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Addressing climate data sources and key records for the Mediterranean Basin in support of an enhanced detection, prediction and adaptation to climate change and its impacts

World Meteorological Organization

MEDARE

Proceedings of the Second WMO/MEDARE International Workshop:

Addressing climate data sources and key records for the Mediterranean Basin in support of an enhanced detection, prediction and adaptation to climate change and its impacts

(Edited by Manola Brunet and Anahit Hovsepyan)

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Edited by

Manola Brunet and Anahit Hovsepyan

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Chairperson, Publications Board
World Meteorological Organization (WMO)
7 *bis*, avenue de la Paix
P.O. Box No. 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0)22 730 84 03
Fax: +41 (0)22 730 80 40
E-mail: Publications@wmo.int

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Summary Report of the 2nd WMO/MEDARE International Workshop on Addressing Climate Data Sources and Key Records for the Mediterranean Basin

By Manola Brunet
MEDARE coordinator

INTRODUCTION:

The second World Meteorological Organization (WMO)/MEditerranean DAta REscue (MEDARE) International Workshop was held in Nicosia (Cyprus) on May 10-12, 2010. It was scientifically and logistically organised by the International Scientific Committee and International Organizing Committee, respectively, (http://www.omm.urv.cat/medare-tarragona/2workshop.html), with the Republic of Cyprus Meteorological Service and the Cyprus Institute - Energy, Environment & Water Research Center being the local organisers. It was sponsored by the WMO-World Climate Monitoring Programme (WCDMP) (http://www.wmo.int/pages/prog/wcp/wcdmp/wcdmp_home_en.html) and addressed to the members of MEDARE Working Group 1 (WG1: http://www.omm.urv.cat/MEDARE/working-group-1.html) and to the MEDARE Steering Group (http://www.omm.urv.cat/MEDARE/steering-group.html), in order to discuss on the identification and selection on a country-by-country basis a set of the longest, reliable and key records for some of the Global Climate Observation System (GCOS) Essential Climate Variables (ECVs, such as temperature, precipitation and air pressure on a daily basis) from different data sources (from national archives to international repositories) over the Greater Mediterranean Region (GMR) that could be targeted and developed by the MEDARE Community (http://www.omm.urv.cat/MEDARE/medare-community.html) in support of an improved detection, prediction and adaptation to climate change and its impacts over the GMR.

Main topics addressed in this workshop were as follows:

- The key role of developing high-quality and long-term climate data and metadata databases in support of an enhanced climate change and climate change impacts research in the GMR
- Assessment and definition of a GMR reference climatological network to be used by scientists, stakeholders, policy-makers and the general public
- The implementation of a metadata inventory on a country-by-country basis, targeting the longest and key national climate records, both digitized and non-digitized time series
- The identification and implementation of WMO-MEDARE projects and funding possibilities at international, European and national scales
- General discussion and initial agreement on the WMO/MEDARE data exchange policy

Twenty five participants from fifteen countries and National Meteorological Services (NMSs) attended the three days long workshop (http://www.omm.urv.cat/MEDARE/list-of-attendees-2workshop.html). During the first day invited experts addressed the key role of developing long, high-quality climate data and metadata for the GMR, while the second day saw presentations from MEDARE/WG1 members on their national climate metadata inventories and key climate records to be developed (digitised, quality controlled and homogenised at the daily scale). At last, the third day continued with discussions among the participants on the best ways to define and agree the MEDARE data and metadata exchange policy and a long-term funding programme to enable undertaking MEDARE projects. This report briefly summarise the two sets of presentations, which are available at the MEDARE website (http://www.omm.urv.cat/MEDARE/2workshop-presentations.html), and lays out the discussions and agreements taken on the final day of the meeting.

SUMMING UP THE PRESENTATIONS FROM DAY 1

WMO climate data management and data rescue programmes, along with the required international coordination, was addressed first (http://www.omm.urv.cat/MEDARE/docs/2workshop/

1_WMO%20Kontongomde%20Nicosia.pdf). The speaker assessed climate data and database management systems – from commercial packages (e.g. CLISYS, CLIDATA) to license free systems (e.g. CLIMSOFT, CLIWARE, JCDMS) – currently operatives over different continents and countries and addressed regional coordination and the role of WMO Regional Climate Centres fostering climate data rescue, preservation and digitisation activities and the development of high-quality and homogenous climate datasets.

A look at MEDARE past activities and achievements, together with the targets and expected outcomes from the workshop, were also discussed (http://www.omm.urv.cat/MEDARE/docs/2workshop/2_MEDARE_background_v2.pdf). The speaker highlighted both current strengths (e.g. involvement of the bulk of Mediterranean NMSs, high international visibility) and weakness (e.g. limited funding for undertaken MEDARE projects or networking, reluctance of funding agencies to fund data rescue – DARE – projects either by national and European or international bodies, national restrictions to access to their assets of climate data) of this WMO Initiative and focused on what it was expected to be achieved during the workshop: to define national and sub-regional climate networks to be targeted as MEDARE projects, to find the best ways to get MEDARE funded and to overcome difficulties on data exchange.

The need for enhancing high-quality climate data availability was also addressed (http://www.omm.urv.cat/MEDARE/docs/2workshop/3_Elena_MEDARE.pdf). The presenter assessed why it is important to enhance climate data availability over this world hotspot region, in which climate variability and recent climate change are intensifying vulnerability of the GMR socio-ecosystems to the impacts of heat waves, water scarcity or desertification, posing big challenges to food security, public health and putting at risk national economies.

Two national experiences in the arena of climate data rescue, digitisation and development of high-quality and long-term climate records were presented next as case studies. The procedures and methodologies followed in order to create the Spanish Daily Adjusted Temperature Series (SDATS), which involved the location, recovering and digitisation of a set of 22 long temperature records (extending through the period 1850-2005) and the techniques employed in order to quality control (QC) and homogenising raw temperature data at the daily scale, were assessed (http://www.omm.urv.cat/MEDARE/docs/2workshop/4_MEDARE_SDATS_T2.pdf). Lessons learnt from the Météo-France DARE program were discussed (http://www.omm.urv.cat/MEDARE/docs/2workshop/5_Jourdain_lessons.pdf), which also involved all the necessary steps to undertake integrated DARE projects (e.g. from searching and locating the data to data dissemination once high-quality climate data have been developed). The speaker assessed the whole DARE procedures and emphasised some of the problems that could be encountered: 1) an integrated DARE process includes search and location of data (more and more data collections and catalogues are accessible through internet at different kind of on-line archives; 2) making a detailed inventory of the located data and metadata (essential step in order to prioritise records to be rescued and ensure their traceability); 3) data preservation (from conditions to keep data safe to storage requirements); 4) data recovering (difficulties related to the scattered data sources, national laws protecting old documentation and to lend the data from the archives); 5) data digitisation (must be undertaken under the supervision of experts in DARE); 6) data quality control and homogenisation (to develop timeseries that are reasonably free of wrong individual values and whose variations only respond to the forcing exerted by meteorological and climatological factors); and, finally, 7) high-quality climate data dissemination (provided through NMSs or other web services, along with their metadata to ensure traceability).

An overview on deficiencies and needs for developing high-quality climate data over the southern Mediterranean countries was provided (http://www.omm.urv.cat/MEDARE/docs/2workshop/6_Azzedine.pdf). Difficulties encountered are related to poor archiving conditions, inadequate training of the staff in charge of archiving, recovering and keeping old data or the data loss when stations were relocated and poor support from the NMS to their climate services departments. Therefore, these countries require strong support (training and financial hold up) on whole procedures to develop high-quality and homogenous climate records. The following talk (http://www.omm.urv.cat/MEDARE/docs/2workshop/7_MEDARE-The%20CIMME%20data%20repository.pdf) was focused on the CIMME data repository, a Cyprus Institute initiative aimed at gathering and provision of atmospheric, oceanic, terrestrial and socio-economic data relevant to climate change assessments over the Mediterranean region and the Middle East. The final talk (http://www.omm.urv.cat/MEDARE/docs/2workshop/8_wis4medare.pdf) focused on the WMO Information System (WIS) for climate data, which is designed to be built on the Global Telecommunication System (GTS) by using international industry standards and provide time-critical data exchange, as well as data access and retrieval services in order to support all WMO and WMO-related international programmes.

OUTLINE OF THE PRESENTATIONS FROM DAY 2

The second day of the workshop mainly saw national presentations from Andorra, Armenia, Bosnia-Herzegovina, Bulgaria, Catalonia, Croatia, Cyprus, FYR of Macedonia, France, Greece, Israel, Italy, Jordan, Morocco, Romania and Turkey NMSs on climate metadata inventories and key climate records to be developed under MEDARE. Representatives from these NMSs gave information on their DARE activities and recent tasks undertaken since the first MEDARE workshop took place in November 2007 and on the old climate data sources and metadata of the records that should be targeted as MEDARE projects in their respective countries. All these talks are available at http://www.omm.urv.cat/MEDARE/2workshop-presentations.html.

Most of the NMS presentations showed that they have been active in DARE activities since the previous MEDARE workshop: ones progressing on locating alternate data sources to the data kept in their national archives and imaging and inventorying the located data kept in perishable media (e.g. Catalonia, Andorra, France, Italy, Bulgaria, Bosnia-Herzegovina, FYR of Macedonia, Greece, Armenia, Israel), while others focused on digitising, quality controlling and/or homogenising their data (e.g. Catalonia, Andorra, France, Italy, Romania, Croatia, Greece, Turkey, Cyprus, Israel, Jordan, Morocco).

However, a number of common problems were also highlighted: scarcity of human and technical resources for undertaking sustainable DARE programmes, lack of well trained personnel on integrated DARE procedures, limited or absence of the required financial resources, poor understanding and relationships between NMSs operational services and their climatological branches. In short, more resources (both financial and personnel) would be required before significant progress to achieve MEDARE end-goals and objectives (http://www.omm.urv.cat/MEDARE/goal-objectives.html) are met.

A brief summary of the selection of long and key national records presented by the participants is given next in geographical order: from western and northern to eastern and southern Mediterranean countries.

Over Catalonia (north-eastern Spain), the presenter from the Catalan Meteorological Service offered to build up the MEDARE climate database by providing 16 (28) daily temperature (precipitation) series from 1950 (1940) onwards, including 5 (14) long (~ 100 years long) temperature (precipitation) records, and one long air pressure record (Barcelona) for the period 1780-2009. All these records are already digitised, but not yet either quality controlled or homogenised. In the case of Andorra, the CENMA/IEA representative provided an overview on their activities and offered daily temperature and precipitation data and metadata for three Andorran stations extending from 1934 onwards. Also the French representative gave a detailed summary on the progress made by Météo-France and offered 5 Mediterranean French stations with daily temperature and precipitation records. The presentation of the Italian Air Force (Italy NMS) gave details on its current DARE efforts, real-time data collection and e-archiving database management (from 1950-1955 onwards), together with its efforts on imaging and digitising historical Italian data (for the 1925-1950 period) and colonial overseas climate data (e.g. over Libya for the 1879-1960 period), as well as offering metadata for 53 Italian temperature and precipitation stations from 1950 and earlier.

Over the North-eastern Mediterranean sub-region (including Greece and the Balkans), the Romanian NMS's presentation gave an overview to the potential of historical climate data (from 1750 onwards) for being rescued/developed and its efforts to preserve, image and digitise its holdings (both data and their related metadata). The Croatian representative also gave a summary of the selected stations from Croatia for the MEDARE climate databases offering 13 stations located along the Adriatic Croatian coast, all of them including both monthly digitised and pending digitisation records for the main Global Climate Observing System (GCOS) Essential Climate Variables (ECV), such as temperature, precipitation, humidity, air pressure, wind (speed and direction), cloud cover and sunshine duration, mainly for the second half of the 20th century but also two long-term stations (one from mid-19th century onwards and other from the late 19th century onwards). Bosnia-Herzegovina's presentation gave hints on its recent DARE activities, which have been focused on imaging and digitising historical information from its assets. Bulgarian NMS presentation also provided insights into its DARE programme, which has been centred on inventorying, imaging, fulfilling in gaps and digitising its climate records. From the Bulgarian meteorological data bank, they offered metadata for 10 stations located within and representing the main climatic types in the country. At these stations, the main GCOS/ECVs are recorded and these time series expand for different periods covering from the late 19th century to the mid-20th century and onwards. After giving a summary of their historical meteorological network, the attendee of the NMS of the FYR of Macedonian, offered metadata for seven stations evenly distributed and representing all climate sub-types within the country. These stations cover a variable period from early to mid-20th century and onwards. Finally, the representative of the Greece NMS showed their recent DARE activities focused on preserving, imaging, inventorying, creating a metadata base and digitising some of their historical climatic records (10 stations and their corresponding records longer than 100 years) and put the accent on the need of looking for cooperation between universities and NMSs in order to further push DARE activities.

The attendees from four NMSs from the south-eastern and southern Mediterranean countries gave their views and information on the DARE activities recently carried out and on their selected stations/records to take part of the MEDARE database. First, Armenia representative addressed their historical climate data holdings and other sources potentially containing relevant meteorological data (e.g. Matenadaran repository), showing the potential to develop long and high-quality climate records at least for 20 long-living stations (12 shorter than 79 years and 8 longer than

80 years) and urging for assistance in order to preserve, image, digitise and develop their timeseries. For Turkey, the representative of the NMS gave a broad picture of its DARE approach, which encompasses not only the recovering of instrumental data but also focuses on "proxy" data. After providing information about old historical records to be recovered from different sources (including Ottoman documents), the metadata for eight long digitised and partially QC stations data from the late-1920s and onwards were offered to take part in the MEDARE metadata and databases. Next, the Cypriot NMS representative gave a summary of their historical holdings for about 80 (17) precipitation (temperature) records starting in 1916 (mainly covering the 20th century and two longer records going back in time to the late decades of the 19th century), which were offered to MEDARE database once recovered and developed. The representative of Israel NMS gave detailed insights into the country's longest temperature (rainfall) records from 9 (17) locations, the progress done on imaging old data and on the problems they have encountered (e.g. changes in data formats, data sources, data QC). Next, the Jordan's climate data and DARE efforts was presented by Jordan NMS attendee. The meteorological history, the climate types for this country and the longest available digitised climate records in the Jordan Climate Data Management System were provided, with a focus on 12 meteorological stations containing long timeseries (6 shorter than 49 years and 6 longer than 50 years), from which the metadata are already available on the MEDARE portal. Finally, the representative from Morocco NMS also gave details on their observational network, climate data flow, historical climate inventory and offered metadata for 7 stations counting with daily and sub-daily data for temperature, precipitation, humidity and sunshine duration.

OUTLINE OF THE DISCUSSIONS FROM DAY 3 ON GETTING MEDARE FUNDED AND DATA EXCHANGE POLICY

The last day of the workshop saw discussions on the selection of the climatological reference network to be targeted over three Mediterranean parts: Western, Central and Eastern Mediterranean, on the definition of a MEDARE data and metadata exchange policy and on funding possibilities for MEDARE projects in order to achieve its end-goal. The first issue was addressed by splitting the attendees into three groups according to the geographical distribution of countries included in each one of these three Mediterranean areas and the last two issues were addressed by all the attendees through moderated round tables.

Each subgroup discussed on which would be the optimal trans-national network composed of the potentially longest, continuous and key daily climate records (temperature, precipitation and air surface) over the three Mediterranean areas that should be developed to reach the required standards for more confidently assessing climate variability and change at regional and sub-regional scales. Tentative lists of key and long climate stations were defined for each subregion, which are composed of a varying number of records depending on the country that are given in each of the national presentations (http://www.omm.urv.cat/MEDARE/2workshop-presentations.html). This exercise raised, however, a number of questions on data exchange that served to introduce the discussion on the MEDARE's data exchange policy.

Most of the attendees gave a number of reasons for which they were not allowed to make freely available their data for research and operational use: e.g. different national data archive and distribution policy, need to sell the data in order to get back the costs of making observations and preparing the data, some governments make their NMS cover part of their budgets, limited human resources for processing the observations and the requests of data, national laws protecting the country's documentary heritage. In short, political and/or financial imperatives were adduced among other reasons in order to explain and justify the currently restricted data exchange and data access. Only few NMSs' attendees (e.g. those from Catalonia and Andorra) showed their will of providing freely access to their historical climate data once their longer records were developed.

After setting these grounds, the participants discussed on how to circumvent data policy issues and how to proceed for making available the identified long records to be developed in the framework of MEDARE. This discussion was introduced by the WMO's representative at the workshop, who recommended establishing the MEDARE guidelines based on the application of the WMO policy and practice for the international exchange of data and products. His suggestions contemplated a set of assertions:

- all the released metadata, data, and products in the context of MEDARE should be regarded as "exchanged under the auspices of WMO";
- the international exchange of data and products under MEDARE is subject to already agreed WMO policy and practices, particularly WMO Resolutions 25 and 40,
- "metadata" in the context of MEDARE is a type of "meteorological and related data and product" as that term is used in the WMO Resolutions 25 and 40) and specific agreements, such as: all MEDARE metadata, data and products will be accessible worldwide on the basis of "free and unrestricted access", except where specifically provided otherwise and subject to WMO policy and practice;
- delivery via the public Internet of metadata, data, and products will be at no charge because such delivery of such material in the MEDARE context has a negligible "cost of reproduction and delivery";
- aggregate and derivative products (including but not limited to indices, extracts of extremes, summaries of trends) are not encumbered by any conditions that may apply to the original data used in the creation of such products, following the spirit of guidelines in WMO Resolution 40, Annex 2, although this does not include the original, adjusted or homogenized data;
- metadata, data and products identified as MEDARE contributions will be officially released for MEDARE exchange within a pre-defined time span and that the policy of "free and unrestricted access" does not apply in the period prior to official release;
- to routinely notify the original contributors regarding access statistics for MEDARE metadata, data, and products;
- any request for data which is not considered freely available in the web should be directed to the contributor and should not be provided by MEDARE.

A vivid discussion followed afterwards, when some of the participants raised the issue on data sharing and exchange under the MEDARE framework. Most of the participants stated they were not able to offer any of the identified long climate records over their countries, even under the MEDARE framework, as they need the previous agreement of their respective Permanent Representative (PR) within the WMO and/or current directors of their NMS. Only few NMS participants stated their services had adopted a free and unrestricted data exchange policy. In parallel, it was also discussed how many records would be reasonable to request to each country/NMS/PR, in order to avoid to overwhelm them with an unreasonably request containing a big amount of climate records. Several ideas emerged from the discussion, but it was mostly accepted the one suggested by the Israel participant, who proposed to request to every PR for a limited number of climate records (e.g. from 5 to 10 records each country, depending on the country size) as a first step to get climate data and to be able to agree on a prioritisation for their recovery/development under MEDARE. Most of the attendees agreed that proceeding as such would give us a better idea of the will of each PR for data exchanging within MEDARE and, therefore, we could assess on the feasibility and convenience of adopting a MEDARE data exchange under the WMO sensible regulations.

Finally, the attendees addressed the issue of getting MEDARE funded, in order to ensure progress and consolidation of its end goal. Most of the attendees assessed current constraints to get funded data rescue projects, since for most of the funding bodies (from national to regional and international agencies) there is a clear reluctance to fund such kind of research projects. Therefore, the attendees suggested as a strategy to overcome this reticence to include data rescue and high-quality datasets development bids as a component of any research proposal that needs high-quality and long climate records for basing on them any posterior analysis. Several ideas emerged during the discussion, from networking bids to developing specific components for data rescue under the framework of national, trans-national, European and international research proposals. The Libyan attendee suggested to explore the ClimDev program in Africa and agreed to provide the contacts for it. Others suggested preparing a bid for networking to the European Science Foundation (ESF) Research Networking Programmes and to the European Cooperation in Science and Technology (COST) Actions, while a few attendees (the Israeli and Jordanian participants) explained their experiences of recovering data through taking part in and making use of specific bilateral-funded research projects.

October 2010

Introduction to the Workshop Proceedings

By Manola Brunet
MEDARE coordinator

This proceedings is the result of the contributions made by the attendees to the 2nd World Meteorological Organization (WMO)/MEditerranean DAta REscue (MEDARE) International Workshop *on Addressing climate data sources and key records for the Mediterranean Basin in support of an enhanced detection, prediction and adaptation to climate change and its impacts* (Nicosia, Cyprus, 10-12 May 2010), which has been organised by the WMO/ World Climate Data and Monitoring Programme (WMO/WCDMP), the Republic of Cyprus Meteorological Service, The Cyprus Institute - Energy, Environment & Water Research Center (EEWRC) and the University Rovira i Virgili (URV, Tarragona, Spain).

The Second WMO-MEDARE workshop built on the results and agreements taken under the First WMO International Workshop on Climate Data Rescue in the Mediterranean Basin and in the experience and activities carried out by the MEDARE Community since its inception, which was endorsed by WMO EC-60 on June 2008. The workshop focused on the strategies for the development of long-term and high-quality climate databases for the Mediterranean Basin, which can support an enhanced detection, prediction and adaptation to climate change and its impacts over the Mediterranean socio-ecosystems. The workshop was addressed to the members of the MEDARE Working Group 1 on Inventorying/assessing/approaching old material sources and holders (http://www.omm.urv.cat/MEDARE/working-group-1.html) and the members of the MEDARE Steering Group (http://www.omm.urv.cat/MEDARE/steering-group.html), while it was open to other scholars and scientists interested in climate data and metadata rescue, preservation, digitization, homogenization, archiving and dissemination across the Mediterranean countries. The following topics were addressed:

- The key role of developing high-quality and long-term climate data and metadata databases in support of an enhanced climate change and climate change impacts research in the Greater Mediterranean Region (GMR.)
- Assessment and definition of a Greater Mediterranean Region reference climatological network to be used by scientists, stakeholders, policy-makers and the general public.
- The implementation of a metadata inventory on a country-by-country basis, targeting the longest and key national climate records, both digitized and non-digitized time series.
- Identification and implementation of WMO-MEDARE projects and funding possibilities at international, European and national scales.
- General discussion and agreement on the WMO/MEDARE data exchange policy.

The proceedings provides information on MEDARE Community activities and progress made since its inception until present, as well as gives updated details on GMR countries contribution to build up the MEDARE on-line metadata and data bases. It is structured into two main sections: the first one dedicated to provide the rationale and examples for developing long and high-quality climate data and metadata and, the second one, devoted to inventor the national climate networks that will take part of the MEDARE data and metadata bases portal. The sections are preceded by the summary report of the 2nd MEDARE workshop and this introduction, along with the references list at the end of the proceedings.

In the first section and after addressing the progress made by the MEDARE Community so far are assessed the needs, difficulties and benefits of undertaking DARE activities by means of two case studies: the development of the Spanish Daily Adjusted Temperature Series and the DARE activities undertaken by Météo-France, which are followed by the role of the WMO/Commission for Climatology (CCl) on its different branches of activity.

The second section is dedicated to review existing national initiatives in the DARE arena and the progress made by National Meteorological and Hydrological Services (NMHS) in the GMR since the inception of the WMO/MEDARE Initiative. It also provides insights at the national level on the key climate records that are being developed by the countries in order to build up the MEDARE data base portal. Efforts made by Catalonia, Andorra, France, Italy, Bulgaria, FYR of Macedonia, Greece, Turkey, Armenia and Jordan NMSs are addressed, along with the national networks selected to take part of the MEDARE on-line climate data portal.

The proceedings ends with a reference list.

The proceedings have been made possible thanks to the help of a number of MEDARE volunteers. The editing of the texts submitted has been carried out by Dennis Wheeler, Constanta Boroneant and Manola Brunet and the reformatting of the proceedings has been made possible thanks to Manola Brunet and Anahit Hovsepyan, which are the editors of the proceedings.

Manola Brunet
Tarragona, December 2011

SECTION I: THE KEY ROLE OF DEVELOPING LONG, HIGH-QUALITY CLIMATE DATA AND METADATA FOR THE GREATER MEDITERRANEAN REGION

The WMO MEDARE Initiative: past activities, current status and prospects: identifying the workshop targets

Manola Brunet, MEDARE coordinator, Centre for Climate Change (C3), University Rovira i Virgili, Tarragona, Spain

ABSTRACT:

This contribution reviews past, present and ongoing activities undertaken by the MEditerranean DAta REscue (MEDARE) Community and its working groups (WPs) since the inception of this World Meteorological Organization (WMO) Initiative. It also assesses current strengths and weakness of MEDARE, as well as setting the grounds for identifying the targets of the 2nd MEDARE workshop hold in Nicosia (Cyprus, May 10-12, 2010).

INTRODUCTION:

Since the WMO/MEDARE Initiative was launched at the International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin (Tarragona, November 2007) and got later the endorsement of the WMO Executive Council (EC)-60 (June 2008: http://www.omm.urv.cat/MEDARE/endorsement.html), the MEDARE Community (http://www.omm.urv.cat/MEDARE/medare-community.html) has been active carrying out many organisational, dissemination, cooperation or research activities, in order to ensure the end goal of MEDARE is achieved; namely, to develop comprehensive, long and high-quality instrumental climate datasets for the Greater Mediterranean Region (GMR) with a focus on the Essential Climate Variables (ECV) of the Global Climate Observing System (GCOS). Such datasets will support and enhance MEDARE Members' ability to better monitor, detect and predict climate variability and change at regional and national levels, thereby allowing Mediterranean countries to develop robust strategies for managing climate related risks and adapting to climate change.

In this article is presented a review of the past, current and ongoing activities carried out by the MEDARE Community since its inception, based on the talk given by the author at the 2nd MEDARE workshop, where the speaker gave a brief summing up of past and recent MEDARE activities and addressed both strengths and weakness of this WMO Initiative, as well as set the grounds for identifying the workshop targets and paving the way for better facing future challenges.

The article is structured as follows: A backdrop on the WMO/MEDARE Initiative is given in section 1. The revision of past, present and ongoing MEDARE's activities are reviewed in section 2, while section 3 deals with the assessment of current strengths and weakness of MEDARE. Section 4 is devoted to set the targets of the 2nd MEDARE's workshop and explore future prospects. Finally, the conclusions are provided in the last section.

A BACKDROP ON THE WMO/MEDARE INITIATIVE

The GMR has a very long and rich history in monitoring the atmosphere, going back in time several centuries in some countries and at least to the mid-19th century across much of the GMR. However, despite the efforts undertaken by National Meteorological and Hydrological Services (NMHS), research centres, universities and motivated individuals in Data Rescue (DARE) activities, available and accessible digital climate data are still mostly restricted to the second half of the 20th century for a few countries and since 1970s for most of the GMR. This reality is preventing the region from developing more robust, accurate and reliable assessments of climate variability and change and its adverse impacts on the socio-ecosystems of the Mediterranean Basin, at the same time it is impeding the development of optimum strategies to mitigate and/or adapt the countries to the current and future impacts of climate change.

To address and remedy these and other shortcomings, the GCOS in collaboration with the Moroccan NMHS organised in Marrakech (Morocco, November 2005) a regional workshop aimed at identifying and assessing deficiencies in climate monitoring programs in the Mediterranean Basin, with the agreement reached of elaborating a Regional Action Plan (RAP) for the Mediterranean Basin where the main Mediterranean climate monitoring shortcomings were addressed. This was achieved in the GCOS' follow-up meeting (Tunis, Tunisia, May 2006) where a draft of the Mediterranean RAP was agreed and later circulated broadly across the region for review prior to its finalization. Among other recommended actions and projects included in the Mediterranean RAP, a DARE project (GCOS 2006: Project 12) was prioritised as one of the actions needed in order to tackle currently limited availability and accessibility to key historical climate data and metadata over this climate change 'hot-spot' region (Giorgi 2006).

Later the WMO/World Climate Data and Monitoring Programme (WCDMP) undertook the lead in fostering and progressing climate data and metadata rescue activities across the GMR by organising along with University Rovira i Virgili (URV) and the Spanish NMHS (Agencia Estatal de Meteorología: AEMet) an international workshop (November 2007, Tarragona, Spain) where it was addressed this essential shortcoming and the WMO/MEDARE Initiative was launched with the agreement of the participants, which came mainly from most of the Mediterranean NMHS (except Albania and Malta) along with other motivated scientists from universities, research centres and international projects (http://www.omm.urv.cat/medare-tarragona/list_of_participants_v2_MBI.pdf) with the aim of fostering, consolidating and progressing climate data and metadata rescue activities across the GMR (Figure 1).

Figure 1: Attendees to the 1st International Workshop on Rescue and Digitization of Climate Records in the Mediterranean Basin (Tarragona, November 2007)

PAST, PRESENT AND ONGOING MEDARE ACTIVITIES

From the moment that the aforementioned workshop ended and before getting the WMO EC-60 endorsement (resolution No. 821/EC-LX/APP-WP 3.5.3.3 in June 2008), different actions were carried out in order to set officially up this Initiative.

Figure 2: The MEDARE web portal implemented at and hosted by C3/URV. http://www.omm.urv.cat/MEDARE/index.html

First, a website for linking and exchanging relevant information among the MEDARE Community was defined, implemented and hosted at the URV website (Figure 2).

Second, organizational aspects were undertaken, including the official involvement of most of the NMHS in the GMR through the WMO official channels. In this regard, a 3-years rotating MEDARE Steering Group (SG) to enable all MEDARE NMHS to be part of the system was constituted (http://www.omm.urv.cat/MEDARE/steering-group.html), being the first SG composed of five members from Mediterranean NMHS (Algeria, Bulgaria, France and Turkey) and three from European Universities in Spain, Switzerland and the UK. Besides 34 Supporting Organizations (23 NMHs and 11 research centres and universities) were involved (http://www.omm.urv.cat/MEDARE/supporting-organizations.html) and the Community was and is composed of about 100 members (http://www.omm.urv.cat/MEDARE/members.html). It was also decided and organised four Working Groups (WGs), whose members were officially nominated by their respective Permanent Representative (PR) within WMO, as listed next:

WG1. Inventorying/assessing/approaching old material sources and holders with 23 members (http://www.omm.urv.cat/MEDARE/working-group-1.html).

WG2. DARE techniques and procedures (including digitization) with 18 members (http://www.omm.urv.cat/MEDARE/working-group-2.html).

WG3. Approaches on best practices for quality controlling and homogenizing specific climate variables with 25 members (http://www.omm.urv.cat/MEDARE/working-group-3.html).

WG4. Promotional activities, bringing MEDARE to the wider scientific and other communities with 15 members (http://www.omm.urv.cat/MEDARE/working-group-4.html).

This structure has allowed the MEDARE Community to undertake many other organizational, implementation and dissemination activities in order to raise awareness on the importance of bringing historical climate datasets into the 21st century, which is paving the way to get achieved the MEDARE's end-goal and objectives.

From the point of view of the implementation of the MEDARE Initiative, other activities, besides the organizational tasks mentioned above, have been carried out. Following up with the action agreed at the 1st MEDARE workshop for building up a comprehensive inventory on Mediterranean long and key climate records for the GCOS' ECVs, the architecture and design of an on-line infrastructure for gathering relevant metadata was carried out and hosted at http://app.omm.urv.cat/urv/, which is being actively contributed by most of the NMHS and research centres involved in MEDARE (Figure 3).

Figure 3: The MEDARE metadata base on-line infrastructure implemented at hosted by C3/URV

Particularly, it has been quite successful gathering information over Southern and Middle East Mediterranean countries, one of the poorest documented and, at the same time, more vulnerable areas in the GMR, for which the availability and accessibility to long and high-quality climate records is highly necessary because its current limited availability is hampering both climate change studies and adaptation assessments to present and future climate impacts.

Also in order to increase our knowledge on the current status of Mediterranean long-term climate records, the MEDARE proceedings from the 1st workshop were produced. In this WMO/WCDMP Series issue, the deficiencies and gaps in the availability and accessibility to long and key Mediterranean climate records on a country-by-country basis, the first comprehensive assessment of such kind over the GMR, were identified (http://www.omm.urv.cat/MEDARE/docs/Proceedings_MEDARE.pdf), while the 2nd MEDARE workshop proceedings is being produced as part from the reports presented at the 2nd MEDARE workshop (http://www.omm.urv.cat/MEDARE/2workshop-presentations.html). It will provide comprehensive information on the national climate networks to be rescued and developed in order to build up the Mediterranean climate databases, end goal of the MEDARE Initiative.

In the area of raising awareness on the urgent need for bringing vital historical data into the 21st century and disseminating MEDARE goal and objectives, different material have been produced and distributed, such as: the MEDARE's poster (http://www.omm.urv.cat/media/documents/Poster_MEDARE_v5.pdf), which has been brought to different scientific meetings or the elaboration and translation into nine Mediterranean languages (e.g. http://www.omm.urv.cat/MEDARE/docs/medare-brochure/MEDARE_broch_ARABIC.pdf). The MEDARE brochure is aimed at raising awareness on the need and benefits of undertaking DARE activities over the GMR and it is being provided to relevant stakeholders (Figure 4).

Figure 4: The MEDARE brochure in Arabic http://www.omm.urv.cat/MEDARE/docs/medare-brochure/MEDARE_broch_ARABIC.pdf

In this regard, the MEDARE WG4 has been active taking part in different scientific meetings and international for a, in order to raise awareness on the need of undertaking integrated DARE activities and publicise the MEDARE aims. Among other international scientific meetings and fora, to mention the following ones in chronological order: the WMO/Commission for Climtaology (CCl) Expert Team on Climate Change Detection and Indices (ETCCDI: Vietnam, December 2007) meeting, the United Nations Framework Convention on Climate Change Expert Meeting on Methods and Tools and Data and Observations under the Nairobi Work Plan on Impacts, Vulnerability and Adaptation to Climate Change (in Mexico, DF, March 2008), the European Geophysical Union Annual Meeting (Vienna, April 2008), the WMO/CCl Expert Team on the Rescue, Preservation and Digitalization of Climate Records (Bamako, Mali, May 2008), the WMO/CCl/ETCCDI/ENSEMBLES meeting (Holland, May 2008), the 31st International Geographical Congress (Tunis, August, 2008), the "Climate Extremes During Recent Millennia and their Impact on Mediterranean Societies" Meeting hold at the National and Kapodistrian University of Athens (Athens, Greece, September 2008), the European

Meterological Society/European Conference on Applied Climatology Meeting (Amsterdam, Holland, September, 2008), the Asociación Española de Climatologia (Spanish Climatological Society) international conference (Tarragona, Spain, October 2008), the CLImate VARiability (CLIVAR)-Spain workshop (Madrid, Spain, February 2009), the Plinius 11th Conference (Barcelona, Spain, September 2009), the Atmospheric Circulation Reconstructions over the Earth Meetings (Bologna, Italy, May 2009 and Exeter, UK, September 2009), the WMO/CCl TEchnical COnference (TECO: Antalya, Turkey, February 2010) or the GCOS Atmospheric Observing Panel for Climate session (Geneva, Switzerland, February 2011).

Figure 5: The EURO4M contribution to enhance availability and accessibility to long and high-quality Mediterranean climate time series *http://www.euro4m.eu/Data_archaeology_in_the_Mediterranean_region.html*

The ongoing MEDARE's main activities include continuing to fulfil the on-line MEDARE Metadata Base infrastructure (http://app.omm.urv.cat/urv/) by MEDARE members that currently contain about 500 Mediterranean historical stations, update the MEDARE website with the outcomes from the 2nd MEDARE workshop and produce its proceedings or undertake the development of the longest climate (daily maximum and minimum temperatures and precipitation amounts and hourly air pressure) records over north African and Middle East Mediterranean countries. These records are being digitised and developed (quality controlled and homogenised) under the opportunity that brings us the new EU-funded project (European Reanalysis and Observations for Monitoring: EURO4M project (5).

MEDARE STRENGTHS AND WEAKNESS

MEDARE Community since its inception has been effective in organizational, publicising and raising awareness aspects, such as: setting up the SG and WGs by getting the concurrence of NMHSs Permanent Representatives within WMO; bringing MEDARE's message to the scientific community and wider audience through the production and dissemination of the MEDARE brochure, workshop proceedings, poster, DVD or scientific meeting attendances. It has been also active in developing and fulfilling the on-line metadata infrastructure for the longest and key Mediterranean records, as well as carrying out both national DARE projects by NMHS (e.g. see national reports at: http://www.omm.urv.cat/MEDARE/2workshop-presentations.html for learning on the different national activities fostered in the DARE arena) and other efforts at the regional scale, like the currently being undertaken under EURO4M over southern and eastern Mediterranean countries.

From the past and ongoing activities, the MEDARE's strengths can be identified. MEDARE has achieved since its inception a high international profile, which has been guaranteed thanks to the endorsement of the WMO-EC/60 and the MEDARE formula (bringing/working together scientists from NMHSs and Universities), with several WMO Regional Associations wanting to follow and implement similar approaches. Also many other actions have been done for raising awareness on the need of fostering DARE projects or for bringing MEDARE to a wider scientific community and audience by spreading its messages in forums and congresses, which also redounded in an increased international visibility. Besides the MEDARE Community has developed the first and most complete and comprehensive metadata base for the Mediterranean Basin and has also encouraged that many Mediterranean NMHS undertaken DARE activities at the national scale, which along with current digitisation efforts supported by funded projects will pave the way for making possible to achieve the end-goal of this Initiative. Therefore MEDARE WG1 and WG4 teams have been dynamic in these fields of activity. However, more actions could have been done even in the mentioned areas such as fulfilling the MEDARE's metadata portal by all participants, fostering documentation exchange such as relevant members reports and assessments through the MEDARE portal or further raising awareness among national and international stakeholders and policymakers.

In the other side, several main weaknesses can be also outlined. The MEDARE Community has still a long way to go before consistent, long and high-quality climate datasets are generated and made available. First steps have been given, but we are still far away of seeing accomplished MEDARE objectives. In that way, there is a need for completing and enlarging the MEDARE climate inventory and on-line metadata base, which will set the grounds for defining future DARE projects at different scales (national, sub-regional and regional). There is also an urgent need to get MEDARE projects funded, since WMO only can support MEDARE meetings, but not DARE projects, at least not at this stage, which means the MEDARE Community has to be creative and explore all possible ways and formulas for getting funds. Due also to current dearth of regular funding, the MEDARE Community had not been able to organise training activities aimed at capacity building in DARE techniques and procedures, including data quality controls (QCs) and time series homogenisation. Therefore and due to both shortcomings, the activities of the WG2 and WG3 have been seen compromised in this initial period, since it is not possible to pass any QCs or homogenise any record without getting digitised data and it is unlikely to be able to digitise data without getting funding. The same can be applied to the organisation of training activities (e.g. regional workshops, summer schools, seminars), as proposed in the MEDARE implementation plan (Jones, 2008).

MEDARE WORKSHOP'S TARGETS AND FUTURE CHALLENGES

Former background on the past, present and ongoing MEDARE activities and efforts, including the assessment of the strengths and weakness of this Initiative, set the grounds for defining the targets and future challenges that the MEDARE Community faces, which are addressed in this section.

One of the main challenges to explore by the attendees to the workshop is getting MEDARE projects funded, both at the national, sub-regional and regional scales. The WMO funds are very limited and mainly intended to support expert meetings organization and implementation, although some resources could be allocated for training, which would be worth to explore. Therefore, one of the urgent needs to address in the workshop is the need for getting competitive funds from international, European and national funding agencies in order to carry out MEDARE projects, capacity building activities and networking on innovative and integrated DARE procedures and methods.

However, to get funds for carrying out DARE activities from scientific funding agencies always encounter the reluctance of funding bodies to support proposals mainly focused on making historical climate data available and it is commonly adduced such DARE projects should be undertaken by NMHS. However, these national bodies face the problem of limited resources, both financial and technical, particularly in less developed and developing countries but not only. Therefore, this challenge requires imagination and further work for allocating DARE projects within the framework of wider research proposals, being this shortcoming an important issue to be further explored in the 2nd MEDARE workshop.

