (UK Department for International

## I.2. Benefits from undertaking data rescue activities

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Development) and FFEM (Fonds Français pour l'Environnement Mondial);

- The New COST action, EUMETNET/ECSN (European Climate Support Network: 23 countries). CIRCE Project - <http://www.circeproject.eu>, MEDCLIVAR and HyMeX, the Scandinavian Grouping in addition to EU funding sources, National Development agencies and Development banks;
- The European Environment Agency which conducted a project with the ECMWF for a fine resolution re-analysis (EURRA), the International Geographical Union (IGU, a member of ICSU) the Commission on Climatology (This is an independent commission of climatologists and geographers (to not confuse with the WMO Commission for Climatology (CCI));
- The WMO resource mobilization office, which could advise on steps and mechanisms to be followed for fund raising to implement DARE projects;

On another hand participants considered the opportunity to develop a strong partnership with universities, interested organizations and schools and voluntary individuals. This partnership would be instrumental in providing human resources such as placement of students and individuals for keying the data. The private sector could also be helpful in preserving and imaging climate records. Climate record digitization however, should be done or supervised by climatologists to ensure quality controlled data following the WMO practices in Data Rescue (Tan et al, 2004) and Data Management (Plummer et al, 2007)

### CONCLUSION:

Climate variability and change constitute the evidence of the changing climate; they have considerable impacts on societies and involve several challenges for government and policy

makers in terms of sustainable growth and development. In order to reduce nation vulnerability to climate change and climate extremes, and help adaptation by an enhanced resilience in particular in developing world, there is a need to work collectively to improve provision of climate data and services to various socio-economic sectors.

Furthermore, these data are always needed to develop new methods and tools to assess climate change, to develop strategies for development issues and to provide an enhanced quality of climate services including the provision of reliable and timely "climate watches " which serves in preparing against climate induced anomalies and extremes. Therefore, Climate information needs amongst research and development sectors will not be satisfied without improving climate data availability, access and provision. Fostering collaboration amongst countries sharing similar climate challenges is a key element for developing agreed solutions to various difficulties facing climate data rescue and exchange. The international workshop on climate data rescue and digitization of climate records in the Mediterranean basin set up a framework of collaboration within the Greater Mediterranean Region (GMR). It produced feasible and realistic recommendations, the most of which is the launch of the WMO MEDARE initiative including the development of a dedicated portal on climate Data and Metadata. It is therefore very crucial that all NMHSs, research institutions and universities interested in the field of Data Rescue and exchange in GMR and elsewhere take this opportunity to adhere to MEDARE initiative and work towards achieving its goals and objectives.

### ABSTRACT:

In most regions of the world there are longer instrumental records than apparent in a cursory search of the web site or the archives of a National Meteorological Service. In many cases these pre-date the founding of the Service, and in some cases they pre-date the founding of the country. It is important that these early records, which were often taken with meticulous care by early scientists and medical doctors are digitized and made available for climatological use. This paper discusses the benefits of bringing these old instrumental records into the 21<sup>st</sup> century.

### INTRODUCTION:

Extending climatic series brings a number of scientific benefits, both to the National Meteorological and Hydrological Service (NMHS) and to the climatological research community in the country and in the region. In this paper, we document with examples a number of the possible benefits. The primary benefit is that the longer records enable trends and other analyses to be more extensive, placing recent records and extremes in the longer context. Longer climatic series also provide instrumental data for more extensive calibration of natural and documentary proxies, both of which have the potential for extending the climatic history further back in time. Longer observational data provide better spatial coverage (in both space and time) for the extended Reanalysis projects, planned to begin in the late 19<sup>th</sup> century. Finally, longer records are useful for assessing impacts of climate change over more extensive time-frames than just the recent past. The following section discusses the above with examples, principally from northern and western Europe.

### PLACING RECORDS IN A LONGER CONTEXT:

Western and northern Europe have the longest instrumental records anywhere in the world. Many extend back at least 100 years before the establishment of the NMHS, sometimes for much longer. Most of these early observations were made by the astronomical and medical community, generally within the major university cities. In some countries, these records have been extensively studied leading to series reaching back to 18<sup>th</sup> century and in the UK (the Central England Temperature, CET, series) to 1659 (Manley, 1974; Parker *et al.* 1992). Figure 1 shows annual temperature series for Fennoscandia, Central England and Central Europe (series derivation detailed in Jones *et al.* 2003a). Figure 2 shows summer (June to August) temperatures over Central Europe back to 1780 illustrating that the record heat wave of 2003 was at least 1°C warmer than the previous warmest summer.

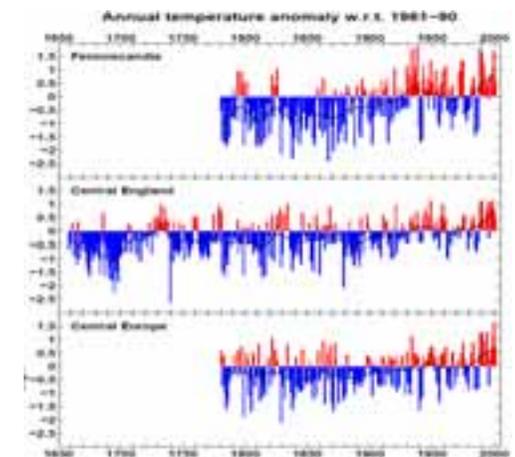


Figure 1: Annual temperature averages (as anomalies from 1961-90) for Fennoscandia, Central England and Central Europe. Regions are defined as in Jones *et al.* (2003a). The smooth line in this and some subsequent plots is a decadal filter.

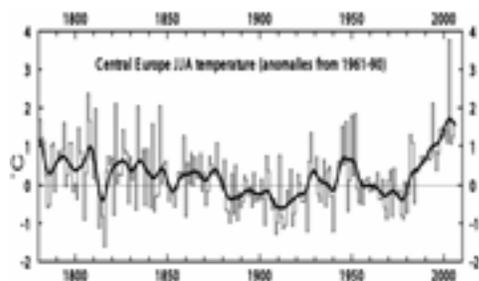


Figure 2: Summer (June to August, 1781-2006) temperatures (anomalies from 1961-90) for Central Europe (35-50°N, 0-20°E). Source: Trenberth *et al.* (2007).

The daily CET record (Parker *et al.* 1992) extends back to 1772 enabling an analysis of extremes to consider the last 230 years. Figure 3 shows an example of changes in extremes (days greater than the 90<sup>th</sup> percentile – warm days for the time of year, and days cooler than the 10<sup>th</sup> percentile – cold days). The development of the daily CET series has required considerable efforts by a number of climatologists over the last 30 years, locating and digitizing the early archival material and then considerable efforts in homogenizing the entire series. The efforts have led to the CET series being the most analyzed climatological times series for a single region anywhere in the world.

#### LONGER RECORDS FOR THE ASSESSMENT OF PROXY EVIDENCE:

Longer climatic reconstructions require information from natural (e.g. trees, ice cores) and documentary (written archives) proxy material. These proxy records must use instrumental records to calibrate the proxy source. In many regions, calibration is hampered by the lack of long instrumental records. In Europe, however, it is generally possible to assess the quality of possible reconstructions, especially the longer decadal-timescale details, for almost 200 years. Figure 4 shows two examples of such calibration exercises using the long instrumental record developed for northern Fennoscandia (Haparanda) by Klingbjør and Moberg (2003). The first shows the potential for further extension from the ice break-up dates in Spring (April/May) on the Tornio river. The second shows the extended calibration of tree-ring measurements near Lake Torneträsk for the summer (June-August) season. Both proxy series show good replication of instrumental temperatures at the interannual and the decadal timescale.

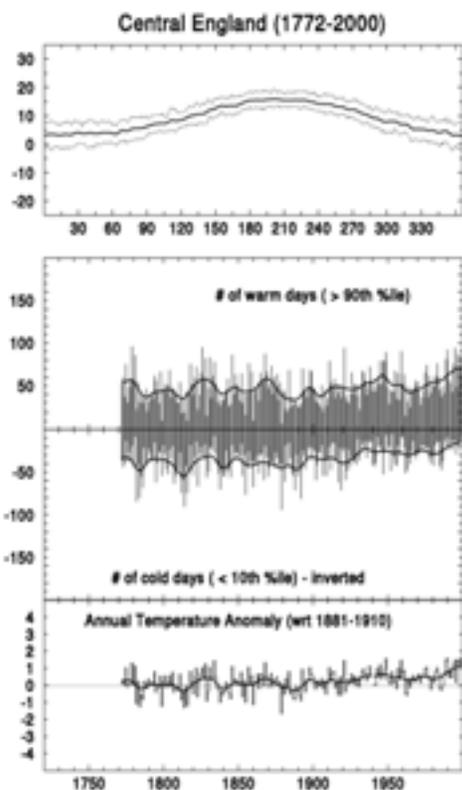


Figure 3: Daily Central England temperature extremes. Top panel: seasonal cycle and 10<sup>th</sup> and 90<sup>th</sup> percentile ranges for the time of year (based on the period 1881-1910). Middle panel: warm day count per year (days above 90<sup>th</sup> percentile) and cold day count (days below 10<sup>th</sup> percentile, inverted). Bottom panel: Annual temperatures (anomalies from 1881-1910).

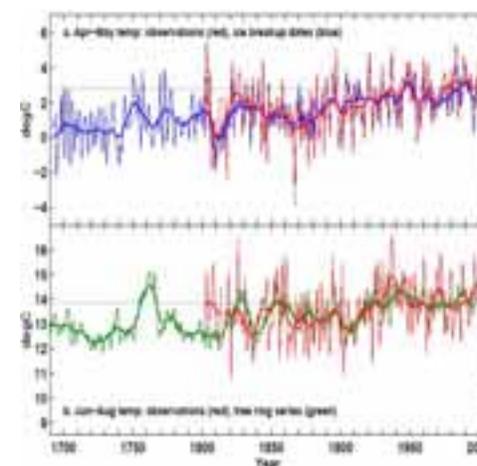


Figure 4: Comparison of instrumental and long proxy records. Top panel: April-May instrumental temperatures (red), calibrated temperatures based on ice break-up dates (blue). Bottom panel: June-August instrumental temperatures (red), calibrated temperatures based on tree-ring width and density data (green).

Isotope records in ice cores provide potentially useful and very long series of climatically important information. They are, however, by their very nature, located in regions a great distance from human habitation. In Greenland, Vinther *et al.* (2006) have extended instrumental temperatures back to the late-18<sup>th</sup> century almost 100 years before official records kept by the Danish Meteorological Institute. Figure 5 shows 30-year running correlations between the 'winter' oxygen isotope data and winter (DJF or DJFM) temperatures from a combination of the early and the official records for southwest Greenland. The figure illustrates the stability of the relationship between the isotope and instrumental records with the natural proxy explaining about 30-40% of the variance of winter temperatures.

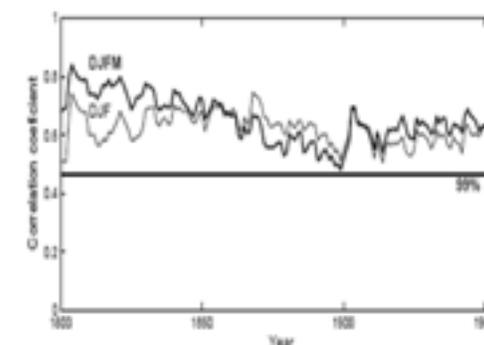


Figure 5: Running correlations between the average 'winter' oxygen isotope value (from three south Greenland ice cores) and the DJF and DJFM winter temperatures. Running correlations are plotted for every 31 years from 1784 to 2005. Values are plotted at the centre of each 31-year period. The straight line is the 99% significance level for a sample of 31.

#### ASSESSMENT OF CHANGES IN EXTREMES:

To assess changes in the frequency of extremes, daily records are required. The CET records has already been discussed in this context (see Figure 3). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) discussed the most comprehensive study of changes in extremes (see e.g. Trenberth *et al.* 2007 and the original study Alexander *et al.* 2006). As temperatures have increased, the occurrence of both warm days and nights have increased while the number of cold days and nights has decreased. The effect on night time temperatures has been slightly more marked than for day times.

### LONGER ASSESSMENT OF THE CIRCULATION INFLUENCE ON SURFACE TEMPERATURE AND PRECIPITATION PATTERNS:

Over western Europe, northerly airflow almost always leads to cooler temperatures. The relationship between airflow direction and surface temperature and precipitation can explain a significant amount of the variance of surface climate variability. The strength of this relationship can, however, vary with time and with climate change can be expected to change in the future. Longer records of surface pressure, temperature and precipitation are required to assess the historic variability of the influence to determine whether recent changes are unusual in a long context. The circulation feature with the strongest influence over much of Europe is the North Atlantic Oscillation (NAO). Jones *et al.* (2003b) discusses the winter manifestation of the NAO and the strength and variability of its influence on European surface climate variability.

### EXTENSIONS OF THE NAO:

The longest record of the winter NAO (back to 1820) has been derived by Jones *et al.* (1997) based on pressure data from Gibraltar in southern Spain and Reykjavik in Iceland. As the NAO is essentially a measure of the westerly wind strength over western Europe, two long pressure records, latitudinally placed, would provide a good surrogate for the more distant locations in Iceland and southern Spain/Azores. The two locations with the greatest potential length anywhere in the world are Paris and London. At both sites, near continuous daily records have been taken since the late-17<sup>th</sup> century. The principal difficulty of developing such records is locating the archival material in the two cities and then digitizing the daily and sub-daily information. For Paris a complete record has been developed back to 1677, but missing most of the years in the 1720s and 1730s. For London, the record is complete from 1698 missing only most of the years

in the 1710s. Searches are still in progress for the missing years. If these are successful, a very useful approximation to the winter NAO will have been developed back to 1698. As daily pressure data are also being digitized for the Amsterdam area, the three sites can be used to develop a long storminess index series using the pressure triangle method developed by Alexandersson *et al.* (2000)

### OTHER USES:

Reanalysis developed by NCEP and ECWMF are being widely used in climatology (see e.g. Trenberth *et al.* 2007). At present they extend back to 1948 and 1958 respectively. Plans are in place to develop extended reanalyses back to the late-19<sup>th</sup> century using surface data assimilation alone. From 1948/1958 the currently available reanalyses use radiosonde data and from the 1970s satellite information. Using surface data alone is less good, but still comparable in error to what is achieved today with a 24-hour weather forecast. Reanalysis products will be improved if more observational surface data (pressure in particular, but also temperature) can be digitized and used in assimilation procedures.

### CONCLUSIONS:

Although most of the examples shown in this paper originate in northern and western Europe, long instrumental records exist for all of the Mediterranean. For more southern regions it should be possible to develop series back for more than 100 years and for northern areas back 150-200 years. As most NMHSs were founded during the second half of the 19<sup>th</sup> century or during the first half of the 20<sup>th</sup> century, it is essential for each NMHS to search out these early measurements. The original records are generally kept in national or learned society archives, sometimes located in the archives of an earlier colonial power. They may not seem important to us now, but this paper has shown that they have a

variety of uses, which will surely expand as scientists become aware of them and they get more widely known. As present day scientists, we owe our forebears much gratitude for taking these early measurements with meticulous care and diligence. Given this effort, it would be a shame if they are left to collect more dust in an archive.

## I.3. Climate data sets availability in RAVI with an emphasis on the Mediterranean RAVI and RA I countries.

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### ABSTRACT:

Here we explore climate data availability for monitoring and research purposes over the World Meteorological Organization (WMO) Regional Association VI (RA VI) and the North African coast (RA I). We also provide an overview on climate datasets available from global datasets, with a focus on RA VI, and other datasets developed under the framework of different European research projects. We also review the potential of climate data to be rescued over sparse data areas in both regions, as well as we give some hints on sources and data keepers to be approached in order to recover the oldest instrumental data. The all over picture obtained is that in Europe especially the (eastern) parts of the Mediterranean area, including the Balkan (RA VI) and the North African coast (RA I), are to be labelled as “data sparse”. This urges to promote the use of already existing and available digitised data sets, the need to search for and preserve documentary observational records (and metadata!) that are threatened by deterioration and to continue or start the digitisation of existing documentary and image file observational records.

### INTRODUCTION:

On 29 June 2007 the European Commission launched a Green Paper with as key message: *Europe must not only make deep cuts in its greenhouse gas emissions but also take measures to adapt to current and future climate change in order to lessen the adverse impacts of global warming on people, the economy and the environment.*

In the CGOS contribution to the Nairobi Work Programme (Draft, 3 Sept 2007, “The Role of Observations in Support of Adaptation”) it is concluded:

*Adaptation of natural and human systems to the impacts of natural climate variability and human-induced climate change is not optional. If climate change is inevitable, then so is adaptation. Further in this report the rationale for DARE (Data Rescue) activities is expressed: At the present time, in many countries neither the quality nor quantity of observations needed is adequate to allow reliable projections needed for adaptation purposes (...) observation networks and data use will need to be strengthened, especially in vulnerable areas.*

This rationale is well in line with the statement made by GCOS in its 2<sup>nd</sup> adequacy report (2003): *The requirement for information on trends and change – makes historical data as important as new observations*

This paper has as aim to improve the use of (historical) data by describing existing available and potential datasets in the Greater Mediterranean Area of WMO RAVI and RAI.

First an overview is given of datasets, often built up by the meteorological observational networks of the NMHS's, available for monitoring and research purposes. Also the existence of sets of observations, made by individuals and occasional networks before the foundation of the NMHS's and the usefulness of paleoclimatic data sets of proxies will be touched.

The outcomes of a questionnaire of DARE activities, addressing the NMHS's with respect to their early and modern observations are presented. The last section offers tracks to potential valuable documentary (paper, image file, film) datasets that deserve to be “dared”

The all over picture obtained is that in Europe especially the (eastern) parts of the Mediterranean area, including the Balkan (RA VI) and the North African coast (RA I), are to be labelled as “data sparse”. This urges to promote the use of already existing and available digitised data sets, the need to search for and preserve documentary observational

records (and metadata!) that are threatened by deterioration and to continue or start the digitisation of existing documentary and image file observational records.

#### INSTRUMENTAL PERIOD:

The scope of this paper is predominantly the instrumental period that starts in the late 17<sup>th</sup> century.

The motivation for carrying out the early meteorological measurements was often pragmatic. One was interested in the climatology (the long term characteristic of the weather) of the area in concern. For instance, in the beginning of the 18<sup>th</sup> century, Dutch engineers carried out regular observations of wind, precipitation and evaporation in the Low Countries to estimate the amount of water that had to be pumped away out of the lakes to reclaim new land (the polders) and the number and geographical locations of the water-windmills that had to be established for this purpose (Engelen, A.F.V. van and Geurts, H.A.M. 1985). From a Hippocratic motivation the physician Herman Boerhaave (1668-1738) promoted the observations of the air pressure because he expected a relation between the air pressure and the dissemination of diseases (Zuidervaart, 2005). From a physical-theological motivation many clergy man carried out individual observations: this served a better understanding of the principles of the weather that was managed by God and so contributed to a better understanding of and raised devotion to Him (Zuidervaart, 2003).

One of the earliest observational networks (ca. 1653) of Europe stems from the Mediterranean. Ferdinand II from Tuscany (1610-1670), measured with thermometers, barometers and hygrometers at several locations in Northern Italy and at several times during the day (Geurts, H.A.M. and Engelen, A.F.V., 1983).

The arrival of the electrical telegraph in 1837 (Samuel Morse, 1791-1872) afforded a practical

method for quickly gathering weather information over a wide area. This data could be used to produce synoptical maps that showed how the state of the atmosphere evolved through time. Especially the army was interested in proper forecasts for planning war actions.

A safe society was one of the major reasons for the foundation of the official NMHS's; the majority around the second half of the 19<sup>th</sup> century. The NMHS's established their observational networks. The (early) 'modern' instrumental data from these networks are the most promising subjects for DARE activities. But one should of course not neglect the earlier 'historical' instrumental observations, needed to extend the longer series back in time.

#### OVERVIEW OF DATASETS:

Examples of data sets which are useful for climate monitoring and generally good accessible are:

The Global Climate Observing system (GCOS) is the global climate observing system, which aim is to ensure the availability from the meteorological services to the research community of satellite and in situ observations for climate in the atmospheric, oceanic and terrestrial domain. The GCOS Surface Network gives access to daily and monthly records of temperature and precipitation from 1016 stations (<http://www.wmo.int/pages/prog/gcos/index.php>)

The Global Historical Climatology Network (GHCN-Monthly) data base, probably the largest in the world, contains historical temperature, precipitation, and pressure data for thousands of land stations worldwide. The length of the record periods varies from station to station, with several thousands extending back to 1950 and several hundreds being updated monthly via CLIMAT reports. The data are available without charge through NCDC's anonymous FTP service (<http://www.ncdc.noaa.gov/oa/climate/ghcn-monthly/index.php>).

Both historical and near-real-time GHCN data undergo rigorous quality assurance reviews.

It is used operationally by NCDC to monitor long-term trends in temperature and precipitation. It has also been employed in several international climate assessments, including the Intergovernmental Panel on Climate Change 4th Assessment Report. Besides this monthly network, also a daily network exists. In RAVI, GHCN encompasses 89 precipitation and 54 mean temperature long series, covering more than 150 years.

The Hadley Centre Central England Temperature data set (HadCET) is world's longest instrumental record of temperature. The mean, minimum and maximum datasets are updated monthly. The mean daily data begins in 1772 and the mean monthly data in 1659. Mean maximum and minimum daily and monthly data are also available, beginning in 1878. These daily and monthly temperatures are representative of a roughly triangular area of the United Kingdom enclosed by Lancashire, London and Bristol. Since 1974 the data have been adjusted to allow for urban warming. Met Office, Hadley Centre: <http://hadobs.metoffice.com/hadcet/>

Improved understanding of past climatic variability from early daily European instrumental sources (IMPROVE) is a EU research project that produced for seven locations in Europe (Padova 1725 >, Milan 1763 >, Central Belgium 1767 >, Uppsala 1722 >, Stockholm 1756 >, San Fernando/Cadiz 1776 > and St Petersburg 1743 >) the longest daily European temperature and pressure series: (<http://www.isac.cnr.it/~microcl/climatologia/improve.htm>)

MedCLIVAR is an international programme which aims to coordinate and promote the study of the Mediterranean climate (<http://www.medclivar.eu/>). It is endorsed by CLimate VARIability and Predictability (CLIVAR), a project of the World Climate Research Programme (WCRP) of the World

Meteorological organisation (WMO) and approved by the European Science Foundation.

A priority of MedCLIVAR is a climate reconstruction for centuries. Luterbacher et al (2006) published an overview of long instrumental and proxy records in the Mediterranean area (table 1).

By comparing contemporary instrumental and proxy records it is possible to translate the latter into instrumental terms, making it possible to extend the instrumental series centuries back in time.

From the map of figure 1 it is obvious that the Balkan and North African regions can be considered as data sparse with respect to the instrumental readings and deserve thus special attention for searching to not yet "dared" data sets.

Location	Time period	Type of 'series'	Temporal resolution	Parameter	Reference
Padova (Italy)	1725 present	Instrumental	Daily	Temperature	Castelli (1986)
Padova (Italy)	1725 present	Instrumental	Daily	Minimum temperature	Castelli (1986)
Padova (Italy)	1725 present	Instrumental	Daily	Maximum temperature	Castelli (1986)
Milan (Italy)	1763 present	Instrumental	Daily	Temperature	Moggi et al. (2002)
Brussels (Belgium)	1767 present	Instrumental	Daily	Temperature	Moggi et al. (2002)
Stockholm (Sweden)	1756 present	Instrumental	Daily	Temperature	Moggi et al. (2002)
San Fernando (Spain)	1776 present	Instrumental and proxy	Daily	Temperature	Moggi et al. (2002)
San Fernando (Spain)	1776 present	Instrumental and proxy	Daily	Minimum temperature	Moggi et al. (2002)
San Fernando (Spain)	1776 present	Instrumental and proxy	Daily	Maximum temperature	Moggi et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Temperature	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Minimum temperature	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Maximum temperature	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Pressure	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Humidity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Wind speed	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Cloud cover	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Ice cover	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Snow cover	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil temperature	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil humidity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil salinity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil pH	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil nutrient	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil moisture	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil temperature	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil nutrient	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil moisture	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil temperature	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil humidity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil salinity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil pH	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil nutrient	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil moisture	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil humidity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil salinity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil pH	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil moisture	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil salinity	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil salinity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil pH	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil nutrient	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil moisture	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil humidity	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil pH	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil nutrient	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil pH	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil nutrient	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil temperature	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil humidity	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil pH	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil nutrient	Yakovlev et al. (2002)
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St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil temperature	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil humidity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil salinity	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil pH	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil nutrient	Yakovlev et al. (2002)
St Petersburg (Russia)	1743 present	Instrumental	Daily	Soil moisture	Yakovlev et al. (2002)
St Petersburg (Russia)					



Institute (KNMI). Quality control uses fixed procedures to check the data and attach quality and homogeneity flags. Analysis refers to calculation of derived indices for climate extremes, according to internationally agreed procedures. Finally, dissemination refers to making available both the daily data (inclusive quality flags) and the indices results to users through the internet.

Today ECA&D has more than 50 partners, contains some 7000 quality controlled time series of, next to temperature and precipitation, variables as air pressure, snow depth, relative humidity, cloud cover and sunshine duration (figure 2) from a network of more than 2000 stations (figure 3). Some 40 derived indices are presented in graphs and thematic maps.

Next to the daily time series of the participants, additionally series from various other projects have been added to the dataset. Among these projects are EMULATE (European and North Atlantic daily to MULTidecadal climATE variability, Moberg and Jones, 2005; and Ansell, 2006), STARDEX (Statistical and Regional dynamical Downscaling of Extremes for European regions, Haylock and Goodness, 2004), MAP (Mesoscale Alpine Programme, Bougeault et al. 2001). GCOS is the Global Climate Observing System, a global surface reference climatological station network (GCOS Surface Network - GSN) built from a selection of the best climate stations in each region of the world (Peterson et al., 1997). The Global Historical Climatology Network - Daily (GHCND) was developed by the National Climatic Data Center (NCDC) and is the largest global data set comprising daily data (NCDC, 2004). The Joint Research Centre in Ispra, Italy houses the MARS-STAT Database containing daily series to develop an interpolated 50-km meteorological European data set for crop forecasting (Genovese, 2001). Additionally, synoptical messages are retrieved from the ECMWF MARS-archive (ECMWF, 2006) and added to the data set each month. These SYNOP data are

exclusively used for updating, extending and filling gaps in existing station.

As put forward in the MEDARE meeting (Tarragona, Spain, 28-30 November 2007) ECA&D (<http://eca.knmi.nl>) offers a suitable platform for the collation, processing, analysing and exchange of new recovered ("Dared") series. For such purposes it is formally recognised as the baseline dataset in the Millennium project. Next ECA&D gives public access to the recently released (November 2007) high resolution gridded dataset, generated by the EU FP6 ENSEMBLES project (<http://www.ensembles-eu.org/>). This project will develop a common ensemble climate forecast system for use across a range of timescales (seasonal, decadal, and longer) and spatial scales (global, regional, and local).

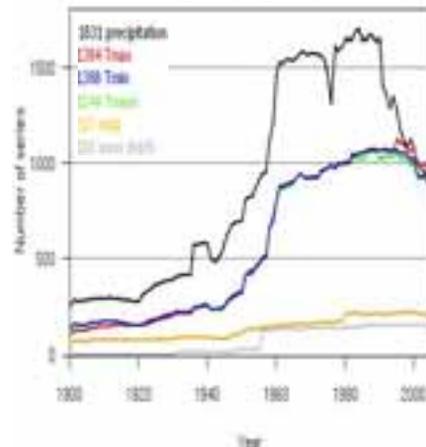


Figure 2: ECA&D; series available per variable



Figure 3: Present station density ECA&D

#### OUTCOMES FOR THE MEDITERRANEAN AREA RA-VI OF A QUESTIONNAIRE ON DATA RESCUE, PRESERVATION AND DIGITIZATION:

This questionnaire was launched in 2005 (van Engelen) and addressed to the ECA&D partners of all NMHS's in RAVI as they have, working with long time series, generally a strong commitment for DARE. One question to the partners was to table per the first day of consecutive 30 years periods the number of stations of which the measurements of temperature and precipitation were available in digital and in paper forms as well.

This is an approach that is comparable with that of a survey (2002) carried out in the Southeast Asia and South Pacific Region (Page et al, 2004). Figure 4 shows the course over time for various countries in RAVI of the number of digitized versus not digitised precipitation and temperature records. The following conclusions could be drawn:

- Generally the number of precipitation stations exceeds the number of temperature stations except Austria and Turkey

- The number of stations is strongly decreasing in Portugal and the Balkan Countries Bulgaria, Slovenia, Serbia, Rep. Macedonia and Turkey. This might reflect shrinking networks; a worrying tendency.
- A notable difference in the number of digitised and non digitised (paper) station records is shown in: Portugal (1840-1990), Switzerland (1840-1990), Slovenia (1870-1960), Bulgaria (1870-1990), Serbia (1900-2004), Turkey (1900-1990) and the Republic of Macedonia (1900-1990). So it might be worthwhile to undertake digitization efforts.
- Spain, Austria and the republic of Macedonia do not have series extending back in time before 1930. This justifies the undertaking of data archaeology actions as carried out in Spain.
- Countries that are recommended to digitise existing 19th century (paper) records are Switzerland, Slovenia and Bulgaria.

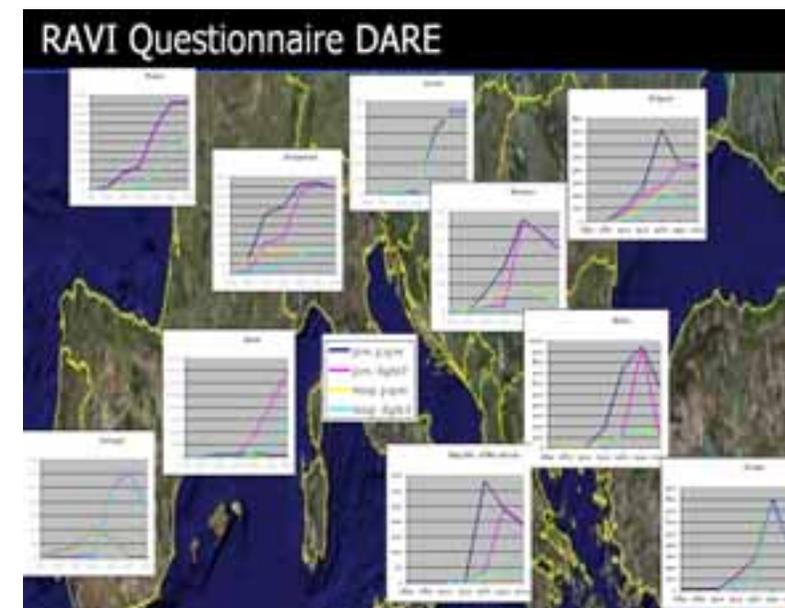


Figure 4: Number of digitized versus not digitised precipitation and temperature records per the first day of consecutive 30 years periods (Aryan van Engelen, 2005, 2007)

### TRACKS TO POTENTIAL VALUABLE DOCUMENTARY DATASETS TO BE PRESERVED AND DIGITISED:

#### *Library of the Ebro Observatory (Tarragona, Spain)*

Ebro was founded by the Jesuits in 1904 and was part of an active network of geophysical observations, run by the Jesuits, with as main activity the exchange of meteorological and climatological data. Currently the library, which is only partly inventoried, contains an abundant collection of meteorological reports dating from the 19<sup>th</sup> and 20<sup>th</sup> century. Fig. 5 shows three promising examples from data sparse areas: the Balkan and Middle East



Figure 5: Examples from the collection of the library of the Ebro Observatory, Tarragona, Spain (María Genesca, Ebro Library).

#### *The African Database*

The historical data rescue program engaged since 1994 by Météo-France has allowed the enhancement of the French climatological heritage, especially for monthly averages of temperature and precipitation for 142 stations in 14 African countries: Benin, Burkina Faso, Cameroon, Central Republic of Africa, Congo, Ivory Coast, Gabon, Guinea, Mali, Mauritania, Niger, Senegal, Chad and Togo (see

figure 6). The data were first available on a set of paper documents, tapes and punch cards. Next step was to put the data of all countries on files covering the period 1880-1950.

In June 2001 a project started that aimed to transform a multi-file and low documented set into a data base structure in CLICOM international format with as characteristic period 1940-1980

([http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp\\_series/documents/WCDMP49\\_Annex12.pdf](http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp_series/documents/WCDMP49_Annex12.pdf)).

For other dare activities in RAI, especially the WMO-Belgian data rescue projects Data Bank and DARE I (microfiching of one million documents of the 9 CILSS countries), reference is made to the WMO Report of the CLICOM-DARE Workshop (San José, 17-28 July 2000) and the Report of the International Data Rescue Meeting (Geneva, 11-13 September 2001), WMO WCDMP report 49 ([http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp\\_series/report49.htm](http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp_series/report49.htm)).

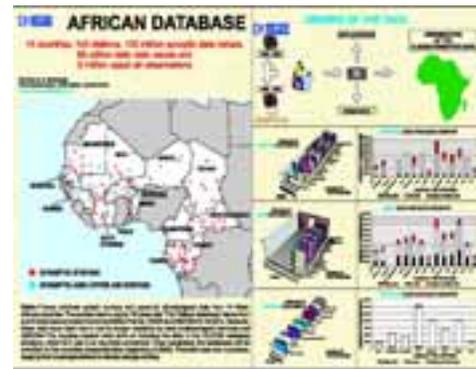


Figure 6: poster African database project (courtesy to Pierre Bessemoulin, MétéoFrance)

#### *Former Italian colonies in RAI*

With Dario Camuffo (CNR, Padova, Italy) the author (van Engelen) had personal communications about meteorological data of the Italian colonial period in Africa, in the countries Libya, Somalia and Ethiopia. Especially data from Libya seems to be relevant for

the analyses of the climate in the Mediterranean part of Europe. But it is likely, according to Camuffo, that more material, also covering the other two Italian colonies can be found in four scientific institutes in Rome and Florence (figure 7)



Figure 7: Maps with sources of observations in the Italian colonial period (provided by Dario Camuffo, CNR, ITALY)

#### *Former Portuguese colonies in RAI*

At a visit (May 2007) to the archives of the Azores Regional Delegation of the Instituto de Meteorologia of Portugal in Ponta Delgada, the author learned that it stored numbers of valuable paper documents with amongst others historical meteorological records from former Portuguese colonies as Mozambique. The documents were in a very bad condition and deserve a thorough stock taking, preservation and subsequent digitisation

#### *NOAA Climate Data imaging project*

Image files of meteorological records are made available by the NOAA Climate Data Imaging project accessible via the NOAA Central Library Foreign Climate Data ([http://docs.lib.noaa.gov/rescue/data\\_rescue\\_home.html](http://docs.lib.noaa.gov/rescue/data_rescue_home.html)). The time period of coverage ranges from the 1830s through the 1970s with most data from the period prior to 1960. Each

series typically includes observations for a number of meteorological and other geophysical parameters. For the area in concern the image files of Algeria, Libya, Egypt and (former) Yugoslavia are relevant.

## I.4. The need of a historical climate data and metadata rescue project for the Mediterranean: the GCOS MedMEDARE project

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### ABSTRACT:

This contribution is focused on describing the context, objectives, status and expected outcomes of the Global Climate Observing System (GCOS) Data Rescue project titled “The Development of Mediterranean Historical Climate Data and Metadata Bases” (MedMEDARE), which is one of the sixteen projects being prioritised in the GCOS Regional Action Plan for the Mediterranean Basin. The MedMEDARE project is aimed at developing quality controlled and homogeneous instrumental climate data and metadata bases for the Mediterranean Basin that can be confidently used for enhancing the detection and prediction of regional climate variability and change, and its impacts over the Mediterranean socio-ecosystems, in order to better define national strategies for the adaptation.

### INTRODUCTION:

Under the GCOS Regional Workshop Programme, aimed at the development of Regional Action Plans (RAPs), took place in Marrakech (Morocco, 22-24 November 2005) the start of the process for the definition of a RAP for the Mediterranean Basin. The GCOS RAPs are intended to identify regional and national needs and deficiencies for climate information, in order to improve systematic observations and data for climate, as they relate to climate policies, national activities and sustainable development. At the same time, RAPs are devoted to agree on a number of key regional priorities and articulate these needs and priorities for bringing them to the attention of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and donor agencies.

The “Marrakech” Regional GCOS Workshop had as aims to identify gaps and deficiencies in climate observing networks and systems in the

Mediterranean Basin and to initiate discussions on the development of the Mediterranean Regional Action Plan, which was aimed at improving regional capabilities in atmospheric, oceanic, and terrestrial data collection and the production and delivery of climate products and services (GCOS, 2006a). GCOS organized this workshop in cooperation with the National Meteorological Service of Morocco, and the Global Environment Facility/UN Development Programme provided funding for the workshop, with additional contributions from the United States and Spain. Figure 1 shows the front-page of the Report of the GCOS Regional Workshop for the Mediterranean Basin, where deficiencies, gaps and needs for enhancing the Mediterranean observing systems for climate are assessed. Workshop participants agreed on the process for the selection of 10 to 15 high priority projects, drawn from a lengthier list of potential topics. These projects should reflect broad regional concerns and add value for people and countries across the Mediterranean region. A follow up meeting to develop the Mediterranean RAP was also agreed.



Figure 1: Front-page of the Report of the GCOS Regional Workshop for the Mediterranean Basin

The Follow-up to GCOS Regional Workshop for the Mediterranean Basin to prepare a draft of the RAP for the Mediterranean Basin was subsequently held in Tunis (Tunisia, 16-18 May 2006) and organized by the GCOS Secretariat and Sahara and Sahel Observatory, as local organiser. About 25 attendees (see Figure 2) discussed the RAP priorities and presented their projects' proposals to fill in current gaps and deficiencies of the Mediterranean atmospheric, oceanic and terrestrial observing systems previously identified, as well as building capacity for data management, analysis, applications, and improve the recovery of historical data across the region. The Mediterranean RAP aims to enhance both regional and national efforts to monitor and detect climate variability and change and their related impacts over the regional and national socio-ecosystems in support of the identification of the best policies aimed at mitigating and adapting the countries to the expectable impacts of current and future climate change. The agreed draft Action Plan, which included 16 project proposals, was then circulated widely across the region for review, being approved and published by GCOS Secretariat in September 2006 (GCOS, 2006b).



Figure 2: Attendees to the Follow-up to GCOS Regional Workshop for the Mediterranean Basin, Tunis, Tunisia, 16-18 May 2006

Among the 16 approved projects, the Project No 12, titled *The Development of Mediterranean Historical Climate Data and Metadata Bases - a GCOS DARE Project (MedMEDARE)*, was devoted to develop quality controlled and homogeneous Historical Climate Data and Metadata Bases for the Mediterranean Basin, which can be more confidently used in climate change detection/attribution studies as well as in the definition of the best strategies to adopt in order to minimize the anticipated environmental and socio-economic impacts associated with a warmer climate.

Here, then, is exposed and discussed the need of such a project, which will enhance the understanding and detection of the Mediterranean climate variability and change, their impacts over the Mediterranean socio-ecosystems and better define policies in order to mitigate climate change and adapt the countries to the expected climate change impacts. Consequently, the needs for developing high-quality historical climate records for the region are stressed in the second section. The third section is focused on describing current status and availability of long-term climate records and the potential for data rescue activities across the region. Aims, status and expected outcomes of the GCOS MedMEDARE project are addressed on section 4; and, finally, in the conclusions section is summarised main issues raised in this report.

#### THE NEEDS FOR THE DEVELOPMENT OF A HIGH-QUALITY DATASET FOR THE MEDITERRANEAN BASIN:

The Mediterranean basin and its margins are very sensitive to a diversity of physical, chemical and biological degradation processes, being specially vulnerable to interannual (and longer timescale) climate variability. Climate change may add to existing problems of soil erosion and salinity, land degradation, loss of biodiversity, water scarcity and desertification. There are also concerns that an increase in the frequency and severity of hotter and

drier conditions may be accompanied by a northward expansion of the area prone to desertification and would lead to a longer fire season, increased fire risk (both in frequency and severity), prolonged drought duration, runoff decrease or decline of hydropower potential, among other negative effects (Alcamo et al., 2007). Such changes pose major threats to water supplies, human health and food production, and have the potential to disrupt the national economies of the countries across the region. These impacts reinforce the need to enhance our knowledge of spatial and temporal patterns of climate variability, and their related causal mechanisms, across the Mediterranean region, in order to better understand, detect, predict and respond to global climate variability and change.

To better analyse and interpret changes in climate variability, climatic extremes and their related impacts over the Mediterranean Basin, long-term, high-quality and reliable climate instrumental records are essential pieces of information required before undertaking any robust and consistent climatic studies. Moreover, the development of the most appropriate environmental and societal climate change adaptation and mitigation strategies also requires high quality climate data. In this latter context, scientists, decision makers and application communities require the best data for their particular needs. High quality and high-resolution climate data is also need for regional detection/attribution studies of climate change (integrating observational and modelling activities), the calibration of satellite data or the generation of climate quality reanalyses.

In addition, there is the pressing social, economical and political need of undertaking robust climate change scenarios generation and their associated future impacts scenarios at the national levels, in order to adapt their socio-ecosystems to the expected impacts of climate change. This requires the best, high-resolutions and reliable instrumental climate records in order to train/verify regional models and validate their outputs. Many countries

across the region have initiated their National Action Plans through developing and defining their best adaptation strategies, and for doing so, they need use not only the best available methods and tools but also the best climate data and observations they can get from their meteorological network. In this regard, the United Nation Framework Convention on Climate Change Nairobi Work Programme on impacts, vulnerability and adaptation to climate change projection (UNFCCC/NWP) is also urging to assist to the countries (specially to the developing countries, including the least developed countries) "to improve their understanding and assessment of impacts, vulnerability and adaptation;... and make informed decisions on practical adaptation actions to respond to climate change on a sound scientific, technical and socio-economic basis, taking into account current and future climate change and variability of national climate change scenarios" (UNFCCC, 2007). One of the most useful and essential way to reach these targets is addressing their needs and deficiencies on climate data and observations, for filling in the identified gaps in support of adaptation.

Summarising up: high-quality/high-resolution climate data are required by scientists, practitioners/sectoral technicians, stakeholders, policy-makers and others end-users in order to improve:

- the understanding of climate variability and change, their forcing factors and their associated socio-ecosystem impacts across the region,
- studies on climate change detection and attribution and, therefore, the inputs for defining/adopting the best national strategies aimed at mitigating present and future climate change impacts over the region,
- current knowledge on climate extremes occurrence, persistence, intensity and severity (including to place them in the long context), as they are causing and will cause high socio-economical impacts,

- the development of climate change scenarios by combining instrumental climate data with projections from Regional Climate Model (RCM) simulations, as well as for the validation of Global Climate Model (GCM) outputs

#### STATUS AND POTENTIAL FOR DATA RESCUE ACTIVITIES OVER THE MEDITERRANEAN:

Unfortunately, and even the wealthy heritage of climate observations in the Mediterranean basin, the availability of climate records is currently very limited both from a spatial and temporal view.

Long and reliable climate records are particularly missed over Southern and Middle East Mediterranean countries. Over south Mediterranean countries climate data availability is remarkably limited to the last 30 years in few countries, with some exception (Tunisia), and non-available at all for other few.

found over the Middle East countries, but including long missing periods in time series due to the disruption of meteorological operational activities related to political conflicts in the sub-region. Over the Balkan region the situation is a bit better, as some countries (i.e. Romania, Croatia) have developed long records for a few key ECVs, although lack of human and financial resources are argued to be among main causes of low data availability over this area (see the corresponding national reports at this issue). Better panoramas is observed over the northern and western Mediterranean countries, as most of them have developed or are developing long and high quality climate records, although they are mostly restricted to some of the main ECVs (temperature, precipitation and pressure) and their spatial coverage is sparse.

Domain	Essential Climate Variables (ECVs)	
<b>Atmospheric (over land, sea an ice)</b>	Surface:	Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour
	Upper-air:	Earth radiation budget, Upper-air temperature, Wind speed and direction, Water vapour, Cloud properties
	Composition :	Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties
<b>Oceanic</b>	Surface:	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Currents, Ocean colour, CO2 partial pressure
	Sub-surface:	Temperature, Salinity, Currents, Nutrients, Carbon, Ocean tracers, Phytoplankton
<b>Terrestrial</b>	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover, Fraction of absorbed photosynthetically active radiation, Leaf area index, Biomass, Fire disturbance.	

Table 1: The GCOS Essential Climate Variables for the atmospheric, oceanic and terrestrial domains, <http://www.wmo.ch/pages/prog/gcos/index.php?name=essentialvariables>

A bit better long-term data availability for some key Essential Climate Variables (ECVs, see Table 1 for definition), as temperature and/or precipitation, is

This assessment applies to both data on a monthly (with better spatial and temporal coverage) and on daily and hourly scales. The later time resolution, in particular hourly data, shows the worst temporal and

spatial coverage across the region including the countries with a bit better data availability. Even more, data is mostly restricted to only some of the main ECVs. A similar uneven geographical distribution appears when looking at the higher spatial scales. Dense data networks, covering from the second half of the 20<sup>th</sup> century onwards, are only available in few northern and western Mediterranean countries, being absent for most of the Mediterranean countries. Figure 3 shows the Mediterranean air temperature network used by Xoplaki et al. (2003) in their assessment of summer temperature variability and its connection to large-scale atmospheric circulation and SSTs over the period 1950-1999.

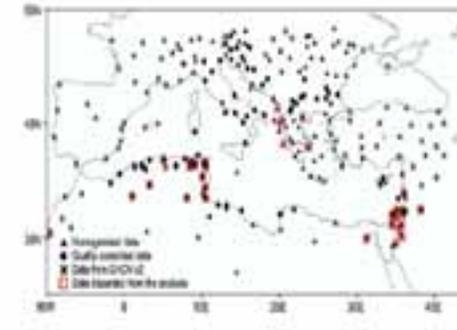


Figure 3: Location map of temperature stations with monthly values showing details of their quality as employed by Xoplaki et al. (2003) in their study on Mediterranean summer temperatures and its connection to large-scale atmospheric circulation and SSTs covering the period 1950-1999

Therefore, over the whole Mediterranean Basin and on national basis there is a very limited availability of high-quality/high-resolution climate data, which is impeding to enhance our knowledge on regional climate variability and change, current and future associated impacts and, then, limiting our ability to better adapt to the countries to the most adverse climate change impacts. Moreover, information for the longer time scales and for changes in extremes

is considerably far away of being good and sufficient. The obtrusive lack of data at the highest time scales is constraining our understanding of changes in climate variability and extremes, which are likely causing higher impacts in the Mediterranean socio-ecosystems than changes in the mean climate.

Against the preceding backdrop, the Mediterranean countries have a very long and rich meteorological monitoring history, going back in time several centuries in some countries (i.e. Italy, France, Spain) and at least to the mid-19<sup>th</sup> century across much of the region. The data scrupulously recorded in the past are held in a high variety of data sources and data keepers: at National Meteorological and Hydrological Services (NMHS) historical archives, other national and international archives and libraries, both public and private or in diverse colonial documentary sources. This wealthy heritage of climate data is, however, largely under-exploited, mainly due to the different political, social and economic situations that exist amongst Mediterranean countries. Although some NMHSs, academic and research institutions across the region have undertaken data rescue activities aimed at transferring historical climate records from fragile media (paper forms) to new media (imaging), fewer long-term records than are needed are readily available in digital form. This reality is preventing the region for developing more accurate assessments of regional climate variability and change. Furthermore, the requirement for high-quality integrated climate products is impeding the adoption of optimum strategies to mitigate and/or adapt to the negative impacts of global climate change over the Mediterranean Basin.

#### THE GCOS MEDMEDARE PROJECT - AIMS, STATUS, PROSPECTS AND EXPECTED OUTCOMES:

The recognition of the big Mediterranean potential for climate data rescue activities together with the limited temporal and spatial availability of high-quality climate datasets led to the selection of a

project focused on the recovery and development of the longest Mediterranean adjusted climate records, as one of the key priorities of the region identified in the GCOS RAP for the Mediterranean Basin. Such a project should target the longest and reliable Mediterranean time series on different time scales (from a sub-daily to a monthly basis) for the ECVs. Therefore, the MedMEDARE project was defined.

The main aim of the Project is to develop quality controlled and homogeneous instrumental climate data and metadata bases for the Mediterranean Basin, which can be more confidently used in climate change detection/attribution studies as well as in the definition of the best strategies to adopt in order to minimise the expectable impacts over the Mediterranean socio-ecosystems associated with a warming world. This general aim will be pursued through carrying out a set of activities leading to reach the following objectives:

- Inventorying, selecting, locating, recovering, digitizing, quality controlling and homogenizing the key and longest Mediterranean records for the atmospheric domain surface ECVs and their corresponding metadata on a national basis
- Developing an integrated, internet based, system to on-line access to the recovered information
- Assisting the involved countries in building capacity in data rescue techniques and procedures and in the updating of data records from their own observing network
- Contributing to sustainable development activities across the region by enhancing and making available the new recovered climate data, in order to make possible better assessments of climate variability and change over the region.

The MedMEDARE project attracted the attention of different Mediterranean NMHSs (Algeria, Cyprus, France, Italy, Morocco, Tunisia, Turkey) and several

research institutes and international organizations. The project is structured in three principal modular and interrelated components:

- Data and metadata location and recovery
- Data and metadata digitisation
- Data quality control and homogenisation

The implementation of these modular components will be carried out both in parallel and in sequential order during a period for 5 years. Currently, the GCOS Secretariat is publicising the Mediterranean RAP among several international forums and bodies, in order to seek for support to the RAP from international donor agencies and to identify a "champion" organization in the region to take the lead in pushing ahead the projects included in the Mediterranean RAP.

The expected outcomes of the MedMEDARE project are among others:

- the recovery and preservation in digital format of key, not currently available, historical surface climate data and their corresponding metadata,
- the development of high-quality and homogeneous long-term climate data and metadata bases for atmospheric surface ECVs over the region,
- the implementation of an on-line, Internet based, accessible system for regularly making available the already validated climate information,
- ensure capacity building and continuity for the involved countries on data rescue techniques and procedures, quality control, homogenization and development of high-quality/high-resolution climate datasets,
- allow NMHSs to improve services and products offered to the end-users or
- increased awareness of the importance of accounting with high-quality climate datasets as an essential and previous step for strengthening

the national development agenda for sustainable development.

#### CONCLUSIONS:

The need and the potential for the development of high-quality and long-term climate datasets over the Mediterranean Basin have been discussed and shown. Both for better detecting, predicting and responding to climate variability and change and for the wealthy heritage of Mediterranean climate data, the achievement of the GCOS MedMEDARE project is in a pressing need if the Mediterranean countries want to be ready to face and minimise the costs of the expectable impacts of global climate change on the Mediterranean socio-ecosystems. The decided involvement of the WMO/World Climate Data Monitoring Programme through, first, the organisation of the International Workshop on Rescue and digitisation of climate records in the Mediterranean Basin and, second, the support to the MEDARE Initiative born in that workshop guaranty the achievement in the near future of this enterprise aimed at providing to the region of reliable climate data.

## I.5. Recovering the Gibraltar record: one of the longest in the Mediterranean

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### INTRODUCTION:

Since 1947 the Gibraltar meteorological station has been situated on the RAF airfield at North Front, but in its long history it has moved site on several occasions (figure 1). These changes and the history of observations in Gibraltar are reviewed in Wheeler (2006) and table 1 summarises the essential features of the various official sites. Such changes present challenges for those seeking to provide a scientifically reliable and homogenised series but given the long period of time over which observations have been made – the rainfall record begins in 1790 for example – such efforts are to be welcomed and make a significant contribution to the better understanding of climatic change in the region.

This paper reviews the progress that has recently been made using sources not hitherto exhaustively explored to provide an authentic series of climate data for this rocky peninsula on the far southern coast of Iberia. These endeavours are by no means complete, and much remains to be achieved, but sufficient has been accomplished to warrant review and to initiate discussion on one the longest instrumental data sets available for the Mediterranean. Some of the problems encountered – and resolved – in the continuing work with these data are by no means unique to Gibraltar and the report offers wider guidance based on experience to those concerned with instrumental data recovery in the region.

location	altitude (m ASL)	dates	notes (summarized from Hurst (1956))
Garrison Library (GL)	7.8	1780 to 1852	This location cannot be confirmed with absolute certainty, but the evidence offered in Wheeler (2006) strongly supports this suggestion
South Bastion (1)	15	1852 to 1913	A garden site and possibly too protected
South Bastion (2) (SB)	12.5	1913 to 1929	This record suggests some interference by war-time installations after 1914.
Alameda Gardens (AG)	31	1929 to 1935	A well-exposed site but the record reveals an increase in mean annual rainfall of 75mm after the move from South Bastion
Windmill Hill (1)	120	1935 to 1940	A representative and well-exposed site
Windmill Hill (2)	119	1940 to 1944	This site was too close to a sharp 30m fall to avoid 'carry over' in westerly winds
Windmill Hill (3) (WH)	107	1944 to 1947	This site was further from the break of slope noted above and is closer to conditions on the Windmill Hill (1)
North Front (1) (NF)	2.4	1947 to 1955	On the RAF airfield between the Rock and mainland Spain
North Front (2)	2.4	1955 to present	Slightly more exposed than North Front (1)

*Table 1: Summary of locations of the 'official' Gibraltar rain gauge site. Bracketed initials provide the key to figure 1*

Gibraltar stands at the far western of the Mediterranean region at 36° 8' N and 5° 26' W and dominates the Straits that bear its name. It is a location of supreme strategic importance and indeed it is thanks to the efforts of the British Army that meteorological observations were begun and sustained for several decades from the late eighteenth century onwards. Gibraltar's Mediterranean setting with its annual summer drought linked to its relative isolation and absence of surface streams ensured that water supply was a perennial issue for the local residents, and it was this concern that prompted the British Army's Royal Engineers Regiment, part of which was stationed in Gibraltar in the late eighteenth century, to gather rainfall data for the purposes of water resource planning. It seems probable that the observations were made close to what is today the Garrison Library on the west side of 'the Rock' (see figure 1).

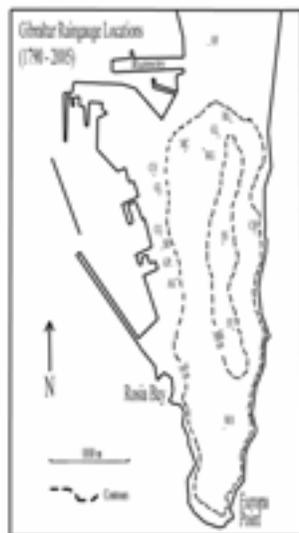


Figure 1: Map showing the various locations of meteorological observatories and rain gauge sites around Gibraltar. For the key to the locations, see tables 1 and 5

Whether the observations were made daily or weekly is uncertain. Regrettably only the annual totals for the 'rainfall season' have survived for the period 1790 to 1812 at which time the rainfall season was considered to start at the end of the summer drought, usually early September, and to continue until the start of the following summer's period of aridity, usually June. From 1812 the monthly data have survived, but the extant daily series does not begin until 1830 with the publication of the day's rainfall in the pages of the local newspaper, the *Gibraltar Chronicle*: a practice that continued until 1936 and until the 1880s provides the only preserved record of the daily observations (after that date the UK Met Office's official registers or 'blue books' of daily records provide the observations). The British Army's interests continued until the initiation of those official registers but responsibility shifted from the Royal Engineers to the Royal Army Medical Corps in 1863.

