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COMMENTS

Data sources for rescuing the rich heritage of Mediterranean historical surface climate data

M. Brunet[1,2]*, P. D. Jones[2,3], S. Jourdain[4], D. Efthymiadis[1], M. Kerrouche[5] and C. Boroneant[1]

[1]*Centre for Climate Change (C3), University Rovira i Virgili, Tarragona, Spain*
[2]*Climatic Research Unit, School of Environmental Sciences, University of East Anglia, Norwich, UK*
[3]*Center of Excellence for Climate Change Research, Department of Meteorology, King Abdulaziz University, Jeddah, Saudi Arabia*
[4]*Météo-France, Toulouse, France*
[5]*Office National de la Météorologie, Alger, Algeria*

**Correspondence: M. Brunet, Centre for Climate Change, URV, Av. Catalunya, 35, 43071 – Tarragona, Spain*
E-mail: manola.brunet@urv.cat

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Availability of long-term and high-quality instrumental climate records is still insufficient and the rich heritage of meteorological surface observations is largely underexploited in many parts of the world. This is particularly striking over the Greater Mediterranean region (GMR), where meteorological observations have been taken since the 18th century at some locations. The lack of high quality and long series here is despite this region being regarded as a climate change hot spot. This article mainly assesses relevant sources containing Mediterranean historical climate data and metadata either from online repositories worldwide or physical archives, with the emphasis here on the rich holdings kept at French archives. A particular case study is the data rescue (DARE) program undertaken by the Algerian National Meteorological Service, as well as some of the past and ongoing projects and initiatives aimed at enhancing climate data availability and accessibility over the GMR. Our findings point to the high potential for undertaking DARE activities over the GMR and the need for bringing longer and higher quality climate time series to support a diverse number of scientific and technical assessments and policies.

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Introduction

Availability, accessibility, or traceability of long-term and high-quality surface climate instrumental records is currently very limited worldwide, although the atmosphere has been thoroughly and regularly monitored since the inception of the instrumental era (Allan *et al.*, 2011; Brunet & Jones, 2011; Thorne *et al.*, 2011a,b). For the period prior to the 1960s there are many more non-digitised land climate records than digitised globally and even after that decade not all the observed climate variables are routinely digitised and readily available particularly at the finest time scales (e.g. sub-daily and daily) or are of adequate quality and reasonably free of inhomogeneities so that they may be confidently used in any climate-related assessment or for the generation of climate products and services. Most of the land meteorological observations recorded in the past are only available in hard copy or imaged form and, therefore, they are unusable for climatic studies or for the development of timely and useful climate services or decadal climate predictions. These are some of the demands for climate products and services, which are nowadays required by society to better detect, predict and to respond to the challenges posed by climate variability and man-made climate change (WMO, 2011).

Long land instrumental records are key elements of information on the past states of the climate system, which contain invaluable clues on historical climate variations, along with the factors that could influence them (Brönnimann *et al.*, 2005; Allan *et al.*, 2011; Brunet & Jones, 2011; Thorne *et al.*, 2011b). These climate time series are, therefore, the basis of climate research, which brings important scientific and socioeconomic benefits. Today a number of socioeconomic and political alternatives rely on the accuracy and reliability of accessible and traceable climate products and services, which are derived in turn from digitised, high-quality, long-term, and traceable climate time series. This underpins the need for rescuing these historical climate assets and bringing long-term and high-quality climate time series into the 21st century making this a matter of paramount scientific and societal interest.

The reduced availability and accessibility to long and reliable climate time series is even more striking

over the area encompassing the Greater Mediterranean region (GMR), where first meteorological observations have been taken in some locations since the 18th century and everywhere from the mid-19th century onwards by National Meteorological Services (NMS) and their precursors. Besides, the GMR is regarded as a climate change hot spot (Giorgi, 2006; Diffenbaugh *et al.*, 2007) and the International Panel on Climate Change (IPCC, 2007) report has stressed the possibility of warmer and drier conditions in the near future leading to more frequent and prolonged droughts, as well as to longer fire season and intensified fire risk (Alcamo *et al.*, 2007). In this regard, the GMR socioecosystems are particularly vulnerable to interannual (and longer timescale) climate variability. These impacts reinforce the need to strengthen our knowledge of spatial and temporal patterns of climate variability, and their related causal mechanisms, across the GMR.