In this regard, the different targets of the 2nd MEDARE workshop were set, as follows:

- To assess progress done by countries since 2007 in their national DARE programmes, along with addressing the difficulties found.
- To define and agree on the national networks composed of the longest and key climate records for temperature, precipitation and air pressure to be rescued and developed (quality controlled and homogenised) at the daily and hourly scales sorted out by the three Mediterranean sub-regions: Western, Central and Eastern Mediterranean.
- To concur and adopt the best strategies to get MEDARE projects and activities funded.
- To discuss a proposal for defining the MEDARE data exchange policy to be approved by the PRs of the involved NMHS.

These and other targets, which could be raised by the participants, might be on the focus of the three-day long workshop. Besides other activities to be carried out in the near future were also suggested: first, the need of continuing with the provision of metadata for the identified Mediterranean sub-regional climatological reference networks to be used, even at national scales, in the detection, prediction and adaptation studies or in any other climate applications, products and services by using the MEDARE metadata portal; second, the edition and publication of the 2nd MEDARE workshop; third, the need for keeping momentum and encouraging the countries/NMHS that have not been able yet to introduce their metadata in the on-line infrastructure for doing so; and fourth, to publicise MEDARE and its on-line metadata base in the coming World Climate Research Programme Open Science Conference to be held in Denver in October 2011.

SUMMING UP

In this contribution, the past, present and ongoing MEDARE activities have been addressed; together with an introductory background on this WMO Initiative. Also a critical review of MEDARE current strengths and weakness and an assessment on the objectives of the MEDARE 2nd workshop has been provided.

The high international profile that the WMO MEDARE Initiative has rapidly gained since it was set up has been made possible thanks to the involvement of most of the Mediterranean NMHS and supporting organizations, as well as it is likely also based on either its formula of bringing together scientists from the operational and scholar worlds or the remarkable efforts paid for carrying out dissemination and raising awareness activities by WG1 and GW4. All this ensure its continuity into the future.

Despite of progress done by the MEDARE Community on setting up its organizational, structure, the implementation of the MEDARE portal (including the metadata base on-line infrastructure) or its active participation in dissemination and raising awareness activities, the MEDARE Community has to face the main weakness highlighted in this article: the need for getting MEDARE projects and capacity building activities funded, along with the definition of a data exchange policy in compliance with WMO regulations. Therefore, the MEDARE 2nd workshop has to address among other these shortcomings.

The Development of the Spanish Daily Adjusted Temperature Series (SDATS): A Case-Study Discussing from Integrated Data Rescue Procedures to Calculation of Area-Averaged Climate Series

Manola Brunet
Dept. of Geography, University Rovira i Virgili, Av. Catalunya, 35, Tarragona 43071, Spain

ABSTRACT

This paper summarise the whole array of procedures involved in the development of high-quality and long-term climate records leading to the creation of area-averaged time-series by using as a case study the development of the Spanish Daily Adjusted Temperature Series (SDATS) carried out under the EU-funded project *European and North Atlantic daily to MULTidecadal climATE variability* (EMULATE), which enabled to generate the EMULATE air pressure, temperature and precipitation datasets over the 1850-2003 period. Therefore, this contribution reviews the whole chain-process for developing area-averaged climate series, with the focus put on the integrated data rescue (DARE) techniques and procedures involved.

INTRODUCTION

In the framework of the EU-funded *European and North Atlantic daily to MULTidecadal climATE variability* (EMULATE) project, the first area-averaged reconstruction of long-term Spanish temperature change was made possible. Figure 1 shows annual variations (1850-2005) of daily mean temperatures over mainland Spain (the Spanish Temperature Series: STS) expressed as anomalies from the reference period (1961-1990). This regional curve, the STS, was calculated by using daily maximum (T_{max}) and minimum (T_{min}) temperature series from the 22 longest and most reliable Spanish records, once these records were recovered, digitised and developed (e.g. time-series quality controlled and homogenised).

This reconstruction enabled to scientifically document the Spanish long-term temperature change (e.g. Brunet et al. 2007a, Trenberth et al. 2007, Blade et al. 2010) and also has been used in several Spanish Governmental assessments, such as the Report on Spanish Climate Change for the Spanish Government Presidency (Abanades-García et al. 2007) or the Spanish Plan for Adaptation to Climate Change Impacts for the Environmental Ministry (Brunet et al. 2007b).

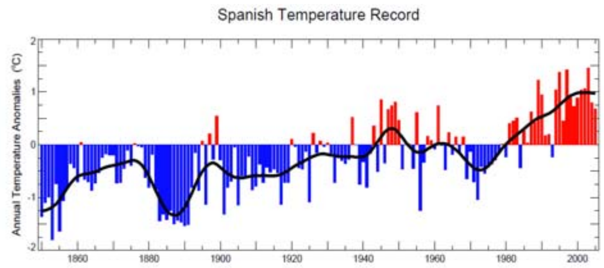


Figure 1: Annual variations (1850–2005) of STS: daily mean temperatures expressed as anomalies (in ºC) from 1961 to 1990 and smoothed with a 13-year Gaussian filter (thick line). Red (blue) colour represents positive (negative) anomalies.

However, this apparently simple plot showing time evolution of Spanish-averaged temperatures involved lots of previous activities and work in the array of the techniques and procedures included in the research field of integrated DAta REscue (DARE). DARE methods include various approaches, ranging from documentary techniques to statistical methods, such as: searching, locating, inventorying, organising and accessing data sources and holders (documentary techniques); data transfer into digital format (e.g. applying OCR software and validation, digitisation), data quality assurance (e.g. checking the data to identify non-systematic errors), homogenisation methods for taking into account systematic biases in climate time-series, evaluation of the uncertainty in the reconstructed time-series, ensuring full traceability of the developed records to their original sources (statistical methods) and, finally, estimating area-averaged series.

This contribution describes, then, the chain-process carried out for developing this long-term monitoring product, with the focus put on the DARE techniques employed, which are aimed at generating long-term, high-quality and homogenised climate time series.

SEARCHING, LOCATING, ACCESSING, ORGANISING AND DIGITISING CLIMATE DATA

Recovering historical climate data and developing long-term and high-quality time-series imply first to search, locate and access to the historical assets. In our case, we contacted first to the Spanish Meteorological Service (Instituto Nacional de Meteorología – INM – at that time) Climatological Department in order to get the catalogue of their datasets, with the focus put on the longest meteorological stations having recorded daily temperature data (e.g. maximum and minimum temperatures). Through inspecting the catalogue containing the list of stations and basic metadata (e.g. station name, code, length of records, percentage and the longest period of missing data), we proceeded to select the network to be recovered and developed.

The rationale for selecting the network was based on various criteria including temporal and spatial coverage, climatic representativeness, long-term continuity of data and potential data quality at highly monitored sites (synoptic or first order stations). Stations with the longest, continuous and most reliable records, either in digital format or hard-copy, were chosen in the first place. They had to extend back to the second half of the 19th century or at least to cover the whole 20th century and had to be at well-spaced locations across mainland Spain. Related to this principle, stations also had to be representative of the different climatic regions of mainland Spain. Besides, stations had to be still in use and likely to continue so for the foreseeable future (Brunet et al. 2008). Figure 2 shows the temperature station network selected and composed of 22 long-term observing sites where daily T_{max} and T_{min} temperatures have been and are being measured. It also provides stations' names, elevation and approximate length of records.

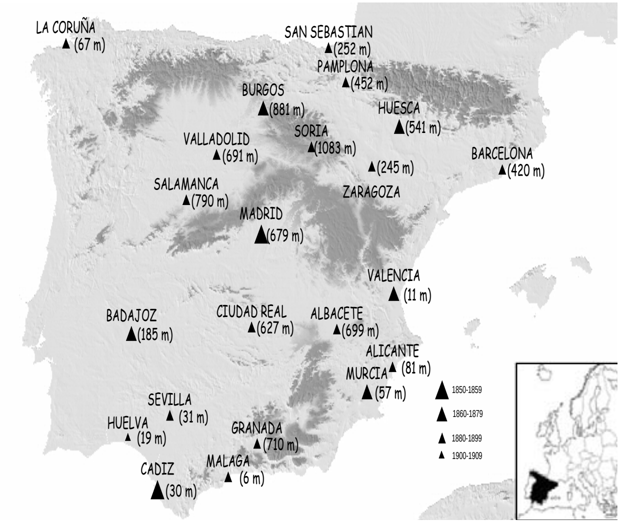


Figure 2: Spanish temperature network location map showing name of stations, elevation and approximate length of records.

Once defined the network and accessed to both the digital part of these records and to the fraction of the data imaged by INM, which were made freely available for mainly using them in our Spanish temperature reconstruction exercise, we undertook intensive searches in relevant documentary sources where other relevant data and metadata could be archived most likely. This step encompassed searches in both Spanish and international data sources and holders. Tables II and III in Brunet et al. (2008) list either the data sources or holders explored and accessed.

After assessing data sources quality (e.g. continuity, reliability, primary or secondary source), we gathered the data and metadata in a number of different formats, such as paper form, microfilm, scans and digital format (from original manuscripts and log-books) and we proceed to inventor the climate data and metadata found, ensuring first the hard-copy or imaged data were not already digitised, and second we defined a plan for imaging (e.g. photographing, photocopying) the relevant data and metadata located in hard-copy. Afterwards, we organised the images taken into a database, in order to identify them and list their contents (.e.g. variables, periods and the available metadata on the observations).

In parallel, we gathered all relevant metadata possible, which were far from complete, but a reasonably well-documented history of the stations and records could be recovered to help build a metadata history for the 22 records employed in this reconstruction. In the metadata archive we kept information on station identifiers, geographical data (coordinates, elevation), climate types, subtypes and variants of each station, dates of station relocations, measurement units, missing data and data sources. Almost complete metadata on thermometric exposures, instruments, observers and historical circumstances covering the observations are also archived in the metadata database. Finally, partial metadata on the micro- and meso-environments around stations were also recovered and kept in the metadata archive.

A plan for transferring the un-digitised/imaged data into digital format was defined. From about the two millions of daily values that conform the temperature network, a 60% of the daily data were already in digital form, which means that we have to digitise about 800,000 daily values only. Since this not very high amount of daily values come from different sources and had several formats, we decided to digitise the data from the images collected, which was a time consuming task undertake by funded university students under our supervision.

Data Archaeology and Quality Control (QC)

Once all the hard-copy data were digitised, we proceed to undertake a data archaeology exercise, in order to identify the different temperature units used mainly in the ancient parts of the records (e.g. Fahrenheit degrees) and convert them into the International System of Units (SI). Thus, we merged the ancient parts of the records recovered/digitised/transformed into SI units by us with the recent parts provided by INM in order to extend back in time as far as possible the records.

Therefore, the 22 Spanish raw T_{max} and T_{min} time series were subjected to diverse QC tests, in order to isolate and flag potentially errant values introduced when recording, manipulating, formatting or archiving the data, as well as for ensuring internal consistency and temporal and spatial coherence of the data. In this regard, the following recommended (Aguilar et al. 2003) set of data quality tests were undertaken with the raw data:

- Gross error checks: e.g. aberrant values (T_{max} and T_{min} values > 50 ºC and < -50 ºC), consistency of calendar dates (no. of days per year and no. of days per month), comparison of monthly averages between those calculated from the digitized daily data and those listed in the accessible original sources
- Tolerance tests, such us, four or more successive identical values, values beyond ± 4 standard deviation (σ)
- Internal consistency: e.g. $T_{max} < T_{min}$
- Temporal coherency, such as values exceeding a 25 ºC difference between consecutive observations
- Spatial coherency: e.g. values exceeding ± 4 σ threshold for the difference between the candidate record and its group of reference time series and visual comparisons among neighbouring stations

From the total amount of daily values quality controlled (~ 2M), only a very small fraction of the entire dataset (11505 = 0.58%) was flagged as potentially erroneous values. After checking the labelled values in the original sources, we could recover/validate about 70% of these values and only the 30% could not be recovered and then they were set to missing. Table 1 gives the number and percentage (in brackets) of the values labelled as suspicious by the different tests past on the raw data.

Table 1: QC results distributed according to the kind of test applied as absolute counts with percentages in parenthesis

	Gross error checks	Tolerance tests	Internal consistency test	Temporal coherency test	Spatial coherency tests
Total of flagged values	4941 (0.25)	5995 (0.3)	161 (0.008)	192 (0.01)	216 (0.01)

Addressing Data Homogeneity and Homogenisation

As widely documented in the relevant literature, the majority of long-term climate time-series have been influenced by non-climatic factors, mainly related to changes in station locations, local environments, instrumental exposures and instrumentation, observing practices or data processing. All these factors can introduce and have introduced gradual or abrupt breaks in the homogeneity of climate records. Therefore, there is a need for homogenising long time-series to ensure their time variations are only the result of the influence induced by meteorological and climatic factors and not by other artificial causes.

There is important to count on as complete as possible metadata on the stations and records in order to guide properly the homogenisation process. Therefore, the metadata gathered when searching and accessing to the ancient records were extremely useful in this step, since our approach for detecting breakpoints in any time-series require information in order to validate or reject them if any physical cause explains the break in homogeneity.

For testing homogeneity and homogenising the Spanish temperature records, we used a relative approach known as the Standard Normal Homogeneity Test (SNHT) developed by Alexandersson and Moberg (1997), which is based on comparing statistical properties from the candidate record to be homogenised and its group of reference records highly correlated with the candidate record. However, relative homogenisation approaches are unable to detect breakpoints if the cause of the inhomogeneity is also affecting to the entire group of reference stations (e.g. any change introduced in a network at more or less the same time and thus affecting homogeneity of all the time-series). Such it is the case of the changeover to new protectors (Stevenson screen) that took place at similar times at most observing sites in the Spanish meteorological network. In this and other cases, different approaches need to be defined to asses the problem.

Therefore, the homogenization procedures applied to the 22 Spanish daily temperature records are as follows: First, we adopted an absolute homogenisation approach to minimize the so-called “screen bias”, which is affecting the earliest parts of the temperature records and is related to changeover in thermometric protectors in Spain. Second, we applied the SNHT to detect breakpoints in the data, establish the correction pattern and estimate the corresponding monthly adjustments. Third, we adopted the Vincent et al. (2002) approach for interpolating the estimated monthly adjustment factors into the daily timescale.

Prior to the generalized use of Stevenson screen, in Spain were in use an open stand so-called Montsouris or French stand (Figure 3). This protector tends to overestimate T_{max} and slightly underestimate T_{min} readings when compared to the observations recorded under Stevenson screen over the Mediterranean climates (e.g. see Brunet et al. 2011 for further information on the screen bias).

Figure 3: Picture showing the reproduction of the old Montsouris stand and the new Stevenson screen as replicated in the Meteorological Garden of Murcia (south-eastern Spain), where dual temperature observations are taken with identical sensors sheltered in a Stevenson screen (back) and in a Montsouris stand (in front).

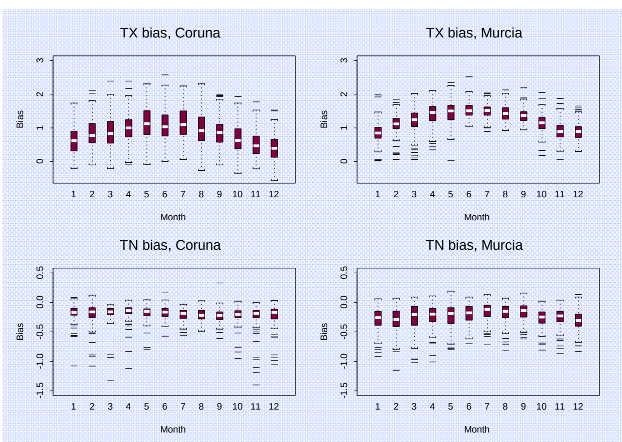


Figure 4: Monthly boxplots of the T_{max} and T_{min} screen bias series for La Coruña and Murcia. Note the difference in scale between the T_{max} and T_{min} plots

Figure 4 depicts the monthly differences between T_{max} and T_{min} readings taken under the Montsouris stand and the Stevenson screen (Montsouris – Stevenson) after getting 6 years of daily paired observations. From these difference time-series (screen bias series) we estimated the monthly adjustments for minimizing from the quality controlled raw data the screen bias following an absolute experimental approach.

Once the quality controlled raw data were minimised for screen bias, we undertook the relative homogenisation exercise by using an adapted SNHT procedure (Brunet et al. 2008), which took the following steps: first to select the groups of candidate and reference stations (r ~ 0.8 among the candidate and the reference records), second to detect and validate the statistically found breakpoints by SNHT, third to define and apply the correction pattern to the monthly series, and fourth to interpolate the monthly factors into the daily scale. Figure 5 shows the frequency distribution of break magnitudes referred to the detected and validated breakpoints after using the SNHT (see Brunet et al. 2008 for further details on the application).

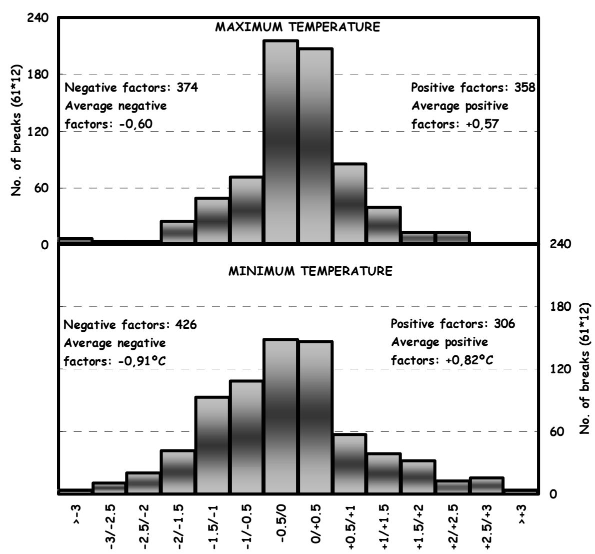


Figure 5: Frequency distribution of break magnitudes referred to the adjusted breaks after using SNHT for homogeneity testing of annual and seasonal averages of daily T_{max} (top plot) and T_{min} (bottom plot) time series for the 1850-2005 period

Once the time-series were homogenised and derived from them the daily mean (T_{mean}) temperature series, assessments like the one shown in Figure 1 could be undertaken confidently, which was made possible by following the procedures described in Brunet et al. (2008) for generating area-averaged time-series and summarised in the next section.

The Development of Area-Averaged climate Series

Regional or area-averaged time series of daily mean, maximum and minimum temperatures for the period 1850-2005, the STS, were constructed by averaging daily anomalies and then adding back the base-period mean, according to the Jones and Hulme (1996) method of separating temperature into its two components (the climatology and the anomaly). This was done for all single records and then we area-averaged them by using the simple inverse distance weighting algorithm. In order to adjust the variance bias present in regional time series associated over time with varying sample-size, we have adopted and applied here the approach developed by Osborn et al. [1997] to correct this bias in STS.

The decadal variations on an annual basis shown in Figure 1 were assessed by means of a Gaussian low-pass filter of 13 terms (dark solid line in Fig. 1) in order to suppress high frequency fluctuations on time scales less than decadal. The Gaussian filter approximates a decadal smoother with sigma equal to 3 standard deviations. It has six weights either side of a central weight (so 13 in all). To extend the smoothed series to the starts/ends of the series, additional values (equal to the average of the last/first 6 years) were added.

Summing Up

The development of long-term and high-quality climate time-series requires undertaking integrated DARE activities, which involve the following tasks:

- Searching, locating, accessing, inventorying and organising the data to be recovered
- Transferring the data into digital format
- Undertaking data archaeology exercises
- Applying quality controls for identifying non-systematic errors in the time-series
- Testing homogeneity and homogenising he time-series
- Estimating area-averaged series

Lessons learnt from the Météo-France Data Rescue program

Sylvie Jourdain

Météo-France, Direction de la Climatologie, Toulouse, France

ABSTRACT:

Data rescue (DARE) is the ongoing process of inventorying, preserving, recovering and then transferring the climate data into computer compatible form for easy access. This paper gives a brief overview of the climate data rescue activities undertaken at Météo-France. Our experience in data rescue and in long series homogenization is discussed in this paper.

INTRODUCTION:

The third edition of the WMO guide of the climatological practices recommends to the NMHS to establish and maintain a data rescue program (WMO, 2010). Historical climate data rescue and homogenization are included in the Météo-France activities since several years ago (Moisselin et al., 2002). A national Data Rescue new program was launched at Météo-France in 2008 aimed at inventorying all Météo-France archives and digitizing the most relevant data. The French climate data rescue program is nationwide and includes overseas territories (French West Indies, French Guyana, French Polynesia, Reunion Island and New Caledonia), as well.

Numerous Archives are scattered over the world and DARE activities are undertaken by national, regional and departmental services. Because of the huge amount of paper records in provincial offices, it was obviously impossible to gather all hard-copies records to be rescued in one single location. Data rescue activities at Météo-France are based on a data rescue team in the Climatology Department and on a network of Météo-France climatologists working in provincial offices, and are coordinated and monitored by the Climatology Department.

Météo-France has recovered climate data from various sources (national and departmental archives), universities archives, numerical libraries, Météo-France archives or the German meteorological office library.

Brandsma (2008) gives the tips and the tricks of data rescue and digitization resulting of the Dutch experience.

In this paper we discuss the French experience with Climate Data Rescue and long series Homogenization. The structure of the paper follows the procedure of climate Data Rescue process (WMO, 2004), which consists of several steps: Search and Locate, Inventor, Preserve and Storage, Recover, Key entry, Quality Check and finally homogenization.

SEARCH AND LOCATE

DARE first task is to know where the data are. French historical manuscripts are kept in numerous archives. Jourdain et al. (2008) explain that French old climate data manuscripts 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.).

In order to overcome this difficulty, guidelines on searching for French climate data sources were written by the Climatology Department to give expertise to Météo-France meteorologists.

In order to locate the data, it is also crucial to search the internet because more and more publications are available on-line. In the context of data imaging projects, historical manuscripts containing climate data have been imaged and put at several websites. A large number of French ancient annals, bulletins, memoirs and journals can be found through internet. Two interesting examples are given: daily observations from France and former colonies were published in French meteorological annals between

1878 and 1920 and can be accessed at NOAA Central Library Foreign Climate Data.

Meteorological observations from astronomical observatories were often published in observatories annals. Numerous annals were photographed by NASA and are available at the SAO/NASA digital library portal.

For France, because of the rich heritage of meteorological data and the dissemination of data sources, the search in sources is an ongoing process and a long-term activity.

INVENTORIZE

The inventory of climate data available in historical archives is essential. Inventory has an old fashioned and dusty image and it is time consuming, but it is fundamental. The WMO guidelines recommend inventorizing immediately after climate data sources are found, but due to the lack of human resources, it is rarely done.

Several years ago Météo-France launched a national program aimed at inventorying all Météo-France archives, but the task is not finished yet because of the huge amount of records and their dissemination in different archives. The inventorying of historical climate data and metadata is not so easy and needs expertise. A guide on climate data and metadata inventory has been written by the Climatology Department to explain the aim of this action, to give the list of the materials that should be inventoried (e.g. climatological diaries, rolls, listings, disks, bulletins) and to recommend a standard format of inventory. It is recommended to inventory all hardcopy material even if the data are already digitized because all information is rarely digitized, particularly upper-air data (balloon pilots) and metadata.

Inventorying involves both the data and related metadata. Metadata are essential to identify the series. Information can be found in data sources themselves like monthly climate tables, daily diaries, and meteorological reports or in separate publications. It is recommended to gather at first all relevant metadata needed to trace the series, such as information about the location of the observations (name of the site, coordinates, and activity), period of the observations, observed variables, hours of observations, etc. These types of metadata are very useful to gather, but also it is important to check whether the records have already been digitized or not. Other metadata in need for homogenizing long time series are, for instance, stations relocation, changes in instruments and in the stations environment or changes of the observer. This type of metadata is rarely collected at this step and must be collected by climatologists during the digitization stage.

Météo-France is involved is several national and international projects including climate data rescue that are contributing to improve the meteorological inventories. For example, the inventories of the meteorological archives in Martinique Island (French West Indies) were made in the frame of the EU-funded CARIBSAT project (http://caribsat.com/).

PRESERVATION AND STORAGE

Historical climate manuscripts are always in danger of being lost for ever and they must be kept in optimal conditions. Preservation is another concern of any DARE efforts and must start before inventorying and digitizing by ensuring the historical sources are kept in good conservation conditions.

Non digital records should be stored in such a way that minimizes their deterioration and loss. They should be stored in a controlled environment to avoid temperature and humidity extremes, pests, fire and flood accidents. The documents are also at great risk from being tossed away because of lack of storage space. An ideal condition would be to keep ancient sources in acid free boxes in air conditioned and secure storerooms.

In France the historical manuscripts from Météo-France, as part of the French public agency, are under protection of the Public Archives Law. The situation is today that most of data in paper form recorded after 1950 is stored at Météo-France in more than 100 offices and the oldest paper records are stored in the national public archives in Fontainebleau. The French archives have been threatened by all sorts of deterioration agents aforementioned. The last two years Météo-France has had to launch several different actions to preserve records on paper form. Two examples are presented below.

French West Indies

Météo-France had to deposit some data records at local public archives because the lack of space and poor storage conditions.

In Martinique, meteorological archives were not stored in a proper air conditioned environment and the risk of mould and insects affecting the documents was very high. Several years ago, one part of the meteorological paper records in Martinique Island were moved into a new appropriate building, which ensured good temperature and humidity conditions.

Paris-Montsouris archives

Due to the French safety fire law, Météo-France had to change the doors of the archives room in the cellar at Paris-Montsouris station. After three winter months since that change, mould could be seen on the books. Figure 1 shows the white mould on the books. Mould was analyzed to know its hazard. Fortunately, the mould was not a danger to human health, and Météo-France decided to clean, inventory, sort and move the papers to another building with better storage conditions. Most of the materials were put into acid free boxes or plastic boxes in order to preserve them.

Books, microfilms and microfiches containing meteorological data from old French colonies are archived at Météo-France in the library and in the Climatology department archive. The inventories of the microfilms and microfiches for Algeria, Tunisia and Morocco were produced.

Figure 1: *Mould in the Paris-Montsouris archive*

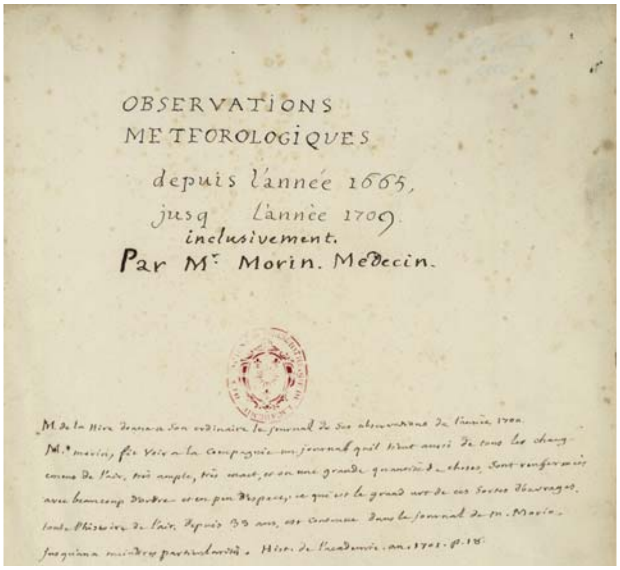
The archive consists of 3050 microfiches and 251 microfilms holding monthly climatic tables and daily meteorological reports for the period 1924-1962. A selection of microfiches containing monthly climatic tables was scanned in the frame of the EU-CIRCE project (http://www.circeproject.eu/). The publications 'Annales du service de Physique et de Météorologie de l'Institut Scientifique Chérifien' from 1935 to 1944 are now available in pdf format. More microfilms and microfiches should be scanned in the frame of other future EU-projects like ERA-CLIM (European Re-Analysis of Global Climate Observations).

French Data and Metadata Recovery

In many cases data can only be found on hard-copy in any archive. Sometimes the material can be loaned (e.g. to the Lyon University), although local archive agencies tend to duplicate the documents providing photocopies or films or scans of the data sheets. Direct digitization in the archive is rarely advisable, as having the data sheets at hand for later checks is very important (Brönnimann et al., 2006).

Data recovery outside Météo-France needs financial resources, several trips, and discussions to come to an agreement in order to organize the duplication of the documents. Several recovery actions have been undertaken in 2010, for example with the Institut de France library, the astronomical observatory in Nice and the library of the Medicine academy

Météo-France recently recovered Morin observations (1665-1709) by scanning this document from the Institut de France library. Figure 2 shows the first page of the manuscript.


OBSERVATIONS METEOROLOGIQUES depuis l'année 1665, jusq l'année 1709 inclusivement. Par Mr Morin. Medecin.

M. de la Hire donna à son ordinaire le journal de ses observations de l'année 1709. M. Morin, fit voir à la compagnie un journal qu'il tenoit aussi de tous les changemens de l'air, très ample, très exact, et où une grande quantité de choses, sont renfermées avec beaucoup d'ordre et en peu d'espace, ce qui est le grand art de ces sortes d'ouvrages. Toute l'histoire de l'air depuis 53 ans, est contenue dans le journal de M. Morin, jusqu'aux moindres particularités. Hist. de l'academie. an. 1709. p. 18.

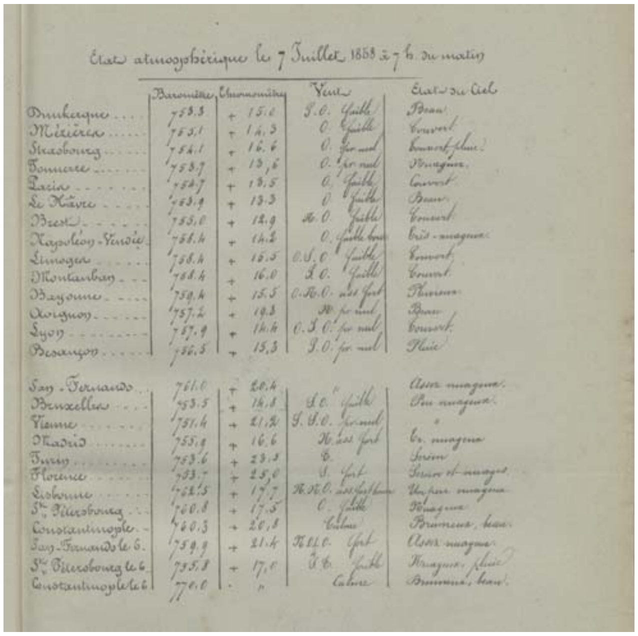
Figure 2: First page of the doctor Morin observations manuscript

Books stored in the Météo-France library

Météo-France central library in Paris stores 480 books from the 15th to the 18th centuries, 750 books and hundreds of meteorological bulletins of the 19th century. The reproduction of all relevant material in the library containing observations is today unthinkable, but a systematic recovery of relevant publications has been undertaken since several years ago.

Some examples of scanned books are listed below:

- Bulletin International de l'Observatoire de Paris 1857-1877. The table for the observations on the 7 July 1858 at 7h is shown in Figure 3
- Nouvelles Météorologiques 1868-1876
- Bulletins Météorologiques de l'Association Scientifique de France 1871-1876
- Annales de la Société Météorologique de France 1849-1921


Etat atmosphérique le 7 Juillet 1858 à 7 h. du matin

	Baromètre	Thermomètre	Vent	Etat du Ciel
Dunkerque	753.3	+ 15.0	S.O. faible	Beau
Mézières	755.1	+ 14.3	O. faible	Couvert
Strasbourg	754.1	+ 16.6	O. fort mod.	Couvert, pluie
Tonnerre	753.7	+ 13.6	O. fort mod.	Nuageux
Paris	754.7	+ 13.5	O. faible	Couvert
Le Havre	753.9	+ 13.3	O. faible	Beau
Brest	755.0	+ 12.9	N.O. faible	Couvert
Napoléon-Vendée	756.4	+ 14.2	O. faible brise	Très nuageux
Limoges	756.4	+ 15.5	O.S.O. faible	Couvert
Montauban	758.4	+ 16.0	S.O. faible	Couvert
Bayonne	759.4	+ 15.5	O.N.O. assez fort	Pluvieux
Avignon	757.2	+ 19.3	N. fort mod.	Beau
Lyon	757.9	+ 14.4	O.S.O. fort mod.	Couvert
Besançon	756.5	+ 15.3	S.O. fort mod.	Pluie
San Fernando	761.0	+ 20.4		Assez nuageux
Bruxelles	753.5	+ 14.8	S.O. faible	Peu nuageux
Vienne	751.4	+ 21.2	S.S.O. fort mod.	
Madrid	755.9	+ 16.6	N. assez fort	Tr. nuageux
Turin	753.6	+ 23.3	E.	Serein
Florence	753.7	+ 25.0	S. fort	Serein et nuages
Lisbonne	762.5	+ 17.7	N.N.O. assez fort	Un peu nuageux
St Pétersbourg	760.8	+ 17.5	O. faible	Nuageux
Constantinople	760.3	+ 20.8	Calme	Brumeux, beau
San Fernando le 6	759.9	+ 21.4	N.N.O. fort	Assez nuageux
St Pétersbourg le 6	755.8	+ 17.0	S.E. faible	Nuageux, pluie
Constantinople le 6	770.0	"	Calme	Brumeux, beau

Figure 3: Paris Observatory International Bulletin on the 07/07/1858 at 7 a.m

National public archives in Fontainebleau

The major source of climate data is the Météo-France archives located in the national archives in Fontainebleau. This climatological archive contains original manuscript with surface and upper-air data from France and former colonies for the period 1820-1970. A huge amount of climate information has been collected and stored there (4400 archive boxes, 1.5 km in a row), but accessing to these sources is precluded due to asbestos presence since 2004. However, Météo-France got a good idea of the content of this archive thanks to the logbooks produced when the documents were stored. A new agreement between Météo-France and Archives Nationales is in preparation in order to re-open access to the French meteorological archives, and digitize all relevant documents and observations. Because of the volume of the archives we are facing, data recovery is a big challenge.

Astronomical observatories:

Several observatories recorded sub-daily and daily meteorological observations (pressure, temperature and precipitation) during the 19th century. Fierro (1991) indicates that 14 observatories recorded meteorological observations in 1889. The records are remarkable and invaluable because of their length and quality, which will permit to create the longest time series in France. Recovery of astronomical observatories is obviously a priority. For some period and some observatories, yearbooks are published in the observatory annals available on internet. But the recovery of the complete long time series is a very long and intensive task. The example of the recovery of Marseille observatory is presented below:

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 retaken from 1761 to 1866 in the old observatory "les Accoules'. Observations in the Marseille Longchamp observatory have been made continuously from 1867 to 2003. In February 2003, Marseille observatory became a precipitation station and the long series of temperature was truncated.

Marseille observatory have published daily data in the "*Bulletins de la commission météorologique des Bouches-du-Rhône*" since 1866 without interruption, and these publications are stored at Météo-France. Data between 1837 and 1863 were published in "Répertoire Statistique de Marseille", but just a fraction of these publications are available from googlebooks for the period 1844-1861. Figure 4 shows the table for February 1839 with three observations of temperature and air pressure per day. These books are stored in the departmental public archives agency. A very fruitful collaboration between the Météo-France climatology team working in the Aix-en- Provence center and the climate historian G.Pichard (1988), expert in Provence meteorological old manuscripts, who photographed all the sheets of these publications, permitted the recovery of the period 1837-1863.

DATES.	9 HEURES DU MATIN.			MIDI.			3 HEURES DU SOIR.		
	BAROME.	Thermomètre du bar.	Thermomètre Extér.	BAROME.	Thermomètre du bar.	Thermomètre Extér.	BAROME.	Thermomètre du bar.	Thermomètre Extér.
	mm								
1	747,30	+ 4°0	—1°7	747,65	+ 4°0	+ 1°5	749,40	+ 4°0	+ 2°7
2	758,35	3,5	—2,6	758,00	3,5	1,4	757,75	3,5	2,9
3	762,60	3,0	-0,7	762,00	3,0	1,9	761,50	3,0	2,4
4	759,55	3,0	+ 3,4	759,05	3,0	6,5	759,30	3,0	7,5
5	766,20	3,3	6,4	766,15	3,3	9,6	765,05	3,4	11,5
6	766,55	4,3	9,9	765,70	4,5	12,3	765,80	5,0	12,9
7	773,70	5,4	9,1	774,00	5,5	13,4	773,85	5,6	12,6
8	774,10	6,0	8,9	773,15	6,0	11,8	771,80	6,5	12,4
9	771,65	7,0	8,1	771,75	7,0	11,1	771,30	7,0	11,4
10	768,85	7,5	7,4	768,70	7,5	10,7	767,80	7,6	12,4
11	765,65	8,0	10,4	765,75	8,0	12,7	766,30	8,2	14,6
12	770,45	8,4	11,6	770,65	8,5	13,6	770,05	8,5	12,7
13	770,55	9,0	6,1	769,50	9,0	10,1	767,50	9,0	12,5
14	768,35	9,0	7,4	767,80	9,0	11,4	761,55	9,0	11,6
15	763,25	9,0	6,7	762,75	9,0	10,4	761,65	9,1	12,3
16	760,85	9,0	7,4	760,25	9,0	9,9	759,35	9,0	10,7
17	755,90	9,1	7,4	754,50	9,1	10,2	752,90	9,1	10,1
18	751,40	9,6	6,5	752,00	9,6	7,4	752,30	9,6	8,4
19	758,55	9,4	5,5	758,30	9,4	7,6	757,10	9,4	9,6
20	751,35	9,3	12,2	750,50	9,3	12,5	749,50	9,3	12,5
21	756,00	9,6	8,4	757,55	9,7	9,6	758,80	9,8	10,4
22	766,10	9,6	5,6	765,55	9,7	9,8	764,55	9,7	11,3
23	762,90	9,6	12,4	762,10	9,9	14,8	760,80	10,0	15,1
24	759,50	10,0	12,2	758,45	10,2	13,6	756,85	10,3	14,6
25	752,20	10,8	10,6	752,90	10,8	11,4	752,80	10,8	11,5
26	760,10	10,3	5,7	759,40	10,2	[illegible]	758,05	10,0	8,3
27	757,30	9,9	6,6	757,30	10,0	8,9	757,60	10,0	9,3
28	762,35	9,2	6,6	762,50	9,2	9,3	761,20	9,2	9,5
	762,20	7,71	7,06	761,93	7,75	9,70	761,16	7,81	10,49

Figure 4: Marseille Observatory observations (February 1839) from Répertoire Statistique de Marseille

Original manuscripts of Marseille observatory prior 1837 are stored in departmental archives agency, which is not willing to lend the data source for digitization. They prefer making films of the data rather than making hardcopies. Copies of films were requested by Météo-France. Then the films were scanned to obtain imaged files. After these two steps of media migration, the result of the recovery is not very satisfactory because of the bad quality of some original manuscripts. In this case the best way would be the digitizing in the archive by an expert able to correctly decipher semi-illegible numbers. Unfortunately, this arduous and time-consuming task that requires experts in climate history is unthinkable by now at Météo-France.

Data Digitization

From the beginning of 2004, the digitization efforts have been focused on surface air observations prior to 1961 with daily and sub-daily resolution. Météo-France has digitized climate data from various formats (e.g. paper form, microfilms, microfiches, images, rainfall strip charts). After recovering, the records are examined, evaluated and a keying format is developed based on the number of stations, period of record, variables and temporal resolution. This crucial and not so easy step is carried out by climatologists. Guidelines on digitization were written by the climatology department. It is recommended not to digitize directly, but after detailed examination of the material, collection of metadata, identification of the observation site and a last check of the data availability in the database. Furthermore it is advisable to write a document including the digitization specifications. Data is keyed by both Météo-France contractors and Météo-France meteorologists; the latter can use the manual input process of the French management tool for climate data, named CLIMSOL. The contractors offer guarantees of 99.9% accuracy, achieved through double keying. Climatologists evaluate the quality of the digitised data.

These digitized data will then be added to the climatological national database called BDCLIM, since the primary component of the national archive resides in the BDCLIM.

The whole process of digitization, from the specifications of the digitization step to the data transfer into the database, is monitored by the DARE team at the Climatology Department. Each step is monitored by keeping track of the names of the actors and the starting and ending dates of their work. Metadata about digitization (observation site, variables, period, digitizer, quality control actors, references of the specifications document are keyed into a spreadsheet intended to trace all the digitization processes. A data insertion report is also archived describing the transfer of data and metadata into the climatological database.