Temperature records begin in 1821 and for the next 50 years are also to be found in the pages of the *Gibraltar Chronicle*. From the outset these data are in daily form, indeed three observations were made each day although the exact times varied through the years creating a problem in respect of reliable homogenisation. Again, the official registers contain the records from the 1880s onwards to the present day.

Air pressure, important because the region provides one of the southern anchor points for the North Atlantic Oscillation Index, was also recorded thrice daily from 1821 onwards with again the record being preserved initially in the local newspaper and latterly in the official registers. Over the years other phenomena came gradually into the record and figure 2 provides a graphical summary of the periods over which the records in one form or another for different phenomena have survived. Nevertheless, the detailed nature of these data differ over time and this report concentrates on the three most important and long-duration of these; temperatures, rainfall and air pressure.



Figure 2: Graphical summary of the climatological record for Gibraltar, showing the years for which different phenomena were recorded

### PRECIPITATION:

The Gibraltar precipitation series, although incomplete as a daily and even as a monthly set, is the longest for the Mediterranean region and is consequently of singular importance. As noted above, it begins in 1790 with 'annual' data but from 1812 is monthly, becoming daily only from 1830. Table 2 summarises the character of the series. The author of this report has abstracted and preserved the important 1830 to 1850 daily series available from the *Gibraltar Chronicle*, and this has usefully added to the official UK Met Office set. Although instrumental precipitation data for the period 1821 to 1830 (when the *Gibraltar Chronicle* published other daily observations) are not available, a series of 'rain days' – the newspaper noting those days when rain was observed to fall - has been abstracted to supplement the series and is discussed in Wheeler (2007). The same publication also describes the methods by which this series has been homogenised to take account of the changes of site that were described in the report's opening section.

frequency of observation	period	source and data residency
annual	1790 - present	UK Met Office
monthly	1830 - 1850	GC & DAW <sup>1</sup>
monthly	1850 - present	UK Met Office
daily	1830 - 1850	GC & DAW
daily	1850 - present	UK Met Office

Table 2: Summary of precipitation data in the Gibraltar series

1. This annual series includes the 'rainfall season' data from 1790 to 1812
2. GC indicates that the source is the Gibraltar Chronicle. The author (DAW) holds the digital version of these data.

Metadata are now recognised as an important part data recovery programmes and, fortunately, something is known of the observational practices in the early, pre-official, years of the record and the Royal Engineer Colonel Henry James published an instruction manual (James, 1861) for all regimental observers in which the required methods of observation and site selection are described, and the instruments described and illustrated. Figure 3 is a copy of the engraving of the rain gauge used at the time, which though different to those in use today seems to have been 'standard issue' at the time. There is, however, no evidence that the change in instrumentation yields any significant registration in the data series that is depicted in Figure 4. Such long periods of record are of particular importance when placing recent changes in the longer-term context and, for example, the trend towards desiccation during the twentieth century is becomes more noteworthy for being seen in this long-term setting.

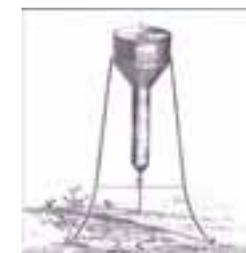


Figure 3: Representation of the 'pluviometer' used by the Royal Engineers in the mid-eighteenth century

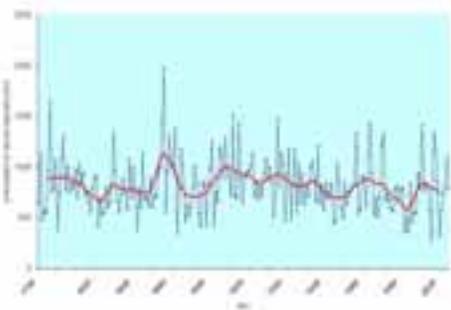


Figure 4: The homogenised long-term annual rainfall series for Gibraltar (1790 to present) with a ten-year Gaussian filter emphasising the more general nature of variations

TEMPERATURES:

The temperature series is daily from its inception in 1821 when the observations were first published in the *Gibraltar Chronicle* (figure 5 is a copy of the first day of publication of these data).

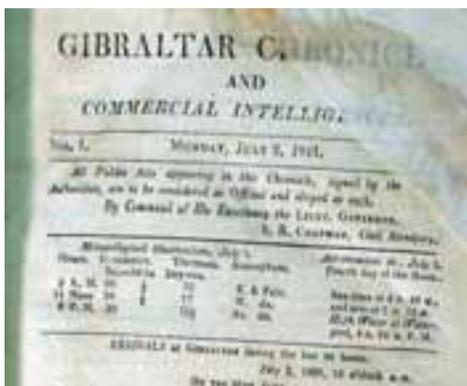


Figure 5: Copy of the first-ever publication of weather observations in the *Gibraltar Chronicle* (2 July 1821). By kind permission of the Gibraltar Government Archives

Until 1852 only the daily fixed hour observations were made, these, for the most part, being taken at 0900, 1200 and 1700 hours local time. The daily maximum and minimum record begins only in 1852 but there is a useful overlap of fixed hour and max/min data that embrace much of the 1850s to 80s. A further point to note, and not one unique for Gibraltar, is that over the first two decades of the record, observations were recorded using vulgar rather than decimal fractions, with numbers rounded to the nearest one-quarter of a degree. The first major problem in homogenising these mixed data, however, is the question of converting fixed hour to corresponding maximum and minimum values. To a limited extent the availability of midday and evening temperatures were useful in this respect, but of greater value were the hourly observations made at nearby Cádiz (100 km to the north-west but similarly situated on the coast at low level) between 1870 and 1950. These detailed records were used to construct monthly correction curves that enabled observations from any hour to be converted to the most probable maximum and minimum temperature for that day. Figure 6 shows the nature of these curves, which are not of course unrelated to the famous Glaisher curves produced in the nineteenth century for southern England but not appropriate for this different climatic setting. These new curves have been used to correct the pre-1852 data but tests have yet to be completed to verify the method by using the data for the overlap years when both fixed-hour and max/min values are available. Figure 7 (with the preceding caveat in mind) depicts the character of medium-term temperature variations in the region and in doing so prompts research questions and gives direction to future studies.

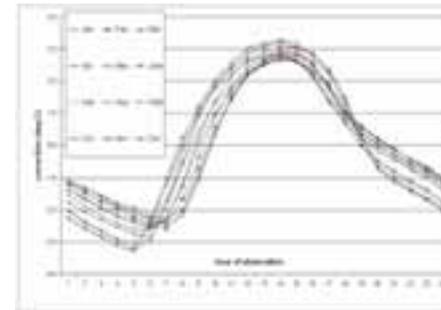


Figure 6: Monthly correction curves for Gibraltar fixed hour observations based on the Cadiz (San Fernando) hourly observations gathered between 1870 and 1940

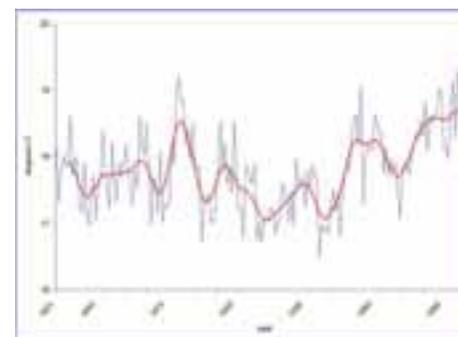


Figure 7: Annual Gibraltar temperature series (1821 to present) with 10-year Gaussian filter

frequency of observation	period	source and data residency
annual and monthly	1852 - present	UK Met Office
annual and monthly	1821 - 1872	GC & DAW
fixed hour observations - daily	1821 - 1850	GC & DAW <sup>1</sup>
max and min. observations - daily	1852 - 1936	GC & DAW <sup>1</sup>
max and min. observations - daily	1852 - present	UK Met Office

Table 3: Summary of temperature data in the Gibraltar series

1. these data have yet to be abstracted in their entirety from the Gibraltar Chronicle and have currently been digitised only to 1872. GC indicates that the source is the Gibraltar Chronicle. The author (DAW) holds the digital version of these data

AIR PRESSURE:

This variable nicely illustrates the importance of sometimes going back to the original data sources and confirms the need for them always to be preserved in some durable and transferable form. For many years the Gibraltar air pressure data set has been one of the choices for the southern end of the North Atlantic Oscillation Index, the others being Punta Delgado (Azores) and Lisbon (Jones, *et al.* 1997). This index is based on monthly aggregated data but recent studies by the author of the original observations for the first three decades of the series (1821 onwards) suggests that minor corrections are needed in light of some idiosyncrasies in the readings, not least of which is a tendency for long runs of several days, even weeks, with the same reading suggesting observer or instrumental errors. Observations were made, as with temperature, three times daily but can be usefully compared with and calibrated against a parallel series of thrice daily readings made in Cádiz (Barriendos, *et al.* 2002). These latter observations appear to be more reliable and demonstrate a general character of day-by-day variation that accords with that to be expected today.. Such reservations notwithstanding, the Gibraltar data are valuable and form an unbroken series the details of which are summarised in table 4. Thus far the thrice-daily air pressure data from the *Gibraltar Chronicle* have been digitised for the period 1821 to 1852, as have the corresponding observations from Cadiz. (Mariano Barriendos, personal communication), although the final calibration between the two to correct the Gibraltar series has yet to be completed although it remains a fruitful area for future research.

frequency of observation	period	source and data residency
annual and monthly	1821 - 1852	GC & DAW
daily	1821 - 1852	GC & DAW
Annual, monthly and daily	1852 - present	UK Met Office

Table 4: Summary of air pressure data in the Gibraltar series

1. GC indicates that the source is the Gibraltar Chronicle. The author (DAW) holds the digital version of these data

OTHER VARIABLES AND SOURCES:

Although of less immediate significance, it should be noted that the pages of the *Gibraltar Chronicle* from 1821 onwards include observations on wind direction and, from 1852, on wind force (estimated on the Beaufort Scale). None of these have yet been digitised. Observations of daily hours of sunshine exist in the UK Met Office archives from 1947 and have been reviewed in Wheeler (2001).

In addition to these official and 'pre-official' observations it is interesting to note that other records also exist in the archives and searches for such supplementary items is always to be recommended as part of any data recovery programme. In this case the most important are the monthly summaries for all Royal Engineers sites for the period 1852 to 1886 that are preserved in published form (HMSO, 1890). An example of these data is presented in figure 8. Further, but far more fragmentary climate records exist for mid-nineteenth century Gibraltar. The most accessible of these were compiled by a member of the Royal Army Medical Corps, E.F. Kelaart and his observations appear in summary form in his publication *Flora Calpensis: contributions to the Botany and Topography of Gibraltar* (Kelaart, 1846). A private diary kept by another medical officer, Sir John Hall (one-time Principal Medical Officer), and covers the period from November 1838 to January 1841. This weather diary is now in the care of the UK Met Office and includes daily temperatures, supplemented by notes on the wind, the weather and 'prevailing diseases'.

Such data sets, whilst of limited temporal span, can provide a useful means of corroborating the longer-term data sets and should not be overlooked in exercises concerned with data recovery and verification.

Figure 8: A copy of a page of summary data from the Royal Engineers publication from 1890

LOST DATA:

It is inevitably the case that valuable observations can be lost, and this is no less true of Gibraltar than of many other places. Such losses do, however, alert us to the need to safeguard, record and preserve what is left and it is known that a number of other sites were in operation in Gibraltar. Prompted no doubt by the demands for water supply planning, the Gibraltar Government established rain gauges observatories at various locations around the Rock. Their details are summarized in table 5. Both Forster (1942) and Hurst (1956) made use of these data in their exhaustive analyses of local rainfall but these records seem, regrettably, to have been lost. Whilst it is understandable that documents from the late eighteenth century, such as the daily or monthly rainfall observations of the Royal Engineers, might have been lost, it should be noted that this potentially valuable collection of rainfall data has been lost within the last decade!

location	Altitude (ft ASL)	dates	Notes (summarized from Hurst (1956))
Moorish Castle (MC)	79	1900 to 1956	The ground is irregular and the site exposed.
Green's Lodge (GL)	247	1825 to 1951	On steep ground, a recording gauge was used in an exposed site made more so by the gauge being located on the roof of a small hut.
Willis Gate (WG)	140	1902 to 1956	Only 150 yards from Moorish Castle and on similar ground.
Catalan Bay (CB)	128	1827 to 1951	Overlooked by the steep east face of the Rock. Various gauges were used here including a recording type, and an 8 inch and, later, 5 inch gauge.
City Hall (CH)	25	1849 to 1956	Over exposed recording gauge on a flat roof.
North Front (NF)	3	1902 to 1940	Located not far from the present site (table 1)
Rock Gun (RG)	375	1832 to 1941	Highly exposed, yielding data, always considered to be of questionable quality.
Convent Garden (CG)	15	1950 to 1956	A 5 inch gauge within the Governor's walled garden and possibly over-protected.

Table 5: Sites of Gibraltar Government rain gauges. Initial letters refer to the key sites in figure 1

CONCLUSIONS:

The Gibraltar series is unique in the Mediterranean for the combination of the length and variety of its climatic record. Digitisation and homogenisation of the full data set has yet to be completed, but the questions raised in this exercise of methods of abstraction, of homogenisation and of the need for meta-data and, where possible, supplementary sources, have a wider currency for a region rich in such sources that have yet to be exploited and their potential realised.

## I.6. A review of homogenisation procedures

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### ABSTRACT:

Many long instrumental climate records are available and can provide useful information in climate research. These datasets are essential since they are the basis of the description of the past climate. But in most cases, these series are altered by changes in the measurement conditions, such as evolution of the instrumentation, relocation of the measurement site, modification of the surroundings, instrumental inaccuracies, poor installation, and observational and calculation rules. These modifications manifest themselves as shifts (inhomogeneities) in the time series. As these artificial shifts often have the same magnitude as the climate signal, such as long-term variations, trends or cycles, a direct analysis of the raw data series might lead to wrong conclusions about climate evolution. A homogenisation method is a procedure that allows the detection and removal of possible effects of artificial changes in the measuring conditions. The problem at hand is tackled in two steps, detection of the inhomogeneities and correction of the series. We provide a review of the various methods currently used, with their advantages and drawbacks, including techniques for daily data.

### INTRODUCTION:

Monitoring and analysis of our climate has become more and more important since it has been found that most of the climate change we have seen over the last fifty years has been induced by the anthropogenic increase of greenhouse gases in the atmosphere, as emphasized in the Intergovernmental Panel on Climate Change (IPCC) reports. Extreme climatic events continue to affect millions of people around the world and are likely to change in the future.

To study this phenomenon, many long instrumental climate records are available and can provide useful information in climate research. These datasets are essential since they are the basis of the description of the past climate, for detection and attribution of climate change at a regional scale and the validation of climate models which predict our future climate. However the prediction of our climate and the mechanisms that control the evolution of extreme events is still largely not understood and can only be understood with an accurate record of the past climate.

The homogeneity of these long instrumental data series (up to 300 years in some cases) has been studied since there became an interest in describing long-term variations in climate. A homogeneous climate time series is defined as one where variations are caused only by variations in weather and climate (Conrad and Pollack, 1950). But in most cases, these series are altered by changes in the measurement conditions, such as evolution of the instrumentation, relocation of the measurement site, modification of the surroundings, instrumental inaccuracies, poor installation, and observational and calculation rules. In many cases, these changes are not recorded in the archives, which are often incomplete. These modifications manifest themselves as a shift in the mean that can be sudden (break point or change point) or gradual. These changes will be called inhomogeneities henceforth. Moreover spurious observations are frequent. As the artificial shifts often have the same magnitude as the climate signal, such as long-term variations, trends or cycles, a direct analysis of the raw data series might lead to wrong conclusions about climate evolution. This is clearly stated in a recent WMO publication (Aguilar *et al.*, 2003): "all of these inhomogeneities can bias a time series and lead to misinterpretation of the studied climate. It is important, therefore, to remove the inhomogeneities or at least to determine the error they may cause".

These problems are not anecdotic. During the constitution of the HISTALP precipitation dataset (Auer *et al.*, 2005), “on average one break could be detected every 23<sup>rd</sup> year in a series of 136 years in length”. 192 precipitation series were studied, and none of them could be considered free of inhomogeneities. Della-Marta *et al.* (2004) show that on average, each of the 99 annual temperature records in Australia’s high quality dataset required 5 to 6 adjustments throughout the 100 year record. Thus the detection and the correction of these aberrations are absolutely necessary before any reliable climate study can be based on these instrumental series. Let us take as an example the series of Pau Airport (France), before and after homogenisation by Caussinus and Mestre technique (2004). The corresponding time series are found in figure 1 and 2.

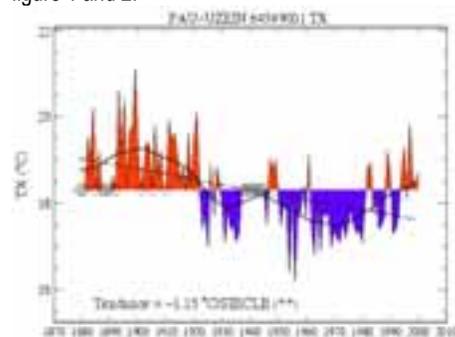


Figure 1: Raw annual maximum temperature series of Pau (before homogenisation)

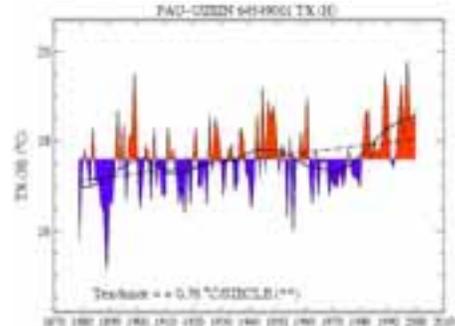


Figure 2: Corrected annual maximum temperature series of Pau. Major shifts were due to relocation in

A homogenisation method is a procedure that allows the detection and removal of possible effects of artificial changes in the measuring conditions. Good reviews of such methods can be found in Peterson *et al.* (1998) or in the proceedings of the homogeneity seminars held in Budapest by the Hungarian Met. Office with support of the WMO (Hungarian Meteorological service, i.e. 1997, 2001).

The problem at hand is tackled in two steps, detection of the inhomogeneities and correction of the series. Once detection is performed, correction factors are estimated, again by means of various methods, usually relying on a computed reference series (supposed homogeneous).

#### DETECTION:

The mostly used “relative homogeneity principle” (Conrad and Pollack, 1950) states that the difference (or ratio for cumulative parameters such as rainfall or sunshine duration) between the data at the tested station and a reference series, usually assumed to be homogeneous, is fairly constant in time, up to the inhomogeneity to be detected. Usually, it is assumed that the distribution of the difference series is normal, and that most of the shifts (inhomogeneities) are step-like changes, which typically alter the average value only, leaving the higher moments unchanged (Alexandersson, 1986). These steps are then to be detected by means of a statistical procedure.

When no homogeneous reference series exist in the same climatic area as the candidate (which is mostly the case when considering long observation series), references are computed, based on averages of surrounding series. These references are indicators of regional climate. Various methods can be to create these reference series. For example, Potter (1981) creates references series by averaging all series but the candidate series. After a first detection stage, clearly inhomogeneous series are excluded from the averaged reference. The most commonly used methods create references by means of

weighted averages of surrounding series (Alexandersson, 1986, Easterling and Peterson, 1993).

Other authors (Jones and Hulme, 1996, Szentimrey, 1999, Mestre, 1999) get around the need for a reference series. Instead of comparing a given series to an averaged reference series whose homogeneity might be problematic, the first step is to compare this series to all other series within the same climatic area by making multiple comparison series. These comparison series are then tested for discontinuities. At this stage, we do not know which individual series is the cause of a shift detected on a difference series. But, if a detected change-point remains fairly constant throughout the set of comparisons of a candidate station with its neighbours, it can be attributed to the candidate station. This approach is more rigorous if no homogeneous reference series exists, however greater interpretation is needed.

Anyway, whatever principle of detection is employed (reference series or multiple comparisons), inhomogeneities have to be detected, which becomes a statistical problem. Initial studies were conducted using visual inspection of the comparison series (see for example Jones and Hulme, 1996) or relied on station metadata (Karl and Williams, 1987).

However, more objective detection procedures were required. The detection procedures that are in widespread use among climatologists (Potter, 1981, SNHT, Alexandersson, 1986) are based on likelihood ratio tests (Hawkins, 1977, Maronna and Yohai, 1978). In these procedures the null hypothesis is tested against the presence of one single change-point in a gaussian sample (SNHT) or a regression model (Peterson and Easterling, 1994, Vincent, 1998), or using a bayesian approach (Perreault *et al.*, 2000). Standard non-parametric tests, based on rank statistics (Wilcoxon rank sum test, Pettit test, 1979) may also be used.

When several change-points are present in the series, which is mostly the case when considering long data series, the previous procedures are usually computed in an iterative way: when a shift is detected, data is then split into two samples that are tested independently, and so on. This is a simple way to proceed, but such algorithms lead to testing changes in smaller and smaller sub-samples, which can be a serious drawback in regards to assessing their statistical significance.

More recent procedures have been specifically designed for multiple change-point detection: MASH (Szentimrey, 1999), Caussinus and Mestre (2004).

When the number and position of change-points are multiple and unknown, two problems occur. The first problem is computational. Selecting  $k$  breaks among  $n$  years becomes rapidly intractable due to combinatorial reasons, when an exhaustive search is made. Rather than using the simple stepwise algorithms already described, a dynamic programming algorithm can be used, whose optimality can be proved, at a moderate computation time (Auger and Lawrence, 1989, Lavielle, 1998 or Hawkins, 2001). The second problem, *i.e.* the number of breaks, is more a problem of model selection rather than a problem of classical hypothesis testing. The use of penalized likelihood or “quasi likelihood methods” can solve this problem in an adequate way (Mestre & Caussinus, 2005). Different criteria might be used, for example: AIC (Akaike, 1973), BIC (Schwartz, 1978, Yao, 1988), Caussinus and Lyazrhi (1997).

In recent years a number of authors in different fields have studied the problem of change-point detection. For example we can cite applications in biostatistics, signal processing and econometrics. Studying these procedures would be of great interest for climatology. For example, Braun, Braun and Müller (2000) use a quasi-likelihood method with a modified Schwartz criterion for DNA segmentation, a procedure close to Mestre and Caussinus (2005) in its principle.

Completely different approaches are also used, mainly in econometrics. These approaches rely on non-parametric regression: a regression function is smooth but for some points where jumps in the function itself or one of its derivatives occur. Such methods are based on differences between left and right estimates. These approaches consist in estimating the left (resp. right) estimates of the regression function using data located on the left (resp. right) of the guessed change-point. Müller (2002) uses kernel smoothing while Gregoire and Hamrouni (2002) appeal to local linear regression. Their essential motivation is that this method has no edge effects contrarily to the kernel smoothing models. Such approaches are much more flexible than the standard parametric methods. Furthermore, recent developments have allowed the use of weakly dependant sequences of data, which is typically the case of daily climatic observations (Ango Nze and Prieur, 2002).

For the moment, these recent approaches are not used at all in climatology, where the most commonly used test is the SNHT and its variants. Comparison between existing detection procedures has been made (Ducre-Robitaille, Vincent and Boulet, 2003), but only older procedures (allowing formal testing of one change vs no change in an iterative version) were compared together in this study. So that the question of the usefulness of new (and more complex) procedures and algorithms has never been answered. Since most authors concentrate on their own procedure they are most familiar with, there is a great need of a formal intercomparison of detection procedures.

#### CORRECTION:

If a reference series is computed, a direct estimation of the correction may be made, by calculating the difference of mean of the comparison series before and after the detected breaks (Alexandersson, 1986 for example). Note that usually the most recent period remains uncorrected, and its "climate" is

taken as a reference. Therefore, once the corrected series are inserted in the database, one may add new data each year without any correction, until a new analysis of the whole set of series is considered.

In Caussinus and Mestre's (2004) technique, as no series is taken as a reference, a suitable two factor ANOVA model is developed. Each series of observations is assumed to be the sum of a climate effect, a station effect and random white noise. The station effect is constant if the series is reliable. If not, the station effect is piecewise constant between two shifts. Outliers may also occur. Standard least squares technique estimation ensures an optimal joint estimation of the climatic signal and of the corrections.

In Brunet *et al.* (2007), the bias in temperature produced by the substitution of the Montsouris shelter by the Stevenson's shelter was minimised with the empirical factors derived from the construction of several Montsouris shelters situated next to the present day Stevenson's screen.

A comparison of the impacts of various correction methods has never been achieved. Furthermore, in such methods, there is always the danger of distant climatic signals from one (or a few) reference series being transferred to many homogenized series, with the final result that existing spatial variability becomes extensively smoothed. This potential drawback has never been quantified, and we propose to study the impact of this effect as well as the estimation of the influence of the correction method.

Another problem is the so-called urban effect when studying temperature series. The "SNHT with trend" test is designed to take into account this effect (Alexandersson and Moberg, 1997) but the effect of urbanization of the surroundings of the observatories has to be investigated further, since greenhouse skeptics continue to argue that a significant portion of the observed warming is only an urban effect

(Hansen *et al.* 2001), even when recent studies (Peterson, 2003 for example) reveal little impact of this phenomenon after homogenisation.

#### DAILY DATA HOMOGENISATION:

Extreme indices have recently been used a lot by the climatological community to assess the impacts of such extreme events on our society. However the use and reliance on extreme indices has outpaced the development of suitable techniques to homogenise the daily data that they are based on.

Homogenisation at a daily time scale is a much more difficult problem. This is not due to the detection of the shifts, since this information may be provided by the analysis of annual or monthly series (some specific procedures have been developed, refer to Wijngaard *et al.*, 2003).

The difficulty here is estimating the correction. When considering annual or monthly data, the effect of the changes affecting the series is assumed to be a rather constant bias, quite easy to estimate. But this is no longer the case when daily data are processed, where corrections should vary according to the meteorological situation of each day. For these reasons, some authors have limited themselves to assess homogeneity using graphical analysis of time series of annual indices derived from daily data to suppress inhomogeneous stations from any further analyses (Peterson *et al.* 2002 or Aguilar *et al.* 2005).

So far in the literature only three approaches have been used to correct daily data. The most simple correction method relies on interpolation of monthly correction coefficients (Vincent *et al.*, 2002), a useful procedure also applied by Brunet *et al.* (2006) to obtain a better performance in the calculation of extreme indices based on daily-temperature, but maybe too simple to provide exact corrections, especially since it only explicitly corrects the mean and not the higher order moments of an inhomogeneity.

For temperature correction, multiple regression including other parameters such as wind-speed and direction, sunshine duration and parallel measurements is probably the best way to proceed (Brandsma, 2004). But such data are extremely rare when considering older data, where usually only precipitation and temperature were observed, although some success can be achieved by reproducing the old measurement conditions (Brunet *et al.*, 2004). Daily precipitation correction also addresses specific problems, as particular attention must be paid to the problem of the number of rainy days (Brunetti *et al.*, 2004).

The latest methods characterize the changes of the entire distribution function using overlap data between observing systems (Della-Marta and Wanner, 2006) which make it possible to correct variance and skewness characteristics of inhomogeneities.

#### CONCLUSION:

As a short conclusion, many methods exist, from many authors, and there is a deep need to intercompare all these procedures. This is the purpose of a COST action that is currently submitted to the European COST Committee.

## I.7. Data rescue and digitization: tips and tricks resulting from the Dutch experience

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### INTRODUCTION:

From 1981 till about 1987 KNMI digitized part of the huge amount of pre-1850 instrumental meteorological data in the Netherlands. The activity was partly financed by the European Union. In total 0.4 million sub-daily observations<sup>1</sup> were digitized. Only recently the data were made freely available to the public at the KNMI website (<http://www.knmi.nl/klimatologie>). In the year 2000, KNMI renewed its efforts in the area of data rescue and digitization with a long-term activity (partly externally funded). Since then many types of data have been digitized and made available to the public. Examples of the data types that have been dealt with are: 18<sup>th</sup> and 19<sup>th</sup> century ship logs (<http://www.knmi.nl/cliwoc/>) amounting to 0.29 million observations, 19<sup>th</sup> century KNMI year books amounting to 0.6 million observations, films with observer log books of the Amsterdam City Water Office amounting to 1.6 million observations and logbooks with rainfall measurements in the 1850-1950 period amounting to 4.7 million observations. At present we are digitizing strip charts and paper rolls from pluviographs (321 stations years in total), the remainder of pre-1850 weather observations, data from the former colonies and metadata archives.

In this paper we discuss our experiences with digitization. We start by presenting examples of the materials that have been used as basis for digitization. Thereafter, we introduce three scanners that are being used for scanning the data, followed by a presentations of four methods used for getting the data into spreadsheets. We conclude the paper by a presentation of twelve do's and don'ts.

<sup>1</sup> An observation is defined as the measurement of all available climate variables at the certain time and location.

### BASE MATERIAL:

#### *Hardcopy (original or copy)*

In many cases, especially in the past, observation books or logbooks were directly used as the source for keying in the data. If for some reasons these documents could not directly be used for digitization, paper copies of them were also being used. During the 1981-1987 digitization project at KNMI, we only used hardcopy data as source for digitization.

Consider some examples of hardcopy material that are being used in our projects. Figure 1 shows an example of handwritten observations from a 17<sup>th</sup> century ship log book. Figure 2 gives an example of tables with printed data from the 19<sup>th</sup> century KNMI yearbooks. As a last example, Figure 3 shows a rainfall strip chart with graphical information. The type of hardcopy material determines to a large extent the digitization method.

An important advantage of using original hardcopy base material is its readability. Disadvantages are the deterioration of the material during the digitization process and the fact that at the same time only one digitizer can work on the data (without making extra copies of the data). Furthermore, the location for digitization is fixed to the location of the hardcopy data.



Figure 1: Example of handwritten observations in a 17<sup>th</sup> century ship log book

Figure 2: Example of printed data in the KNMI yearbook of 1869

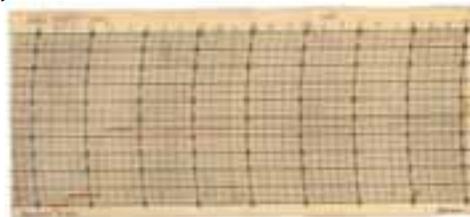


Figure 3: Example of a daily rainfall strip chart of De Bilt in 1897

#### Films

Hardcopy historical climate data is sometimes stored in archives that are not willing to lend the data for digitization. They prefer making films of the data rather than making hardcopies. Copies of the films can mostly be requested or the films can be studied on the spot using a film-reader. As an example consider the hourly meteorological data (1784-1963) of the Amsterdam City Water Office. These data are stored in thousands of logbooks in the archives of the municipality of Amsterdam. The logbooks are, however, not allowed to leave the archive. In 1984 the archive put all the data on film and KNMI obtained a copy of them (Figure 4). KNMI has a film-reader that can be used to both view and print the data.

The quality of the images on films is mostly excellent and if high quality films are used (e.g. polyacetate films), they may last for more than 200 years. Therefore, films are an ideal source for preserving data. As with the hardcopy data, only one digitizer can work on a film (without making extra copies of them) and the location for digitization is fixed to the location of the films and the film-reader.



Figure 4: Copies of the films of the Amsterdam City Water Office in the archive of KNMI in De Bilt

#### Digital images

Digital images of the data may be obtained by scanning or digitally photographing the hardcopy documents. There are also scanners available that can make digital images of films (or microfiches). In fact, the films of the Amsterdam City Water Office were transformed to digital images before keying the data into spreadsheets. For the actual keying of the data we used several working places with two screens next to each other, one with an image and one with a spreadsheet. With the increasing quality of scans and the growing storage capacity of

computer systems the use of digital images as data source becomes more and more feasible.

The use of digital images has two important advantages compared the use of hardcopy data or films. First, the images can be used by more persons at the same time and at any location. Second, together with the digitized data also the images of the original data can easily be provided (e.g. via the Internet). An advantage of the latter is that the user has the possibility to go back to the original data. Especially for the older handwritten data this may be advantageous. Both digital images and films may serve as an extra backup of the hardcopy data in case of calamities. A disadvantage of digital images is the sustainability of the files. File formats like jpeg or gif will likely change in the future to other formats. This may require file conversions of the original files. In that process errors may easily be made.

#### SCANNERS:

##### Bookscanner

Figure 5 shows one of our students working with the so-called CopiBook bookscanner (<http://www.iiri.com/i2s/copibook.htm>). We use this scanner for scanning books and old documents containing climate observations and metadata.



Figure 5: CopiBook bookscanner

The scanner has a book cradle to prevent damage of books and scans two colour or greyscale pages with a resolution of 300 dpi in 7 or 2½ seconds, respectively. It provides, among others, automatic location and cropping of the documents. The new price of this type of scanner is about EUR 25.000,-. A much cheaper solution may be obtained by using a digital camera on a stand.

##### Large-format scanner

For the scanning of long paper rolls with registrations of self-recording rain gauges we obtained the Context Chameleon G600 large-format scanner (<http://www.context.com>). The rolls have a length of about 10 m and we were not allowed to physically cut the them into smaller pieces. The Context large format scanners are one the very few scanners that allow for the scanning of long documents (limited only by the storage capacity of the computer). In Figure 6 the scanner is being used at KNMI for the scanning of the paper rolls. The Chameleon scans the rolls in color with a resolution of 400 dpi and a speed of 2.5 cm/s. It can handle documents with a width up to 1 m and we therefore use it also for digitizing maps. The new price of this type of scanner is about EUR 12.000,-.



Figure 6: Context Chameleon G600 large-format scanner

### Fast document scanner

We obtained the Canon DR5010C fast document scanner (<http://www.canon-europe.com>) for scanning about 100.000 strip chart self-recording rain gauges. In addition the scanner can also be used to quickly scan books whose cover and back may be removed. The scanner scans in color with a maximum resolution of 600 dpi and a speed of 20 strip charts or pages per minute. Figure 7 shows how the scanner is being used for scanning strip charts.



Figure 7: Canon DR5010C fast document scanner

### HOW TO GET THE DATA INTO THE SPREADSHEETS:

#### Manually typing

The most common method for getting data into spreadsheets is manually keying the data. For handwritten material this is still the only feasible method, but also for printed data it is often the most obvious method. The person that keys the data into the spreadsheet should learn to blindly use the numeric keypad (on the right hand side of the keyboard) with sufficient speed. The use of predefined shortcuts for entering non-numeric data may speed up the process. At KNMI we use manually typing for about 70% of our data.

### Using Optical Character Recognition (OCR)

The use of OCR may be feasible when the observations are printed with sufficient quality in the documents. About 10 years ago KNMI experimented with this type of data entry for some of the KNMI yearbooks. The basis for OCR is the digital images of the data. When the quality of the originals and the images is poor, OCR may require a lot of post processing and, therefore, may probably not be much faster than manually typing. It should also be realized that the OCR results must be combined in files and quality checked. Since our experiment with the OCR software, the software may have improved and may be more suited to digitize printed climate records in old documents. We recently started experimenting with the OCR software ABBYY FineReader (<http://www.abbyy.com/>). In January 2008, a 4-year EU-project starts, focusing on the improvements of OCR for old printed documents (<http://www.impact-project.eu>). Note that OCR for handwritten material is still not feasible.

### Using Speech Recognition Software(SRS)

In the year 2002 we experiment with the use of SRS. At that time, we were manually keying the 1.6 million observations of the Amsterdam City Water Office. It was hoped that the use of SRS would alleviate the manual typing of the data. We used the software named *Dragon NaturallySpeaking*. The software needs to learn the voice of the speaker and the speaker should be able to work without background noise. We found that the combination of the software with spreadsheets was not optimal and soon decided to go on with manually keying the data. However, it may be that newer SRS versions may be more feasible than the one used by us. In addition, when funds are available, it may be interesting to work with a specialized company to suite the SRS to your digitization needs.

### Using automatic curve extraction software

Self-recording rain gauges have been applied for continuous rainfall measurements at a selected set of KNMI stations since the end of the 19th century. At first, rainfall was recorded on daily (Figure 3) and sometimes weekly rainfall strip charts. Thereafter, from about 1980 through 1993, paper rolls were used to register rainfall for about 10-20 days per roll. From 1994 onwards, rainfall measurements are transferred electronically and operationally stored at 10-minutes resolution (for some selected stations at 1-minute resolution). Until now, the strip charts and paper rolls have been used mainly for extracting hourly values. In infrastructural design (e.g. sewer systems, tunnel drainage) there is, however, a need for long rainfall series with much higher resolution than 1 hour. Fortunately, the charts and rolls can be used to extract rainfall with a time resolution of about 5 to 10 minutes.

We are developing a procedure that largely automates the labor-intensive extraction work for rainfall strip charts and paper rolls. Although developed for rainfall, it can be applied to other elements as well. The procedure consists of four basic steps: (1) scanning of the charts and rolls to high-resolution digital images using the scanners in Figures 6 and 7, (2) applying automatic curve extraction software in a batch process to determine the coordinates of cumulative rainfall lines on the images, (3) visually inspecting the results of the curve extraction, (4) post-processing of the curves that were not correctly determined in step (3). Although KNMI is still perfecting the software, several tens of station-years have successfully been digitised. The time resolution is about 5 minutes. In total 321 station-years are being digitized. It is planned that the data will become available in 2009.

### DO'S AND DON'TS:

*Start with an inventory of historical climate data*

Before starting to digitize, quality control and disclose historical climate data, an inventory should be made of all sources containing historical climate observations. Depending on the purpose the project, the inventory can be made on a scale ranging from a single institute (like a meteorological office) to a group of countries. The inventory should clearly show the opportunities for extending back in time the existing digital time series. It needs to reveal all known time series (both in hardcopy and digitized format), the station names, the observed parameters, their resolution, the observation period, the location where the data are stored, etc. In the year 2000 we made such an inventory at KNMI (Brandsma et al., 2000). An inventory may be helpful in the process of obtaining support and funds for the work that still needs to be done.

*Check if the data is already available somewhere in digitized form*

Unfortunately not all digitization efforts are well coordinated. As a result, it may not always be obvious if a data source has already been digitized. For example, consider a scientist that undertakes a digitization effort to digitize a particular time series needed for a scientific publication. After the series is digitized and used for the publication nobody cares about the series and after some time it may even be forgotten that the series has ever been digitized. The problem here is that to actually disclose the series to the public, some extra steps are needed that the scientist did not include in the planning of his digitization effort. For series of former colonies, it may be profitable to check the existence of digitized data internationally.

*A professional should check the data source before having it digitized*

Before starting the digitization, a professional should inspect the data source to look for changes in parameters, units, formats, missing data and other important metadata. This information is needed for constructing templates for keying the data into

spreadsheets and for the construction of a metadata file. The templates should closely resemble the format of the data source to minimize keying errors. Sometimes summary measures are also provided in the data source. In that case it is advised to integrate formula in the spreadsheets to automatically calculate these measures from the keyed data. A comparison of the calculated summary measures with those in the data source may reveal keying errors. The amount of work required to construct digitizing templates, largely depends on the type of data source.

*Gather all relevant metadata and supply them (at least in English) together with the digitized data*

All relevant metadata concerning the series should be gathered and supplied together with the digitized data. Metadata may be found in the data sources themselves or separate publications. In addition, meteorological institutes often keep hardcopy files containing information about a particular station and the observed variables. The search for metadata may be time consuming.

It may be handy to distinguish between two types of metadata, which we define here as type I and type II metadata.

**Type I metadata.** Metadata needed to trace a times series. This type of metadata provides information about: location of the observations, time period(s) of the observations, observed variables, observation frequency and information about how the data are available (digital, hardcopy, quality of the data).

**Type II metadata.** Metadata needed (along with type I-metadata) to homogenize time series. This type of metadata provides information about: changes in instruments, relocation (horizontal and vertical) of the instrument, changes in methodology of the measurements, availability of parallel measurements and changes in the environment (growing of trees, urbanization, etc.).

For historical climate data it is common to enclose the most important metadata in the header of the file (often type I-metadata). Figure 8 gives an example of the header of one of the historical data files available via the KNMI website. Other metadata, like photographs, detailed descriptions of the data, analysis of the data, may be provided in separated reports or papers (often the type II-metadata).

*Figure 8:* Example of the header the file with historical data from Leiden (1697-1698) as available from the KNMI-website at: [http://www.knmi.nl/klimatologie/daggegevens/antieke\\_wrn/](http://www.knmi.nl/klimatologie/daggegevens/antieke_wrn/)

*Use university students for typing in your data*

KNMI has good experience in working with students of the nearby University of Utrecht. The students get a part-time contract for the duration of the project, mostly for 4-12 hours a week. They are relatively free to plan their work according to their (ever changing) study schedule and the work pays better than many other student jobs. We request from the students that they can work fast with a good precision. We advise them to work not longer than 4-5 hours per day because most digitization work requires a level of concentration that cannot be kept the whole day.

It is recommended to experiment with the data to see what realistic digitization speed and accuracy of typing can be obtained by the digitizers. This helps to plan the allocation of manpower and serves as a

guiding line for the digitizers. Their work should be checked regularly for speed and accuracy.

*Don't forget to rigorously quality control your data*

Quality control (QC) should be an integral part of each digitization project. QC procedures should correct for typing errors, accidental changes of columns, etc.

*Don't assume that processing the data after digitization is routine work*

Data are often keyed into several spreadsheets that need to be combined after finishing the actual digitization. Several errors can be made in that process. For instance, not all spreadsheets may be chronologically put together, or changes in columns or number of variables may not be adequately accounted for. These types of errors may be much more sincere than the occasional typing errors.

*For many data sources it is worthwhile to supply images of the original*

For the analysis and homogenization of historical climate data it is often needed to go back to the original data. The original data may contain important metadata that is not available elsewhere, like information about the changes in instruments and units. Also, when there has not been a rigorous QC it may be needed to check suspect values in the original data. For the latter reason KNMI decided to make scans of all data that was digitized in the 1981-1987 period. The scans will be provided together with the already available digitized data them via the KNMI website.

*Use the operational infrastructure of your institute for centrally archiving (including back-up) of digitized data and digital images*

It is important that the archiving of the digitized data and the corresponding images are integrated in the operational infrastructure of the institute. In this way

all digital information can be centrally stored and backups can easily be made. At KNMI the historical climate data is available via the network drives and a backup is stored in a mass storage system. As an extra safety guarantee, a few times per year backups of the data are sent to a supercomputer in Amsterdam.

*Assess the sustainability of your storage media*

Tapes, floppies, CD-Roms, films, etc. have all a limited life time. Moreover, also the hardware needed to read these storage media may slowly disappear. Therefore, each digitization project should consider the sustainability of the required storage media and the hardware needed to read them. If the data is stored and backups are made as described in 5.9, then the need for the mentioned storage media may diminish. In all cases, however, attention should be given to the sustainability of the file types. Common file types like pdf, jpeg, bmp, etc. are probably not everlasting and may need transformation in the future into other types.

*Put the data freely on the internet and provide the world databases with a copy*

The commercial value of the majority of digital historical climate data is negligible. On the other hand, its scientific value cannot be underestimated. The power of many analyses for climate change and variability is in the existence of large datasets with high-quality historical climate data. These datasets exist because countries freely provide their historical data on their websites and/or to the world databases. As such, institutes that put their historical data freely on the Internet contribute to the study of climate change and variability. In addition, the free distribution of historical climate data may be a good publicity for the institute and (when people start using the data) may also help in detecting errors in the data and in the finding of new metadata.

*Enjoy your work*

Digitization and disclosure of historical climate data has a somewhat old-fashioned and dusty image. This is undeserved! The old climate data represent the reference that the World needs to assess the present and future climate. Numerous scientific journal papers and books are published each year making use of these data. Although the actual digitization work is often labour-intensive, new techniques are becoming available to scan, digitize and disclose the climate data via the Internet in a more efficient way than was possible previously. In summary, there is plenty of reason to enjoy this type of work.

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## SECTION II: EXISTING REGIONAL INITIATIVES AND DATASETS

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## II.1. Atmospheric Circulation Reconstructions over the Earth (ACRE) and WMO DARE missions over the Mediterranean

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### INTRODUCTION:

The Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative is an 'end-to-end' project which facilitates both the historical global terrestrial and marine observational data needs of three surface-observations-only climate quality reanalyses, and the seamless feeding of 3D weather products produced by these reanalyses into climate applications and impacts models. It involves collaborations between three main partners: the Queensland Climate Change Centre of Excellence (QCCCE) in Australia, the Met Office Hadley Centre in the UK, and the Cooperative Institute for Research in Environmental Sciences (CIRES)—a joint institute of the National Oceanic and Atmospheric Administration (NOAA) and the University of Colorado in Boulder, USA. ACRE is also linked closely with the activities of the Global Climate Observing System (GCOS) Atmosphere Observation Panel for Climate (AOPC)/Ocean Observation Panel for Climate (OOPC) Working Group on Surface Pressure (WG-SP)

On the data side, ACRE will facilitate the recovery, rescue, extension, quality control & consolidation of global historical terrestrial & marine instrumental daily to sub-daily surface observations covering the last 100-250 years. The prime focus of these activities will be on atmospheric pressure, sea surface temperature and sea-ice. These variables will be archived respectively in the International Surface Pressure Data bank (ISPD) of the GCOS AOPC/OOPC WG-SP, the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) repository via the REcovery of Logbooks And International Marine data (RECLAIM) project, and in the National Snow and Ice Data Center (NSIDC) data base.

The ISPD and ICOADS observations will be used in three surface-observations-only reanalyses:

- the 20th Century Reanalysis Project (1892-2007)

- an early to mid-19th Century to present reanalysis
- and a North Atlantic-European region mid 18th-early 19th Century to present reanalysis

All of these reanalyses will be generated at the NOAA Earth Systems Research Laboratory/CIRES CDC, University of Colorado in the US.

The above reanalyses will produce a 56 member ensemble (realisations) of some 68 3D atmospheric weather variables every 6 hours on a 2° latitude x 2° longitude grid over the globe. These reanalysis products will be vital to new investigations of the variability and changes in observed and modelled climate and extremes. ACRE will also facilitate the downscaling and seamless linking of these reanalysis products into an immense range of climate applications models and activities.



*Figure 1: Schematic of digitised global terrestrial and marine data coverage with time. In the most recent period back to the late 1940s, European Center for Medium range Weather Forecasting (ECMWF) ERA and National Centers for Environmental Prediction (NCEP) type reanalyses which include all surface, balloon, aircraft and satellite data. The ACRE-facilitated surface-observations-only reanalyses will use observations over the full period back from the present. The thick red line shows the percentage of the globe covered by digitised surface observational data (%), with prominent dips during World War 2 and World War 1 (the effect of additional World War 2 data is not included) and little data prior to 1850.*

## ACRE AND MEDARE INTERACTIONS IN THE GREATER MEDITERRANEAN REGION (GMR):

The ACRE initiative is keen to work with the MEDiterranean climate DATA REscue (MEDARE) project and its activities to assess the current state, and to improve the extent, of data recovery, rescue, imaging, digitisation, quality control and archiving of very long daily to sub-daily atmospheric pressure data series across the greater Mediterranean region (GMR). This will link with the MEDARE aim to develop a comprehensive high quality instrumental climate dataset for the GMR, with a strong focus on the Essential Climate Variables (ECV) of GCOS.

In making a thorough assessment of the current holdings of daily to sub-daily instrumental observations in various repositories and archives across the GMR, it is important to realise that considerable data exist both prior to countries achieving independence and/or the establishment of the oldest National Meteorological and Hydrological Services (NMHS) around the 1850s. Much data exist in hard copy form in the repositories and archives of the various colonial powers which once administered now independent nations across the GMR. In some circumstances, countries have been administered by several colonial powers who vied for control of them and their resources. This can lead to a range of situations which either complicate or aid data recovery and rescue. At one extreme, material may be scattered across a number of archives in different countries with varying degrees of access. At the other extreme, if material is not found in one country or archive it may be available in another country or archive due to the frequent exchange of meteorological data and publications amongst the major NMHS in the colonial period. Finally, it is vital that data recovery and rescue activities focus on a wider range of potential repositories of historical meteorological observations, both prior to and after the establishment of NMHS (See Figure 2).

## SOURCES OF OLD METEOROLOGICAL OBSERVATIONS

<b>EARLY METEOROLOGICAL NETWORKS</b>	
Mannheim, Societas Meteorologica Palatina 1781-1792	
Société Royale de Médecine (F) 1776-1789	
(Ophélie: <a href="http://www.ipsl.jussieu.fr/~ypscce/ophelie.html">http://www.ipsl.jussieu.fr/~ypscce/ophelie.html</a> )	
Bayerische Ephemeriden (G) [Bavarian Academy of Science] 1781-1789	
<b>OBSERVATORIES</b>	<b>LIGHTHOUSES</b>
Astronomical	
<b>MEDICAL</b>	<b>PORT AUTHORITIES</b>
Hospitals	Harbour Masters
<b>MILITARY</b>	<b>MISSIONARY</b>
Royal Engineers (UK)	Jesuit
Army Medical Corps (UK)	
US Signal Office	
<b>CONSULAR</b>	<b>GENERAL PUBLICATIONS</b>
	Diaries
	Newspapers
	Pamphlets
	Journals
	Learned Societies

Figure 2: Various sources of old historical meteorological observations

In order to create the most comprehensive, high quality and high resolution instrumental climate dataset for the GMR as is possible, ACRE is working to foster close co-operation amongst a number of projects and initiatives with a European-Mediterranean data rescue component. Along with MEDARE, the other main players which need to be engaged and co-operating are the Mediterranean CLimate VARIability and Predictability (MedCLIVAR) project, the EC FP6 Climate Change and Impact Research: the Mediterranean Environment (CIRCE) project, and the European Climate Support Network (ECSN).

An important aspect of close linkages between ACRE and MEDARE is that the 3D atmospheric weather variables produced by the ACRE-facilitated reanalyses will be readily available to MEDARE. Such products can then be downscaled by statistical methods or regional models to provide 100-250 years of high resolution climatic/weather data for the study of climatic variability and change across the GMR.

## CONCLUSION:

ACRE needs to recover, image, digitise, quality control and archive large amounts of terrestrial and marine surface observations to 'fuel' the long historical surface-observations-only reanalyses it is facilitating. This is an enormous and expensive logistical task, requiring linkages with international scientific infrastructures, the NMHS and the research community. Working closely with projects such as MEDARE, brings with it the benefit that all of these elements are already available, focused and interacting on a mutual task for a specific region on the globe. If a number of data rescue projects around the world, such as MEDARE, are brought into the ACRE initiative, this allows the full range of international scientific endeavours to be brought to bear on the problem. In the case of MEDARE, this can be even further enhanced through ongoing involvement with projects and initiatives such as MedCLIVAR, CIRCE and ECSN. The individual projects themselves also benefit from working with ACRE, in that the best quality and quantity of data can be recovered and brought together for mutual benefit.

Interactions between ACRE and MEDARE also bring together a wealth of scientific experience in dealing with not only all aspects of data rescue, but also imaging, digitising, quality controlling and archiving. The comprehensive high quality, high resolution instrumental climate dataset for the GMR that will be produced will be an important element in the global data base necessary for the creation of the best quality surface-observations-only reanalyses possible. It will also ensure that MEDARE has early access to the 3D atmospheric weather variables produced by the ACRE-facilitated reanalyses – products essential for a better assessment of climatic variability and change impacts across the GMR.

## II.2. Availability and quality of Italian secular meteorological records and consistency of still unexploited early data

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### ABSTRACT:

Italy boasts a role at the highest level in the development of meteorological observations. As a consequence, a heritage of data of enormous value has been accumulated over the last three centuries. In spite of this huge heritage of data, and even if most records were subjected to some sort of analysis, until a few years ago only a small fraction of Italian data were available in computer-readable form.

In the last years, thanks to extensive data digitisation performed within a number of national and international projects, the situation has improved rapidly. Moreover, further improvement is expected for the next future as other activities are in progress or planned for the next years. However, in spite of such improvement, a significant fraction of Italian data is still unexploited and will probably continue to remain as such also in the near future.

Within this context, the aim of the paper is to give an overview of present Italian data availability and quality, highlighting the importance of recent data recovery and homogenisation.

### INTRODUCTION:

Italy boasts a role at the highest level in the development of meteorological observations. This role is well demonstrated by the invention of some of the most important meteorological instruments and the establishment of the first network of observations, the "Rete del Cimento", which was set up by Galileo's scholars and operated from 1654 to 1667, with stations both in Italy and in some surrounding countries. The strong Italian presence in the development of meteorological observations is confirmed by six stations that have been in operation since the 18<sup>th</sup> century (Bologna, Milan, Rome,

Padua, Palermo and Turin) and other fifteen stations whose observations started in the first half of the 19<sup>th</sup> century (Aosta, Florence, Genoa, Ivrea, Locorotondo, Mantua, Naples, Parma, Pavia, Perugia, Trento, Trieste, Udine, Urbino and Venice). As a consequence, a heritage of data of enormous value has been accumulated in Italy over the last three centuries.

### RECOVERING ITALIAN DATA AND METADATA:

*The first national collections of monthly temperature and precipitation data*

The great importance of the Italian observational records has been known for a long time and many attempts have been made to collect data into a meteorological archive. The first attempt to perform a systematic collection of Italian monthly precipitation data was made just after the National Central Office for Meteorology and Climate was founded (1880). This work was then updated and revised in different steps in the following decades. The same work was performed for mean temperatures, albeit concerning a lower number of stations and only some selected periods. A list of the principal references reporting Italian monthly records is given in table 1 of Brunetti et al. (2006), which also shows a list of the principal Italian meteorological year-books.

Besides the previous activities, a very high number of monographic studies, involving the collection of single Italian station records, have been carried out in the last two centuries. A rather complete list of the resulting publications is given in Narducci (1991). Unfortunately, a relevant fraction of them was published in grey literature and in Italian, thus the results were not easily available to the international scientific community. The large use of grey literature in reporting the activities on single stations makes it also not easy to update the inventory reported in Narducci (1991) and to get a clear picture of which records are really available. A list of the most

relevant recent publications is given in Nanni *et al.* (2008).

In spite of the huge heritage of data and even if most records were subjected to some sort of analysis, until a few years ago only a small fraction of Italian data was available in computer readable form. In the last years extensive data digitisation has been performed and the situation has improved rapidly. A detailed discussion of the recent improvement in the availability of Italian secular temperature and precipitation series is reported in Brunetti *et al.* (2006) and Nanni *et al.* (2008). A synthesis of the main activities that enabled to get to the current database of Italian secular records is reported hereinafter.

#### *The UCEA70s data-set*

The first step towards the digitisation of the Italian secular series was made in the 1970s when, in the frame of a national project funded by the Italian National Research Council (CNR), a set of 26 precipitation and minimum and maximum temperature records was transcribed from yearbooks to digital supports. The resulting data-set, usually known as the UCEA (Ufficio Centrale di Ecologia Agraria, Rome) secular series data-set (hereinafter, we will refer to this as the UCEA70s data-set), consisted both of daily and monthly records, generally covering the 1870-1970 period (Lo Vecchio and Nanni, 1995). The main drawbacks of this data-set were a rather high portion of missing data, and the lack of any kind of metadata.

#### *The CNR 90s data-set*

A further improvement in the availability of digitised data was made in the second part of the 1990s, in the frame of a new CNR project (Reconstruction of the past climate in the Mediterranean area), that allowed the UCEA secular series data-set to be updated, completed, and revised. The resulting data-set is extensively discussed in Buffoni *et al.* (1999) and in Brunetti *et al.* (1999). In comparison with the

UCEA70s, the new data-set (hereinafter CNR90s), besides updating to 1996 and including some new series, presented both an extension of the covered period and a lower fraction of missing data, thanks to an extensive work of data digitisation. Moreover, also the previously available UCEA70s data were subjected to new quality check procedures. Such procedures allowed both the identification of typing errors, and the awareness that sometimes, in the UCEA70s data-set, monthly precipitation amounts were calculated as a sum of daily precipitation even for months with incomplete data. This mistake, a very common one especially at the end of the 19<sup>th</sup> century, was eliminated, either by invalidating the data or replacing them with data from other sources.