The ideal would be to digitize all material, but resources are limited. Digitization of the surface essential climate variable, such as air temperature, precipitation and atmospheric pressure) must be supported.

Data Dissemination

Data is stored in the national database and climate data is available to the public 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 made freely available to the public.

Long-term Series Homogenization

Many long instrumental climate records are available in France, but most of these long-term series are heterogeneous. Météo-France began a new national homogenization program coordinated by the Climatology Department extending through the period 2009-2011. Homogeneity testing and data adjustments are applied to monthly averages of daily maximum and minimum temperatures and precipitation amounts, in order to create a dataset of long-term monthly homogenized series. This program aims the development of more than 200 French monthly homogenized maximum and minimum temperature series and more than 500 monthly homogenized precipitation series composed of records longer than 50 years.

The development of these datasets has required considerable efforts by a dedicated group of climatologists, mainland and overseas, trained and managed by experts working at the Climatology Department.

This action is associated with the national DARE program because most of the temperature series archived in the French national climatological database are available from 1959. Furthermore huge efforts are dedicated to collect metadata concerning the long term series and to digitize these metadata.

Long climatic series are homogenized by the Caussinus-Mestre (2004) statistical method, which allows the detection and correction of time-series breakpoints in homogeneity. Each single series is tested against neighboring stations within the same climatic area by sorting them out in sub-groups composed of 10-20 series each.

Detection and correction are carried out with moving neighborhoods based on the knowledge of the climatologist and statistical correlation. The homogenization of mainland temperature time-series required about 20 groups, while for precipitation more than 50 areas were required.

We present now the principal lessons learnt from the Météo-France homogenization program.

Identification of inhomogeneities is not always easy because poor quality of some time series and the presence of outliers. Also, low correlations among the long-term series selected introduce another constraint. Maugeri (2008) discusses the problem of low correlation for Italian precipitation long-term series. These issues indicate:

- A last quality check must be performed on the monthly long series before homogenization because the presence of spurious data is detrimental to the two steps of the homogenization: break assignment for an outlier and outlier impact when calculating correction factors.
- Selection of reliable series is essential too. Do not hesitate to reject mediocre series during the homogenization process.
- Metadata collection must be performed before homogenization: such as changes in instruments, relocation (horizontal and vertical) of the instrument, changes in observational practices, and changes in the environment f the station are among those factors causing breakpoints in time series homogeneity. Metadata are used as a supplement to the statistical testing, in order to validate/reject the breaks given by th statistical test and precise the shift dates. Unfortunately metadata are often not complete or are missing.
- The most frequent identified reasons for inhomogeneities in French temperature series are due to systematic changes in shelter, network automation and relocation.
- The results reveal that professional weather stations series have more breaks than the climatological stations because of systematic changes in instrumentation during the second half of the 20th century (Jourdain et al., 2008b).
- The quality of the homogenization depends on different factors: quality of the series and correlation between the series, which vary due to the spatial pattern of the parameter and the density of the network.
- The use of the homogenization software is easy. However, homogenizing is a hard and time-consuming task that must be carried by experts, in order to ensure the series are in the same climatic area. Otherwise the method will find erroneous breaks.
- The choice of the neighborhood stations has a significant impact on the correction and therefore on the results. The series used for estimating the adjustments must be carefully selected. Besides, some problems can appear for those stations located in the border of the area group.
- It is difficult to solve problems like simultaneous instrument changes for a limited region and a specific network (for example in France: shelter changes for all synoptical stations between 1967 and 1972). It is useful to gather in the same data

set different networks: climate stations and professional stations

Many statistical homogenization procedures have been developed for detection and correction of the inhomogeneities. All these procedures have been compared in the frame of the COST action HOME that should provide a new improved method to homogenize temperature series in 2011.

HOMOGENIZED LONG-SERIES DISSEMINATION

Annually and monthly homogenized French long-term series and the related metadata concerning the homogenization (e.g. stations used to build the series, date of breaks, correction coefficients, residual breaks amplitude) are archived in the national database on specific SQL tables. In order to response to requests from customers and to improve the dissemination of the homogenized series, a product of long and homogenized series was designed. This product contains for each selected series: an ASCII file with monthly homogenized climate data, a file with metadata about the homogenization. A guide explaining the homogenization procedure is also available. Another software tool was developed to download the product from the Météo-France intranet. Each homogenized series is delivered with the corresponding metadata. Figure 5 shows the metadata file for the Toulouse-Blagnac monthly homogenized minimum temperature series.

Metadata for Toulouse:

- period: 1878-2000
- quality of the homogenized series : good
- list of the stations used to build the long series, along with their periods: Toulouse Observatory (31555016) from 1878 to 1920, Toulouse-Francazal Airport (31157001) from 1921 to 1946 and Toulouse-Blagnac (31069001) from 1947 onwards.
- 5 breaks found in the original series: 1888, 1920, 1946, 1970, 1987
- Residual amplitude of breaks : 0.20°C

• Série TOULOUSE-BLAGNAC (MTN031069001)

- Masquer les informations

Description générale				
Numéro Météo-France	Nom usuel	Date début	Date fin	Qualité
31069001	TOULOUSE-BLAGNAC	01/1878	12/2000	bonne qualité

Liste des stations de la série			
Numéro Météo-France	Nom usuel de la station à défaut celui de la commune	Date début	Date f
31555016	TOULOUSE	01/1878	12/1920
31157001	TOULOUSE-FRANCAZAL	01/1921	05/1927
31157001	TOULOUSE-FRANCAZAL	06/1927	12/1946
31069001	TOULOUSE-BLAGNAC	01/1947	12/2000

Liste des ruptures de la série	
Date des ruptures	Amplitude minimale détectable de la série
12/1888	
12/1920	
12/1946	0,25
12/1970	
12/1987	

Figure 5: Metadata for Toulouse homogenized time series (1878-2000)

CONCLUSIVE REMARKS

Météo-France archives contain a very large amount of unexploited climate data. Data rescue and long-term series homogenization are included in the Météo-France goals since several years. This nationwide program, which includes the four overseas territories, is managed by the Climatology Department. DARE activities are time-consuming and need human resources. In France, these activities are carried out by a dedicated team at the Climatology Department and a network of meteorologists experts scattered across France. Because of large number of DARE actors, efforts have been put to improve methodologies associated to the search of documents, inventories, digitization and monitoring tools.

In the last years, the situation has improved thanks to the big effort made for inventorying and digitizing, but most of the French historical data are still on hard-copy and, therefore, at risk of being deteriorated and lost for ever. Although these efforts paid, big parts of the data are not already recovered.

NUMERICAL LIBRARIES

Institut de France Library Catalog :
http://www.bibliotheque-institutdefrance.fr/catalogues/catalogues.html

Royal Medizin Academy Archives Inventory
http://www.academie-medecine.fr/userfiles/file/SRM/index.html

SAO NASA/Astronomic Data System
http://adsabs.harvard.edu/historical.html

NOAA Central Library Climate Data
http://docs.lib.noaa.gov/rescue/data_rescue_french.html.

The CCI role on fostering climate data availability, through OPACE 1 and OPACE 2 activities

Serhat Sensoy
Turkish State Meteorological Service, Ankara, Turkey

ABSTRACT

WMO Commission for Climatology (CCI) is one of the 8 technical commissions of World Meteorological Organization. CCI usually meet once every four years. 15th Session of the commission was held in Antalya, Turkey from 18 to 24 February 2010 and unanimously elected Dr Thomas Peterson, Chief Scientist at NOAA's National Climatic Data Center in Asheville, North Carolina and Mr Serhat Sensoy, Chief of the Climatology Division of Turkish State Meteorological Service (TSMS) as the president and vice-president of the CCI, respectively, for the next four years.

WMO CCI's vision is “To provide world leadership in promoting expertise and international cooperation in climatology” and its mission is “To stimulate, lead, implement, assess and coordinate international technical activities within WMO under the World Climate Programme and the Global Framework for Climate Services (GFCS) to obtain and apply climate information and knowledge in support of sustainable socio-economic development and environmental protection.”

The Commission for Climatology advises and guides the activities of the World Climate Programme, through the World Climate Applications and Services Programme, and the World Climate Data and Monitoring Programme while providing support to many activities under the framework of the Climate Agenda.

CCI Management Group for 15th Intercessional Period is consisted from ten members and they made 1st meeting in Geneva from 19 to 22 May 2010. During the meeting they elected members of the task/expert teams and they made a work plan for the coming 4 years.

Data rescue and availability was mainly subjected in the Open PAnel of CCI Experts (OPACE) 1 and 2 which are related to Climate Data Management and Climate Monitoring and Assessment, respectively.

WMO COMMISSION FOR CLIMATOLOGY FOR 15TH INTERSESSIONAL PERIOD'S NEW STRUCTURE

The new structure for the WMO CCI 15th Intersessional Period is shown in Figure 1. CCI Management Group for this Intercessional Period is consisted of ten members and they made the1st meeting in Geneva during 19 to 22 May 2010. During the meeting they have elected the members of the task/expert teams and they made a work plan for the coming 4 years.

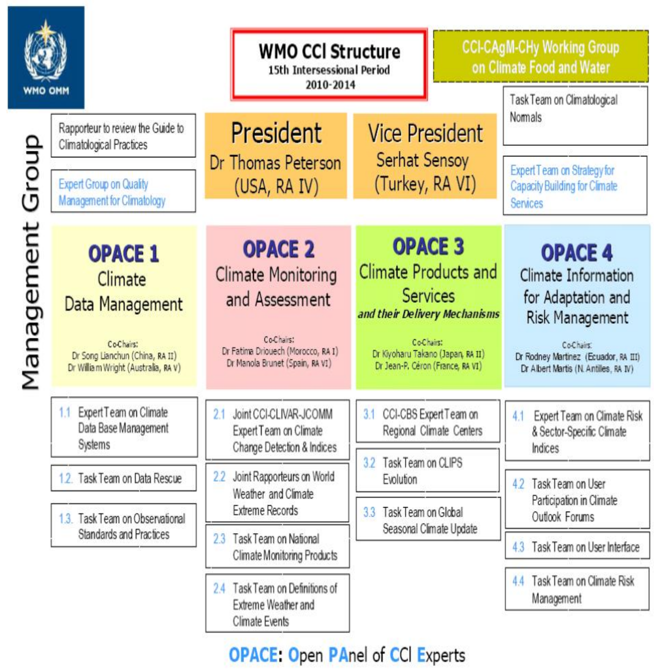


Figure 1: WMO CCI 15th Intersessional Period's Structure (http://www.wmo.int/pages/prog/wcp/ccl/index_en.html)

OPACE I CLIMATE DATA MANAGEMENT

The objective of OPACE 1 is to assess the progress made in the migration from Climate Computing (CLICOM) to a new Climate Data Management Systems (CDMSs) and to improve model description for interoperable climate databases including functionalities of Geographical Information Systems and other data services.

The activities of OPACE 1 includes support to data rescue activities worldwide and working with WMO programmes such as WMO Space Programme, WMO Integrated Global Observing System, WMO Information System, Global Climate Observing System, Education and Training Programme, International Polar Year and the World Climate Research Programme, which would result in developing climate observations and related climate data aspects.

OPACE 1 Expected deliverables

- Finalize the ongoing work on climate observations requirements, including, in particular, the provision of peer-reviewed guidelines on the use of automatic weather stations in climatology and capacity-building status and requirements on climate observations for developing countries;
- Undertake, in cooperation with the Commission for Instruments and Methods of Observation, the establishment of standards related to the measurement of snowfall, snow depth and solid precipitation and the performance of automatic weather stations and alternate standards for climate observations in mountainous terrain;
- A new Climate Metadata catalogue based on the former World Climate Data Information Referral Service, which should provide a more in-depth description of climate Metadata for improved climate data discovery and exchange through the WMO Information System;
- Assessment report on the progress made in migration from Climate Computing to new Climate Data Management Systems (CDMSs) and improved model description for interoperable climate databases and related management systems including functionalities of Geographical Information Systems and improved data services;
- Monitoring Report on Data Rescue worldwide including support to and progress review of the Atmospheric Circulation Reconstructions over the Earth Project, the Mediterranean Data Rescue Initiative, and similar initiatives in other regions;
- Guidance on minimum set of requirements for National Meteorological and Hydrological Services to benefit from space-based data, radar data and data from other remote sensing platforms for climate studies and applications;
- A project study for the implementation of a High Quality Global Climate Data Management System, including the design of an operational manual on the collection, quality control, dissemination and exchange of climate data;
- Advise on the organization of seminars, conferences and training workshops on climate data including data rescue, CDMSs and climate data exchange;
- Improved collaboration and working arrangements with other WMO programmes and cosponsored programmes, such as the WMO Space Programme, WMO Integrated Global Observing System, WMO Information System, Global Climate Observing System, Education and Training Programme, International Polar Year and the World Climate Research Programme, which would benefit in developing climate observations and related climate data aspects.

EXPERT TEAM ON CLIMATE DATA BASE MANAGEMENT SYSTEMS (ET-CDMS)

Terms of Reference:

- Assess the current WMO Climate Database Management Systems (CDMS) since their first evaluation in 2001 and the development of new systems;

- Work in collaboration with the WMO WIS project office on using inter-operable systems to integrate and exchange NMHSs climate data and data from other sources such as remote sensing data, Geographic Information Systems, and data from applications sectors;
- Keep technology watch on software and the capability of data transfer through various means including mobile phones; and develop guidance and advice to the Members on the most practical, secure, reliable and affordable technologies in this domain;
- Develop and implement a monitoring mechanism for a continued updating of the CDMSs;
- Liaise with CBS, CHy, JCOMM and CAgM and the space programme on the any relevant issues related to climate data management and related systems;
- Assess the success of past and current capacity building activities in implementing new CDMSs operationally in replacement of CLICOM, and revise them as necessary;
- Submit reports in accordance with timetables established by the OPACE co-chairs.

ET-CDMS Members:

- Steve Palmer (Chair) - UK
- Dennis Stuber (Co-Chair) - France
- Alpha Barry - Guinea
- Anyuan Xiong - China
- Bruce Bannerman (CCI rep to ET-MDI)- Australia
- Radim Tolasz - Czech Rep
- Gilkes Lloyd - Barbados
- Rachid Sebbari - Morocco

Associate Experts:

- Ersin Simsek - Turkey
- 2.Frank Kaspar - Germany
- 3.Jeff Arnfield - USA
- 4.Johannes Behrendt – Germany

Past activities on CDMS

Two questionnaires have been carried out by WMO on CDMSs in 1995 and 2009

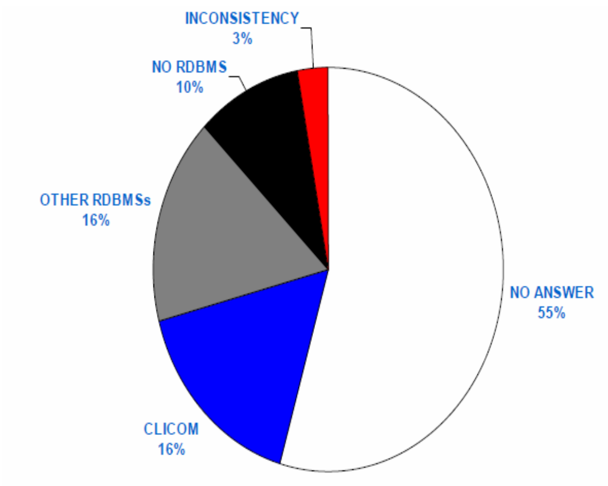


Figure 2: CDMS questionnaire results in 1995

According to the questionnaire carried out by the WMO, only 45% of the 182 members replied to the questionnaire (Figure 2). Based on 83 replies, 44% were managing data but not Metadata, and 40% were having no data quality code in their data model.

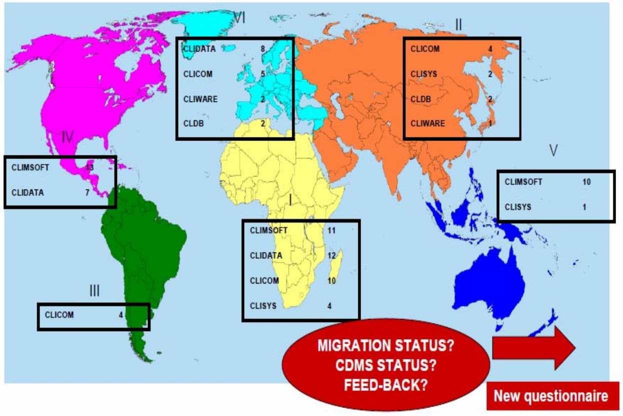


Figure 3: CDMS status's assessment in 2009

According to the CDMS questionnaire result shown in Figure 3, there is no information for 42% of country/area. Climsoft (34), Clidata (27) and Clicom (23) are the most installed CDMSs (out of totally 84 installed).

Expert Team Data Rescue (ET-DARE)

Terms of Reference:

- To establish and record, through contact with interested parties including data users and data centres, general and specific needs for the rescue of historic observational data and metadata records;
- To assess regional needs for data rescue projects and to investigate associated synergies across different region, WMO programmes and commissions and other international Climate Data Recovery initiatives such as the Atmospheric Circulation Reconstructions over the Earth (ACRE) Project, the Mediterranean Data Rescue Initiative (MEDARE), and similar initiatives in other regions;
- To explore, document and make recommendations for addressing the needs for workshops, conferences and training events pertinent to this topic;
- To set up an International Data Rescue web portal (I-DARE);
- To submit reports to the OPACE-1 Co-chairs; and
- Task team lead to inform the OPACE co-chairs that the task is finished and that the team can be dissolved.

Members:

- Aryan Van Englen (Chair) - Netherlands
- Joseph Kimani (Co-Chair) - Kenya
- Rod Hutchinson - Australia
- Tom Ross - USA
- Umesh Joshi - India
- Alaor Dall'Antonia Jr. - Brazil
- Yusuf Ulupinar – Turkey
- Jose Antonio Guijarro - Spain

OPACE II Climate Monitoring and Assessment

The objective of OPACE 2 is to improve methodologies and standards for defining extreme weather and climate events that are of major societal impacts, develop standards for creating global, regional and national databases on extreme weather and climate events, improve the WMO Climate Monitoring System and the implementation of Climate Watch Systems at the regional and national levels, with the provision of guidance on the content, dissemination and related alert systems.

Its activities include the development of guidelines on methodologies and standards for defining extreme weather and climate events and the organization of climate indices workshops of the Joint CCI/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices.

OPACE II Expected deliverables

- Review report on the existing indices and provision of peer-reviewed guidelines on new climate indices;
- A new strategy for climate indices workshops of the Joint CCI/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices considering the requirements of the Global Framework for Climate Services and the contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change;
- Guidelines on methodologies and standards for defining extreme weather and climate events that are of major societal impacts and assessing their attribution and return periods in the framework of a changing climate, such as for drought, heat waves, extreme precipitation anomalies and wind storms;
- Project proposal for developing standards for creating global, regional and national databases on extreme weather and climate events;
- Updated WMO Website on the world records on weather and climate extremes;
- Guidance/advice on best practices in the use of satellite products for climate monitoring and climate change detection and provide an assessment of the most current level of suitability of these products to climate monitoring applications;
- Recommendations for improving WMO Climate System Monitoring including real-time identification of extreme weather, methodologies and datasets for assessing climate trends and variations; and dissemination mechanism for timely informing on extreme weather and climate events;
- Review report on the implementation of climate watch systems at the regional and national levels, with provision of guidance on the content, dissemination and related alert systems, taking into consideration the recommendations from various regional workshops organized by the World Climate Data and Monitoring Programme on climate monitoring and implementation of climate watch systems;
- Improved collaboration and working arrangements with other WMO Programmes and cosponsored programmes such as the WMO Space Programme, WMO Integrated Global Observing System, WMO Information System Disaster Risk Reduction, Atmospheric Research and Environment Programme, Education and Training Programme, Global Climate Observing System, World Climate Research Programme and the International Polar Year, which would benefit in developing climate monitoring knowledge, user requirements and standards.

JOINT CCL/CLIVAR/JCOMM EXPERT TEAM ON CLIMATE CHANGE DETECTION AND INDICES

Terms of Reference:

- Provide coordination and help organize collaboration on climate change detection and indices;
- Further develop and publicize indices and indicators of climate variability and change and related methodologies, from the surface and subsurface ocean to the stratosphere, with consensus;
- Encourage the comparison of modeled data and observations, perhaps via the development of appropriate indices for both sources of information;
- Coordinate these and other relevant activities the ET chooses to engage in with other appropriate working bodies including of those affiliated under OPACE-4, WCRP and JCOMM as well as others such as GCOS, CBS, CIMO,

CAgM, CHy, IPCC and START; and regional associations;

- Explore, document and make recommendations for addressing the needs for capacity-building in each region, pertinent to this topic with consideration of the GFCS requirements; and
- Submit reports in accordance with timetables established by the OPACE 2 co-chairs with the main deliverables being the provision of a review report on the existing indices, a peer-reviewed guidelines on new climate indices; and the development of new strategy for ETCCDI workshops considering the requirements of the GFCS and the contribution to the IPCC AR5.

CCI Members of the ET-CCDI:

- Albert Klein-Tank (Co-Lead) - The Netherlands
- Blair Trewin - Australia
- Matilde Rusticucci - Argenatina
- Zhai PanMao - China

Rapporteurs on World Records of Weather and Climate Extremes

Terms of Reference:

- Work with the OPACE 2 to create guidelines and appropriate mechanism (e.g. ad-hoc Assessment Committee) on verification of national, regional and global extremes;
- Work on the creation, verification and documentation of a database of national, regional and global extremes;
- Take the lead in creating and maintaining a database of extreme records, and in documenting such events, e.g. in peer-reviewed scientific papers;
- Develop guidelines and recommendations for continuing this record of extremes beyond the fourteenth intersession CCI period;
- Promote quality management system in the work of the rapporteur including the provision of the guidelines and reports;
- Submit reports in accordance with timetables established by the OPACE 2 co-chairs;

Joint Rapporteurs:

- Randall Cerveny (Chair)- USA
- José Luis Stella (Co-Chair) – Argentina

Task Team on National Climate Monitoring Products

Terms of Reference:

- Consider the existing of national climate monitoring products and determine which of these products are the most important from a scientific perspective as well as which products generate the most interest among the general public within those countries;
- Consider the existing capabilities within developing countries to potentially produce the climate monitoring products documented in (1) above
- Develop a list of about two to six national climate monitoring products that the team recommends Members to produce;
- Precisely document the construction of this priority list of national climate monitoring products in a publication intended to be an addition to the WCDMP publications;
- Determine if it would be helpful to develop software to calculate these products and, if so, what programming language would be appropriate for the software;

- Should software be deemed appropriate, either create the software or only recommend that such software be created;
- Report to OPACE-2 co-chairs; and
- Task team lead to inform the OPACE co-chairs that the task is finished and that the team can be dissolved.

TT-NCMP Members:

- John Kennedy (Chair) - UK
- Ladislaus B. Chang'a(Co-Chair) - Tanzania
- Andrew Watkins - Australia
- Dereck Arndt - USA
- Olga Bulygina - Russia
- Mesut Demircan - Turkey
- Raj Booneeday - Mauritius
- Mohamed Semawi - Jordan

Task Team on Definitions of Extreme Weather and Climate Events

Terms of Reference:

- Considering the existing work and studies, including by WMO communities and others which relate to climate extreme events, their definitions, geographical distribution, space and time scales, intensity, etc;
- Taking into account the gaps in and the need for developing common definition related to climate extreme events with particular focus on heat waves, cold waves and severe precipitation and storms events (not including those related to tropical cyclones);
- Provide guidance to the Members on methodologies and standards for defining extreme weather and climate events and assessing their attribution and return periods, and advice on adequate computational tool for the assessment;
- Provide an advice on developing an inter-operable data base for climate extreme events with focus on regional and national levels;
- Liaise with other commissions, programs, co-sponsored programs and regional and international projects and agencies to develop linkages and partnership on this subject;
- The software should be deemed appropriate, either create the software or recommend that such software be created;
- Report to OPACE-2 co-chairs; and
- Task team lead to inform the OPACE co-chairs that the task is finished and that the team can be dissolved.

Members:

- Ren Fumen(Chair) - China
- Pattanaik Dushmenda(Co-Chair) - India
- Randall Cerveny - USA
- Blair Trewin - Australia
- Boris Sherstyukov - Russia
- Andreas Walter - Germany
- Diallo Aissatou - Guinea

ETCCDI Past Activities

Six regional workshops were held to fill the gap in the global extreme analyses (Figure 4).

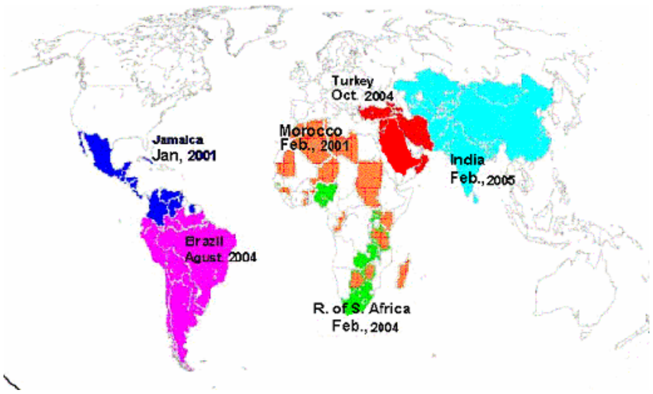


Figure 4: ETCCDMI Regional workshops (Peterson, 2006)

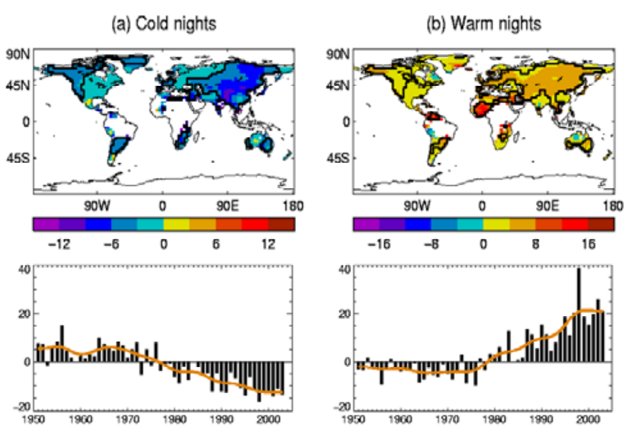


Figure 5: Trends in (a) cold nights (TN10p) and (b) warm nights (TN90p)

According to global indices results (published by Alexander et al. 2006), cold night has been decreasing and warm night has been increasing in the whole world (Figure 5). Trends were calculated only for the grid boxes with sufficient data (at least 40 years of data. Black lines enclose regions where trends are significant at the 95% confidence of level. Same result obtained for cold days (TX10p) and warm days (TX90p) (Alexander, 2006).

CONCLUSION:

WMO Commission for Climatology (CCl) is one of the 8 technical commissions of the World Meteorological Organization. CCl usually meet once every four years. The 15th Session of the commission was held in Antalya, Turkey during 18 to 24 February 2010. At that time the CCl Management Group (MG) consisted of the President, Vice-President, and 8 Co-Chairs of the four Open Panels of selected CCl Experts (OPACEs).

Also, during the session the Commission decided that the CCl MG would establish additional teams, groups or rapporteurs (as required) to undertake the identified tasks, for example for data rescue (DARE). CCl decided that TT-DARE should work to provide a Monitoring Report on Data Rescue worldwide and provide support to and progress review of the Atmospheric Circulation Reconstructions over the Earth (ACRE) Project, the Mediterranean Data Rescue Initiative (MEDARE), and similar initiatives in other regions (URL 1).

The CCl Management Group made its 1st meeting in Geneva during 19 to 22 May 2010. During the meeting almost all team members were selected from the list of 214 volunteers from 54 countries who are currently members of different panels (OPACEs).

In order to ensure climate data availability through OPACE 1 and OPACE 2, CCl constituted 7 Task/expert Teams of which terms of reference, deliverable and members were mentioned in this paper.

SECTION II: KEY MEDITERRANEAN CLIMATE RECORDS AT THE NATIONAL, SUB-REGIONAL AND REGIONAL LEVELS. THE MEDARE METADATA BASE PORTAL: NATIONAL CLIMATE METADATA INVENTORIES PRESENTATIONS FROM NMHS

Potential meteorological data and metadata for Catalonia to be part of a Mediterranean database

Marc Prohom and Mònica Herrero
Area of Climatology – Meteorological Service of Catalonia

Introduction and State-of-the Art of the CATDARE Project

The Meteorological Service of Catalonia (SMC) was established in 2001 as a public entity of the Catalan Autonomous government[1] (Generalitat de Catalunya), recovering the former SMC that was running since 1921 until 1939. At present the institution is organized into four main technical areas: Applied Research and Modelling, Forecasting, Climatology and Information and Communication Technologies.

Among the main functions of the Unit of Climatology, maintenance, data rescue and preservation of all sorts of climatic database and metadata are considered tasks of especial interest. Following these objectives, the CATDARE project focuses on these topics and is structured into three steps:

- To analyze the climatic documentary or digital sources, identifying as many as possible meteorological stations or observatories, and the meteorological series associated to these sites.
- To create a metadata database for each of the sites compiled: METADEM.
- To construct a database of quality controlled and homogenised series on a monthly and daily basis (mainly for temperature and precipitation).

One of the main issues that have to be accomplished in this project is to unify within a unique database all sources containing climatic data. In the case of Catalonia, four main repositories has been analysed, i.e.: the national database of the Spanish Meteorological Office (1910-2010), the database from the former Meteorological Service of Catalonia (1921-1939), the database from the Astronomical Society of Barcelona (1910-1921) and the database from the first meteorological network, coming from several sources (1895-1910). In addition, an enormous effort has been paid to recover data and metadata from the longest and more complete climatic series, that from Barcelona, encompassing the period from 1780 onwards.

Apart from data rescue, during the last months, most of the work has been centred on "cleaning" the series, i.e., to assign one climatic series to one site and ID code, avoiding composites of series under a unique ID code or site. Metadata identification is a current concern, and new information has been added recently, especially from inland sites. Finally, a critical period (1995-2001) with plenty of missing values, due to changes in the data format used and transmitted by the observers, has been filled and currently more continuous series are already available.

Potential Data Availability for MEDARE Community

Thanks to the advances made in the recent years, the Catalan Meteorological Service is ready to provide a good number of climatic series, in a daily base, and covering the main variables: maximum and minimum temperature (TX and TN) and precipitation (PPT). In relation to the spatial coverage, almost all climatic regimes of the area are represented, with less information for the central and eastern part of the Pyrenees.

Temperature

For temperature data, 16 daily TX and TN series with the common period 1950-2010 are already available and quality controlled, and a reduced amount of gaps (<15%) is reported. For these series, monthly means have been analysed for homogeneity by

[1] The Spanish constitution enabled Spanish autonomous regional governments, as Catalonia, to officially set up their own public regional meteorological services. The Catalonian Autonomous Parlament approved the Meteorological Law (15/2001 of November the 14th) and reinstated the Meteorological Service of Catalonia, which coordinates with AEMET to carry out their competences and for avoiding overlaps over Catalonia (editors' statement).

means of Caussinus and Mestre approach (Caussinus and Mestre, 2004) and the corrected series are ready for use. In addition, the longest daily and sub-daily series for Barcelona (1780-up to the present) is almost all digitized, but not yet quality controlled and analysed for homogenization.

Precipitation

The original Catalan precipitation network has a better spatial coverage, and more series can be used. Thus, 28 daily and monthly PPT series for the common period 1940-2010 are available, with less of 15% of missing data. Among these series, there are 14 stations that go back in time to 1917, with a similar percentage of gaps (figure 1). Again, Barcelona provides the longest series with data, covering the period 1800-up to present, but with some gaps at the beginning of the period (1808-1813).

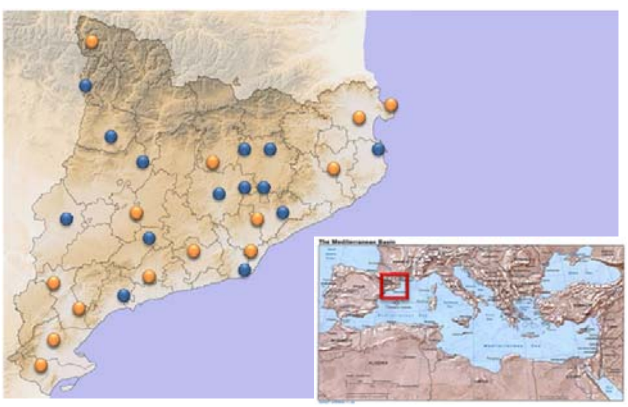


Figure 1: *Location of daily precipitation series available from the CATDARE project. In blue circles, series covering the period 1940-2010, and in orange those encompassing the common period 1917-2010*

Additional data

Pressure daily and sub-daily data are available for Barcelona since 1780 up to present, with most of the monthly values homogenised thanks to an EU funded research project.

Advances on Homogenization of Historical Data and other Climate Research efforts in the Principality of Andorra

Pere Esteban and Ramon Copons
Snow and Mountain Research Center of Andorra – Institut d'Estudis Andorrans (CENMA-IEA; www.iea.ad)

ABSTRACT:

In this article we first show the recent results in terms of climate change analysis obtained for the Principality of Andorra thanks to the meteorological series homogenization work made during 2008-2009. Annual and seasonal trends based on the 1934-2008 precipitation and temperature observations of FEDA (Andorran Energy Supply Company) were obtained. Previously, a quality check procedure was applied, followed by direct revision on the original data for correcting the errors detected. Finally, series homogenization was applied following two independent methods, Caussinus-Mestre and SNHT. Warming trends were obtained for temperature, mainly for summer maxima, while non significant trends were identified for precipitation.

Secondly, based on daily weather data subjected to quality control, the main indices proposed by the ETCCDI (Expert Team on Climate Change Detection and Indices) were calculated for the Ransol station (1640 m).

Finally, the new high elevations sites automatic weather stations network of Andorra is briefly presented.

INTRODUCTION:

The Principality of Andorra is located in the Pyrenees range, between France and Spain. It is a small and hilly country with the highest altitudes around 2900 m and the lowest around 800 m. Andorra has a sub-Mediterranean climate, characteristic of the northern Mediterranean coast. Inland location, topography and the south-face location over the Pyrenees are clearly important with regard to the final properties of the climate, as for example in terms of seasonal precipitation regime (see Figure 1).

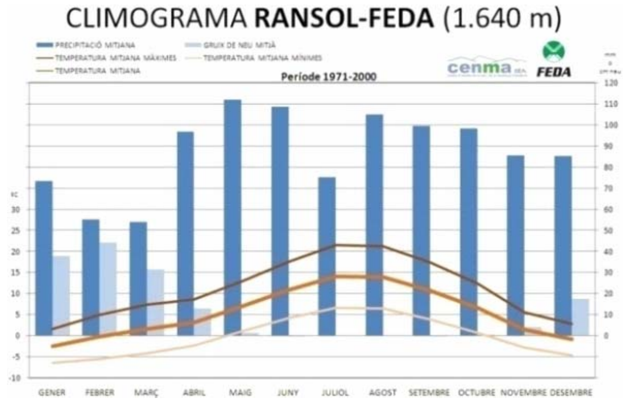


Figure 1: Climatogram, including snow depth, of the Ransol weather station

Nevertheless, the low and well oriented topography of the French side of the Pyrenees enables easy entrance of Atlantic air masses from the north and northwest, mainly affecting the northernmost areas of the country. Then, high temporal and spatial variability are another Andorran climate characteristic despite of the low extension of the country (468 km^2).

Responsibility for meteorological issues, mainly from the forecasting point of view, was adopted by Meteo-France in the early 80s. Nevertheless, scientific research centered on many climate topics is developed by CENMA/IEA (Centre d'Estudis de la Neu I la Muntanya de l'Institut d'Estudis Andorrans), a public company oriented to research and dissemination. Climate change is a main research issue for CENMA/IEA, and in this regard relevant effort has been made recently for recuperation and correction of historical meteorological data of Andorra. Participation of CENMA/IEA in the European Action COST ES0601 on climate series homogenization has reinforced and helped for obtaining the results shown in this article.

HOMOGENIZATION OF ANDORRAN TEMPERATURE AND PRECIPITATION TIME-SERIES AND ESTIMATED TRENDS FOR THE 1934-2008 PERIOD

With the objective of obtaining reference climatological information for advancing on climate variability analysis and climate change impacts over Andorra and the Pyrenees, revision and correction of historical Andorran data was made between 2008 an 2009. The data used corresponds to 3 manual weather stations located between 1100 and 1640 m: Central, Engolasters and Ransol. These 3 long meteorological records are property of FEDA (Forces Elèctriques d'Andorra), the Andorran electricity supply company, that offers easy and fast access to the original data that can be found in their archives since the beginning of the observations.

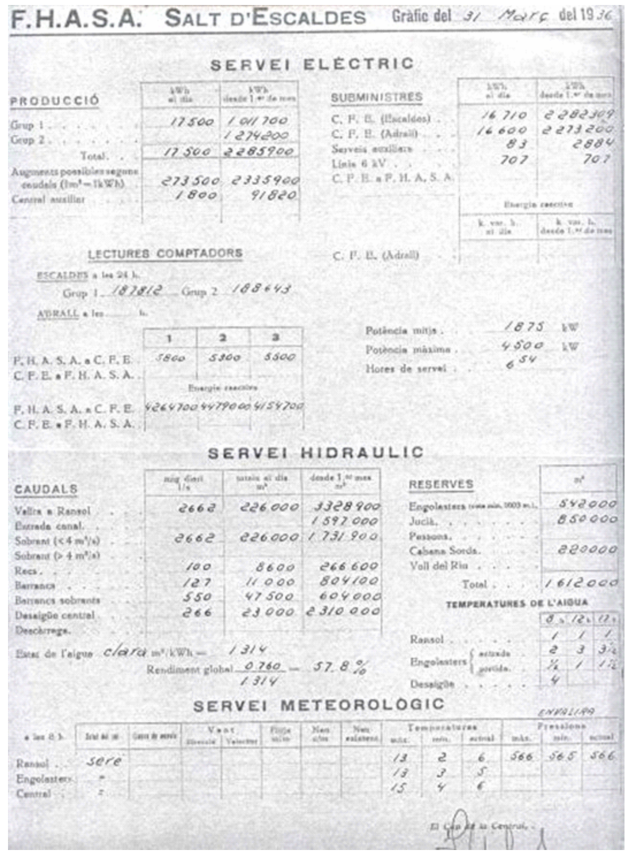
Figure 2: The Ransol weather station.

Quality check and homogenization

Following Brunet et al 2008, a test associated to identify duplicated data, outliers, excessive differences between successive days, days with minimum temperature higher than maximum temperature, and rounding effect were applied. Several problems were detected and solved in a very high percentage. Then, despite of the limitations associated to the 1ºC rounding of the data series analyzed, nearly continuous (99,9%) and revised daily information since 1934 to 2008 was produced.

In order to ensure consistent results, homogeneity assessments were applied following two different methods. On one hand, the Standard Normal Homogeneity Test (SNHT) (Alexanderson et al 1997) based on the criteria described by Aguilar et al. 2002 and Brunet et al 2008; and on the other hand, the homogenization method based on the Caussinus-Mestre (2004) approximation were also applied. For precipitation series Wang's (2007, 2008) RhTestV3 test has been also applied.

Break points were detected at all three temperature series and corrections were required. For precipitation, the series at Ransol observatory proved to be homogeneous and no correction was necessary. The Ransol station was considered as reference station for obtaining the precipitation trends for the other two stations.



F.H.A.S.A. SALT D'ESCALDES Gràfic del 31 Març del 1936

SERVEI ELÈCTRIC

PRODUCCIÓ	kWh al dia	kWh desde 1.er de mes
Grup 1	17500	1011700
Grup 2		1274200
Total	17500	2285900
Augments possibles segons caudals (1m³ = 1kWh)	273500	2335900
Central auxiliar	1800	91820

SUBMINISTRES	kWh al dia	kWh desde 1.er de mes
C. F. E. (Escaldes)	16710	2282309
C. F. E. (Adrall)	16600	2273200
Serveis auxiliars	83	2884
Línia 6 kV	707	707
C. F. E. a F. H. A. S. A.		