In spite of significant improvements, also the new CNR90s data-set had the fundamental limitation of very poor metadata availability. Moreover, the number of stations was still too low and some regions, especially in Central and Southern Italy, presented a very poor coverage. These deficits prevented the data from being subjected to extensive homogenization procedures.

#### *The contribution of CLIMAGRI and of other National and International projects*

After the conclusion of the 1990s CNR project, some Northern Italy monthly mean temperature records were shared within the EU ALPCLIM project to set up a data-set covering a region centred on the Alps (Greater Alpine Region). Their comparison with the records of the other countries of this area showed some systematic differences.

The difficulties in subjecting the CNR90s data-set to extensive homogenisation, and the not complete agreement of the Northern Italy records with the others from the Greater Alpine Region, clearly highlighted that, at the end of the 1990s, the collection of metadata and the improvement of station density were fundamental problems in the correct detection of temperature and precipitation trends over Italy.

Within this context, in the year 2000 a new research programme with the aim of obtaining homogenised Italian secular temperature and precipitation records was established. It was initially developed within a National Project of the Ministry of Agriculture and Forests (CLIMAGRI – Climate Change and Agriculture, see [www.climagri.it](http://www.climagri.it), complete but in Italian, or [www.fao.org/sd/climagrimed/](http://www.fao.org/sd/climagrimed/), less complete but in English), then an extension of the activities was performed within the EU-FP5 ALP-IMP project (see [www.zamg.ac.at/ALP-IMP](http://www.zamg.ac.at/ALP-IMP)), within two more projects funded by the Italian Ministry for Education and Research (PRIN 2001 - Local climate variability in relation to global climatic change phenomena; FIRB 2001 – Frequency evolution of extreme precipitation events and droughts in Italy in the last 120 years and its impact on biosystems), and within the U.S.-ITALY bilateral Agreement on Cooperation in Climate Change Research and Technology. Thanks to the availability of resources from these projects, and considering that other activities were in progress in Italy concerning both single stations and Italian Regional Administrations (see Nanni *et al.*, 2008 for a list of the most relevant recent contributions), the initial aim of homogenising the existing records was extended and the construction of a completely new and larger set of data and metadata was planned as well.

#### *Metadata collection*

Metadata collection was performed with two main objectives: i) to understand the evolution of the Italian meteorological network and ii) to reconstruct the “history” of each available station in the data-set.

The evolution of the National network was investigated both by analysing a number of reports and papers on this issue, and by studying the proceedings of the principal conferences and meetings that led to the establishment and rapid growth of a National network of meteorological stations from the Italian political unity (1860) to the first decades of the 20<sup>th</sup> century. References, results

and methods are summarized in the final report of the first year of the CLIMAGRI project (Maugeri *et al.*, 2002). The reconstruction of the network evolution is very important for data homogenisation, especially when homogenisation is mainly based on statistical methods, as they often fail in identifying breaks that affect a high fraction of stations within a short period. This happens when breaks are due to changes in instruments and methods caused by new standards imposed by the network management, for example, as a consequence of new national or international standards. A very good synthesis of the efforts produced in the last three decades of the 19<sup>th</sup> century to standardise the meteorological observations is given in the International Meteorological Codex of G. Hellmann and HH. Hildebrandsson (1907). Two interesting examples on the effect of the introduction of new standards on data homogeneity are given in Brunetti *et al.* (2006) and in Auer *et al.* (2005). The first study explains the disagreement between the Northern Italy temperature records and the others of the Greater Alpine Region linked to a progressive substitution of the meteorological windows, initially suggested by the Italian Central Office, with ground-level Stevenson screens. The second estimates the impact of the progressive tendency to perform precipitation observations at ground level as opposed to roof level.

The research on the history of the single stations was performed both by analysing a large amount of grey literature (monographic studies, bulletins, reports, etc...) and by means of the UCEA archive. This archive is very rich, since UCEA was, in the past, the National Central Office for Meteorology and Climate. All information was summarized in a document containing a card for each data series (Maugeri *et al.*, 2004). Each card is divided into three parts. In the first part, all the information obtained from literature is reported. In the second part, there are abstracts from the epistolary correspondence between the stations and the Central Office. In the third part the sources of the data used to construct

the record are summarized. These cards had a fundamental role in supporting data homogenisation.

Metadata are particularly important for the records beginning in the 18th century. For such early records it is absolutely necessary to reconstruct the used instruments and their exposure, the adopted observational methodologies, the times of observation and so on. Recovering such metadata generally requires both the study of local archives and the analysis of all available information on regional and National networks. Such studies (which are generally based on accurate rescue activities aiming at the recovery of the information stored in different types of historical documents, including archives, letters and so on) are absolutely necessary in order to ensure that the records can be effectively used in past climate reconstruction researches. A synthetic overview of the activities that were performed on the most important Italian station records is given in table 1.

#### DATA HOMOGENISATION:

##### *The problem*

In the last decades the scientific community has become aware of the fact that the real climate signal in original series of meteorological data is generally hidden behind non-climatic noise caused by station relocation, changes in instruments and instrument screens, changes in observation times, observers, and observing regulations, algorithms for the calculation of means, and so on. So, at present, the statement that time series of meteorological data cannot be used for climate research without a clear knowledge about the state of the data in terms of homogeneity has a very large consent.

##### *Direct and indirect methods*

There are different ways of solving homogeneity problems, and the choice of the most suitable one is strictly related to the data-set characteristics

(metadata availability, station density, and so on) and to the examined region (Aguilar *et al.* 2003).

Meteorological series can be tested for homogeneity and homogenised both by direct and indirect methodologies. The first approach is based on objective information that can be extracted from the station history or from some other sources, the latter uses statistical methods, generally based on comparison with other series. Direct methods have the advantage of providing detailed information about the time location of the inhomogeneities and about the sources that caused them. Unfortunately, metadata are not always available and complete. Moreover, it is generally difficult to convert them into quantitative values for the correction of the discontinuities. On the other hand, indirect methods are more suitable to calculate correcting factors to eliminate the breaks, but the identification of inhomogeneities is not always easy and unambiguous because: i) inhomogeneities and errors are present in all meteorological series, making it difficult to objectively assign the breaks to one or another of them, ii) correlation among data series depends on various factors (regional patterns, climate elements under analysis, time resolution of data, and so on) and when the common variance (squared correlation coefficient) between the candidate and the reference series is too low, the potential discontinuity signal in an homogeneity test disappears into statistical noise. For Italy such problems concern particularly precipitation records, as it is often difficult to have more than 50% of common variance for distances greater than 100 km. So, in spite of the strong increase in the station density, the application of indirect homogenisation methods has still some setbacks that can be overcome only by means of strong metadata information support (Brunetti *et al.*, 2006).

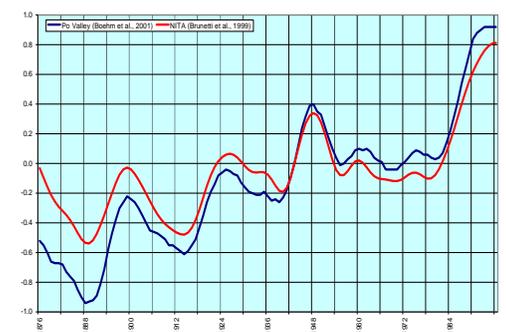
##### *Homogenisation of Italian Temperature and Precipitation records*

In Buffoni *et al.* (1999) and Brunetti *et al.* (1999), an attempt was made aimed at homogenising precipitation and temperature data for Italy. Due to the low amount of metadata and the rather low station density, the homogenisation was performed by considering a weighted average among some neighbouring series as a reference series, with the confidence that the average procedure could eliminate or reduce the inhomogeneities in the reference series. Unfortunately, this is not always true, in particular for limited regions or single networks, where some simultaneous changes in the instruments or measurement methods can occur. By following this procedure, only the most relevant breaks were eliminated, but some minor (but not negligible) problems persisted. This was highlighted when some data from Northern Italy were shared, within a wider data-set covering the Greater Alpine Region (Figure 1).

In the last years, as previously mentioned, the Italian data-set was remarkably enlarged with the collection of many new series, and a rich metadata archive was set up. This heritage of data and metadata, together with the improvement of the homogenisation techniques, led us to reconsider at the beginning of the 2000s the entire homogenisation procedure.

The new homogenisation of the Italian temperature and precipitation secular records is discussed in detail in Brunetti *et al.* (2006). Testing and adjusting procedure were performed in regional sub-groups of 10 series using a revisited version of the HOCLIS procedure (Auer *et al.*, 1999). HOCLIS rejects the a priori existence of homogeneous reference series. It consists of testing each series against other series, by means of a multiple application of the Craddock test (Craddock, 1979), in sub-groups of 10 series. The test is based on the hypothesis of the constancy of temperature differences and precipitation ratios. The break signals of one series against all others are then collected in a decision matrix and the breaks are assigned to the single series according to

probability. This system avoids trend imports and an inadmissible adjustment of all series to one or a few "homogeneous reference series". However, even if this method overcomes most of the problems concerning the hypothesis of the a priori existence of a homogeneous reference series, a margin of subjectivity in break identification persists, especially when discontinuities are not very high. In this case the signal in the homogeneity test is not so clear and, as at present there is not a universal approach to the use of the indirect homogenisation methods, the choice of whether to homogenize or not to homogenise may be strictly linked to the researcher's "philosophy". This point is an important open question of research concerning the reconstruction of the past climate, that is at present time addressed by important research projects, as the EU COST action HOME (Advances in Homogenisation Methods of Climate Series: an integrated approach).



*Figure 1: Northern Italy average temperature series according to the data homogenised as in a) Brunetti *et al.* (1999) and b) Böhm *et al.* (2001). In order to better display the long-term evolution, the series are filtered with an 11-year window 3-year  $\sigma$  Gaussian low-pass filter*

When the signal is not clear our "philosophy" is to homogenise the data only in the following cases: i) when there is some information in the metadata, ii) when more reference series give coherent adjustment estimates and their scattering around the

mean value is lower than the break amount. In our opinion, only in these cases the corrections really improve the data quality, whereas in other cases there is a high risk of introducing corrections whose associated errors are higher than the corrections (Brunetti *et al.*, 2006).

Once we decide to correct one break, the series used to estimate the adjustments are chosen among the reference series that result homogeneous in a sufficiently long sub-period centred on the break year, and that well correlate with the candidate one. We chose to use several series to estimate the adjustments to be sure about their stability and to prevent unidentified outliers in the reference series from producing bad corrections. Moreover, it often happens that homogeneous sub-intervals between two detected breaks are so short that the signal-to-noise ratios of the adjustments obtained with only one reference series are very low. So, using more series allows us to correct a great number of short sub-periods that would have to be left unchanged otherwise. The adjustments from each reference series are calculated on a monthly basis, and then they are fitted with a trigonometric function in order to smooth the noise and to extract only the physical signal (the adjustments often follow a yearly cycle) (Brunetti *et al.*, 2006). The benefits of using smoothed adjustments instead of the rough ones are well described in Auer *et al.* (2005). The final set of monthly adjustments is then calculated by averaging all the yearly cycles, excluding from the computation those stations whose set of adjustments shows an incoherent behaviour compared with the others. When a clear yearly cycle is not evident, the adjustments used to correct the monthly data are chosen as constant through the year and are calculated as the average among the monthly values for temperature, and as the weighted average for precipitation, where the weights are the ratios between monthly mean precipitation and total annual precipitation (Brunetti *et al.*, 2006).

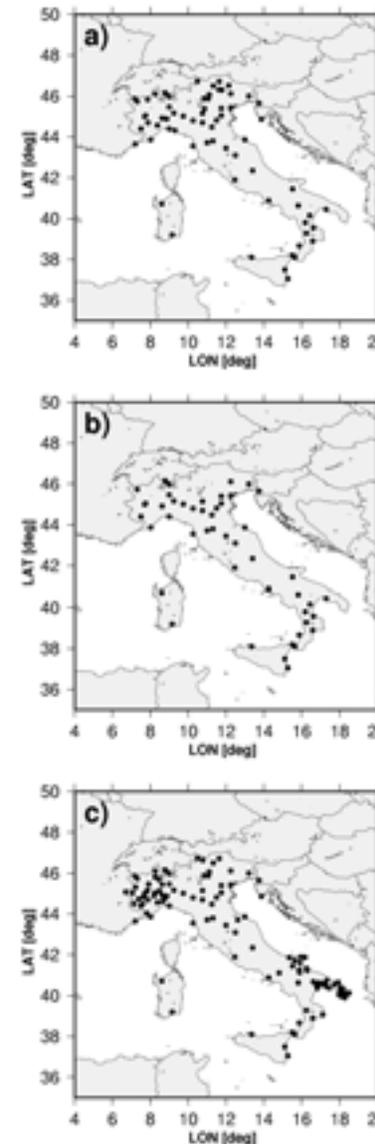
Generally, in our data, temperature additive adjustments resulted in more or less pronounced, but rather steady, annual courses. The monthly adjustment factors for precipitation series, in contrast, showed in many cases a non-evident annual course and, in the majority of cases, a constant correction was made. Some exceptions were the stations with a predominant snowy winter precipitation (Brunetti *et al.*, 2006).

Our homogenization software is freely available and we encourage all researcher that may be interested in using (and hopefully contributing to improving) it to contact us. Some useful information for the researchers interested in our homogenisation activities is available at [www.isac.cnr.it/~climstor/hom\\_training.html](http://www.isac.cnr.it/~climstor/hom_training.html).

#### *Availability of Temperature and Precipitation homogenised records*

Figure 2 illustrates the spatial distribution of the Italian homogenised temperature and precipitation records.

The data-set comprises 67 mean temperature series, 48 minimum and maximum temperature series, and 111 precipitation series. Precipitation has the best data availability: there are 111 records and 75 of them cover at least 120 years. There are 18 records that exceed 160 years, whereas 6 cover at least 200 years. There is also a very good availability of monthly minimum and maximum temperature records (48 series) that is probably unique in the world (70% of them are longer than 120 years). Finally, 67 mean temperature series are available, 80% of which are longer than 120 years (Brunetti *et al.*, 2006). It is worth noticing that, for a significant fraction of the station records, also daily data are available. This fraction is particularly high for minimum and maximum temperatures, whose daily data-set almost coincides with the monthly one. Conversely, for precipitation, only 50% of the monthly data-set is available on a daily resolution.



*Figure 2: Location of the Italian stations with secular records for a) mean temperature, b) minimum and maximum temperature, and c) precipitation (Adapted from Brunetti *et al.* (2006))*

So the data-set of the monthly records is partially calculated from daily data and partially from data that are available only with monthly resolution (Brunetti *et al.*, 2006). When daily records were available, a preliminary quality check was performed on a daily basis, both for temperature and precipitation, by self-consistency checks and intercomparison among different stations and parameters (for temperature, a comparison between minimum and maximum values was performed and daily temperature range series were extracted and checked too). Details on the quality check of the daily data are given in Maugeri *et al.* (2002; 2004).

It is worth noticing that the availability of secular temperature and precipitation records is continuously increasing, as important new activities are in progress. However, the records that were recovered in the last two years are not included in the homogenised record dataset, as the last systematic homogenisation of the Italian records is still the one discussed in Brunetti *et al.* (2006). We plan to get an updated version of the homogenised dataset in the next few years.

#### *Other variables*

As far as other variables are concerned, a lot of work has still to be performed. As far as homogenised records are concerned, the only variables for which there are secular records are pressure and cloudiness (see figure 2 in Auer *et al.*, 2007) and the available data cover only Northern and Central Italy. In particular the best data availability concerns the Po Plain, for which also an 18<sup>th</sup> century daily regional pressure record is available (Maugeri *et al.*, 2004).

The situation is better if also non-homogenised data are concerned (Figure 3) even though a significant fraction of the available records display important breaks.

So, even though some important secular records are already available, extensive data digitisation is still to be performed in the next years in order to extend the reconstruction of past climate variability and change

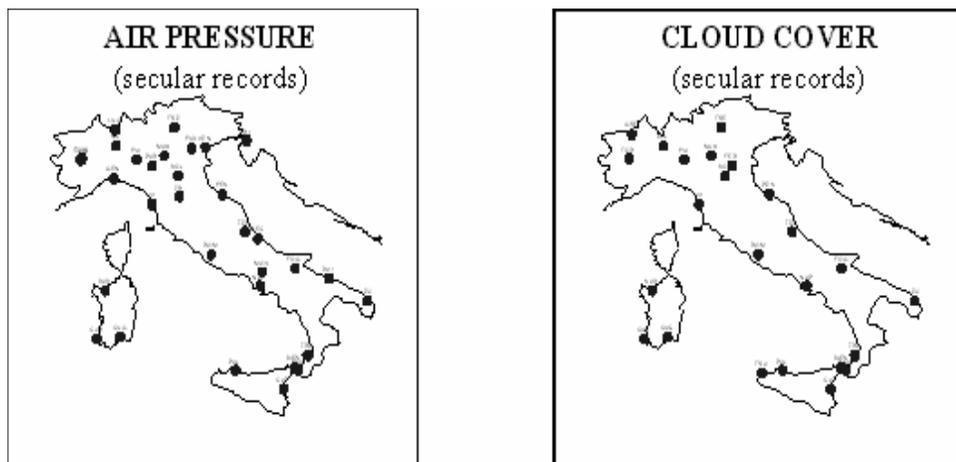


Figure 3: Location of the Italian stations with secular records for a) pressure, b) cloud cover. For a significant part of the records data homogenisation has still to be performed. As far as other variables are concerned, the secular database encompasses 2 humidity and 15 snow cover series

from temperature and precipitation to all other variables. Among the most important data sources to be exploited there are the Italian daily weather reports (Bollettino Meteorico Giornaliero). A complete record of them is available at the Ufficio Centrale di Ecologia Agraria for the period 1879-1940. UCEA archives also contain a very rich collection of Italian station data. Also this data source should be better exploited in the next years, with particular focus to variables as cloudiness, sunshine duration and humidity.

#### Adjustments of the Italian Temperature and Precipitation records

A detailed discussion of the adjustments applied to the Italian secular temperature and precipitation records is reported in Brunetti *et al.* (2006)

Actually the homogenisation of the initial part of the temperature records was very difficult, not only as a consequence of low station density, but also because all records are affected by important errors depending on a number of factors. The most important factor seems to be the progressive

introduction of the minimum and maximum thermometers that allowed a much more accurate estimate of the daily extremes than previous observations at sunrise and in the afternoon. Another very important factor is the progressive substitution of the initial thermometer metal screens with meteorological windows, such as the one initially suggested by the Italian Central Office (for a general discussion of the homogeneity problem of the most ancient thermometer records see Camuffo and Jones, 2002). Unfortunately, metadata concerning the first part of the records are available only in some cases. So, in many cases, especially for minimum and maximum temperatures, the data could not be subjected to homogenization. The main consequence of these difficulties is that we have a lower confidence in the results of data homogenisation for the years before 1865, i.e. before the Italian Ministry of Agriculture, Industry and Trade began to define instrumentations and standards and to collect data for the whole national territory. The situation is better for precipitation records, as they do not present so many homogeneity problems in the initial period. However, also in this case before 1865 station density is rather

low and the results of homogeneity testing and adjusting have a lower confidence than in the following period (Brunetti *et al.*, 2006).

In our opinion the temperature evolution before about 1865 is at present time an open question not only for Italy, but also for wider European areas like the Greater Alpine Region. An interesting discussion of this problem is reported by Frank *et al.* (2007) that display that, before the 1860s, the Greater Alpine Region temperature record reported in Auer *et al.* (2007) shows anomalies that are significantly higher than the ones obtained estimating temperature by means of tree rings. The fact that the Auer *et al.* (2007) temperature record may be overestimated before the 1860s seems to be also confirmed by the differences between the Northern Italy average temperature series according to the data homogenised as in a) Auer *et al.* (2007) and b) Brunetti *et al.* (2006), even though such a conclusion has to be considered with great caution due to the difficulties that partially hampered the homogenization of the early part of the Brunetti *et al.* (2006) dataset. At present, new research is in progress concerning the early part of the Italian and the Greater Alpine Region records and in the next months a new version of the homogenised records will be available.

A very interesting step to be performed after data homogenization is the comparison among the homogenised and the original series. This issue can be investigated by analysing the adjustment series. As these series contain the values that were added to (multiplied by) the original temperature (precipitation) records in order to produce homogeneous data, this analysis will reveal any systematic errors in the original records.

A complete discussion of the results of such a comparison for the Italian records is reported in Brunetti *et al.* (2006). The most important result is that the temperature records adjustments display an evident positive trend. It is probably due to a progressive evolution of thermometer location, from

meteorological windows as the one initially suggested by the Italian Central Office to ground-level Stevenson screens. This evolution began in the late 19th century and continued in the following decades, being particularly important around World War II.

So, the analysis of the adjusting series reveals that the use of the original data in estimating long-term temperature evolution gives negatively biased results. This result is in agreement with the findings of other authors as Böhm *et al.* (2001) and Begert *et al.* (2004).

#### CONCLUSIVE REMARKS:

In the last years, thanks to extensive data digitisation performed within a number of national and international projects, the data-set of Italian monthly temperature and precipitation secular records was updated and greatly improved, both in station density and in metadata availability. Moreover, it was subjected to a detailed quality control and homogenisation procedure and analysed for trends.

The activities highlighted the crucial role of data homogenisation. In fact, most of the series turned out to be inhomogeneous, containing one or several shifts that, in the case of temperature series, systematically biased the original data, the mean adjustment series being affected by a relevant trend. So, using the original data in estimating long-term temperature evolution gives negatively biased results. Such awareness may be useful also for other Mediterranean countries that plan to perform past climate reconstruction activities in the next future.

Further improvements in the availability of the Italian secular records are expected as other activities are in progress or planned for the next years. However, in spite of such improvement, a significant fraction of Italian data is still unexploited and will probably continue to remain as such also in the future, as the resources devoted to data and metadata rescue activities are, at present, rather low.



**INTERNATIONAL DATA RESCUE PROJECTS:**



NOAA data rescue efforts under the CDMP program have an international component that fosters cooperation in the exchange of data. In order to have the most complete global database available to researchers and other users, NOAA, under the CDMP program, is rescuing and digitizing data in many areas of the world where there are gaps and holes in available global climate and environmental databases. Successful joint data rescue projects have been completed or are in process with the following countries: Uruguay, Chile, Finland, Sweden, Germany, Malawi, Senegal, Kenya, Vietnam, Mozambique, United Kingdom, Mexico, and Canada.

Cameras and computer equipment used to image data in Uruguay were provided by NOAA's National Weather Service in conjunction with CDMP. Meteorological technicians and scientific advisors on-site image the data, which are then copied to CD-ROM and sent to NOAA's National Climatic Data Center (NCDC). These images are then indexed and stored in a searchable secure access system. The images are then evaluated and a keying format is developed based on the number of stations, period of record and data elements received. These data are then keyed by CDMP contractors; CDMP staff then evaluate the quality of the keyed data. These data will then be added to NOAA's global synoptic database, and a copy of the data files and format will be sent to the partner country.



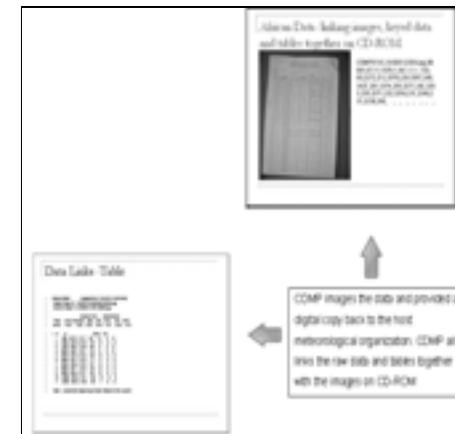
In 2006, CDMP coordinated with Mexico's National Meteorological Service (SMN- Servicio Meteorologico Nacional) in a joint venture to preserve valuable daily surface weather observations dating from 1981 to as far back as 1877. These observations are from 92 national observatory stations and about 35 cooperative observing stations located throughout Mexico. The observations are contained in paper logbooks stored in non-climate-controlled conditions. These records were in danger of loss or significant deterioration from environmental hazards such as moisture, mold and insects. Imaging stations were set up at the



SNM to image all 431,000 pages. These data are also being keyed, which is a challenge since the data were recorded in at least 20 different logbook formats.



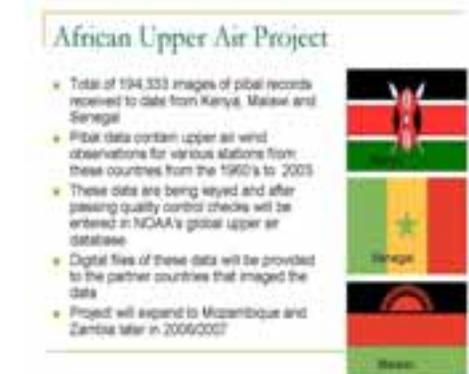
These Mexican data will be used in the enhancement of indices used by the North American Climate Extremes Monitoring system. This system, includes the North American Drought Monitor, an integral tool for drought planning. The Drought Monitor is a cooperative effort between drought experts in Canada, Mexico and the United States to monitor drought across the continent. The integration of the additional Mexican data should help improve the Drought Monitor by increasing the historical record of precipitation data.



This allows the host meteorological agency quick and easy access to original images, summarized data, and raw keyed data useful for verification, analysis and research.



CDMP supports various marine projects which include locating, acquiring, imaging and keying marine records. Several significant marine collections have been images and keyed, including 1910-1912 merchant marine data and logbooks collected during WWI and WWII. Additional marine rescue activities include observations from Voluntary Observing Ships (VOS) and East India Company logbooks which are a collection of early marine observations taken mainly in the 1700's on trading routes between Europe and India.



## II.4. Deficiencies and constraints in the DARE mission over the Eastern Mediterranean

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Turkish State Meteorological Service, Ankara, Turkey

Upper air projects with various African countries help to fill in valuable missing periods and gaps in upper air pressure, humidity and wind observations. These data are used in various international global upper air re-analysis projects.



GIS Service Files allow visual links to stations, inventories and access to the data



Station display of NCEP database reporting hourly/daily data. Clicking on markers will lead to inventory information and allow user to extract actual data.

### Additional International Projects

- Foreign Climate Data Imaging by NOAA's Central Library: Project goal of the project is to preserve and disseminate unique climatological data from national sources.
- Period of record cover 1920s through the 1970s with most data from the period prior to 1960. Each series typically includes observations for a number of meteorological and other geophysical parameters.
- Involves documents from over 14 countries in Africa, 8 in Asia, 8 in Europe, 10 in North America, 1 Pacific Island and 2 in South America.



### GIS Data Portal

- NCEP's GIS Portal allows users to view, access, and utilize in situ station data through NCEP's Geographic Information System (GIS) portal. Interactive maps, associated metadata, and advanced Open Geospatial Consortium (OGC) services, such as Web Map Services (WMS) and Web Feature Services (WFS) are available.
- <http://gis.ncep.noaa.gov/aimstools/gis.jsp>

### ABSTRACT:

Climate change results from anthropogenic pressures on the complicated interactions between the atmosphere, oceans, cryosphere, surface lithosphere and the biosphere, which comprise the climate system. Climate change is extremely complex and global in its influence, meaning that cooperative activities with international and interdisciplinary programs are indispensable for monitoring and predicting climate change and disseminating reliable information about it.

Historical climate data are very important, and hard copy observations need to be digitized in order to detect natural climate variability over as long a period as possible. An International Data Rescue meeting in 2001 (September 2001, Geneva) re-defined Data Rescue as: *An ongoing process of preserving all data at risk of being lost due to deterioration of the medium, and the digitization of current and past data into computer compatible form for easy access.*

In order to detect the spatial and temporal extent of various country's historical climate data and their DARE activities, a questionnaire has been prepared and sent to eastern Mediterranean countries. Although only seven countries replied to this request (Turkey, Georgia, Jordan, U.A.E., Israel, Libya, I.R. of Iran), it is clear that there are many historical sources that need to be recovered and digitized. Many countries have also expressed their intention to rescue their data, but they mentioned some constraints on such activities and the need for help from WMO and other international organizations. Turkey, Georgia, Jordan, U.A.E. and Israel have historical climate data from 1842, 1844, 1925, 1936 and 1846 respectively, and some of these observations are still awaiting digitization.

The measurements of temperature in Istanbul were firstly published in 1842 in the newspaper "Ceride-i Havadis" (Oguz, A, 1947). The Turkish State Meteorological Service (TSMS) was founded in 1937 and before this date there are some old data in volumes recorded under the Ottoman Empire as follows: French Meteorological Service has some data in volumes of the Bureau Central Meteorologique, 1868-1897: Bulletin International XIII-XXV Annee, Jan 1-Dec 31, Paris, France. Three climate books for Istanbul from 1896 to 1914 can be found in the meteorology museum in Ankara. They are in the Ottoman language, and need to be translated and then digitized. During the 1<sup>st</sup> World War (1915-1918), some German scientists carried out meteorological observations from 1915 to 1918 and they published them in a book entitled "Zum Klima der Türkei". These examples show that there is the potential to recover early data for the above sites in Turkey. Some of the pressure data are already presented and available in the ACRE Project at <http://www.cdc.noaa.gov/Pressure/> and <http://www.hadobs.com/> which are: Istanbul (EMULATE) 1866-1880 [daily] (Hadley Centre) 1847-1848; 1854 [monthly] (ADVICE/CRU, UEA, Phil Jones) 1856-present [monthly], Izmir (Hadley Centre, Rob Allan) 1864-1873; 1890-1899; 1906-1994 (gaps) [monthly]

After the recovery, digitization and reconstruction of past climate data, it will be possible to run RCLimDex software to produce climate indices and to detect climate change from historical times to the present. One study has been undertaken for the Middle East and published at: [www.agu.org/pubs/crossref/2005/2005JD006181.shtml](http://www.agu.org/pubs/crossref/2005/2005JD006181.shtml)

**DATA RESCUE (DARE) PROJECT:**

The Data Rescue (DARE) project is aimed at assisting countries in the management, preservation and use of climatic data from their own territories. DARE commits to data storage via microfilm and microfiche, and eventually to digital media through CLICOM and other means. The urgency for these activities is magnified, when the original written manuscript records, which may date back more than 100 years, are in danger of deteriorating and of being lost. The DARE project in Africa, funded primarily by Belgium, dates back to 1979 and the Belgium-supported phase was terminated in mid 1997. It has resulted in more than five million documents from more than 30 countries being saved on microfilm. In 1995 a DARE project began in the Caribbean with funding support from Canada.

**NEW DARE STRATEGY:**

In the mid-1990's, technological advancements made it possible to optically scan printed climate data as a new method of creating digital climate archives. This technology permits the data not only to be preserved, but also to be in a form for exchange via computer media. However, it is now recognized that these data must be moved into digital databases for use in analyses and climate change studies. Optically scanning images certainly preserves the data and is a major improvement over hard copy media, in addition placing the data in full digital usable form will make it accessible to many more users.

An International Data Rescue meeting (September 2001, Geneva) re-defined Data Rescue as: *An ongoing process of preserving all data at risk of being lost due to deterioration of the medium, and the digitization of current and past data into computer compatible form for easy access.*

This definition implies that:

1. Data should be stored as image files onto media that can be regularly renewed to prevent the deterioration of the medium (cartridges, CDs, DVDs etc.)
2. Data should be key-entered in a form that can be used for analyses.

New data rescue projects are being implemented in many countries (Vietnam, Rwanda, Jamaica, and Honduras), (WMO, WCDMP)

**METHOD:**

A DARE questionnaire has been prepared and sent to all GCOS focal points in eastern Mediterranean countries (Georgia, Armenia, I.R. of Iran, Azerbaijan, Bulgaria, Russia, Greece, U.A.E., Syria, S. Arabia, Libya, Lebanon, Jordan, Israel, Yemen, Iraq, Egypt, Cyprus, Bahrain, Turkey) in order to learn their overall data situation and status. The questionnaire contains the following parts:

- A. General information
- B. Climate data rescue activities
- C. Inventory of digitized data
- D. Inventory of not digitized data
- E. Assessment of meteorological archives and data availability
- F. Problems, constraints and recommendations

The questionnaire has been sent to 20 countries. 7 of them have responded (red) while 13 did not.



Figure 1: Countries DARE questionnaire sent

Local WMO station code	Station name	Geographical details (Latitude, Longitude, alt)	Variables	Length of records	Time resolution	Preliminary assessment (app %)
17062	Iskender	40°14, 29°07, 31m	Temp, Taux, Press, W speed, 80%	1845-1987	daily	Published in the newspaper "Cumhuriyet" (some weeks per month)
17062	Iskender	40°14, 29°07, 31m	Temp, Taux, Press, W speed, 80%	1845-1987	monthly	French Meteorological Service has some relation to Istanbul (some data)
17062	Iskender	40°14, 29°07, 31m	Temp, Precip., Precip. in speed & dir, 80%	1845-1987	daily	Some data missing in 1970 World War II era collected as a book called "Cumhuriyet" for the book about
17112	Calicut	40°12, 29°07, 31m	Pressure, Temp., 80%, wind speed & direction	1915-1918	monthly	
17128	Beypazarı	39°45, 27°17, 21m		1918		
17022	Beypazarı	40°17, 29°07, 31m				
17024	Beypazarı	40°19, 27°09, 31m				
17139	Angora	39°47, 32°18, 80m				
17123	Eskişehir	39°49, 30°01, 80m				
17134	Konya	37°18, 32°01, 80m				
17086	Sivas	39°43, 37°01, 120m				
17189	Diyarbakır	37°14, 40°02, 47m				
17191	Adana	36°54, 35°01, 71m				

Table 2: Inventory of non-digitized data - Turkey

Local WMO station code	Station name	geographical details	variables	length of records	time resolution	assessment (app %)
42949	Zagreb	42.1	temp	1968	nd-daily	2%
17179		41.8				
42948	Dubrovnik	42	temp	1968	nd-daily	2%
17177		41.6				
42947	Sibenik	42.3	temp	1916	nd-daily	2%
17180		42.1				
41748	Osijek	41.7	temp	1918	nd-daily	2%
17149		41.8				
41846	Milutinac	41.8	temp	1912	nd-daily	2%
17141		44.6				

Table 3: Inventory of non-digitized data – Georgia

Local WMO station code	Station name	geographical details	variables	length of records	time resolution of the records	preliminary assessment app
4780	Tbilisi, Eng. Min. Stn., Old City	41°45'N, 44°50'E, 760m	T, Ts, Tn	1869-1914	daily	Not known yet
New yet	Sukhumi	42°42'N, 41°38'E, 480m	T, Ts, Tn	1869-1873, 1895-1911, 1948-1914	daily	Not known yet
New yet	Batumi	42°05'N, 40°59'E, 20m	T, Ts, Tn	1884-1908	daily	Not known yet
New yet	Sopri (Old Ave)	42°05'N, 40°47'E, 25m	T, Ts, Tn	1879-1889, 1894-1903	daily	Not known yet

Table 4: Inventory of non-digitized data – Israel

**QUESTIONNAIRE RESULTS:**

DARE information	Turkey	U.A.E	Jordan	Georgia	Israel	Libya	I.R. of Iran
Data entry software	MS-Word	CLIP	COM	Parsons	MS Software	CLICOM	SP data which are produced in IBM PC Archives, data storage (Acrobat)
Data management	Inform	Oracle	Oracle	Oracle	ACROSS	Inform	Inform
Starting year of Observations	1942	1938	1923	1944	1940	1923	1929
Starting year of digitization	1928	1938	1981	1981	1940	1929	1987 (Turkey)
% of digitized data	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%	75-100%
Need to not digitized data	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Name of Respondent	Serdar Sensoy, UCDMP	Muhammad Sensoy	Nabil Sensoy	Faruk Sensoy	Amir Sensoy	Shadi Sensoy	Abbas Sensoy

Table 1: Countries responding to the DARE questionnaire and their information

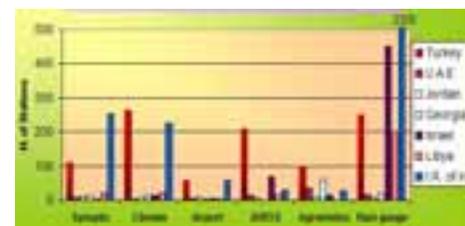


Figure 2: Current stations in eastern Mediterranean countries

## HISTORICAL CLIMATE RECORDS FROM OTTOMAN EMPIRES:

Some early climate records in Turkey started around 1840 in the schools, hospitals, embassies, plus some volunteers like scientists, engineers, priests etc. These observations were not of continuous form, and most of them were not saved carefully.

First scientific observations were started in 1856 by Ritter (engineer) in the Bosphorus Observation Park, and were installed 6m above sea level with a 2m surface temperature shield.

Another set of observations were carried out by Mr. William Henri Lyne from 1865-1886. This man lived 30 years in Haydarpasa, Istanbul as a guard at the English cemetery. Lyne performed observations in his garden and observed rainfall, max and min temperature and wind. He recorded them in a book and sent them to London.

In August 1841, Ceride-i Havadis newspaper started to give information about the temperature in Istanbul and also gave some information on how temperature can be measured, what the summer temperature was in S. Arabia (28-30°C), the winter temperature was in Petersburg (-30 °C) and in Siberia (-40°C) in order to improve public opinion about climate.

Historical records from the Ottoman Empire are as follows:

- The measurements of temperature for Istanbul were firstly published in 1842 in the newspaper "Ceride-i Havadis". These measurements were performed by foreign volunteers (Oguz, A., 2007).
- Official observations were started in 1868 at the Observatoire Impérial Météorologique de Constantinople. French Records from 1868-1897 included monthly pressure, Tmax, Tmin, precipitation and daily max prec., wind speed and direction, RH%, number of rainy, snowy, foggy, lightning days

- Ottoman records (3 climate books) cover the periods 1896-1901, 1901-1907, 1907-1914 (daily record): this includes wind speed and direction, Precipitation, Humidity, Temperature and Pressure daily data
- German records during the 1st World War were collected and published in "Zum Klima der Türkei" 1915-1918", (Weickmann, L.)
- Records from Kandilli Observatory (1926-1936)
- Turkish State Meteorological Service from 1937

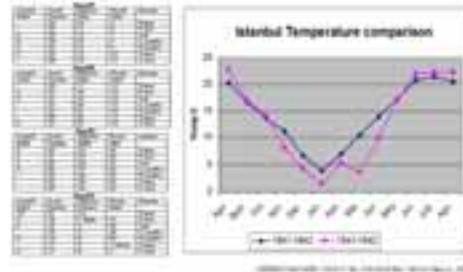


Figure 3: Istanbul Temperature 1841-42 vs. 1941-42, by Ceride-i Havadis



Figure 4: French records for Istanbul from 1868 to 1897

French records, Observatoire Impérial Météorologique de Constantinople from 1868 to 1897 (monthly – annual record). Recorded parameters are pressure, Tmax, Tmin, precipitation and daily max precipitation, wind speed and direction, RH%, number of rainy, snowy, foggy, and lightning days.

### Ottoman Records from 1896 to 1914

Three climate books for Istanbul for the periods 1896-1901, 1901-1907, 1907-1914 (daily record) can be found in the Turkish State Meteorological Service (TSMS) museum in Ankara. Recorded parameters are wind speed and direction, Precipitation, Humidity, Temperature and Pressure. These volumes are in the Ottoman language and need to be translated and then digitized



Figure 5: Historical records from the Ottoman Empire

### GERMAN RECORDS DURING THE 1ST WORLD WAR:

During the 1st World War, the Germans carried out meteorological observation from 1915 to 1918.



Figure 6: German records during the 1st World War

### CLIMATE CHANGE DETECTION, MONITORING AND INDICES STUDIES – RCLIMDEX:

After the reconstruction of past climate data, it will be possible to run RCLimDex software to produce climate indices which will show climatic trends from historic time to the present.



One study has undertaken for the Middle East and published by Zhang, X. B. et al. <http://www.aqu.org/pubs/crossref/2005/2005JD006181.shtml>



Authorities must be aware of them in order for them to be rescued and made available to serve the public benefit.

- 50 years of Ottoman Empire climate records (1868-1918) need to be translated and digitized. A project to digitize historical values must be established.
- Paleo sources also can give very important information about ancient climates and there is a need to compare them with the present.
- After the reconstruction of past climate data, it will be possible to run RClimDex software to generate climate indices and to detect climate change from historic times to the present.

#### ACKNOWLEDGEMENTS:

Thank you very much Dr. Manola Brunet from University Rovira i Virgili for the invitation to attend the International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin. I also appreciate that Dr. Buruhani Nyenzi and Dr. Omar Baddour from WMO have supported my participation.

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## II.5. Status, constraints and strategies for fostering DARE activities over the Balkan area

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#### ABSTRACT:

The objective of this study is to document data rescue (DARE) activities over the Balkan region, aimed at identifying and generalizing status, progress and obstacles for rescuing and digitizing climate data.

In order to get insights on the availability of the longer climate records and data rescue activities over the Balkan region, a questionnaire was sent to all national meteorological services in the Balkans. Based on this survey, the software and technical equipment for data entry and management have been identified. The present study gives information on the availability of digitized and non-digitized climate records in the region. The majority of the organizations that have answered to the survey showed, as the main problems related to DARE activities, insufficient financial resources and qualified staff, lack of technical equipment and specific software. Besides, they made clear the importance of establishing and fostering the exchange of information between institutions at national and international levels.

#### INTRODUCTION:

The analyses of long time-series enable a better understanding of the climate system, its changes and the impacts over the socio-ecosystem. In this regard, the rescuing of long climate records and especially their availability in digital format are crucial issues both for scientific and practical purposes.

The objective of this study is to describe data rescue (DARE) activities over the Balkan region, and its aim is to identify and generalize the status, progress and obstacles for rescuing and digitizing climate data.

#### METHODS - QUESTIONNAIRE:

In order to collect the necessary information a questionnaire was sent to all meteorological services in the Balkan countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, FYR Macedonia, Montenegro, Romania, Serbia and Turkey.

The questionnaire contains the following parts:

- G. General information
- H. Meteo data rescue activities
- I. Inventory of digitized data
- J. Inventory of not digitized data
- K. Assessment of meteorological archives and data availability
- L. Problems, constraints and recommendations

#### RESULTS:

The 80 % of the questionnaire was filled in. The organizations that have filled the questionnaire are as follows:

Albania - Hydrometeorological Institute,

Bosnia and Herzegovina - Federal Hydro Meteorological Institute B&H,

Bulgaria – National Institute of Meteorology and Hydrology,

FYR Macedonia - Hydrometeorological Service of Macedonia

Montenegro - Hydrometeorological Institute,

Romania - National Meteorological Administration,

Serbia - Republic Hydrometeorological Service of Serbia and

Turkey - Turkish State Meteorological Service

Despite of established contacts Meteorological services from Greece and Croatia did not send their answers.

Based on the national responses, the state of data rescue activities over the Balkan countries is here presented.

**A. General information**

Over the majority of the countries, instrumental measurements started during the 19<sup>th</sup> century (i.e. Romania, Albania – at the middle of the 19<sup>th</sup> century, Bosnia and Herzegovina, Bulgaria – at the end of 19<sup>th</sup> century), meanwhile for Turkey they officially started in 1927 and for FIR Macedonia – since 1947.

The type and number of stations, included in the meteorological network of the Balkan countries, is presented in figure 1. Rain gauge stations predominate in most of the countries, followed by climatic and synoptic stations. Besides, agrometeorological or phenological stations take part of this network, as well.

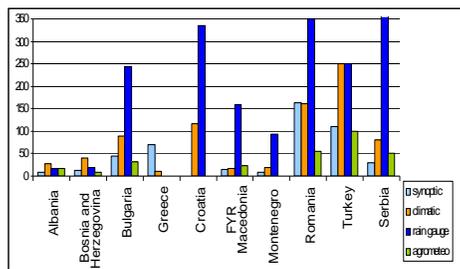


Figure 1: Type and number of stations, included in the Balkan meteorological network

**B. Meteorological data rescue activities**

During recent years meteorological data rescue activities in the Balkan countries are focused on digitizing both the information measured in the meteorological network and its associated metadata. With respect to the software used for data entry and data management, most of the organizations have listed Oracle, Clicom and CliData. Besides, MetDAS,

Integrated Meteorological System – MICROSTEP-MIS software and Informix are also used. The contact and discussions between institutions is necessary in order to define advantages and disadvantage of applying these software. Most of the Balkan countries (except Romania and Turkey) do not develop their own software for data base development. In regard of specific features of climate data, it is necessary to adapt existing software and to develop specific ones.

About 50% of countries that filled the questionnaire estimated available equipment for data rescue as good. However, for the 38% of the countries available equipment is poor.

Table 1 shows the status of data rescue strategies undertaken by the Balkan countries. Most of them have developed or are developing their strategies for data rescue. The activities are directed to archive the data on the computers and to develop digital data bases in order to enable an appropriate data treatment.

	Yes, we have developed strategy	Yes, we are developing strategy	No
Albania	X		
Bosnia and Herzegovina		"CLEAN" and "ORACLE" the 80% of historical archive is captured with digital camera, and archived on the computer	
Bulgaria	preservation of all climate data and corresponding metadata, and their transfer from paper records to digital form in order to be imported into relational database for easy access; scanning the documents from the files of the stations, creating digital image archive of all paper records, including the logs records from self-recording devices		
FYR Macedonia	Through software and proprietary equipment		
Montenegro			X
Romania		activities aiming at digitizing the data. A strategy at department level is under construction	
Serbia			X
Turkey	One has entry software generated with INFORMIX SQL, and all the climate data - digitized from 1926 to today		

Table 1: Data rescue strategies over the Balkan countries

**C. Inventory of digitized data**

Data digitization efforts are very important in order to facilitate data exchange and treatment. The 50% of

the countries that filled the questionnaire have more than 50 % of their data digitized (fig. 2). Only Turkey has more than 75% of the data digitized. Turkish State Meteorological Service pointed out all climate books with information from 1926 onwards are digitized.



Figure 2: Percentage of digitized meteorological data

With regard to the observational history (metadata) of the Balkans meteorological network, the situation among the Balkan countries is different. The leading position is for Turkey, with the 75 – 100 % of their metadata having been digitized. However, the 25 % of the countries have not digital metadata and another 25 % have up to only 25 % of the metadata digitized (fig. 3). As it is well-known, the information about metadata is very important for homogenizing time series and studying long-term climate variability and change.

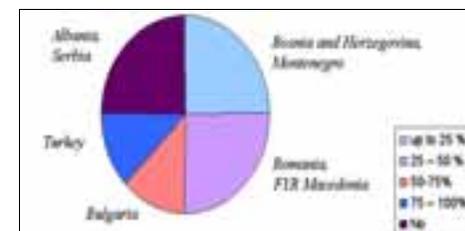


Figure 3: Station history (metadata) in digital format

All organizations said to have meteorological data in digital format from at least 1940-1950s onwards (Table 2). Bosnia and Herzegovina, Bulgaria and Romania have digitized time series since the end of

the 19<sup>th</sup> century onwards on a daily time resolution. For Turkey, the digitized time series are from 1926.

Country	Variable	Length of records	Time resolution of the records	Percentage estimated of year (1970-2000)
Albania	A.S. readable	1977 - present (1947-1967) - present (1967 - present, 1977 - present)	Daily	100%
Bosnia and Herzegovina	A.S. readable	1983-2007	Monthly, daily	no
	A.S. readable	1983-1987, 1993-1994, 1995-1996, 1997-2007	Monthly, daily	27 years
Bulgaria	A.S. readable	1983-1987, 1993-1994, 1995-1996, 1997-2007	Monthly, daily	19 years
	A.S. readable	1983-1987, 1993-1994, 1995-1996, 1997-2007	Monthly, daily	19 years
FYR Macedonia	A.S. readable	1983-1987, 1993-1994, 1995-1996, 1997-2007	Monthly, daily	19 years
	A.S. readable	1983-1987, 1993-1994, 1995-1996, 1997-2007	Monthly, daily	19 years
Romania	A.S. readable	1983-1987, 1993-1994, 1995-1996, 1997-2007	Monthly, daily	19 years
	A.S. readable	1983-1987, 1993-1994, 1995-1996, 1997-2007	Monthly, daily	19 years
Turkey	A.S. readable	1926 - present	Daily	100%
	A.S. readable	1926 - present	Daily	100%

Table 2: Inventory of digitized data – typical examples (according answers to the questionnaire)

**D. Inventory of non-digitized data**

It is important to have information about non-digitized data in order to estimate the work that has to be done for their rescue. The answers from Balkan countries about non-digitized data are very different and it is difficult to summarize them. The longest non-digitized records in most of the countries are precipitation or temperature, and the period to be digitized is about more than 60 years (Bulgaria, Bosnia and Herzegovina). Except these elements data for ice deposition; hail (Romania), pressure, relative humidity, wind speed and direction (Turkey), air pressure, humidity, wind speed and direction, cloudiness, visibility, snow cover depth, meteorological phenomena, sunshine duration, soil temperature, etc. (Bulgaria) are also available in non-digital format. The Balkan

meteorological services keep non-digitized data (paper format) in a special repository and fractions of the data are stored in museums (Turkey).

*E. Assessment of meteorological archives and data availability*

State of meteorological archives

The 75 % of the organizations that filled the questionnaire with respect to the rate of the state of their digital archives replied that they are in good state, meanwhile the 50% of the responses with respect to state of data kept in paper format are considered good, as well (fig. 4).

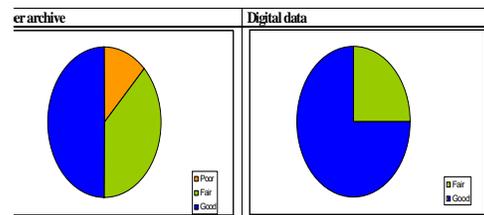


Figure 4: State of meteorological archives in Balkan countries according to the estimation of the Balkan Meteorological Services

Data availability

According to the answers of the questionnaire, the Balkan Meteorological Services provide free meteorological data for scientific purposes, and in some cases for governmental institutions. The data are also available upon payment for public and private organizations, insurance companies and other end-users.

It is another very important aspect to be addressed: the need of establishing a good working scheme for data exchange between meteorological and other institutions.

For some of the Balkan countries, there is a meteorological data base outside of meteorological services of the country. Meteorological data bases are also located at Synoptic Centre (under Ministry

of Defense – Albania), Government Statistical Department (FYR Macedonia), NOAA, Met-Office or IPCC (for Turkey). This cooperation between institutions is very important in order to ensure and foster research activities.

*F. Problems, constraints and recommendations*

Countries from the Balkan region point as the main constraints for data rescue activities to the following problems: insufficient financial resources (for 27 % of the organizations) and insufficient number of qualified staff (19%), as shown in figure 5. At the the third place, there are problems related to the lack of technical equipment (16%). For the 13% of the meteorological services the problem related to the lacking of specific software and compatible data from different measurements / organizations are outlined. Only 6% of the organizations point out that the system for information exchange between different institutions does not work well and 1% consider legislative problems.

As “other problems” the organizations point out to the following:

- some records are carried out by different institutions, and due to that it is difficult to have a complete archive;
- discrepancy of metadata;
- some records are in different languages and it is necessary to be translated and then digitized (the translation takes additional financial and human resources).

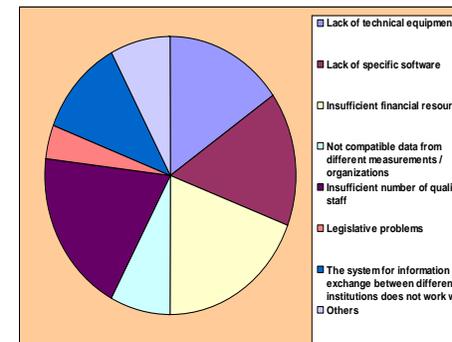


Figure 5: Constraints for data rescue activities in the Balkan region

CONCLUSION:

Recommendation for fostering data rescue activities:

The following recommendations can be made on the base of answers of the questionnaire:

- Better promotion of the importance of metadata would trigger more interest and funds for rescuing activities;
- Authorities should be aware of historical observations, and it must be allocated enough budget to translate and digitize them.
- All countries point out that training in data rescue activity is necessary.

Finally, it is necessary to establish a good-working scheme for fostering information exchange between institutions at national and international levels, in order to provide sufficient information for research on weather and climate.

ACKNOWLEDGEMENTS:

Author appreciates very much the questionnaire answering from experts and researchers from Meteorological services in Albania, Bosnia and

Herzegovina, Bulgaria, FYR Macedonia, Romania and Turkey.

## II.6. Why Data Rescue and Digitization (DR&D) Efforts need Non-Profit Organizations

Richard I. Crouthamel

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### INTRODUCTION:

Nearly all organizations involved with environmental data rescue and digitization (DR&R) are either government or educational organizations which depend on either federal revenue or grants to carry on their work. While universities have some experience with obtaining data rescue and digitization funding, nearly all these efforts must be linked to specific research projects that require input of historic environmental data. Few university grant funds are available for DR&R activity not related directly to specific research projects.

Likewise, government agencies are nearly always required to relate their need for DR & R to current operational or scientific needs, even when those data being rescued are paper, microfiche, microfilm or magnetic tape records produced by their own agency.

What many scientists from universities and most government researchers do not seem to understand is that they must actively and constantly “market” the DR & R need and process to their funding organizations instead of waiting for whatever funds are left over from “more important”, “more visible”, “more exciting” or “more politically expedient” activities.

### HONEST BROKERS:

In the U.S., non-profit organizations must undergo a lengthy and strict process to earn the classification of a “501(c)(3) non-profit organization” as defined by the U.S. Internal Revenue Service (IRS). Such non-profits are not permitted to “make a profit” with all revenues received offset by operational expenses. There are no “owners or stockholders”. Such non-profits are essentially “honest brokers” with no political or profit/commercial motive for their actions. As such, these organizations (like ours) are totally focused on the cited organizational goal. In IEDRO’s case, the goal is simply, locating, rescuing and digitizing all historic environmental data available

throughout the world and making those data openly and unrestrictedly available to the world’s scientific and educational community.

As a non-profit and non-governmental organization, we are in a particularly good position to be trusted concerning the data we are associated with which we help rescue and digitize. Being non-governmental, our search and subsequent rescue and digitization of historic data is not tied to any scientific or political point-of-view. There is little chance a non-governmental, non-profit entity will be accused of finding, rescuing and digitizing only those data that espouse a particular scientific theory or political strategy. We simply rescue data with no qualifications or reservations.

### MARKETING THE NEED:

As with all other organizations, we must have income to survive. Unlike most universities which receive funds from many sources such as tuition, taxes, grants, etc. and federal government agencies from tax revenue, we must “sell” the importance of what we do (DR&R) to individuals convincing them that our activities will do more to protect humanity than any other organization to which they could contribute their money. Thus we are perhaps more experienced in marketing the importance of what we do than the rest of the data rescue and digitization organizations.

### POTENTIAL TO PROVIDE NON-GOVERNMENTAL AND NON-UNIVERSITY FUNDING:

Since we exist outside of the government and university regimes, we are not restricted by sources of funds received from individuals and corporations to carry on our work. The only legal requirement is that no profit is made. Thus, we can solicit funds from the private sector business entities and individuals in ways not available to government and university DR&D efforts. By partnering with government and universities, we can use these

funds under our parochial control to assist in whatever DR&D projects are envisioned. Our ability to raise funds outside of government and universities can focus on:

- Non-profit foundation grants
- Corporate donations
- Individual donations
- Fund raising through EBAY, Internet sites
- Donations from fraternal organizations (Lions Clubs, Rotarians, Elks)

#### MARKETING:

As was previously stated, non-profits must “market” the need for their existence to funding sources. What many governmental and university entities do not realize is that “marketing” is a critical component of DR&D success. The most pervasive problem to obtaining funding for DR&D is the funding organization’s non-interest and apathy for what the DR&D community does.

#### PASSION VS. LOGIC:

The Passion...Data Rescue and Digitization is not as glamorous as a tidal wave 10 meters high wiping out 250,000 people in a few hours. The fact that such an occurrence is experienced once a century (as with the 2003 Indonesian Tsunami) does not preclude public and private donors from “investing” BILLIONS of dollars (or Euros) to set up a warning system that may give a limited warning to future potential victims. The threat, perceived by the donors, is real (they saw it with their own eyes), non-controversial (everyone wants to help those who are affected), non-political (all political parties are in favor of spending money to help people), and donors can view what they are getting for their money (the wind-up radios given to families; the sirens installed; the pamphlets given to every school child).

The Logic...Environmental Data Rescue and Digitization if given 10% of the billions given to establish the Pacific All Hazards Warning System as a result of the 2003 Indonesian Tsunami were provided to rescuing and digitizing historic weather records alone, 2,000,000 – 3,000,000 people on this planet could be saved every year, not 250,000 every hundred years.

#### MARKETING PROCESS:

All organizations whose goals are environmental data rescue and digitization must market to everyone, especially funders, the critical importance of DR&D to the health and well-being of all humanity. Heretofore, most DR&D entities relied on whatever funding was “left over” after more important “operational” or “project” needs were met. Many times the left over was zero and DR&D efforts ceased.

#### HOW DO YOU “MARKET” DR & D:

All organizations must clearly show the direct link between locating, rescuing and digitizing historic data and those critical human endeavors on which those digitized data have a positive effect on humanity.

What is lost on many organizations and their potential donors is that unlike other donor funded efforts, DR & D of specific environmental data (i.e. old weather records) have positive effects on more than one field of endeavour. For example, historic weather observations over the Rio Escondido River Basin in Nicaragua from 1958 to 1998 provide precipitation amounts which are critical input to baseline the computer models that provide guidance to hydrologists trying to forecast flood stages after heavy rains. Those same rescued and digitized observations provide statistically sound probabilities of the frequency of drought in Nicaragua so that farmers can plant more appropriate crops or know how much of their harvest they must save to get their

family through a year of drought and no crop yield. The wind speeds in those same historical observations are used by architects to safely design buildings and bridges to withstand anticipated high wind loads. Winds, temperatures and humidity measurements cited in those same rescued and digitized observations help health care officials determine to where the next outbreak of malaria will spread so that they can arrive in a threatened area with inoculations and spraying equipment before the disease arrives, saving hundreds of children and elderly. Those same observations allow meteorologists to add additional data to those historic severe weather events and reanalyze the hydrometeorological situation with much greater opportunities to understand what happened and why so that warnings in the future will be more accurate and timely.



Drought caused famine      Poorly designed structures

The benefit areas identified by IEDRO are:

- More accurate flood warnings
- Reduction in mal-nourishment and starvation
- Preventing the spread of disease
- Providing safer construction
- Providing better severe weather forecasts
- Assist in climate change and global warming studies

#### VOLUNTEERS:

In addition to marketing data rescue and digitization, one of the best attributes a non-profit organization has is its ability to attract and retain individuals who volunteer their time, knowledge and experience in assisting us to reach our DR&D goals. Many governmental and university organizations, contending with either policy or the rule of law or union agreements cannot accept volunteer workers. Non-profits depend on them. Also, with volunteers, an organization can seek the exact skill set and experience needed for the time period needed without running the risk of having to continue their “employment” beyond the task at hand. Universities and government offices usually do not have that luxury. Non-profits have the ability to provide volunteers to:

- Write articles for the media
- Volunteer to assist National Hydrometeorological Services with training
- Make presentations on the need for Data Rescue and Digitization
- Lobby government and university representatives
- Participate in television and radio programs
- Research “data in jeopardy” that need to be rescued and digitized

#### DATA IN JEOPARDY:

In addition to those data identified by government and university organizations and agencies, non-profit volunteers have their own personal and professional resources to locate data in jeopardy of being lost forever.



An example of direct non-profit volunteer support are 504,000 rescued and digitized surface hydrometeorological observations from an observation site in Punta Arenas, Chile at the southern tip less than 100 miles from the Antarctic Continent. These weather observations date back to 1874 and were meticulously taken by Jesuit priests at a small school. The regional museum in Punta Arenas has preserved these original paper-based observations. Previously the earliest surface data for the area in custody of the National Meteorological Service of Chile dated only back to 1966. The museum preferred not to allow any government agency (either in Chile or the U.S.) to rescue “their” data fearing it would be sold instead of provided openly and unrestrictedly to the world community. The museum agreed to the non-political, non-profit IEDRO completing the DR&D to everyone’s benefit.

#### SUMMARY:

Non-profit, non-governmental organizations are distinct assets to all data rescue and digitization efforts, providing services, funding and volunteers to assist government and universities. They should be used, encouraged and invited to participate in all DR&D programs, projects, meetings and conferences.

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## SECTION III: REVIEWING NATIONAL MEDITERRANEAN DARE PROJECTS

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### III.1. Early stages of the recovery of Portuguese historical meteorological data

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#### ABSTRACT:

Here we present the first results achieved with the project SIGN (Signatures of environmental change in the observations of the Geophysical Institutes). The project's main goal is to convert into a digital database the historical meteorological data, recorded since 1856 until 1940 in several annales published by the 3 Portuguese Geophysical Institutes (of Lisbon, Porto and Coimbra) and the Portuguese Meteorology Institute. The different sets of historical data contain monthly, daily and sometimes hourly records of pressure, temperature, precipitation, humidity, wind speed and direction, cloud cover, evaporation and ozone. The published data cover several stations in mainland Portugal, the Azores and Madeira islands and in former Portuguese African and Asian colonies. The main objective is to use the data to study the changes that have taken place in the historical records during the last 150 years, when the recovered data is merged with the post-1941 data stored in the Meteorology Institute digital database. The other aim is to make the data available to the meteorology community at large. Direct observations of pressure data for Lisbon in the 1856-1940 period were prioritised and have been manually digitised, being later subjected to quality control tests. Digital historical records of Lisbon temperature, relative humidity and precipitation data have been obtained through corrected OCR techniques applied to published hourly or bi-hourly tables. Preliminary digital results are also available for several stations in mainland Portugal, Azores and Madeira. Data for the Escola Médico-Cirúrgica station in Porto during the 1861-1898 period are already in digital format. All datasets are subjected to an initial quality control test, to detect wrong values, with more comprehensive tests to be applied at later stages.

At the same time, detailed metadata files are being compiled for each station. This work will show the preliminary analysis results for the digital historical database obtained so far.

#### INTRODUCTION:

The 3 Portuguese Geophysical Institutes of Lisbon, Porto and Coimbra possess the oldest meteorological time series in the country, most of them having been published yearly in Annales. The Lisbon Meteorological Observatory (current Lisbon Geophysical Institute) worked as the first Meteorological Office in the country and initiated the publication of its Annales in 1856. The Coimbra Annales were first published in 1864, whereas the Porto publications started in 1861 for the Escola Médico Cirúrgica station, later replaced by the Serra do Pilar station, the current Porto Geophysical Institute station. These publications contain detailed sets of daily, sub-daily, monthly and annual data that are now starting to be digitised by project SIGN. There are also some datasets which are still in handwritten records and that have not been published in the Annales. These are essentially in possession of the Porto Geophysical Institute for the 1888-1905 period and of the current Portuguese Meteorological Institute, created after 1946, and which is the repository of many non-catalogued sets of handwritten data starting around 1905 corresponding to stations spread all over Portugal. The SIGN project also intends to digitise the maximum of these datasets as possible. As the Portuguese Met. Office has already digitised most of the stations data after 1941, Project SIGN aims to digitise the data prior to this date and join the two datasets. From 1864 to 1946 the Lisbon Annales contain a vast set of meteorological data from stations of mainland Portugal, the Isles of Azores and Madeira and of former Portuguese colonies. In the library of the Lisbon Geophysical Institute is also

a collection of Annales from the Portuguese Ministry of Colonies, which contains daily, sub-daily and monthly data for many stations of Angola, Mozambique, Guinea-Bissau, Cape Vert, East Timor, São Tomé, Goa (India) and Macau for the 1910-1946 period. In this project we intend to recover as many data as possible from these collections, by defining priority stations with long time series.

#### DIGITAL RECOVERY PROCESS:

The meteorological data contained in the Lisbon Geophysical Institute Annales are presented in a vast number of printed tables from 1856 to 1999. The data for 1856-1940 are being digitised using two distinct processes: manual typing and corrected OCR techniques. First, to preserve the Lisbon historical Annales, all their pages are being transformed into digital images (TIFF files), using a scanner, with a resolution of 300dpi. This work is being performed by a hired company, SCN – Sistemas. We have nevertheless opted to manually type the first volume of the Annales (1856-1863), containing mainly monthly data for the Lisbon station, since the tables in this volume are of many varied types, which are not repeated in the following years. The volumes from 1864 to 1940 are essentially being digitised using corrected OCR techniques, applied to the scanned tables in the TIFF files. This part of the work is being performed both at the Lisbon Geophysical Institute, using the Fine Reader ABBYY OCR software, and by the hired company (SCN – Sistemas), with the OmniPage OCR software.

To simplify the digitisation process, model table frames were produced separately in Excel, corresponding to the monthly tables that have the 1864-1940 daily or monthly data for Lisbon and other posts. For some meteorological variables, like pressure, temperature, relative humidity and wind direction and speed, the Lisbon data are printed on an hourly or bi-hourly basis. Other meteorological

fields have daily values. For several other posts, data is given at specific hours (9a.m., 12p.m., 3 p.m. or 9 p.m.) for ten-day averages (1864-1873, 1888-1905) or daily (1874-1887, 1906-1940).

The OCR software was applied to the changeable part of each table and saved in the Excel format. The resulting Excel files were then copied and pasted to the model Excel tables. However, the direct OCR process produces many errors that need to be corrected. Fortunately the printed daily tables contained also ten-day and monthly averages, which were then used to check and, eventually, correct the tables.

The following step was to save every corrected Excel table as an ASCII file (format TXT). These files can then be used as input in FORTRAN programs that merge the consecutive years and produce long time series. With these programs it is also possible to check the obtained time series and to apply several additional tests to the data. At this stage we have already obtained monthly and daily digital historical records of Lisbon pressure, temperature, relative humidity, precipitation, wind direction and speed, cloud cover, evaporation, and ozone data for the 1864-1875 period. We also have digitised all the data corresponding to the other posts in mainland Portugal, Isles and former colonial territories from 1864 to 1875.

We have nevertheless chosen to manually type the direct observations of pressure for Lisbon for the 1864-1940 period, in order to accelerate the compilation of this important variable and participate in the International Pressure Databank, the 20<sup>th</sup> century reanalysis supported by GCOS/AOPC/OOPC Surface Pressure Working Group (SPWG) and ACRE project, a task already accomplished.

#### LISBON GEOPHYSICAL INSTITUTE:

##### Period 1856-1863

For the 1856-1863 period, only maximum, minimum and daily average temperatures for Lisbon were printed in the Annales. The daily temperature series already digitised in this project are shown in Fig. 1. The other variables were stored only on a monthly average basis. As mentioned before, all the data in this period were manually digitised into Excel tables and submitted to preliminary control tests.

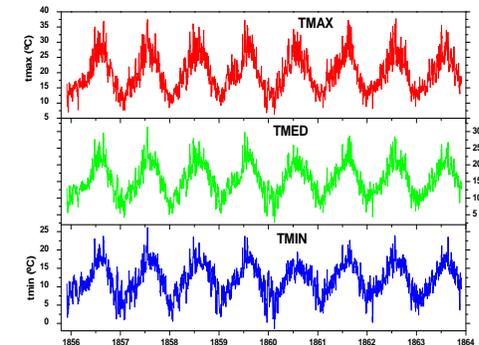


Figure 1: Daily maximum (*tmax*), average (*tmed*) and minimum (*tmin*) temperatures in the Lisbon Geophysical Institute from December 1855 to November 1863. The average daily temperature is obtained from the 9 a.m., 9 p.m., *tmax* and *tmin* temperatures.

Figs. 2 and 3 present the monthly surface pressure at level station, and the monthly accumulated precipitation and evaporation for this early period of historical data.

Other meteorological variables at 4 observation times that have already been digitised for the 1856-1963 period include temperature, relative humidity, wind speed, ozone and cloud cover, all printed in the Annales on a monthly basis.

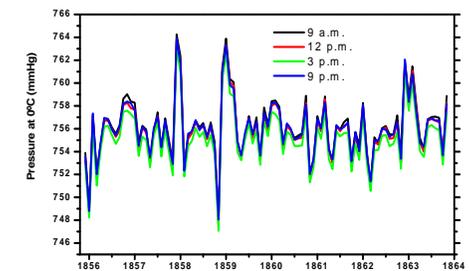


Figure 2: Monthly station level pressure observations in the Lisbon Geophysical Institute from December 1855 to November 1863, at 4 observation times. The pressure is corrected for 0°C, but doesn't include the gravity correction.

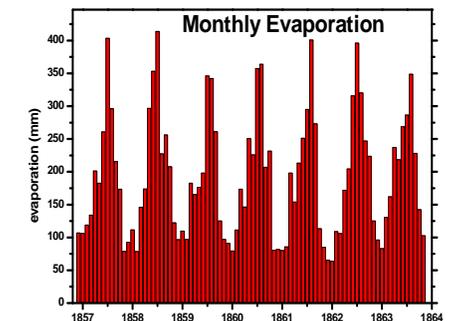
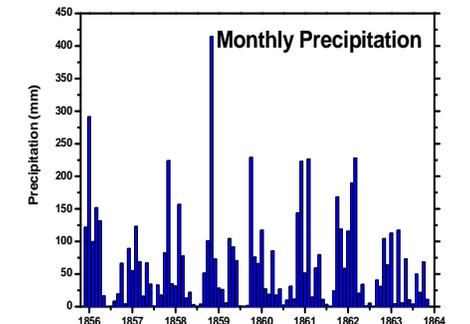


Figure 3: Monthly accumulated precipitation (top) and evaporation (bottom) observed in the Lisbon Geophysical Institute from December 1855 to November 1863.

Period 1864-1940

For the following period (1864-1940), the Annales published Lisbon daily data on hourly (1864-5, 1918-1940) or bi-hourly (1866-1917) tables with pressure, temperature, relative humidity and wind direction and speed. These were obtained with continuous registration meteorological instruments, and the continuous records were corrected by the direct observations performed 4 or 5 times per day. Cloud cover was also observed and registered at these times. Ozone was observed 2 times per day. Ozone cards were changed at 9 a.m. and 9 p.m. every day, giving measurements for the daytime and night time periods. Precipitation, evaporation, grass temperature, radiation temperatures and ground depth temperatures were evaluated once per day.

The SIGN project has already digitised the Lisbon daily data for the 1864-1875 period with corrected OCR techniques. Fig. 4 shows the daily temperature at 9 a.m., 12 p.m., 3 p.m. and 9 p.m. that resulted from direct observations and that has already been digitised. The 12 p.m. series is unfortunately cut short in November 1865, because it stopped being published, as the tables switched from hourly to bi-hourly (data every 2 hours).

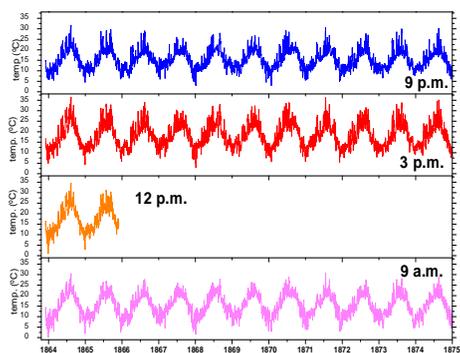


Figure 4: Daily temperature observations in the Lisbon Geophysical Institute from December 1863 to December 1875, at 4 observation times

Fig. 5 presents the monthly distribution of wind direction for the same period. This graphic was obtained from the direction distributions printed every 2 hours in the Annales. The YY axis in the figure represents the number of observations per month. The wind was distributed by 16 directions plus the calm (C) and variable direction (V) categories, as indicated in the figure. Fig. 5 a predominant Northern quadrant direction for the wind in Lisbon is shown.

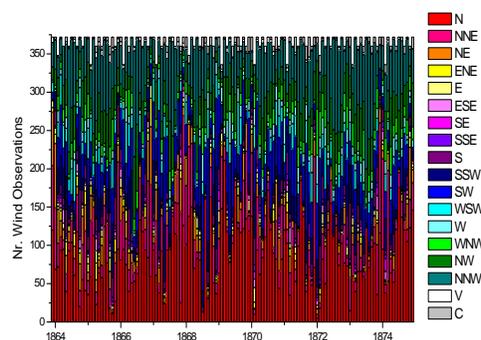


Figure 5: Monthly distribution of wind direction observed in the Lisbon Geophysical Institute from December 1863 to December 1875.

We show here another 3 meteorological fields that have already been digitised for the 1864-1875 period, cloud cover (Fig. 6) and maximum and minimum grass temperatures (Fig. 7).

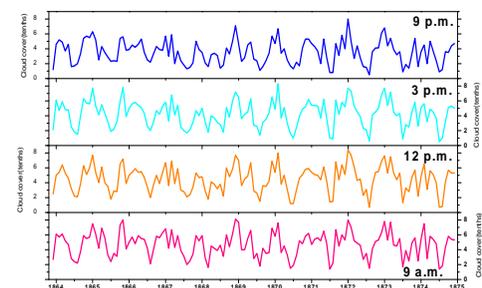


Figure 6: Monthly cloud cover, obtained from daily observations in the Lisbon Geophysical Institute from

December 1863 to December 1875, at 4 observation times.

For cloud cover we chose to represent the monthly averages, although daily values have been published in the Annales. Grass temperatures are plotted on a daily basis.

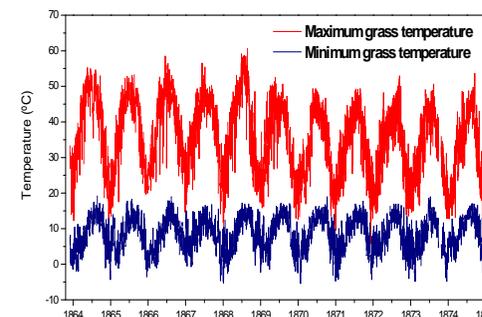


Figure 7: Daily maximum and minimum grass temperature observations in the Lisbon Geophysical Institute from December 1863 to December 1875.

Fig. 7 visually suggests a negative trend in the maximum grass temperature series for this period, but this could be due the existence of heterogeneities in the series. Although preliminary error detection tests have been applied to all data digitised so far, homogeneity test still have to be performed and are one of our priorities in the forthcoming work for this project.

Daily pressure data (1864-2006)

The complete series of Lisbon station level pressure resulting from direct observations were obtained by manually typing the 1864-1940 observations and joining these with the (already digitised) 1941-2006 values supplied by the Portuguese Meteorological Office. From the 5 daily series obtained, corresponding to the 9 a.m., 12 p.m., 3 p.m., 6 p.m. and 9 p.m. observation times, we show here the 9 a.m., 3 p.m. and 9 p.m. series in Fig. 8. The 9 p.m. series is not complete, because observations at this time were not performed during some years.

From 1864 to 1937, pressure values were read and published in mmHg, whereas from 1938 onwards, the publication was in mb or hPa. Nevertheless, reading in hPa only started in Lisbon on the 15 December 1993. For Fig. 8 we converted all the values to hPa and have taken away the gravity correction, which had been applied intermittently after 1938. Metadata information for the Lisbon pressure published in the Annales refers that in 1895 there is a jump of +0.25 mmHg. A previous study by Ferreira e Antunes (2000) for the Lisbon 1970-1994 series has also detected a jump of -1.14 hPa on the 15 December 1993. Both these jumps were due to changes in the barometer used. We have also concluded from the Annales metadata that observations changed from local time (-37min) to GMT in 1947.

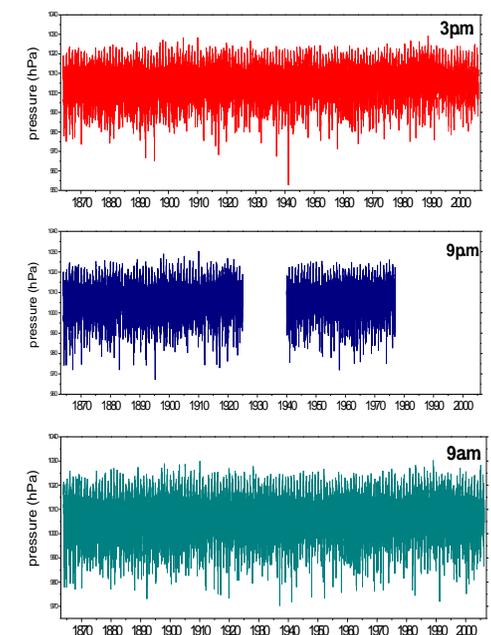


Figure 8: Daily station level pressure observations in the Lisbon Geophysical Institute from December 1863 to March 2006, at 3 observation times

(pressure corrected for 0°C, gravity correction is not included).

The Lisbon pressure series are to be submitted in the near future to homogeneity tests, such as the SNHT (Alexandersson, 1986) and others. These pressure series have already been sent to the GCOS/AOPC/OOPC SPWG of WMO that is producing a tropospheric reanalysis for the early 20<sup>th</sup> Century. The Lisbon surface pressure data has also been sent to the ACRE (*Atmospheric Circulation Reconstructions over Europe: European Mean Sea Level Pressure series back into the 18th Century*) project.

**OTHER METEOROLOGICAL STATIONS:**

Preliminary digital results are also available for several stations in mainland Portugal, and in the islands of the Azores, Madeira, Cape Vert and São Tomé. For the 1864-1873 period, decadal (10 days averages) and monthly data were essentially manually typed and for the 1874-1875 period the daily data was treated with OCR software.

The Coimbra daily data for 1864-1940, which has been published separately in the Coimbra Annales is being dealt with by the Coimbra Geophysical Institute. For the two Porto meteorological stations, daily data of the Escola Médico-Cirúrgica in the 1861-1898 period was previously digitised using manual typing by the Porto Geophysical Institute and was analysed in this work. The data was subjected to preliminary tests, and some gross errors have been corrected. Other more refined tests are being applied to detect more typing mistakes and errors. Fig. 9 shows the station level pressure and maximum and minimum temperatures for this historical station. Other fields available for the Escola Médico-Cirúrgica station are relative humidity, wind direction and speed, ozone, cloud cover and precipitation. Pressure values for this station at 9 a.m., 12 p.m. and 3 p.m. have been sent to the ACRE project.

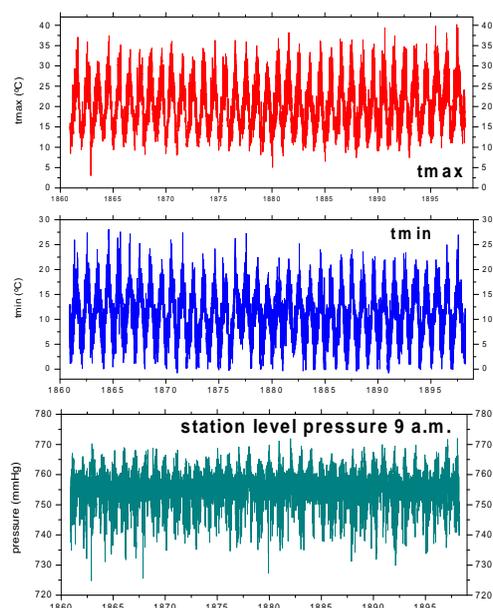
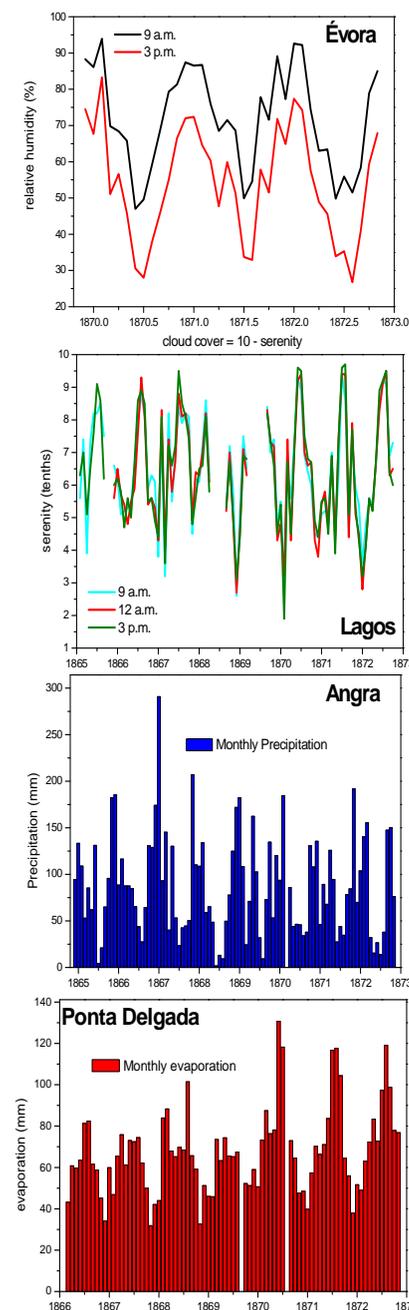
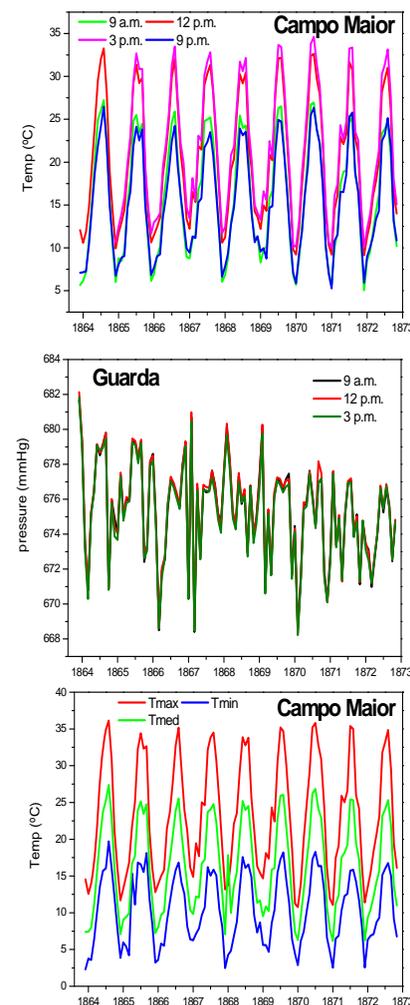


Figure 9: Daily station level pressure (at 9 a.m. GMT) and maximum and minimum temperature observations in the Porto Escola Médico-Cirúrgica station December 1860 to March 1898 (pressure corrected for 0°C).

Meanwhile, the Porto Serra do Pilar station daily data for the 1888-1940 period is currently being digitised by the Porto Geophysical Institute, under the supervision of project SIGN. The Serra do Pilar station is still operational at the present time and has one of the longest meteorological series in Portugal, together with the Lisbon and Coimbra Geophysical Institutes stations.

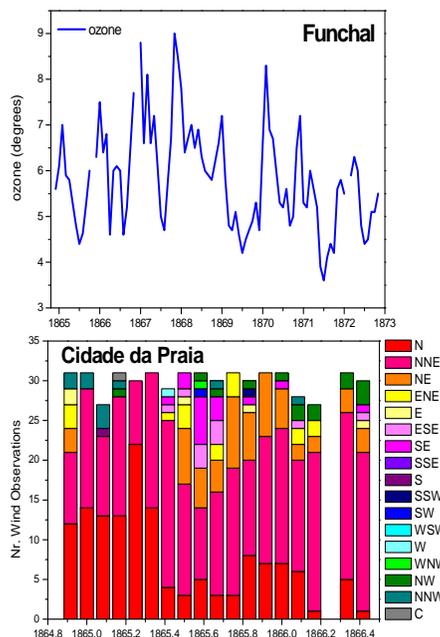
Other priority stations currently being digitised are: Moncorvo, Montalegre, Guarda, Serra da Estrela, Campo Maior, Évora, Faro, Lagos and Sagres in mainland Portugal, Angra do Heroísmo and Ponta Delgada in the Azores, Funchal in Madeira, Cidade da Praia in Cape Vert, Luanda in Angola and São Tomé. For the 1864-1873 period, where only decadal and monthly average observations were published, we selected the range of stations and meteorological fields presented in Fig. 10. The daily

data for the 1874-1875 period for these stations (not shown here) have already been digitised in Excel tables.



## III.2. An overview of the problematic of long climatic series at the national data bank of INM (Spain)

José A. López Díaz  
Head of the Basic Climatology Area at INM



*Figure 10: Monthly average values of station level pressure, temperature, relative humidity, serenity (cloud cover=10-serenity), precipitation, evaporation, ozone and wind direction distribution for the Guarda, Campo Maior, Évora, Lagos, Angra (Azores), Ponta Delgada (Azores), Funchal (Madeira) and Cidade da Praia (Cape Vert) stations, for the December 1864 to November 1873 period.*

### FINAL REMARKS:

All the data digitised so far through manual typing and corrected OCR has been subjected to preliminary tests to correct errors resulting from the process or some errors included in the Annales.

Currently digital images (TIFF files) of the Lisbon Annales are already available for the 1856-1912 period.

The Lisbon Geophysical Institute possesses the former Portuguese Ministry of Colonies Annales for the 1910-1946 period, which are also being

considered for digitisation, at a later stage. Tables with the stations included in these Annales have already been produced.

As future work, we plan to proceed with the digitisation process until 1940 and merge the pre-1941 digitised data with the post-1941 sets stored in the Meteorology Institute digital database. We also intend to continue to apply error detecting tests and, if possible, correct the errors. It is our main priority to apply homogeneity test to all series of digitised data and, if possible, correct the heterogeneities.

As stated in the beginning, one of the main goals of project SIGN is to use the long historical data series to study the changes that have taken place during the last 150 years, particularly those related with extremes. In this topic, we plan to adapt a synoptic weather type (WT) classification scheme for Portugal (Trigo and Dacamara, 2000) to recently available daily SLP fields reconstructed for Europe since 1850 (Ansell et al., 2006). This daily WT classification will be useful to evaluate climatic trends and extremes of precipitation and temperature over Portugal between 1850 and the present time.

Finally, one of our main tasks is to make the digital data available to the scientific community at large, by constructing a website for project SIGN with download links to the material obtained in the project.

### ACKNOWLEDGEMENTS:

This work has been supported by the Portuguese institution Fundação para a Ciência e Tecnologia, through project SIGN (contract ref. POCTI/CTA/47803/2002).

### ABSTRACT:

Here there is described the longest Spanish temperature and precipitation records available in the National Data Bank at the Agencia Española de Meteorología (AEMET: Spanish Meteorological Office). It is assessed both the length of records and the fraction of missing data. Besides, it is briefly discussed the potential for data rescue as part from the sources hold at the AEMET Library and the undergoing data rescue activities

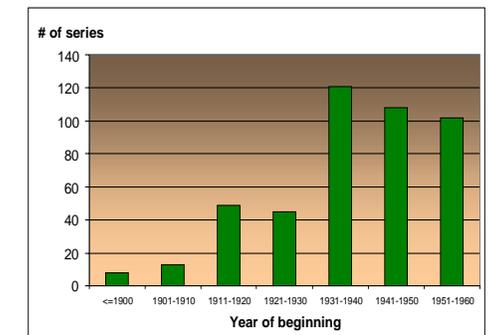
### INVENTORY OF LONG DATA SERIES IN THE NATIONAL DATA BANK (NDB) AT AEMET:

The problem of inventorying the long climate data series stored in the NDB is not so easy as it could seem at first sight due mainly to the fact that over the years it has been rather usual for stations to suffer changes in location that have impacted their long series and entailed changes of climatological station code in the database. In other quite numerous cases, we find more than one station in relative proximity operating at the same time, and one or the other of these may fail for a period of time, which also complicates things.

Since we did not want to have to go through all this complication operating on a case by case basis, we devised a procedure for making an inventory in an approximate way by taking advantage of the fact that, as a rule, the change in the climatological station code has proceeded in the past following a rule. This rule is that new station codes for new station locations in the proximity of a given station (for instance in the same city) share the root (made up of 4 characters) with the "mother" station. We have then considered the different stations codes with the same root as belonging to the same long series.

### LONG TEMPERATURE SERIES:

Figure 1 is a histogram showing the number of long daily temperature series stratified according to the year of beginning. We see an increasing trend up to the 1930 decade, which is the one with more starting series. Note also the jump in number of series before and after this decade, which includes the Spanish Civil War. The new government after the war impelled the creation of new observation sites. Note also that since that "optimum" decade the number of new series falls smoothly until the last decade included.



*Figure 1: Histogram of long daily temperature series according to the year of beginning*

On Figure 2, is shown the longer temperature series according to the number of missing data. This figure is only an approximation since we did not compute exactly the daily missing data but estimated this on the basis of the monthly records. We see that there is an important share of the total number of series with more than 20% missing daily data, what is certainly not satisfactory for many purposes.

When both the aforementioned criteria, i.e. starting year and percentage of missing data, are combined we get fig. 3. This shows a complex picture: for series beginning earlier than 1910 the number with less than 5% missing data and more than 5% missing data are roughly the same, though slightly

more the former; the years 1911-1930 gave birth to series with a great predominance of more than 5% missing data, and finally the years 1931-1960 show a return to approximate equilibrium between the less than 5% and more than 5% missing data, though with more of the latter. One factor that explains the abrupt improvement after 1930 is undoubtedly the Spanish Civil War which caused a lot of missing data. And one may conjecture a sort of Darwinian survival of the fittest hypothesis to explain the better behaviour of the oldest (before 1910) series, as well as the fact that the three years of the war get more diluted on their impact over the percentage of missing data as the series get longer. More detailed numbers are given in table 1.

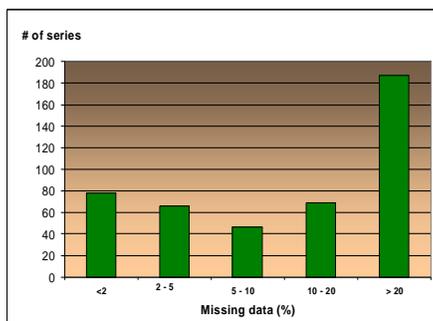


Figure 2: Histogram of long daily temperature series according to percentage of missing data.

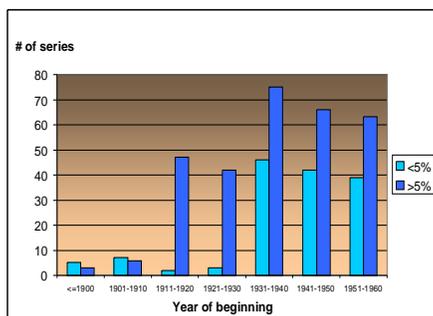


Figure 3: Histogram of long daily temperature series classified according to both year of beginning and percentage of missing data.

Daily temperature						
# of series with rate of missing data (%)						
Start. year	<2	2-5	5-10	10-20	>20	# of series
<=1900	2	3	2	1	0	8
1901-1910	5	2	2	3	1	13
1911-1920	1	1	3	8	36	49
1921-1930	2	1	6	6	30	45
1931-1940	22	24	14	19	42	121
1941-1950	22	20	11	9	46	108
1951-1960	24	15	8	23	32	102
Sums	78	66	46	69	187	446

Table 1: Statistics for daily temperature series

Table 2 contains the numbers for the double classification of monthly temperature series according to the two criteria used for daily series, namely starting year of the series and percentage of missing data. There are more series with monthly than with daily data, as one would expect, and this difference is especially significant in the longest series, those beginning earlier than 1900: 8 with daily data against 38 with monthly data. This points to an important potential for daily data rescue in the NDB.

Monthly temperature						
# of series with rate of missing data (%)						
Start. year	<2	2-5	5-10	10-20	>20	# of series
<=1900	14	6	5	4	9	38
1901-1910	7	1	2	1	1	12
1911-1920	5	1	6	8	37	57
1921-1930	2	1	4	7	29	43
1931-1940	12	24	12	20	43	111
1941-1950	25	17	9	10	43	104
1951-1960	27	16	17	32	50	142
Sums	92	66	55	82	212	507

Table 2: Statistics for monthly temperature series

**LONG PRECIPITATION DATA SERIES:**

The same type of inventory has been done with the long precipitation series. The results are shown in figs. 4, 5 and 6. Note that the scale in the y axis is changed, since there are roughly three times more precipitation series than temperature series. Fig. 4

shows that the precipitation series peak, as regards their starting year, in the 1940 decade, a bit later than the temperature series. In fig. 6 we see that again the Spanish War leaves a very noticeable footprint in the percentage of missing precipitation data, with the pre-war decades suffering the most in terms of percentage of missing data.

Form tables 3 and 4 we gather that again it is in the longest series where the difference between monthly and daily data is more acute, and in fact we have at the moment 8 daily precipitation series starting before 1900, compared to 40 with monthly data

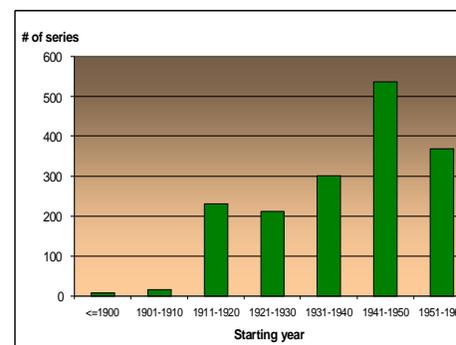


Figure 4: Histogram of long daily precipitation series according to year of beginning

Daily precipitation						
# of series with rate of missing data (%)						
Start. year	<2	2-5	5-10	10-20	>20	# of series
<=1900	0	6	1	1	0	8
1901-1910	7	2	2	1	4	16
1911-1920	4	9	19	34	166	231
1921-1930	4	11	20	29	148	212
1931-1940	30	37	47	58	129	301
1941-1950	106	82	73	109	167	536
1951-1960	92	72	51	52	102	369
Sums	242	219	213	284	715	1673

Table 3: Statistics for daily precipitation series

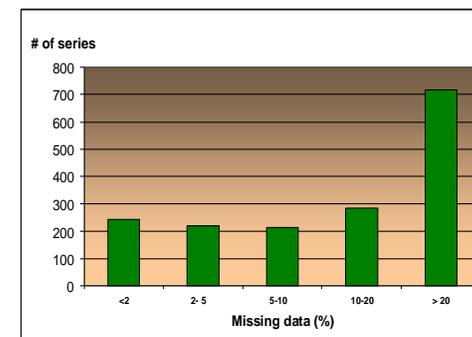


Figure 5: Histogram of long daily precipitation series according to percentage of missing data.

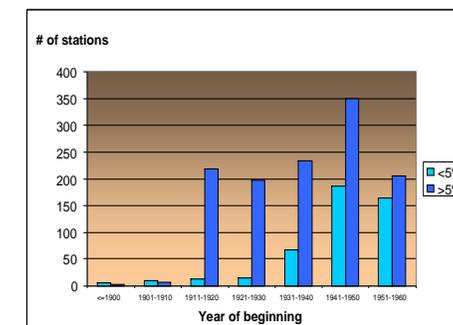


Figure 6: Histogram of long daily precipitation series classified according to both year of beginning and percentage of missing data.

Monthly precipitation						
# of series with rate of missing data (%)						
Starting year	<2	2-5	5-10	10-20	>20	# of series
<=1900	15	5	7	8	5	40
1901-1910	6	6	5	1	3	21
1911-1920	15	12	25	38	154	244
1921-1930	7	13	19	29	141	209
1931-1940	37	31	41	58	120	287
1941-1950	134	79	69	102	144	528
1951-1960	156	97	100	128	159	640
Sums	370	243	266	364	726	1969

Table 4: Statistics for monthly precipitation series

### METADATA:

Recently there has been a clear growth in the interest in and demand for metadata by the users of climatological data. The capture and storage of metadata have been greatly simplified by the development of specific input screens for metadata in the NDB of INM with Oracle system. An example of these is shown in fig. 7.

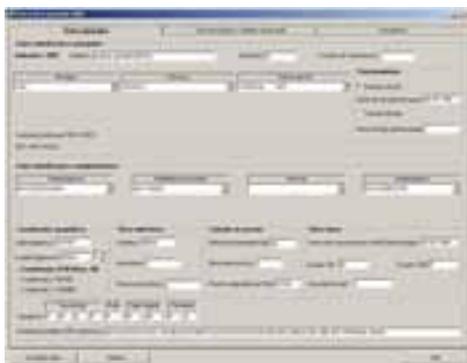


Figure 7: First input screen for metadata at the NDB, with general data (expanded here), type of station and climate variables, and instrumentation.

Currently we are making efforts to recover old metadata, with an emphasis on the changes of location of stations, which produce new station codes. There is a need for the improvement of coordination between the different units at INM sharing responsibilities in metadata management.

A new very important challenge is the automatization of the climatological network with the related issues of homogeneity which make very clear the need of overlap between manual and automatic stations for a period of at least two years when a long series is involved.

### RECENT INITIATIVES IN THE DATA RESCUE FIELD:

There is a variety of types of old climatological books in the archives of INM that contain data, both daily and monthly, that could potentially be digitised. We

have carried out recently a fairly systematic research in the Madrid INM archive, classifying this information and collating it with the information in the NDB in order to assess the potential for digitation of old data. In particular we have found daily data from 24 stations in annual books starting in 1894 and ending in 1944 that are not at the moment in our data base over this whole period. So we will start a process of digitation of the missing years.

The activity in the field of generating long homogeneous series at INM has received recently an important boost in connection with a project launched by the Spanish Environment Ministry to generate climate change regional scenarios. Within this project there is a part devoted to climate data which includes the generation of long temperature and precipitation homogeneous series. This part will be coordinated by University Rovira i Virgili, and the Climatology Area of the INM will be one of the partners.

## III.3. THE SNOW AND MOUNTAIN RESEARCH CENTRE OF ANDORRA (CENMA): OVERVIEW OF THE ANDORRAN METEOROLOGICAL RECORDS

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### ABSTRACT:

Since the beginning of 2007 a new research centre on natural sciences is running in the Principality of Andorra. In this new centre, part of the IEA (Andorran Research Institute) and called CENMA (Snow and Mountain Research Centre of Andorra), the research on climatology and meteorology is also considered, specially since the natural hazards point of view. A new AWS network, a filtered database and a mesoscale meteorological model adapted to Andorra are being implemented. The knowledge about the observations that exist or have existed in Andorra, and the location of the original data is being investigated. Afterwards, the inclusion in the new database of the historical data recovered is planned. Nowadays, the CENMA is in touch with the Catalan Meteorological Service for obtaining the information related to the weather stations existing in Andorra before the Spanish Civil War which were property of this regional meteorological service. On the other hand, the recovery and homogenisation of the long series of Andorra, with observations since 1934, is being carried out during this spring. In the next future, temperature, precipitation, and snow height filtered data at 1100 and 1600 m. will be able for the MEDARE community.

### THE SNOW AND MOUNTAIN RESEARCH CENTRE OF ANDORRA (CENMA):

On January 2007, the government of Andorra created a new research center related to the IEA (Andorran Research Center) for the study of the physical sciences over this country. It was the beginning of the CENMA (Snow and Mountain research center of Andorra), and one of the main topics considered to work in is mountain climatology.

One of the first actions was the design of a new meteorological network. Currently (February 2008),

one station is in operation (Figure 1), and next summer the installation of a network of automatic weather stations (AWS) will be completed (Figure 2). The current AWS include temperature, precipitation, snow height, wind force and direction, solar radiation, snow temperature and pressure observations. All these measures follow the WMO operational recommendations. The data, received via GSM at our centre in Sant Julià de Lòria will be validated using a semi-automated process.



Figure 1: Aixàs, the first automatic weather station of the CENMA network. This AWS is functioning since November 2007

On the other hand, historical meteorological data of Andorra is also another CENMA target, and in this regard we will recover, complete and homogenize the existing series.

### HISTORICAL DATA IN ANDORRA:

#### Data since 1934:

In 1927, an ambitious and important project began in the Principality of Andorra: the construction of the infrastructure to ensure electrical power supply to the Andorran population, which was finished in seven years. It was in 1934 when three observations sites were created (figure 2). One of them was located at 1100m (Central) and two at 1600 m (Ransol, and Engolasters). Since their installation, these weather

### III.4. Identification and digitization of instrumental climate data from Catalan documentary sources

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stations have been property of FHASA, the Andorran Hydroelectric Company, nowadays called FEDA.

The variables observed once a day (8 hour local time) are precipitation, maximum and minimum temperature, and snow depth. Apparently the series are continuous for the 3 weather stations and without location changes. Despite of that, during the next months we are going to work with the original data to identify erroneous values and generate detailed metadata for each of the three weather stations.

In addition, in the Andorran archives we have localized weather observations between 1955 and 1982 over another location of the country (Ansalonga). In the next future, it will be also digitised and corrected.

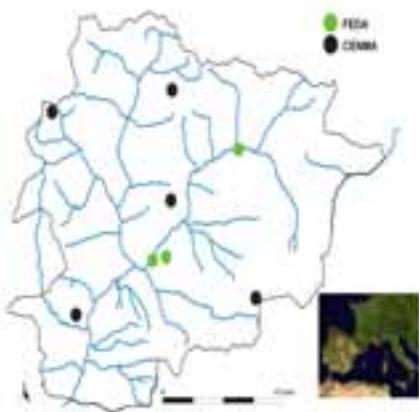


Figure 2: Geographical location of Andorra and spatial distribution of the CENMA and FEDA weather stations.

#### Data previous to 1934

Thanks to the Catalan Meteorological Service, we have information on weather observations over Andorra previous to the ones related to FHASA/FEDA. In table 1 it can be observed that the oldest records began at 1896. Unfortunately, even if all these data were considered, the period until 1934 couldn't be complete covered.

Weather Station	Observer	Variable observed	Period
Ordino	M. Ubach	Temperature / Precipitation	1928-1951
les Escaldes	A. Areny	Temperature / Precipitation	1926-1951
Soldeu	J. Borrell	Temperature / Precipitation	1928-1935
Sant Julià de Lòria	A. Bou	Precipitation	1926-1952
Anyós	Ll. Moliné	Precipitation	1909-1917
Andorra la Vella	A. Dellarés	Precipitation	1896-1900
Andorra la Vella	Riegos y Fuerzas del Ebro	Precipitation	1913-1914

Table 1: List of located observations over Andorra previous to 1934 (Authors: Marc Prohom and the Catalan Meteorological Service).

#### CONCLUSIONS AND NEXT FUTURE WORK:

The Principality of Andorra, a mountainous country over the Pyrenees, has continuous weather observations since 1934 in three sites. These data cover altitudes from 1100 to 1650m, without any gap in the temperature, rainfall and snow depth series. These data could be a valuable contribution to the MEDARE community to obtain climatic results over a mountainous region.

During 2008 all the data of FEDA will be corrected and homogenized thanks to the consult of the original manuscripts. Complementary, detailed metadata is also in course of being finished. At the moment Andorra is in touch with the Action COST ES0601. The main objective is to apply the more advanced methodologies of correction and homogenisation of meteorological data to the Andorran series.

#### ACKNOWLEDGMENTS:

To Pierre Bessemoulin and Manola Brunet for contacting and inviting us for participating at the MEDARE Workshop in Tarragona on November 2007. Special thanks to Marc Prohom (Catalan Meteorological Service) for sending us the information related to the Andorran weather observations previous to 1934. Also thanks to Jordi De Juan and Joan Grau from FEDA.

#### INTRODUCTION:

On the 14th November 2001, the Catalan Parliament passed the Meteorology Law whereby the Servei Meteorològic de Catalunya (Meteorological Service of Catalonia, SMC) was established as a public entity of the Generalitat of Catalonia, the Autonomous Government. Among the functions stipulated by the law, the maintenance of the meteorological data base of Catalonia and the promotion of investigational activities with regards to meteorology and climatology received special support.

As a consequence of the upheaval historic events suffered by Catalonia, especially during the 20<sup>th</sup> century, and the non-existence of a unique meteorological institution until the first third of that century, the climatic information available is incomplete and has been scattered all over the country. Bibliography on the historical evolution of both climatology and meteorology in Catalonia is generous and complete: Barriendos (2001), Sureda (2003), Roca *et al.* (2004), Prohom (2006). Due to this situation and following the objectives set by the Meteorology Law, the SMC has initiated and ambitious project of climate data rescue, from late 18<sup>th</sup> century to the present, and covering the whole Catalan territory. This project includes identification, cataloguing and digitalization of instrumental data, with the final objective of keeping this information in a unique and public data base.

Within this paper a quick look on the state-of-the-art of this project is made, with special interest on the data sources already explored and the methodology used to extract the climatic information. At the end, some preliminary results are shown and the expected research to be done in the future.

#### DATA SOURCES:

As previously mentioned, the absence of a unique and complete climate data base for Catalonia makes necessary the identification and cataloguing of those documentary sources thought to be holding climate information. Here we describe three of these sources.

##### The National Data Base

A digitized climate data base is already available from the Spanish Meteorological Institute (INM), known as the National Data Base (Banco Nacional de Datos). Thanks to an agreement signed between both institutions, the SMC has access to the climate data from those weather stations located in Catalonia. This data base consists of about 880 precipitation series and 520 temperature series, mainly covering the period 1910 to the present. Although other climate variables are also available, within this first stage of the research only temperature and precipitation data have been treated, leaving the remaining climate variables for future researches.

In order to have a first view of the quality of the series received, an analysis of the temporal and spatial distribution of the series was firstly undertaken, with especial attention on the number and length of the gaps detected. Thus, a remarkable fall in the number of rainfall series was detected by the end of 1980s all over the Pyrenees, as a consequence of the automation of many hydroelectric power stations.

Jointly with the digitised data, the SMC have had access to the scanned pluviometric cards sent by the observers to the meteorological office (most of them handwritten). Thanks to that, lots of false gaps have been filled and some errors, probably introduced during the digitisation process, have been corrected. The same procedure will be followed for the thermometric cards also available in scanned format. Once finished with this contrasting task, the results

will be communicated to the INM in order to avoid duplicates.

#### The SMC Historical Archive

The former Meteorological Service of Catalonia was established in 1921. During 17 years of existence this institution gave an extraordinary boost to meteorology and climatology in Catalonia, and some of its work acquired international prestige. Among the works which had a widespread impact outside of Catalonia are the participation in the production of the *International atlas of clouds and of states of the sky*, the contribution to the *International Polar Year* (1932-33), and the design of the *Jardí rain-gauge*. However, in 1939, the SMC was suppressed and its archives and belongings confiscated by the Franco troops during the Spanish Civil War.

The archives of the old SMC were returned to the Generalitat in 1983. Some years later, these collections, which contain meteorological data, administrative documents, correspondence and an abundance of charts, were catalogued and since 2003 are available at the *Institut Cartogràfic de Catalunya* (Cartographic Institute of Catalonia). From the catalogue, we can check that the archive not only contains documents from the period in which this institution was operating, but also documentation from other contemporary and previous institutions. It contains for example bibliographic material from the Experimental School of Agriculture of Barcelona (*Granja Escola Experimental d'Agricultura de Barcelona*) that was established in 1895, and created the first meteorological weather station network covering both Catalonia and the Balearics. Additional material is also available from the Catalan Observatory of Sant Feliu de Guíxols (1905-1910) and from the Astronomical Society of Barcelona (1910-1923), institutions that coordinated and expanded the previous network.

The detailed catalogue makes possible an easy identification of those materials containing instrumental data to be digitised. Thus, more than 50

thermopluviometric series have been located and information on the metadata has been also recovered and stored. In addition, for preservation of the contents, a project of scanning the whole documentary batch was initiated in 2007.

#### The Royal Academies of Medicine and Sciences and Arts of Barcelona

In 2007, a third stage in the data rescue process was started. In association with the Department of Modern History of the University of Barcelona, the archives of two ancient institutions were analysed: the Royal Academy of Medicine and the Royal Academy of Sciences and Arts, both in Barcelona. This two institutions were established in late eighteenth century and were thought of having conserved climatic information in their archives. Thus, the archive of the Royal Academy of Medicine houses the original meteorological observations made by Dr. Francesc Salvà in Barcelona, initiated in January 1780 (see figure 1). Although most of the climatic information was already explored and extracted (Barriendos et al., 1997; Rodríguez et al., 2001), there is still useful information to be digitised. In addition, efforts have concentrated on scanning the originals for preservation purposes.



Figure 1: Meteorological observations made by Dr. Francesc Salvà in Barcelona, January 1780. The measurements were made three times a day, and included: air temperature, air pressure, winds and sky appearance (Source:

ARAMB, Francesc Salvà, *Taules Meteorològiques*, 3 vols, 1780–1824).

Apart from the three sources of climatic data consulted, other published material has also been analysed (i.e., meteorological annals and bulletins). Table 1 shows some of this material.

Bibliographic source	Author/s	Kind of data	Temporal resolution	Temporal coverage
<i>Meteorologia Catalana.</i>				
<i>Observacions de Sant Feliu de Guíxols. Resultats de 1896 (parcial) al 1905</i>	Rafael Patxot	Rainfall	Monthly	1896-1905
<i>Pluviometria Catalana</i>	Rafael Patxot	Rainfall	Monthly	1906-1910
<i>Atlas pluviométric de Catalunya</i>	Joaquim Febrer	Rainfall	Monthly	1861-1925
<i>Butlletins de la Sociedad Astronómica de Barcelona</i>	SAB	Rainfall *	Monthly	1910-1921
<i>Notes d'Estudi</i>	Former SMC	Rainfall *	Monthly	1921-1936
<i>Resumen de Observaciones Meteorológicas</i>	OM / OCM / ICM / OfCM / SMN	Several variables	Monthly / Daily	1868-1961?

Table 1: Bibliographic sources containing climatic information.

\* In some cases, other meteorological variables were included SAB, Astronomic Society of Barcelona / SMC, Meteorological Service of Catalonia / OM, Madrid Observatory / OCM, Central Meteorological Observatory / ICM, Central Meteorological Institute / OfCM, Central Meteorological Office / SMN, National Meteorological Service

#### METHODOLOGY:

Once the sources of climatic information have been exposed, here we show the methodology followed in order to classify the information. First, the whole volume of information is transferred into a unique data base, the METADEM (Catalan acronym for Metadata of Meteorological Stations). This data base contains all the information available for each of the meteorological sites identified. Apart from geographical data (i.e., latitude, longitude, altitude,

city, region) and temporal coverage, additional data is also included: observers, environmental conditions of the surroundings, instrumental equipment, measurement conditions (for temperature, if the thermometers are/were placed in appropriate shelters or screens), methods of observation (time in which the observation is/was made), units of measure. Whenever possible, the exact date in which one of these metadata changes is also pointed out, very useful for the later homogeneity testing process. The appearance of METADEM is shown in figure 2.



Figure 2: Example of a METADEM file designed for thermometric and rainfall weather stations.