Energia reactiva

	k. var. h. al dia	k. var. h. desde 1.er de mes
C. F. E. (Adrall)		

LECTURES COMPTADORS

ESCALDES a les 24 h.

Grup 1 187812 Grup 2 188643

ADRALL a les ... h.

	1	2	3
F. H. A. S. A. a C. F. E.	5800	5300	5500
C. F. E. a F. H. A. S. A.			
Energia reactiva			
F. H. A. S. A. a C. F. E.	4264700	4479000	4154700
C. F. E. a F. H. A. S. A.			

Potència mitja 1875 kW

Potència màxima 4500 kW

Hores de servei 6 54

SERVEI HIDRAULIC

CAUDALS	mig diari l/s	totals al dia m³	desde 1.er mes m³
Valira a Ransol	2662	226000	3328900
Entrada canal			1597000
Sobrant (< 4 m³/s)	2662	226000	1731900
Sobrant (> 4 m³/s)			
Recs	100	8600	266600
Barrancs	127	11000	804100
Barrancs sobrants	550	47500	604000
Desaigüe central	266	23000	2310000
Descàrrega			

Estat de l'aigua clara m³/kWh — 1314

Rendiment global 0760 / 1314 — 57.8 %

RESERVES	m³
Engolasters	542000
Juclà	850000
Pessons	
Cabana Sorda	220000
Vall del Riu	
Total	1612000

TEMPERATURES DE L'AIGUA

		8 h.	12 h.	17 h.
Ransol		1	1	1
Engolasters	entrada	2	3	3½
	sortida	½	1	1½
Desaigüe		4		

SERVEI METEOROLÒGIC

ENVALIRA

a les 8 h.	Estat del cel	Vent Direcció	Vent Velocitat	Temperatures màx.	Temperatures mín.	Temperatures actual	Pressions màx.	Pressions mín.	Pressions actual
Ransol	sere			13	2	6	566	565	566
Engolasters	"			13	3	5			
Central	"			15	4	6			

El Cap de la Central,

Figure 3: Example of the original documents of FEDA along with the meteorological observations (bottom).

Trends

The non parametric method of Sen (1968) adapted by Wang and Swail (2001) was used for trend estimation of the temperature series adjusted by the SNHT and for the Ransol precipitation series, while the least squares method was applied to the Caussinus-Mestre corrected data.

For temperature series (see Table 1 and Table 2), significant trends at the 95% confidence level based on Mann-Kendall test were calculated for annually averaged maximum temperature (for both methods) and the annual mean of minimum temperature (for Caussinus-Mestre). At seasonal scales, summer shows the most relevant warming for maximum temperature (significant for the two methods), while for minimum temperature winter shows higher trend considering the results of SNHT and summer positive trend based on Caussinus-Mestre outputs.

Table 1	AVERAGE MAXIMUM TEMPERATURE (ºC) **Decadal trend [confidence levels]**
1934-2008	**CAUSINUS-MESTRE / SNHT**
ANUAL	**0,10* [0,01/0,18]** / **0,12* [0,03/0,21]**
Winter	0,14 [0,00/0,30] / 0,08 [-0,07/0,23]
Spring	0,07 [-0,08/0,22] / 0,08 [-0,10/0,24]
Summer	**0,17* [0,03/0,32]** / **0,25* [0,09/0,41]**
Autumn	0,03 [-0,11/0,18] / 0,06 [-0,10/0,20]

Table 2	AVERAGE MINIMUM TEMPERATURE (ºC) **Decadal trend [confidence levels]**
1934-2008	**CAUSINUS-MESTRE / SNHT**
ANUAL	**0,07* [0,00/0,15]** / 0,07 [-0,07/0,20]
Winter	0,11 [-0,02/0,23] / **0,18* [0,04/0,31]**
Spring	0,03 [-0,12/0,15] / -0,01 [-0,20/0,18]
Summer	**0,14* [0,03/0,24]** / 0,13 [-0,01/0,26]
Autumn	0,02 [-0,11/0,12] / 0,06 [-0,07/0,18]

It is interesting to highlight that the comparison for a shorter period (1971-2008) with the study of Brunet et al. 2007 for Spain (1973-2005) show very good agreement in the results, either in terms of time series values or their trends or statistical significance (increasing and significant trends have been estimated for annual, spring and summer maximum temperatures, and for annual, spring, summer and autumn minimum temperatures).

For precipitation (Table 3), no significant trends were estimated in Ransol time series for the complete period 1934-2008, but for the period 1950-2008 the results show a decreasing trend in the total amount of precipitation. The decreasing trend of precipitation amount has been found to be significant on an annual and summer basis despite of their high interannual variability.

More details about this research can be found at Esteban et al. (2010): http://www.iea.ad/images/stories/Documents/CENMA/Revista_CENMA/Revista_Cenma5/5-article3.pdf (in Catalan)

Table 3	PRECIPITATION (mm) Decadal trend [confidence levels]
	1934-2008 / 1950-2008
ANUAL	-0,43 [-3,24/0,85] / **-4,26* [-7,80/-1,03]**
Winter	-0,42 [-1,83/0,85] / -1,48 [-3,12/0,41]
Spring	0,02 [-0,81/0,96] / -1,00 [-2,43/0,42]
Summer	-1,02 [-1,88/0,03] / **-2,44* [-3,74/-1,13]**
Autumn	0,35 [-0,90/1,64] / -0,28 [-2,16/1,49]

ETCCDI INDICES FOR ANDORRA 1950-2010

Based on the daily quality controlled climate data, which were used for calculating the annual and seasonal temperature and precipitation trends, the 27 climate change indices recommended by the ETCCDI were calculated for the Ransol station using the free software RClimDex (Zhang and Yang, 2004). The analysis returned interesting results, as the calculated trends for these indices show general changes for this Andorran station for the period 1950-2010 are in line with the results obtained over neighboring areas (Esteban et al. 2011).

For air temperature, a significant increasing trend of warm days (TX90P) and a decreasing trend of cold days (TX10P) were found (Figure 4). Then, in agreement with the annual/seasonal results, the observed warming is mainly related to changes in maximum temperatures. Furthermore, increases of the Growing Season Length (GSL) and of the Warm Spells Duration (WSDI) were found.

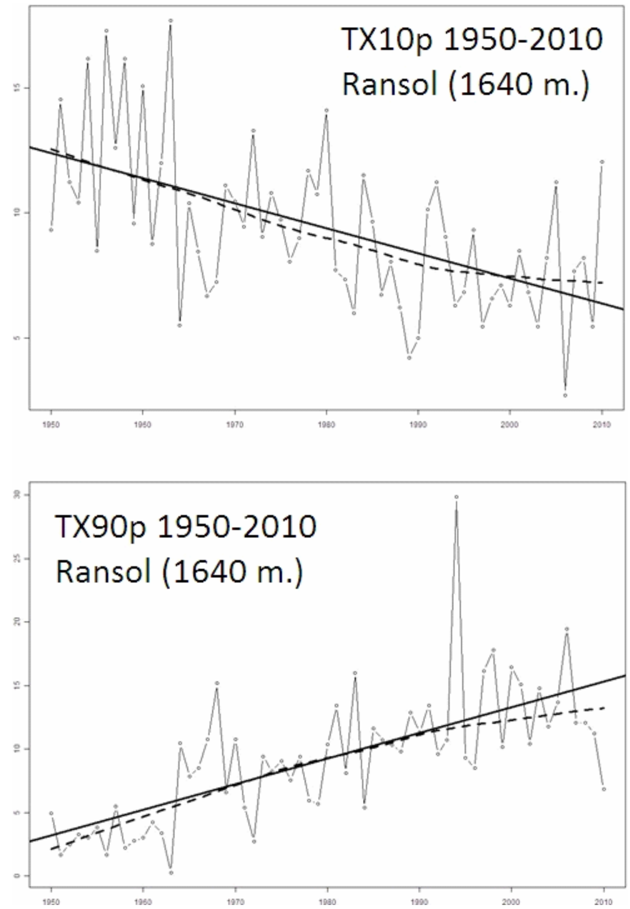


Figure 4: Graphical trends of cold (top panel) and warm (bottom panel) days for Ransol.

As for precipitation, a significant reduction of total precipitation (PRCPTOT) (Figure 5) and other several indices associated with user defined precipitation thresholds were found, such as days with more than 10 mm total precipitation (R10mm), days with more than 20 mm total precipitation (R20mm) or years with total amount of precipitation higher than the 99th percentile for the period 1961-1990 (R99p). The results show also a significant decrease of the number of consecutive wet days (CWD) (Figure 5).

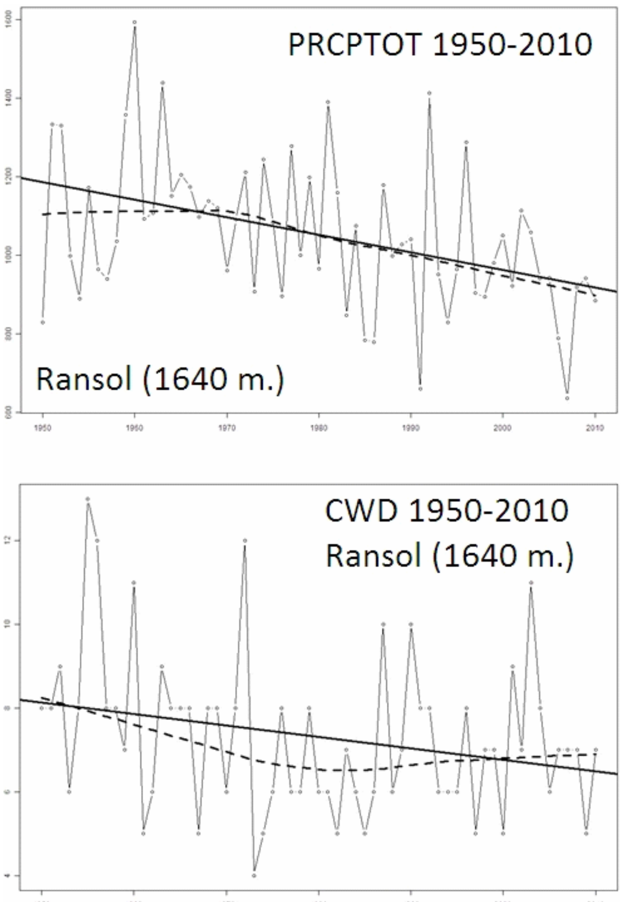


Figure 5: *Graphical trends for annual precipitation (top panel) and consecutive wet days (bottom panel) for Ransol station.*

ADVANCES ON THE AUTOMATIC WEATHER STATION NETWORK IN ANDORRA

As explained in the previous MEDARE proceedings (Esteban et al., 2008), in 2007 CENMA planned to install a new high elevation meteorological network based on automatic weather station (AWS). The main objective is to advance the knowledge of meteorology, climate and snow dynamics at high elevations (1600-3000m.). At present, this network is operational and the distribution of the 5 AWS over Andorra's territory is shown in Figure 6. Figure 7 presents the Bony de les Neres AWS, where one can see on the main pylon the temperature, humidity, wind velocity/direction, snow depth and other sensors, while on the secondary pylon the Geonor T200B precipitation sensor adapted for cold and windy conditions is shown. Observations are recorded every 10 minutes.

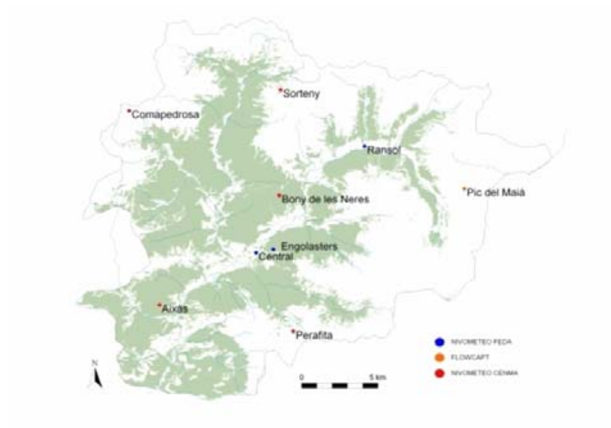


Figure 6: *Location of the CENMA (red) and FEDA (blue) weather stations. In orange, a future location of a new weather station also oriented to nivological issues.*

Additional to the monitoring and research activities presented above, the CENMA/IEA also provides advice to other Andorran public departments or to private companies that wish to install new AWS or manual observatories, pointing out on the minimum conditions required and on the existing international regulations. A special effort was put by CENMA/IEA on generating complete metadata about all the Andorran weather observations.

Figure 7: The Bony de les Neres automatic weather station (2100m).

CONCLUSIONS AND FURTHER WORK

Important advances have been made recently in Andorra on historical data recovery and adjustment. Collaboration with other centers and participation in initiatives like MEDARE or COST Action ES0601 can be considered as crucial for understanding the work presented in this document. Nevertheless, more work will be done during the next future, considering the forthcoming outputs of the Action COST ES0601 (ending on 2011) and new research projects will be also considered at Pyrenean scale. The next steps on the development of long and high-quality climate series will be focused on daily data homogenization and on estimating definitive ETCCDI indices. All these corrected data will be used in 2012 for calibration of statistical models in order to obtain downscaled scenarios for Andorra.

ACKNOWLEDGEMENTS

To Enric Aguilar, Manola Brunet and Constanta Boroneant (Center for Climate Change (C3), Tarragona, Spain), Marc Prohom (Meteorological Service of Catalonia, Barcelona, Spain), Olivier Mestre, Sylvie Jourdain and Jean-Michel Soubeyroux (Meteo-France, Toulouse, France) and Jordi Dejuan (FEDA, Andorra). Also thanks to the COST Action ES0601 – Advances in Homogenization Methods of Climate Series: an Integrated Approach (HOME) and to the 2011-2012 CTP Project "Influència del Canvi Climàtic en el Turisme de Neu al Pirineu".

Key Mediterranean Climate Records in Southern France

Sylvie Jourdain, Laurence Laval, Thierry Offre
Météo-France, Direction de la Climatologie, Toulouse, France
Météo-France, Direction Inter-Régionale Sud-Est, Aix-en-Provence, France

ABSTRACT:

This contribution is focused on the identification and the selection of a set of long and high-quality climate records for South France, in support of an enhanced detection, prediction and adaptation to climate change and its impacts. Here we start with a short description of the evolution of the French meteorological network, and then we discuss the selection procedures of the stations. We conclude the paper with the presentation of the recovery of Nice climate records, along with the discussion of the difficulty to build reliable long-climate records going back in time to the 19th century.

INTRODUCTION:

The long-term goal of the WMO-MEDARE initiative is to develop a high quality Mediterranean climate dataset.

Each partner of the project was asked to identify for his country those *long-term* climate records that are essential for defining climate reference networks, which can be confidently used in, for instance, climate change assessments at national, sub-regional and regional scales once developed. The records to be targeted should be the longest and, potentially, best and continuous time series.

The requirements were to select reliable long series in the Mediterranean climate with instrumental data for some essential climate variables (e.g. temperature, precipitation, pressure, wind) with a daily or sub-daily resolution and, if possible, extending back in time to the 19th century.

HISTORICAL CLIMATE DATA IN FRANCE

The climate data availability depends on the history of the French meteorological network. The history of the French observations is briefly reviewed and the key dates are given below:

1856: first meteorological network, called *Le Verrier* network and dedicated to weather forecast, consisted of 24 stations covering the whole national territory with 3 observations per day. Le Verrier (1868) describes the evolution of this network. Three stations from this network are in the Mediterranean area: Avignon, Narbonne and Draguignan. Observations for 13 out of the 24 stations are published in the Daily Paris observatory bulletin from 1858 to 1878. Bulletins were imaged and Avignon pressure and temperature records are being digitized.

1865: new climate stations network with daily and sub-daily observations in primary schools made by teachers (Noël, 1995).

1878: creation of the first meteorological office called Bureau Central Météorologique. Most of the astronomic observatories started to record sub-daily or daily meteorological observations (pressure, temperature and precipitation) at the end of the 19th century in Bordeaux (1880), Marseille-Longchamp, (1866), Toulouse-Jolimont (1838), Lyon-StGenis (1879), Nice (1881), Parc Saint-Maur, Perpignan (1882).

The network at national scale was based on these observatories and the data of these observatories were published in the Meteorological yearbooks known as Annales du Bureau Central Météorologique between 1878 and 1914. Most of them are available on the internet via the NOAA Central Library Foreign Climate Data (http://docs.lib.noaa.govrescue/data_rescue_home.html. Pressure, temperature and rainfall data for France printed in these annals were digitized and recently inserted in the French climatological database. Observatories records are remarkable and invaluable because of their length and quality. Marseille observatory have published the daily data in "*bulletins de la commission météorologique des*

Bouches-du-Rhône” since 1866 without any break. Handwritten manuscripts are stored in the observatory archives or departmental archives. Toulouse and Nice data are published in observatory annals, available on the internet on web-sites dedicated to astronomy.

In the framework of the national DARE program, Météo-France initiated the process of collecting the observatories time series from different institutions (universities) and documentary sources. In the last years, thanks to extensive digitization performed within the national project, the data-set of sub-daily temperature and pressure secular records was updated and greatly improved between 1878 and 1920.

1920: the new meteorological office, named “Office National de la Météorologie“(ONM) was created in 1920 with a new synoptic network composed of 17 stations in 1921. Observations are published in *Bulletins mensuels de l’Office National de la Météorologie.* New synoptic stations were gradually created at airports and astronomic observatories, and they no longer belonged to the national network.

1940-1942: the meteorological network in France was partially destroyed and disorganized with one network in the occupied France and managed by the German met office (Reichswetterdienst) and the other in free France managed by the French met office (ONM) with 4 principal stations in free France (Marignane, Toulouse, Clermont-Ferrand and Lyon, according to Fierro (1991)).

1943-1944: until the mid 1944, the French meteorological network was managed by the German meteorological office. Several years ago, the German met office (DeutscherWetterdienst) recovered monthly tables of 25 French climate stations with 3 observations per day during the period 1940-1944 and recently supplied the manuscripts to Météo-France.

1945: after the Second World War, a new meteorological office was created known as *Météorologie Nationale.* The new synoptic network reached 100 stations located mainly at airports.

Long Time-Series Identified for the MEDARE Data Portal

Mediterranean climate

In France, the Mediterranean climate occupies the South-Eastern part: from Perpignan to Nice with the highest mean annual maximum temperature greater than 20°C (figure 1)

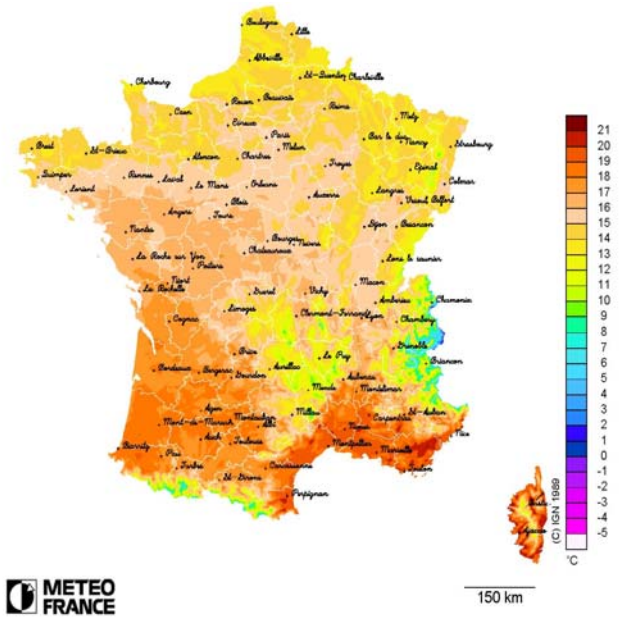


Figure 1: *Mean annual maximum temperature (1970-2000).*

Météo-France meteorological stations network

Météo-France current network of synoptic and climate stations can be freely viewed on the climatheque web-site: http://climatheque.meteo.fr/aide/climatheque/reseauPostes/ and time series availability are offered on http://climatheque.meteo.fr/okapi/accueil/okapiWebClim/index.jsp.

Selection procedure

We have followed the procedures described by Brunet et al (2006) for the development of the Spanish Daily Adjusted Temperature Series in order to create the dataset. The rationale for selecting the network was based on various criteria, including those French stations within the Mediterranean climate, temporal and spatial coverage, long-term continuity of data and data quality.

Synoptic stations with the longest, continuous and most reliable records longer than 50 years were chosen. Stations had to belong to the synoptic network, they have to be in use now and in the foreseeable future and had to be well-spaced in the Mediterranean climate area. We rejected the semaphore stations due to bad representativeness of the location for these stations. The series had to be longer than 50 years without relocation. At last, the choice was guided by the catalog of long-term monthly homogenized temperature series. Homogenization is carried out by using the Caussinus and Mestre (2004) technique. Homogenization of Toulouse (1878-2000) and Perpignan (1872-2000) monthly temperature series is described in Mestre (2000).

Meteo-France efforts in data rescue and homogenization of long climatological series enabled the construction of a French monthly homogenized temperature (minimum and maximum) database for the 20th century. Homogenization using the Caussinus-Mestre (2004) technique was undertaken. The location map of these homogenized long series in South France is shown in Figure 2.

Key stations in the Mediterranean climate area with air pressure, temperature and precipitation series longer than 50 years without any relocation since 1949 were selected.

According to these principles, 4 stations were selected: Marignane Airport, Montpellier Airport, Nice Airport and Perpignan Airport.

We also selected to add Toulouse station to the dataset, although the station is not in the Mediterranean climate area. Toulouse, located in the Garonne Bassin, is under both Mediterranean and oceanic influences for temperature and precipitation respectively. Toulouse is in the MEDARE great Mediterranean domain in the South-West of France, not far from Spain (around 100km) and has long-term, high quality and reliable climate series.

Figure 2: *Location map of the French homogenized secular temperature series for the 20th century (Moisselin et al., 2002).*

In order to extend back in time the records prior to 1880, we proceeded to merge the records registered in observatories or schools with those observations taken in the nearest airports. One problem is that most of observatories were built at the top of a hill in sub-urban or countryside area for better astronomical observations, when airports are situated on the plain. Figure 3 illustrates the situation of the Nice Observatory, which is located far away from the sea. Another problem is school series have numerous gaps in summer.

Table 1: The selected French network for MEDARE. Station codes, city and station names, geographical coordinates

Météo-France Codes	WMO CODE	LOCATION	STATION NAME	LAT	LON
13054001	7650	Marignane	Marignane Aéroport	43.441	4,65
34154001	7643	Montpellier	Mauguio Aéroport	43.577	3,40
06088001	7690	Nice	Aéroport	43.649	6,17
66136001	7747	Perpignan	Aérodrome	42.737	3,75
31069001	7630	Toulouse	Blagnac Aéroport	43,62	1,38

Table 2: The selected French network. Local code, station name, altitude, length of daily temperature records and length of sub-daily air pressure records

Météo-France code	STATION NAME	ALT (m)	DAILY TEMPERATUR E LENGTH	SUB-DAILY PRESSURE LENGTH
13054001	Marignane	5	1921-1943/12 1945/09-2010	1947-2010
34154001	Montpellier Mauguio Airport	2	1946 -2010/12	1946-2010
34172001	Montpellier Domaine de l'air	81	1924-1942/11	_
6088001	Nice Airport	2	1942/07 - 2010	1942/07-2010
66136001	Perpignan aéroport	42	1924/11-1942/11 1944/01-1944/06 1945/02- 2010	1949/01-2010
66136003	Perpignan Observatoire	30	1884/01-1932/04	1885/01-1914/12 1921/08-1924/10
31069001	Toulouse Aéroport Blagnac	151	1947/01-2010	1947/01-2010
31157001	Toulouse Francazal	164	1922/07-1943/06 1944/12-2010	1922/07-1943/06 1944/12-2010
31555016	Toulouse Observatoire Jolimont	195	1878-1923	1878-1923

The lengths indicated in Table 2 correspond to data availability in the French climatological database in 2010.

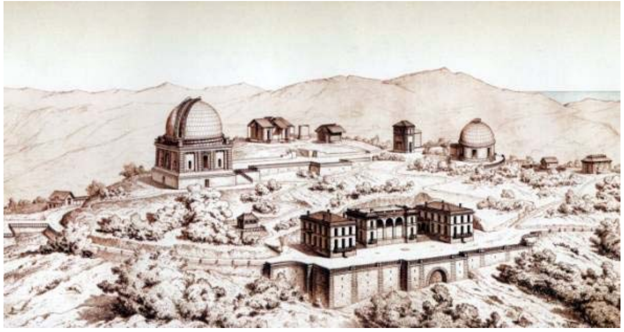


Figure 3: *Nice Mont-Gros observatory (end of the 19th century).*

Perpignan and Toulouse daily temperature records can be extended back in time to the end of the 19th century by using other climate-related observatory series. Unfortunately the French stations with the longest and reliable series are situated in big cities and, therefore, affected by the urban development.

We want to highlight that the number and the times of the hourly observations have changed in meteorological professional stations across the 20th century. Prior to 1949 observations were registered 3 times a day (7, 13, 18 UTC), but after 1949 observations in synoptic stations were registered 8 times per day and observations are stored on hourly scale in the database from 1993 onwards.

DATA AND METADATA SOURCES FOR NICE

The development of high quality and long-term datasets constitutes a multitask activity, which includes data location, recovery of the records, digitization, quality check and homogenization.

Météo-France undertakes exhaustive searches in the meteorological sources held in local, national archives and libraries.

For the recovery of the Nice climate data, several meteorological sources were visited and inventoried:

the Cessole library of the Masséna museum, the Météo-France departmental station archives and Nice observatory archives. Municipal archives were not visited, but the visit is expected to be made in 2011. Meteorological observations in Nice began in the 18th century, following the details given next:

- Daily data from 1763 to 1765 for Nice was located in the Cessole library. The data is kept in written letters by Doctor Smollett (1763-1765).
- Nice 1849-1878: This is the first long series with a length of thirty years. The observations were made by M. Teysseire in Nice with thermometers hanging from a window 16 meter above the soil. Monthly data are kept in books written by Teysseire (1872 and 1881) located in the Cessole library. Metadata and monthly data were recovered and imaged.
- Nice military hospital 1864-1880: Monthly rainfall were digitized and inserted in the climatological database. Meteorological bulletins from military hospital are stored in the Cessore library from December 1864 to March 1865 but military hospital daily data from March 1865 onwards have not been located.
- Nice primary school 1865-1924: Monthly rainfall data were digitized but daily data were not located and, then, not digitized. The records of this station are very useful to lengthen Nice airport series and should be recovered:
- Nice Mont-Gros observatory 1884-1935: The complete series of original manuscripts are archived in the Nice observatory archives. Monthly climatic tables from 1914 to 1935 are stored at Météo-France and data from October to December 1914 are printed in "Annales du Bureau Central Météorologique". Data and metadata were published in observatory annals too and were digitized from these sources. Unfortunately it is not possible to merge these records with the airport records because of the altitude of the observatory (347m)
- Nice Masséna 1928-1942: villa Masséna, today Masséna Museum, situated at Promenade des Anglais, in the city, not far from the airport. Data were partially recovered from this Météo-France station for the period between 1928 and 1938. The inventory shows gaps in 1935 and 1937. Nice city printed specific meteorological monthly bulletins from 1928 to 1931. Then observations were published in annals "Annales de l'office météorologique de la ville de Nice" from 1932 to 1938. Annals for the 2 years 1932 and 1933 were recovered and digitized. The other annals are located in the Nice municipal library but have not yet been recovered.
- Nice airport from July 1942: Nice Airport daily and sub-daily data are stored in the national database from 1942/07 onwards. Nice airport is situated on the coast at low level very near the city. Data from 5 different sites around the airport were compiled from July 1942 to April 1946.

CONCLUSIONS:

In the last years, the situation has improved with a big effort of data searching, inventorying and digitizing, although most of French data are still on paper form. The example of the Nice's records illustrates the fact that France has a wealthy heritage of meteorological observations, but big parts of the data are not yet recovered. The development of reliable long series in the French Mediterranean basin is impossible without taking into account the contribution of local meteorologists and the collaboration with local holders.

Consistence and Management of Italian Climatic Archives. Future developments

Col. Tiziano Colombo (PhD) and Maj. Gianpaolo Mordacchini (PhD)
CNMCA, Pomezia, Italy

The Climatology Department of the Italian Air Force Met Service belongs to the *Centro Nazionale di Meteorologia e Climatologia Aeronautica* (CNMCA), which is located in the military airport of Pratica di Mare, near Rome, website http://clima.meteoam.it. The Department is organized into three divisions: electronic archive, paper documentation and dynamic climatology. In this report we concisely describe the main activities and the future projects inherent to the first two divisions, particularly those concerned with the data rescue (DARE) of historical data.

Currently data collection is performed using 84 manned weather stations (observatories), about 100 automatic stations (data collection platforms), and 6 upper air stations (rawinsondes), (Figure. 1). The network has not changed significantly throughout its history of almost one century.

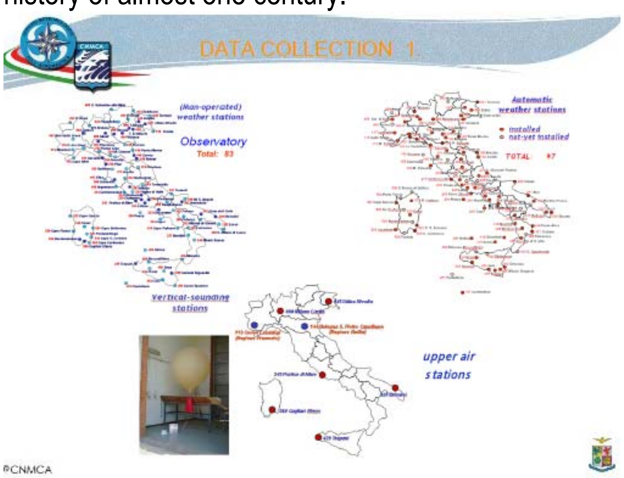


Figure 1: The Italian meteorological network

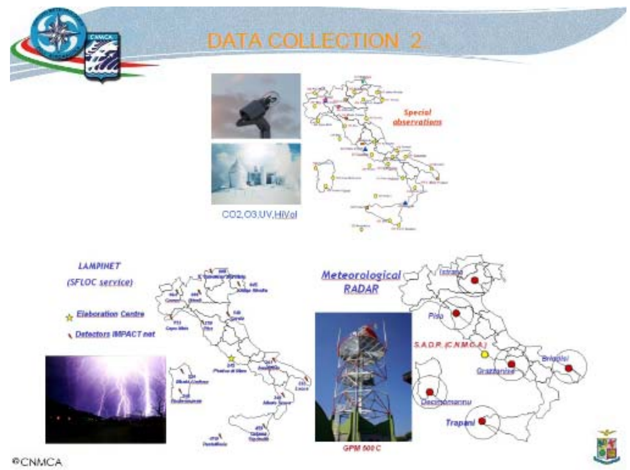


Figure 2: Complementary Italian meteorological network

Besides ordinary measurements and messages' production (SYNOP, SYREP, CLIMAT, METAR, TEMP), the Italian Air Force network includes also a number of observatories devoted to special measurements (e.g. Mount Cimone), particularly CO_2, O_3, UV radiation etc., a special system for electrical discharges detection and some meteorological radar sites, see Figure. 2. A new manual/automatic network (standard weather stations) is currently being installed and will provide measurements at intervals of the order of minutes independently of the message emission.

All the daily-produced messages are continuously conveyed to CNMCA, feeding a 60 year-long electronic archive. The current effort aims at integrating the archive together with all the basic quality control (QC) procedures, concerning the message comparison and the temporal and spatial consistence, in a unique web-like system (named *Epimeteo*, see Figure. 3), including the main homogenization procedures, the automatic calculation of statistics and some relevant climatic and agro-meteorological indices.

Figure 3: The Epimeteo archive on-line system

Apart from the usual data services, several climate applications have been realized using the electronic archive. In particular, two climate atlases have been prepared. The first is a climatological atlas that contains a variety of meteorological parameters, both direct and indirect, in table and graphical formats, and has been developed using evidence from 71 weather stations on the basis of the secondary CLINO 1971-2000 system. The other (named *Baracca* from the name of a famous First World War Italian pilot) is devoted to aeronautical applications, and deals with various types of statistics and developments from METARs relevant to flight on several Italian airports.

Other uses of the archive include various climatic studies, as for example the validation of ICTP regional climate model for extreme phenomena. Among the techniques currently employed in the elaborations there are some useful non-linear analysis tools, such as singular spectrum analysis, wavelet analysis and neural networks. These more sophisticated data analysis tests are performed using MatLab tools (Figure. 4).

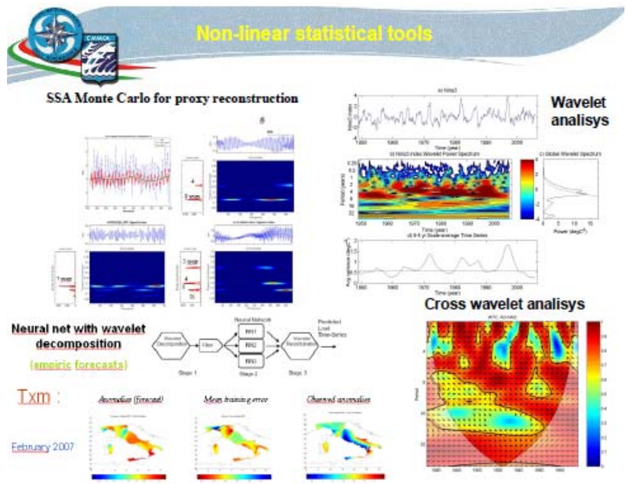


Figure 4: Non-linear analysis tools available at the Italian Meteorological Service

In the IT infrastructure renewal particular attention was given in metadata station analysis. For this reason a relational data base (DB) has been created in order to reconstruct and compare the histories of the stations, assess their suitability for climatological purposes (e.g. to identify and correct the spurious inhomogeneities within the time series) and for operational purposes (Figure. 5). The DB population with the historical metadata has still to be completed.

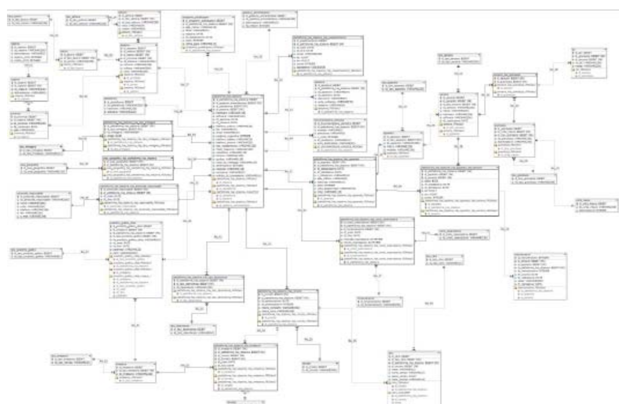


Figure 5: Details of the relational metadata base infrastructure at the Italian Meteorological Service

Today, the electronic archive contains many Italian observation collections starting from 1950/55. We are now working to retrieve and insert additional data from as early as 1920/1925 through information provided by NOAA and the direct digitizing from the meteorological models contained into the paper archive. Similar work has already led to the filling of many gaps in several time series and will probably be repeated after the general inventory, planned at the beginning of 2011. Indeed, our DARE activities are currently committed to restructuring of a new air-conditioned building where all the paper material and the microfilms will be transferred, catalogued and made safe. For the paper-based and historically significant material a protective treatment in vacuum chamber will be performed before transfer.

In the historical archives some other meteorological observations over the Mediterranean area, for example from Libya and Rhodes are present. For the colony's papers documentation (including Somalia, Eritrea and Ethiopia) the total number of weather stations present in the archive is about 84 for observation periods ranging from 1879 to 1960. The actual coverage, however, does not correspond to the actual Italian colonization period; indeed, in 1879 more strict commercial relationships with Libya and Eritrea were embarked upon. Inevitably the periods of observations are not continuous, and vary from station to station. Nevertheless the archive contains, for some stations, for example Tripoli, periods of 30 years of data, and for many stations, clusters of 10 years of data. With regard to data formats, there are several types available from the synoptic meteorological codes (Figure. 6), to the decoded tables of measurements (Figure. 7). Several volumes of printed daily tables are also present, in which can be found all the available and reliable measurements from the African colonies of one year or longer.

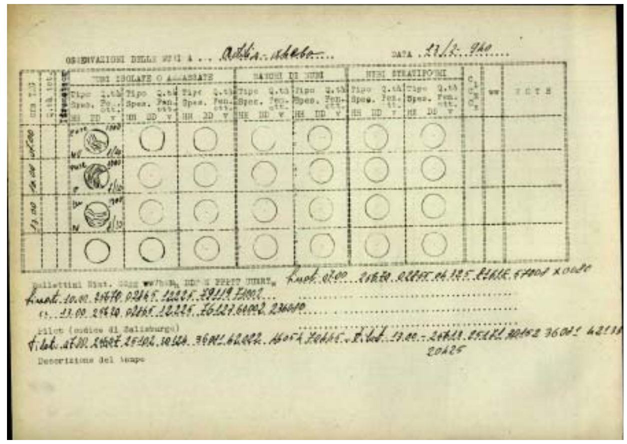


Figure 6: Example of data formats from the synoptic meteorological codes

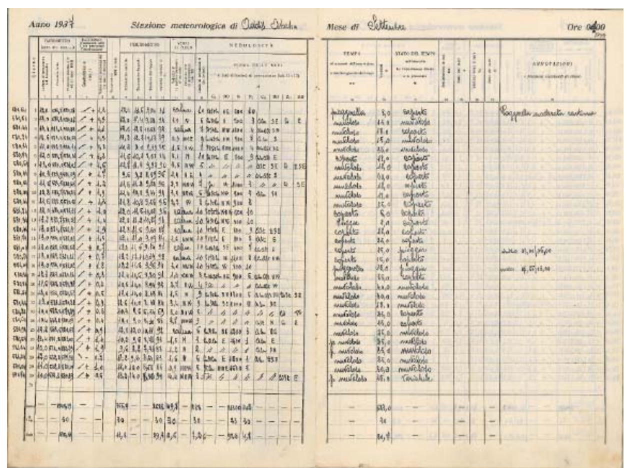
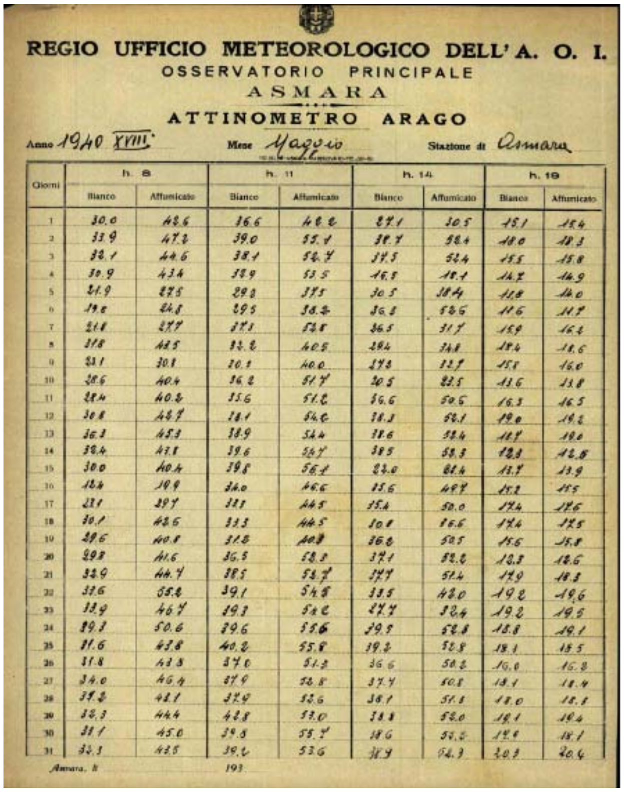


Figure 7: Example of data format from the decoded tables of measurements

The observation types range from ordinary measurements, roughly corresponding to our present-day synoptic observations, to some special observations, such as solar radiation, evapotranspiration, etc. These special observations have different table formats, depending on the particular measurement type (Figure. 8 for the observation table related to an old but very accurate Arago actinometer).



REGIO UFFICIO METEOROLOGICO DELL'A. O. I.
OSSERVATORIO PRINCIPALE
ASMARA
ATTINOMETRO ARAGO

Anno 1940 XVIII · Mese Maggio · Stazione di Asmara

Giorni	h. 8 Bianco	h. 8 Affumicato	h. 11 Bianco	h. 11 Affumicato	h. 14 Bianco	h. 14 Affumicato	h. 16 Bianco	h. 16 Affumicato
1	30.0	42.6	36.6	48.2	27.1	30.5	15.1	15.4
2	33.9	47.2	39.0	55.1	38.7	58.4	18.0	18.3
3	32.1	44.6	38.1	52.7	37.5	52.4	15.5	15.8
4	30.9	43.4	38.9	53.5	46.5	48.1	14.7	14.9
5	21.9	27.5	29.2	37.5	30.5	38.4	11.8	14.0
6	19.8	24.8	29.5	38.2	36.8	58.6	11.6	11.7
7	21.8	27.7	37.3	52.8	36.5	31.7	15.9	16.2
8	31.8	43.5	32.2	40.5	28.4	34.8	18.4	18.6
9	23.1	30.8	20.3	40.0	27.3	32.7	15.8	16.0
10	28.6	40.4	36.2	51.7	20.5	22.5	13.6	13.8
11	28.4	40.2	35.6	51.2	36.6	50.5	16.3	16.5
12	30.8	42.7	38.1	54.6	38.3	52.1	19.0	19.2
13	36.3	45.3	38.9	54.4	38.6	52.4	18.7	19.0
14	38.4	47.8	39.6	56.7	38.5	58.3	12.3	12.8
15	30.0	40.4	39.8	56.1	22.0	28.4	13.7	13.9
16	12.4	19.9	34.0	46.6	35.6	49.7	15.2	15.5
17	23.1	29.7	33.3	44.5	15.4	50.0	17.4	17.6
18	30.1	42.6	33.3	44.5	30.8	16.6	17.4	17.5
19	29.6	40.8	31.8	40.8	36.8	50.5	15.6	15.8
20	29.2	41.6	36.5	52.3	37.1	52.2	12.3	12.6
21	32.9	44.7	38.5	52.7	37.7	51.4	17.9	18.3
22	37.6	55.2	39.1	54.8	33.5	42.0	19.2	19.6
23	33.9	46.7	39.3	54.2	27.7	32.4	19.2	19.5
24	39.3	50.6	39.6	55.6	39.5	52.8	18.8	19.1
25	31.6	43.8	40.2	55.8	39.2	52.8	18.1	18.5
26	31.8	43.3	37.0	51.3	36.6	50.2	16.0	16.2
27	34.0	46.4	37.9	52.8	37.4	50.8	18.1	18.4
28	37.2	42.1	37.9	52.6	38.1	51.8	18.0	18.1
29	32.3	44.4	42.8	53.0	38.8	52.0	18.1	18.4
30	31.1	45.0	39.3	55.7	38.6	53.2	17.9	18.1
31	32.3	43.5	39.2	53.6	38.9	54.3	20.3	20.4

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Figure 8: Example of the observation table from an accurate Arago actinometer

With regard to the present and future DARE developments, we have already started a project to obtain a scanned copy of large volume of African station models, storing them in pdf format. At the moment almost 50 % of the work, consisting of a scan of over 23,000 forms, has been completed thanks to three subsequent public tenders secured from 2007 to 2009 with the Italian Civilian Protection sponsorship. This activity consisted of scanning of about 90,000 weather-maps before 1964 over the central Mediterranean scenario, starting from paper and microfilm support, and of about 70,000 instrumental diagrams, from thermohygrometers, anemometers, rain gauges, and barographs. In addition, we plan to participate to the Climate Data Modernization Program (CDMP): this allows us to send to NOAA the pdf files in order to complete the digitization. All data will be freely available at the end of the work to the whole scientific community on the NCDC website.

The full digitization of the observation records starting from instrumental diagram (stripes) was studied in detail but it has been considered too expensive in relation to the present fund arrangements. For this type of material only the completion of activities of cataloguing and scanning is planned for the coming years.

Currently the Climatology Department of the CNMCA is engaged in a deep IT infrastructure renewal, ranging from the public website (that allows the dissemination and the marketing of the data) to the DB's expansion and enhancement (station data/metadata, other meteorological networks, other products and so on) and the related operational tools for climatological QC, statistics, indices, etc. Importance is also attached to the metadata station DB, useful mainly in homogeneity studies. In parallel an intensive DARE programme has been pursued thanks to the help of the Italian Civilian Protection and the NOAA/NCDC, to whom we express our deepest gratitude. Colonial historical data will be soon freely available on the NCDC website. We expect Italian data to accord to a common MEDARE definition and data policy and related license of use.

Inventory of Climate Metadata for Selected Synoptic Stations of the National Institute of Meteorology and Hydrology in Bulgaria

Tania Marinova and Anelia Gocheva
National Institute of Meteorology and Hydrology – BAS – Blvd. Tsarigradsko shose 66, Sofia 1784, Bulgaria

INTRODUCTION:

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 country territory. The number of stations continued to increase gradually but in the nineties many meteorological and precipitation stations were closed due to the lack of sufficient financial recourses and this situation continues at present.

For the time being the meteorological network of the National Institute of Meteorology and Hydrology at the Bulgarian Academy of Sciences (NIMH–BAS) is composed of 42 synoptic (8 synoptic and 3 climatic observations per day), 87 climatological (3 climatic observations per day) and 244 precipitation stations (1 observation per day). This network is shown in Figure 1.

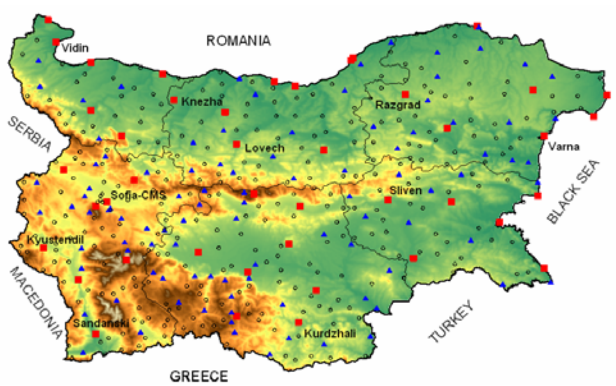


Figure 1: Meteorological network of the NIMH in Bulgaria: synoptic (squares), climatological (triangles) and precipitation (circles) stations

The climate data records in paper form are stored in the Meteorological Archive of the NIMH–BAS from the beginning of their respective measurements. All available digitized climate data is imported and stored into the Meteorological database (MDB) of the NIMH–BAS.

Climate metadata inventory includes observational history of the stations (stations metadata) as well as variables metadata. In order to prepare metadata about different meteorological elements, an inventory of both paper records and digitized climate data series in the MDB has to be completed.

On paper form, the results of climate metadata inventory for 10 selected synoptic stations from the meteorological network of the NIMH–BAS, representative for the basic climatic districts in the country, are presented.

SELECTION OF REPRESENTATIVE METEOROLOGICAL STATIONS FOR THE CLIMATIC DISTRICTS OF BULGARIA

The adopted division into climatic districts of Bulgaria (*L. Subev, S.Stanev, 1959*) is carried out in a way allowing its connection with the genetic climatic classification of Europe (by *B. P. Alisov*) and reveals practically more significant climatic peculiarities over the country. The basic division is implemented following first the climatic division of the continent and further in conformity with more considerable climatic features over larger climatic units. Thus the territory of Bulgaria is divided into 2 climatic districts, 4 sub-districts and 25 regions.

The climatic districts are determined according to the peculiarities of the atmospheric circulation over the country and the corresponding precipitation regime – with summer maximum in the *European-Continental* district and winter maximum in the *Continental-Mediterranean* one.

The determination of the sub-districts (*Moderate-Continental, Transition-Continental, South-Bulgarian and Black-Sea*) is connected with the gradualness of the transition and the entering of some typical climatic peculiarities of one of the districts into the other. The climatic regions are differentiated in accordance with differences in the precipitation amount and air temperature characteristics in different regions of the climatic sub-districts. Naturally, the local physical-geographical conditions reinforce or reduce one or another climate peculiarity.

Since differences in the regime of atmospheric circulation (from north to south) can be regarded, influencing lowlands and adjacent mountains in different ways. At the same time, remarkable climatic differences can be seen due to differences in altitude. Due to that a *Mountain Climatic Region* is established, encompassing locations at higher elevations than 1000 m (Fig. 2).

Ten synoptic stations from the meteorological network of the NIMH – *Vidin, Knezha, Lovech, Razgrad, Sofia, Kyustendil, Sliven, Sandanski, Kurdzhali and Varna* (marked on the maps on Fig. 1 and Fig. 2) have been selected. They conform about 25% of the number of acting synoptic stations in Bulgaria, which likely represent the most complete set of eight hourly meteorological measurements per day. At the same time, they are almost uniformly distributed over the country's territory). Seven of them (*Vidin, Knezha, Lovech, Razgrad, Sofia, Kyustendil, Sliven*) are situated in the *European-Continental* district and three of them (*Sandanski, Kurdzhali, Varna*) in the *Continental-Mediterranean* district. This stations distribution is approximately proportional to the territorial extension of both climatic districts.

The stations *Vidin, Knezha, Lovech, Razgrad* and *Sofia* represent the *Moderate-Continental* district; the stations *Kyustendil and Sliven* to the *Transition-Continental* district; the stations *Sandanski* and *Kurdzhali* to the *South-Bulgarian* district; and *Varna* represent the *Black-Sea* climatic sub-district. The selection of these stations is also proportional to the territorial extent of the different climatic sub-districts.

The ten selected meteorological stations represent the different climatic peculiarities of Bulgaria: the most-northern (*Vidin*), southern (*Sandanski*), western (*Sofia, Kyustendil*) and eastern (*Varna*) regions, as well as inside North (*Knezha, Lovech, Razgrad*) and South (*Kurdzhali, Sliven*) Bulgaria.

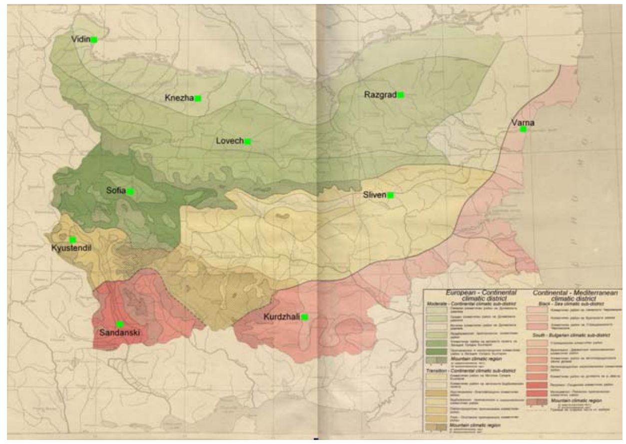


Figure 2: Climatic division into districts in Bulgaria showing the 10 representative stations selected.

The Central Meteorological Station (CMS) in *Sofia* (more than 2 millions of citizens) and to some extent the station in *Varna* (more than 500 thousands inhabitants and up to 1 million and more in summer) can be considered as representative stations for the typical microclimate of the big cities. *Knezha* and *Kyustendil* (in hollow) represent the specific microclimate of concave terrain and the stations *Vidin* and *Varna* are typical for water bodies microclimatic conditions to being located along the *Danube River* and *Black Sea Coast.*

Metadata Inventory for 10 Selected Synoptic Stations on the Territory of Bulgaria

Climate metadata inventory includes basic metadata about observational history of the selected synoptic stations and different meteorological variables (air temperature, precipitation, atmospheric pressure, relative humidity, cloud cover, wind direction and speed, duration of sunshine).

Stations metadata inventory

Basic metadata about the stations (station name, WMO code, geographical location and opening date) is presented in Table 1.

Table 1. Metadata of the 10 selected synoptic stations in Bulgaria

Station name	WMO code	Latitude	Longitude	Altitude (m)	Starting date
Vidin	15502	43.9942 N	22.8526 E	31	01.10.1907
Knezha	15520	43.4800 N	24.0696 E	117	01.01.1910
Lovech	15525	43.1633 N	24.7007 E	220	01.06.1937
Razgrad	15549	43.5662 N	26.5079 E	346	01.01.1946
Varna	15552	43.2125 N	27.9525 E	39	01.01.1959
Sliven	15640	42.6777 N	26.3399 E	259	01.01.1892
Kurdzhali	15730	41.6468 N	25.3853 E	337	16.10.1929
Sandanski	15712	41.5501 N	23.2674 E	206	01.05.1930
Kyustendil	15601	42.2838 N	22.7131 E	520	01.01.1892
Sofia-CMS	15614	42.6553 N	23.3847 E	586	01.02.1952

Detailed information about location of the stations, surrounding area, etc., is given below:

Synoptic station Vidin

Land use: Hilly-flat terrain. The town of Vidin is situated to the east of the station at 1 km distance and the Danube river flows northeast at 3 km distance from the city. To the west of the station, at 150–180 m distance, there is a building of 6 m height. The administration building (height 6 m) is situated to the north at about 100 m distance from the station. The park "Nora Pizanty" is in the vicinity of the meteorological park in the west and north.

Soil type: Leached chernozems
Surface coverage: Grass

Synoptic station Knezha

Land use: The station is situated between the Iskar valley and the Skat valley. Hilly-flat relief. The river Danube is at a distance of about 22 km in the north. The greenhouse (measurements 13 x 13 x 3 m) is situated at a distance of about 50 m. The laboratory building (measurements 50 x 8 x 12 m) is behind the greenhouse. Agricultural lands are near the meteorological park over the east and north sides.

Soil type: Typical chernozem
Surface coverage: Grass

Synoptic station Lovech

Land use: Hilly-flat relief. The town of Lovech is situated in North Bulgaria between the Balkan Mountains and the Danube lowland. The Osum River flows through the town. The meteorological station is located in the northwest side of the town (1.5 km from town centre). The administration building (measurements 14 x 11 x 6 m) is at a distance of 12.5 m to the east of the station.

Soil type: Grey forest soils
Surface coverage: Grass

Synoptic station Razgrad

Land use: Hilly-flat relief. The town of Razgrad is situated in North Bulgaria. Agricultural lands are surrounding the meteorological garden towards east and south. The building of the Agricultural school (height between 8 and 10 m) is situated south at a distance of about 80 m from the observing site.

Soil type: Typical chernozems
Surface coverage: Grass

Synoptic station Varna

Land use: Flat and open terrain. The town of Varna is situated on the Black Sea Coast. The meteorological station is located in the park "St. Nikola". The surrounding buildings are sparse (heights around 10–12 m). The Sea Garden of Varna town is at a distance of about 1 km southwest from the station. The residential district "Chayka", built up with high block of flats, is located about 300–400 m far away of the station in the north side.

Soil type: Calcareous chernozems
Surface coverage: Grass

Synoptic station Sliven

Land use: The town of Sliven is situated in East Bulgaria in Sliven valley close to the southern foot of the Balkan Mountains. The meteorological station is located in the north-eastern part of the town, in the vicinity of the Sports Centre. The meteorological park (measurements 14 x 16 m) is arranged on a artificially made place to be higher than the surrounding area. The building of Hydrometeorological Observatory is at a distance of about 20 m to the east where the terrain is lower. In the north side of the station, in a distance of 200 m, there is the public stadium. In the same direction in a distance of 250 m there is a residential area conformed by blocks of flats. The Technical School is at a distance of 300 m to the south. The observation site is open and representative.

Soil type: Leached grey forest soils
Surface coverage: Grass

Synoptic station Kurdzhali

Land use: The town of Kardzhali is situated in South Bulgaria in the area of East Rhodope Mountains on both sides of the Arda River, showing a hilly and broken terrain. The meteorological station is located in the north-western part of the town at 1.5 km distance from the Arda river. The meteorological park is arranged at a distance of 100 m from the administrative building. The terrain is inclined to the south-southeast. The place is open and representative.

Soil type: Eroded leached cinnamonic forest soils
Surface coverage: Grass

Synoptic station Sandanski

Land use: The town of Sandanski is situated in South-west Bulgaria in Sandanski valley at the foot of the Pirin Mountains. The Struma river flows at a distance of about 2 km to the west. The valley topography is strongly broken, but around the river Struma it is flat. Sandanski valley is surrounded by high mountains (Pirin, Belasitsa, Ograjden and Ali Botush). The meteorological station is located at a distance of about 2.5 km from the centre of the town, in the vicinity of the experimental agricultural station for cultivation of southern crops. There are hothouses at a distance of about 25 m and a forest shelter belt (acacia) at a distance of about 100 m to the west. There are single fruit-trees (height 3 m) at a distance of 30 m to the south, a penthouse (height 4 m) at a distance of 15 m to the north, acacia and fruit-trees and other low buildings at a distance of 35 m to the east below the level of the station. The river Sandanska Bistritsa flows at a distance of 800 m toward the south-east direction of the station.

Soil type: Leached cinnamonic forest soils
Surface coverage: Grass

Synoptic station Kyustendil

Land use: The town of Kyustendil is situated in the Kyustendil valley in the south-western part of Bulgaria. The Osogovo Mountains are situated in the south-west of the town. The meteorological station is located in the eastern part of the town. The administration building (height 10 m) is located at a distance of about 60–70 m in the east side.

Soil type: Leached cinnamonic forest soils
Surface coverage: Grass

Synoptic station Sofia-CMS

Land use: Sofia is situated in Sofia valley which is surrounded by Vitosha Mountain, the Balkan Mountains and other lower mountains and hills. The meteorological station is located in the vicinity of NIMH–BAS in the eastern part of Sofia in the “Mladost”,residential district, where the buildings have different heights. The meteorological garden is located at a distance of about 50–60 m to the south of the NIMH buildings (height 10–15 m).

Soil type: Leached smolnitza
Surface coverage: Grass

Inventory of climate time series

Inventory of paper records in the Meteorological Archive of NIMH

A full inventory of the paper records stored in the Meteorological Archive of the NIMH–BAS was carried out in 2002, when all materials were moved into a new premise. Thanks to that the gaps in the long-term climate series could be fixed (for synoptic and climatological stations they are less than 5 %).

Inventory of digitized climate records in Meteorological database of NIMH

The main purpose of this inventory is to specify the available digitized data (starting date, interruption periods, real gaps). In this connection it should be noted that there are 2 cases of missing data in MDB, as follows:

Case 1. Missing data for whole years, months or particular days and times. In this case, the inventory is completed by a specially developed storeing procedure in MDB – it works on a particular period for a station and the final result of its execution is a report about missing rows.

Case 2. Missing data for some of the meteorological elements in particular row/rows in MDB.

In both cases some of the missing data are real gaps while the others for some reasons have not been digitized yet. In order to separate the real gaps: in *case 1* a database table was created where information about the real gaps (whole years, months or particular days, hours) in the climate data series to be imported (Table 2); *in case 2* different quality flags are used for the real gaps.

Table 2. Database table for missing observations

ST	YY	MM	DD	HH
Station_number	1959			
Sation_number	1972	2		
Station_number	1972	5	6	
Station_number	1972	12	15	21

The results of the inventory of climate data series for different meteorological elements are given in Table 3 (starting date for every variable and interruption periods).

It can be seen that there is a gap of about 6 year in sunshine duration measurements only at station Kyustendil. Also sunshine duration is not measured at the stations Lovech and Razgrad.

Table 3. Variables metadata for 10 selected synoptic stations in Bulgaria

Station / Meteorological element	*Vidin* 01.10.1907	*Knezha* 01.01.1926	*Lovech* 01.01.1952	*Razgrad* 01.01.1946	*Varna* 01.01.1959
Minimum air temperature	01.04.1910	01.01.1926	01.01.1952	01.01.1951	01.01.1959
Maximum air temperature	01.04.1910	01.01.1926	01.01.1952	01.01.1951	01.01.1959
Hourly air temperature	01.01.1910	01.01.1926	01.01.1952	01.01.1951	01.01.1959
Precipitation	01.01.1910	01.01.1926	01.01.1952	01.01.1951	01.01.1959
Atmospheric pressure	16.03.1953	07.09.1944	01.01.1955	01.09.1978	01.08.1984
Relative humidity	01.01.1910	01.01.1926	01.01.1952	01.01.1951	01.01.1959
Cloud cover	01.01.1910	01.01.1926	01.01.1952	01.01.1951	01.01.1959
Wind direction and speed	01.01.1910	01.01.1926	01.01.1952	01.01.1951	01.01.1959
Sunshine duration	01.05.1970	01.08.1942	NO	NO	01.03.1950
Station / Meteorological element	*Sliven* 01.01.1892	*Kurdzhali* 16.10.1929	*Sandanski* 01.01.1931	*Kyustendil* 01.01.1892	*Sofia-CMS* 01.02.1952
Minimum air temperature	01.01.1900	16.10.1929	01.01.1931	01.01.1906	01.02.1952
Maximum air temperature	01.01.1900	16.10.1929	01.01.1931	01.01.1906	01.02.1952
Hourly air temperature	01.01.1900	16.10.1929	01.01.1931	01.01.1906	01.02.1952
Precipitation	01.01.1900	16.10.1929	01.01.1931	01.01.1906	01.02.1952
Air pressure	01.01.1900	01.12.1956	01.01.1931	01.01.1906	01.10.1952
Relative humidity	01.01.1900	16.10.1929	01.01.1931	01.01.1906	01.02.1952
Cloud cover	01.01.1900	16.10.1929	01.01.1931	01.01.1906	01.02.1952
Wind direction and speed	01.01.1900	16.10.1929	01.01.1931	01.01.1906	09.05.1952
Sunshine duration	01.03.1975	01.01.1950	01.08.1950	01.03.1961–28.02.1962; 01.09.1968	01.06.1952

A summarized information on the proportion between digitized climate records and those available only in paper form for the selected stations is presented in Table 4, where the periods with digitized and non-digitized climate records at synoptic (00, 03, 06, 09, 12, 15, 18, 21 h UTC) and climatic (05, 12, 19 UTC) observing times are given. The inventory is separately made for synoptic and climatic observations, since there is not coincidence in the observing times between both kinds of stations, except only at 12 UTC).

Actually, the climate information for climatic stations is almost digitized, while for synoptic stations it is mainly for the period 2000–2010.

Table 4. Length of digitized and non-digitized climate records for 10 selected synoptic stations in Bulgaria

Synoptic station	*Time resolution of the records*	*Length of digitized records*	*Length of records available only in paper form*
Vidin	8 synoptic obs/day	07.1998 – 2010	1979 – 1998
	3 climatic obs/day	04.1910 – 2010	10.1907 – 1909
Knezha	8 synoptic obs/day	07.1998 – 2010	1954 – 1998
	3 climatic obs/day	01.1926 – 2010	–
Lovech	8 synoptic obs/day	07.1998 – 2010	1975 – 06.1998
	3 climatic obs/day	01.1952 – 2010	–
Razgrad	8 synoptic obs/day	06.1999 – 2010	1979 – 05.1999
	3 climatic obs/day	01.1951 – 2010	1946 – 1950
Varna	8 synoptic obs/day	04.1999 – 2010	1984 – 03.1999
	3 climatic obs/day	01.1959 – 2010	–
Sliven	8 synoptic obs/day	01.1997 – 2010	1957 – 1996
	3 climatic obs/day	01.1900 – 2010	1892 – 1899
Kurdzhali	8 synoptic obs/day	01.1997 – 2010	1959 – 1996
	3 climatic obs/day	10.1929 – 2010	–
Sandanski	8 synoptic obs/day	07.1998 – 2010	1950 – 06.1998
	3 climatic obs/day	01.1931 – 2010	–
Kyustendil	8 synoptic obs/day	07.1998 – 2010	1954 – 06.1998
	3 climatic obs/day	01.1906 – 2010	1892 – 1905
Sofia – CMS	8 synoptic obs/day	01.1992 – 2010	1960 – 1991
	3 climatic obs/day	02.1952 – 2010	–

CONCLUDING REMARKS

Ten synoptic stations from the meteorological network of the NIMH–BAS, representative of the different Bulgarian climatic districts, have been selected and the results of the work carried out for inventorying climate metadata about the observational history of the stations and the different measured meteorological variables have been presented. Almost all available hourly records in paper form at the climatic stations are digitized while at the synoptic stations only are digitized hourly observations for the last decade. Situation is similar for the rest of synoptic stations over the whole country.

As for the climatological stations (with observations only at the climatic observing times) available paper records are practically all digitized from the beginning of the respective measurements. Also significant part of the information from precipitation stations (one observation per day) is digitized (the whole period 1960–2010 for most of them and for some of the stations also the period 1950–1959). With respect to records of meteorological phenomena in paper form, they are only digitized for the last two decades. In order to digitize all available paper records from the meteorological stations in Bulgaria, additional human recourses have to be involved.

MEDARE Activities at the Macedonian Hydrometeorological Service

Silvana Stevkova
Hydrometeorological Service, Former Yugoslavian Republic of Macedonia

Introduction

The Republic of Macedonia is situated in the southeastern part of Europe, in the central part of Balkan Peninsula, approximately crossing the latitude of 42^{o} 50’ North and longitude of 22^{o} 00’ East. The total surface area of our country is 25,713 km^2 (Figure 1).

Although it is small in size, its relief is very diverse. The plain covers 19.1% of the total surface area, the mountain terrains represent 79%, and 1.9% belongs to water surfaces.

According to the topography aspect the Republic of Macedonia is a mountainous country. The forests cover more than one third of total territory of the country while the agricultural area covers 25%.

Different types of climate characterize the country: continental, changed continental, sub-Mediterranean (changed maritime), mountainous climate as well as their various subtypes.

Figure 1: FYR of Macedonia *g*eographical location

History of Hydrometeorological Activities

Hydrometeorological activities in our country have long and rich tradition. Meteorological measurements and observations on our territory were established in 1891 in Skopje and in 1896 in Bitola and lasted until 1899 and 1911.

During the World War I meteorological measurements and observations were performed for the military need at three measuring points of our territory (Bitola, Prilep and Udovo) under the supervision of the German army and three precipitation stations (Strumica, Kocani and Skopje) under the supervision of Bulgarian authorities. Measurements were performed on air temperature, wind, humidity, precipitation, air pressure, insolation etc. Also pilot balloon measurements have been done, which are a kind of contemporary upper air measurements and observations.

Historical records for Skopje for the period 1891-1899 had been published in Jahrbucher der k.k. Zentral-Amstalt fur Meteorologie und Erdtmagnetismus, Wien and for Bitola for the period 1896-1911 in Annales du Bureau Centrale Meteorologique de France, Paris.

The first organized meteorological measurements and observations in the Republic of Macedonia had been established in 1923, which were suspended at the beginning of World War II.

In 1947, the Hydrometeorological Office of the Federal People's Republic of Yugoslavia was founded and a new meteorological network was formed. In 1993, the Republic of Macedonia, as an independent country became a member of the WMO.

Meteorological Stations Network

The meteorological observing system consists of 14 main meteorological stations, 16 climatological stations, 160 precipitation stations, 4 automated weather stations (2 at the Airports), and 24 phenological stations (Figure 2).

The climatological data are archived in the Climatological database management system CLIDATA.

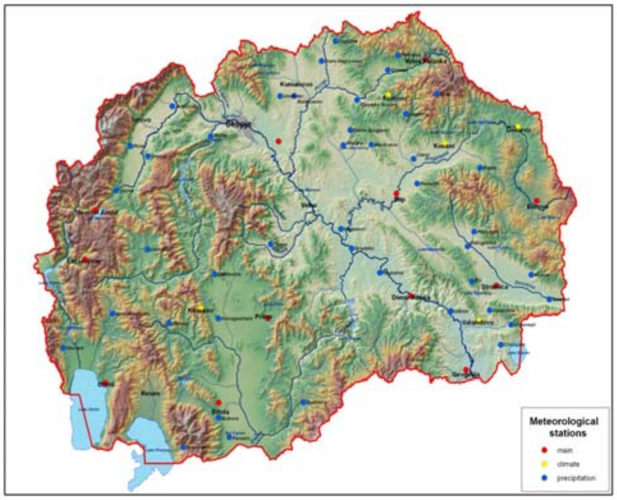


Figure 2: Macedonian meteorological network

STATIONS AND LONG TERM OBSERVATIONS

Referring to the climate data sources and key records for the Mediterranean Basin for the necessity of investigation on the relationship between large scale climate variability and regional variability of climate, observations from seven Meteorological Stations could be used together with the large scale analysis:

Selected locations represent different climatic types and subtypes affecting the climate of our territory, which are a combination of three major climate drivers that meet over our region:

- Mediterranean,
- Continental
- Mountain

According to the climate types proposed by Ristevski (Filipovski et al. 1996; Ristevski, 2006), defined mainly with regard to altitude, and according to the typical annual cycle of mean monthly air temperature and precipitation amount, six geographical regions of the Republic of Macedonia were treated separately in the analysis (Figure 3):

- South eastern part with *sub-Mediterranean* climate
- Central part with combined *sub-Mediterranean /continental* climate
- *Southern* part with *continental* climate;
- *South western* part with *continental* climate;
- *Eastern* part with *continental* climate;
- North-western part with prevailing *mountain /Alpine* climate

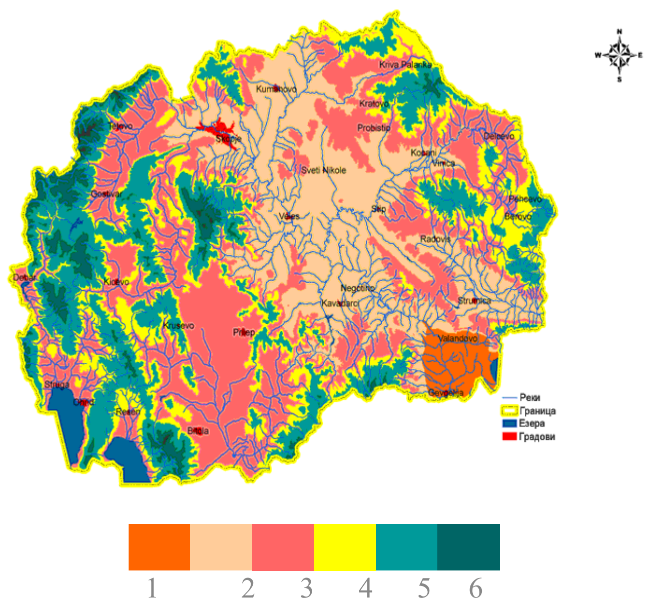


Figure 3: Climate types over the FYR of Macedonia

Referring to climate data sources and key records for Mediterranean Basin in support of an enhanced detection, prediction and adaptation to climate change and climate impacts, we have selected seven main meteorological stations, prepared metadata and station history and also measurement of meteorological elements and phenomena (Figure 4).

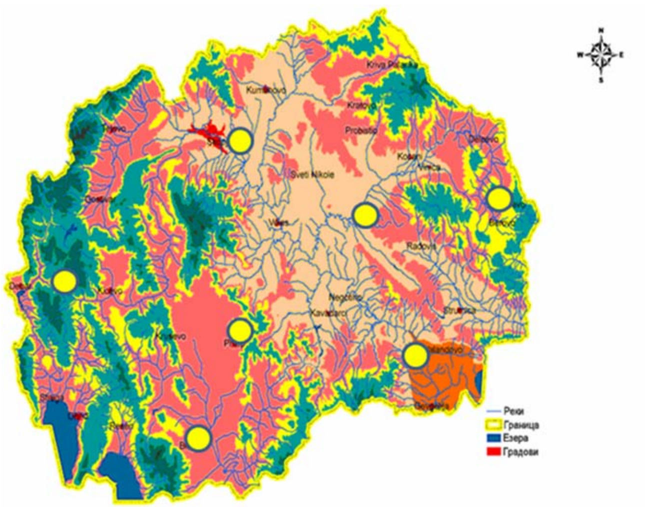


Figure 4: MEDARE provisional meteorological stations

The name and starting year of the selected stations are:

- Demir Kapija (1932)
- Stip (1926)
- Berovo (1925)
- Skopje – Petrovec (1924)
- Prilep (1923)
- Bitola (1927)
- Lazaropole (1948)

Hourly measurements and observations of all meteorological elements and phenomena are performed and recorded in observation reports at all main meteorological stations except at those stations which work 12 hours. Continuous measurements have been performed since 1947 at all these stations. Standard elements and phenomena are measured by basic classic instruments and their appropriate recording instruments at main meteorological stations. The observed variables are:

- Temperature
- Relative humidity
- Atmospheric pressure
- Wind direction and speed
- Precipitation quantity and intensity
- Sunshine duration
- Evaporation
- Soil temperature

According to the investigation of data from the selected meteorological stations we found a small percentage of missing daily data compared with the length of records, but the percentage of non-digitized data is larger (Figures 5, 6 and 7).

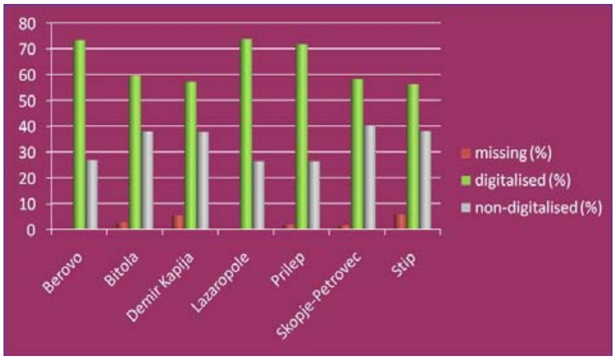


Figure 5: Percentage of missing (red columns), digitized (green) and non-digitized (grey) data for daily mean, maximum and minimum temperatures series

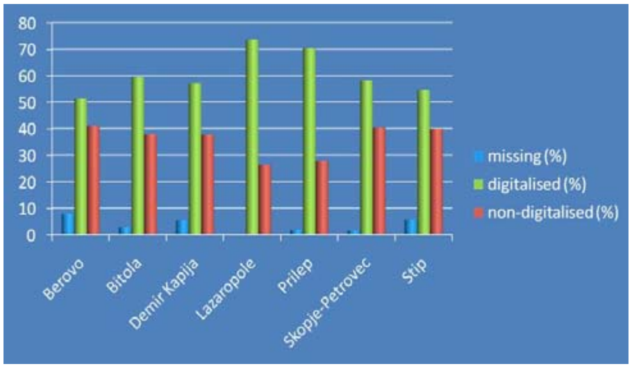


Figure 6: Percentage of missing (blue columns), digitized (green) and non-digitized (orange) data for daily precipitation series

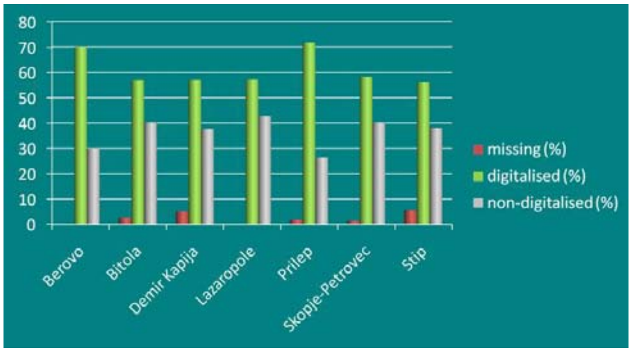


Figure 7: Histogram giving the percentages of missing (orange columns), digitized (green) and non-digitized (grey) data for daily air pressure series

The Hydrometeorological Service has data from a a long observational period (nearly ninety years) of precipitation records from Meteorological Stations Berovo, Bitola, Prilep, Skopje – Petrovec and Stip. The length of the temperature, precipitation and air pressure time-series is given in Figure 8.

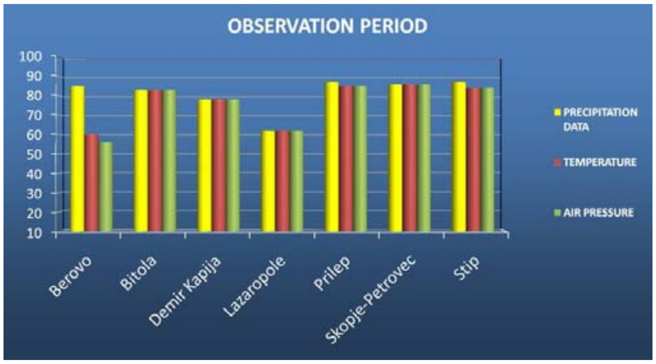
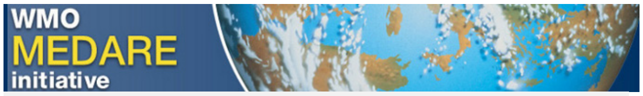


Figure 8: Histogram showing the length of historical daily temperature, precipitation and air pressure time-series (in years) selected for the MEDARE database

MEDARE METADATA BASE

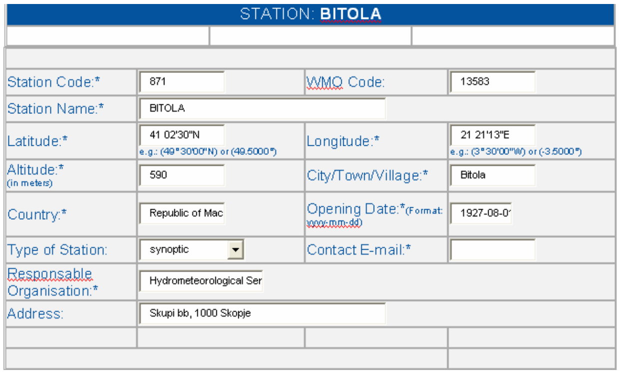
In the MEDARE metadata base we put information for seven Meteorological stations with the longest time series, which are located in different climatic zones. This information refers to: *Current Station Details, Station Time Series and Station History*, as shown in Figure 9a, b and c.



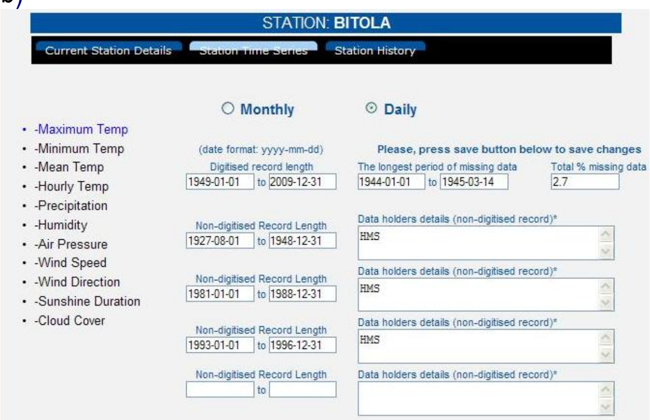
Your Search:

- 734-LAZAROPOLE
- 941-DEMIR KAPIJA
- 871-BITOLA
- 925-BEROVO
- 802-SKOPJE - PETROVEC
- 911-STIP
- 853-PRILEP

a)



b)



c)

Figure 9: Screen capture of the MEDARE metadata base on-line applicative showing list of FYR of Macedonia list of stations (a), current station details for Bitola station (b) and time series for Bitola station (c)

Past and Current Activity Concerning Climate Change and Climate Variability

The Meteorological Department in the Hydrometeorological Service has taken part in the implementation of the following projects:

- First National Communication Under the United Nations Framework Convention on Climate Change, 2003
- Macedonia's Second National Communication Under the United Nations Framework Convention on Climate Change, 2006
- Participation in Plan Preparation of the Health Sector, WHO Project on Health Protection From Climate Change
- Mitigating Climate Change Through Improvement of Energy Efficiency in Building Sector
- National Capacity Needs Self-Assessment for Global Environmental Management United Nations Development Programme

Data Status for Future Research

The National Meteorological Service has to provide end-users, decision makers and scientific community long term climate data sets for climate research activities. Until now we have not taken any activity for data rescue of historical records. These goals could be reached in the near future when the gaps in the long time series will be filled in and data will be transferred into digital form. Preserving all the data in paper form with suitable techniques is another issue to be aware of. Data rescue and digitization are complex and expensive tasks that require support.