Once the information for a single site is filled in, the climatic series generated in each site is analysed. Thus, the series are subjected to a quality control process and homogeneity analysis. Although this step is already defined, only a few number of series have been treated as a test control. The information obtained during these processes will be stored in another data base: BDSCLIM (Catalan acronym for Data Base of Climate series). Related to this stage, the SMC is now involved in the Action COST-ES0601: Advances in Homogenisation of Climate Series: An integrated Approach (HOME), a European working group that has as main objective the definition of uniform criteria for homogeneity testing of climate series. The results obtained from this project will improve the quality of the final series.

### III.5. Data Rescue activities at Météo-France

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#### SOME PRELIMINARY RESULTS:

As a result of the tasks initiated, some preliminary results are already available. For the period previous to the Spanish Civil War, 150 thermopluviometric series that were undiscovered or lost have been recovered, and in about 200 series the temporal coverage has been expanded. In addition, 400 pluviometric series have been improved thanks to a successful process of filling gaps. Finally, for most of the series information on the metadata has been rescued, a crucial issue to be considered in the homogeneity process.

#### MORE TO BE DONE...

The project of instrumental data rescue initiated by the Meteorological Service of Catalonia has just begun. Many other activities to be done in the future years are already defined, with the final objective of improving our knowledge on the Mediterranean climate history.

- The research should be extended to the rest of the meteorological data: sunshine duration, cloudiness, air pressure, wind speed and direction,... being the results included on METADEM and BDSCLIM.
- The analysis of the SMC historical archive should also include other batches, as those related to the correspondence kept between the observers and several institutions or meteorological offices.
- The search for new climatic data should include other documentary sources (i.e., local and county archives).
- The historical newspapers are a potential source of climatic data. Many papers published local climate data in an easy readable format during the 19<sup>th</sup> century and the first half of the 20<sup>th</sup> century, and could enhance the number of series available or improve the quality of those already identified.

To sum up, the project that has just started is of great climatic interest and the results will be used for a better understanding of our past climate and will be crucial for future research.

#### INTRODUCTION:

Data rescue activities at Météo-France are managed by the Climatology Department (*Direction de la Climatologie*) in Toulouse and undertaken by national, regional and departmental services. These activities include old instrumental climate data preservation, digitization and quality control, and they require a good working knowledge in the meteorology history and organization of French archives. France has a very long and wealthy meteorological history, going back several centuries with a very significant legacy of climate data.

Great efforts have been dedicated to locate relevant data sources and conduct inventories of the paper archives; the instrumental records are indeed stored at various archives dispersed in France and published in many books and newspapers. A national Data Rescue project has been launched at Météo-France in 2008 aiming at inventorying all Météo-France archives.

Great efforts have been made also to collect the metadata. France has the benefit of having several meteorological stations in the same city but the full identification of the relevant historical site and its linking to an already identified site in the national Climatological Data Base (BDClim) is generally a time-consuming task. Once this is completed, climate data are digitized and then inserted into the BDClim, as the primary component of the national archive resides in the BDClim. The newly inserted data are subject to some QA/QC procedures before validation. A very significant amount of monthly and daily data have been stored in the BDClim. The data are available to different types of users through the internet by the so-called "*Climathèque*", the Météo-France climate data and products access service (<http://climatheque.meteo.fr>). The products catalog is available free of charge to the public

This paper gives a brief overview of the French meteorology history, the data rescue programs since

1994, the homogenization programs, the long instrumental records available in the BDClim and the North-Africa records stored at Météo-France.

#### SECULAR METEOROLOGICAL RECORDS:

This chapter briefly gives the French meteorology history focusing on the long term climate records.

The French began systematic meteorological observations at the end of the 17<sup>th</sup> century over France, but few scientists had meteorological instruments, consequently meteorological documents before the 18<sup>th</sup> century are very rare.

Doctor Louis Morin made thermometric and barometric observations in Paris from February 1665 to July 1713. His work is noteworthy for the length and his assiduity with which he collected the data. His reports are stored in the Sciences Academy archives, and the daily temperature and pressure observations are available in Legrand and Legoff (1992).

The first rainfall observations, made at the Paris Royal Observatory, began in 1688 and the first thermometric, hygrometric, and barometric observations at the Paris Observatory are made by Philippe de la Hire in 1699. The figure 1 shows the first page of the report written by the scientist P. de la Hire (1699) and the monthly rainfall in 1699 in Paris. Observations were sent to the Sciences Academy but the original paper records before 1785 disappeared. Monthly rainfall and annual extremes of temperature and air pressure are published in the books *Mémoires de mathématiques et Physique* stored by the Sciences Academy. There is a gap in the time series between 1755 and 1784.

In accordance with Renou (1880), Paris observatory readings taken in the 18<sup>th</sup> century were published in several publications: *mémoires de l'académie des sciences, la connaissance des temps, le journal de Physique, le journal de médecine de chirurgie et de pharmacie, le journal oeconomique, le Journal de Paris...* The 19<sup>th</sup> century observations in Paris

observatory can be found in several annals: Annales de Physique Chimie, Comptes rendus de l'Académie des Sciences Annales de l'Observatoire de Paris, observations de Cotte à Montmorency.

Renou (1880) performed a very useful study on the long instrumental series in Paris from 1649 to 1880 and provides several mean and extreme pressure long series for example a mean monthly pressure series from 1757 to 1878.

MEMOIRES DE L'ACADEMIE ROYALE

OBSERVATION DU BAROMETRE, du Thermomètre, & de la quantité d'eau de pluie & de neige, fondue qui est tombée à Paris dans l'Observatoire Royal pendant l'année 1699.

PAR M. DE LA HIRE.

Les observations de la quantité d'eau de pluie qui tombe à l'Observatoire, ont été faites de la même manière que celles des années précédentes. On a placé pour cet effet dans la Tour découverte un vaisseau de fer blanc, qui a quatre pieds de superficie, & qui a des rebords tout autour de 6 pouces de hauteur. Ce vaisseau a un peu de pente vers l'un des Angles, où il y a une petite ouverture avec un bout de tuyau qui conduit toute l'eau qui tombe dans ce vaisseau, dans une cruche qu'on place au-dessous, & au-dessus qu'il a plu, on prend un très-grand soin de mesurer exactement toute l'eau qui s'est amassée dans la cruche, ce qu'on écrit dans un Registre particulier. Cette mesure se fait dans un petit vase de figure cubique, qui a son côté de 3 pouces, enforte que 32 lignes de hauteur d'eau dans ce petit vase, valent une demi-ligne de hauteur sur la superficie du grand vaisseau de fer blanc: c'est pourquoi on a tracé autour du bord d'en haut de ce petit vase cubique, qui n'est point fermé par dessus, une ligne à 4 lignes de distance du bord, afin qu'en remplissant ce petit vase jusqu'à la hauteur de cette ligne, on ait la valeur d'une demi-ligne de hauteur d'eau qui est tombée. Voici l'état de ce qui est tombé dans chaque mois de cette année.

Lignes.		Lignes.	
Janvier	11	Avril	36
Février	11	Mai	22
Mars	11	Juin	29

Figure 1: Rainfall observations La Hire (1699)

During the 18<sup>th</sup> century, Mannheim, which was at that time the Capital of the Rhine Palatinate, became the centre for arts and science under the Elector Karl Theodor who, in 1780, founded the Societas Meteorologica Palatina. The correspondents made three daily observations, submitting the records to Mannheim for comparison and later publishing them in the Society's annual Ephemerides. In 1781, in France, there were observers in Dijon and in la Rochelle (Beaupaire, 1994).

According to Angot (1895), the first temperature and precipitation observations in Bordeaux go back to

1714 but with some gaps in the 18<sup>th</sup> century. The Bordeaux temperature dataset can be reconstructed without a break in continuity till 1822. In Montpellier, temperature observations made by M. Bon began in 1705 and pressure observations started later in 1757. Observations are published in memoirs (*société des Sciences à Montpellier*) and in annals (*société de médecine de Montpellier*).

In Lyon, air pressure and temperature observations were made from 1738 to 1780 in the Royal school "collège royal". After a long gap, due to the destruction of the observatory, the observations resumed in 1818 in the high school « lycée Ampère ». Meteorological observations started in the Saint-Genis de Laval observatory in 1879.

The Marseille Observatory was set up in 1702 in the Sainte-Croix Academy and the meteorological observations were made there from 1706 to 1752. After a break, observations were made from 1761 to 1866 in the old observatory "les Accoules". The observations in the Marseille Longchamp observatory have been made continuously since 1867.

Dijon is another old climate series: observations begin in 1763 and are published in memoirs (*mémoires de l'Académie de Dijon*) until 1867.

In 1778, the Royal Society of Medicine was founded in France under the sponsorship of King Louis the 16<sup>th</sup>, in order to keep a detailed and permanent exchange of information with other doctors of the kingdom on medical and meteorological matters. The French meteorologist Louis Cotte seriously committed himself to the creation and maintenance of a large network of meteorological observation stations for the Royal Society.

The Royal Society of Medicine in Paris created a meteorological network in 1776 and animated it to 1792. More than 200 doctors sent their daily observations to L. Cotte (1774).

Louis Cotte published monthly summaries in memoirs called "*mémoires de médecine et de chirurgie médicale*" from 1776 to 1786.

Desaive et Leroy Ladurie (1972) collected the climate records from the academy of medicine archives and studied their thermal information for 17 years. They controlled the data and could select 8 reliable and complete series from these manuscripts. Beaupaire (1994) provides the inventory of these manuscripts.

Figure 1: Observations météorologiques Novembre 1785, L.Cotte, *mémoires de médecine et chirurgie médicale* (1788)

Long and reliable climate series are rare in the first half of the 19<sup>th</sup> century in France. Long series can be built in Bordeaux, Dijon, Marseille and Paris.

The advent of telegraph's technology in the early 1850's had strengthened the 17<sup>th</sup> century idea of establishing meteorological networks. On the 14 of November 1854, the loss sustained by the Anglo-French fleet as a result of a heavy storm in Balaclava during the Crimea war, precipitated to the forefront the need for the development of the synoptic study of meteorological systems. Following this disaster, Le Verrier, Director of the Paris

Observatory compiled data on how this storm had moved toward the east across Europe. This work led in France to the establishment of the first national storm warning service, based on the gathering of telegraphic meteorological reports. The telegraphic meteorological network set up by the Paris Observatory in 1856. In 1856, the French meteorological network consisted of 24 stations covering the whole national territory. Thirteen stations could transmit the observations made at office opening hours by telegraph. The telegraphists made the observations and transmitted 3 observations every day at 7h (or 8h), 15h and 21h. They measured pressure and temperature, estimated the wind and observed the sky.

Figure 2: Daily Paris observatory bulletin December 1857

In addition some astronomic observatories in Bordeaux (1880), Marseille Longchamp (1866), Toulouse (1838), Lyon (1879), Nice (1881), Perpignan(1882) started to record sub-daily or daily meteorological observations (pressure, temperature and precipitation) in the 19<sup>th</sup> century. The records

are remarkable and invaluable because of their length and quality. Yearbooks are often published in observatory annals. Marseille observatory have published the daily data in "*bulletins de la commission météorologique des Bouches-du-Rhône*" since 1866 without any break.

The first meteorological office called *Bureau Central Météorologique* was created in 1878 and published yearbooks known as *Annales du Bureau Central Météorologique* from 1878 to 1920.

Angot (1897, 1900) developed a long term homogenized data set. He built 14 homogeneous monthly mean temperature series for the period 1851-1900 in France. Homogeneous series for the South of France are available in 5 cities : Lyon, Toulouse, Bordeaux, Marseille, and Perpignan. There are few measurement made at the same location over this long period. Relocations are numerous; so, incorporating data from different locations is necessary to reconstruct the long series. Fortunately, Angot (1900) described the concatenations and the corrections.

A new meteorological office, l'Office National de la Météorologie (ONM) was created in 1919, a new synoptical network was created in 1920 with 17 stations. The observations are published in *Bulletins mensuels de l'Office National de la Météorologie*. Meteorological stations spatial distribution was disrupted for the aviation needs. New stations were created in airports and astronomic observatories and no longer belong to the national network.

In 1945, after the Second World War, a new meteorological office was created known as *La Météorologie Nationale*. The new synoptical network reached 100 stations.

#### METEOROLOGICAL ARCHIVES IN FRANCE:

Climate data are hidden in many places in France: in Météo-France archives (in at least 100 different sites: national or departmental public archives,

science academy archives, universities or scientists associations libraries, observatory libraries, ministry of Defense archives; etc.). Additionally more and more publications are available on Internet.

The most important archives are presented in this section.

#### *National Archives*

Repeatedly from 1976 to 1994, Météo-France deposited a vast amount of paper records at the National Archives of France in Fontainebleau. The data covers the period 1841-1993 and concerns France and Africa. The inventory is accessible on the National Archives Website but the data itself have not been accessible for several years, mainly because the buildings are polluted by asbestos (<http://www.archivesnationales.culture.gouv.fr/cac/fr>)

#### *Météo-France Archives*

Météo-France central library in Paris:

The library was created in 1878, gathering old collections from the Paris observatory and the *Société Météorologique de France*, with periodical collections beginning in the 18<sup>th</sup> century. 480 books from the 15<sup>th</sup> to the 18<sup>th</sup> centuries, 750 books of the 19<sup>th</sup> century, 19000 books and 11000 titles of periodical and periodical serials (including climatic publications of many countries) are held and available for consultation.

Climatology department archives in Toulouse:

Météo-France archives in Toulouse contain surface and upper-air climatological data: reports from synoptic and semaphore stations since 1920 and reports from climatological stations since 1961.

Departmental stations

Old climate reports in paper form with observations made in the national meteorological office before 1961 have been collected and archived in the Météo-France departmental stations (CDM).

#### Departmental Archives

There is a departmental public archives service in each department in France. These public services store large amounts of meteorological records, especially rainfall in the 19<sup>th</sup> century. More and more services provide their catalog on the Internet. Inventories and documents can also be consulted in departmental archives rooms, but borrowing is not permitted. Consequently, Météo-France uses to buy microfilms or image files from public archives in accordance with the inventories to preserve and to digitize data. Some departmental archives are very rich in climate historical data.

For example, Marseille observatory manuscripts are stored by the *Bouches-du-Rhône* departmental archives.

University libraries

Thanks to historians, some French universities have collected rare regional books containing meteorological data.

Recently very fruitful collaborations with French universities in Lyon and Marseille have been established and have allowed the gathering, scanning and preservation of very old documents in paper form.

#### *Académie des Sciences archives*

Academy Science archives the *Mémoires de mathématiques et Physique* since 1700. Some books are available on the Academy website.

#### *Académie nationale de Médecine library*

The National Academy of Medicine library holds the documents from the Royal Society of Medicine (1776-1793), particularly *les mémoires de médecine et de physique médicale*.

#### *French numerical libraries on the website*

More and more French libraries scan books to make them available on websites. Some websites are very

rich in old meteorological data. The most important is the digital library *Gallica* maintained by the National Library (Bibliothèque Nationale de France). This library contains several Academy Sciences annals for the 18<sup>th</sup> and 19<sup>th</sup> centuries. They can be downloaded as pdf files from the scanned books (*les comptes rendus de l'académie des sciences, les actes de l'académie de Bordeaux et les Annales de Physique Chimie*).

#### MÉTÉO-FRANCE DATA RESCUE PROGRAMS:

##### *First program: 1994-2004*

The historical Data Rescue program initiated in 1994 by Météo-France aimed at enhancing as first aim the content of the BDClim database, and focused especially on monthly averages of daily maximum and minimum temperatures and precipitation for the 1880-1950 period, was poor in data so far. The motivation for undertaking such work was to develop long time series of climate data, which would allow to estimate long term trends (e.g. over the whole 20<sup>th</sup> century) after homogenization of these time series. At that time, homogenization of yearly and monthly data was considered much more feasible than daily data.

This first data rescue program has allowed the enhancement of French climatological legacy, especially for monthly values of daily maximum and minimum temperatures and rainfall. The digitisation effort was mainly devoted to the 1880-1950 period, until then poor in data. Data published in national and departmental climatological books from Météo-France archives and libraries were digitized.

##### *Second program: since 2004*

In 2004, Météo-France launched a new data rescue program, which gave priority to rainfall, temperature, air pressure and sunshine duration data on a daily basis for France mainland and French overseas territories, in order to address extremes.

Millions of data have been keyed and these data are now available in *Météo-France* operational climatological database BDCLim.

### HOMOGENIZATION:

The Climatology Department of Météo-France strives to enriching the French climatological legacy in reliable and usable series and at developing long-term high quality and homogeneous climate records. Climate change study using raw long-term data is hazardous due to many breaks caused by displacement of meteorological stations, replacement of sensors, modifications of the local environment, etc.. Long-term data homogenization appeared as an imperative step prior to calculating long-term trends. Homogenization tools, based on statistical method developed by Caussinus-Mestre (2004) technique, allowed the detection and correction of breaks.

#### First Météo-France homogenization program:

Météo-France homogenized 70 monthly temperature series, 300 monthly rainfall series, 25 monthly mean sea level air pressure for the period 1901-2000 (Moisselin et al., 2002).

Eighteen sunshine duration series have been homogenized over the period 1931-2000 (Moisselin et Canellas, 2005).

Homogenized series are available through the BDCLim, while raw data are kept unchanged

#### Homogenization program:

Météo-France began a new air temperature homogenization programme managed by the climatology department last year. Homogeneity testing and data adjustments are applied to maximum and minimum temperature in order to create a dataset of long-term complete and homogeneous series since 1951. This program aims to develop around of 200 French monthly adjusted minimum and maximum temperature series.

Monthly maximum and minimum temperature series are considered separately. This action is associated with the national data rescue program. Furthermore great efforts are dedicated to collect metadata in the departmental weather centres and to digitize these metadata.

### DATA AVAILABLE IN THE FRENCH CLIMATOLOGICAL DATABASE BDCLIM:

The primary component of the national archives resides in the BDCLim. The long-term series availability is treated in this section.

Stations with monthly data are in larger numbers than stations with daily data, particularly before 1920: 77 stations with monthly temperature on 1880 versus 15 stations with daily temperature; 155 stations with monthly temperature versus 92 stations with daily data. The oldest daily temperature is in January 1816 in Paris but there are less than 7 stations with daily temperature values before 1875 in the BDCLim.

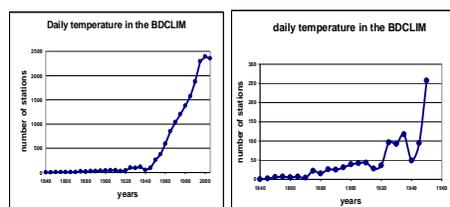


Figure 3: Number of stations with daily temperature in the BDCLIM for the 1840-2000 period (left panel) and 1840-1960 (right panel)

The number of stations with daily temperature in BDCLim since 1840 are shown in Fig. 4.

The impact of world wars is evident in the Fig.4 (right panel). The amount of daily data has been increasing constantly from 1945 to 2000, from 94 stations in 1945 to 2389 in 2000.

The oldest monthly rainfall series begin in Paris in 1688 but old daily rainfall before 1875 are rare: the

BDCLim contains 12 stations with daily rainfall in 1870 and 531 stations with monthly rainfall.

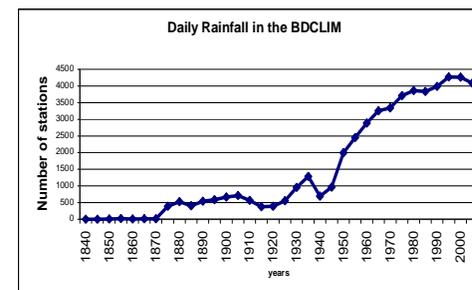


Figure 4: Number of stations with daily precipitation in the BDCLim

Despite of the very large legacy of data and the efforts paid on data digitization, only a small fraction of daily data is available in the BDCLim.

Four long-term series in the South of France and Paris Montsouris have been selected. The data availability for these series are presented in the Table 1.

The gap in the data due to the Second World War appears in most of the synoptical stations. However, Marseille and Paris series do not present gaps during the second world war.

Paris, Marseille, Perpignan, Toulouse are in the group of the 8 most reliable long daily temperatures series that can be selected for the period 1901-2000 in France.

#### Météo-France network in 2008

Météo-France climatological network consists of a combination of the real-time 180 synoptical stations and 1000 automatic stations network as well as the climate stations.

Observations from around 1200 automatic stations are collected in real time whereas 3800 rainfall and 2000 temperature observations from co-operating observers come in as collectives at the end of the month.

The current network of Météo-France synoptic and climate stations can be viewed freely on the climattheque web-site <http://climattheque.meteo.fr/aide/climattheque/reseauPostes/>

Station	Daily temperature	Daily rainfall	Monthly temperature	Monthly rainfall
Bordeaux observatory	1906 - 1914	1880 - 1955	1880 - 1955	1880 - 1955
Floirac	1955			
Bordeaux Merignac	1920 - 1940 03/1945 -	1920 - 1940 1940 - 1945 -	1920 - 03/1945 -	1920 - 1940 03/1945 -
Marseille Longchamp observatory	1868 - 2003	1868 -	1868 - 2003	1868 -
Marignane	1921 - 1943 08/1945 -			1921 - 1943 08/1945 -
Paris Montsouris	1873 -	1873 -	1873 -	1873 -
Perpignan observatory	1882 - 1932	1882 - 1932	1882 - 1932	1882 - 1932
Perpignan aéroport	12/1924- 11/1942 01/1944- 06/1944 02/1945 -	12/1924- 01/1942 01/1944- 06/1944 02/1945 -		12/1924- 11/1942 01/1944- 06/1944 02/1945 -
Toulouse Francazal	1922- 06/1943 12/1944 -	1922 - 06/1943 12/1944 -	1922- 06/1943 12/1944 -	1921 - 1947 -
Toulouse Blagnac	1947- 1878 -			1844 - 1984
Toulouse observatory	1914 1934 - 1940 1946 - 1971	1874- 1940 1952- 1984 with gaps	1844 - 1924 with gaps	

Table 1: Climate data availability for 5 long-term French stations

### CLIMATE SERIES FROM OLD FRENCH COLONIES: ALGERIA, MOROCCO, TUNISIA:

Microfilms and microfiches containing daily data from old French colonies are archived at the Climatology department in Toulouse. A thorough inventory has been undertaken. The inventories for Algeria, Tunisia and Morocco are available, consisting of 3050 microfiches and 251 microfilms for the period 1924-1962. It is likely that this data have been given to these countries when they became independent in the 1960's. However, Météo-France is ready to collaborate with the countries in order to organise the access to the data.

Additionally books dedicated to colonies are stored at the Météo-France library in Paris

### CONCLUSIONS:

France has a rich meteorological legacy but most of the daily data before 1961 have not been digitized. Climate data are disseminated in many archives and publications in France. The Météo-France archives contain a very large amount of unexploited climate data.

In the last years, thanks to the data digitization efforts carried out within a national project, the situation has improved but a significant fraction of French data is still on paper form and not already inventoried.

### NUMERICAL LIBRARIES:

Sciences Academy archives,  
Histoire et Mémoires de l'Académie royale des sciences  
[http://www.academie-sciences.fr/archives/histoire\\_memoire.htm](http://www.academie-sciences.fr/archives/histoire_memoire.htm)

Medic : Paris Medicine university numerical library, Royal society of medicine  
<http://www.bium.univ-paris5.fr/histmed/medica.htm>

NOAA library (Annales du Bureau Central Météorologique 1878-1920)  
[http://docs.lib.noaa.gov/rescue/data\\_rescue\\_french.html](http://docs.lib.noaa.gov/rescue/data_rescue_french.html)

Gallica (*Bibliothèque Nationale de France*)  
<http://gallica.bnf.fr/>

## III.6. Data Rescue Activities at Slovenian Meteorological Office

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### INTRODUCTION:

Slovenia, with the area approximately 20.000 km<sup>2</sup>, is situated between the Alps in the north, Adriatic Sea in the southwest and Pannonian plain in the east. The terrain is complex with high altitude variability (from 0 m up to 2864 m). On this very small territory three major climate systems (Sub-Mediterranean, Alpine and Continental) interact between one another and contribute to variable climate conditions. A large part of Slovenian territory consists of mountains or lower hills, which are influenced from Adriatic Sea on the southwest and continental climate from Pannonian basin on the east. This is the reason for very high precipitation variability. There are regions in western part of the Julian Alps, where annual precipitation exceeds 3500 mm, while in the east it hardly reaches 900 mm per year. The same high variability is well expressed in temperature conditions, where there is more temperate climate with smaller temperature differences on the west and more severe climate with higher temperature differences (daily and seasonal) on the east. This variety is also reflected in climate variability over time and it is an important factor determining the impact of global climate change in the country. Due to described strong spatial variability of weather and climate variables dense meteorological network is essential.

A vivid history of Slovenia had a strong influence on the history of climate monitoring and climate data archives. According to political regulation at time, the central meteorological archives were operated by different institutions. Even at present all resources of Slovenian historical meteorological data haven't been discovered yet. From the beginning of instrumental meteorological measurements in 1850, Slovenia belonged to Austro-Hungarian Monarchy. With small exception, almost all Slovenian territory was in Austrian part of Monarchy. The north-eastern part of Slovenia, called Prekmurje, belonged to autonomous Hungarian part. After the First World

War in 1918, Slovenia was a part of Yugoslav Monarchy, with exception again. The south-western part of the country, called Primorska, belonged to Italy. After the Second World War Slovenia was one of Republics in the Social Federative Republic of Yugoslavia, Hydro-meteorological Institute of Slovenia was a part of federal Hydro-meteorological Institute with headquarter in Belgrade. From June 1991 Slovenia is an independent republic. In 2003 Hydro-meteorological institute of the Republic of Slovenia was reformed and joined with other institutions in Environmental Agency of the Republic of Slovenia (ARSO).

### METEOROLOGICAL NETWORK:

The first preserved meteorological measurements in Slovenia started in March 1850 in the capital city of Ljubljana. In the first years after 1850 the meteorological network was very sparse till 1895, when more than 50 stations were set up in a very short period. The number of stations was quite constant till 1920, when there was a strong decrease due to financial crisis after the First World War. After some years there was a significant increase, especially in number of precipitation stations. During the Second World War observations at the majority of the stations measurements were interrupted and continued soon after the end of the war. Some completely new stations begun to operate in the postwar period and in 1950 there were altogether 200 stations operating. The network continued to grow in the next three decades and reached the maximum in 1977 with 360 operating stations. After the maximum there was a significant reduction in the number and in 2007 only 216 classical stations are left (Figure 1). Comparatively, network of climatological stations was far more reduced than precipitation station network. The reduction has been partly mitigated by the introduction of automatic weather stations. In the last 20 years 32 Automatic Weather Stations have been set up. Currently, four main types of meteorological stations are in

operative use. Observers at synoptic stations make hourly observations. There are three observations per day (7 a.m., 2 p.m., 9 p.m.) at climatological stations, while at precipitation stations only one observation daily is made at 7 a.m.

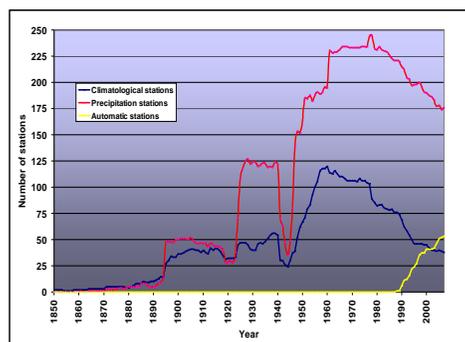


Figure 1: Number of Slovenian meteorological stations according to the station type in the period 1850–2007.

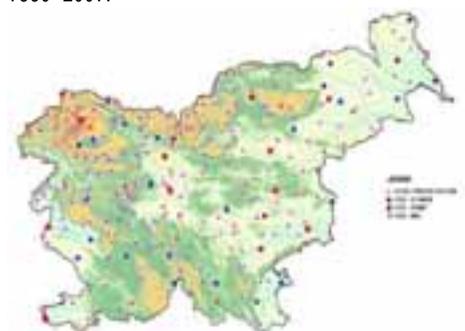


Figure 2: Spatial distribution of different types of meteorological Stations on the territory of Slovenia.

At the latter type of the station only daily precipitation sum, total and fresh snow depth and weather phenomena are observed or measured. Automatic weather stations send meteorological data in half-hour intervals. Sampling interval of 5 minutes is used for precipitation sums and half-hour for other variables. Statistics (mean, max, min, standard deviation) is calculated for each interval. In 2007 Meteorological Office, which represents National

Meteorological Service, had 13 Synoptic Stations, 26 Climatological Stations, 176 Precipitation Stations and 32 Automatic Weather Stations (Figure 2).

#### DATA COLLECTION, ACCESS AND DATABASES:

Most of the material (logbooks, reports, pluviograms, thermograms etc.) is collected in the Agency on monthly basis. Reports and paper charts are stored in archive, where temperature and humidity conditions correspond to the requirements of such premises. Manual measurements are digitized on daily basis at 13 synoptic stations and on monthly basis for other stations using an application that visually resembles the paper reports and logbooks (Figure 3). Pluviograms and sunshine recorder cards are digitized with one to two month delay, other cards only when needed. SYNOP reports and data from automatic weather stations are stored in database in near-real time. All data from classical stations is processed and put into the database using the same software system.



Figure 3: Application for digitizing data from climatological stations.

For the period 1961–2007 almost all climate series have been digitized, while prior to that only for

synoptic and some other selected stations digitization process has been completely finished. A large part of data is still only in paper archive. Lately, a lot of activity (also in the framework of international projects such as Interreg project FORALPS) is focused on data rescue and digitization. From the beginning of 2004 we have digitized and controlled 1356 years of daily data from the period before 1961. The consequence of systematical digitization of all climate data after the year 1961 is that the larger part of digitized data series have length of 40 to 60 years (Figure 4). Only minor part of data series are longer, but there is quite a significant portion of data series with shorter length, mostly due to closing down the stations in last 30 years.

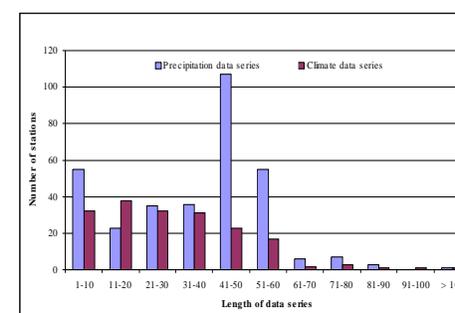


Figure 4: The number of station data series with different length.

Data from automatic weather stations and data loggers is stored in Oracle and PostgreSQL relational databases. VMS text-file archive and PostgreSQL relational database working on Linux server contain all meteorological data, including radar measurements in PostgreSQL DB. Original data, quality controlled and interpolated data for clients and derived data (monthly etc.) are stored separately in different tables.

#### DATA RESCUE ACTIVITIES:

As already mentioned, a large portion of data from the time before 1961 has not been digitized yet. To

predict future climate as reliably as possible, the knowledge of past climate conditions is essential. Long data series of all meteorological variables are the most important information about the past climate. That is why more attention has been assigned to data rescue activities in recent years.

#### Data and Metadata recovery

From the beginning of observation period, when Slovenia was part of Austro-Hungarian Monarchy, not all logbooks are preserved. Some of them were destroyed or lost, especially from the period during the Second World War. Although original logbooks have been destroyed, some data could be recovered from other sources such as newspapers, yearly publications, etc. From the period discussed, Slovenia possesses Austro-Hungarian Jahrbuchs and newspaper Laibacher Zeitung. In later two years of daily observations for Ljubljana (three observation times per day) was found. Some of Jahrbuchs are in possession of ARSO, while some of them were found in library of University of Ljubljana. These books are not allowed to be copied and that is why the digitization was performed by photographing them.



Figure 5: Precipitation data is stored in boxes and arranged by stations.



Figure 6: Meteorological logbooks from different time in past when Slovenia was a part of other countries.

Along with meteorological data archive of metadata is also very important. In the past metadata has not always been considered important for climatological analysis. Therefore a lot of metadata has been lost.

When reconstructing metadata, all documentation of meteorological station and observing site (sketches,

photos, descriptions of site), meteorological logbooks, old records of meteorological stations (Jahrbücher, Annali Idrologici, local lists), and old articles are checked out. For specialised information of the past (charts, plans etc.) some other institutions (National and University Library, Geographical museum, University of Ljubljana) are contacted. Even older meteorological observers are sometimes a good source of information.

For reconstruction of the past locations of meteorological site at least the address of the observer is needed, because geographical coordinates from that time are not exact. Many times the location of meteorological station could be predicted on the basis of observer's profession like priest, school master..., because they were living in the school or in the building next to the church. Most of the churches still exist today, with the exception of south region called Kočevska, where almost all churches have been destroyed. Old sketches of meteorological stations are good source of information too. Sketches from the time of Austro-Hungarian and Yugoslav Monarchy are very precise (Figure 8), even their update is reliable. From later period, after Second World War, the sketches are smaller and usually not updated, they are usually even without date.



Figure 7. Application for browsing digital metadata



Figure 8. Example of precise and updated sketch of station in Brijuni, Croatia

With all collected information, the location of meteorological station is reconstructed and it is located on a map, ortho-photo or plan; the location is visited, new pictures are taken and text description

of the site is prepared. The reconstruction can't be taken for granted; the surrounding of the site is often changed and could not always be reconstructed even in the text description. Finally metadata is digitized and users can browse them using special application (Figure 7).

### Digitization

Before the digitization process, graphical evidence of ARSO digital archive as well as paper archive was created (Figure 9). It shows what kind of meteorological data is available for specific meteorological station, period of observation and current state of data (digitized/nondigitized). Data series with only precipitation data are marked with different colour as data series for which additional meteorological variables are available. Incomplete data years are also marked and number of days with complete data is given. Nondigitized data is marked according to the current place of storage (different color for different place/country).

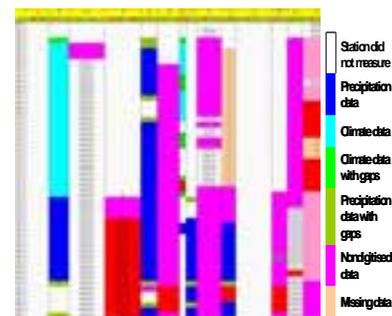


Figure 9. A section of graphical evidence of meteorological stations

Evidence shows, that ARSO archive contains about 24.000 years of data. There are approximately 6.500 years of data that still have to be digitized. Almost all digitized data has information about precipitation, while only about 5.500 years of data include temperature measurements and other meteorological measurements and observations.

Digitization of historical data is performed using the same application as for current data, where fundamental logical control is integrated. There are many problems concerning digitization of meteorological data from original logbooks:

- Unreadable data due to decayed material or overwritten documents
- Irregular observing time
- Measurements with historical instruments (Six's thermometer)
- Measurements in historical units (Paris lines)



Figure 10. Some examples of original logbooks

By the digitization of historical data many errors occur because of constantly changing forms of logbooks. The technicians should be very careful in interpreting every single document. Since Agency don't have enough human resources for data rescue activities, additional manpower was employed, mainly students. Students of meteorology and physics proved to be very successful (small number of errors, successful and reliable reading of documentation, correct interpretation of records...) in digitization procedure.

### Quality control and validation

Quality control of current data is of minor difficulty compared to quality control of historical data. Today data from all working meteorological stations is digitized and controlled collectively, so there is enough data for comparison and spatial quality control. Additional data resources are also used like radar and satellite measurements. And in case of necessity there is possibility to check and clarify suspicious values with observer. When performing

quality control of historical data, all these advantages disappear. Usually there is not enough digitized data from neighbouring stations and spatial control cannot be used. There are no radar images or additional material to verify the suspicious values. Some logical controls, control of inner consistency and a rough spatial comparison (with more distant stations) are the only possibilities for validating the data. It is usually time-consuming work, while validation of single suspicious value could take a lot of investigation to verify it.

### Homogenization

On the territory of present-day Slovenia, meteorological observations have been performed for about 160 years. In such a long period it is impossible to assure constant observing location with unchanged surrounding. At the beginning observations were mostly performed at cloisters and schools and there was no reason to change the observing site. Later on, observational network was adapted to world meteorological standards and many new observing sites were established. New weather observers were employed and observing sites were usually placed near their homes. When observer stopped to register, observing site was moved near new observers' home. Nowadays it is hard to find new volunteers who would take the responsibility of daily observations for relatively small payment and when observer dies, weather station usually "dies" with him. The number of observing sites is rapidly decreasing and the observation network has to be reorganized. Some classical weather stations are moved to a new site and some are replaced by automatic weather stations. By replacement there is always an attempt to find a nearest new location or at least observing place with similar climate, but microclimate is often changed. Moreover, microclimate has often been changed also because surrounding of observing site has been changed, especially in urban environment (new buildings, roads, etc.).

In 160 years of weather observation, methods of observing and measuring have been changing, more frequently in the beginning of measurement period. In that time it often happened that thermometers were placed on window shelves, balconies, terraces, trees and not properly sheltered from direct sunlight. Later, when measurement procedures were unified after world meteorological standards, instruments found their place in instrument shelter or so called Stevenson's screen and measurements became comparable. During the history of observation also types of instruments and observing times have been changing.

All this changes of observing sites and its surrounding caused false signals in data sets, which should be removed before any serious climate analyses. Standard Normal Homogeneity Test (SNHT – implemented in application AnClim, Stepanek) and Craddock test (implemented in application by Michele Brunetti, ISAC – CNR, Bologna) were tested and results were compared. A new routine for calculating the reference series was developed. It is useful especially for the period, when there is a poor spatial coverage of observations and it is hard to find representative reference series. Artificial reference data series is entirely interpolated from all available data for the period (except the testing one). The routine is searching for similar weather situations as they were on interpolating day, using variety of different meteorological variables.

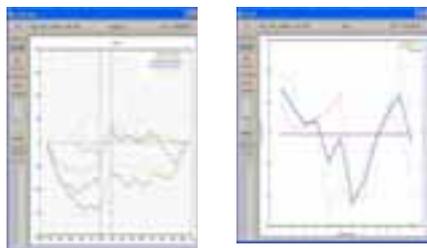


Figure 11. Quality control function for Ljubljana temperature series, calculated from several different reference series.

Data series from Ljubljana have been homogenized using both test mentioned before. Although the station moved seven times from the beginning of observations in 1850 (Figure 13) only two significant breaks have been found (Figure 11). The first break was identified in 1919 and the second in 1930. Both breaks had been caused by changes of observation locations. It is interesting that observing site did not move a lot. Macro location did not change at all, only micro location did. From January in 1919 till 1924, thermometers were placed above window of room with central heating. After this time, thermometers were put on a window shelf at eastern part of the building. It is not quite sure if thermometers were there till 1930 or they were changing locations in the meantime, but it is sure that measured temperatures were too high, so locations had the same microclimate. From 1930 on, measured temperature is representative for Ljubljana region and no more breaks were found, even though the location was changed in 1948. Period from 1850 till 1895 still has to be investigated in detail, but more neighbouring stations has to be digitized first to have more data for reference series.

The results from both homogenization methods were similar. For the first break in 1919  $+0.8$  °C and for the second break in 1930  $-1.0$  °C temperature difference on yearly basis was discovered. Also minimum and maximum temperatures were homogenized and results were downscaled using daily adjustments.

Climate indices for Ljubljana data series were calculated on original and on homogenized data. Results were quite different. The number of frost days and ice days has decreased quite considerably, while the number of summer days has increased. According to linear trend the average annual temperature in Ljubljana has increased for  $2.2$  °C in last 140 years (original data:  $1.7$  °C). Long-term average on homogenized data is  $0.2$  °C lower than the original one.



Figure 13. Seven different locations of Ljubljana meteorological station.

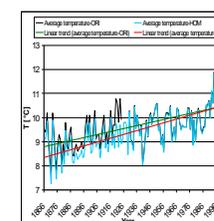


Figure 14. Original and homogenized temperature with linear trend in Ljubljana.

### FUTURE ACTIVITIES:

Although long time series are of a great value for climate analysis and regional climate change assessment, data rescue has not very high priority compared to other activities in NMS. It is mainly because data rescue activities need a lot of resources and is very time demanding job. ARSO aims to maintain DARE activities and enhance them joining different international projects. The international projects including DARE activities are good opportunities for knowledge and experience exchange, data exchange and also for locating additional historical data resources. Recently, ARSO has been actively involved in Interreg FORALPS project, where one of the working packages involved DARE activities. ARSO has positive experience with the project, achieving good results in data rescue, digitization and homogenization.

### INVENTORY OF LONG DATA SERIES ON THE TERRITORY OF SLOVENIA:

Currently 21 already digitized long data series are available from the territory of Slovenia:

- 5 locations with temperature and precipitation measurements (79 – 151 years)
- 15 locations with only precipitation measurements (79 – 112 years)
- 1 mountainous location (2565 m, 52 years)

WMO / station No.	Name of station	$\lambda$	$\varphi$	h [m]	Length [years]
38	PLANINA POD GOLICO	14.05750	46.46750	970	85
48	KREDARICA	13.85389	46.37944	2514	52
140150	LJUBLJANA - BEŽIGRAD	14.51722	46.06583	299	151
140230	CELJE	15.25250	46.24472	244	108
321	ŠMARTNO PRI SLOVENJ GRADCU	15.11611	46.49000	455	93
331	POLIKI VRH	15.70028	46.64167	280	79

Table 1: Climate stations with completely digitized data sets

WMO / station No.	Name of station	$\lambda$	$\varphi$	h [m]	Length [years]
9	KRANJI	14.34600	46.23600	394	109
12	ZGORNJA BESNICA	14.27972	46.26278	480	82
15	ŠKOFJA LOKA	14.29726	46.17253	367	107
18	LESKOVICA	14.08778	46.14861	805	106
21	DAVČA	14.07417	46.19778	960	79
44	BOHINJSKA BISTRICA	13.95500	46.27333	510	97
50	KRANJSKA GORA	13.79361	46.48667	804	108
167	HRIB	14.59300	45.70400	825	88
184	LUČINE	14.20639	46.06306	639	73
216	ZGORNJE LOKE PRI BLAGOVICI	14.78778	46.17306	390	100
221	LAŠKO	15.23917	46.15722	228	112
235	KOSTANJEVICA - BROD	15.46000	45.86528	150	83
258	ADLEŠIČI - GORENJIČI	15.32194	45.51389	250	81
278	LUČE	14.75056	46.35500	520	109
320	DRAVOGRAD	15.03250	46.59194	385	104

Location with additional climate data longer than 40 years

Table 2: Precipitation stations with completely digitized data sets



Figure 15: Station locations with completely digitized data sets

### III.7. Digitization and Data Rescue in Croatia

Janja Milković  
Meteorological and Hydrological Service of Croatia

There are additional 29 potential long data series:

- 7 locations with temperature and precipitation measurements (93 – 151 years)
- 22 locations with only precipitation measurements (79 – 112 years)

They are selected according to available metadata. All selected series are longer than 78 years, have no or only few gaps and are potentially of good quality according to metadata. Additional 1210 years should still be digitized to complete these data series.

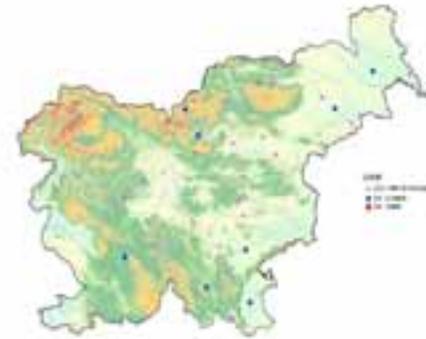


Figure 16: Station locations with longer data sets, which are not completely digitized

WMO/ station No	Name of station	°	°	h [m]	Length [years]	Years to complete
141120	FOSTOJNA	14.19750	45.76639	533	108	27
141180	KOČEVJE	14.85417	45.64628	457	129	10
141210	NOVO MESTO	15.18222	45.80194	220	117	40
141200	ČRNOMELJ-DOBLIČE	15.15033	45.55028	157	125	68
309	STARŠE	15.77111	46.46750	240	89	43
352	LENDAVA	16.47722	46.55722	190	83	37
359	VELIKO DOLENO	16.29250	46.83657	308	78	22

Table 3: Climate stations with not completely digitized data sets

WMO/ station No	Name of station	°	°	h [m]	Length [years]	Years to complete
181	SENJ/OSTINAD	14.2111	46.04000	627	109	51
189	TOPOLSKI MEDVODAH	14.375	46.03333	660	92	34
208	KALINADSEN/JANJEM	15.116	46.01667	525	79	20
217	ZGORNJI TUHINI	14.775	46.22639	576	104	58
242	MOKRONOG	15.154	45.94194	274	95	35
246	DVOR	14.936	45.80361	195	79	21
251	KOČEVJE/POKLANE	15.080	45.72389	200	99	53
260	PREGRAD	15.080	45.50556	375	91	45
266	SENJ/JUR	15.400	46.21611	266	112	66
269	VOJNİK	15.308	46.23333	273	112	66
271	GOMILŠČA	15.050	46.24722	294	101	68
276	GORNJI GRAD	14.812	46.23639	428	112	55
279	SOČAVA	14.696	46.40263	658	112	66
282	KOPRIVNA	14.760	46.45611	840	80	21
291	ZGORNJI RAZBOR	15.000	46.40000	864	103	57
314	LOVČENAPOLJCI	15.398	46.53333	420	83	19
315	ŠK. DUBINA/OSTREM	15.458	46.61300	870	85	39
319	PODURE	15.172	46.63167	760	82	35
324	RIENČANA/POHORU	15.233	46.54033	600	85	43
343	PTUJ	15.888	46.40028	235	94	48
345	ORUŠJANE	15.938	46.34600	241	83	37
350	VEREJ	16.170	46.58100	182	82	25

Table 4: Precipitation stations with not completely digitized data sets

#### HISTORICAL REVIEW OF METEOROLOGICAL OBSERVATIONS AND DATA:

Historically, the visual observation and monitoring of weather without instruments was performed sporadically and periodically across the world. In Croatia, the documentation of weather is older than two millennia. Records are found in monastery and town annals, in reports on historic events, battle descriptions, travel records, medical bulletins and elsewhere.

The beginnings of instrumental meteorological measurements in Croatia occur sporadically some twenty years before Galileo designed the thermometer with liquid in 1611. The bulk of these records are not in our meteorological data archives.

Meteorological observations unite two kinds of data – visual observations of weather phenomena such as clouds, atmospheric optical and acoustic phenomena, storms, etc. and instrumental data on temperature, humidity and pressure, wind direction and speed, precipitation amount, etc. Globally, such complex observations began during the 18<sup>th</sup> century. In Croatia they began in the first quarter of 19<sup>th</sup> century sporadically, and continuously in the second part of the same century. It can be said that systematic meteorological observations started in 1851, when observation data from Dubrovnik station were published in the meteorological yearbook of the Austro-Hungarian Empire. This station unfortunately did not operate continuously. The oldest Croatian station operating continuously is the Zagreb-Grič, established in 1861. Apart from the Zagreb-Grič, there are a number of stations which have a long tradition of collecting meteorological data: Osijek, Požega, Gospić, Crikvenica and Hvar. All the data recorded at these stations are saved on magnetic media and can be used for various purposes, such as climate change research.

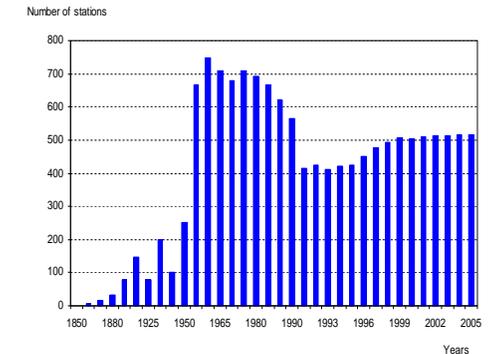


Figure 1: Total number of Croatian meteorological (main, ordinary and precipitation) stations.

The number of meteorological stations increased steadily up to the end of the 19<sup>th</sup> century, although there were frequent discontinuations of observations, mostly due to the moving of observers. By 1900, 168 meteorological stations were established.

During the period from the second part of the 19<sup>th</sup> century until 1991 (Croatian independence), Croatia was part of the Austro-Hungarian Monarchy and the former Yugoslavia, plus there were also two World Wars as well as the war in Croatia (1991-1995), and because of all these factors parts of the historical data records were irretrievably lost.

Before the establishment of the Meteorological and Hydrological Service of Croatia (MHSC) in 1947, meteorological observations were conducted by the Geophysical Institute, which is now a department of the Faculty of Science in Zagreb. Before Croatia gained independence in 1991, its meteorological service had been a part of the meteorological service in the former Yugoslavia.

#### PRESENT SITUATION OF METEOROLOGICAL OBSERVATIONS AND DATA:

The Meteorological and Hydrological Service (MHS) of Croatia consists of five divisions and three separate departments (Fig. 2). The general

meteorology division consists of two departments, the Meteorological Observations Department and the Data Processing Department. The main tasks of the Data Processing Department are: collecting, controlling, processing and storage of data, as well as climate monitoring.

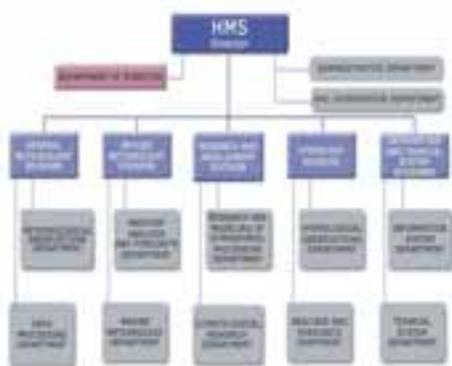


Figure 2: Organizational structures of the Meteorological and Hydrological Service

Today, the Croatian meteorological network consists of 41 main meteorological stations (MMS), 116 ordinary meteorological stations (OMS) and 336 precipitation stations (PS), 2 radiosonde and 8 radar stations and 34 automatic weather stations. Figure 3 shows the number of main, ordinary and precipitation stations (for the period 1947 – 2005) and Figure 4 the spatial distribution of the main and ordinary meteorological stations.

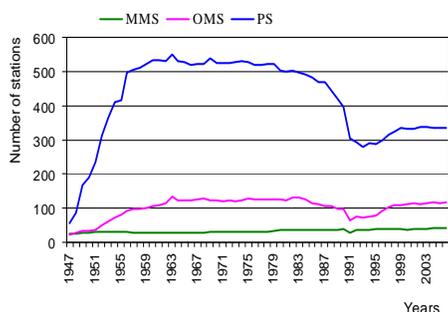


Figure 3: Number of main, ordinary and precipitation stations in Croatia



Figure 4: Spatial distributions of main and ordinary meteorological stations in Croatia

Climate monitoring started in Croatia in 1983. There is a special meteorological network for climate monitoring consisting of 30 meteorological stations. They are situated all over the Croatian territory, and have complete data series for the period from 1961 to 1990. For climate monitoring, the two most important meteorological elements, air temperature and precipitation amounts, are analysed. On a regular basis there are such analyses for every month, season and year. The results of the climate monitoring on a monthly basis can be found in a Bulletin, published since 1987, which also contains synoptic situations, hydrological, ecological, biometeorological, agrometeorological as well as hail suppression information. There is also version on CD, as well as on web site: <http://meteo.hr>. The results of climate monitoring on both seasonal and annual bases can be found in Reviews, published since 1983, as well as on the above web site.

For an example of such analyses for temperature on a monthly basis, Figure 5 shows air temperature anomalies in December 2007. The legend is as follows: white colour is about normal temperature

anomalies, above it is different blue colours that indicate cold, very cold and extremely cold, than normal values. Below white normal values is yellow, red and brown colours indicating warm, very warm and extremely warm. There are similar analyses for precipitation amounts. Figure 6 shows monthly precipitation amounts expressed as a percentage of normal values for the period 1961-1990. The legend is as follows: white colour is about normal precipitation anomalies, above it is yellow, red and brown colours indicating dry, very dry and extremely dry. Below white normal values are different green colours that indicate wet, very wet and extremely wet, than normal values.



Figure 5: Temperature anomalies in December 2007



Figure 6: Precipitation anomalies in December 2007

**DIGITIZATION, DATA RESCUE AND DATA STORAGE:**

Several actions to digitize data have been undertaken. Computer data processing and storage was introduced in Belgrade, former Yugoslavia, in 1968 and was situated there till 1980. At the very beginning, of computer data processing, the data were stored as punch cards. Over time, the technology of data processing has evolved and changed so that considerable parts of these data stored as punch cards were irretrievably lost.

In January 1981, computer data processing and storage of climatological data (measurements three times a day at 7, 14 and 21 hours local time), of the main meteorological stations, as well as ordinary climatological stations, started in Zagreb.

Ten years later, in January 1991, computer data processing and storage of all precipitation stations data were also started. In the same year, data entry of hourly values of different meteorological elements were carried out.

The data from the radiosonde stations have been stored on magnetic media since 1971. As a part of the Hydrological Operational Multipurpose System (HOMS), in 1984 digitalization of the recording rain gauge charts were started. Since 2005, different meteorological charts (thermograms, hygograms and barograms) have been digitised using a scanner.

It should also be mentioned that all requested software for input data checking and processing are made in our Service.

Data from main, automatic and radiosonde stations are received in digital form in real time. Climatological and precipitation stations data are operationally digitized from paper observation forms on a monthly basis. Historical data (climatological data before 1981, and precipitation data before 1991) are digitized as much as possible or on request.

The quality control of climatological data has several stages: 1) the validity check of data range, performed mostly during data digitization; 2) the check for completeness; 3) the check for climatological, internal and temporal consistency which is both automated and manual and 4) the check for spatial consistency that is only manual and, as such, highly subjective.

The data from the main meteorological stations are of better quality than those from climatological ones. The main reason is that the observers at the main meteorological stations are professionals while those from climatological stations are non-professionals.

The control of the historical time series is done using the same methods as the near real-time quality control, but takes certain additional features into account, such as historical changes in measurement times and units. Typical problems include missing or incomplete metadata and sparse neighbouring stations.

Once the quality control is done, the data are stored in a database and the data series can be tested for inhomogeneities and processed further, or could be used for different purposes.

Until 1999, all controlled and processed data have been stored in the MicroVAX computer, and since 1999 the data have also been stored in the UNIX operational system.

Historical data in different paper forms are stored in Zagreb (Figure 7) and at the main meteorological stations in Karlovac, Križevci (Figure 8) and Gospić.



Figure 7: Different types of meteorological archive stored in Zagreb



Figure 8: Different types of archive stored in Križevci

#### DATA ACCESS:

Controlled and processed data were stored in the MicroVAX computer until the end of 1999, and since then the data have also been stored in the UNIX operational system.