Figure 10: Two samples of un-digitized data kept at the FYR of Macedonia Meteorological Service

MEDARE initiative will help us to do the first steps by:

- Defining the partners platform, the station network and data exchange policy among countries in the Mediterranean Basin
- MEDARE goals can be achieved with the project proposal within several directions depending on

the country needs and priorities. For example, we need and are interested to perform historical archive research on meteorological observations which were carried out on our territory by other countries (Turkey, France, Austria, Italia, Bulgaria, Serbia and Albania), but we realize that our priority should be the meteorological data that we already own. To achieve this goal we need to use advanced techniques for archiving, equipment procurement and staff training.

The MEDARE Initiative of WMO: Progress of Climate Data Rescue in Greece

Athanasios D. Sarantopoulos, Antonis Lalos, and Nikos Karatarakis
Hellenic National Meteorological Service, Hellenicon, Greece

INTRODUCTION:

MEDARE is an acronym of MEditerranean climate DAta REscue. The MEDARE initiative of WMO aims at incorporating old climate records into existing digitized data sets, thereby extending their time-series. Climate data rescue is very important. When available climate data spans over longer time periods, better weather forecasts are obtained, forecasting of extreme weather phenomena is improved, computer simulations of epidemics are more accurate, and finally design of engineering structures, such as dams and bridges, heavily based on hydrological and wind records, is more reliable. This brief report describes the progress of climate data rescue at the Hellenic National Meteorological Service (HNMS).

MEDARE MEETINGS:

The World Meteorological Organization put the MEDARE Initiative under its auspices. Up to this point, WMO has provided support for organizing meetings and financing travel and lodging for the participants.

Four working groups were formed each of which being dedicated to a specific step in data rescue (DARE) activity as shown in Table 1. The participants in MEDARE workshops were encouraged to act as members in one or more working groups.

Table 1: MEDARE Initiative Working Groups

Working Group	Task
1	Inventorying/assessing/approaching old material sources and holders
2	DARE techniques and procedures (including digitization)
3	Approaches on best practices for quality controlling and homogenizing specific climate variables
4	Promotional activities, bringing MEDARE to the wider scientific and other communities

The first meeting of MEDARE took place in Tarragona, Spain in November 2007 and was well-attended. Participants from the WMO and the Mediterranean Region took part with great enthusiasm with oral presentations and following discussions.

HNMS has been officially involved in the first working group, however, additional work has been done, in relation to the topics of other working groups.

The second MEDARE workshop took place in Nicosia, Cyprus in May 2010. Although it was the Working Group I meeting, some members belonging to other working groups participated in.

STEPS IN HISTORICAL DATA RESCUE:

A data rescue project is most likely to succeed if work is done methodically. As it was stressed during the Tarragona meeting, in order to accomplish the final objectives, the procedure to follow must include the following steps:

- Collection of material/Inventory
- Physical protection of archives
- Photographing/Scanning of paper data
- Development of Metadata database
- Data entry
- Quality control of data
- Data homogenization
- Data dissemination.

PRIORITIES OF THE HELLENIC NATIONAL METEOROLOGICAL SERVICE:

HNMS has started working in data rescue about four years ago. The top priority was the physical preservation of archives and their protection from dust, high humidity, and possibly rodents. New archival facilities were set up in order to protect the paper documents which were stored into plastic airtight boxes.

A small metadata database was developed using appropriate software. This database is a station registry, keeping important station information for 150 meteorological stations. It contains information on the type of instruments, describes the periods of operation of each station and, enlists all recorded meteorological parameters.

A high-resolution digital camera with a stand and lighting fixtures at each side was purchased. The camera was tested and tuned for optimal use in varying light conditions.

Finally, a flatbed A3 scanner was used to scan documents and a 1TB external hard disk was purchased to store the saved data.

NEW CLIMATOLOGICAL DATABASE:

HNMS put into operation a new climatological database in spring 2010. The new database system characteristics are as follows:

- It is based on Net technology
- It is powered by SQL Server
- It is web-based and user-friendly
- It is accessed through the HNMS intranet
- Climatological data is precomputed
- Features automatic and manual (human) quality control
- Data is sent directly into the system from most of meteorological stations
- It incorporates data from Automatic Weather Stations existing in the network
- It contains quality-controlled data for 141 Synoptic and Climatological Stations spanning a period from 1951 to 2004
- Climatological and synoptic data are merged into a single table.

HUMAN RESOURCES FOR DARE:

DARE project requires dedicated personnel who should work systematically on each phase of DARE.

The data rescue team at HNMS comprises two permanent employees. Also, the graduating college students who usually stay at HNMS for two months to accomplish their practical training required by their universities are involved in DARE activity. The students typically major in the fields of Meteorology, Mathematics, Physics, or Engineering. For the work they do, they receive credits from their universities. Up to now, the universities which have participated in the DARE project are:

- National Technical University of Athens
- University of Athens
- Harokopeion University
- University of the Aegean
- Technical University of Crete.

At the beginning of this project, the students used to work only during summer months. Lately, HNMS managed to have them involved continuously throughout the year. In principal, this is a consequence of mutual satisfaction between the students, HNMS, and the boards of participating universities.

Usually, the working time of a student is five hours, daily. Their typical work consist in photographing paper copies of data tables, performing direct data entries into spreadsheets, and, finally, doing a quality control of digitized data. Occasionally, students´ work extends beyond the typical DARE activities and may, for instance, be related to further statistical analysis of rescued data or specific classification. Finally, the students are required to document their work and produce a full report about their contribution to DARE project at HNMS.

CURRENT PROGRESS:

Despite the fact that there is a severe shortage of permanent personnel at HNMS, significant work on DARE has been done so far. The results are summarized below.

Approximately 1000 pages in A4 format, containing monthly data for various stations have been photographed. Also, several data sheets were scanned. However, because the quality of the scanned images was very poor it was decided to further proceed with photographing the documents.

A case study has been done in order to determine the effect of urbanization on the mean monthly temperature of two stations, namely that of Patras and Agrinio for the period of 1931 to 2003. The results show that, although urbanization rate was similar for both cities, a positive trend appeared only for the mean monthly temperature of Patras.

Another DARE project was related to temperature data rescue at six meteorological stations from the island of Crete (Figure 1). These stations are Anogeia, Siteia, Herakleion, Gortyna, Chania, and Ierapetra. The rescued data span over the period 1931-1960.

Figure 1: The Island of Crete

Furthermore, in addition to photographing the paper documents and direct data entry, the homogenization of temperature data has been achieved by using two methods for five meteorological stations located in the Eastern Aegean Sea namely, the islands of Lesvos, Chios, Kos, Rhodes, and Samos. The reason for this selection was the close proximity of the climatological characteristics of their locations.

Finally, partial metadata for 41 meteorological stations has been added to the MEDARE web-portal created prior to the Nicosia meeting. The address of the portal is http://app.omm.urv.cat/urv/. Once all metadata is collected, a final selection of meteorological stations to be used for data rescue will be done.

THE CASE OF HOLARGOS:

Holargos meteorological station deserves special attention. It is located in the homonymous suburb of Athens and was housed in the Hellenic Ministry of Defense premises. The meteorological and climatological data were recorded for only a short period of time, approximately seven years.
When rescuing Holargos temperature data, it was noted that during the period of operation of the station, an unusually low temperature of -7^{o}C has been recorded on January 19th, 1964.

Furthermore, a close examination of data from surrounding meteorological stations proved that -7^{o}C was the lowest temperature recorded at an urban station in Attica for the month of January (Table 2).

Table 2: Absolute minimum temperatures for Attica MS for January

Station	Year	Month	Day	Tmin(^{o}C)
Holargos	1964	1	19	**-7,0**
Tatoi	1964	1	19	-6,0
Spata	1990	1	10	-6,0
Nea Philadelfeia	1964	1	19	-5,8
Spata	2000	1	28	-5,2

The conclusion of this finding is that data rescue is very important even when short time-series are available and examined.

Oldest Time-Series of Greek Data:

Examining our records, it was found that the oldest recorded data was from the National Observatory of Athens (NOA) station.

It must be noted that this data is not in the possession of HNMS but it is kept in the NOA archives.

A list summarizing the oldest time-series of meteorological data recorded in Greece is shown in the Table 3.

Table 3: Oldest time-series of Greek data

Station Code	Station name	Latitude	Longitude	Altitude (m)	Period
16714	Athens Observatory	37,96	23,71	107	1876-1990
16645	Trikala Thessalias	39,51	21,76	110,2	1892-1972
16661	Volos	39,36	22,95	2,6	1894-1948
16732	Naxos	37,1	25,36	9,8	1894-1954
16648	Larissa	39,65	22,45	73,6	1894-1954
16726	Kalamata	37,06	22,01	11,1	1894-1955
16641	Corfu	39,61	19,91	4	1894-1956
16686	Mesologi	38,36	21,41	1	1894-1959
16675	Lamia	38,86	22,43	17,4	1894-1969
16689	Patras	38,08	21,73	1	1894-1972

Summary and Future Work:

Our experience in DARE shows that data rescue activity is a long and tedious undertaking. It requires a lot of resources and must be well-planned.

Up to now, only monthly temperature data has been photographed and only a small amount of the records have been entered into a database. It is worth mentioning that some daily data is available, however, containing a lot of gaps in the time-series. Greece has participated in many wars during the past century and this is the main reason why the time-series are sparse. Nevertheless, as much as possible, priority will be given to rescuing data with longer time-series.

As it turns out, a high percentage of data available on paper support is not of high quality since most of recorded parameters are written in pencil but not in ink. This means that it is equally difficult to photograph or scan them. Therefore, direct data entry must be done.

Immediate results were obtained when the data were rescued from Holargos station. This case overemphasized the importance of data rescue effort.

We acknowledge the close and very fruitful cooperation with the universities. For college students, it proved to be very attractive to do their practical training at HNMS. They have got the satisfaction of their work and the experience in dealing and retrieving climatological data. The demand is increasingly high and it was very pleasant for both parties, i.e., academic institutions and HNMS, to work together. In the future, it is likely that Master's or Doctoral Theses be devoted to DARE projects.

We plan to seek help from the National Archives or monasteries, in order to share their valuable expertise in data rescue. Such entities have experience and have accomplished significant work in data rescue for years and we consider that their advice is precious and it will be highly appreciated.

Finally, during the MEDARE meeting in Tarragona it was reported that some old meteorological records exist for a few Greek stations. The data was recorded during the periods of the Ottoman and Italian occupation. An attempt will be made to locate that data on paper support and have these copies handed over to HNMS to rescue the climatological data.

ACKNOWLEDGMENTS:

The author would like to acknowledge Spyros Katsaros from the National Technical University of Athens for his hard work and his devotion during his stay at the HNMS.

Combined Efforts to Address Different Data Sources in Turkey in order to Extend Back in time on Key Climate Records

Serhat Sensoy, Turkish State Meteorological Service, Kalaba, Ankara, Turkey

ABSTRACT:
In this study, 'data rescue' has been defined. The Little Ice Age and its effect on Turkey are examined and meteorological records from the Ottoman Empire to the Republic of Turkey are investigated. Water records as a source of life quoted from various documents are also inquired into together with natural proxy sources in Turkey (tree-rings, dendrochronology of Anatolia, speleothem caves) have been investigated. Digitized climate records and DARE activities in Turkey are presented. Attention is also given to the State of the Climate repots and activities on Eastern Mediterranean Climate Center.

DATA RESCUE (DARE) PROJECT

The Data Rescue (DARE) project is aimed at assisting countries in the management, preservation and use of climatic data over their own territories. DARE commits to microfilm and microfiche, and eventually to digital media through CLICOM and other means, the original written manuscript records which may date back more than 100 years and in many cases are in danger of deteriorating and of being lost.

New DARE strategy

In the mid-1990s, technological advancements made it possible to optically scan 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 first be transferred 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, but placing the data in full digital usable form will make the data more widely accessible.

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:

- 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.)
- Data should be key-entered in a form that can be used for analyses.

THE LITTLE ICE AGE (LIA) AND ITS EFFECT ON CRISIS IN OTTOMAN TURKEY AND BALKANS

The LIA can now be defined in terms of particular weather events clustered in certain multi-decadal periods from c.1300 to 1870 (Grove 1988; Pfister et al. 1999; Fagan 2000; Pfister 2005). Among the most severe such periods were those from the 1570s to 1610s and the 1670s to 1710s, the latter sometimes referred to as the "Late Maunder Minimum" (Pfister 1994 and 2005;Luterbacher et al. 2001; Xoplaki et al. 2001).

With regard to the cause of the LIA, there are two major theories to explain the variations in European climate. The first explanation is that volcanic activity created dust veils, reducing solar input leading to abnormally cold weather (Luterbacher et al. 2001). The second explanation focuses on the impact of the North Atlantic Oscillation (NAO).

In the seventeenth century, the Ottoman Empire (c.1300-1923) suffered a major crisis from which it never fully recovered. After reaching its zenith in the mid-1500s, the empire began to suffer from increasing economic turmoil and social unrest

(Akdag 1963 and 1971). Beginning in the 1590s, a series of rebellions known as “Celalis” swept the countryside, driving peasants into flight. The crisis persisted through the 1600s, and despite the resilience of the Ottoman state, its attempts to restore order and resettle the land met with little success (Barkey 1994).

Underlying this entire crisis was an abrupt demographic shift. While there are no complete censuses of Ottoman lands before the 19th century, regional studies based on a variety of tax records reveal a consistent and striking pattern. Many regions of Anatolia and present-day Greece, after a century of rapid growth, were suddenly lost half or more of their population. Table 1 gives a small but representative sample of the depopulation that occurred.

Table 1: Population change in several sancaks and kazas in Anatolia and Greece (Erder and Faroqhi 1979; Özel 2004). Tables are given in households or adult male taxpayers

Region	1520s-50s	1560s-90s	1610s-40s	Region	1520s-50	1560s-90s	1610s-40s
Karahisar	6.661	13.679	7.755	Atalanti	1.353	1.810	960
Kocaeli	5.439	-	4.730	Boeotia	238	256	211
Bafra	-	3.546	1.415	Bozok	-	41.484	4.461
Samsun	-	39.609	6.068	Amasya	-	12.923	833

The traditional historiography used to blame this decline on degenerate sultans and viziers who strayed from Ottoman political and military traditions. In the 1950s, historians of French *Annales* School were the first to link these events with environmental factors, including climate (Braudel 1949;Utterstrom 1955; Inalcık 1978). Peter Kuniholm, who compiled the first tree-ring databases for the Aegean region, also observed the striking correlation between poor growing seasons and disasters in the Ottoman Near East (Kuniholm 1990).

Table 2 demonstrates both the unusual clustering of extreme weather events and their close association with famines and other disasters of the 17th century in the Mediterranean. Names and dates on the left display the standard deviations from recent mean precipitation evidenced by respective dendroclimatology studies. Of particular interest is the period 1590-1620, marked by both the most extreme climate events and the most devastating setbacks for the Ottoman Empire. In examining the long-term impact of climate, moreover, the severe weather of the 1680s and 1690s may have been just as important, upsetting a potential Ottoman recovery. Viewed this way, the timing of LIA events with historical events makes a strong though circumstantial case for climate-related disaster (White, 2006).

Table 2. Climate Events in the Ottoman Empire in 1570-1625; 1682-1691

Year	Touchan	Crete	Greece	Other weather event	Other Events
1570		drought			Locust invasion in Italy
1571					Rising grain prices
1572					Severe winter in Anatolia
1573					Epidemic in Salonica then Cyprus, Edirne
1574					Famine in Anatolia
1575		Severe winter			Famine continues
1576		Severe winter			Famine, widespread epidemic in Anatolia
1577			Severe winter,	frozen lakes	
1578					Locust invasion in Azak
1579					Famine in E.Med, Epidemic in Salonica
1580					Shortage in western Anatolia
1581					
1582					
1583					Drought in Syria
1584					Drought and famine in Syria,
1585		Severe winter			Anatolia and Aegean
1586		Severe winter			Locust and famine in Çorum
1587				Dry fog in Italy	
1588		Very severe winter			Shortage in Istanbul
1589		Drought, famine			Shortage in Levant, Janissary revolt
1590		Very severe winter	Severe winter		Shortage in Damascus epidemics in
1591	longest	Severe winter			Istanbul (1590-1592)
1592	recorded			Dry fog in Italy	Famine in Damascus
1593	dry period				Plague outbreak in Anatolia
1594	in 600 yrs	Severe winter			Prohibition on grain exports
1595	1591-5	drought and famine		Danube freezes	Invasion of mice in Trablusgarp;
1596					Famine outbreak of Celali uprisings
1597					
1598					Famine, epidemic in Istanbul
1599					
1600					Locust invasion in Italy
1601	longest	Very severe winter		eruption of Huaynaputina	Beginning of “great flight”
1602	recorded	Very severe winter		Danube freezes (1601-2)	
1603	Wet period				
1604	In 600 yrs	Very severe winter			
1605					Canbuladoglu rebellion in Syria
1606				Danube freezes, coldest	
1607	Extreme			European winter in 1000	
1608	drought	Very severe winter		yrs	
1609					
1610	drought				
1611					
1612				Snowy winter	Invasion in Cyprus 1610-1628;epidemic
1613		drought			In Istanbul (1612) drought in Syria
1614					Shortage in Damascus
1615					Shortage in Zulkadirlu
1616					
1617		severe winter,			
1618		deluge			
1619					
1620				Bosporus freezes,	
1621				Dry fog in Italy	
1622			severe winter,		Sultan Osman deposed
1623			Freezing lakes		
1624					
1625		Drought and flight			Major epidemic in Istanbul
1682			severe winter,	Dry fog in Italy	
1683			severe winter,		
1684				Ex. severe winter in Italy	
1685					
1686			Cold wet winter	Harsh winter ice on	Golden Horn
1687			severe winter,		Ottoman defeat at Mohac, famine in Balkan
1688	recurring				
1689	drought			Dry fog in Italy	Flooding in Edirne
1690			famine in Athen	Volcanic eruption e. cold	
1691		Drought, famine		Famine in N. Europe	Major state nomad settlement in Syria

Sources: Akkemik et al. 2005; Grove and Conterio 1994, Kuniholm 1990, Luterbacher et al. 2004 ; Touchan et al. 1999, 2002, 2005 ; Xoplaki et al. 2001

One example being: 24 April 1782. Record of the firman about the water resources transferred by Sultan Suleiman the Magnificent from Kağıthane area to the mosque he has built in Istanbul, that are under the threat of drying up because of trees being cut down in the nearby forest. The act of cutting trees where these water resources are located is strictly forbidden; and goods such as horses and carriages of those who do not observe the law will be confiscated, they will be fined lifelong hard labour and the forest wardens who have tolerated cutting trees from these forests shall be fined likewise.

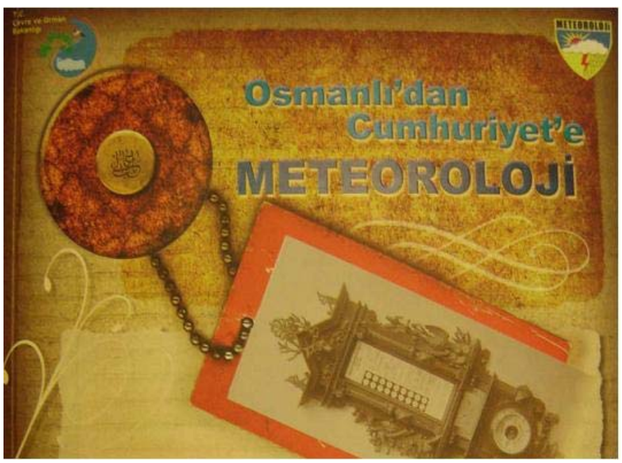


Figure 1: Meteorology from Ottoman Empire to the Republic of Turkey (TSMS, 2010)

Figures 1, 2, 3 and 4 illustrate some samples of ancient Ottoman documentation.

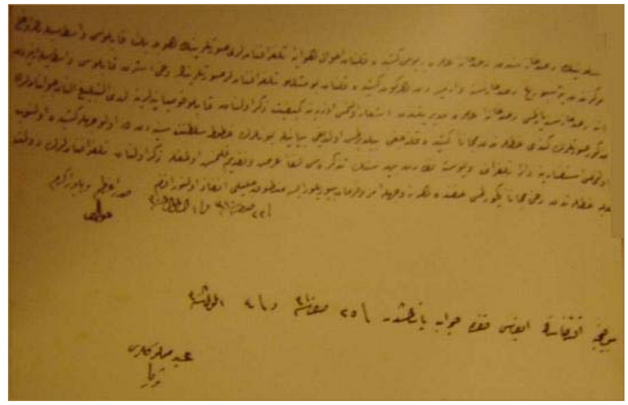


Figure 2: Document stating that the telegram line belonging to the Selanik (Thessalonica) Observatory and the Imperial Observatory should be permitted to use the state lines free of charge (State Archive, 2009)

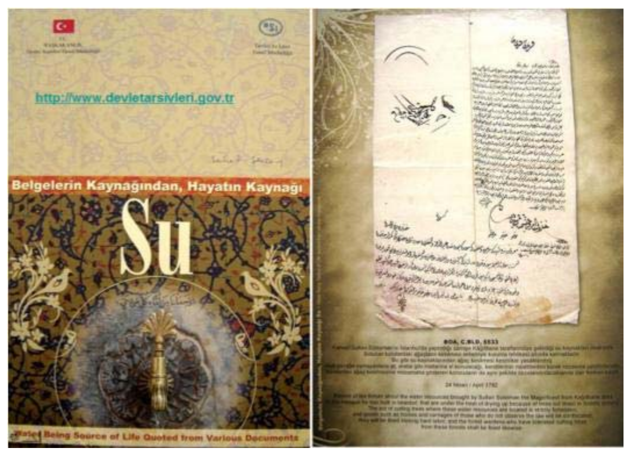


Figure 3: Water as the source of life here being quoted from various documents (State Archive and SHW, 2009)

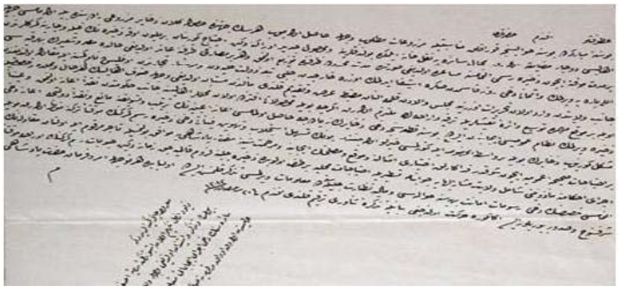


Figure 4: Sultan order dated 7 February 1866 (State Archive, 2009)

The desired output was not forthcoming in Bosnia due to the severe drought. In Herzegovina, moreover the output is not sufficient even to meet the need for seed corn. The distressed people started migrating. One or two million okas of grain are needed before new harvest. The Sultan's order is here about a one-off exemption of tax levied in the Gayla and Carine customs offices and for the grain to be imported by the Merchant Oflis of Mostar on condition that the price is fifty for each oka and payment to be made in the fall.

HISTORICAL RECORDS FROM OTTOMAN EMPIRES

Climate records in Turkey started around 1840 in the schools, hospitals, embassies, the records being made by volunteers such as scientists, engineers, priests etc. These observations are not in a continuous form and most of them have not been properly conserved.

The first scientific observation was started in 1856 by Ritter (an engineer) in the Bosporus observation park where 2m surface temperature shield was installed some 6m above sea level.

Another observation series was prepared by Mr. William Henri Lyne between 1865 and 1886. This man lived 30 years in Haydarpasa, Istanbul as a guard of the English cemetery. He took his observations in the garden of his house and observed rainfall, maximum and minimum temperatures and wind. He recorded them in a journal and they were then sent to London.

In August, 1841 the Ceride-i Havadis newspaper has started to publish information about temperatures in Istanbul and also give some information on temperatures elsewhere: for example, summer temperature in S. Arabia (28-30ºC) and winter temperature in Petersburg (-30 ºC) and Siberia (-40ºC). This was done with a view to improving public opinion about climate. We can also cite:

- The measurement of temperatures for Istanbul were firstly published in 1842 in the newspaper " Ceride-i Havadis". These measurements were performed by the foreign volunteers (Oguz, 2007).
- Official observations were started in 1868 in the Observatoire Imperial Meteorologique de Constantinapole. French Records run from 1868 to 1897 and included monthly pressure, maximum and minimum temperatures, precipitation and daily maximum precipitation amount, wind speed and direction, relative humidity, and number of rain, snow, fog, lightning days
- Ottoman records (3 climate books) from 1896-1901, 1901-1907,1907-1914 (daily record) They are include wind speed and direction, precipitation, humidity, temperature and air pressure in daily form.
- German records during the 1st World War collected at "Zum Klima der Turkei" (1915-1918)
- Records from Kandilli Observatory (1926-1936)
- Turkish State Meteorological Service from 1937-

Tables 3 and 4 give details on non-digitized climate data from different sources, while and Figure 5 shows 1841 and 1941 temperature comparison for Istanbul.

Table 3: Inventory of Turkish not digitized data

Local/WMO station codes	Stations names	Geographical details (latitude, longitude, altitude)	Variables	Length of records	Time resolution of the records (i.e. monthly, daily)	Preliminary assessment of time series gaps
17062	Istanbul	4058, 2905, 33m	Tmax, Tmin, Prec.	1841-1867	daily	Published in the newspaper " Ceride-i Havadis. Some weeks gap
17062	Istanbul	4058, 2905, 33m	Tmax, Tmin, Prec, W. speed, RH%	1868-1897	monthly	French Meteorological Service has some volumes **and published in French Annales**
17062	Istanbul	4058, 2905, 33m	Temp, Pressure, Precip, w.speed & dir, RH%	1896-1914	daily	Saved in the TSMS museum Needs to be translated and digitize
17112 17220 17022 17026 17130 17123 17244 17090 17280 17351	Gallipoli Smyrna Sunguldak Sinope Angora Eskisehir Konya Siwas Diarbekir Adana Jerusalem Mossul	4013, 2640, 6m 3843, 2717, 29m 4127, 3149, 137m 4201, 3510, 32m 3957, 3253, 891m 3946, 3031, 801m 3758, 3233, 1031m 3945, 3701, 1285m 3753, 4012, 677m 3659, 3521, 27m	Pressure, temp, RH%, wind speed & direction	1915-1918	monthly	These data belong to 1st World War. They are collected in a book called "Zum Klima der Turkei" **This book provided by DWD**

Table 4: Historical pressure data from different sources (Allan, 2006)

STATION	START	END	LAT	LONG	Eevation	Status	SOURCE & REMARKS
TURKEY							
Bayukdere	179906250900	179910281700	36.517	36.083		1	Google Book Search - William Whitman
Bebek	18480101	18531231	41.067	29.033		1	Google Book Search
Chennecally	179911040800	179911301700	40.195	26.405		1	Google Book Search - William Whitman
Constantinople	18391121	18410714	41.022	28.981		2	Google Book Search
Constantinople	18470101	18470104	41.022	28.981		1	La Météorologie
Constantinople	18541201	18560331	41.022	28.981		1	Google Book Search
Constantinople	18581201	18670131	41.022	28.981		1	GAZETTE MEDICALE D'ORIENT
Constantinople	1868	1914	41.022	28.981		1	EMULATE data?
Constantinople	1915	1918	41.022	28.981		1	EMULATE data? German records - DWD???
Istanbul	1929	2010	40.967	29.083		1	Turkish Meteoriological Service
Diyarbekir	186909010800	187605310800	37.919	40.211		1	EMULATE + Bulletin International
Galata	179912010800	180004301700	38.3	32.217		1	Google Book Search - William Whitman
Gallipoli	18540701	18541031	40.467	26.717		1	Google Book Search
Kaisaria	1849100110	184911271000	38.69	35.36		1	La Météorologie
Kourou-Tchezme	18561101	18581231	41.022	28.981		1	GAZETTE MEDICALE D'ORIENT + Google Book Search
Kourou-Tchezme	18590101	18591231	41.022	28.981		1	GAZETTE MEDICALE D'ORIENT
Kourou-Tchezme	18600101	18600831	41.022	28.981		1	GAZETTE MEDICALE D'ORIENT
Pera	18470101	18471231	41.037	28.975	68	1	La Météorologie
Scutari	18660101	18861231	41	29.5		1	EMULATE 1866-1880 All in UK Climatological Returns
Smyrne	186909010800	187109280800	38.43	27.13		1	French Annales + Bulletin international
Smyrne	18900101	18991231	38.43	27.13		2	French Annales
Smyrne	190504010700	1913122030	38.43	27.13	2	2	French Annales
Smyrne	190801010800	19340131	38.43	27.15		1	NOAA Central Library - MISSING 1915-1923
Izmir	19350101	1971	38.45	27.25		2	NOAA Central Library
Ankara	192511120700	1971	39.967	32.8		2	NOAA Central Library
Trebisonde	18311107	183112071600	41.02	39.75		1	Google Book Search
Trebisonde	18480315	18480731	41.02	39.75		1	La Météorologie
Trebisonde	188301010920	188907312120	41.02	39.75	28	2	French Annales + Jesuit records - Ebro University
Samsoun	188301010236	188912311436	41.3	36.32	8	2	French Annales
						(1=DIGITISED; 2=SCANNED; 3=HARD COPY)	

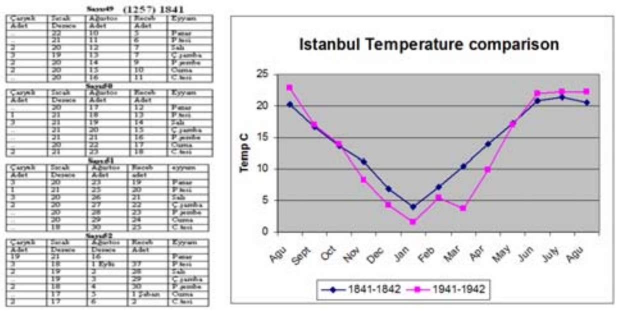


Figure 5: Istanbul Temperature in 1841 by Ceride-i Havadis and its comparison with 1941

French Records

In the Ottoman Empire some French scientists had carried out meteorological observations in Observatoire Imperial Meteorologique de Constantinapole from 1868 to 1897 (monthly – annual record). The recorded parameters were air pressure, maximum and minimum temperatures, precipitation and daily maximum precipitation amount, wind speed and direction, relative humidity, and the number of of rain, snow, fog and lightning days. Figure 6 shows an example of French data sources.

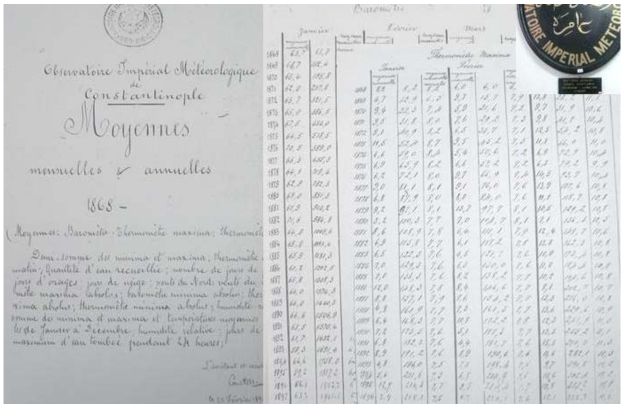


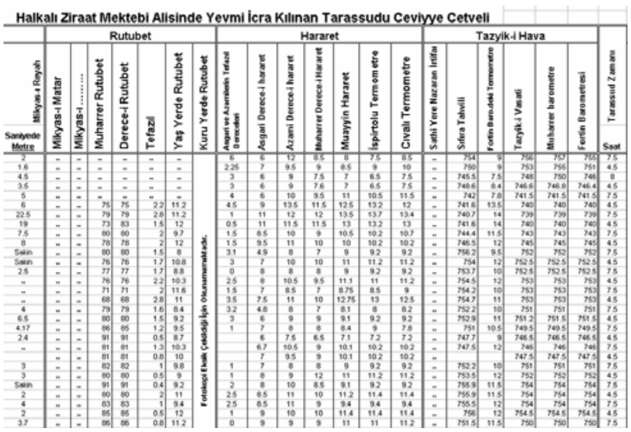
Figure 6: Monthly air pressure records for Istanbul from 1868-1897

Ottoman Records

Three climate books for Istanbul from 1896-1901, 1901-1907, 1907-1914 (daily record) can be found in the TSMS Museum in Ankara. Recorded parameters are wind speed and direction, precipitation, humidity, temperature and air pressure. They are in the Ottoman language and need to be translated and then digitized. Figures 7, 8 and 9 show examples.

Figure 7: Historical records from Ottoman Empire (TSMS Museum)

Figure 8: Ottoman observation record (TSMS Museum)



Halkalı Ziraat Mektebi Alisinde Yevmi İcra Kılınan Tarassudu Ceviyye Cetveli

Mikyas-ı Reyah	Rutubet							Hararet								Tazyik-i Hava						Tarassud Zamanı
Saniyede Metre	Mikyas-ı Matar	Mikyas-ı	Muharrer Rutubet	Derece-i Rutubet	Tefazil	Yaş Yerde Rutubet	Kuru Yerde Rutubet	Asgari ve Azamilerin Tefazul Dereceleri	Asgari Derece-i hararet	Azami Derece-i hararet	Muharrer Derece-i Hararet	Muayyin Hararet	İspirtolu Termometre	Civalı Termometre	Sathi Yere Nazaran İrtifa	Sıfıra Tahvili	Fortin Baro.daki Termometre	Tazyik-i Vasati	Muharrer barometre	Fortin Barometresi	Saat
2	-	-	-	-	-	-	Fotokopi Eksik Çekildiği İçin Okunamamıştır.	6	6	12	8.5	8	7.5	8.5	-	754	9	756	757	755	7.5
1.6	-	-	-	-	-	-		2.25	7	9.5	9	8.5	9	10	-	750	9	753	756	751	4.5
4.5	-	-	-	-	-	-		3	6	9	7.5	7	6.5	7.5	-	745.5	7.5	748	750	746	8
3.5	-	-	-	-	-	-		3	6	9	7.6	7	6.5	7.5	-	748.6	8.4	746.6	746.8	746.4	4.5
5	-	-	-	-	-	-		4	6	10	9.5	11	10.5	11.5	-	742	7.8	741.5	741.5	741.5	7.5
6	-	-	75	75	2.2	11.2		4.5	9	13.5	11.5	12.5	13.2	12	-	741.6	13.5	740	740	740	4.5
22.5	-	-	79	79	2.8	11.2		1	11	12	12	13.5	13.7	13.4	-	740.7	14	739	739	739	7.5
19	-	-	73	83	1.5	12		0.5	11	11.5	11.5	13	13.2	13	-	741.6	14	740	740	740	4.5
7.5	-	-	80	80	2	9.7		1.5	8.5	10	9	10.5	10.2	10.7	-	744.4	11.5	743	743	743	7.5
8	-	-	78	78	2	12		1.5	9.5	11	10	10	10.2	10.2	-	746.5	12	745	745	745	4.5
Sakin	-	-	80	80	1.5	8		3.1	4.9	8	7	9	9.2	9.2	-	756.2	9.5	752	752	752	7.5
Sakin	-	-	76	76	1.7	10.8		3	7	10	10	11	11.2	11.2	-	754	12	752.5	752.5	752.5	4.5
2.5	-	-	77	77	1.7	8.8		0	8	8	8	9	9.2	9.2	-	753.7	10	752.5	752.5	752.5	7.5
-	-	-	76	76	2.2	10.3		2.5	8	10.5	9.5	11.1	11	11.2	-	754.5	12	753	753	753	4.5
-	-	-	71	71	2	11.6		1.5	7	8.5	7	8.75	8.5	9	-	754.2	10	753	753	753	7.5
-	-	-	68	68	2.8	11		3.5	7.5	11	10	12.75	13	12.5	-	754.7	11	753	753	753	4.5
4	-	-	79	79	1.6	8.4		3.2	4.8	8	7	8.1	8	8.2	-	752.2	10	751	751	751	7.5
6.5	-	-	80	80	1.5	9.2		3	6	9	9	9.1	9.2	9.2	-	752.9	11	751.2	751.5	751.5	4.5
4.17	-	-	86	85	1.2	9.5		1	7	8	8	8.4	9	7.8	-	751	10.5	749.5	749.5	749.5	7.5
2.4	-	-	91	91	0.5	8.7			6	7.5	6.5	7.1	7.2	7.2	-	747.7	9	746.5	746.5	746.5	4.5
-	-	-	81	81	1.3	10.3			6.7	10.5	9	10.1	10.2	10.2	-	747.5	12	746	746	746	7.5
	-	-	81	81	0.8	10			7	9.5	9	10.1	10.2	10.2	-			747.5	747.5	747.5	4.5
3	-	-	82	82	1	9.8		1	7	8	8	9	9.2	9.2	-	752.2	10	751	751	751	7.5
3	-	-	80	80	0.5	9		1	8	9	12	11	11.2	11.2	-	753.5	12	752	752	752	4.5
Sakin	-	-	91	91	0.4	9.2		2	8	10	8.5	9.1	9.2	9.2	-	755.9	11.5	754	754	754	7.5
2	-	-	80	80	2	11		2.5	8.5	11	10	11.2	11.4	11.4	-	755.9	11.5	754	754	754	4.5
4	-	-	83	83	1	9.4		2.5	8.5	11	9	9.4	9.4	9.4	-	755.5	12	754	754	754	7.5
2	-	-	85	85	0.5	12		1	9	10	10	11.4	11.4	11.4	-	756	12	754.5	754.5	754.5	4.5
3.7	-	-	86	86	0.8	11.2		0	9	9	9	11	11	11.2	-	751.5	11.5	750	750	750	7.5

Figure 9: Translated observation record by Zekai Erdal Art Historian, Director of Van Airport Station

GERMAN RECORDS

During the 1st World War (1915-1918), some German scientists carried out meteorological observations from 1915 to 1918. Figure 10 gives a German climate record.

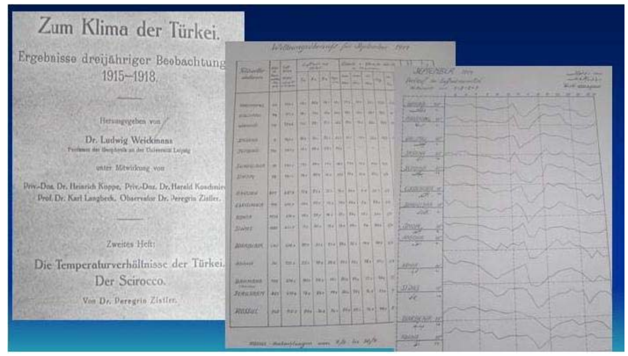


Figure 10: German records during the 1st World War (Zistler, 1926)

FOREIGN SCIENTIST'S RECORDS

Atatürk, who is founder of the Turkish Republic, invited Hungarian Prof. Antal Rethly in order to start meteorological observations in Turkey. Prof. Rethly carried out this task from 12.11.1925 to 30.10.1927. He opened some meteorological stations over Anatolia traveling more than 10.000 km to do so. He prepared reports to prevent air pollution in Ankara and suggested that Etlik around is better place for the city settlement (Figure 11).

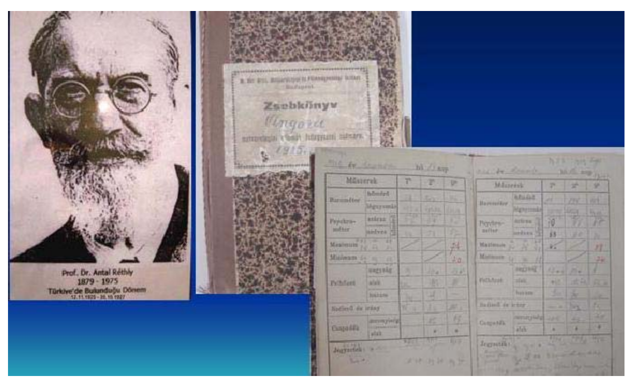


Figure 11: Meteorological observations recorded by Prof. Antal Rethly

TURKISH STATE METEOROLOGICAL SERVICE

The Turkish State Meteorological Service, TSMS, was founded in 1937. It is the only legal organization which provides all meteorological information in

Turkey. TSMS have been carried out observations, forecasts, data, and all other information for public and sectors (www.meteor.gov.tr).