Figure 9: First page on the Intranet website



Figure 10: Chosen meteorological element – air temperature

Year	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
Jan	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-1.0	-1.1	-1.2	-1.3	-1.4	-1.5	-1.6	-1.7	-1.8	-1.9	-2.0	-2.1	-2.2	-2.3	-2.4	-2.5	-2.6	-2.7	-2.8	-2.9	-3.0	-3.1	-3.2	-3.3	-3.4	-3.5	-3.6	-3.7	-3.8	-3.9	-4.0	-4.1	-4.2	-4.3	-4.4	-4.5	-4.6	-4.7	-4.8	-4.9	-5.0	-5.1	-5.2	-5.3	-5.4	-5.5	-5.6	-5.7	-5.8	-5.9	-6.0	-6.1	-6.2	-6.3	-6.4	-6.5	-6.6	-6.7	-6.8	-6.9	-7.0	-7.1	-7.2	-7.3	-7.4	-7.5	-7.6	-7.7	-7.8	-7.9	-8.0	-8.1	-8.2	-8.3	-8.4	-8.5	-8.6	-8.7	-8.8	-8.9	-9.0	-9.1	-9.2	-9.3	-9.4	-9.5	-9.6	-9.7	-9.8	-9.9	-10.0	-10.1	-10.2	-10.3	-10.4	-10.5	-10.6	-10.7	-10.8	-10.9	-11.0	-11.1	-11.2	-11.3	-11.4	-11.5	-11.6	-11.7	-11.8	-11.9	-12.0	-12.1	-12.2	-12.3	-12.4	-12.5	-12.6	-12.7	-12.8	-12.9	-13.0	-13.1	-13.2	-13.3	-13.4	-13.5	-13.6	-13.7	-13.8	-13.9	-14.0	-14.1	-14.2	-14.3	-14.4	-14.5	-14.6	-14.7	-14.8	-14.9	-15.0	-15.1	-15.2	-15.3	-15.4	-15.5	-15.6	-15.7	-15.8	-15.9	-16.0	-16.1	-16.2	-16.3	-16.4	-16.5	-16.6	-16.7	-16.8	-16.9	-17.0	-17.1	-17.2	-17.3	-17.4	-17.5	-17.6	-17.7	-17.8	-17.9	-18.0	-18.1	-18.2	-18.3	-18.4	-18.5	-18.6	-18.7	-18.8	-18.9	-19.0	-19.1	-19.2	-19.3	-19.4	-19.5	-19.6	-19.7	-19.8	-19.9	-20.0	-20.1	-20.2	-20.3	-20.4	-20.5	-20.6	-20.7	-20.8	-20.9	-21.0	-21.1	-21.2	-21.3	-21.4	-21.5	-21.6	-21.7	-21.8	-21.9	-22.0	-22.1	-22.2	-22.3	-22.4	-22.5	-22.6	-22.7	-22.8	-22.9	-23.0	-23.1	-23.2	-23.3	-23.4	-23.5	-23.6	-23.7	-23.8	-23.9	-24.0	-24.1	-24.2	-24.3	-24.4	-24.5	-24.6	-24.7	-24.8	-24.9	-25.0	-25.1	-25.2	-25.3	-25.4	-25.5	-25.6	-25.7	-25.8	-25.9	-26.0	-26.1	-26.2	-26.3	-26.4	-26.5	-26.6	-26.7	-26.8	-26.9	-27.0	-27.1	-27.2	-27.3	-27.4	-27.5	-27.6	-27.7	-27.8	-27.9	-28.0	-28.1	-28.2	-28.3	-28.4	-28.5	-28.6	-28.7	-28.8	-28.9	-29.0	-29.1	-29.2	-29.3	-29.4	-29.5	-29.6	-29.7	-29.8	-29.9	-30.0	-30.1	-30.2	-30.3	-30.4	-30.5	-30.6	-30.7	-30.8	-30.9	-31.0	-31.1	-31.2	-31.3	-31.4	-31.5	-31.6	-31.7	-31.8	-31.9	-32.0	-32.1	-32.2	-32.3	-32.4	-32.5	-32.6	-32.7	-32.8	-32.9	-33.0	-33.1	-33.2	-33.3	-33.4	-33.5	-33.6	-33.7	-33.8	-33.9	-34.0	-34.1	-34.2	-34.3	-34.4	-34.5	-34.6	-34.7	-34.8	-34.9	-35.0	-35.1	-35.2	-35.3	-35.4	-35.5	-35.6	-35.7	-35.8	-35.9	-36.0	-36.1	-36.2	-36.3	-36.4	-36.5	-36.6	-36.7	-36.8	-36.9	-37.0	-37.1	-37.2	-37.3	-37.4	-37.5	-37.6	-37.7	-37.8	-37.9	-38.0	-38.1	-38.2	-38.3	-38.4	-38.5	-38.6	-38.7	-38.8	-38.9	-39.0	-39.1	-39.2	-39.3	-39.4	-39.5	-39.6	-39.7	-39.8	-39.9	-40.0	-40.1	-40.2	-40.3	-40.4	-40.5	-40.6	-40.7	-40.8	-40.9	-41.0	-41.1	-41.2	-41.3	-41.4	-41.5	-41.6	-41.7	-41.8	-41.9	-42.0	-42.1	-42.2	-42.3	-42.4	-42.5	-42.6	-42.7	-42.8	-42.9	-43.0	-43.1	-43.2	-43.3	-43.4	-43.5	-43.6	-43.7	-43.8	-43.9	-44.0	-44.1	-44.2	-44.3	-44.4	-44.5	-44.6	-44.7	-44.8	-44.9	-45.0	-45.1	-45.2	-45.3	-45.4	-45.5	-45.6	-45.7	-45.8	-45.9	-46.0	-46.1	-46.2	-46.3	-46.4	-46.5	-46.6	-46.7	-46.8	-46.9	-47.0	-47.1	-47.2	-47.3	-47.4	-47.5	-47.6	-47.7	-47.8	-47.9	-48.0	-48.1	-48.2	-48.3	-48.4	-48.5	-48.6	-48.7	-48.8	-48.9	-49.0	-49.1	-49.2	-49.3	-49.4	-49.5	-49.6	-49.7	-49.8	-49.9	-50.0	-50.1	-50.2	-50.3	-50.4	-50.5	-50.6	-50.7	-50.8	-50.9	-51.0	-51.1	-51.2	-51.3	-51.4	-51.5	-51.6	-51.7	-51.8	-51.9	-52.0	-52.1	-52.2	-52.3	-52.4	-52.5	-52.6	-52.7	-52.8	-52.9	-53.0	-53.1	-53.2	-53.3	-53.4	-53.5	-53.6	-53.7	-53.8	-53.9	-54.0	-54.1	-54.2	-54.3	-54.4	-54.5	-54.6	-54.7	-54.8	-54.9	-55.0	-55.1	-55.2	-55.3	-55.4	-55.5	-55.6	-55.7	-55.8	-55.9	-56.0	-56.1	-56.2	-56.3	-56.4	-56.5	-56.6	-56.7	-56.8	-56.9	-57.0	-57.1	-57.2	-57.3	-57.4	-57.5	-57.6	-57.7	-57.8	-57.9	-58.0	-58.1	-58.2	-58.3	-58.4	-58.5	-58.6	-58.7	-58.8	-58.9	-59.0	-59.1	-59.2	-59.3	-59.4	-59.5	-59.6	-59.7	-59.8	-59.9	-60.0	-60.1	-60.2	-60.3	-60.4	-60.5	-60.6	-60.7	-60.8	-60.9	-61.0	-61.1	-61.2	-61.3	-61.4	-61.5	-61.6	-61.7	-61.8	-61.9	-62.0	-62.1	-62.2	-62.3	-62.4	-62.5	-62.6	-62.7	-62.8	-62.9	-63.0	-63.1	-63.2	-63.3	-63.4	-63.5	-63.6	-63.7	-63.8	-63.9	-64.0	-64.1	-64.2	-64.3	-64.4	-64.5	-64.6	-64.7	-64.8	-64.9	-65.0	-65.1	-65.2	-65.3	-65.4	-65.5	-65.6	-65.7	-65.8	-65.9	-66.0	-66.1	-66.2	-66.3	-66.4	-66.5	-66.6	-66.7	-66.8	-66.9	-67.0	-67.1	-67.2	-67.3	-67.4	-67.5	-67.6	-67.7	-67.8	-67.9	-68.0	-68.1	-68.2	-68.3	-68.4	-68.5	-68.6	-68.7	-68.8	-68.9	-69.0	-69.1	-69.2	-69.3	-69.4	-69.5	-69.6	-69.7	-69.8	-69.9	-70.0	-70.1	-70.2	-70.3	-70.4	-70.5	-70.6	-70.7	-70.8	-70.9	-71.0	-71.1	-71.2	-71.3	-71.4	-71.5	-71.6	-71.7	-71.8	-71.9	-72.0	-72.1	-72.2	-72.3	-72.4	-72.5	-72.6	-72.7	-72.8	-72.9	-73.0	-73.1	-73.2	-73.3	-73.4	-73.5	-73.6	-73.7	-73.8	-73.9	-74.0	-74.1	-74.2	-74.3	-74.4	-74.5	-74.6	-74.7	-74.8	-74.9	-75.0	-75.1	-75.2	-75.3	-75.4	-75.5	-75.6	-75.7	-75.8	-75.9	-76.0	-76.1	-76.2	-76.3	-76.4	-76.5	-76.6	-76.7	-76.8	-76.9	-77.0	-77.1	-77.2	-77.3	-77.4	-77.5	-77.6	-77.7	-77.8	-77.9	-78.0	-78.1	-78.2	-78.3	-78.4	-78.5	-78.6	-78.7	-78.8	-78.9	-79.0	-79.1	-79.2	-79.3	-79.4	-79.5	-79.6	-79.7	-79.8	-79.9	-80.0	-80.1	-80.2	-80.3	-80.4	-80.5	-80.6	-80.7	-80.8	-80.9	-81.0	-81.1	-81.2	-81.3	-81.4	-81.5	-81.6	-81.7	-81.8	-81.9	-82.0	-82.1	-82.2	-82.3	-82.4	-82.5	-82.6	-82.7	-82.8	-82.9	-83.0	-83.1	-83.2	-83.3	-83.4	-83.5	-83.6	-83.7	-83.8	-83.9	-84.0	-84.1	-84.2	-84.3	-84.4	-84.5	-84.6	-84.7	-84.8	-84.9	-85.0	-85.1	-85.2	-85.3	-85.4	-85.5	-85.6	-85.7	-85.8	-85.9	-86.0	-86.1	-86.2	-86.3	-86.4	-86.5	-86.6	-86.7	-86.8	-86.9	-87.0	-87.1	-87.2	-87.3	-87.4	-87.5	-87.6	-87.7	-87.8	-87.9	-88.0	-88.1	-88.2	-88.3	-88.4	-88.5	-88.6	-88.7	-88.8	-88.9	-89.0	-89.1	-89.2	-89.3	-89.4	-89.5	-89.6	-89.7	-89.8	-89.9	-90.0	-90.1	-90.2	-90.3	-90.4	-90.5	-90.6	-90.7	-90.8	-90.9	-91.0	-91.1	-91.2	-91.3	-91.4	-91.5	-91.6	-91.7	-91.8	-91.9	-92.0	-92.1	-92.2	-92.3	-92.4	-92.5	-92.6	-92.7	-92.8	-92.9	-93.0	-93.1	-93.2	-93.3	-93.4	-93.5	-93.6	-93.7	-93.8	-93.9	-94.0	-94.1	-94.2	-94.3	-94.4	-94.5	-94.6	-94.7	-94.8	-94.9	-95.0	-95.1	-95.2	-95.3	-95.4	-95.5	-95.6	-95.7	-95.8	-95.9	-96.0	-96.1	-96.2	-96.3	-96.4	-96.5	-96.6	-96.7	-96.8	-96.9	-97.0	-97.1	-97.2	-97.3	-97.4	-97.5	-97.6	-97.7	-97.8	-97.9	-98.0	-98.1	-98.2	-98.3	-98.4	-98.5	-98.6	-98.7	-98.8	-98.9	-99.0	-99.1	-99.2	-99.3	-99.4	-99.5	-99.6	-99.7	-99.8	-99.9	-100.0

Figure 11: Mean monthly air temperature data for the period 1961 - 1990

The website provides an easy procedure to access weather, climate, agrometeorological and hydrological data, as well as actual data, weather forecasts materials and other relevant information (Figure 9). Figures 10 and 11 show one example of how to get climatological data. If you are interested in climatological data you should choose that option from the main menu (Fig. 9). After that, from the menu shown in Figure 10 you can choose meteorological elements you want. If you are interested in temperature data, then you choose that option and the result is as shown in Figure 10. Similar procedures apply for other meteorological information.

There is also the possibility to get the data for private or business purposes. There is a website and this website provides an easy procedure to access weather, climate and hydrological data from Croatia, whether they are needed for private or business purposes. The most commonly sought information is that concerned with the weather conditions (including weather forecast) and climatological data, and can be obtained in the textual or graphical form (tables, graphs etc) or in a form of your choice. The information provided must be paid according to the current price-list of the Croatian Meteorological and Hydrological Service. The price-list is provided with the offer. If you are satisfied with the terms and conditions of the offer, and after the payment is completed, the requested data and the invoice will be delivered by registered post within ten days (or e-mail if the request is urgent).

If the data requested are needed as for high school or university thesis, or for scientific research, they are free of charge, but written confirmation from the university is requested.

Figure 12: Part of inventory list of all meteorological materials stored in our archives

number, local number, geographical coordinates, height above sea level, period of observations, period of observations on magnetic media etc.). According to that list, about 50% of all existing meteorological data and information are stored on magnetic media.

There are some plans for digitalization of historical meteorological data, as well as their rescue. We would like to digitize the rest of the meteorological data as soon as we can. However, data rescue and digitalization are very complex and expensive processes and it will not be an easy task. The realization of this aim will depend on financial resources.

Web of the Meteorological and Hydrological Service of Croatia: <http://meteo.hr/>

## III.8. Digital records and data rescue in the Hydrometeorological Institute of Montenegro

Vera Andrijasevic, Hydro-meteorological Institute of Montenegro

### HISTORY:

The first systematic measuring of meteorological observations in free Montenegro was conducted on 1 September 1882 in Podgorica. The measurements included basic climate elements, atmospheric temperature, precipitation, humidity, pressure and wind direction. At the same time, during 1882, meteorological measurements started in the towns of Bar and Ulcinj for maritime purposes. As of 1887, measurements also started in the towns of Cetinje and Nikšić, and later on in other urban parts of the Principality of Montenegro. A central meteorological service in Montenegro was established in 1931 and was operational until 1941.

Upon adoption of a Decree on Establishment of Hydrometeorological Service in Montenegro, the Hydrometeorological Institute started with operations on 20 December 1947 as a governmental agency. Precipitation, maritime, meteorological, climatological, synoptical, agrometeorological and hydrological stations that were controlled by the army fell under the jurisdiction of the Hydrometeorological Institute.

Today, the Hydrometeorological Institute of Montenegro (HMZCG) is organized in four sectors with 114 full-time employees. In the network of stations including 120 meteorological stations, 40 hydrological stations, 36 water quality stations and 17 air quality stations, there are 49 full-time employees, with over a 100 part-time observers being engaged in observing, measuring and collecting meteorological, hydrological and ecological parameters. There are 65 employees working in expert units of the Institute in Podgorica.

### METEOROLOGICAL STATIONS:

The meteorological station network includes 10 main (2 airport stations), 18 climatological and 92 rainfall stations.

Measurements are taken every hour at the main stations. These data are received in the center in Podgorica every hour, and then synop messages are sent to the Global Telecommunication System. All observers have to fill in data in paper form in a prescribed format – a meteorological diary. In a database we enter only the data measured three times per day (at 7:00, 14:00 and 21:00 in CET). At the main stations apart from classical measurements with instruments, we have automatic weather stations. These stations have operated since 2002.

At climatological stations, observers take measures three times per day (at 7:00, 14:00 and 21:00 in CET). These data are entered into the meteorological diary and the database.

At rainfall stations, data are measured at 7:00 Central European Time (CET).



Figure 1: Meteorological stations

**DIGITIZED DATA:**

The Hydrometeorological Institute has been using the CLICOM program with Dataease for its database (DB) management system since 1987. There are forms for data entering and validation, tables with metadata (station ID, station name, latitude, longitude, altitude, the beginning and end date of observations, remarks, and the observation schedule), station elements, and derived data (monthly data, e.g., mean, extreme, sum, number of days with...),. All digitized data are available in two formats: Clicom DBM file and ASCII file.

All elements which are entered in the DB, are classified in data sets.

*Data sets*

- 001set- tmax, tmin, prcp, tmin5cm, sunshine-daily total amount, snow-amount and new (daily data)
- 002set- press, temp, temp wet bulb, rel hum, wind-direction, speed and intensity, visibility, cloud, ground condition (7:00, 14:00 and 21:00)
- 003set-daily averages calculated from 002set.
- 004set-type of precipitation, atmospheric occurrences-1-17 position
- 005set-wind gust-max speed, wind gust-direction (daily data)
- 006set-sea temp (7:00, 14:00 and 21:00)
- 007set-daily amount of precipitations
- 009set- ground conditions on 2, 5, 10, 20, 30, 50, 100cm depth (7:00, 14:00 and 21:00)

- 013set-max 10min wind speed, direction of max 10min wind
- 101set-wind- direction, speed and intensity (hourly data)
- 102set-temp of dry bulb (hourly data)

Tables 1, 2 and 3 show details of Montenegro meteorological network, type of stations and climatic elements that are digitized for various stations.

**ARCHIVE:**

Climatic data records in paper form are kept in the archives of Hydrometeorological Institute of Montenegro. The Archive was located in Niksic station. Most of the material is marked and stored in carton boxes.

station ID	station name	type of station	first year	dataset															
1342000	Podgorica-Golubovci	MAON	1978	001	002	003	004												
13461000	Bar	MAON	1949	001	002	003	004	005	006	009	013	101							
13459000	Herceg Novi	MAON	1949	001	002	003	004	005	006	009	013	101	102						
13465000	Kolašin	MAON	1949	001	002	003	004	005		009		101							
13458000	Nišić	MAON	1949	001	002	003	004	005		009			102						
13463000	Podgorica	MAON	1949	001	002	003	004	005		009		101	102						
13363000	Pljevlja	MAON	1949	001	002	003	004	005		009		101							
13457000	Tivat	MAON	1957	001	002	003	004												
13562000	Ulcinj	MAON	1949	001	002	003	004	005	006	009		101							
13361000	Zabljak	MAON	1958	001	002	003	004												

Table 1: Main meteorological station in Montenegro

station ID	station name	type of station	first year	dataset															
13ANDRIJ	Andrijevića	Climatological	2004	001	002	003	004												
13467000	Berane	Climatological	1950	001	002	003	004	005		009									
13458000	Budva	Climatological	1949	001	002	003	004		006										
13PETROV	Bečarica	Climatological	2003	001	002	003	004		006										
13BPOLJE	Bijelo Polje	Climatological	1950	001	002	003	004						009						
13CRKVIC	Čibucica	Climatological	1952	001	002	003	004												
13468000	Četina	Climatological	1949	001	002	003	004										009		
13DAHILJ	Đasirkevač	Climatological	1955	001	002	003	004												
13GRAHOV	Grabevo	Climatological	1953	001	002	003	004												
13KOTORS	Kotor	Climatological	1977	001	002	003	004		006										
13KRSTAC	Krstac	Climatological	1954	001	002	003	004												
13MOJKOVA	Mojkovac	Climatological	2000	001	002	003	004												
13PLAVO	Plav	Climatological	1966	001	002	003	004												
13PLUZOV	Pluzine	Climatological	1995	001	002	003	004												
13ROZAJE	Rozaje	Climatological	1968	001	002	003	004												
13SAVNIK	Savnik	Climatological	1999	001	002	003	004												
13VELIMO	Velimlje	Climatological	1954	001	002	003	004												
13VIRPAZ	Virpazar	Climatological	1951	001	002		004												

Table 2: Climatological network in Montenegro



- Unconformity with Windows and Network environment;
- Impossibility of automatic entering of data received from AWSs;
- Impossibility of storing different types of information;
- Non – existence of proper tools for data utilization and processing.

According to the recommendations of the World Meteorological Organization (in May, 2002), the Czech database CLIDATA is suggested as optimum for this region, mainly due to the fact that the CLIDATA system was designed to replace the old CLICOM system. It is intended for the archiving of climatology data, for data quality control and for the administration of climatology stations and station observations. Due to the above mentioned situation, our Computer Centre is facing many technical difficulties concerning the loading, retrieving and archiving of the data.

#### ADVANTAGES OF CLIDATA:

CLIDATA offers a wide range of services:

- Data Quality and Control
- Data Validation
- Data Acquisition
- Archiving of Climatology Data
- Automatic Data Processing
- Rainfall Intensity Charts
- Precipitation and Runoff Model Support
- User Defined Extreme Values
- Output Products
- Geographical Information System
- Climatological Database Network
- Customized Data Import

- User Friendly Graphical Interface
- Easy Data Management
- High Level of Security

The big advantage of the system is the well-developed data quality control functions. All daily data stored in the database go through series of flexible procedures in order to check primary data and set them a quality flag. The system forbids the changing of validated data. Three levels of control mechanism are applied in CLIDATA:

- by definition
- by quality control formula
- by spatial analyses

#### DARE ACTIVITIES:

One of the more important DARE activities at the Hydrometeorological Institute of Montenegro is the development of a climatological database. We estimate that it will take about two years to make this feasible. This means that we need time to develop a training program, import all digitized data from CLICOM and construct procedures for quality control. Through this project we plan to digitize the available historical data.

## Climate Data Rescue in the National Institute of Meteorology and Hydrology of Bulgaria

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#### INTRODUCTION:

The first systematic instrumental meteorological observations in Bulgaria were carried out most probably about the mid-19<sup>th</sup> century, according to the available sources (*M. Borisov et. al., 1988*). In the course of six months (from February to July 1850) air temperature was measured 3 times daily in the town of Koprivshitsa. After the year 1860 several attempts were made to organize instrumental observations of the basic meteorological elements, but they were carried out for short periods at different locations in the country.

On the 1<sup>st</sup> of February 1887 the first Bulgarian meteorological station was opened in Sofia and regular observations started a month later on the 1<sup>st</sup> of March. The Bulgarian Meteorological Service (BMS) was established in 1890. In 1894 the BMS managed 15 second-class and 8 third-class meteorological stations as well as 60 precipitation stations on the territory of the country. The number of the stations did not increase rapidly, and at the end of 1928 the meteorological network included 69 meteorological and 174 precipitation stations (*Andreev, 2004*). According to Kirov, (1950) significant enlargement of the national meteorological network took place during the period 1929–1930, as well as in the next several years. In 1950 the total number of the stations reached the figure of 570 stations (160 meteorological stations from first to forth class and 410 precipitation stations). The number of the stations continued to gradually increase, but in the 1990s started a declining in the number of operational stations, as many meteorological and precipitation stations were closed due to the lack of sufficient financial recourses.

The climate records held in paper form from the beginning of the measurements in the Bulgarian meteorological network are stored in the

Meteorological Archive of the National Institute of Meteorology and Hydrology (NIMH).

The digitization of the climate records began at the end of 1970s (punched cards were used for this purpose). In 1976 the Computing Centre of NIMH was opened and during the next several years the data from the punched cards were transferred into magnetic tapes and disks. In 1992 the Computing Centre was closed and NIMH switched to personal computers. In the meantime, the available digitized information was transferred to diskettes, and actually the development of a meteorological database (MDB) started using Relational Database Management System (RDBMS) ORACLE 5.2 in the environment of DOS (*Kanarchev, Terziev 1991*).

At the end of 1999, all possibilities for further development of MDB were used and it was decided to continue to work with other database software: The RDBMS MS SQL Server, version 7.0 in the environment of Windows NT Server version 4.0, in view of its lower price in comparison with the ORACLE products. It turned out that the decision was very appropriate not only from a financial point of view but also with regard to the database management and activities. The staff of the Meteorological Database Management Division (MDBMD) gained experience by using it, as well as from the experience of other countries working with relational databases for climatological purposes (*Climate Databases in Europe, 1996*). A lot of work was done in MDBMD in the next several years, such as: building the structure of the new database Meteodb (basic, code and meta tables), data transfer from the old ORACLE database into Meteodb, standardization of the programs for meteorological data digitization in view of its import into the new database, development of programs for processing of all digitized data in old formats in order to be imported into the database, etc.

From the beginning of 2002 to the end of 2005 the main activities concerning MDB were carried out within the framework of a project from the scientific

plan of the NIMH. For the time being RDBMS MS SQL Server 2000 is used in the environment of Windows Server 2003.

Thus, data rescue activities in the NIMH include preservation of all climate data and corresponding metadata, collected in the national meteorological network on the territory of Bulgaria and their transfer from paper records to digital form in order to be imported into relational database for easy access according to the recommendations of the World Meteorological Organization (WMO) – *WCDMP Report No. 49 (2002)*, where the definition of Data Rescue is given. The Guidelines on Climate Data Rescue by *Tan et al., 2004* is another important and helpful document with respect to data rescue process.

In the paper data rescue status in NIMH of Bulgaria is presented and the main problems are pointed out. The lack of sufficient human and financial resources is the greatest obstacle to the Bulgarian data rescue process concerning the necessity of faster digitization of climate data available only in paper format and the generation of a digital-images archive of all climate records, including the tape records from self-recording devices.

#### PRESERVATION OF PAPER RECORDS:

The paper records of NIMH as a part of the Bulgarian Academy of Sciences Archives are under protection of the Public Record Law in the country, reflected in the NIMH Regulations. Thus, the climate data records in paper form are stored in the Meteorological Archive of NIMH from the beginning of the measurements.

In 2002 all paper records were moved into appropriate building where the temperature-humidity conditions correspond to the requirements for such type of premises. Most of the materials were put into cardboard (Figure 1a) or plastic boxes (Figure 1b) in view of their preservation.



Figure 1: Meteorological archive of NIMH

In this regard, a full inventory of the paper records was made and the gaps in the long-term climate series were estimated (for synoptic and climatological stations they are less than 5 % while for precipitation stations they are about 10 %).

Frequent use of climate data, available only in paper form, and deterioration of this medium as well, has caused the destruction of some records (Figure 2).

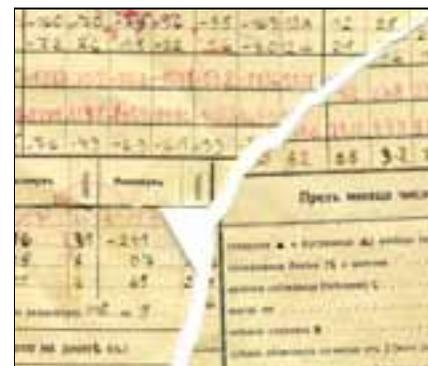


Figure 2a: Partially destroyed climatic table K-4 from the Meteorological Archive of NIMH.

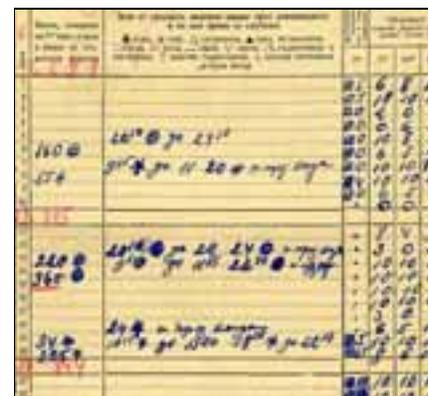


Figure 2b: Partially destroyed precipitation diary from the Meteorological Archive of NIMH.

That is why the creation of a digital-images archive of all climate records, including the tape records from self-recording devices, is of the first importance and has to be started as soon as possible. Unfortunately, the lack of sufficient financial resources does not allow implementation of this preservative action at the moment.

Digital-images archives of historical climate records have been created in different parts of the world in the framework of international Data rescue projects including WMO projects (*Page et al., 2004*), i.e. the necessary funds could be provided through

appropriate projects at the national, regional, European levels.

#### DIGITALIZATION OF CURRENT AND HISTORICAL DATA:

Current data from 40 (the total number is 44) synoptic stations (8 synoptic and 3 climate obs/day), 91 voluntary climatological stations (3 climatic obs/day) and 243 voluntary precipitation stations (1 obs/day), presented on Fig.3, are digitized at the Hydrometeorological observatories or at the Regional Centres of NIMH in Pleven, Varna, Plovdiv and Kjustendil.

Historical data from the Meteorological Archive of NIMH are digitized by the technical staff of MDBMD.

Data transfer to computer-compatible form is completed by means of specialized programs (Table 1) with ASCII output for direct import into corresponding tables of the meteorological database Meteodb (RDBMS MS SQL Server 2000).

Programs	Data
SYNOPT	Hourly synoptic data (02, 05, 08, 11, 14, 17, 20, 23 h local times)
SVK	Hourly climatic data (07, 14, 21 h local times); Atmospheric phenomena
SOT	Hourly soil temperatures (07, 14, 21 h local times)
RJO	Daily data from precipitation stations (07 h local time)

Table 1: Programs for digitization of meteorological data

These programs execute data entering, correcting and examining, as well as verification for incorrect symbols, syntax errors, permissible values of elements, belonging to a certain interval of values or code table, etc.

Standard applications are also used (MS Excel, Pe2) to digitize hourly data for sunshine duration and total solar radiation.

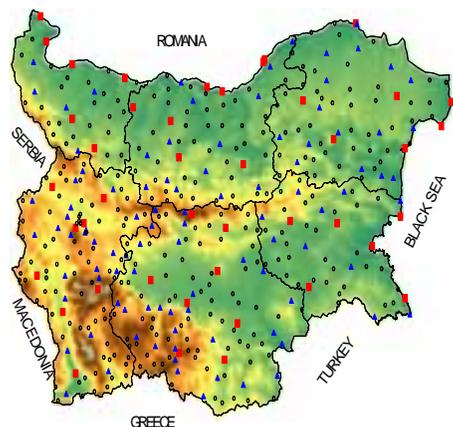


Figure 3: Meteorological network of NIMH in Bulgaria: synoptic (squares), climatological (triangles) and precipitation (circles) stations

The results from the inventory of digitized climate records as well as of all available paper records from the three types of meteorological stations (synoptic, climatological and precipitation) are given for particular years in Table 2. The inventory is made separately for synoptic and climatic observations carried out at different local times in synoptic stations (they coincide only at 14.00 h local time).

Sample date	Synoptic stations		Climatological stations		Precipitation stations	
	Paper	Digitized data synoptic obs.	Paper	Digitized climatic obs.	Paper	Digitized
Jan 1901	–	–	32	3	82	19
Jan 1931	–	–	91	48	216	74
Jan 1961	21	–	208	160	585	130
Jan 1991	39	–	147	141	334	334
Jan 2006	43	39	96	96	296	296
Jan 2008	44	40	91	91	243	243

Table 2: Number of stations with paper records and digitized data referred to different sample dates from the period 1901–2008.

Summarized information about the proportion between digitized climate records and those available only in paper form is presented in Table 3, where the periods with digitized and non-digitized climate records for synoptic, climatological and precipitation stations are given.

Type of the station	Time resolution of the records	Length of digitized records	Length of records available only in paper form
Synoptic stations	8 synoptic obs/day	2000–2007	From the beginning of the respective measurements until 1999.
	3 climatic obs/day	From the beginning of the last century until now. There are missing periods before 1991 (days, months or years), available only in paper form.	Separate days, months, years for some of the stations before 1991, available only in paper form.
Climatological stations	3 climatic obs/day	From the beginning of the last century until now. There are missing periods before 1991 (days, months or years), available only in paper form.	Separate days, months, years for some of the stations before 1991, available only in paper form.
Precipitation stations	1 obs/day (cloudiness) – 3 obs/day	1960–2007	From the beginning of the respective measurements until 1959.

Table 3: Length of digitized and non-digitized climate records.

Regarding to the proportions between digitized data and the information available only in paper form, it is obvious that a lot of work has to be done to digitize the paper records from synoptic (climatic observations), climatological and precipitation

stations especially before the year 1960. Much more serious is the situation with the data from synoptic stations (synoptic observations) digitized since 2000 with some exceptions. Thus, digitization of the past climate data, available only in paper form, will not be completed by the technical staff of MDBMD in the near future.

Also the tendency of decreasing the number of climatological and precipitation stations on the territory of the country can be seen in Table 2. Actually in the 1990s and onwards, many stations were closed for financial reasons and this process continued during the last years. After January 2006, one synoptic station was opened but 5 climatic and 53 precipitation stations were closed. This year we are facing the same problem.

#### STATIONS HISTORY:

All synoptic, climatological and precipitation stations have files with paper records including station description and detailed information about their activities since the beginning of the respective measurements till now.

Stations documents are digitized by means of MS Excel but this process is not entirely completed and, besides, there are some omissions in the stations history (metadata). For this reason efforts to update the files of the stations are made in the Regional Centres of NIMH in view of the importance of metadata for data processing in meteorological database MeteoDB, as well as for homogenizing long-term climate series, which is one of the main tasks in the next several years.

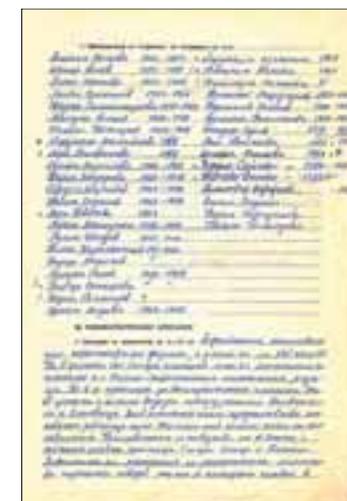


Figure 4a,b: Digitized documents from the file of Sofia-CMS (starting date: 1 January 1952)

In 2006 an initiative for scanning the documents from the files of the stations started and, at present, almost the half part of the work has been completed. Digital images of some documents from the file of the Central Meteorological Station in Sofia (Sofia-CMS) are presented on Figure 4.

## METEOROLOGICAL DATABASE METEODB:

### Database structure

The structure of database Meteodb consists of basic, code and meta tables (Marinova and Fidanova, 2006), presented on Fig.4. Current and historical meteorological information is imported into the basic tables. They contain only row data (hourly, daily). Almost all digitized historical data has been stored in Meteodb with the exception of the old-format digitized information from precipitation stations (mostly before 1971) – for example, the biggest basic table H\_CLIM contains more than 12.5 millions rows or about 11400 station years.

The different codes used to enter data into computer-compatible form are stored into the code tables with the corresponding descriptions.

The first three meta tables, shown in table 4, include information about identifier number of the stations, their names and specific measurements in some of the stations (sunshine duration and soil temperature), which are necessary for data processing in Meteodb.

The common meta table STATION is partially filled up and it contains detailed information about the stations (identifier number, name, geographical location, type, changes of type, land use around the station, measuring instruments, moving, interruption periods, etc.).

Name	Description
<b>BASIC TABLES</b>	
H_SYNOP	Hourly synoptic data – 02, 05, 08, 11, 14, 17, 20, 23 h local times
H_CLIM	Hourly climate data – 07, 14, 21 h local times
PHENO	Atmospheric phenomena
H_SD	Hourly sunshine duration data
H_SOILT	Hourly soil temperatures – 07, 14, 21 h local

	times
RAIN	Data from precipitation stations – 07 h local time
<b>CODE TABLES</b>	
KODC_CH	Type of high clouds – climatological stations
KODS_CH	Type of high clouds – synoptic stations
KODC_CM	Type of middle clouds – climatological stations
KODS_CM	Type of middle clouds – synoptic stations
KODC_CCU	Type of cumulus – climatological stations
KODC_CST	Type of stratus – climatological stations
KODC_CNS	Type of nimbostratus – climatological stations
KODS_CL	Type of low clouds – synoptic stations
KOD_RK	Type of precipitation
KODCR_PHENO	Type and intensity of atmospheric phenomena – climatological and precipitation stations
KODC_PHS_PHE	Starting and ending of atmospheric phenomena – climatological stations
KODS_WW	Weather at the moment of observation or during the last hour – synoptic stations
KODS_WP	Past weather – synoptic stations
KODC_ES	Soil condition – climatological stations
KODS_ES	Soil condition – synoptic stations
KODS_ESS	Soil condition under snow – synoptic stations
KODC_S	Snow cover depth – climatological stations
KODS_S	Snow cover depth – synoptic stations
KODS_BT	Character of barometric tendency
KOD_FLAGS	Quality flags
KODC_VIS	Mean horizontal visibility – climatological stations
KOD_WD	Wind direction

KOD_WS	Wind speed
<b>META TABLES</b>	
STATION_SYNOP	Synoptic stations
STATION_CLIM	Climatological stations
STATION_RAIN	Precipitation stations
STATION	Synoptic, climatological and precipitation stations

Table 4: Basic, code and meta tables in Meteodb

### Main activities in Meteodb

#### Standard data processing

Data processing is completed by specially developed storing procedures written in Transact-SQL (Fig.5). The basic conception, accepted for data processing in Meteodb, is to work with one station for a fixed period of time – month, year or several years, taking into consideration particular missing values of meteorological elements or dates, as well as particular whole months and years. At present, if there are missing values in a data set, the corresponding daily, monthly or annual categories are not calculated as the results will not be correct. More than 70 stored procedures for standard meteorological data processing were developed, as follows:

- Daily, decade, monthly or annual mean/sum of the different meteorological elements;
- Monthly and annual reports for different meteorological elements on the basis of data from all available stations in the database or for a station for a certain period.

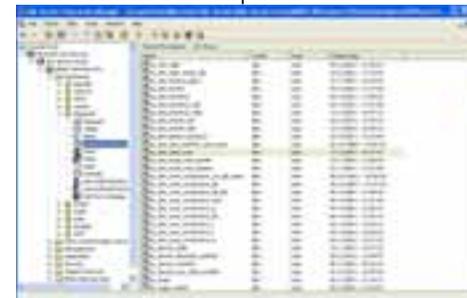


Figure 5: SQL Server Enterprise Manager – Transact-SQL stored procedures menu

The monthly and annual reports for the basic meteorological elements, measured in 2006 at Sofia-CMS, are presented in Figure 6.

#### Data quality control

It is regularly completed, as follows: Verification for missing observations, missing values of a certain meteorological element or parameter, permissible values and intervals of variation, correspondence with the code tables, etc.; Expert control on the basis of monthly and annual reports and comparison with meteorological stations – analogs.

#### Standard and specialized customer requests

Standard data requests are completed by using stored procedures for standard meteorological data processing. In case of non-standard requests specialized stored procedures are developed, in order to improve services for the users of meteorological information.

#### Applications

Currently, two applications are used in MDBMD: *MDBCOR* – Data corrections in Meteodb; *MDBLight Meteodb data visualization* (spatial presentation of meteorological parameters on the map of Bulgaria).

These applications use directly the results of the execution of specially developed Transact-SQL stored procedures. In case of need the results are stored into temporary tables and in this way the corresponding application can be used by many users.

СОФИЯ-ЦЕНТЪР, 2006 г. МЕСЕЧНИ И ГОДИШНИ ИЗВОДИ														
МЕСЕЦ	ТЕМПЕРАТУРА НА ВЪЗДУХА, °C					БРОЙ ДНИ С								
	7	14	21	СРЕДНА	МАКС.	7	14	21	СРЕДНА	МАКС.				
Януари	-1.2	0.0	-2.2	0.8	-0.4	0	0	0	0	0				
Февруари	0.1	1.0	0.5	0.9	0.4	0	0	0	0	0				
Март	1.5	2.5	1.8	1.9	1.4	0	0	0	0	0				
Април	4.2	5.5	4.5	4.7	4.1	0	0	0	0	0				
Май	7.8	9.5	8.5	8.6	8.1	0	0	0	0	0				
Юни	11.5	13.5	12.5	12.5	12.0	0	0	0	0	0				
Юли	15.2	17.5	16.5	16.4	15.9	0	0	0	0	0				
Август	18.5	20.5	19.5	19.5	19.0	0	0	0	0	0				
Септември	15.0	16.5	15.5	15.7	15.2	0	0	0	0	0				
Октомври	10.5	12.0	11.0	11.2	10.7	0	0	0	0	0				
Ноември	6.5	7.5	6.5	6.8	6.3	0	0	0	0	0				
Декември	1.5	2.5	1.5	1.8	1.3	0	0	0	0	0				
Год.	7.5	14.3	9.7	10.3	15.6	5.5	36.0	20	-18.7	8	22	94	63	

Figure 6: Monthly and annual reports for Sofia-CMS from MeteoDB

Air temperature deviations (°C) in January 2007 from the mean monthly values, relative to the period 1961–1990 and for representative meteorological stations, are shown on Fig.7. Another map concerning precipitation in % in August 2007 from the mean monthly sums for the same period is presented on Fig.8. The period 1961–1990 is recommended by WMO for determining the norms of the different meteorological elements.



Figure 7: Air temperature deviation (°C) in January 2007 from the mean monthly values relative to the period 1961–1990.

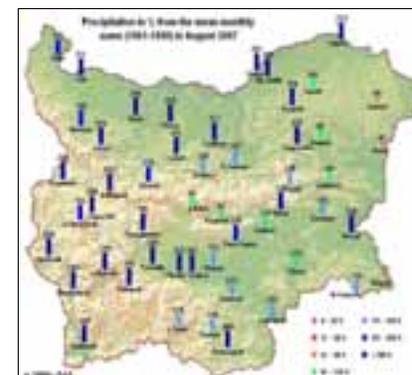


Figure 8: Precipitation totals in August 2007 in % from the mean monthly sums relative to the period 1961–1990.

Similar maps, presenting air temperature and precipitation distribution over Bulgaria, can be obtained by the application MDBLight for particular years, as well as for longer periods. Also, there are possibilities for developing specific maps.

Data transfer from the Regional Centres of NIMH and Meteorological Archive of NIMH into MeteoDB and the main database activities are shown on Fig.9. As can be seen the specially developed Transact-SQL stored procedures are very important part of MDB – they select the necessary information from database tables and actually through them the main activities in MeteoDB are performed.



Figure 9: Scheme of data transfer into MeteoDB and main database activities

Also it has to be pointed out that only raw meteorological data is imported into the database, while processed data for different purposes is obtained by stored procedures. In this regard, processed information is not stored into the database.

**DATA ACCESS:**

The data from Meteorological database of NIMH is freely available for:

- Operational activities and scientific investigations in NIMH and the Regional Centres of NIMH.

### III.10. Data Rescue Operations at Hellenic National Meteorological Service

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Hellenic National Meteorological Service, Division of Climatology-Applications

- National Assembly, Presidency, Council of Ministers and Ministries, State Agencies, Court, Investigation, Prosecutor's Office, Police, social services, regional and municipal authorities with the exception of the data requests through the mentioned institutions in connection with financially supported projects, for experts in civil trials, etc.
- The lack of sufficient human and financial resources is the greatest obstacle to the data rescue ongoing process. The national/regional/European DARE project implementation seems to be the best solution.

#### ACKNOWLEDGEMENTS:

The author is thankful to P. Simeonov, V. Alexandrov, T. Petrova and S. Radeva for their support in preparing the present paper.

With the exception of the cases explicitly mentioned in the NIMH Regulations, when meteorological information is free of charge, in all other cases it is upon payment.

#### CONCLUSIONS:

With respect to the data rescue status in NIMH of Bulgaria the following conclusions can be drawn:

- At present, paper records are stored under favourable conditions, but the materials of early dates as well as those being in use more often are not in good state. That's why creating of digital-images archive of all paper records, including the tape records from self-recording devices, is of the first importance and has to be started as soon as possible.
- It is necessary to expedite entering of current and past data, available only in paper form, into computer-compatible form in order to import them into meteorological database of NIMH Meteodb.
- Almost all available digitized data is imported into Meteodb with the exception of the old-format digitized information from precipitation stations, mostly before 1971.
- It is very important to update the files of the stations with regard to data processing and homogenization, and in this way, to complete metadata digitization and importation into the database. These activities are carried out in the regional Centres of NIMH in Pleven, Varna, Plovdiv and Kjustendil.

#### ABSTRACT:

This paper describes data rescue (DARE) operations of historic meteorological data at Hellenic National Meteorological Service (HNMS).

DARE is helping meteorologists improve their forecasts, study extreme weather phenomena better, and have a better understanding of local climate. Engineering design of various structures is safer if longer hydrological and wind records are used in the calculations. Farmers benefit greatly by getting more accurate forecasts, which guide them significantly in planting and harvest. Finally, DARE may assist in disease prevention.

HNMS started DARE operations in summer 2007 and first priority was to locate and collect data records, organize them, and store them in air-tight plastic containers to protect them from further deterioration. Preliminary tests are underway in order to decide optimal settings for scanning or photographing different categories of documents found while a complete plan of action gets formulated. Future steps will be to complete digitization, do data entry, quality control and homogenization, data correction, and finally data merge thus creating a unified database.

When the DARE process is completed data time series are expected to grow by several years. New database created will be greatly enhanced and become more useful.

#### INTRODUCTION:

HNMS was founded in 1931 under the Ministry of Aviation. Today it operates under the auspices of the Air Force General Staff of the Hellenic Ministry of Defence.

HNMS mission is to provide meteorological support to national defense and national economy for the

safety of life and property. It is staffed both by military and civilian personnel working in its central headquarters and several meteorological stations throughout the country.

HNMS has developed many collaborations with universities, research institutes, governmental agencies, and ministries on various projects aimed at improving the services provided to its customers and society and promoting research. Finally, HNMS has established close cooperation with various European and international bodies and represents Greece in WMO, ECMWF, EUMETSAT, EUMETNET, ECOMET, ICAO, and NATO (HNMS Website: <http://www.meteo.gov.gr>).

Since 1900, HNMS and its predecessor had established over 150 meteorological stations. Many of them were closed due to human resource reallocations, budget cuts, change in land use or moved to new location.

Currently the central database contains data for 99 synoptic, 73 climatological, 3 upper air, 42 agricultural, and 36 automatic weather stations (see Figure 1). Stations currently in operation are shown in Figure 2. It should be noted that the chart contains two additional types of stations, namely, 10 buoys and 9 operating aboard commercial ships all under Greek flag, which send in regular observations. In the past as many as 30 ships sent their observations to HNMS but for unknown to us reason their number has decreased significantly.

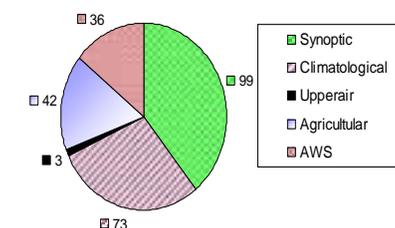


Figure 1: Stations with digitized data

Data records cover measurements of parameters typically taken every three hours for synoptic stations

and three times a day for climatological stations. Data for synoptic and climatological records stored in HNMS database start in the 1950s. On the other hand, agrometeorological observations were digitized at a later period, namely, in 1977, and ship data is available in digital form since 1988.

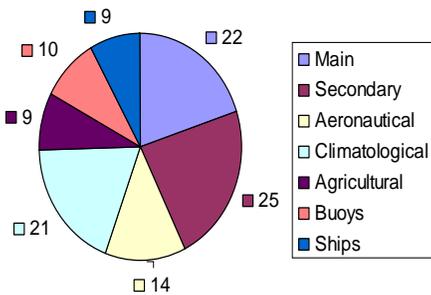


Figure 2. Active stations

Currently data entry has been completed through 2004 and quality control has gone through 2003 for all station types except climatological, where data are checked and corrected through 1997. All data has been organized in 50 database tables accessible by direct or embedded SQL code.

Historical data exists for about 152 stations in paper form for the period of 1900-1950. Despite the fact that data recorded are not continuous and contain gaps, they should nevertheless be digitized the soonest so they become available to the public while they are most useful.

#### COMPUTER SYSTEM:

The computing system of HNMS prior to the Athens Olympic Games in 2004 was upgraded significantly. Technical characteristics and features of new database system are as follows:

##### Technical Characteristics of HNMS DBMS

- HP-UX Server (model RX5670)
- Empress version 8.62
- 4 processors

- 8 GB memory
- 2 disks (mirrored)
- 0.5TB capacity
- MARS2 (Meteorological Archiving Retrieval System)

##### Features:

- RDBMS
- JDBC/ODBC
- DSQL
- C++
- SPSS scripts
- 15 clients.

Besides Empress, additional databases used at HNMS are:

- Oracle—used with AWS
- DatClim/DATBAS—used for producing climatological reports (FORTRAN-based)
- MetStationDB—contains station metadata (MS Access-based)
- MS EXCEL sheets (used in the Department of Hydrology).

Finally, newly developed Java-based programs are used for data entry and SPSS scripts are used to compute climatological parameters on demand.

Following sections present information about historical data, arguments about the need to rescue old data, and describe first HNMS data rescue efforts, operations currently underway, problems encountered and the future work planned.

#### HISTORICAL METEOROLOGICAL DATA IN GREECE:

As mentioned above, vast amounts of historical meteorological data exist in paper form for 152 weather stations. Period covered is 1900-1950 for synoptic stations and 1930-1970 for climatological stations.

In addition to HNMS many other governmental organizations such as the National Observatory of

Athens (NOA), the Department of Agriculture, universities, private companies like the Electric Power Company, and groups of amateurs operate manual or Automatic Weather Stations throughout the country but their data is not in any way used by HNMS. Incidentally, NOA maintains records that date back to the mid of the 19<sup>th</sup> century (1863) and has been digitized in its entirety (Dimitra Founta of National Observatory of Athens, private communication).

Since data collected by each organization mentioned above is not being stored in a central location accessible by all, DARE operations at HNMS discussed here are merely a subset of DARE operations in Greece.

To the best of our knowledge there hasn't been yet a concerted effort to unite all weather data owned by different organizations in the country. The only exception is weather observations recorded in ships or buoys, which are channelled systematically to HNMS databases. Data coming from other sources are available, with great delays, upon special request and for a specific project.

Finally, it was reported recently that for parts of Greece previously occupied by the Austro-Hungarian, the French, the Russian, the British and the Ottoman Empires there exist meticulous sets of meteorological records which cover the occupying periods (Allan, 2007). Some of the places mentioned in this report are Thessaloniki, Rhodes, Corfu, Ioannina, and Lekane (near Souda).

There is definitely a great need to develop a single database containing all available weather data collected in Greece, old and new. However this is a Herculean task which will take time and money to complete. Experience shows that most organizations tend to guard their data and are unwilling to share it under a common platform.

Typically, digitization of weather-related data lagged behind data collection. This is due to the fact that in many cases digitization started as soon as computer equipment became available. As the digitization

process proceeded forwards in time significant amounts of records in paper form were left behind. Despite the fact DARE may be a somewhat boring, tedious process the benefits from digitizing old records cannot be overstressed.

#### WHY RESCUE METEOROLOGICAL DATA?

There are some very good reasons for rescuing and digitizing historical data. Some of them are the following:

- Forecasting models are more accurate when longer time-series are used.
- Extreme weather phenomena are studied more thoroughly.
- Design of engineering projects which critically depends on weather measurements is more reliable when very long climatological records are used. Structures like bridges, water reserves, tall buildings etc., whose behavior depends greatly on hydrological or wind properties, are safer if during their design process longer weather records were taken into consideration.
- Accurate weather forecasts are very helpful to farmers as they can be a safe guide to them in planting or during harvest.
- Better study of weather inflicted epidemics is done. Lack of early warning signals may be detrimental, cause great damage, and kill many people.
- The study of periodic events for a particular geographical region improves greatly when longer records are analyzed.
- Finally, we have better understanding of local climate when we look at more data.

## DATA RESCUE OPERATIONS AT HNMS:

### *Early Work*

Data rescue at HNMS started in summer 2007 and has since become an ongoing process. Earlier, a meteorological stations database was created which contains useful metadata about the entire meteorological network. It will be of great help as DARE develops.

Initially HNMS DARE project employed a small group of people. Their job amounted to locating and collecting paper records produced prior to 1950, which were grouped by station, and doing a detailed inventory. They next stored the logs in air-tight plastic containers to protect them from further deterioration from high humidity, mold, or vermin.

Paper records were found spread out in various locations within HNMS headquarters and the task of collecting and grouping them will be time consuming and expected to last for a long time. The earliest records found start in 1840 and at logs for Athens station, which since its opening moved many times.

During the initial phase of the project, which lasted a few months, the team already managed to gather enough material to fill several large plastic containers, each one containing documents mostly filled with monthly data from about 152 meteorological stations. It is worth mentioned that the DARE team during their search found out that many years ago a significant amount of paper records were destroyed or sent for recycling as they were considered useless.

It should be noted that to this date only 3-hour SYNOP data are stored in HNMS central database. Both METARs, which are sent every half hour, and CLIMATs, which are sent once a month, are saved in temporary locations. Recently developed web-based software enables access to these data as well, which covers the period of 2003 to today.

Daily and monthly data for most parameters are computed on demand. Some monthly data for a few

parameters exist which are stored in smaller databases developed and maintained by Hydrology and Agrometeorology Departments and do not always cover the entire period of operation of the meteorological network.

HNMS is currently developing its first genuine climatological database which will contain data computed on a daily, monthly, etc. basis. Rescued data should be eventually stored side-by-side for research and other purposes.

### *Current Focus*

The success of the DARE project will depend greatly on systematic uninterrupted work, continuous funding and appropriate human resource allocation.

Early on, it was deemed necessary to understand in depth all aspects of the project. Good methodology and long term planning will streamline operations and save effort and time. DARE is a step-by-step process and must be carried out methodically over time.

Accumulation of data has recently slowed down until a complete plan of action gets formulated. Current focus is to lay out an optimal plan of future work, always taking into consideration results from in-house tests and the accumulated experience of similar to HNMS organizations in foreign countries.

In order to decide how DARE will be finally carried out, heavy testing is necessary. Making crucial decisions early on contributes greatly to the overall success of the project

## PROBLEMS:

### *Issues Surfaced*

Due to limited funding at the beginning stages of the project, it was decided to first carry out DARE operations by making use of existing equipment. Therefore, an A3 flatbed scanner was used to carry out various tests and estimate data storage requirements.

During testing, several issues surfaced which require immediate attention. Some of the questions raised along with respective answers are listed below:

*Q: What should the first steps be in HNMS DARE project?*

*A:* Identifying possible locations of old documents should be the first task. Interviews with elder co-workers may provide very useful information and speed up the process. So far documents were either found stored in various closets throughout the central headquarters or piled up in boxes in the old archive room. Additional storage locations may be uncovered as the search continues so one must keep on searching again and again.

*Q: Should the scanner create color or black and white images?*

*A:* Color images take up more space, nearly double according to some early tests, but preserve more information. For example, in a color image you can distinguish numbers written in pencil, which are usually computed parameters, from those written in ink.

*Q: What should the scanner's resolution be?*

*A:* Higher resolution results in larger images. Testing must be done to determine optimal scanner resolution and necessary thresholds for the types of documents used. After a few tries with a certain category of documents a minimum resolution of 150dpi proved to be sufficient for on-screen reading. A higher resolution is required for reading printed rescued material.

*Q: What is the best naming practice?*

*A:* A simple naming scheme should be used. Otherwise the process may be slowing down. Color coded plastic containers may come handy and speed up future identification of archived material.

*Q: Should scanned images be resized?*

*A:* It is not clear at this point whether sizing down documents should be done. A general rule is to keep

consistency throughout the process and thus size should be kept the same for similar categories of documents.

*Q: When should scanned images be checked for quality?*

*A:* Scanned images should be checked for readability upon their creation.

*Q: How many people should be used in a scanner-based DARE process?*

*A:* No less than two. One person places the document in the scanner and the other operates the computer.

### *Technical/Logistical Questions*

In order to determine final course of action some technical and logistical issues should be resolved. Some of them are given below.

*Q: Is a scanner better than a digital camera?*

*A:* According to International Environmental Data Rescue Organization (IEDRO) a digital camera is more efficient than a scanner (Rick Crouthamel, president of IEDRO, USA, private communication). A computer controlled camera is less expensive and in times of power failure batteries can be used. Also, cameras do not damage fragile paper documents as do scanners. Finally scanners tend to break down more frequently as they have more moving parts.

*Q: Is it necessary to do testing with a digital camera?*

*A:* It is necessary to do testing with both a scanner and a computer-controlled digital camera in order to decide when to use one over the other. It has been made clear that both a camera and a scanner should be used, each one for different tasks. This stems from the experience of DARE groups in other countries as presented in 2007 MEDARE Tarragona Workshop.

*Q: Should data entry be done with OCR software?*

A: Data entry should be done with manual typing. In the past this author experimented with OCR of handwritten numeric data found in typical HNMS data logs. Test results showed that, at best, OCR success rate didn't exceed 25%, which meant that, practically, it takes longer to correct faulty OCR data than do direct manual data entry. Experiment was carried out using a high resolution scanner and accompanying state-of-the-art OCR software.