Atmospheric Circulation Reconstructions over the Earth (ACRE) Project

Some of the pressure data are already presented and available in ACRE Project at http://www.cdc.noaa.gov/Pressure/ and http://www.hadobs.com/

Istanbul (EMULATE) 1866-1880 [daily] (Hadley Centre) 1847-1848; 1854 [monthly] (ADVICE/CRU, UEA, Phil Jones) 1856-present [monthly],

İzmir (Hadley Centre, Rob Allan) 1864-1873; 1890-1899; 1906-1994 (gaps) [monthly]

Paleoclimatology – The Study of Ancient Climates

How do we reconstruct climate?

- Tree Rings
- Glacial Ice Cores
- Ocean Sediments - The ratio of oxygen 16 to oxygen 18 preserved in the steady rain of dead organisms
- Radiocarbon dates of organic material
- Pollen samples found in packrat middens and lake bed samples
- Variations in desert varnish coatings found on rocks in the arid southwest
- Variations found in peatbog deposits
- Sedimentary rock records

Tree Rings

How does a tree produce annual rings?

There are two main types of ring producing trees. The primary cellular component of tree rings is the tracheid. Tracheids are long tubular cells that make up the xylem. Tracheids formed in the beginning of the growing season are thin walled and low in density. These cells constitute what is called the earlywood. As the end of the growing season nears, climate conditions become less conducive and growth slows. Tracheids become darker and more thick-walled, forming the latewood. Finally, when the growth season ends, there is a marked boundary at the edge of the ring. Figure 12 sows a cross section of a conifer.

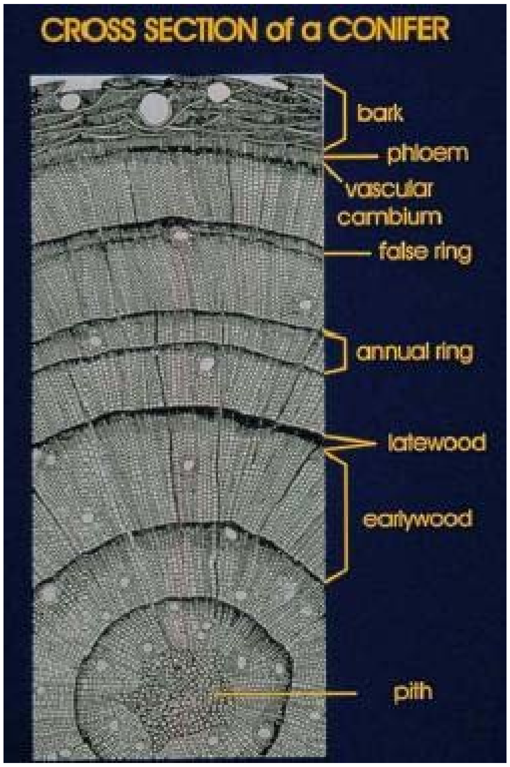


Figure 12: Cross section of a conifer

Dendrochronology

Dendrochronology is tree-ring dating.

Simply stated, trees grow two rings per calendrical year. For the entire period of a tree's life, a year-by-year record or ring pattern is formed that in some way reflects the climatic conditions in which the tree grew. These patterns can be compared and matched ring for ring with trees growing in the same geographical zone and under similar climatic conditions. Following these tree-ring patterns--the sum of which we refer to as chronologies--from living trees back through time, it is possible to compare wood from old or ancient structures to our known chronologies, match the ring patterns (cross-dating), and determine precisely the age of the wood used by the ancient builder. Figure 13 illustrates a dendrochronological record.

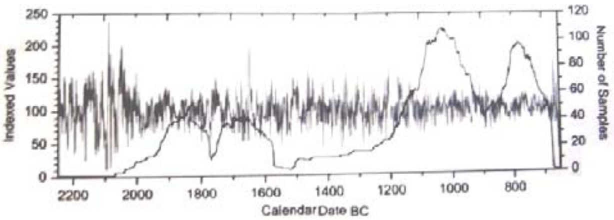


Figure 13: Dendrochronological Dating in Anatolia: The Second Millennium BC (Kuniholm, I. P. et all, 1990)

Dendrochronological Dating in Anatolia

Prof Kuniholm, P. and co-workers spend 30 years in Turkey and they have produced valuable Anatolia Dendrochronology Database (Kuniholm, I. P. et all, 1990), which is shown in Table 5.

Table 5: Anatolia Dendrochronology Database

-1290	99.9	102.0	79.5	45.4	62.0	104.4	146.1	141.1	124.8	86.3
-1280	94.0	82.1	71.7	95.4	67.1	80.6	99.8	106.4	79.0	112.0
-1270	87.4	92.5	51.5	124.1	60.2	59.4	71.5	82.0	99.4	91.2
-1260	114.5	114.9	148.9	74.5	95.7	85.6	69.8	122.8	111.2	93.6
-1250	130.5	133.0	118.0	103.2	76.3	99.3	111.6	95.4	125.5	98.7
-1240	102.8	81.8	62.6	88.7	73.7	117.7	87.7	123.2	71.5	90.3
-1230	89.5	59.3	65.5	96.7	81.9	98.2	85.1	110.7	76.1	96.9
-1220	124.6	98.1	98.9	117.6	114.1	151.5	54.7	77.7	107.4	85.3
-1210	119.1	101.0	149.2	135.4	119.0	107.8	150.0	169.2	137.3	123.2
-1200	123.3	115.2	109.0	82.1	83.5	91.5	101.1	99.7	105.8	99.0
-1190	53.5	61.1	62.0	102.3	85.8	80.3	84.2	103.6	106.4	73.6
-1180	78.0	80.0	109.9	95.6	73.8	100.8	149.1	134.6	155.2	128.9
-1170	73.3	77.9	137.1	115.4	125.4	139.5	114.5	145.0	124.6	98.2
-1160	78.4	109.8	95.0	84.6	100.8	97.6	111.4	80.6	104.5	72.2
-1150	88.2	91.0	67.6	95.3	112.7	88.6	118.4	97.6	70.5	76.9
-1140	92.1	116.5	127.5	148.4	114.4	138.4	121.4	104.4	127.6	123.1
-1130	119.1	126.2	114.1	85.3	128.5	111.9	99.6	79.1	85.2	81.2
-1120	112.7	112.5	108.9	71.7	104.5	106.8	109.2	123.0	103.8	65.7
-1110	102.6	112.5	109.0	83.6	96.3	80.9	109.1	63.2	71.2	81.3
-1100	105.4	81.9	97.9	88.9	106.0	95.7	117.2	65.9	61.2	95.3
-1090	120.2	104.5	106.6	110.3	70.4	127.7	89.0	99.5	811.0	77.3
-1080	96.9	103.5	114.9	122.6	112.5	93.8	93.0	95.8	88.4	92.6
-1070	97.1	101.2	101.5	123.8	72.3	98.8	100.2	103.5	105.0	98.6
-1060	101.6	85.3	104.4	71.1	72.8	84.2	69.5	111.2	115.3	89.4
-1050	98.4	102.6	118.0	111.6	87.6	96.8	121.2	126.4	115.6	89.7
-1040	108.1	108.3	95.1	97.0	88.3	89.7	102.6	99.3	106.3	90.3
-1030	95.4	118.7	117.8	111.7	106.6	113.3	124.7	86.4	105.1	101.0
-1020	106.0	105.0	105.9	74.8	71.9	100.4	99.5	102.6	113.4	101.7
-1010	99.4	104.7	116.6	117.4	115.8	75.4	104.9	108.0	119.6	108.6
-1000	72.1	93.8	82.9	127.5	108.4	102.3	110.6	129.7	93.2	123.1
-990	125.5	101.0	97.6	119.5	126.7	85.6	83.6	103.0	108.9	114.2
-980	103.8									

17	17	17	17	17	17	17	17	17	17
17	17	17	17	17	17	17	17	17	17
17	17	17	17	17	17	17	17	17	17
18	18	18	18	18	19	19	19	19	19
20	20	20	20	20	20	20	21	20	21
21	21	21	21	21	21	21	22	22	22
22	22	22	22	23	24	24	24	24	25
25	25	25	25	25	25	25	25	25	25
25	25	25	25	26	26	26	26	25	25
25	27	27	27	27	29	29	30	30	30
30	30	30	31	31	33	33	34	35	35
35	35	34	36	37	37	36	36	36	37
38	39	40	42	42	43	44	45	45	45
46	46	47	47	47	48	49	49	50	50
52	52	54	54	54	54	55	57	57	56
56	57	57	56	57	58	58	58	58	60
61	59	59	58	58	59	59	60	62	62
62	62	63	62	61	61	61	61	61	61
62	63	63	63	65	65	67	69	70	72
72	73	73	74	75	77	77	77	78	79
80	82	83	83	84	85	86	89	90	90
91	95	96	96	96	97	98	98	96	97
99	99	98	97	97	96	96	96	97	98
98	99	98	98	98	98	98	98	99	100
101	99	98	99	98	100	103	104	104	105
106	106	106	108	108	108	108	108	108	108
108	107	109	106	106	107	108	107	108	106
105	107	106	105	104	104	103	103	103	102
102	102	102	102	101	100	100	100	101	101
100	100	99	99	100	100	100	101	101	101
101	100	100	97	97	97	95	92	90	90
90									

Number of samples in data set: 284

Number of rings in data set : 35484
Length of data set : 1051 years

Instructions for reading the table: information for the 1051 years from 2030 BC to 980 BC is presented as a growth index for each year, ten years to a line numbered 0-1, and a histogram showing the sample abundance for each year. Thus the information for 1171 BC (which reads 77.9) should be understood as follows: Average ring-growth was 77.9 % of normal. Normal is here the mean growth index.

Speleothem (Cave Deposit) Data

Speleothems are mineral deposits formed from groundwater within underground caverns (Figure 14). Stalagmites, stalactites, and other forms may be annually banded or contain compounds which can be radiometrically dated. Thickness of depositional layers or isotopic records can be used as climate proxies.

Figure 14: General view of Karaca Cave near Gumushane showing well developed stalagmites and stalactites

There is a multi-disciplinary research project which is carried out by University of Birmingham, University of Ankara and some institutions in order to investigate environmental change in Northeast Turkey. Details are presented at http://www.gees.bham.ac.uk/research/ENVNET

Turkish Digitized Data

- All the daily and monthly climate data (260 stations) have been digitized from 1926 to today. They are quality controlled from 1975-
- All upper air data (7 stations) have been digitized from 1985-
- All AWOS minutely data (210 stations) are been stored automatically from 2002-
- All Rainfall Intensity data (250 station) have been stored from 1993-
- Satellite and Radar data have been stored from 2003-
- NWP data have been stored from 2006
- Forecast bulletin have been stored from 2001 (still needs to scan from 1968)

Although the Turkish station network is quite good there are some breakpoints in data due to location change and urbanization (Kuglitsch et al. 2009).

Figure 15 provides details on the no. of breakpoints in time-series homogeneity for the Mediterranean region, including Turkish time-series

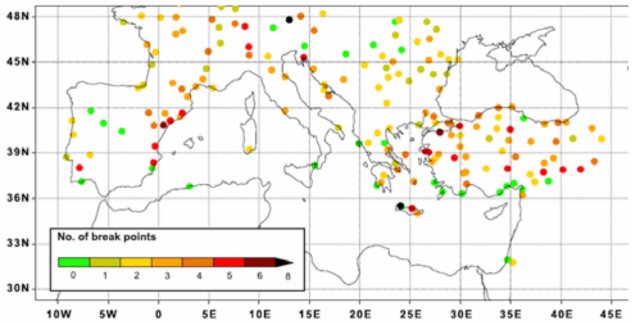


Figure 15: The number of breakpoints detected for each series indicated by color

Conclusions

- Long term climate records (instrumental and proxy) are very important for climate analysis, climate change detection, and mitigation and adaptation studies.
- There are explored and unexplored historical records in the eastern Mediterranean countries. But only a few people are aware of them. Authorities must be aware and consider of them in order to rescue and preserve them for the public benefit.
- Ottoman Turkey and the Balkans have suffered to a great extent the effects of Little Ice Age. Due to the prolonged drought, decreased wheat production resulted famine epidemic, and migration, many people migrated or perished.
- 50 years of Ottoman Empire climate records (1868-1918) need to be translated and digitized.
- Paleo-sources also can give very important information about ancient climate and offer the possibility of comparisons with the present.
- Prof Kuniholm, P., et all spend 30 years in Turkey and they have produced a valuable Anatolia Dendrochronology Database which is worth of attention.
- TSMS has quiet long digitized climate records from 1926 to now. But there are huge amount of historical records still waiting to be digitized.
- TSMS has been carried out climate analyses, contributing State of the Climate Reports and serving to support the WMO RA VI pilot RCC network to eastern Mediterranean Countries.

Current status of the observational network and climate data in Armenia

Anahit Hovsepyan
Armenian State Hydrometeorological and Monitoring Service, Yerevan, Armenia

INTRODUCTION:

Armenia is a small, typical mountainous country, located in the north-eastern part of Armenian plateau and occupies the area of about 30 000 sq. km with very complex topography and big variety of climate conditions. The diversity of climate zones, geographical location and complexity of the relief explain the necessity of dense meteorological observation network.

Armenian State Hydrometeorological and Monitoring Service is the authorized organization, which is responsible for hydrometeorological and climate related activities in the country, including the meteorological, hydrological, agrometeorological, actinometrical, radiation and ozone observations, scientific investigations, provision of climate/hydrological products, specialized consultations and weather warnings distributed to government authorities, private users, public and media. The history of meteorological observations in Armenia goes back to the midst of 19th century; the first observation station was established in Gumri in 1843. Since then about 290 observation sites have operated in Armenia during different periods, the highest density of network was in early 1960s when 77 stations were operating. Current observation network consists of 47 meteorological stations, 28 rain-gauge sites and 94 hydrological posts located in 7 main river basins. Based on the inventory and detailed analysis of data, 21 meteorological stations have been selected as reference network which serves as a basis for studying climate variability and change. Though the majority of data is digitized, nevertheless urgent actions are to be taken to rescue the big amount of valuable historical data and, moreover, the metadata which are still kept in paper books, since all the paper copies are endangered.

Other sources of climate information and data available in Armenia are old manuscripts, which are archived in the manuscript repository – Matenadaran, the Institute of Ancient Manuscripts and books. There is also another very comprehensive source of data The Satellite Application Facilities for Climate Monitoring (CM-SAF), which provides data for such Essential Climate Variables, as solar radiation components, cloud cover parameters and water vapor. These data have certain advantages, like very high resolution and availability in near-real time. But for applying these data to our region it is necessary to conduct some research to compare these data with in-situ observations and then to develop and apply merging technique.

ARMENIA IN BRIEF:

Armenia is situated in the north-eastern part of Armenian plateau, with the area of about 30000 sq. km, the maximum length is up to 360 km from the north-west to the south-east and the width up to 200 km in the widest part from west to east. Armenia is bordering Georgia to the North, Azerbaijan to the east and south-west, Turkey to the west and Iran to the south. Relief is basically mountainous and consists of numerous high mountain ridges (about 47% of the territory), intermountain hollows, extinct volcanic mountains, plateau and plains. The lowest altitude is about 370 m above sea level and the highest point is 4095 m (M. Aragats), the average altitude across the country is 1850 m. The major part of the country is located in the zone of 1500-2000 m a.s.l. Geographical location of Armenia and its complex mountain terrain have conditioned the diversity of natural conditions across the country. There are six climatic zones from dry subtropical to rigorous high mountainous and from everlasting snowcaps to warm humid subtropical forests and semi-desert steppes.

Figure 1: Geographical location of Armenia

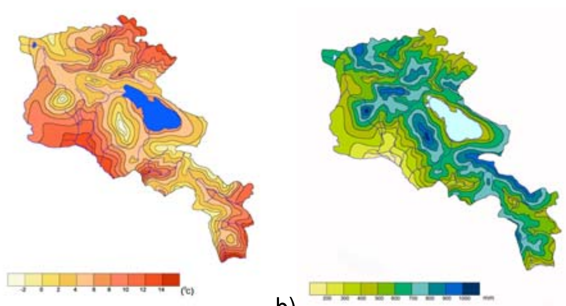
CLIMATE CONDITIONS:

Climate of Armenia is continental with hot and dry summers and severe snowy winters. There are four distinct seasons, i.e. winter (DJF), spring (MAM), summer (JJA) and autumn (SON).

Annual mean air temperature over Armenia is 5.5ºC; in the altitudes higher than 3000 m the annual average temperature is negative (-3ºC), while in lower altitudes (500-1000) the annual average temperature is about 12-14º (Fig.2a). In January, the average air temperature fluctuates between –13ºC (high mountains) and +10ºC (lowlands), depending on the altitude and peculiarity of the relief.

The absolute minimum temperature in Armenia is –42ºC recorded in Ashotsk (on the northwestern part of the country). During summer the average temperatures vary from 10ºC in high mountain regions to +24 up to +26ºC in lowlands where the absolute maximum temperature reached +43ºC in Meghri situated in the extreme south of the country.

The climate of Armenia is rather arid. The mean annual total precipitation is 592 mm and this amount is distributed quite unevenly across the country (Fig. 2b). In lowlands the total annual precipitation is about 200-250 mm, while in the mountains and highlands it reaches 1000 to 1100 mm. The rainiest periods are April-May and October-November, when about 40% of annual precipitation is being observed while the driest months are July and August which stand for only 10% of total annual rainfall.



a) b)

Figure 2: Annual air temperature (ºC) (a) and total precipitation (mm) (b) over Armenia (1961-1990 climatology)

METEOROLOGICAL OBSERVATION NETWORK:

The history of meteorological observation in Armenia counts more than one and a half century. First observation station was established in 1843 in Gyumri and the second one in 1844 in Yerevan. Initially, the observations were made sporadically and were not very accurate.

From the beginning of observations till present about 288 observation sites, including 80 meteorological stations and more than 180 rain-gauge sites have operated across the country (Figure 3) in different periods, but many of them have been closed.

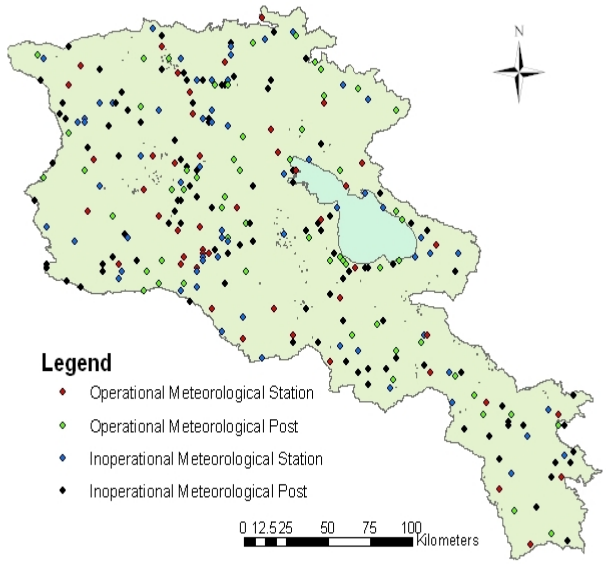


Figure 3: Location of observation sites (stations, rain-gauges) ever operating in Armenia

Figure 4 presents the evolution of meteorological observation network in Armenia starting from the beginning till present. The complete operational observation network consisted of about 23 meteorological stations was formed in the midst of the 1920s. The highest density of meteorological network was reported in 1962 (Figure 4) when 77 manned stations were operating.

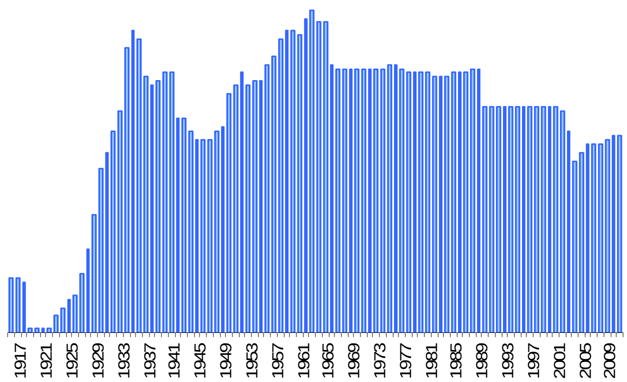


Figure 4: Evolution of meteorological observation network in Armenia

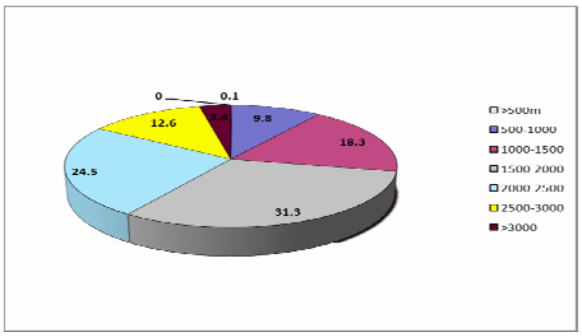
At present, the meteorological network of Armstatehydromet consists of 47 meteorological stations (including 3 specialized) which report synoptic and daily data, and 28 rain-gauge sites measuring precipitation twice per day. Five stations have data time series longer than 100 years; those are unique in the region due to their high mountainous location and duration of operation. However, it should be noted that several historical meteorological stations for some periods have operated as rain-gauge sites and vice versa. This information should be indicated in the station metadata during the digitization procedure for such stations and posts.

The diversity of climate conditions and the large fluctuation of altitudes across the country explain the necessity of dense meteorological observation network. The percentage of each elevation zone (a) from the total area and distribution of stations on different elevations (b) is presented on the figure 5.

Most of altitude zones are quite well represented by the stations and the number of stations is proportional to the area of each zone. Nevertheless, there is a gap in the vertical distribution of stations, since the zone 2500-3000 m a.s.l. which occupies about 13 percent of the entire territory is not represented by any station. Therefore, it is highly important to fill in this gap by re-opening the stations that earlier have operated in these regions.

In the current network, 12 stations are high-mountainous and located at the elevations above 2000 m above sea level, out of them 6 are remote and hard-to-reach stations. One of those stations is Aragats high-mountainous established in 1929 and situated at altitude of 3229 m above sea level. It is the only station in the Caucasus region located at such high altitude with long time series of temperature, precipitation and other meteorological variables and therefore it plays an important role in the investigations of regional climate variability and change. In 2008 it was included in the GCOS Surface Network (GSN) and since then it provides historical data and monthly updates (CLIMAT) to the network.

a)



b)

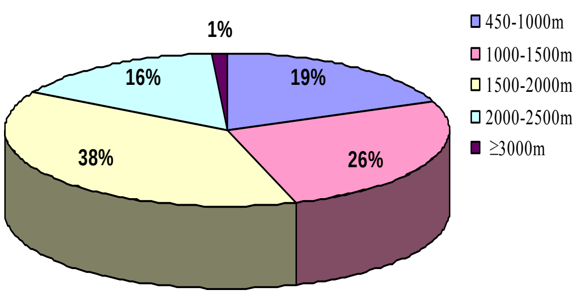


Figure 5: The distribution of altitudes over Armenia (a) and the distribution of meteorological stations for different zones (b)

The meteorological observations at classical stations are accomplished according to the requirements and instructions for operation of the hydro-meteorological stations and posts, as well as according to the Directive on global observations system (Volume 1, Published in 2003). The accuracy of the equipment and procedures of monitoring are in line with the WMO requirements and instructions (Manual No. 8, WMO "Meteorological Instruments and Methods of Operation"). Until 1935 the meteorological measurements were taken two times per day, since 1936 to 1965 the observations were taken four times per day and starting from 1966 the meteorological observations are conducted 8 times a day, every three hours.

DATA STORAGE AND ARCHIVING:

Currently at the Armstatehydromet the CLICOM system with DBMS Database undergoes an upgrade with CLiWare automated system. Synoptic and daily data from all meteorological stations are stored in the database. About 30% of data have the time series longer than 60 years, 10% - longer than 80 years and 5 stations have the time series longer than 100 years. The current method used for data quality control is a non real-time one and it is mostly made manually after transmitting the data from the database. Therefore, the data still contains big amount of errors, which is due to poor quality check system in CLICOM.

Along with the database, the historical meteorological records from 1885 to 1992 are stored in annual books and table sheets while the meteorological data since 1992 till present are stored in station monthly books. The agrometeorological observations are stored in books starting from 1949 and the hydrological data are stored in yearbooks starting from 1926. Generally, all the paper copies are endangered; therefore urgent actions have to be taken to rescue the big amount of valuable historical data.

IDENTIFICATION OF REFERENCE NETWORK:

The result of detailed analysis and inventory of existing data shows that the time series from 21 stations (Table 1) could serve as a basis for climate change assessment and studies. Out of these stations, four have the period of observation shorter than 50 years, five stations have between 51 and 60 years of observations, six stations have between 61 and 80 years of observations and six stations have more than 80 years of observations. These stations are distributed across the country as such that they represent each climatic and elevation zone. These reference stations have served as a basis for climate related studies performed in the Armstatehydromet.

Table 1: List of stations included in climatological reference network

Name of station	Elevation (m)	Number of years
Gyumri	1523	48
Ijevan	695	49
Sisian	1615	49
Gavar	1950	50
Yerevan	1113	55
Hankavan	1957	55
Vorotan pass	2387	56
Aparan	1891	59
Vanadzor	1376	59
Jermuk	2066	61
Ararat	819	75
Urtsadzor	1060	77
Meghri	661	79
Goris	1398	80
Stepanavan	1400	80
Aragats, h.m.	3229	81
Fantan	1799	81
Kadjaran	1980	82
Martuni	1943	83
Masrik	1940	84
Hrazdan	1766	85

Several reasons for the inhomogeneities of time series have been identified, which are common at most of the stations and can be listed as: displacement, upgrade of instruments, different frequency of observations, new observers, change of the surrounding area of the station, etc. The time series from the selected stations are homogenized manually, applying respective transition coefficients for different frequency of observations, station relocation, upgrade of instruments, etc.

The metadata are stored in station books, i.e. technical passport for each station, containing all the information about a station, starting from the date of establishment, geographical location, description of surrounding area, technical equipment, report on regular inspections on the condition of instruments, change of observer, replacement of instrument etc. This valuable information is not digitized, and these paper books need to be rescued.

Other sources of Climate Information:

The Institute of Ancient Manuscripts Matenadaran is a unique repository of ancient manuscripts located in Yerevan, Armenia. It holds one of the world's richest repositories of medieval manuscripts and books which span a broad range subjects, including history, philosophy, medicine, literature, science, art history and cosmography. The Matenadaran is in the possession of nearly 17,000 manuscripts and 30,000 other documents. Old manuscripts of this repository, meteorological hazards observed in the past and documented by witnesses and historiographers not only in Armenia but also in the region and all over the world.

Figure 6: The Institute of Ancient Manuscripts Matenadaran in Yerevan, Armenia

Satellite Derived Products:

Other very important and comprehensive sources of climate information are the products derived from satellite data, which are an important component in the climate observing system. They consist of conventional observations, remote sensing data and data sets which are created by means of numerical weather prediction models. The satellite-derived data provide a high spatial coverage compared to the conventional surface networks. As such, they can fill the gaps in the areas with scarce coverage of observations such as oceans or land regions with sparse conventional observations. They also provide information which cannot be measured from the ground, like the outgoing radiation at the top of the atmosphere. The Satellite Application Facility on Climate Monitoring (CM-SAF) generates and archives high-quality datasets for specific climate applications, through the exploitation of satellite measurements with the state-of-the-art algorithms to derive information about the climate variables of the Earth system. In addition to that, it provides high quality and reliable data sets with high spatial and temporal resolution. These data, in conjunction with the observation time series will significantly improve the monitoring of the climate system in Armenia and in the entire region (Figure 7).

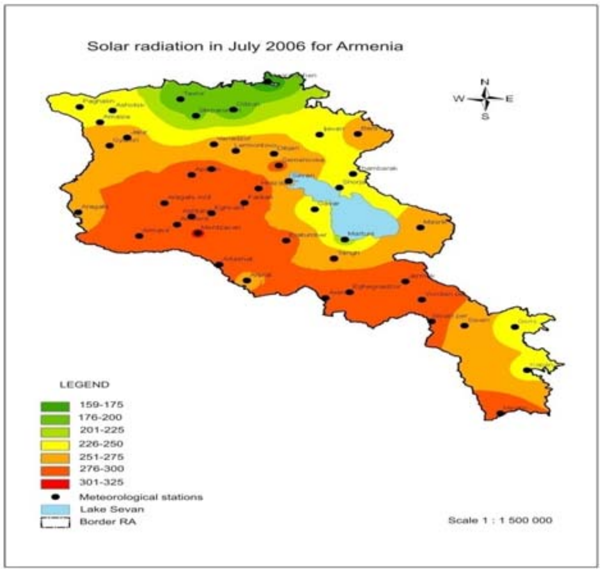


Figure 7: Sample map of solar radiation for Armenia, based on merged satellite/observation data

CONCLUSION:

Armenia has a long history of meteorological observations, which goes back to the midst of the 19th century. The diversity of climate conditions and the large fluctuation of altitudes across the country explain the necessity of dense meteorological observation network. At present, the meteorological network of Armstatehydromet consists of 47 meteorological stations (including 3 specialized), which currently report both synoptic and daily data. In addition to that 28 rain-gauge sites are measuring precipitation twice per day. Nevertheless, there is a gap in the network, since the altitude zone of 2500-3000 m a.s.l., which occupies about 13 percent of the entire territory, is not represented by any station.

The historical observation data are stored in the database managed with the CLiWare automated management system. The long time series with periods of observation ranging between 80 and 100 years are available in digital form for scientific studies. About 20 stations covering almost all elevation zones of the country have been identified as a potential reference network to represent all climate zones. The data from the selected stations are homogenized manually, applying respective transition coefficients for different frequency of observations, station relocation and upgrade of instruments. The quality check is also applied manually in non real time.

In spite of the availability of the database at Armstatehydromet, where most of observed meteorological data is archived in digital form, there are still a huge amount of valuable data and information stored on paper copies, in particular as part of historical records, metadata (in form of station books and technical passports), which are endangered to be lost and for which there is an urgent need for rescue the valuable information they contain.

The Observational Networks at the Jordan Meteorological Department

Mohammad Semawi
Meteorological Department P.P. Box 341011, Amman 11134, Jordan

INTRODUCTION:

Jordan is situated 80 km to the east of the Mediterranean Sea between the latitudes 29° 11’ N and 32° 42’ N and the longitudes 34° 54’E –38° 15’ E, having the surface of 89,329 km^2.

More than 90.2% of the country’s area is arid and receives annually less than 200 mm of rain, with precipitation pattern being latitude, longitude and altitude dependent. Rainfall decreases from north to south, west to east and from higher to lower altitudes. The relief of Jordan is extremely diverse. The eastern shore of the Jordan River, – the western part of the country – which is called the Ghor or the Jordan valley, represents the world deepest rift. This low land is stretching from north to south revealing areas with 200-400 m below MSL (Dead Sea is 408 m below MSL) forming climatic zone that annually receives up to 300 mm of rain and less than 120 mm in the south.

To the east of the Ghor the terrain extends abruptly upward comprising the hilly region. The elevation of this highland reaches approximately 1150 m above MSL in Ras Muneef. But in the southern part of the country it is higher than that; it reaches 1854 m above MSL at Um AL- Dami Mountain near the southern border where precipitation increases from less than 300 mm in the south to more than 500 mm in the north.

The hilly land slopes down eastward forming a semi-desert plateau called the Badia region. The area of the Badia region is approximately 75% of the total area of the country with elevations between 500 and 1200 m above MSL. This area includes all lands receiving annual rainfall of 50 to 200 mm and has general characteristics of seasonal contrasts in temperature.

Numerous deep wadis “valleys” created during winter due to mountains rain-fed floods cross the northern and southern heights. Such diversity of topography within a small country leads to great differences in climate.

CLIMATE IN JORDAN:

The climate in Jordan is predominantly Mediterranean. It is similar to the climate found in California U.S.A, Southeastern coast of Africa and Southeastern coast of Australia.

The climate of Jordan is marked by sharp seasonal variations in both temperature and precipitation. It is characterized by hot dry summers and cool wet winters. Summer starts around mid May and winter starts around mid November, with two short transitional periods in between (autumn and spring). Figure 1 shows main bioclimatic zones in Jordan

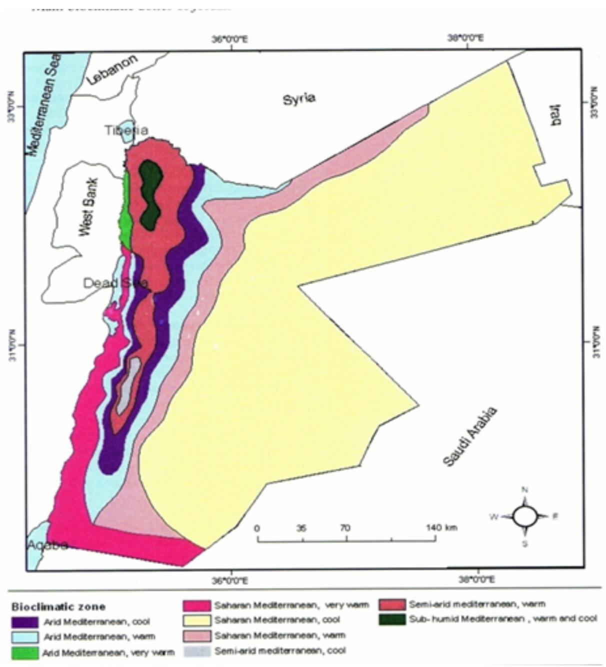


Figure 1: Main bioclimate zones of Jordan

The climate of Jordan could be divided into 4 main types according to the topography of the country, which has very well marked longitudinal zones in spite of its small area:

- Hilly Regions: characterized by cool dry summer and cold wet winter with good amount of rainfall.
- The Ghor: characterized by very hot summer and warm winter with rainfall amount around 77-392 mm.
- The Badia: characterized by very hot dry summer and cold with very little precipitation and clear sky during most of the year.
- The Gulf of Aqaba: characterized by very hot summer and warm winter with extremely little amount of precipitation.

Figure 2 give the location of the weather stations at the Jordan Meteorological Department.

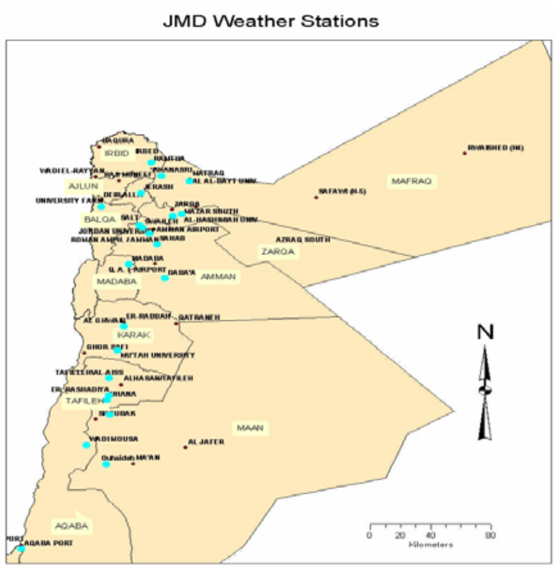


Figure 2: Weather stations network over Jordan

METHODS OF DATA COLLECTION AND INSTRUMENTATION:

Climate data (i.e. precipitation, soil moisture, soil and air temperatures, humidity, wind speed and direction, and solar radiation) are collected by from wide network of weather stations run by the Jordan Meteorological Department (JMD) .

The different classifications of the JMD network depend on the purpose of the information provided, time and frequency of readings. Stations involve arrangement of measurement, instruments, include thermometers to measure dry-bulb, wet-bulb, maximum, minimum and soil temperatures sun shine recorders, humidity meter, anemometer, pressure paragraphs, manual rain gauge rainfall recorders, evaporation pan, etc. Weather instruments are installed at the sites for readings of pressure, dry-bulb and wet-bulb temperatures, relative humidity, wind, sunshine duration, rain, solar irradiance, soil temperatures, soil moistures and evaporation, other observations on cloudiness, visibility, and state of weather are made at fixed times by eye.

According to WMO guide for climatological practice s and as a part of the worldwide weather watch, the JMD weather stations network (Table 1) consists of the following types:

- Principle or synoptic stations: the observations involve readings, taken either continuously or every three hours of pressure, dry-bulb and wet-bulb temperatures, relative humidity, wind, sunshine duration, rain, solar irradiance, soil temperatures, soil moistures, evaporation; other observations on cloudiness, visibility and state of weather are made at fixed times by eye.
- Agro-climate stations: are as synoptic stations except that their readings involve measurements for agriculture purposes like dew, solar irradiance, moisture contents and, grass minimum temperatures.
- Climate stations: at least twice a day, readings are taken of pressure, dry-bulb and wet-bulb temperatures, wind, cloudiness and state of the weather, along with the daily maximum and minimum temperatures, daily rainfall and remarks of any fog, frost or thunderstorms, etc.