Q: *Is quality control necessary?*

A: Quality control is necessary throughout the project. Computed parameters should be checked and all applicable procedures of quality control should be used. HNMS has just finished drawing comprehensive quality control procedures, effective immediately, which cover range, limit, step, and consistency checks (Tzanakou et al. 2008). However, there may be needed additional checks, depending on the quality of rescued data, which will have to be developed on demand.

Q: *What should you do with digitized data?*

A: Digitized data should be stored to HNMS central database and made available to international DARE community after passing successfully quality control and being homogenized. When possible, faulty data and heterogeneities should be corrected. Finally old and new datasets should be merged to form a unified archive.

Q: *What should you do with stored images?*

A: Stored images should be stored along with manually entered data. They should be made available to the customers as they can sometimes provide additional information.

Q: *What about metadata?*

A: Station metadata should be kept. Although it may be difficult to have instrument descriptions for early records, they should be included when available. Finally, graphical images (proxies etc.) should be used along the way to express the overall progress

and give information about gaps in time series, archive condition, inventories created, etc.

Q: *Should professional help be sought?*

A: At this point there are no thoughts for using professional help. Project will continue by either HNMS employees or graduating students from local universities. In latter case, students will be given clear instructions and be strictly supervised. Some consultation with experts in photography and document archiving has been done which proved very useful. For complex types of documents rescued, however, such as strip charts from thermographs, barographs, or other instruments professional help and funding from external sources should be used.

Q: *What is the key to success in DARE projects?*

A: Continuity, proper funding for purchasing needed equipment and commitment of trained personnel will guarantee the success of the project. Finally consultation with international experts will save time.

#### FUTURE PLANNING:

Future steps of DARE project include scanning or digitally-photographing of documents, creation of extended data inventory, storage of documents in Dexion-type selves with appropriate labeling, manual data entry, quality control of digitized observations, homogenization, data correction (when possible), and finally permanent storage in HNMS central database. New computer programs will have to be developed to assist in data entry.

Finally, as mentioned above, saved data will be made available to the international DARE community. Cost of delivery of both data and metadata is determined by Greek Laws (FEK(B)42/1-2-1991, FEK(B)420/1-7-1992, FEK(A)187/6-8-1998, and FEK(B)656/28-5-2003). However new pricing policy is currently been developed taking into account WMO guidelines.

#### RESULTS AND CONCLUSIONS:

HNMS started data rescue efforts in summer 2007 and has shown a strong commitment to bring this tedious project to completion.

Physical protection of old archives stored in various locations within HNMS headquarters was given high priority. Several documents were collected, tabulated, and stored safely in plastic containers. A first metadata database was created.

Next, extensive testing with A3 flatbed scanner was done in order to determine device settings for optimal scanning of various types of documents found. This kind of testing was carried out by a single person and during this process several problems surfaced which caused delays along the way. Answers to issues raised helped fine-tuning operations. Similar tests will soon be made with computer controlled digital camera.

In retrospect, trying to work with existing equipment alone is probably not the best thing to do but it was an action dictated by economics. As more funds become available in the near future project activity will go full speed assuming the right manpower is assigned.

In closing, data rescue is a time consuming but necessary step-by-step process. DARE projects are best tackled if broken down into small tasks some of which, to a great extent, can get completed independently of each other. Continuity in funding and appropriate allocation of trained personnel is the key to success. Finally manual data entry cannot be avoided and constitutes a very critical and demanding phase of the project.

All in all, DARE projects are beneficial to society: Very crucial in safer construction, better forecasting, early flood prevention, and better understanding of climate.

#### ACKNOWLEDGMENTS:

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## III.11. Processing of meteorological monitoring data bases of Georgian mountainous regions

Z. Tskvitinidze, L. Kartvelishvili, N. Gogishvili, M. Pkhakadze and N. Kutaladze

### ABSTRACT:

Conditions of regime data processing are being analysed for stations and posts of the Georgian State Network of Meteorological Observation. Problems concerning the production and management of the regime-climatic data base are considered.

### INTRODUCTION:

The complicated problem of the study of natural environment of Georgia is directly connected with the analysis of climatic observations. The range of observations is very diverse; besides the duration and intensity of the observation coverage varies according to the site (Hydrometeorological researches in Georgia, 1981).

During the past century important data have been obtained with which to characterize the natural environment, and for defining the meteorology, agrometeorology, aerology, actinometry, atmospheric electricity, hydrology, torrents and snow cover in the mountains; they also assist in the study of glacier conditions, ozonometry, radiometry, hydrochemistry, atmospheric air pollution and several other fields. It must be noted however that the development of satellite technology facilitated the implementation of the remote sensing at a number of levels and provide possibilities for particular perspectives on the diversity of the observed characteristics, as well as the application of the data. The variety of data embrace different, usually independent phenomena, nevertheless there are often complicated inter-relationships between them. Such considerations inevitably influence the manner in which the data can and are applied and processed.

Our aim is to consider the machine processing systems of data of the Georgian State Network of Meteorological Observations, taking into account the

evolution of technology and reviewing the possibilities for the performance of the regime-climatic information bases.

The technology of data collection from meteorological observation networks and the consequent machine processing of obtained information relies on the systematization and standardization of data gathering and recording. Over the study period in question the performance, character and provision of technology has undergone a notable evolution. In conditions that prevailed in the former USSR the direction of the activity of the Hydrometeorological Service, which was concerned with regime-data processing storage, was based on a centralized system of machine processing. Such were the limitations of these systems that occasions arose when storage had to be devolved to alternative media such as perfocard, magnetic film, etc. The occasional deficiencies of large-scale e.c.m. systems limited the full development of databases.

As a consequence, the local monitoring and storage services fell behind those of other nations and regions. This proved to be a particular problem for the Georgian mountain regions. This failure can be attributed to the following factors: according to established order of the former USSR, materials for the regular hydrometeorological observations made by Georgian hydrometeorological network were sent to principal organization of the USSR (located in Russian Federation, c.Obninsk), where they were digitized into data bases. This was an acceptable procedure at that time but after the collapse of the USSR, and since 1992 difficulties arose regarding the provision of security and rescue of meteorological monitoring materials stored in paper form.

At present only a proportion of the paper records have been transferred. These data cover the last 15 years for 9 stations and 20 locations on the Georgian mountain region's hydrometeorological network. It represents, however, only 20 % of the data. The

problem is manifold: for example, one station alone during the course of one month using the standard notebook of observations contains 20 parameters and daily observations made every three hours, together with other specific observations. This alone provides some 50,000 figures. Other sites have twice daily observations of temperature and rainfall as a minimum recording activity. The sites mentioned above have yielded nearly 100 million figures. Such volumes of data place unrealistic demands on the storage and retrieval systems.

Computer processing of digitized data provides for effective quality control of primary information, by using of different level algorithms, which carry out both the standardization of the data form and help to identify errors and outliers. The latter process identifies and average of 0.5 to 1% errors. In all this suggests that as many as 500,000 erroneous observations may require correction: a very laborious and demanding task.

Currently the introduction of personal computers, as well as the modernization of format of stored data presentation, create favorable conditions for processing the data, and make more readily-available the operational data bases. In future, the installation of new computer technology at the level of the observation network will change the balance of data usage and it will be possible to meet more effectively the local and more wide-ranging needs for data provision.

Materials obtained by the Georgian State Network of Meteorological observations, taking into account the preceding points, process the data through a number of stages (see Figure1):

- Meteorological observation stations: these carry out the observations and measurements using the recognized systems and procedures for observation and coding recording the data on official registration monthly notebooks and passing these data to the next level.

- Methodical supervision of Observation Network: this is where checking of materials received from the network is conducted. The tasks include the assessment of doubtful data, correction of such data using established techniques and the analytical control of overall data quality;

Transmission of observation materials to recording media, completion of the entire cycle of machine data processing, final assessment of doubtful data, completion of the updating task, preparation of the generalized tables of processed data and making all the aforesaid available to potential users.

Meteorological data of the stations of the Georgian State Network of Meteorological Observation include most recognized parameters secured from [2], and include the following:

- diurnal data on precipitation and extreme air temperature;
- observations on atmospheric events;
- results of snow- survey;
- observation data on atmospheric precipitation by pluviograph;
- information on dangerous and hazardous hydrometeorological events.

Completion of the entire cycle of machine processing of monthly regime data of meteorological observations is based on the requirements of the unified software complexes. Dissemination is undertaken by the World Data Center (Obninsk, Russian Federation) using and coding primary data and drawing on different storage media where necessary. Having passed the first quality check, the coded data of stations and posts are then input to the system. Software systems make possible the implementation of automatic quality control of computerized materials based on the identification of essential data characteristics and anomalies. The next stage of control requires the implementation of further (semantic, statistic, spatial, etc.) quality

control checks. Particular attention is paid to the form of tables of summary statistics as well as to the individual observation data using common software to examine the relevant data bases.

Figure 1 represents a map of the distribution of stations and locations of the Georgian State Network of Meteorological Observations (for 1992-2003) and Figure 2 represents the same for the period 2005-2006. They reveal a sharp reduction (Tskvitinidze et al., 2001) of observations points, which indicates a numbers of negative factors. Unfortunately after 2006 this degeneration process became sharper and active stations reduced to 15 stations and to 20 other sites.

The list of stations and sites of the State Network (in alphabetic order and corresponding international numbers and numbers on the map) are presented in Table 1.

Monthly-organized data bases are structured as a common file format, where the data are presented by separate pages. The pages have a double numbering for which one corresponds to the whole processed data, and the other to the identification of the corresponding data from separate stations (posts). Materials for each station in the data base are represented as follows:

pages:	1	- Title-page
	2-5	- data on the observation terms
	7	- diurnal data
	8	- atmospheric events
	9	- monthly results
	10-11	- soil temperature
	12	- average meanings of soil temperatures on the terms
	13	- diurnal soil temperature
	14	- data of heliometer
	15	- data of thermometer
	16	- data of hygograph
	17	- data of pluviograph
	18	- extraordinary hydrometeorological events

If any part of station data is missing from the listed sequence this is indicated at title-page.

During machine presentation of the data from the smaller sites (posts), the automatic numbering is not implemented, as the data acquired by the machine processing can be placed on one page. This is because the observation and measurements carried out by the Georgian State Hydrometeorological Observation Network Posts do not include data of atmospheric precipitation from pluviographs or observations on dangerous and hazardous hydrometeorological events.

Implementation of the available technology for the machine processing of regime data of meteorological observation stations and posts, and the organization of data bases provides an opportunity to optimize use and access of these databases. This is of particular importance where technology provides for the automatic recording of observations and which do not require the copying out of data and carrying out of labor-intensive technical works for their preparation to satisfy requirements of selected models of environment research. It is possible to review data bases using algorithms to arrange for the presentation of specified parameters by automated methods, which considerably reduces time, necessary for preparation of data and excludes mistakes related to manual data manipulation.

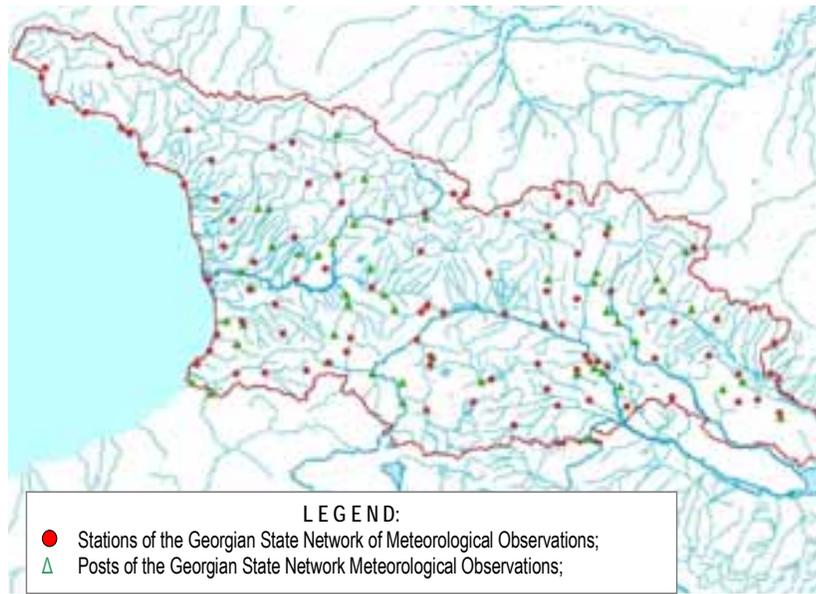


Figure 1: Map-scheme of distribution of stations and posts of Georgian State Network of Meteorological Observations (by condition of 1998)



Figure 2: Map-scheme of distribution of stations and posts of Georgian State Network of Meteorological Observations (by condition of 2004-2006)

#	Station, post	# on the map-scheme	Area altitude	Weather-vane altitude		Anemorumbometer altitude	# on the map-scheme	International number
				with light board	with heavy board			
1	Abastumani	1884 – 2006	1265		10.5		4184280 - /29	37 506
2	Ambrolauri**	1937	544		10.0		4254320 - /6	37 308
3	Akhalgori	1940 – 2005	760		10.5		4214450 - /46	
4	Akhalkalaki	1900 – 2006	1716		11.2		4144350 - /45	37 602
5	Akhaltsikhe	1874	989.2		11.0		4174300 - /35	37 514
6	Batumi	1947	11		10.7	10.0	4184160 - /47	37 484
7	Barisakho	1902 – 2004	1290.8				4254490 - /7	
8	Bakhmaro	1922 - -	1926				4194230 - /25	37 492
9	Bolnisi	1909	534		11.3	10.0	4154460 - /41	37 621
10	Borjomi	1877 – 2005	789.7				4184340 - /30	37 515
11	Gardabani	1896 - - 2006	300				4154510 - /43	37 632
12	Goderdzi cross	1960 – 2006	2030.2		11.0	10.0	4164250 - /51	47 507
13	Gori	1847	609		10.5		4204410 - /24	37 581
14	Gurjaani	1914 – 2006	410		10.2	10.0	4184580 - /33	37 566
15	Dedoplistskaro	1872 – 2006	800	11.2	11.1	10.0	4154610 - /44	
16	Dusheti	1892 – 2006	922				4214470 - /18	37 437
17	Zugdidi	1929 - -	118.0	10.9	10.7	10.0	4254190 - /5	37 239
18	Tbilisi, ghms	1844 (1965)	427		10.5	10.0	4184480 - /31	37 546
19	Tbilisi, amss*	1934	462		10.0	10.0	- /32	37 549
20	Tetritskaro	1947 - - 2006	1150				4164450 - /31	
21	Telavi	1932	568.0		10.6		4194550 - /32	37 503
22	Tianeti	1914 – 2006	1099		11.3	10.0	4214490 - /39	37 439
23	Torsa	1975 – 1995	10		10.5	10.0	4244180 - /8	
24	Lagodekhi	1929 – 2004	429.2		11.6		4184630 - /34	37 572
25	Lentekhi	1941 – 2006	731.3	11.1	11.1		4284270 - /1	37 295
26	Manglisi	1882 – 2005	1194				4174440 - /36	37 535
27	Marneuli	2001 – 2006	432	10.0	10.0		4154480 - /42	
28	Martvili	1940 – 2005	176.0		10.8	10.0	4244240 - /9	
29	Mta-sabueti	1940	1242		10.0	10.0	4204350 - /22	37 409
30	Mukhrani	1922 – 2006	550		11.0	10.0	4194450 - /26	37 541
31	Radionovka	1947 – 2006	2100		10.0	10.5	4154390 - /40	37 603
32	Sagarejo	1916 – 2006	802		11.1	10.0	4174530 - /37	37 536
33	Samtredia	1892 – 2005	28	10.8	10.8		4224240 - /14	37 385
34	Sakara	1892 – 2006	148	11.1	11.1	10.0	4214300 - /17	37 404
35	Sachkhere	1941 – 2006	455	10.8	11.1	10.0	4244340 - /11	37 403
36	Senaki	1891 – 2006	34	11.0	11.1	10.0	4234210 - /13	
37	Tkibuli	1897 – 2005	593		11.2		4244290 - /10	37 313
38	Pasanauri	1932	1070		10.0	10.0	4244470 - /12	37 432
39	Poti	1912	1		11.0	10.0	4214160 - /16	37 379
40	Kobuleti	1938	7		11.2		4184180 - /48	37 481
41	Kutaisi	1935	113.0		10.9	10.0	4224260 - /15	37 395
42	Kazbegi, vill.	1939 - - 2006	1809.4				4274470 - /4	
43	Kvareli	1885 – 2006	449	11.6	11.6		4194580 - /28	37 583
44	Shovi	1928 - - 2006	1508.6				4274370 - /3	
45	Shuakhevi	1979 - - 2005	385		10.0	10.0	4164220 - /52	
46	Chakvi	1897 – 2006	30				4174180 - /49	
47	Chokhatauri	1968 – 2006	144				4204230 - /20	37 388
48	Tsageri	1930 – 2006	474				4274280 - /2	37 298
49	Tsalka	1931 – 2006	1458		12.6		4164410 - /38	37 537
50	Tsipa	1897 – 2005	673	10.8	10.0		4204340 - /21	37 513
51	Khashuri	1938 – 2006	690			15.0	4204360 - /23	37 417
52	Khulo	1930 – 2006	946				4164230 - /50	37 498
53	Adigeni	1983 - - 2006	1151.0				414104242 - /90	

Table 1: General description of Georgian meteorological network

## III.12. Rescue and Digitization of Climate Records in the Climatological Service of the Lebanese Meteorological Department

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### INTRODUCTION:

Lebanon is located on the Eastern coast of the Mediterranean Sea Basin (Lat. 33:10 – 34:40 N - Log. 35:15 – 36:10 E). It has a surface of 10452 Km<sup>2</sup> (2/5 of which are mountains with a mean height of 550 m, covered by snow from 900 m till 3086 m). Rain fall amount: 800 mm on the coastal plain, 900 – 1650 mm on mountains, 225–650 mm on interior plain, Bekaa ). Capital: Beirut. Figure 1 shows the location map of Lebanon on its Mediterranean context.

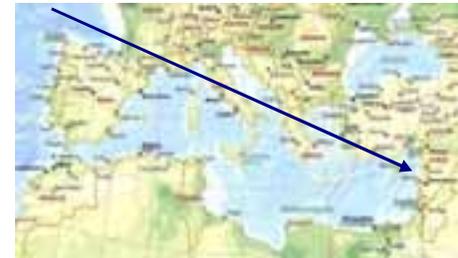


Figure 1: The Mediterranean Basin

### THE METEOROLOGICAL DEPARTMENT IN LEBANON:

Measurements of some meteorological elements in Lebanon are as old as from the second half of the 19th century, which were recorded by Professors of American University of Beirut and Saint Joseph University.

Official instrumental observations began in 1921, under the auspices of the French Mandate on Lebanon (1920-1943), and have continued to the present day, but with changes of stations settings and instrumentation. The 4th of July 1921, is considered the Official Date of Birth of the Lebanese Meteorological Services, which was mainly set up for covering the need of meteorological forecast, with the establishment of a special center for this purpose. Later, 6 Synoptic Meteorological Stations, Radiosonde Station, Wind Radar, were mounted. 187 Meteorological Stations were distributed in the different Lebanese regions.

Meteorological Services kept on developing until 1975, when an unhappy Civil War overwhelmed Lebanon. Most of the stations and equipment, of LNMS were destroyed.

After the war, the Meteorological Department planned to reconstruct the National Network. This project started on 1994 with the installation of 2 complete AWOS (Milos 500-From Vaisala - Finland) at Beirut International Airport and in Tripoli\_IPC (on the North Coast of Lebanon). Later, a Lebanese-French financial Protocol was signed on summer 1997, which included the installation of several automatic weather stations, as follows:

- a. For Surface observations: 7 Complete Synoptic Stations, 3 Agrometeorological Stations and 9 Climatological Stations connected to METEO Centre at Beirut Airport, 16 Climatological Stations unconnected (using PCMCIA card) and 7 Climatological Stations are prevue to be installed in few months time.
- b. For Marine observations: 3 Buoys installed along the Lebanese coast.
- c. Upper Air observations: 1 Radiosonde Station at Beirut.
- d. Weather Radar, to detect Thunder Storms and Probability of Rainfall

Figure 2 shows the meteorological network for Lebanon

### THE TASKS OF THE CLIMATOLOGICAL SERVICE IN LEBANON:

The Lebanese Climatological Service has as main tasks to measure and estimate statistical means of different weather parameters: temperature, humidity, evaporation, precipitation, wind, solar radiation, air quality and environmental parameters (CO, CO<sub>2</sub>, CH<sub>4</sub>, NOX, O<sub>3</sub>), sea swell, and Aerosols, etc., through using the NMS network, which is distributed all around Lebanon.

The climatological data coming from the NMS network is the essential input for developing the climatological data base, which helps to carry out different studies, including those assessing changes in weather extremes. These assessments are needed in order to decrease its negative impacts on the life in this region and on the natural resources, especially: water and power !

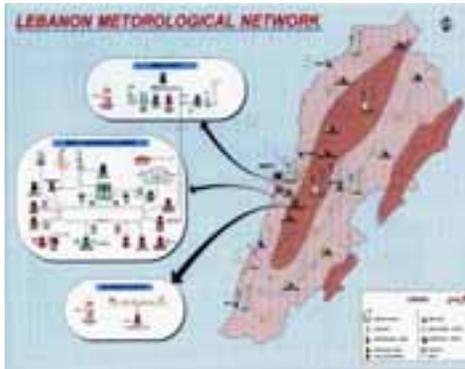


Figure 2: The Lebanon meteorological network

#### BENEFICIARIES FROM THE LEBANON METEOROLOGICAL SERVICES:

Several sectors are among the end-users and beneficiaries of our service: Public - Government – Business - Agriculture - Building and construction - Legal - Insurance - Retail and Manufacturing - Consulting - Environment – Media - Energy - Telecommunications - Water - Transport (Aviation, Marine, Road and rail).

Lebanese weather stations report a mixture of snapshot from weather hourly observations (synoptic observations) and weather daily summaries (climate observations). Observations from synoptic stations are collected in real time.

However, climate observations from 16 climate stations come in as collectives at the end of the month. All climate stations record hourly and daily maximum and minimum temperatures, air temperature, relative humidity, rainfall, wind,

insolation, global radiation, base of clouds and visibility range.

#### GOALS AND ACTIVITIES OF THE LEBANESE CLIMATOLOGICAL SERVICE (LCS):

##### *The goals of the LCS*

Main goals are the preservation of archives containing data in paper format, data quality control and management, safeguard of the national climatic data bank, to assist end users on their climatological requests and to publish periodic climatic information.

##### *Activities of the LCS:*

1. Climatological data management and control
2. Issue of periodic climatological publications
3. Development of climatological products for end users
4. Management and transfer of climatological data from 45 stations, which are keyed, quality controlled and archived. The oldest Climatological document in paper format goes back to 1921, and it is available in the Digitized Archive.

##### *The LCS Databank:*

The LCS Databank contains:

- 8 Synoptic observations (every 3 hours and daily observations).
- Hourly parameters (visibility, clouds, temperatures, relative humidity, vapor pressure, wind, rainfall, present and past weather ...)
- Daily parameters (meteorological phenomena, gust, extreme temperatures, extreme humidity, evaporation, and rain fall duration ...),
- Daily precipitation amount, daily minimum and daily maximum temperatures, agrometeorological parameters, such as soil

temperature, humectation, wind at 2 meters, sun duration and global radiation.

Table 1 shows details (geographical coordinates, elevation, codes, etc.) for the old manual stations and new automatic weather stations network over Lebanon.

##### *Data digitization:*

1996 was the year that begun the data management by means of a CLICOM System provided by the World Meteorological Organization (WMO). Different tasks were performed as follows:

- Adapting CLICOM entry.
- CLICOM started in 10 locations on the 1992
- Entering data before-1953 and after-1997
- Data collected on floppy disk and stored on hard disk.

Reports are stored by station. Most of archive paper forms ranked, and fall down, due to the Civil War in Lebanon (1975 – 1990).

We planned to digitize climatological data (monthly averages of daily temperature and monthly rainfall amount for the period 1931- 2007), in order to develop long and homogenized time series and estimate with them long-term trends.

Later, a second program started in Lebanon: the digitization of temperature, rainfall, sunshine duration, wind frequency and air pressure on a daily basis, in order to address changes in climate extremes over the periods 1960 – 1990 and 1970 - 2000.

Using an Excel application, the following parameters were digitized on a monthly basis: temperature, dew point, relative humidity, mean sea level pressure, station level pressure, wind speed & direction, rainfall, evaporation, sunshine duration, global radiation, cloud cover, weather phenomena (sandstorms, thunderstorms, frost, haze,...).

#### DATA MANAGEMENT AND DATA RESCUE STRATEGY:

Before 2002 there was used the CLICOM database which has several weaknesses, such as limited imports – Dos system – No graphical interface, etc. Lately, a new strategy based on more up to date software is being planned as follows:

- Collecting data from the different observation networks.
- Archive and management of the network stations data.
- Digitizing an running simple control tests, and validating local database,
- Making backups of the data every six months.
- Data archiving through making a first copy on PC internal Hard Disk and a second copy on an external one.
- National Climatological Applications requested by national end-users, studies, etc.
- Ensure data rescue activities throughout the coordination with national Universities and Institutes...

##### *Efforts in Data Rescue*

Most of the daily temperature and rainfall data are already digitized and are available from the database.

Efforts on searching old documents containing climate data at national and international sources are undertaken, as well as digitizing all data available in already located climatological documents.

The estimated cost for digitizing hourly data exceed 20,000 \$, although scanning these documents could be considered an intermediate and cheaper solution to avoid loss of data. Currently, there is an ongoing project to automatically digitize documents.

### *The development of the LCS strategy in Data Rescue*

The LCS strategy for enhancing climate data rescue in Lebanon is currently focused on going into a project of scanning the paper archive, beginning with the oldest records and stations history (Metadata) held in paper format.

#### *What we do now and what we want to do?*

For Rainfall: Most of the daily data are digitized, but for early years some are only on a monthly basis.

For Temperature and other parameters: a lot still need to be done.

Candidate stations for developing long term series: Beirut Airport, Tripoli, and Zahlé.

Scanning old data files from hard copies and for the 1921-1996 period.

Securing more our climatic databank and generating missing data.

Homogenizing the series before the storage of climate data

Reception, digitization and classification of technical documents.

Raw and developed data are managed through Local Project (data entry, software developed at the LMS, with continuous improvement actions).

Hourly and Daily observations of Automatic Weather Stations (most of them available since 1994) represent a total volume of about 10 GB and they are growing every day

Climate change assessments (Indices, Climate Models...)

Create Database. Make maps for Climatic Atlas.

### TREATMENT AND DATA STORAGE:

#### *Loading data and Calculation:*

Daily loading SYNOP messages of 8 Main stations of various parameters.

Daily loading data from 3 Agrometeorological stations.

Monthly loading files from 35 Climatological stations.

Daily and monthly treatment and update of records.

Parameters developed data from the statistics on the long runs, as means and normal, quintiles and monthly records. Frequencies and wind roses

Homogeneity testing of climatological series: Search for possible causes of heterogeneity (relocation, changes in the surroundings and environment, and changes in instruments, etc.), trends in series, etc.

#### *Data quality control:*

It is being completed, as follows: Verification for missing observations, missing values of a certain meteorological element or parameter, permissible values and intervals of variation, correspondence with the code tables, etc.; Expert control on the basis of annual reports and comparison with meteorological stations – analogs.

### THE USE OF CLIMATE PRODUCTS:

Data visualization and reporting. Graphics

National Statistical Studies of Climate: The Climate Clues. Samples:

- Annual Rainfall Average. (Totals compared with the normal)
- Frequency of maximum and minimum Temperatures.

Worked out: Combining several meteorological elements to characterize the climate of our Region and its evolution.

Special studies: Combine climatological data with physical and socio-economical data to meet the needs of planners and policy makers in various fields

of activity: Agriculture, Energy, Health, Tourism and Transportation.

### PRESERVATION OF PAPER RECORDS:

The majority of climate data, in paper form, are stored in the Meteorological Archive of LMS, since we began recording. Figure 3 shows three examples of documents containing vital climate data. At present, paper records (those being often not in good state) are stored under favorable conditions. That explains why we are on a hurry run to create a digital images archive of all climate paper records, as it is of greater importance in order to rescue these data. This task has to be started as soon as possible to avoid further deterioration, as well as digitizing these data as faster as possible.



*Figure 3: Some examples of old climate data kept in hard copy at the Lebanese archives of the Lebanon Meteorological Service*

Old climate and precipitation data are bound and stored in boxes arranged by stations. Most of the material were put into plastic boxes with regard to their preservation. In this way, a full inventory of the paper records was made and the gaps in the long-term climate series were estimated (for climatological stations, they are less than 15 % of the data).

A lot of work has to be done to digitize the historical data from climatological and precipitation stations. Much more serious is the situation with respect to the data from synoptic stations, which are digitized since 1997, with some exceptions. Unfortunately, digitization of the past climate data, available only in paper forms, will not be completed in the near future.

### STATIONS HISTORY, METADATA, PLANS FOR THE FUTURE:

All synoptic, climatological and precipitation stations have file records, including station description and their activities, since the beginning of measurements up to now.

Stations documents giving details of their history are digitized with MS Excel Programme, but this process is not entirely completed, and there is some missing information of the stations history.

For these reasons, we are making efforts to update the files of the stations since the beginning of this year 2008, in view of the importance of metadata for the execution of stored procedures in the meteorological database, as well as for the homogenization of long term climate series. It is one of the main tasks to carry out in the next year, after we have taken the initiative to start scanning the documents from the files of the stations.

In 1996, computer data processing of all precipitation or temperature stations were started. In this year, data entry of hourly values for different meteorological elements will be carried out.

Locally developed software for data input, checking and processing data is made in LMNS. Once the quality control is done, the data are stored into the data base. Our plan for the future is to store all quality controlled data into the LINUX Operational System.

Old climatological and precipitation station data are operationally digitized from paper forms on an hourly and daily basis. Historical data (climatological and precipitation data before 1994) are digitized as much as we can, or on request.

#### DATA SAVING AND MANAGEMENT:

Manually from 1931 till 1995: The earliest record on daily scale belongs to Beirut Airport station, which began on the first of February 1931, which has to be controlled (all data must be checked for data quality, such as "element limits", internal consistency", "element relationships", temporal & spatial consistency, "rate of change", nearby stations), processed, archived.

Utilization of CLICOM programme from 1995 until 2002: The starting to digitize climate data took place on 1995 by using "CLICOM Programme". They were entered all hard copy data and files from LNMS and saving them. But, by the end of February 2002, CLICOM Programme was not in use anymore because of many difficulties, such as: Problems coming from non compatibility between CLICOM equipment and AWOS Network. Besides, working under Dos Operating System, couldn't process long climate series, especially hourly data, and the exported data were not standard to be transferred into another system.

After February 2002: The recent development of a locally made programme in LNMS allowed us replacing CLICOM Programme and to saving and exploiting climate data until we succeed in obtaining the CliSys, with the funding of WMO. Using our locally developed program, we can perform a variety of tasks: Data entry from old papers, data entry from

current observations, archiving and analyzing climate data, rescuing climate data: Monthly and Annual Backup (All Databases & Application), generating different reports, exporting in printable form or Excel worksheets. Finally, it can retrieve and calculate any data from the database without changing the original database and can include upper air, marine and environmental data.

Long-term Averages: Averages for consecutive periods of 30 years, with the latest covering the period 1961-1990. LMNS updates averages at the completion of each decade. These averages help us to describe our climate, used as a baseline to which current conditions can be compared, and they are used in our studies on climate change impacts in Lebanon and the Mediterranean Basin.

Definitively, all main parameters are digitized, but only for main stations and upon users request or for research needs. On the other hand, the AWOS save data automatically, for all stations installed by the Lebanese – French Protocol. The time steps on records are: Hourly, daily, and monthly, in most stations, plus records of 5min, 10min and 30 minutes for rainfall amount, and records of 30 minutes for marine data.

#### PROBLEMS! TIME SERIES GAPS:

Lebanese long-term climate records have several gaps due to the closing stations on 1941 (during Second World War) and the events occurred in Lebanon on 1949, 1958, 1967 and during the Civil War (1975 – 1990), as well as during the Israelian Occupation of Lebanese territories. The majority of climatological stations were destroyed with the corresponding losing of climate series, as reregistered paper disappeared from LNMS.

The climate records from old stations, which were in operation on the 19<sup>th</sup> century by American University of Beirut and Saint Joseph University, are stored in LMNS archive, but contain many gaps.

Most of the data coming from old stations, and available in paper format, are waiting for being digitized; tasks that are expectable to be completed in 2 years time, after mapping their contents.

Considerable gaps in data (frequently entire years) for many stations, lack of detailed metadata, in technical equipment and lack of sufficient human and financial resources are the greatest obstacles to the data rescue process. Insufficient number of qualified staff, different data formats and non standard times of observations, difficulties in applying quality controls due to the paucity of stations in the earliest years are other problems to be solved.

Great efforts are dedicated to locate relevant data sources: Archives are located in many places, such as American University of Beirut, Saint Joseph University, National Statistics Bureau, and others. Some archives are not accessible and documents borrowing are not always possible.

Vast amounts of paper records are archived in the METEO-LIBAN, despite the lack of resources, both human and financial, a lot of work has to be done to inventory and digitize the data. The effort will be growing inside LMNS.

Finally, we can say that digitization is a very complex and expensive process. So, it will not be an easy task. Realization, of course, depends on financial situation.

By the end of this brief approach, we hope to have explained our needs and how to benefit of the MEDARE programs, applications, practical studies for scientists, experiences from developed Meteo Services (like those in France, Spain and Germany), to resolve the difficulties and problems at the national scale for developing national long-term climate records, transferring the data from paper form to microfilms, digitization issues. The goal is to facilitate the generation of mid range and long range prediction, concerning climate variability and change.

TABLE 1: DETAILS FOR OLD MANUAL STATIONS AND NEW AUTOMATIC WEATHER STATIONS NETWORK

Station Name	OMM Code	Latitude °	Longitude °	Altitude (m)	Start Date
Coastal Zone - Region of the North					
Kouachra		34:36 N	36:12 E	400	1962
Qlaiaat (Akkar)		34:35 N	36:00 E	5	1947
Qaabrin		34:34 N	36:02 E	25	1964
Qoubayat		34:34 N	36:17 E	540	1957
Beino		34:32 N	36:11 E	510	1966
Halba		34:32 N	36:05 E	160	1966
El-Abde	40115	34:31 N	36:00 E	40	1998
Tripoli-Mina		34:27 N	36:49 E	20	1940
Balamand		34:22 N	35:46:00	420	1999
Bared - Moussa		34:26 N	36:00 E	250	1964
Bakhoun		34:24 N	36:01 E	630	1964
Zgharta		34:23 N	35:54 E	110	1964
Bechmezzin		34:19 N	35:48 E	275	1964
Chekka		34:18 N	35:43 E	15	1964
Abou - Ali		34:18 N	35:52 E	250	1964
Amioun		34:18 N	35:49 E	300	1964
Coastal Zone - Region of the Center					
Kaftoun		34:16 N	35:45 E	215	1951
Bartroun		34:15 N	35:40 E	20	1999
Kafar-Halda		34:14 N	35:49 E	580	1940
Amchit		34:09 N	35:39 E	135	1966
Jounieh_Kaslik		33:59 N	35:37 E	5	1968
Fatré		34:05 N	35:42 E	410	1944
Ghazir		34:01 N	35:40 E	390	1948
Ghosta		33:59 N	35:40 E	650	1948
Zouq-Mikayel		33:58 N	35:37 E	70	1943
Beyrouth - AUB		33:54 N	35:29 E	35	1877
Beyrouth - USJ		33:53 N	35:30 E	45	1938
Beyrouth-Nazareth		33:53 N	35:31 E	90	1928
Beyrouth -I.Géo		33:52 N	35:31 E	55	1965
Beyrouth - AIB	40100	33:48 N	35:29 E	15	1931
Beyrouth - RS		33:48 N	35:29 E	15	1949
Qornet-Chehwan		33:55 N	35:42 E	605	1949
Arbaniyé-Jisr		33:53 N	35:42 E	510	1959
Jamhour		33:50 N	35:34 E	410	1955
Choueiffat		33:48 N	35:31 E	100	1957
Souq-el-Gharb		33:48 N	35:34 E	700	1948
Abey		33:44 N	35:31 E	730	1965
Jisr-el-qadi		33:43 N	35:34 E	260	1948
Dmit		33:42 N	35:30 E	350	1946

## stal Zone - Region of the South

Insariye		33:25 N	35:16 E	160	1964
Douair		33:23 N	35:25 E	380	1964
Jarmaq		33:23 N	35:32 E	400	1964
Habbouch		33:24 N	35:29 E	440	1964
El-Qasmiyé		33:21 N	35:15 E	30	1964
Tyr		33:16 N	35:12 E	5	1999
Jouaya		33:14 N	35:20 E	300	1964
Qana		33:12 N	35:18 E	300	1964
Lebaa		33:33 N	35:27 E	360	1999
Aitaroun		33:07 N	35:28 E	680	1964
Ain-Ebel		33:07 N	35:24 E	765	1964
Alma-Chaab		33:06 N	35:11 E	385	1964

## Mountain Zone - Region of the North

Michmich		34:29 N	36:10 E	1080	1964
Syr-ed-Denniyé		34:23 N	36:02 E	915	1999
Bouhairret-Toula		34:19 N	35:58 E	1135	1966
Kafar-Sghab		34:17 N	35:58 E	1310	1962
Bcharré-Ville		34:15 N	36:00 E	1460	1966
Bcharré-Usine		34:15 N	36:01 E	1400	1938
Les Cèdres	40105	34:15 N	36:03 E	1925	1937
Hasroun		35:29 N	35:59 E	1375	1962

## Mountain Zone - Region of the Center

Maifouq		34:11 N	35:47 E	875	1966
Kanat Bakiche		33:58 N	35:48 E	1700	1964
Laqlouq		34:08 N	35:51 E	1700	1939
Tiurzaya		34:07 N	35:46 E	880	1939
qartaba	40133	34:06 N	35:51 E	1140	1999
Ghebalé		34:04 N	35:43 E	970	1964
Faraya-Village		34:01 N	35:49 E	1320	1964
Faraya-Mzar		34:00 N	35:51 E	1840	1964
Rayfoun		33:59 N	35:42 E	1050	1948
Qlaiaat		33:58 N	35:41 E	1050	1943
Beskinta		33:57 N	35:48 E	1220	1966
Bikfaya		33:55 N	35:41 E	900	1948
Jour-el-Haouz		33:52 N	35:45 E	1290	1966
Arsoun		33:52 N	35:41 E	750	1945
Ras-el-Maten		33:51 N	35:40 E	920	1941
Falougha		33:50 N	35:44 E	1250	1966
El-Orayé		33:48 N	35:41 E	1010	1928
Dahr-el-Baidar	40110	33:49 N	35:46 E	1510	1962
Bhamdoun		33:47 N	35:38 E	1090	1946
Ain-Zhalta		33:45 N	35:42 E	1080	1939
Majdel-Maouch		33:43 N	35:37 E	810	1946
Fraidis / Barouk		33:43 N	35:42 E	1250	1966
Kafar-Nabrakh		33:43 N	35:38 E	1020	1944
Beit-ed-Din		33:42 N	35:15 E	880	1940
Jdeidet-ech-Chouf		33:40 N	35:37 E	770	1943
Moukhtara		33:39 N	35:36 E	810	1940
Jbaa=ech-Chouf		33:37 N	35:38 E	1130	1964
Bayssour	40135	33:45,827 N	35:33,414 E	978	1999

Jezzin	40136	33:33 N	35:35 E	945	1928
Beit-eddine-Loqch		33:34 N	35:33 E	835	1964
Qaitoulé		33:32 N	35:33 E	900	1964
Jbaa-Halawi		33:29 N	35:31 E	800	1964
Dahr-Darajé		33:28 N	35:36 E	1150	1964
Jarjouaa		33:27 N	35:31 E	850	1964
Rihan		33:27 N	35:34 E	1090	1965

## Interior Zone - Region of the Oronte River

Hermel	40138	34:24 N	36:23 E	700	1999
El-Qaa		34:21 N	36:28 E	650	1965
Fakehé		34:15 N	36:24 E	1060	1959
Nabha		34:11 N	36:13 E	1100	1966
Arsal		34:11 N	36:25 E	1400	1961
Yammouné		34:08 N	36:02 E	1370	1938
Deir_ej_Ahmar	40139	34:07 N	36:08 E	1080	1999
Chlifa_Flawi		34:05 N	36:04 E	1120	1943
Younin		34:05 N	36:16 E	1200	1966
Haouch-Dahab		34:02 N	36:06 E	1010	1953
Baalbek		34:00 N	36:12 E	1150	1930

## Interior Zone - Region of the Litany River

Kafar-Dan		34:01 N	36:03 E	1080	1966
Haouch-Snaid		33:56 N	36:04 E	995	1956
Qaa-el-Rim		33:53 N	36:53 E	1320	1939
Sarain		33:53 N	36:05 E	1000	1945
Haouch-el-Ghanam		33:52 N	36:02 E	955	1950
Tell-Amara		33:51 N	35:59 E	905	1953
Rayak	40102	33:51 N	36:00 E	920	1932
Zahlé	40101	33:51 N	35:55 E	990	1952
Ksara		33:50 N	35:54 E	920	1928
Chtaura		33:49 N	35:52 E	920	1953
Terbol		33:49 N	35:59 E	890	1954
Taanayel		33:48 N	35:52 E	880	1957
Anjar		33:44 N	35:56 E	925	1938
Ammiq		33:43 N	35:47 E	870	1961
Mansoura		33:41 N	35:29 E	860	1938
Soultan-Yaaqoub		33:39 N	35:52 E	1400	1966
Kherbet-Qanafar		33:38 N	35:44 E	950	1955
Joubb-Jannin		33:38 N	35:47 E	920	1946
Qaraoun-Village		33:34 N	35:43 E	950	1953
Qaraoun-Barrage	40141	33:33 N	35:41 E	855	1963
Machghara		33:32 N	35:39 E	1070	1938
Markaba		33:29 N	35:39 E	670	1969

Gharifé		33:38 N	35:34 E	680	1964
Katermaya		33:37 N	35:27 E	380	1964
Saida		33:34 N	35:23 E	5	1999
Sfarai		33:33 N	35:20 E	570	1941
Maghdouché		33:31 N	35:23 E	230	1964
Anqoun		33:30 N	35:26 E	380	1946
Deir-el-Zahrani		33:26 N	35:27 E	450	1964
Arab-Salim		33:26 N	35:31 E	580	1946

## AUTOMATIC STATIONS NETWORK

Station Name	OMM Code	Latitude °	Longitude °	Altitude (m)	Start Date
Beirut_Airport	40100	33:49 N	35:29 E	12.3	Fév 1931
Beirut_Golf	40109	33:50,866 N	35:28.516 E	27	Fév 1998
Houch_el_Oumara	40101	33:50 N	35:54 E	920	juil.-97
Dahr_el_Baidar	40110	33:49 N	35:46 E	1524	7/1/1997
Al_Arz_Les_Cèdres	40105	34:15 N	36:03 E	1916	août-97
Rayak_Amara	40102	33:51 N	36:00 E	905	août-97
El-Abdeh	40115	34:31 N	36:00 E	40	nov.-97
Sour	40120	33:16 N	35:12 E	5	déc.-97
Tripoli_IPC	40103	34:27 N	35:49 E	5.5	sept.-94
Zahrani	40118	33:30,414 N	35:20,450 E	10	nov.-99
El_Olaiaat_Akkar	40131	34:35 N	36:00 E	5	nov.-99
El-Qoubayat	40132	34:34 N	36:17 E	540	nov.-99
Qartaba	40133	34:06 N	35:51 E	1150	nov.-99
El_Qoussaibeh	40134	33:52 N	35:39 E	585	nov.-99
Bayssour	40135	33:45,827 N	35:33,414 E	978	déc.-99
Jezzin	40136	33:33 N	35:35 E	955	juil.-01
Faqra	40137	33:59,248 N	35:48,696 E	1710	juin-00
El_Hermel	40138	34:24 N	36:24 E	700	juin-05
Deir_El_Ahmar	40139	34:07 N	36:08 E	1080	juin-05
El_Quaraoun_Barrage	40141	33:33 N	35:41 E	855	juin-00
Balamand	40142	34:22 N	35:46 E	442	mars-00
Syr_Ed_Dennyeh	40143	34:23 N	36:02 E	915	janv.-01
Kafar_Chakhna	40144	34:21,292 N	35:51,902 E	260	mars-00
Kaslik_Jounieh	40146	33:59 N	35:37:00	20	mars-00
Deir_el_Kamar	40147	33:41,853 N	35:33,875 E	794	mars-00
Barouk_Fraidis	40148	33:43 N	35:42 E	1250	mars-00
Saida	40149	33:34 N	35:23 E	5	mars-00
Lebaa	40111	33:33 N	35:27 E	360	mars-00
El_Qassmieh	40113	33:21 N	35:15 E	30	mars-00
El_Qaa	40114	34:21 N	36:28 E	650	janv.-04
Douris	40118	34:00 N	36:12 E	1150	Avril-03
Kafar_Oouq_Rachaya	40122	33:30 N	35:51 E	1235	avr.-03
Tannourine	40123	34:12,467 N	35:55,896 E	1838	déc.-00
Kafar_Dounine	40124	33:13,962 N	35:23,743 E	560	juin-00
Marjayoun	40104	33:21 N	35:35 E	760	No Data
El_Mechref	40128	33:43 N	35:27 E	250	Juin 2002
Tripoli_Bouée	40103	34:27 N	35:49 E	0	05/08/97
Beirut_Bouée	40140	33:50,866 N	35:28,516 E	0	22/11/99
Zahrani_Bouée	40119	33:30,414 N	35:20,450 E	0	10/11/99

### III.13. Long Meteorological Records in Israel – Availability and Status

By Avner Furshpan  
Israel Meteorological Service

Zone de L'Intérieur - Région Hasbani

Yanta		33:36 N	35:56 E	1500	1961
Deir-el-Achayer		33:34 N	36:01 E	1280	1964
Kafar-Qouq		33:32 N	35:54 E	1210	1962
Rachaya		33:30 N	35:51 E	1235	1930
Kfair-ez-Zait		33:26 N	35:45 E	940	1964
Hasbaya		33:24 N	35:41 E	750	1943
Marjayoun	40104	33:21 N	35:35 E	760	1942

#### BACKGROUND:

Instrumental measurements commenced in the Land of Israel as early as 1846/7 in Jerusalem (rain measurements in the Old City). More observations (including other elements) were made in the 19<sup>th</sup> century in Nazareth, Jaffa, Gaza, Haifa, Sarona (now Tel Aviv) and several other locations. Paper records containing data from these stations are stored in the Israel Meteorological Service (IMS) archive. Some of the measurements, however, are not continuous and contain many gaps.

Broad continuous meteorological measurements (mainly rainfall) started in the beginning of the 20<sup>th</sup> century, especially after the end of World War I. The number of stations increased considerably in the 1920's and 1930's, as a result of the efforts of the British Mandate Government and of Professor Ashbel from the Hebrew University of Jerusalem, who established climatological stations in new Jewish settlements.

Figure 1 presents the growth of the rainfall stations network in Israel over time.

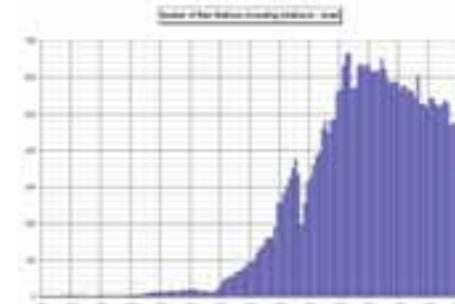


Figure 1: Evolution of the number of rainfall stations in Israel over time.

With regard to the availability of the data above, almost all the rainfall measurements are stored in the IMS archive as digitized daily records. As for other elements, most of the 19<sup>th</sup> century data is, as indicated above, on paper along with some of the 20<sup>th</sup> century data.

Over the last few years the IMS has been continuously promoting data entry actions for paper records progressing backwards from 1963. Currently about 75% of the known data from the 1920's and ahead has already been entered into the database. It should be emphasized, however, that only part of the data have been subjected to routine quality procedures.

Recently the IMS has started a scanning project. The characterization of the technical specifications has been completed and the actual work is scheduled to begin in the second half of 2008. Priority will be given to 19<sup>th</sup> century data and students are already working on the oldest paper records, in order to map their content and prepare them for scanning. It should be mentioned, however, that data entry of this material will demand considerable preparation work due to the complexity of the data (units, formats etc.) and shortage in manpower.

Problems that arise from the experience gained to date, with regard to the availability of old records and the creation of long climate data sets include: considerable gaps in data, often entire years, for many stations; lack of detailed metadata (exact location, exposure etc.); lack of knowledge about the instrumentation used; different data formats and non-standard times of observations; difficulty in applying quality control and reconstruction techniques due to the paucity of stations in the early years.

A particularly difficult problem to produce long and homogeneous climate records (especially temperature) in our region is the dramatic change of the landscape over the last century, and that should be taken into consideration in carrying out homogenization procedures.

The focus of this document is on long meteorological records in Israel. Detailed information about stations with such records is given in the next paragraph.

**LONG METEOROLOGICAL RECORDS:**

As mentioned in the previous paragraph, a distinction should be made between rain records and records of other elements.

As for the rain, the available data, with some exceptions, have been digitized and are stored in a database as daily values, except for a relatively small number of stations with monthly accumulations. Figure 2 shows a few examples of stations with relatively long records along with their digitized periods.

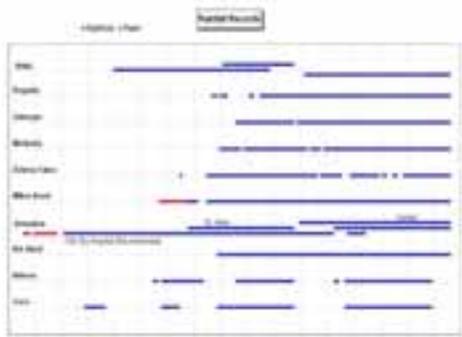


Figure 2: Digitized vs. paper. A graphical representation of availability of rain data in the IMS archive for selected stations. Full diamonds reflect digitized data while open circles show data that is on paper only. The example is typical and represents status of most of the rain data in the IMS archive.

Contrary to the extensive digitization of rainfall records, much of the temperature data and that of the other elements are still on paper and need to be digitized. Figure 3 is similar to figure 2 with some examples of long temperature records.

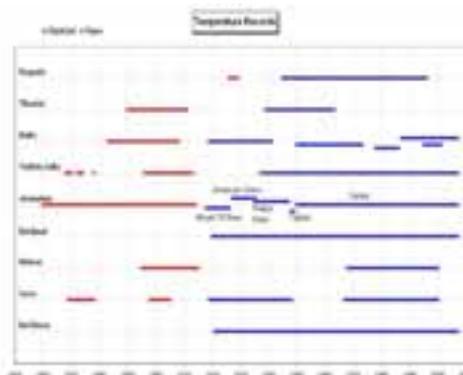


Figure 3: Digitized vs. paper. A graphical representation of availability of temperature data in the IMS archive for selected stations. Full diamonds reflect digitized data while open circles show data that is on paper only.

As was mentioned, the aim of this section is to highlight some of the longest meteorological records in Israel and to provide metadata and information concerning the availability of data.

For the reasons mentioned above, the information is given separately for rain and for the other elements. Emphasis is given mainly to stations that are still active today, although in some cases priority was given to geographic considerations. Furthermore, a more recent station was included in main cities even if its record is not necessarily a continuation of that of the oldest one.

Table 1 gives the basic metadata for selected rainfall stations, while table 2 refers to stations that measure other elements as well. Data in Table 1 are all digitized unless indicated otherwise. In order to keep the table in a tight and accessible format, additional information is added as comments at the bottom of the tables with clear reference to the relevant station. In table 1 'Exist' in the field "gaps" indicates that there is more detailed information about this issue in the comments below. The comments may include other important information as well.

Station numbers are internal IMS numbers with 6 digits for the rain stations and 4 digits for the climate stations.

No.	station numbers	station name	geographical coordinates	altitude (meters)	activity period	time resolution of the records	gaps
1	245170	Jerusalem, English Mission Hospital, Old City	N 31°46'38" E 35°13'50"	760	1846/47-1974/75	daily (see comments)	Exist
2	244850	Jerusalem, St Anne	N 31°46'54" E 35°14'09"	735	1908/09- today	daily	Exist
3	244730	Jerusalem, Central	N 31°46'51" E 35°13'19"	815	Jan. 1950-today	daily	None!
4	135600	Tel Aviv, Ha_Qiryia	N 32°04' E 34°47'	25	1879/80-1959/60	Daily, a few monthly	Exist
5	134850	Tel Aviv, Qiryat Shaul	N 32°07' E 34°49'	40	1944/45-today	Daily, a few monthly	Exist
6	120100	Haifa, German Colony	N 32°49' E 34°59'	10	Nov. 1880-1938/39	Daily, a few monthly	None!
7	120150	Haifa, D. O. (District Office)	N 32°49' E 34°59'	10	1921/22-1947/48	Daily, from 03/1948 monthly	None!
8	120200/ 120202	Haifa, Harbour	N 32°49' E 34°59'	10/30	1952/53 - today	Daily	None!
9	251850	Be'er Sheva	N 31°14' E 34°47'	270	1921/22-1956/57	Daily	None!
10	251690	Be'er Sheva	N 31°15'09" E 34°48'00"	280	1957/58-2002/03	Daily	None!
11	242950	Latrun, Monastery	N 31°50' E 34°59'	200/270	1900/01- today	daily from 1906/07	Exist
12	121700	Zikhron Ya'aqov	N 32°34' E 35°57'	140	Jan. 1905- today	daily	Exist
13	136650	Miqwe Israel	N 32°01' E 34°47'	20	1907/08- today (see comments)	daily from 1925/26	Exist
14	320500/ 320502	Deganya Alef	N 32°42' E 35°34'	-200	1917/18- today	daily from 1936/37	Exist
15	246550	Beit Jimal	N 31°43'32" E 34°58'37"	360	1919/20- today	daily from 1925/26	None!
16	210150/ 149/148/ 151	Kefar Gil'adi	N 33°15' E 35°34'	340	1921/22- today	Daily, some monthly	Exist
17	221450	Merhavia	N 32°36'18" E 35°18'24"	60	1920/21- today	daily from 1937/38	Exist

Table 1: A list of selected stations with long rainfall records in Israel. Additional information is given in the comments below. Activity period is refers to the digitized data.

No.	station numbers	station name	geographical coordinates	altitude (meters)	activity period	time resolution of the records	gaps
18	120750	Yagur	N 32°45' E 35°05'	30	1923/24 - today	daily from 1937/38	Exist
19	211900	Har Kenaan	N 32°58'54" E 35°30'25"	934	1939/40 - today	Daily	Exist

Table 1: Continuation...

Comments for table 1 (For quick reference, comments' numbers are according to the field No. in the table):

- 245170; Jerusalem, English Mission Hospital, Old City - The series is reconstructed (see Rosenan 1955). Daily data exists but with less confidence. Gaps: seasons 1849/50; 1859/60; 1963/64-1966/67; part of 1967/68.
- 244850; Jerusalem, St Anne - Gaps: seasons 1948/49-1962/63. Rosenan used this station, among others, for the reconstruction of the English Mission Hospital series.
- 244730; Jerusalem, Central – Located on the roof of Generali building, 4 floors above the ground. Also was used by Rosenan for the reconstruction of the English Mission Hospital series.
- 135600; Tel Aviv HaQiryā - Data before 1948/49 is actually from Sarona (a Templar agricultural settlement). It is actually the same place and probably the measurements were taken very close to each other. Since 1948/49 the station was located in the courtyard of what was the Israel Meteorological Service before it was moved to its present building at Bet Dagan in 1962. Gaps: part of 1889/90; seasons 1890/91-1897/98; part of 1899/1900; part of 1904/05; seasons 1917/18-1923/24 and 1944/45-1947/48.
- 134850; Tel Aviv, Qiryat Shaul – Cannot be considered as a continuation of Tel Aviv HaQiryā series but it may help in the reconstruction of that series better than coastal stations like Sede Dov due to its more inland location. Gaps: 1948/49; Jan. 1958; part of 1959/60.
- 120200/120202; Haifa, Harbour – Although very close to the German Colony (120100) and D.O. (120150) stations it is not necessarily a continuation of their series. It seems it gets less rain. In November 2001 the station was moved about 100 meters SSE and was erected on a roof of a building 30 meters above sea level.
- 251850; Be'er Sheva – Relocations: 12/1950 to the police courtyard. 02/1952 to the municipal plant nursery. 10/1952 was moved 50 meters to the north. Closed in 1957 and moved to the Negev Institute (see 251690).
- 251690; Be'er Sheva – Located at the courtyard of the Negev Institute. From 2003/04 onwards automatic station reports at the same location.
- 242950; Latrun, Monastery – According to Ashbel (1945) it seems that the series consists of two stations (the "new" one began in 1927/28 at a different height). Gaps: Seasons 1914/15-1918/19; 1948/49-1958/59; part of 2005/06.
- 121700; Zikhron Ya'aqov - Gaps: Seasons 1906/07-1914/15; part of 1957/58; Nov. 1962;

Oct. 1964; part of 1966/67-1968/69; part of 1980/81 and 1983/84; 1984/85; 1987/88-1988/89; Apr. 2005.

- 136650; Miqwe Israel - Data from 1897 until 1907 exists on paper and in Ashbel (1945). Gaps: Seasons 1912/13-1914/15. Slight relocations (up to 50 meters) due to growth of trees.
- 320500/320502; Deganya Alef - Relocation (250 metres) at summer of 1999. Data since then is under 320502. Gaps: Seasons 1919/20; 1923/24-1930/31; 1933/34-1934/35.
- 210150/210149/210148/210151; Kefar Gil'adi – On 18/12/1974 - relocation 120 meters westward (station number was changed to 210149). On 17/11/1975 a change to a small orifice rain gauge (station number was changed to 210148). On 30/8/1978 a change back to a standard rain gauge. On 01/2000 another move to the current location (station number was changed to 210151). Gaps: 1925/26; Oct. 1929; 1932/33; Jan. to May 1935; Oct. 1938; 1949/50; 1952/53; part of 1975/76 is interpolated.
- 221450; Merhavia - Gaps: 1928/29; part of 1931/32; 1953/54; 1958/59.
- 120750; Yagur - Gaps: season 1974/75 all monthly values are interpolated (original data is missing).
- 211900; Har Kenaan – Dramatic change of landscape over time though mainly in early years (see text ahead). Gaps: part of 1961/62; part of 1962/63; all of 1963/64.

Comments for table 2 (For quick reference, comments' numbers are according to the field No. in the table):

- The data for Jerusalem consists of measurements in several stations (see 1 to 5) that worked for short periods and that are not necessarily linked to each other. However, an effort was made to describe this data because

this is essentially the only place in Israel where a long series can theoretically be achieved. This is due to the fact that data from the English Mission Hospital (rain station 245170) are available on paper as far back as 1861. The exact content of this data has not been mapped yet but we intend to do so in the near future.

- 7850; Be'er Sheva – Gaps: Tx and Tn – 04-12/1928; 10/1938-07/1939; 04-12/1948; most of 1949. Hourly data has more gaps.
- 4640; Har Kenaan – Gaps: 06-07/1939; 07/1961; 10/1961-08/1964. Until 1965 hours 6, 12, 18; 1966-1986 - 6, 9, 12, 15, 18. Many gaps during 1987-1991. 1992-1999 - 6, 12, 18; 1999-2004 8 observations. From 2005 some gaps. Pressure data from 1942. Wind speed was reported from a Dines anemometer on the roof of the building. Wind records were achieved in the 50's and 60's but later the exposure was much obstructed. Since 1996 an automatic station reports also at the same location (anemometer was moved a bit and the pole is higher).
- 2010; Tel Aviv, Sede Dov – Station was moved in 10/1994. From 11/1994 under number 2011. Since 11/2000 under number 2012 due to a shift towards automatic measurements for some elements.

No.	station numbers	station name	activity period	Variables and gaps
1	6777	Jerusalem, Mt. of Olives	04/1918-12/1926	Tx,Tn, Evp (Piche). Some gaps especially in 1919/20. A few in 1923. Altitude 830 m. coordinates: N 31°46' E 35°14'. See comment on undigitized data of the English Mission Hospital station.
2	6760	Jerusalem, Amer. Colony	01/1927-03/1935	Tx,Tn, Evp. (Piche). Altitude 760 m. coordinates: N 31°47'30" E 35°13'46"
3	6775	Jerusalem, Palace Hotel	04/1935-12/1947	Tx,Tn, Evp. (Piche), T, Tw, pressure and cloudiness. Some gaps, especially 1946/7 with pressure and cloudiness. Altitude 760 m. coordinates: N 31°46'41" E 35°13'20"
4	6779	Jerusalem, Talbiyeh, Bet Tarsha.	11/1948-12/1949	Tx,Tn, T, Tw, pressure and cloudiness. 03/1949 missing. Pressure missing in 1948. Altitude 790 m. coordinates: N 31°46' E 35°13'
5	6770 (244730)	Jerusalem, Central	12/1949-today	Tx,Tn T, Tw, pressure, visibility and cloudiness. Until 1973 8 observation a day. After that hours 6, 12, 18. 8 observations again 1999-2003. Later partly missing.
6	7150 (246550)	Beit Jimal	01/1920- today	Tx,Tn (Evp. Piche until 1969), T, Tw, cloudiness (only until 1958 with gaps 1923-1939), visibility (1939-1967 with many gaps). Hours 6, 12, 18. Sporadic gaps. Mainly during summer. 2000 is missing.
7	7850 (251850)	Be'er Sheva	04/1921-10/1957	Tx,Tn, T, Tw, wind and cloudiness. Until 1938 only at 6GMT. Later 6, 12, 18 See comments for gaps.
8	7840 (251690)	Be'er Sheva	11/1957-2003	Tx,Tn, T, Tw, pressure, visibility and cloudiness. Until 1991 8 observation a day. After that 6, 12, 18 and later on only partial.
9	4640 (211900)	Har Kenaan	1939 - today	Tx,Tn (Evp. Piche until 1969), T, Tw, pressure, wind, visibility and cloudiness. See comments for gaps.
10	2030	Tel Aviv, Reading	08/1939-02/1972	Tx,Tn, T,Tw, pressure, wind. Minor gaps. Wind until 1961. Hours; 6, 12, 18.
11	2010/ 2011/ 2012	Tel Aviv, Sede Dov	01/1971-2004	Tx,Tn, T,Tw, pressure, wind, cloudiness. 8 observations a day with some gaps. See comments for location changes.

Table 2: A list of selected stations with long temperature records in Israel. Most of the stations appear in table 1 so geographic information is ignored for these stations. For quick reference the number of the rain station, which appears in table 1, is added in parenthesis. Here also some additional information is given in the comments below.

**ADDITIONAL REMARKS:**

*Change in landscape*

The dramatic change in the landscape, which was mentioned in the first paragraph as a possible obstacle for the construction of long and homogeneous climate records, is best demonstrated in the case of Har Kenaan station in Safed. Figures 4a to 4d show photos of the station in the years: 1939 (first year of operation), 1952, 1957 and 2005. It seems, however, that most of the dramatic change took place during the early years. It is clear that most of the other stations have gone through changes in their exposure but probably not to the same extent (Bet Jimal, as a counter-example, was probably exposed to relatively minor changes, due to its unique location in the courtyard of a monastery).



Figure 4a: Har Kenaan station, 1939, looking east (photo: IMS archive)



Figure 4b: Har Kenaan station, 1952 looking (photo: IMS archive)



Figure 4c: Har Kenaan station, 1957, looking west (photo: IMS archive)



Figure 4d: Har Kenaan station, 2005 looking south east (photo: IMS archive).

*Completing gaps*

Another important point that should be mentioned is that although most of the data and metadata stored at IMS, it is possible that some minor gaps in the rainfall data may be found in libraries, private collections, and especially in agricultural settlements known as kibbutzim. Another important source for completing gaps could be publications like that of Ashbel (1945).

*Long climate series – Rosenan.*

As an excellent example for a dedicated attempt to produce long climate series, it is particularly rewarding to read the important work done by N. Rosenan: "One hundred years of rainfall in Jerusalem - a homotopic series of annual amounts" (Israel Exploration Journal, Vol. 5, No. 3, 1955).

Much experience and insight may be gained concerning long climate series and the difficulties encountered in producing them. Rosenan extended his work further up to 1972 and it was later extended to the 1974/75 season (see station 245170 in table 1).

#### CONCLUDING REMARKS:

An effort was made to give as much information as possible about the longest meteorological records in Israel. The IMS digitized archive contains more stations with relatively long records but covering shorter periods and containing longer gaps than the stations included in this report.

It should be added that there are other extensive records that are still on paper; they are not discussed in this report since they cover relatively short periods or they cannot be merged with existing digitized records. The IMS is mapping the content of these records and will provide information about them at a later stage.

## III.14. Rescue and digitization of climate data in Cyprus

Stelios Pashiardis, Cyprus Meteorological Service

#### ABSTRACT:

The paper summarizes the history of meteorological observations in Cyprus, the current network of meteorological stations, the quality control procedures to check the raw data and the key-entry of climate data to the existing database system. Furthermore, details of the prepared inventories of digitized rainfall and temperature data are presented, including the existing digitization procedures to convert autographic charts to digital data. Finally, an overview of the assistant required to key-entry the historical climate data into digital form is outlined.

#### INTRODUCTION:

Data rescue is an ongoing process of preserving all data at risk of being lost due to deterioration of the medium and digitizing current and past data into computer compatible forms for easy access (WMO, 2004). These rescued data combined with already available data will enable better assessments of projections of the climate into the future that can serve as input for the policy makers to mitigate losses due to natural disasters and it will provide enhanced information for economic development (WMO, 2002). High-quality and long climate time series are required to study natural variability of the climatic system and detect any climate change.

In the year 2000, The Cyprus Meteorological Service started a program on data rescue, in order to digitize historical climate records. The aim of the program is to make historical climate data from Cyprus digitally accessible, with the highest possible time resolution and quality. The resulting high-quality datasets are needed to properly assess climate change and variability. Moreover, the datasets are also required to validate climate models. The output of these models is the basis for the development of climate change policies and climate scenarios for the 21<sup>st</sup>

century, which are increasingly being used in climate change impacts and adaptation studies.

The objective of this paper is to search and locate historical datasets, to prepare inventories for the meteorological stations operated during the last century, set out priorities to rescue existing meteorological data either from registers of manual observations carried out by observers or from autographic charts like thermohygrographs or pluviographs. In the next section a short history of meteorological observations in Cyprus will be presented. Section 3 describes the efforts taken by the Climatology Unit to digitize and check the quality of temperature and precipitation data. The study will concentrate on two essential meteorological variables, i.e. temperature and precipitation.

#### HISTORY OF METEOROLOGY IN CYPRUS:

The basic steps of the evolution of the meteorological observations in Cyprus are outlined in Table 1, while the number of climatological and precipitation stations operated in various years during the last century are given in Table 2.

The first known meteorological observations in Cyprus were carried out at Larnaka in the period October 1866-June 1870 by the British, Vice Consul of Cyprus Mr. Thomas B. Sandwith (Hadjiannou, 2000). At that time the island was part of the Ottoman Empire. The meteorological instruments (thermometers, rain gauge and barometer), were supplied by the Board of Trade through the Scottish Meteorological Society. The Society established various climatological stations in different parts of Europe with the view of collecting reliable information regarding the climates of places which might be recognized as sanitararia.

In 1878, Cyprus passed under British Administration. In 1881 Dr. F.W. Barry, the Sanitary Commissioner for the Government of Cyprus, installed meteorological stations in Nicosia, Famagusta, Larnaka, Pafos and Kyrenia, the instruments being

supplied by the Meteorological Council. In 1882 another station was installed in Limassol. New precipitation stations were installed in the following years and by 1902 there were in operation 7 climatological stations measuring at least temperature and precipitation and about 35 precipitation stations. The new climatological station was installed in 1902 at Akheritou, a village near Famagusta, where irrigation works were carried out.

The first notes on the climate of Cyprus based on meteorological records were published in the Journal of the Scottish Meteorological Society in 1879 (Buchan, 1879), in the Quarterly Journal of the Meteorological Society in 1883 (see Correspondence and Notes, 1883) and in the Quarterly Journal of the Royal Meteorological Society in 1903 (Bellamy, 1903; and Correspondence Respecting the Drought in Cyprus, 1903). Information on weather conditions in Cyprus appeared also in Official Reports of the Colonial Authorities, particularly in cases of adverse weather conditions.

The station network continued to be expanded and in 1931 there were in operation 7 climatological stations and about 60 precipitation stations. In the next 30 years new meteorological stations were added to the network. In 1961, there were in operation about 28 climatological stations and about 90 precipitation stations. These meteorological stations were located at District Medical Offices, at the Offices of the Public Works Department, at Forest Stations, at Police stations, at places where irrigation works were carried out and in private establishments. Stations at Elementary and Secondary Schools were installed in the years after 1960.

For many years and up to 1956, the Public Works Department had the responsibility for meteorological observations in Cyprus. Although, simple observations had been made and stored over these long periods, checking and use of these data by professional meteorologists had been extremely

limited. Apart from the most essential applications by engineers from time to time, there seems to have been no analysis of the data up to that year. In 1957 the responsibility for Meteorology was handed over from the Public Works Department to a Meteorological Office headed by a qualified Meteorologist responsible directly to the Secretary of Natural Resources. Instructions were issued to part time observers at the outstations, three Technical Notes were written and a start was made on providing climatological data in a form suitable for use by various authorities, especially agriculturists and hydrologists.

1866:	Starting time of the first meteorological observations at Larnaka carried out by the British Vice Consul of Cyprus.
1878:	Cyprus under British Administration.
1881:	Installation of the first climatological stations in the main cities of the island (Nicosia, Famagusta, Larnaka, Pafos, Kyrenia and Limassol (1882)), measuring mainly temperature and precipitation.
1902:	New climatological station was installed at Akheritou, a village near Famagusta and 34 precipitation stations were operated.
1931:	There were in operation 7 climatological and 60 precipitation stations. The Health Services had the responsibility for carrying out the meteorological observations until 1945 when they handed over to the Public Works Department.
1957:	The responsibility for meteorological observations was handed over from the Public Works Department to a Meteorological Office under the Secretary for Natural Resources.
1961:	Expansion of the network of stations. There were in operation 28 climatological and 90 precipitation stations.
1967:	Establishment of Meteorological Service by appointing a scientist in the office.

1968:	A specialist from World Meteorological Organization (WMO) organizes the Meteorological Service.
1970:	Decade of intensive developments by the implementation of a long term plan.
1974:	The Meteorological Service has no access to 11 climatological and 35 precipitation stations located in the part of Cyprus occupied by the Turkish troops.
1976:	Establishment of the Meteorological Office at Larnaka Airport to provide meteorological services to civil aviations after the closing down of Nicosia Airport and the cessation of services provided by the R.A.F. Met. Office.
1981:	Installation of a Radiosonde Station for upper air meteorological observations at Athalassa. A project in Agricultural Meteorology with the assistance of WMO was initiated.
1983:	A new Meteorological Office was established at Pafos Airport to provide services to civil aviation.
1984:	Installation of an actinometric station at Athalassa.
1986:	Installation of a meteorological satellite system at the Meteorological Office of Larnaka Airport.
1990:	Installation of the first computerized system in the Office. Development of a software to digitize autographic charts.
1997:	Installation of an automatic system of upper air observations.
1998:	Installation of new radiation sensors to measure all radiation components at Athalassa.
2000:	Establishment of a network of 18 Automatic Weather Stations to replace some of the existing manual climatological stations.
2001:	Development of Climate Database System (ENVIS) to digitize both manual and autographic charts. Key entry of data in the ENVIS database system from paper or existing ASCII or EXCEL files.

2007:	The current meteorological network of stations consists of 40 climatological stations, 105 precipitation, 2 synoptic, 1 upper air, 1 actinometric and 18 AWS. One synoptic station is operated at Akrotiri by the British Meteorological Office in Cyprus.
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Table 1: History of Meteorological Observations in Cyprus

Year	No. of Climatolog. Stations	No. of Rainfall Stations
1881	5	5
1902	7	36
1910	10	55
1931	7	60
1951	21	61
1961	28	90
1974a	42	136
1974b	31	101
1980	45	105
1990	47	112
2000	40	105
2007	40	105
a: Before the Turkish invasion (June)		
b: After the Turkish invasion (July)		

Table 2: Climatological and Rainfall Stations in Cyprus

During the anomalous conditions in Cyprus in 1959-1960 and 1963-1964 the progress towards an organized Meteorological Office was again retarded but its identity as a separate Office under the administration of the Ministry of Agriculture and Natural Resources was maintained. For many years in the 1960's the Office remained without a Head and qualified meteorological personnel. The Government of the Republic, recognizing the role which meteorology should play in a rapidly advancing country with significant agricultural development and a permanent water deficiency, appointed a science graduate to the Meteorological Office in 1967 and arranged for the visit of a WMO

expert in 1968. The expert made a thorough evaluation of the requirements of the country in all aspects of meteorology.

In 1971, the first considerable advance was made towards implementing the Government's aim of developing its Meteorological Service using the expert's advices and a long-term plan as foundation. The post of the Meteorologist (Head of the Meteorological Service) was filled throughout 1971 and 1972 by an expert of the WMO. The expert left from the Office in January 1973 and the post of the Head of the Service was filled by promotion of a Meteorological Officer. Appointments of new personnel were made in 1973 and in the following years.

With the implementation of the long-term plan, the Meteorological Service was developed rapidly after 1971. The station network was further expanded, new methods of quality control were introduced, the meteorological data were digitized and processed and a number of climatological studies were prepared. In July 1974, the progress of the Meteorological Service was again retarded due to the Turkish invasion in Cyprus, when a number of meteorological stations were lost in the occupied part of the island. The climatological stations were reduced from 42 to 31 and the precipitation stations from 136 to 101. After this situation new priorities were set up.

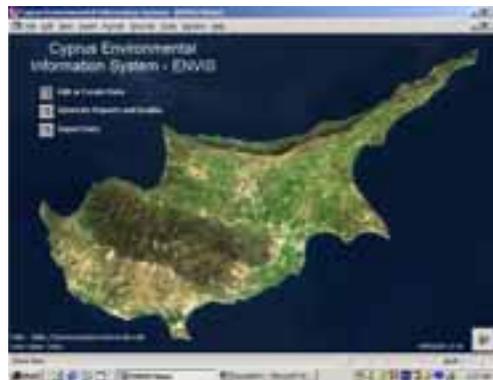
The Meteorological Service established in 1976 a Meteorological Office at Larnaka Airport to provide meteorological services to civil aviation, after the closing down of Nicosia Airport and the cessation of services provided by the R.A.F. Met. Office. The strengthening of the Synoptic and Aeronautical Unit, as regards both staff and equipment, continued in the following years and by 1980 the Unit reached its full development. The development of Meteorology in Cyprus continued in 1981 with the establishment of a Radiosonde Station for upper air meteorological observations.

With the aim of providing improved services to agriculture and particularly to routine agricultural operations a new project in Agricultural Meteorology was initiated in 1981 with the assistance of the WMO and the United Nations Development Program. In October 1983 a new Meteorological Office was established at Pafos Airport to provide services to civil aviation at this airport. In 1986 a meteorological satellite receiving station was installed at the Meteorological Office at Larnaka Airport. In 1998 an actinometric station was installed at Athalassa, where all radiation components are measured covering the full range of solar spectrum.

By 2000, 18 Automatic Weather Stations were installed with the intention to replace the manual observing system. At the same time a climatological Database System (ENVIS) was introduced and a big volume and meteorological data were transferred to this system (Figure 1). Details of the digitized data of temperature and precipitation are given in the next sections.

Figure 1: ENVIS Climatological Database

### ENVIS-Climatological database



In the recent years, particular attention is given to the computerization of the climatological archives and the preparation of statistical tables and

publications on the climate of Cyprus. Currently, the stations network has 40 climatological, 105 precipitation, 2 synoptic stations, 1 upper air and 1 actinometric station. Figure 2 shows the currently running network of stations which is relatively dense.

### Network of stations

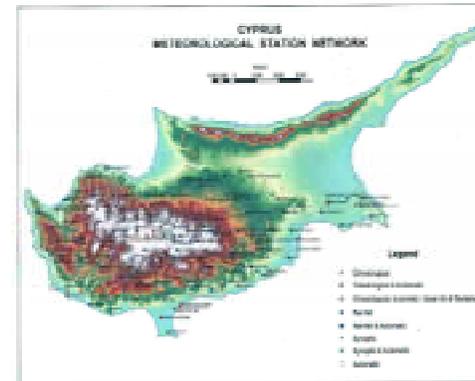


Figure 2: Network of meteorological Stations in Cyprus

### DATA RESCUE AND DIGITIZATION PROCEDURES:

#### Temperature

Temperature is one of the essential climate variables measured since 1881 in the main cities of the island. The quality control of all the meteorological elements started after 1970 when the Meteorological Service was established. Each climatological station is equipped with maximum, minimum, dry and wet thermometers, while, thermohygrographs were installed after 1950. A quality control procedure was developed to compare the manual observations at 0800 and 1400 hrs LST with those obtained from the thermohygrographs. With respect to the time step of the observational program three different temperature variables can be distinguished:

- Hourly Temperatures obtained from Thermographs.

- Daily Maximum and Minimum Temperatures obtained from the manual observations.
- Mean Daily Maximum and Minimum Temperatures obtained from the processing of daily values.

For the first type of data, a software program was developed using a digitizer, where the graph of daily or weekly temperatures is converted to a table in an ASCII or EXCEL format (Fig. 3). An inventory of the Thermohygrographs with the starting time for each climatological station was established. With respect to the volume of the computerized data obtained from the Thermohygrographs Table 3a summarizes the information.

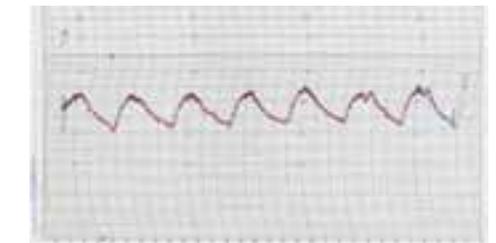


Figure 3: Digitization of Thermograph

Two-Hourly Temperatures		METEOROLOGICAL SERVICE													
		AIR TEMPERATURE (°C) - INSTANTANEOUS VALUES													
Day	02:00	04:00	06:00	08:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	24:00	Aver.	Max.	Min.
1	27.2	26.8	26.0	23.0	23.2	24.5	23.6	23.0	21.7	20.6	20.6	21.8	20.2	24.6	20.0
2	27.5	26.5	25.1	22.8	22.2	23.4	22.8	21.9	20.4	20.2	20.2	20.9	20.0	24.8	20.7
3	24.7	24.5	25.1	23.4	22.8	23.5	23.2	23.3	21.9	20.8	20.8	22.2	20.5	23.5	24.8
4	26.1	24.2	23.4	22.1	21.9	23.9	23.5	23.8	23.0	20.7	20.0	20.5	24.1	26.8	23.8
5	25.5	23.8	25.0	23.3	23.2	26.2	25.8	25.3	25.5	25.2	23.8	23.0	25.9	26.2	23.0
6	24.8	23.8	22.7	21.2	20.2	20.7	20.7	20.5	20.2	20.7	20.1	24.0	22.1	20.7	22.7
7	25.2	23.5	23.4	23.2	23.2	23.0	23.5	23.8	22.9	22.9	24.1	23.0	23.6	23.0	23.4
8	23.0	20.5	22.3	21.4	21.3	23.5	23.2	23.0	22.6	25.3	23.5	23.5	25.7	26.2	20.5
9	23.2	23.2	22.8	21.7	20.2	21.7	23.5	23.5	23.5	23.5	24.1	23.5	23.6	23.1	23.1
10	23.8	23.5	23.0	22.2	20.5	22.8	23.2	23.3	20.2	20.2	20.4	24.8	23.6	25.3	23.0
11	24.0	23.0	22.0	22.2	21.3	23.9	24.2	23.7	23.5	22.2	20.4	25.8	23.8	24.2	23.0
12	24.1	23.0	22.0	22.2	21.3	23.3	23.3	23.3	21.6	20.2	20.4	25.1	23.2	23.0	23.0
13	22.1	22.3	21.8	20.2	20.8	21.5	20.1	20.2	20.6	20.3	24.5	23.6	23.5	20.1	23.8
14	20.8	21.2	22.5	20.6	20.5	21.1	20.3	20.0	20.2	20.5	24.0	23.5	23.5	20.5	21.2
15	23.0	22.0	22.3	20.4	20.5	21.6	21.3	20.0	20.1	20.0	24.5	23.0	23.0	20.8	22.0
16	23.5	23.0	22.3	20.3	20.3	23.6	23.8	23.0	20.4	21.1	25.4	24.5	23.4	23.8	22.3
17	24.0	23.5	24.0	22.2	21.3	24.2	23.3	23.5	22.7	20.4	25.2	25.5	23.8	24.2	23.5
18	24.5	23.0	23.0	20.6	20.2	23.4	23.2	23.0	20.7	20.2	23.8	23.8	23.8	24.2	23.0
19	24.6	23.8	23.0	20.2	22.0	24.6	23.3	24.1	20.8	20.7	26.4	24.8	23.7	24.6	23.0
20	23.1	22.2	22.2	20.8	20.2	23.4	23.0	22.9	20.1	20.5	22.5	22.2	22.2	23.4	22.2
21	23.2	23.0	24.3	21.5	21.5	23.3	23.3	24.2	24.1	21.3	25.8	23.3	23.5	24.2	23.2
22	24.0	23.2	23.0	20.1	20.3	23.9	24.2	24.1	21.3	20.8	23.3	23.5	23.2	24.2	23.2
23	25.2	24.0	24.3	21.5	21.8	24.1	24.6	24.6	22.4	20.5	24.4	24.4	24.4	25.0	23.0
24	22.8	22.7	21.7	20.0	20.0	21.1	20.4	20.8	20.5	20.7	23.6	24.6	24.1	27.1	24.5
25	25.4	25.1	24.1	21.3	21.8	23.8	23.0	23.0	21.3	21.1	27.1	25.1	25.6	23.0	24.9
26	25.2	24.9	25.3	21.1	21.3	24.8	22.4	21.1	20.5	20.7	25.7	25.5	24.8	24.8	24.9
27	24.7	23.5	24.7	20.5	20.2	24.7	23.1	23.0	20.2	21.4	25.6	24.1	24.7	23.5	23.5
28	24.8	23.4	24.0	21.2	21.2	23.8	23.5	23.8	20.2	20.0	23.4	23.3	23.9	23.5	23.4
29	24.8	23.8	23.8	20.4	20.4	24.1	23.2	23.2	21.1	20.4	26.1	24.2	24.2	25.2	23.1
30	25.5	24.5	24.8	21.8	21.8	24.6	24.5	24.5	23.5	23.5	26.1	24.1	23.9	24.1	23.1
31	25.5	24.0	23.8	20.4	20.4	24.4	24.1	24.6	23.0	23.0	27.8	26.4	26.3	26.1	23.8
32	24.4	23.8	22.8	20.6	20.6	23.9	23.7	23.9	22.0	22.0	26.1	24.6	24.6	25.1	23.1
33	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
34	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
35	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
36	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
37	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
38	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
39	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
40	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
41	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
42	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
43	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
44	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
45	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
46	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
47	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
48	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
49	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
50	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
51	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
52	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
53	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
54	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
55	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
56	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
57	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
58	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
59	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
60	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
61	23.8	22.7	21.7	20.0	20.0	21.1	20.1	20.6	20.0	20.0	23.0	23.0	23.0	24.1	23.8
62															

ENVIS Database system. The data before 1976 are in paper format. An inventory of the starting and closing date of each climatological station was established. Table 3b shows the number of stations operated during various periods and the format of the data

1961 - 1975	Paper	16
>1976	Digital	all

Table 3b: Daily Maximum and Minimum Temperature Data

Stations	Period of records
Stavros Psokas	1953-
Prodromos	1952-
Amiantos	1949-
Platania	1955-
Saittas	1951-
Lemesos	1903-
Lefkosia	1892-2000
Kornos	1956-
Larnaka Marina	1951-

Table 3c: Mean Daily Maximum and Minimum Temperature Data

**PRECIPITATION:**

Precipitation is the second essential climate variable measured since 1881 in Cyprus. The measurements are taken by voluntary observers every morning. For the data since 1970, a quality control procedure is implemented which is based on the comparison of the daily precipitation values given by the observers with the data obtained from the rain recorders. The daily values are plotted on a map and contour lines are drawn to check the validity of the values. However, before 1970, the check of the quality of the data was based on the Thiessen polygon method. For each station metadata information is available concerning the periods of the estimated data and the time of the relocation of some stations. With respect

Finally, long series of records of mean daily maximum and minimum temperatures obtained from the processing of daily data are available. Table 3c shows the starting and ending time of the data. These long series of records were used by Price et al (1999) to detect climate trends of temperature during the last century at two locations in Cyprus. According to this study, the annual mean temperatures showed an increasing trend of approximately 1°C/100 years, while minimum temperatures have generally increased at a larger rate than the maximum temperatures, resulting in a decrease in the long-term diurnal temperature range. This decrease ranges from -0.5°C/100 years to -3.5°C/100 years, depending on the location. The reduction in the diurnal temperature range is consistent with observations from other parts of the globe, and may indicate that the climate in this region of the globe is part of a larger global climate change that has been occurring over the last century. The changes in the diurnal temperature range can possibly be explained by increases in cloud cover and/or tropospheric aerosols or by increasing urbanization of Cyprus.

Period	Format of Data	Stations
1950 - 1976	Charts	23
1976 -1980	Paper	46
>1980	Digital	all

Table 3a: Data from Thermohygrographs

Period	Format of Data	Stations
<1950	Paper	26
1951 - 1960	Paper	30

to the time step of the measurements, two different variables can be distinguished:

- Hourly precipitation and rainfall intensities obtained from the rain recorders, and
- Daily precipitation as measured from the rain gauges by the observers.

Regarding the first type of the data, a digitized program is used which allows the calculation of the maximum amounts of rainfall in different time intervals starting from 5 minutes to 6 hours. The graph of the rain recorders is converted to digital values and two tables are created, with the first one showing the hourly values and the second one the starting and ending time of each rainstorm including the highest amounts of rainfall in the given time intervals (Fig. 4). An inventory of the rain recorders and the period of the operation of each one was prepared. Table 4a shows that the rain recorders data have been digitized since October 1990. The rest of the available data are either in paper format or in graph of the rain chart itself.

Period	Format of Data	Stations
<1971	Charts	25
1971 - 1990	Paper	52
>1990	Digital	All

Table 4a: Rain recorders Data

Period	Format of Data	Stations
1881 -1900	Paper	7
1900 - 1916	Paper	72
> 1916	Digital	All

Table 4b: Daily Precipitation Data



METEOROLOGICAL SERVICE  
PRECIPITATION INTENSITIES

Type of rain recorder: (Type A)  
Unit: mm  
STATION: 592-4130-LEFKARA(DM)      MONTH: February      YEAR: 2007

Day	Start time	End time	Duration (hr:Min)	Scored	5 min	10 min	15 min	30 min	1 hr	3 hr	6 hr	Total
1	12:30	14:20	0:50	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	3:00	2:00	1:00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

METEOROLOGICAL SERVICE  
HOURLY RAINFALL (mm)

STATION: 592-4130-LEFKARA(DM)      MONTH: February      YEAR: 2007

Day	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total	
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 4: Digitization of rain chart

With the second type of observations, i.e. daily precipitation as measured from the rain gauges most of the data are in digital form since October 1916. An inventory was prepared showing the starting and ending time of each station. According to the results of the inventory, there are more than 70 stations with long periods of records (>90 years). There is a need to check the quality of the data before 1916 and digitize them. Table 4b summarizes the available daily precipitation data.

A statistical analysis of the long series of daily data was performed by FAO in cooperation with the Departments of Water Development and Meteorological Service with the objective to detect any changes on the precipitation regime of the island and re-assess the country's water availability and water use (FAO, 2002). Statistical analysis of the precipitation records available over the period of the

### III.15. Meteorological National Institute (MNI, Tunisia) Report under the MEDARE Rescue and Digitization of climate data

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hydrological years 1916/17-1999/00 shows a step change around 1970, with the mean annual precipitation in the recent period lower by 100 mm or more than the older period. This decrease ranges between 15% and 25% of the mean annual precipitation of the older period. As a consequence there is a decrease of the mean annual inflow to dams which varies between 24% and 58%. Similar results were obtained by IPCC where the scenarios of the climate change show a positive trend for temperature and negative trend for precipitation in the Eastern Mediterranean.

#### CONCLUSIONS AND RECOMMENDATIONS:

Data rescue is an ongoing process of preserving all data at risk of being lost due to deterioration of the medium and digitizing current and past data into computer compatible forms for easy access. According to the presented summarized tables, there is a need to prepare a strategic plan to rescue the meteorological data kept in the archives of the Meteorological Service or the National Store Department. With the aim to digitize most of the data which are in paper or chart format, one week of the time of the staff of Meteorological Service is devoted to transfer the data from the paper to the existing database system. Further to the temperature and precipitation data, there is a need to digitize other climate data such as upper-air and synoptical observations. Cooperation should be established between Cyprus Meteorological Service and the Met-Office in London since before the independence of Cyprus, the British Administration had the responsibility of synoptical observations in the island. Furthermore, the British Met. Office continues to carry out synoptical observations at Akrotiri.

It has to be stressed that the Climate Database system should be upgraded to improve the capacity of the existing one and allows the digitization of the upper-air and synoptical observations. The existing database system (ENVIS) has limitations. The climate databases offered by WMO can replace the

existing one. Furthermore, metadata information could be keyed into these database systems.

During the last 10 years, 18 Automatic Weather Stations were installed with the aim to replace part of the manual Climatological Stations. These stations are running in parallel together with the conventional stations in order to compare their measurements.

For climate change studies, homogenized data should be used. Therefore, the data rescue project should include homogenization methods, which can be used by all the Mediterranean countries in their efforts to compare their results. Inhomogeneities result from e.g. changes in instrumentation, repositioning of instruments, changes in the surroundings like the growth of trees and the expansion of cities, and the changes in observational practices. It can be concluded that a Data Rescue project to digitize at least the essential climate variables, is considered important for the Meteorological Service of Cyprus. Technical Assistance and guidance is essential in order to have good quality of climate data, which can be used for various climatological studies.

#### INTRODUCTION:

Climate data are nowadays heavily solicited for the purpose of study expanded in various areas. The characterization of climate, the determination of its variations and study its evolution are basic needs for planners, policy makers and operators in various sectors of activity.

In order to better respond to these demands, it is essential to have long time series of homogeneous and high-quality climatic data and so that all the data described in detail the atmospheric conditions that have occurred in the past.

Efforts have been made long in Tunisia as part of the world to remember weather conditions through instrumental measures of several weather elements (temperature, air pressure, rainfall, relative humidity, evaporation, wind, sunshine, clouds and atmospheric phenomena).

Climatology manages all weather observations in carrying out the functions of collection of recent observations, monitoring the quality of data received, archiving of technical documents, backup of climatological data on computer new media, and management of Climatological Database for the preparation and provision of information and climate studies.

The findings of climate studies rely on the quality of data used, homogeneity tests are applied and interpreted with the use of metadata.

The organization of data, the product development and the preparation of climatological information evolve to best satisfy the various end users.

#### ORGANIZATION OF CLIMATE DATA:

All weather observations recorded by synoptic, agrometeorological, climatological and rainfall stations of the MNI are stored in analog form on paper documents. Since 1982 the climatological time series have been also stored in a digital database.

Table 1 shows the increase in the number of observation station since 1950

Station type	Number of stations				
	1950	1970	1990	2000	2008
Synoptic	8	18	25	26	27
Agrometeorological	5	8	18	24	28
Climatological	11	38	39	45	46
Rainfall	83	125	146	158	162

*Table 1: Number and type of stations from the MNI meteorological network*

The synoptic stations measure 40 parameters hourly and 64 daily.

The agrometeorological stations record similar measures to the synoptic stations apart from atmospheric pressure.

The climatological stations measure 8 parameters 3 times a day and 16 daily parameters.

The rainfall stations measure only the daily precipitation amount.

The instrumental weather observations go back to the late nineteenth century and are available and archived in analog form. Most of the documents relating to the period 1970-1990 have been microfilmed, which facilitated the update of wrong data input identified with quality control tests, especially those relating to the period 1970-1979 which were treated way.

The digitization of climatological records has been done since a workshop within the MNI in 1982.

The automatic observation stations were activated in 2000.

The Climate Database can be uploaded both from the files of digitized records and from collection files

as a result of daily or monthly data download of automatic weather stations.

The total amount of observed and processed data since 1950 is currently around 60 GB and it is managed by an RDBMS with continuous actions of improvement.

In order to get the longest possible climatological time series, it is planned to explore the archives and to highlight interesting climate information to make an electronic copy and conduct their digitalization if possible.

A census of these records yet not digitized is a program of national importance and possibly in a broader context (MEDARE).

Table 2 shows some documents already have been identified:

	Elouate	Tunis	Kalbia	Jendouba	Kairouan	Mnasser	Slak	Gabis	Jetta	Remidi	Giba	Toussur
1957												1957
1958												1958
1959												1959
1960												1960
1961												1961
1962												1962
1963	*	*	*	*	*	*	*	*	*	*	*	1963
1964	*	*	*	*	*	*	*	*	*	*	*	1964
1965	*	*	*	*	*	*	*	*	*	*	*	1965
1966	*	*	*	*	*	*	*	*	*	*	*	1966
1967	*	*	*	*	*	*	*	*	*	*	*	1967
1968	*	*	*	*	*	*	*	*	*	*	*	1968
1969	*	*	*	*	*	*	*	*	*	*	*	1969
1970	*	*	*	*	*	*	*	*	*	*	*	1970
1971	*	*	*	*	*	*	*	*	*	*	*	1971
1972	*	*	*	*	*	*	*	*	*	*	*	1972
1973	*	*	*	*	*	*	*	*	*	*	*	1973
1974	*	*	*	*	*	*	*	*	*	*	*	1974
1975	*	*	*	*	*	*	*	*	*	*	*	1975
1976	*	*	*	*	*	*	*	*	*	*	*	1976
1977	*	*	*	*	*	*	*	*	*	*	*	1977
1978	*	*	*	*	*	*	*	*	*	*	*	1978
1979	*	*	*	*	*	*	*	*	*	*	*	1979
1980	*	*	*	*	*	*	*	*	*	*	*	1980
1981	*	*	*	*	*	*	*	*	*	*	*	1981
1982	*	*	*	*	*	*	*	*	*	*	*	1982
1983	*	*	*	*	*	*	*	*	*	*	*	1983
1984	*	*	*	*	*	*	*	*	*	*	*	1984
1985	*	*	*	*	*	*	*	*	*	*	*	1985
1986	*	*	*	*	*	*	*	*	*	*	*	1986
1987	*	*	*	*	*	*	*	*	*	*	*	1987
1988	*	*	*	*	*	*	*	*	*	*	*	1988
1989	*	*	*	*	*	*	*	*	*	*	*	1989

Table 2: Tunisian stations and years, for which documentary climate data is available.

AVAILABLE DATA:

The accumulated meteorological observation data show the climate history of Tunisia since 1950.

The analysis of this database requires continuous actions of improvement and modernization of the tools used. Equipment and management programs are adapted to the needs.

The use of an Open Database Management System can secure the data, develop good climate products and meet as soon as possible requests for information from the various sectors of activity.

The Climate Database assures weather observations done on all of MNI networks; it contains all the hourly and daily data observed at the national meteorological stations, most since 1950.

The data is structured in the form of tables

Table Name	Data Type	No. Lines
HOBS	Hourly data / main stations	6 260 327
QP	Daily data / main stations	417 440
SYNTEMP	Recent hourly data	1 671 410
CRQTEMP	Recent daily data	82 230
TCMS	Daily data / substations	733 500
TSOL	Ground temperature	269 092
PLUIE	rainfall	46 163
PHENO	Meteorological phenomena	28 733
MOBS	Monthly data / main stations	13 896
MTCMS	Monthly data / substations	24 562

Table 3: Details on the tables at MNI containing climate data

THE DATA COLLECTION:

The digital storage of data requires a considerable effort in data collection, entry and quality control.

The data collection of automatic stations will be done by questioning either by direct reading at each automatic station by the staff of each meteorological region.

The collection is standardized by the type of station (synoptic, agrometeorological or climatological) and by the observation period (hourly or daily). The files received at the central site are merged by data type. Each dataset is controlled, loaded into the Climatological Database and subsequently used for the development of climate products.

The programs which make up this data acquisition channel have been developed in-house at the MNI.

The chain of data collection and processing from automatic stations includes a step for monitoring the quality of data received. A computer program tests the accuracy of the data received and displays doubtful data. At the same time, it allows the correction of wrong values.

THE CLIMATE PRODUCTS:

Requirements of internal services at the MNI and external users in data and climate products are done through software consulting and climate data extraction. The production of statistics, analyses and spatio-temporal representation in the form of tables, graphs or climate maps is done through standards software.

Tests of homogeneity and some gap-filling methods have been applied to the time series of different climate parameters during the preparation of the Climate Atlas of Tunisia.

A model to forecast monthly and seasonal precipitation-amounts in Tunisia is operated regularly in the service of Applied Climatology following the signature of a Memorandum of Understanding with Meteo-France, which has led to the installation of the climate-model Arpege in the MNI.

Quality control-methods were established as a result of comparisons made in relation to other model outputs and what has actually been observed.

Climate changes on a global level are regularly monitored. The MNI contributes within the National Committee for syntheses on the assessment of climate change in Tunisia and in the region in recent decades.

The evidence of irreversible climate changes and the development of scenarios for future climate concerns remain in the field.

The Institute website ([www.meteo.tn](http://www.meteo.tn)) offers a large number of weather products.



### III.16. ALGERIAN experience on data digitization and management

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Office National de la Météorologie, Centre Climatologique National, ALGERIA

#### National Meteorological Service of Algeria:

The National Climatic Centre, «Centre Climatologique National», is one of the four central departments of the Algerian Meteorological Service, the "Office National de la Météorologie (ONM)".

The Centre's mission includes:

- Collecting data from the different observation networks
- Preservation of archives in paper form
- Data quality control and management
- Safeguarding the national climatic data bank
- Assist end users on climatology
- Regular publication of climatic information

The central department operates through six regional sub-divisions (and divisional centers) :

- East region (Constantine)
- Central region (Algiers)
- West region (Oran)
- South-East region (Ouargla)
- South-West region (Bechar)
- South region (Tamanrasset)

Currently the climatological network (400 weather stations) is composed of:

- 77 Synoptic stations (8 automatic)
- 182 climatological stations
- 117 automatic weather stations with monthly archiving

There is a new network in the process of installation that is composed of:

- 40 automatic weather stations in the South region equipped with DCP

- 10 automatic weather stations for the urban region of Algiers.

In collaboration with the Global Atmosphere Watch program, Algeria initiated one GAW station on 1992.

For GCOS network, the Service have four GSN stations and one GUAN station.

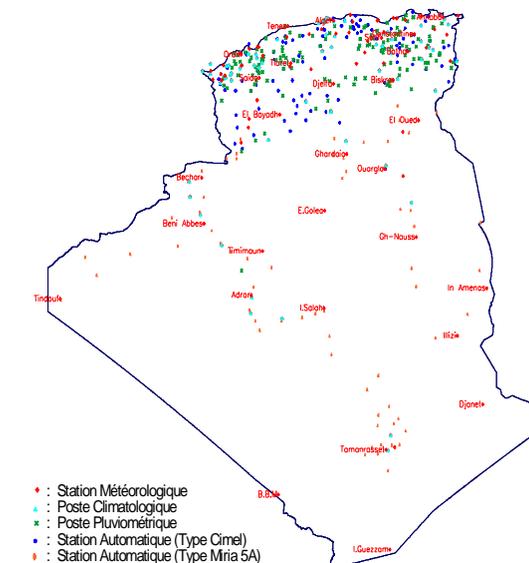


Figure 1: Surface network of Algeria

#### HISTORY OF DATA MANAGEMENT:

The Algerian National Meteorological Service began electronic data management in 1970 with an IBM 1160 computer, by using punch cards. But digitisation using punch cards was a difficult task.

In 1976 a development project gave more powerful equipment for data processing, this consisting of three NORSK DATA computers from Norway that were used for telecommunications and data processing.

The Climatological Section developed in-house Fortran language routines for digitizing data and

controlling their quality. Data for the 1953-1991 period were saved on magnetic tapes.

Key entry data were not made in real time, as the documents are sent from the stations by postal mail to the central service.

The first Personal Computer, an Olivetti M24 (4Mhz, 640 Ko RAM, 10 Mo Hard Disk, 5"1/4 floppy disk) became available on 1986.

On 1987, the Service started data key entry (precipitation and temperature) using IBM XT PC's based on "Datastar" software given by Meteo-France. Data from principal and climatological stations are digitalized in the six meteorological regions of Algeria. Data are sent then to the central service on floppy disks.

The CLICOM system began on 1989. After adapting it to Algerian needs and developing a Fortran routine for data quality control (QC), the Service started using CLICOM for ten points, which became named CLICOM centres in 1992.

The development of a QC routine was necessary to control DAILY Data against SYNOPTIC data. The CLICOM system controls the data only by type DAILY or SYNOPTIC. The CLICOM system was progressively installed in each of the 70 principal station between 1995 and 2003.

Data on magnetic tapes are transferred from the NORISK DATA computer to Olivetti M24 PCs and stored on floppy disks and on the PC hard disks. The transfer task was the equivalent of 1163 years of data and was drawn from 50 stations and 30 months to complete. A major problem was that magnetic tapes were not compatible with other systems.

#### DATA DIGITIZATION AND MANAGEMENT:

Currently each main station enter and control the data in situ. They create CLIMAT messages and then the monthly ASCII files are disseminated through a FTP server. The monthly files contain for each day 8 synoptic observations (29 parameters by

observation) followed by daily observations (36 parameters). Daily data (precipitation and temperatures) from the Climatological stations are keyed in the regions.

#### The synoptic databank

From a number of 28 stations in 1971, the number of stations has risen to 77 in the last few years, as shown in Figure 1.

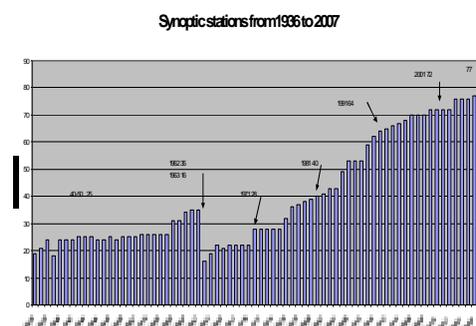


Figure 1: Time evolution in the number of stations of the Algerian meteorological network

Only six stations have a continuous observation period from 1936 to 2007.

The data are stored by year files in ASCII format, each day is described on 9 lines. Each line is an observation time for hourly data (8 lines for the 8 HLY observations (00, 03, 06, 09, 12, 15, 18, 21 H UTC)). The line contains also 3HLY parameters (Visibility, clouds, temperatures (T Td Tw), humidity, vapor pressure, pressures, wind, rainfall, present weather, past weather ...).

The line 9 for the day contains DLY parameters (specific phenomena, gust, extremes temp, humidity, evaporation, rain fall, duration ...)

Quality control is applied to the data, 115 QC tests for 3HLY data and 75 QC tests for DLY data.

#### Daily databank

The data, daily precipitation amount, daily minimum, daily maximum temperatures are stored by station in ASCII format (Dataease).

Quality control is applied on the data, 8 QC tests.

#### AWS databank

The data are stored by station in ASCII format and by type of automatic weather station:

MIRIA AWS T, U, RR, DDFF (3HLY) from 1992.

CIMEL AWS T, U, RR, DDFF (6M, HLY, DLY) from 2000.

XARIA AWS T, U, RR, DDFF, PPP, INS, R\_glo, R\_dif (Min, 6M, HLY, DLY) from 2006.

AURIA AWS T, U, RR, DDFF (HLY) from 2007 (new network)

#### Metadata

We have two types of Metadata files

Type 1: full information on instruments and position of the station (done by synoptic stations)

Type 2 : information on position of the station.

#### ARCHIVING:

Manuscripts are archived on two sites: before 2003 in ORAN (West Algeria) and from 2003 in Algiers (Central Algeria).

The oldest manuscript is from 1856.

Two rooms are reserved, one for daily reports and the other for monthly summaries.

Reports are stored by station and ranked by hydrological basin

Electronic archiving by using scanners A3 format started on year 2000.

Storage of images is done on CDs.

272 000 daily reports were scanned for 17 stations on period 1949-2002 and stored on 367 CD's. Each daily report is on 4 images.

#### CONCLUSION:

What we do now:

Quality Control of old data files (1953-1991) copied from magtapes

Quality Control of rainfall stations data

Develop Quality Control routines to check new files from AWS Xaria and Auria

Create detailed Metadata files for synoptic stations

What we want to do:

1. Secure more our climatic data
2. Homogeneous data
3. Generate missing data
4. Climate change (indexes, climatic model)
5. Create Database (DBMS)
6. Make maps for Climatic Atlas

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## Abbreviations

ACRE: Atmospheric Circulation Reconstructions over the Earth

AEMET: Agencia Española de Meteorología (Spain)

ALP-IMP: Multi-centennial climate variability in the Alps based on Instrumental data, Model simulations and Proxy data (EU research project)

AOPC/OOPC/WG-SP: Atmosphere Observation Panel for Climate/Ocean Observation Panel for Climate/Working Group on Surface Pressure (WG-SP)

ARSO: Environmental Agency of the Republic of Slovenia

BDClim: French Climatological Data Base

BDSCLIM: Catalanian Data Base of Climate Series

CCI: Commission for Climatology (WMO)

CDMP: Climate Database Modernization Program (NOAA)

CENMA: Snow and Mountain Research Centre of Andorra

CET: Central England Temperature

CLICOM: Climate computing (WMO) software

CLIMAGRI: Climate Change and Agriculture

CLIVAR: Climate Variability and Predictability

CLIWOC: Climatological Database for the World's Oceans 1750-1850 (EU research project)

CNES: Centre National d'Etudes Spatiales (France)

CNR: Italian National Research Council

CSIRO: Commonwealth Scientific and Industrial Research Organisation

DARE: Data Rescue

DCs: Developing Countries

DFID: UK Department for International Development

DR&R: Data Rescue and Digitization

ECA&D: European Climate Assessment and Dataset

ECMWF: European Centre for Medium-Range Weather Forecasts

ECVs: Essential Climate Variables

EMULATE: European and North Atlantic daily to Multidecadal climate variability (EU research project)

ENSO: El Niño/Southern Oscillation

EPCA: European Commission Preservation and Access

ETCCDI: Expert Team on Climate Change and Indices

CIRCE: Climate Change and Impact Research: Then Mediterranean Environment (European research project)

ECSN: European Climate Support Network

EUMETNET: The Network of European Meteorological Services

EUMETSAT: European Organization for the Exploitation of Meteorological Satellites

EURRA: European Regional Reanalysis Project

FFEM: Fonds Français pour l'Environnement Mondial

GCMs: Global Climate Models

GCOS: Global Climate Observing System

GDCN: Global Daily Climate Network (NCDC)

GEO: Group of Earth Observations

GHCN: Global Historical Climatology Network (NCDC)

GHCN: Global Historical Climatology Network (NCDC)

GMR: Grater Mediterranean Region

GSN: GCOS Surface Network

GUAN: GCOS Upper-Air Network

HadCET: The Hadley Centre Central England Temperature data set

HMZCG: Hydrometeorological Institute of Montenegro

HNMS: Hellenic National Meteorological Service

HOME: Advances in homogenisation methods of climate series: an integrated approach

HyMeX: Hydrological cycle in the Mediterranean Experiment

IEDRO: International Environmental Data Rescue Organization

IGU: International Geographical Union

IMPROVE: Improved understanding of past climatic variability from early daily European instrumental sources (EU research project)

IPCC: Intergovernmental Panel of Climate Change

KNMI: Royal Netherlands Meteorological Institute

LCS: Lebanese Climatological Service

LDCs: Least Developed Countries

LMNS: Lebanese Meteorological National Service

MEDARE: Mediterranean Data Rescue Initiative

MedCLIVAR: Mediterranean Climate Variability and Predictability

MedMEDARE: The Development of Mediterranean Historical Climate Data and Metadata Bases - a GCOS DARE Project

METADEM: Catalanian Metadata of Meteorological Stations Database

MeteoDB: Meteorological database of Bulgaria

MHSC: Meteorological and Hydrological Service of Croatia

MILLENNIUM: European climate of the last millennium (EU research project)

MNI: Meteorological National Institute of Tunisia

MSAP: Madrid Statement and Action Plan

NAO: North Atlantic Oscillation

NCDC: National Climatic Data Center

NCEP: National Centers for Environment Prediction

NIMH: National Institute of Meteorology and Hydrology of Bulgaria

NMHSs: National Meteorological and Hydrological Services

NOAA: National Oceanic and Atmospheric Administration (USA)

NWP: Nairobi Work Programme (UNFCCC)

OCR: Optical Character Recognition

ONM: Office National de la Météorologie (Algeria)

OPAG: Open Programme Area Group (WMO/CCI)

QA: quality assurance

QC: quality control

QCCCE: Queensland Climate Change Centre of Excellence

RA: Regional Association (WMO)

RAPs: Regional Action Plans (GCOS)

RCMs: Regional Climate Models

RDBMS: Relational Database Management System

RECLAIM: Recovery of Logbooks and International Marine Data

SIDSs: Small Island Developing States

SIGN: Signatures of environmental change in the observations of the Geophysical Institutes (Portuguese research project)

SMC: Servei Meteorològic de Catalunya

SRS: Speech Recognition Software

UNFCCC: United Nations Framework Convention on Climate Change

URV: University Rovira i Virgili

WCDMP: World Climate Data and Monitoring Programme

WCRP: World Climate Research Project

WMO: World Meteorological Organisation

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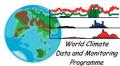
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- WCDMP-52 GUIDELINES ON CLIMATE OBSERVATION NETWORKS AND SYSTEMS (WMO-TD No. 1185)
- WCDMP-53 GUIDELINES ON CLIMATE METADATA AND HOMOGENIZATION (WMO-TD No. 1186)
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- WCDMP-56 FOURTH SEMINAR FOR HOMOGENIZATION AND QUALITY CONTROL IN CLIMATOLOGICAL DATABASES (Budapest, Hungary, 6-10 October 2003) (WMO-TD No. 1236)

- WCDMP-57 REPORT OF THE RA V DATA MANAGEMENT WORKSHOP (Melbourne, Australia, 28 November-3 December 2004) (WMO-TD No. 1263)
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