Table 1. Jordan Meteorological Department Weather Stations

Station Name	District Name	Station Type	Observations		WMO #	Latitude			Longitude			Elevation
			Repetition	Time of measurements G.M.T								
Amman Airport	Amman	Synop	8 *	00, 03, 06, 09, 12 ,15, 18, 21	40270	31	59	N	35	59	E	781
Jordan University	Amman	Normal Climate	2	06, 12		32	1	N	35	53	E	980
Roman Ampt.Amman	Amman	Normal Climate	3	06, 09, 12		31	57	N	35	57	E	750
Swaileh	Amman	Synop	3	06, 09, 12	40269	32	0	N	35	54	E	1050
Q.A.I.Airport	Amman	Synop	8*	00, 03, 06, 09, 12, 15, 18, 21	40272	31	43	N	35	59	E	722
Wadi Al-Qattar	Amman	Main Climate	2	06, 12				N			E	863
Baqura	Irbid	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40253	32	40	N	35	37	E	-170
Irbed	Irbid	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40255	32	33	N	35	51	E	616
Ramtha	Irbid	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40252	32	30	N	35	59	E	590
Wadi El-rayyan	Irbid	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40256	32	24	N	35	35	E	-200
Sama	Irbid	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21		032	35	N	35	42	E	332
Deir Alla	Balqa	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40285	32	13	N	35	37	E	-224
Salt	Balqa	Synop	8	00, 03, 06, 09, 12, 15, 18, 21	40268	32	2	N	35	44	E	796
University Farm	Balqa	Climate	2	06, 12		32	10	N	35	37	E	-230
Mafraq	Mafraq	Synop	8*	00, 03, 06, 09, 12, 15, 18, 21	40265	32	22	N	36	15	E	686
AL-MEDWAR	Mafraq	Normal Climate	2	06,12		032	17	N	36	0	E	840
Rwaished (H4)	Mafraq	Synop	8*	00, 03, 06, 09, 12, 15, 18, 21	40250	32	30	N	38	12	E	683
Safawi (H5)	Mafraq	Synop	8*	00, 03, 06, 09, 12, 15, 18, 21	40260	32	12	N	38	08	E	674
Shoubak	Ma'an	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40300	30	31	N	35	32	E	1365
Ma'an	Ma'an	Synop	8	00, 03, 06, 09, 12, 15, 18, 21	40310	30	10	N	35	47	E	1069
Wadi Mousa	Ma'an	Normal Climate	3	06, 09, 12	40313	30	19	N	35	28	E	1115
Al Fjaij	Ma'an	Main Climate	2	06, 12		30	33	N	35	38	E	1263
Ouhadeh	Ma'an	Main Climate	2	06, 12		30	10	N	35	36	E	1293
Al Jafer	Ma'an	Synop	8*	00, 03, 06, 09, 12, 15, 18, 21	40305	30	17	N	36	09	E	865
Wadi Dhulall	Zarqa	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40267	32	09	N	36	17	E	580
Azraq North	Zarqa	Main Climate	2	06,12		31	51	N	36	49	E	533
Zarqa Refinery	Zarqa	Normal Climate	2			32	05	N	36	07	E	555
Ghabawi	Zarqa	Synop	8*	00, 03, 06, 09, 12, 15, 18, 21	40244	31	59	N	36	13	E	725
ZARQA	Zarqa	Normal Climate	4	06, 12	40273	032	08	N	36	07	E	644
Al-Hashimiah	Zarqa	Main Climate	2	06, 12		32	06	N	36	11	E	575
Azraq South	Zarqa	Synop	8*	00, 03, 06, 09, 12, 15, 18, 21	40288	31	50	N	36	49	E	521
Alhasan/Tafileh	Tafileh	Normal Climate	2	06, 12	40298	30	47	N	35	43	E	1200
Tafileh / Eiss	Tafileh	Main Climate	8	00, 03, 06, 09, 12, 15, 18, 21	40298	30	50	N	35	38	E	1260
Al Rashadiah	Tafileh	Main Climate	2	06, 12		30	42	N	35	38	E	1500
Khanasry	Tafileh	Main Climate	2	06, 12		32	24	N	36	03	E	863
Ghor Safi	Karak	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40296	31	2	N	35	28	E	-350
Al Ghwair	Karak	Main Climate	2	06, 12		31	14	N	35	45	E	980
Daba'a	Karak	Main Climate	2	06, 12		31	36	N	36	3	E	750
Qatraneh	Karak	Normal Climate	8	00, 03, 06, 09,	40275	31	15	N	36	07	E	768
Mu'tah	Karak	Normal Climate	2	06, 12		31	3	N	35	42	E	1105
Er Rabbah	Karak	Agriculture	8	00, 03, 06, 09, 12, 15, 18, 21	40292	31	16	N	35	45	E	920
Ras Muneef	Ajlon	Synop	8	00, 03, 06, 09, 12, 15, 18, 21	40257	32	22	N	35	45	E	1150
Madaba	Madaba	Normal Climate	2	06, 12		31	43	N	35	48	E	785
King Hussien International Airport	Aqaba	Synop	8*	00, 03, 06, 09, 12, 15, 18, 21	40340	29	33	N	35	0	E	51
Aqaba Port	Aqaba	Coastal Marine	2	06, 12		29	31	N	35	00	E	2
Jarash	Jarash	Main Climate	2	06, 12		32	16	N	35	54	E	540

* Observations are taken hourly and the standard G.M.T (00, 03, 06, 09, 12, 15, 18, 21)

A climate station provides less information than a synoptic or agro-climate station. Readings of the measurements at synoptic stations are done at the fixed Greenwich Mean Time "G.M.T." (i.e. 00, 03, 06, 09, 12, 15, 18 and 21). JMD station names of each kind, and the daily frequency of the observations are shown in the Table below, where thirteen (13) synoptic stations and eight (8) agro-climate stations with daily frequency of observations at 00, 03, 06, 09, 12 15, 18 and 21 (G.M.T.), the majority of the climate stations take measurements at 06 and 12 (G.M.T.).

METHODS FOR QUALITY ASSURANCE:

Historically, the climate section manager would receive reports from field stations once per month in a hand-written format (no real time data). Most climate and agro-climate data in JMD have been recorded on charts; most of the emphasis on quality assurance is made on chart data and the comparison with the recorded values on the logbooks. The general procedure for quality assurance consists of first inspection of the charts for problems such as stuck pens or missing ink lines and reading observer's notes before fixing any numbers. He and his staff quality controls these data and passes them along to data-entry staff to input the values to the JMD database (Oracle 9i). These values would then be printed and reviewed again for data-entry accuracy. Another step for quality control takes place while computerizing the data using the entry forms of the Jordan Climate Data Management software (JCDMS), an Oracle-based system built by the JMD for data processing and retrieval.

The agro-climate division receives daily-value reports from field stations every 10 days and once per month in a hand-written format. The measured data undergo manual check against human and instruments errors and then is transferred to a new computerized database.

Rainfall data sources in JMD are available from two main sources. The first one is collecting daily totals and rainfall intensity (depths accumulated at various times) data. Commonly, rainfalls are collected in simple volumetric gauges located throughout JMD weather network and provide general information about the spatial variation of daily, monthly, and annual precipitation. Each day at a prescribed time (usually 8:00 am local time) the station observer records in a data log the height of a water column in a fixed rain gauge. The gauge is then emptied and prepared for the next day measurement. The value read at 8 am is identified as the daily rainfall amount for the previous day. For example, the measured value at 8 am on 17th of January is recorded as the daily rainfall amount for 16th of January. The rainfall intensity data are available at rainfall recording stations (Table below) that are fewer in number than the simple volumetric gauges used for daily rain collection. Chart recorders (pluviograph) are serviced daily, weekly, or monthly, depending on the design of the instrument and the length of the chart in the recorder. The station observer records the date and the time when the pen begins and ends on the chart and, also notes any special conditions, such as snow or damage to the chart. Each month, all charts are sent to the main office for processing (Table 2).

Table 2. Strip charts archive

Daily Strip Chart				
Missing Charts	Archive Charts	Period	STATION	No.
396	2100	1949-2005	Amman Airport	1
72	586	1964-2005	Ma'an	2
45	1844	1965-2005	Irbed	3
82	879	1982-2005	Shoubak	4
5	508	1983-2005	Qatraneh	5
467*	1331	1962-2005	Deir Alla	6
146	1876	1967-2005	Baqura	7
25	306	1967-2005	Aqaba Airport	8
16	1407	1971-2005	Wadi El-Rrayan	9
9	446	1982-2005	Azraq North	10
50	90	1980-2005	Wadi Mousa	11
13	230	1980-2005	Al Jafer	12
39	1083	1973-2005	Q. A. I. Airport	13
407	874	1970-2005	Wadi Dhulail	14
12	1326	1976-2005	Ras Muneef	15
22	712	1978-2005	Ghor Safi	16
6	540	1980-2005	Azraq South	17
11	824	1985-2005	Swaileh	18
Weekly Strip Chart				
Missing Charts	Archive Charts	Period	Station	No.
6	118	1965-2005	Rwaished (H4)	19
7	65	1976-2005	Madaba	20
7	262	1982-2005	Jordan University	21
5	132	1965-2005	Mafraq	22
4	109	1975-2005	Er-Rabbah	23
5	87	1981-2005	University Farm	24
8	64	1991-2005	Salt	25
13	119	1975-2005	Alhasan/Tafileh	26
12	124	1981-2005	Safawi (H-5)	27
21	127	1976-2005	Ramtha	28

STATION NETWORK AND OBSERVATION PERIODS:

The historical weather network of the Jordan Meteorological Department (JMD) is a moderate-quality sized data set of hourly (every 3 or 6 hours) daily and monthly averaged data for temperature, total precipitation and other weather parameters, developed to assist in the weather forecast and climate research. The JMD network is comprised of 46 surface weather stations and one upper air station; the period of record varies for each station but in general it includes the period 1970-2005.

The JMD has implemented a new project for automatic weather stations. Two automatic weather stations have been recently installed in Baqura and Amman airport and other two automatic weather stations with temperature, wind and rainfall sensors were installed in Deir ala and Wadi Dhulall. Unfortunately, the automatic weather stations are not networked and data are not available in any format.

Rainfall is closely monitored during the rainfall season, which is usually from September, till May. The JMD rainfall gauges are spread through out the kingdom. There are two kinds of rain gauges used at JMD weather network; manual gauge and the recorder rain gauge. Data from 55 rain gauges were available in digital format.

All rainfall recorders and manual gauges in the JMD have the collecting area of 200 cm². Rainfall amounts from rain recorders and manual gauges are collected daily at 08:00 am, Jordan local time.

The percentage of missing data for the synoptic and agro–climate stations is less than 13% for temperatures and less than 7.5% for rainfall. The Table 3 shows that missing data percentage for climate stations reaches 33% for temperatures and 23% for rainfall records.

At most of the sites, the manual gauge had more years of available records than in the case of the recorder, so some differences in the average annual precipitation are attributable to the slightly different record lengths. In most cases, however, the differences indicate some missing periods of observations at the recorders during many years of data collection.

The procedures for estimating the missing data are not applied in the JMD and the data for these stations are not adjusted either for homogeneity.

Table 3. Period of observations and missing data percentage

Station Name	Missing Data				Period	Years with	Years with	Missing data Percentage	
	Temperature		Precipitation						
	Years	Month	Years	Month				Temp	Prec
Baqura	1967 1969 1970	1, 2, 3, 4 12 1	1967 1969 1970	1, 2, 3, 4 12 1	40	37	37	7.5	7.5
Deir Alla	1952	1, 2, 3, 4,5	1952	1, 2, 3, 4,5	53	52	52	1.9	1.9
Ghor Safi	2005	13/12			30	29	30	.03	0.0
Irbed	2005	3, 4, 5, 6, 7, 8, 9, 10, 11, 12			50	50	50	0	0
Er Rabbah	1962 1963 1964 1965 1966	4, 5, 6, 7, 8, 9, 10 1, 5, 6, 7 6, 10, 11 1, 2, 6, 10	1965	11	44	39	43	11	2.2
Shoubak	1960 1962 1963 1964	1, 2, 3, 4, 5, 6, 7 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10			45	41	45	8	0
Wadi Dhulall					37	37	37	0.0	0.0
Wadi El-rayyan	1971	5	1970 1971	10, 11 1,5	44	43	42	2.2	4.5
Swaileh	1985 2004	6, 7 5	2004	5	20	18	24	10	0
Alhasan/Tafileh	1993 1999	11 3	1999	3, 9	32	30	31	6	3
Qatraneh					21	21	21	0.0	0
Roman Ampt.Amman	1999 2002	1 2	1999 2002	1 2	31	28	28	9	9
	2003	9	2003	9					
Madaba	1969 1976 1999	1, 2, 3, 4, 5, 6, 7, 8 1, 2, 3, 4 8			35	32	35	8	0
Wadi Mousa	1984 1985 1993 1994 1995 1998 1999	1, 2, 3, 4, 8, 9 5 2 2, 3, 4 8, 12 6, 7, 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8	1993 1994 1995 1998 1999	2 2, 3, 4, 5, 6 6, 12 5, 6, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8	21	14	21	33	23
Salt	1991 2002	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 5	1985 1986 1987 1988 1989 1990 1991 2002	10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, 12 11, 12 5	13	11	8	15	61
Aqaba					46	46	59	0.0	0
Ras Muneef	1976	1,2,3,4,5,6,7			28	27	0	3.5	0
Amman Airport					82	82	82	0.0	0
Rwaished (H4)					44	44	44	0.0	0
Mafraq	1953 1956 1957 1958 1959	1,2 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6			52	47	52	10	0
Safawi (H5)					41	41	41	0	0
Azraq South	1980	1, 2, 3, 4, 5, 6, 7, 8, 9, 10			24	23	24	4	0.0
Q.A.I.Airport	1970	1, 2, 3, 9			34	33	34	3	0
Ma'an	2003 2005	5 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 ,11, 12	2003	5	45	43	44	4.5	2.5
Al Jafer	1976 1977 1978 1979 1980	9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12			40	35	40	12.5	0

OTHER OPERATIONAL COMPONENTS OF THE JMD:

The National Forecasting Center (NFC) prepared predictions about general and specific weather phenomena for a given area based on observations of such weather related factors as atmospheric pressure, wind speed and direction, precipitation, cloud cover, temperature, humidity, frontal movements, etc.

The NFC is connected to the new RMDCN Network of Regional Association VI of the WMO. Meteorologists use several tools to help them to forecast the weather for Jordan. These tools fall under two categories: tools for collecting data and tools for coordinating and interpreting data.

- *Tools for collecting data* include:
  - Instruments such as thermometers, barometers, hygrometers, rain gauges, anemometers, wind socks and vanes, Doppler radar and satellite imagery (SDUS, PDUS, HRPT, MDD, SADIS, and RETIM). Raw data and products (GRID, GRIB, T4) received from Global and Regional centers (Offenbach, Toulouse, Braknell)
  - Message switching system (AMSS) comprising of Pilot/standby Servers and LAN connecting the forecasting offices at civil and military airports (TCP/IP Protocol used for data transmission), SADIS products used at Queen Alia International Airport for aviation purposes, MDD satellite broadcasts received as standby to AMSS and SADIS systems (Figure 13).
  - The forecasting offices and observing stations are connected to the national forecasting center through telephone lines, ISDN and Internet services and fax machines.
- *Tools for coordinating and interpreting data* include:
  - weather maps and models products from Global and Regional centers (Offenbach, Toulouse, Braknell).

Recently the JMD started a pilot project aim at linking a number of weather stations to the NFC and the database center. ArcView 8.2 single use (licensed for arc map, arc calatlog and spatial analysis) is installed at the JMD climate division for GIS users. Figure 3 shows the network of the JMD telecommunication system.

In a typical weather forecast, the collected data are analyzed in order to issue the short weather forecast (1-7 days) for Jordan, which can be provided by the NFC and via internet web page www.jomeeteo.gov.jo. Also, the NFC receive seasonal forecast from many world centers (ECMWF and IRI).

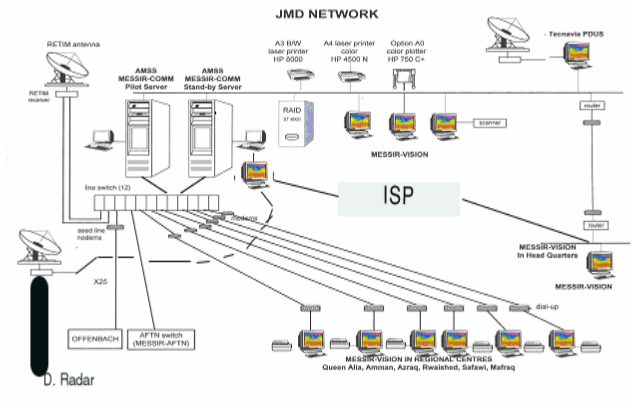


Figure 3: JMD network of telecommunication system

AVAILABLE DATA AND DATABASES:

Climate and Agro-climate databases at JMD

Climate and agro-climate data are available in digital format in the Oracle database; the size of the database is more than 700MB. It is comprehensive and contains the data stored on all climate and agro-climate parameters in Jordan. The period of observation for some data spans from 1922 to current day. The database contains data for hourly, daily and monthly climate data. Below, there is a description of those type of data collected and stored in the climate database.

The climate and agro-climate database contains more than 35 tables. The names of the tables and the fields of the database are shown in the Table 4. The main tables contains; DAILY_DATA, HOURLY_DAILY_DATA and MONTHLY_DATA

For hourly data, each station has a unique identification number which is stored in the tables of the database. Also, the coordinates of the location, the element code, the date of measurements (year, month, day) and the value of the measurements are stored for each station. This data is collected throughout the year on a monthly basis and it is stored accordingly; it is available in digital format and can be extracted and used for analysis. The four hourly data at 00, 06, 12 and 18 GMT are the main primary data in the climate and agro-climate database, while the measurements taken at the intermediates time 03, 09, 15 and 21 GMT are still not computerized and archived on paper forms.

Daily data are the data taken from measurements one time every 24 hour such as, maximum and minimum temperature, evaporation and rainfall at specified time for each parameter. Also, each station in this table has unique identification number, element code, date (year, month, day) and the value of the measurements.

The DAILY_DATA, HOURLY_DAILY_DATA and MONTHLY_DATA are joined with other tables to derive other information, including meta-data, date of extreme element, etc.

The JMD Database contains data tables needed for:

- Information system (Site, Definition, Instrument, User privilege).
- Metadata (Station info, Station instrument, Elements, Station elements, Station location update).
- Data Entry (Upper air, Daily, Synoptic).
- View Climate Data (Daily element extreme, Synoptic element extreme, Monthly data, Daily data, Synoptic data)

Detailed information on what those tables contain is summarized below:

- Reporting or output (Climate data, Metadata, Normals)
- Rainfall intensity data for selected stations through opendate has been digitized and exists in digital format from Access and Oracle databases.

The Jordan Climate Data Management System (JCDMS) application -,based on Oracle developed by Jordan Meteorological Service- Climate Division, has the capability to import and export climate data in digital format and also to generate other climate and agro-climate information.

The JCDMS Reference Manual provides full details on how to use the JCDMS application for data entry, data retrieve and how to generate the reports.

Modifications can easily be done for any request of climate data through new SQL statements.

A variety of agro-climate elements from the agro-climate database, on basis of daily and 10-day information can be printed out or exported in digital format. The table 4 shows the agro-climate elements available from the agro-climate stations for the period indicated under each station.

Daily rainfall and rainfall intensity data are available in digital format. More than 50,000 rainfall strip charts have been digitized using the RAINDIGITIZER software.

Data can be distributed upon request to customers and to various sectors on hourly, daily basis, every 10 days or at the end of each month. Daily precipitation amounts, daily maximum and daily minimum temperatures at 46 stations from the JMD climate database are available in digital format for: every 6 hours, daily, 10-day, monthly averages and long term monthly means or “normals” observations.

Table 4. The agro-climate elements available in the agro-climate database

Agro-climate stations							
Station	Baqura	Deir Alla	Ghor Safi	Irbid	Wadi Dhulall	Rabba	Shoubak
Period	1968-	1953-	1975-	1955-	1968-	1955-	1961-
The agro-climate elements available from the database							
Minimum Temperature: °C, 10-Day Mean							
Maximum Temperature: °C, 10-Day Mean							
Grass Minimum Temperature: °C, 10-Day Mean							
Evaporation Class "A" Pan: mm/day, 10-Day Total							
Precipitation: mm, 10-Day Total							
Sunshine Duration: hours, 10-Day Mean							
Solar Radition: cal/cm²/day, 10-Day Mean							
Net Terrestrial Radition: cal/cm²/day, 10-Day Mean							
Net Radiation: Cal/cm²/day, 10-Day Mean							
Wind speed: km/h, 10-Day Mean							
Growing Degree Days, Threshold Temperature: 5°C, 10-Day Total							
Growing Degree Days, Threshold Temperature: 7.1°C, 10-Day Total							
Growing Degree Days, Threshold Temperature: 10°C, 10-Day Total							

Growing Degree Days, Threshold Temperature: 12.5°C, 10-Day Total						
Agro-climate Stations						
Station	Baqura	Ghor Safi	Irbid	Wadi Dhulall	Rabba	Shoubak
Period	1977-	1977-	1977-	1977-	1977-	1977-
The agro-climate elements available from the database						
Reference Crop Evapotranspiration Class "A" Pan: mm/day, 10-Day Total						
Reference Crop Evapotranspiration: mm/day, 10-Day Total						
Maximum Relative Humidity: %, 10-Day Mean						
Minimum Relative Humidity: %, 10-Day Mean						
Vapoure Pressure: mb, 10-day mean						
Saturation Deficit: mb,10-day						
Days Number With Relative Humidity <40% , 10-Day Mean						
Days Number with Relative Humidity >70% , 10-Day Mean						
Agro-climate Stations						
Station	Deir Alla	Ghor Safi	Irbid	Wadi Dhulall	Rabba	Shoubak
Period	1986-	1986-	1986-	1986-	1986-	1986-
The agro-climate elements available from the database						
Sub-zero hours, 10-Day Total						
Cooling hours, 10-Day Total (temperature 0.1 - 7 °C)						

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Abbreviations

ACRE: Atmospheric Circulation Reconstructions over the Earth

ADVICE: Annual to Decadal Variability in Climate in Europe (EU research project)

AEMET: Agencia Española de Meteorología (Spain)

ASCII: American Standard Code for Information Interchange

AWOS: Automated Weather Observing System

AWS: Automatic Weather Station

BDCLIM: French Climatological Data Base

BMS Bulgarian Meteorological Service

C3: Centre for Climate Change at URV (Spain)

CAgM: Commission for Agricultural Meteorology (WMO)

CARIBSAT: Caribbean Satellite Environmental Information System

CATDARE: Catalan Data Rescue project

CBS: Commission for Basic Systems (WMO)

CCl: Commission for Climatology (WMO)

CDMP: Climate Database Modernization Program (NOAA)

CDMS: Climate Data Management System

CENMA/IEA: Snow and Mountain Research Centre of Andorra/Andorran Studies Institute

CHy: Commission for Hydrology (WMO)

CIMME: Climate Change in the Mediterranean and the Middle East

CIMO: Commission for Instruments and Methods of Observations (WMO)

CIRCE: Climate Change and Impact Research: The Mediterranean Environment (European research project)

CLICOM: Climate computing (WMO) software

CLIDATA: Climate Data Management from HMI - ATACO

ClimDev: Climate Development program for Africa

CLIMSOFT: Climate Software from Zimbabwe-Guinea-Kenya-Met offices

CLIMSOL: Climate data management and digitisation tool at BDCLIM

CLISYS: Climate System from Météo-France

CLIVAR: Climate Variability and Predictability project (WCRP)

CLIWARE: Climate data management system from Russian Federation

CM-SAF: Satellite Application Facilities for Climate Monitoring (at DWD)

CNMCA: *Centro Nazionale di Meteorologia e Climatologia Aeronautica (Italy)*

COST Action: European Cooperation in Science and Technology

CRU: Climatic Research Unit at UEA (UK)

CWD: *Consecutive Wet Days Index* (from the ETCCDI core climate extreme indices)

DARE: Data Rescue

DWD: Deutscher Wetterdienst (Germany NMS)

ECMWF: European Centre for Medium-Range Weather Forecasts

ECVs: Essential Climate Variables from GCOS

EEWRC: The Cyprus Institute - Energy, Environment & Water Research Center

EMULATE: European and North Atlantic daily to Multidecadal climate variability (EU research project)

ESF: European Science Foundation

ETCCDI: Expert Team on Climate Change and Indices

ET-CDMS: Expert Team on Climate Data Base Management Systems (WMO/CCl)

ET-DARE: Expert Team on Data Rescue (WMO/CCl)

EURO4M: European Reanalysis and Observations for Monitoring (EU research project)

FEDA: Andorran Energy Supply Company

GCOS: Global Climate Observing System

GFCS: Global Framework for Climate Services (WMO)

GMR: Grater Mediterranean Region

GSL: Growing Season Length Index (from the ETCCDI core climate extreme indices)

GSN: GCOS Surface Network

GTS: Global Telecommunication System

HNMS: Hellenic National Meteorological Service (Greeze)

HOME: Advances in homogenisation methods of climate series: an integrated approach (COST Action ES0601)

ICTP: International Centre for Theoretical Physics (Italy)

ID: Identification code

I-DARE: International Data Rescue web portal

IPCC: Intergovernmental Panel of Climate Change

IPCC-AR5: Intergovernmental Panel of Climate Change/Fifth Assessment Report

IRI: International Research Institute for Climate and Society (USA)

JCDMS: Jordan Climate Data Management System from JDM (Jordan)

JCOMM: Joint Commission for Oceanography and Marine Meteorology

JDM: Jordan Meteorological Department

LIA: Little Ice Age

MDB: Meteorological Database (at NIMH–BAS)

MEDARE: Mediterranean Data Rescue Initiative (WMO)

METADEM: Catalonian Metadata of Meteorological Stations Database

Météo-France: French Meteorological Service

NAO: North Atlantic Oscillation

NASA: National Aeronautics and Space Administration

NCDC: National Climatic Data Center (USA)

NFC: National Forecasting Center at JMD (Jordan)

NIMH-BAS: National Institute of Meteorology and Hydrology at the Bulgarian Academy of Sciences (Bulgaria)

NMHSs: National Meteorological and Hydrological Services

NMSs: National Meteorological Services

NOA: National Observatory of Athens station (Greeze)

NOAA: National Oceanic and Atmospheric Administration (USA)

NWP: Numerical Weather Prediction

OCR: Optical Character Recognition

ONM: Office National de la Météorologie (Algeria)

OPACE: Open Panel of CCl Experts (WMO/CCl)

PR: Permanent Representative within WMO

PRCPTOT: Total Precipitation Index (from the ETCCDI core climate extreme indices)

QC: quality control

R10: Annual count of days when PRCP≥ 10mm Index (from the ETCCDI core climate extreme indices)

R20: Annual count of days when PRCP≥ 20mm Index (from the ETCCDI core climate extreme indices)

RA: Regional Association (WMO)

RAP: Regional Action Plan (GCOS)

RCC: Regional Climate Centre (WMO)

RMDCN: Regional Meteorological Data Communication Network (WMO)

SAO/NASA: Smithsonian Astrophysical Observatory/ National Aeronautics and Space Administration

SDATS: Spanish Daily Adjusted Temperature Series

SI: International System of Units

SMC: Servei Meteorològic de Catalunya

SNHT: Standard Normal Homogeneity Test

SQL: *S*tructured Query Language

START: System for Analysis, Research and Training

STS: Spanish Temperature Series

TECO: WMO/CCI Technical Conference

TSMS: Turkish State Meteorological Service (Turkey)

TT-NCMP: Task Team on National Climate Monitoring Products (WMO/CCI)

TX10P: Cold days (from the ETCCDI core climate extreme indices)

TX90P: Warm days (from the ETCCDI core climate extreme indices)

UEA: University of East Anglia (UK)

URV: University Rovira I Virgili (Spain)

WCDMP: World Climate Data and Monitoring Programme

WCRP: World Climate Research Project

WIS: WMO Information System

WMO/EC: World Meteorological Organisation-Executive Council

WMO: World Meteorological Organisation

WSDI: Warm Spells Duration Index (from the ETCCDI core climate extreme indices

Reports published in The World Climate Data Programme (WCDP)/World Climate Data and Monitoring Programme (WCDMP) Series

WCDP-1	WMO REGION III/IV TRAINING SEMINAR ON CLIMATE DATA MANAGEMENT AND USER SERVICES, Barbados, 22-26 September 1986 and Panama, 29 September 3 October 1986 (available in English and Spanish) - (WMO-TD No. 227)
WCDP-2	REPORT OF THE INTERNATIONAL PLANNING MEETING ON CLIMATE SYSTEM MONITORING, Washington DC, USA, 14-18 December 1987 - (WMO-TD No. 246)
WCDP-3	GUIDELINES ON THE QUALITY CONTROL OF DATA FROM THE WORLD RADIOMETRIC NETWORK, Leningrad 1987 (prepared by the World Radiation Data Centre, Voeikov Main Geophysical Observatory) - (WMO-TD No. 258)
WCDP-4	INPUT FORMAT GUIDELINES FOR WORLD RADIOMETRIC NETWORK DATA, Leningrad 1987 (prepared by the World Radiation Data Centre, Voeikov Main Geophysical Observatory) - (WMO-TD No. 253. p. 35)
WCDP-5	INFOCLIMA CATALOGUE OF CLIMATE SYSTEM DATA SETS, 1989 edition (WMO-TD No. 293)
WCDP-6	CLICOM PROJECT (Climate Data Management System), April 1989 (updated issue of WCP-I 1 9) - (WMO-TD No. 299)
WCDP-7	STATISTICS ON REGIONAL NETWORKS OF CLIMATOLOGICAL STATIONS (based on the INFOCLIMA World Inventory). VOLUME II: WMO REGION I - AFRICA (WMO-TD No. 305)
WCDP-8	INFOCLIMA CATALOGUE OF CLIMATE SYSTEM DATA SETS - HYDROLOGICAL DATA EXTRACT, April 1989 - (WMO-TD No. 343)
WCDP-9	REPORT OF MEETING OF CLICOM EXPERTS, Paris, 11-15 September 1989 (available in English and French) - (WMO-TD No. 342)
WCDP-10	CALCULATION OF MONTHLY AND ANNUAL 30-YEAR STANDARD NORMALS, March 1989 (prepared by a meeting of experts, Washington DC, USA) - (WMO-TD No. 341)
WCDP-11	REPORT OF THE EXPERT GROUP ON GLOBAL BASELINE DATASETS, Asheville, USA, 22-26 January 1990 - (WMO-TD No. 359)
WCDP-12	REPORT OF THE MEETING ON HISTORICAL ARCHIVAL SURVEY FOR CLIMATE HISTORY, Paris, 21-22 February 1990 - (WMO-TD No. 372)
WCDP-13	REPORT OF THE MEETING OF EXPERTS ON CLIMATE CHANGE DETECTION PROJECT, Niagara-on-the-Lake, Canada, 26-30 November 1990 - (WMO-TD No. 418)

Note: *Following the change of the name of the World Climate Data Programme (WCDP) to World Climate Data and Monitoring Programme (WCDMP) by the Eleventh WMO Congress (May 1991), the subsequent reports in this series will be published as WCDMP reports, the numbering being continued from No. 13 (the last 'WCDP" report).*

WCDMP-14 REPORT OF THE CCI WORKING GROUP ON CLIMATE CHANGE DETECTION, Geneva, 21-25 October 1991

WCDMP-15 REPORT OF THE CCI EXPERTS MEETING ON CLIMATE CODE ADAPTATION, Geneva, 5-6 November 1991 - (WMO-TD No. 468)

WCDMP-16 REPORT OF THE CCI EXPERTS MEETING ON TRACKING AND TRANSMISSION OF CLIMATE SYSTEM MONITORING INFORMATION, Geneva, 7-8 November 1991 - (WMO-TD No. 465)

WCDMP-17 REPORT OF THE FIRST SESSION OF THE ADVISORY COMMITTEE ON CLIMATE APPLICATIONS AND DATA (ACCAD), Geneva, 19-20 November 1991 (also appears as WCASP-18) - (WMO-TD No. 475)

WCDMP-18 CCI WORKING GROUP ON CLIMATE DATA, Geneva, 11-15 November 1991 (WMO-TD No. 488)

WCDMP-19 REPORT OF THE SECOND CLICOM EXPERTS MEETING, Washington DC, 18-22 May 1992 - (WMO-TD No. 511)

WCDMP-20 REPORT ON THE INFORMAL PLANNING MEETING ON STATISTICAL PROCEDURES FOR CLIMATE CHANGE DETECTION, Toronto, 25 June, 1992 (WMO-TD No. 498)

WCDMP-21 FINAL REPORT OF THE CCI WORKING GROUP ON CLIMATE DATA AND ITS RAPPORTEURS, November 1992 - (WMO-TD No. 523)

WCDMP-22 REPORT OF THE SECOND SESSION OF THE ADVISORY COMMITTEE ON CLIMATE APPLICATIONS AND DATA (ACCAD), Geneva, 16-17 November 1992 (also appears as WCASP-22) - (WMO-TD No. 529)

WCDMP-23 REPORT OF THE EXPERTS MEETING ON REFERENCE CLIMATOLOGICAL STATIONS (RCS) AND NATIONAL CLIMATE DATA CATALOGUES (NCC), Offenbach am Main, Germany, 25-27 August 1992 - (WMO-TD No. 535)

WCDMP-24 REPORT OF THE TENTH SESSION OF THE ADVISORY WORKING GROUP OF THE COMMISSION FOR CLIMATOLOGY, Geneva, 20-22 September 1995 (also appears as WCASP-34) - (WMO-TD No. 711)

WCDMP-25 REPORT OF THE FIFTH SESSION OF THE ADVISORY COMMITTEE ON CLIMATE APPLICATIONS AND DATA (ACCAD), Geneva, 26 September 1995 (also appears as WCASP-35) - (WMO-TD No. 712)

WCDMP-26 REPORT ON THE STATUS OF THE ARCHIVAL CLIMATE HISTORY SURVEY (ARCHISS) PROJECT, October 1996 (prepared by Mr M. Baker) - (WMO-TD No. 776)

WCDMP-27 SUMMARY REPORT OF THE MEETING OF THE THIRD SESSION OF THE CCI WORKING GROUP ON CLIMATE CHANGE DETECTION, Geneva, 26 February - 1 March 1996 - (WMO-TD No. 818)

WCDMP-28 SUMMARY NOTES AND RECOMMENDATIONS FOR CCI-XII FROM MEETINGS CONVENED TO PREPARE FOR PUBLISHING THE FIFTH AND SIXTH GLOBAL CLIMATE SYSTEM REVIEWS AND FOR A PUBLICATION ON THE CLIMATE OF THE 20TH CENTURY, July 1997 - (WMO-TD No. 830)

WCDMP-29 CLIMATE CHANGE DETECTION REPORT - REPORTS FOR CCI-XII FROM RAPPORTEURS THAT RELATE TO CLIMATE CHANGE DETECTION, July 1997 (WMO-TD No. 831)

WCDMP-30 SUMMARY NOTES AND RECOMMENDATIONS ASSEMBLED FOR CCI-XII FROM RECENT ACTIVITIES CONCERNING CLIMATE DATA MANAGEMENT, July 1997 (WMO-TD No. 832)

WCDMP-31 REPORTS FOR CCI-XII FROM RAPPORTEURS THAT RELATE TO CLIMATE DATA MANAGEMENT, July 1997 - (WMO-TD No. 833)

WCDMP-32 PROGRESS REPORTS TO CCI ON STATISTICAL METHODS, July 1997 (prepared by Mr Christian-Dietrich Schönwiese) (WMO-TD No 834)

WCDMP-33 MEETING OF THE CCI WORKING GROUP ON CLIMATE DATA, Geneva, 30 January - 3 February 1995 - (WMO-TD No. 841)

WCDMP-34 EXPERT MEETING TO REVIEW AND ASSESS THE ORACLE-BASED PROTOTYPE FOR FUTURE CLIMATE DATABASE MANAGEMENT SYSTEM (CDBMS), Toulouse, France, 12-16 May 1997 - (WMO-TD No. 902)

WCDMP-35 REPORT OF THE ELEVENTH SESSION OF THE ADVISORY WORKING GROUP OF THE COMMISSION FOR CLIMATOLOGY, Mauritius, 9-14 February 1998 (also appears as WCASP-47) - (WMO-TD No. 895)

WCDMP-36 REPORT OF THE MEETING OF THE CCI TASK TEAM ON CLIMATE ASPECTS OF RESOLUTION 40, Geneva, Switzerland, 10-1 1 June 1998 - (WMO-TD No. 925)

WCDMP-37 REPORT OF THE MEETING OF THE JOINT CCI/CLIVAR TASK GROUP ON CLIMATE INDICES, Bracknell, UK, 2-4 September 1998 - (WMO-TD No. 930)

WCDMP-38 REPORT OF THE MEETING OF THE WMO COMMISSION FOR CLIMATOLOGY (CCl) TASK GROUP ON A FUTURE WMO CLIMATE DATABASE MANAGEMENT SYSTEM (CDMS), Ostrava, Czech Republic, 10-13 November 1998 and FOLLOW-UP WORKSHOP TO THE WMO CCl TASK GROUP MEETING ON A FUTURE WMO CDMS, Toulouse, France, 30 March-1 April 1999 - (WMO-TD No. 932)

WCDMP-39 REPORT OF THE MEETING OF THE CCl WORKING GROUP ON CLIMATE DATA, Geneva, Switzerland, 30 November-4 December 1998 - (WMO-TD No. 970)

WCDMP-40 REPORT OF THE MEETING ON CLIMATE STATISTICS, PRODUCT DEVELOPMENT AND DATA EXCHANGE FOCUSING ON CLICOM 3.1, Geneva, 25-29 January 1999 - (WMO-TD No. 971)

WCDMP-41 PROCEEDINGS OF THE SECOND SEMINAR FOR HOMOGENIZATION OF SURFACE CLIMATOLOGICAL DATA, Budapest, Hungary, 9-13 November 1998 (WMO-TD No. 962)

WCDMP-42 REPORT OF THE MEETING OF EXPERTS ON THE CLIMATE OF THE 20TH CENTURY, Geneva, 26-30 April 1999 - (WMO-TD No. 972)

WCDMP-43 REPORT OF THE TRAINING SEMINAR ON CLIMATE DATA MANAGEMENT FOCUSING ON CLICOM/CLIPS DEVELOPMENT AND EVALUATION, Niamey, Niger, 03 May-10 July 1999, (WMO-TD No. 973)

WCDMP-44 REPRESENTATIVENESS, DATA GAPS AND UNCERTAINTIES IN CLIMATE OBSERVATIONS, Invited Scientific Lecture given by Chris Folland to the WMO Thirteenth Congress, Geneva, 21 May 1999 - (WMO-TD No. 977)

WCDMP-45 WORLD CLIMATE PROGRAMME - WATER, DETECTING TREND AND OTHER CHANGES IN HYDROLOGICAL DATA, Zbigniew W. Kundzewicz and Alice Robson (Editors) - (WMO-TD No. 1013)

WCDMP-46 MEETING OF THE WMO CCI TASK GROUP ON FUTURE WMO CLIMATE DATABASE MANAGEMENT SYSTEMS (CDMSs), Geneva, 3-5 May 2000 (WMO-TD No. 1025)

WCDMP-47 REPORT ON THE ACTIVITIES OF THE WORKING GROUP ON CLIMATE CHANGE DETECTION AND RELATED RAPPORTEURS, 1998-2001 (May 2001, updated from March 2001) (WMO-TD No. 1071)

WCDMP-48 REPORT OF THE FIRST SESSION OF THE MANAGEMENT GROUP OF THE COMMISSION FOR CLIMATOLOGY (Berlin, Germany, 5-8 March 2002) (also appears as WCASP-55) (WMO-TD No. 1110)

WCDMP-49 REPORT ON THE CLICOM-DARE WORKSHOP (San José, Costa Rica, 17-28 July 2000); 2. REPORT OF THE INTERNATIONAL DATA RESCUE MEETING (Geneva, 11-13 September 2001) (WMO-TD No. 1128)

WCMDP-50 REPORT OF THE CLIMATE DATABASE MANAGEMENT SYSTEMS EVALUATION WORKSHOP (Geneva, 11-13 September 2001) (WMO-TD No. 1130)

WCDMP-51 SUMMARY REPORT OF THE EXPERT MEETING FOR THE PREPARATION OF THE SEVENTH GLOBAL CLIMATE SYSTEM REVIEW (7GCSR) (Geneva, 16-19 September 2002) (WMO-TD No. 1131)

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)

WCDMP-54 REPORT OF THE CCI/CLIVAR EXPERT TEAM ON CLIMATE CHANGE DETECTION, MONITORING AND INDICES (ETCCDMI) (Norwich, UK, 24-26 November 2003) (WMO-TD No. 1205)

WCDMP-55 GUIDELINES ON CLIMATE DATA RESCUE (WMO-TD No. 1210)

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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WCDMP-63	RA VI TRAINING SEMINAR ON CAPACITY BUILDING IN CLIMATE-RELATED MATTERS (Yerevan, Armenia, 2 – 5 October 2006) (WMO-TD No. 1386)
WCDMP-64	JOINT CCL/CLIVAR/JCOMM EXPERT TEAM ON CLIMATE CHANGE DETECTION AND INDICES (Niagara-on-the-Lake, Canada, 14 - 16 November 2006) (WMO-TD No. 1402)
WCDMP-65	EXPERT TEAM ON OBSERVING REQUIREMENTS AND STANDARDS FOR CLIMATE (Geneva, 28 - 30 March 2007) (WMO-TD No. 1403)
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WCDMP-68	CLIMATE DATA MANAGEMENT GUIDELINES *(Available on CD)*
WCDMP-69	MEETING OF THE CCL EXPERT TEAM ON THE RESCUE, PRESERVATION AND DIGITIZATION OF CLIMATE RECORDS (Bamako, Mali, 13-15 May 2008)
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WCDMP-73	REPORT OF THE CCI EXPERT TEAM ON WCP REQUIREMENTS FOR METADATA (Toulouse, France, 11-13 March 2009)
WCDMP-74	REGIONAL WORKSHOP ON CLIMATE MONITORING AND ANALYSIS OF CLIMATE VARIABILITY: IMPLEMENTATION OF CLIMATE WATCH SYSTEM IN RA II WITH FOCUS ON MONSOON AFFECTED AREAS (Beijing, China, 10–13 November 2009)
WMO/TD-1550	ASSESSMENT OF THE OBSERVED EXTREME CONDITIONS DURING THE 2009/2010 BOREAL WINTER