The Mediterranean countries have a very long and rich monitoring history in the atmospheric domain, going back in time several centuries in some countries (i.e. Italy, France, Spain) and at least to the mid-19th century onwards across much of the region. However, available digital climate data are mostly restricted to the last third of the 20th century onwards, but their accessibility is restricted due to economic or political issues that rule out much data sharing, despite World Meteorological Organization (WMO) Resolution 40 (WMO Cg-XII, 1995). The existing surface climate data heritage is largely underexploited.

Enhancing availability, accessibility and traceability to historical climate time series over a climate change hot spot region (such as the GMR is considered), whose socioecosystems are very sensitive to climate change and where its potential impacts are large brings a number of scientific and societal benefits. High-quality (i.e. quality controlled and homogenised), high-resolution (both in time and space) and long-term (longer than centennial scale) climate time series are the basic and key input for undertaking more robust climate analysis or for generating any climate service, product and application.

To locate, organise, assess, and preserve data sources is the first step to be taken prior defining or undertaking any plan to digitise historical record and subject the digitised series to quality controls, looking to identify non-systematic errors, homogeneity testing to assess systematic biases or for homogenising if inhomogeneities are found and the accompanying metadata provide clues for validating and adjusting the identified breakpoints in homogeneity.

This article is aimed at documenting relevant historical data owners/holders and data sources containing Mediterranean climate data and metadata in non-digital format especially for the poorest documented Mediterranean parts, the southern and Middle East regions. Its emphasis is the investigation of online repositories worldwide and the French archives holdings, comprising data over France and overseas. An exemplar case study will look at the Algerian holdings one of the poorest documented world region: the northern African sub-region, and describes some of the past and ongoing data rescue (DARE) initiatives that are improving availability, accessibility and traceability of historical climate data over the GMR.

The article is organised as follows: historical climate data sources and holders, both online repositories and physical archives, are explored first splitting the section into three parts focused on the following: (a) relevant online repositories worldwide containing historical climate data for southern and Middle East Mediterranean countries, (b) the French archives and holdings comprising not only historical climate data over France but also for its past colonies in North Africa, and (c) the ongoing DARE program set up by the Algerian NMS as a case study. The second section is devoted to a discussion of ongoing DARE initiatives supported by international, European, and national bodies, while the last section summarises the study and provides some concluding remarks.

1. Exploring Mediterranean climate data sources and holders

Despite the rich heritage of historical surface climate data and although some NMSs and academic institutions have recently undertaken DARE activities aimed at transferring historical climate records from fragile media (paper forms) to new media (imaging), few of the necessary long-term records are readily available in digital form. Furthermore, the requirement for high-quality integrated climate products is impeding the development of optimum strategies to mitigate and/or adapt to the negative impacts of global climate change over the Mediterranean Basin. This stems from the lack of long-term digital records.

However, recently the digitisation (scanning) of collections of documents with meteorological/climatic data provides the opportunity to extend climatic studies to earlier periods. This section first explores worldwide online repositories containing relevant historical climate data that can be employed for extending back in time reliable climate records over the GMR and, in the second, insights are provided into the holdings kept at French archives. The section ends with the assessment of the DARE activities undertaken by the Algerian NMS.

1.1 Online repositories of historical climate data of interest for the GMR

Significant fractions of historical surface climate data kept in hard copies (e.g. meteorological collections, such as monthly bulletins and annual reports, monographs, observatories reports) thanks to the generalised exchange of meteorological data that took place during the 19th century and earlier among scientific institutions have been and are being imaged and entered into online repositories as a result of various

efforts and initiatives. Climatic research for the GMR has been restricted to periods back to the mid-20th century, although a large disparity in the spatial coverage of the observational networks used can be highlighted, with the lowest spatial and temporal coverage over Southern and Middle East Mediterranean countries.

Nowadays, the largest online repository of worldwide imaged meteorological/climatological data from different sources is available from the United States National Oceanic and Atmospheric Administration (NOAA)/National Climate Data Center (NCDC)/Climate Data Modernization Program (CDMP: http://www.ncdc.noaa.gov/oa/climate/cdmp/cdmp.html), which contains about 56 millions of images (~9 Tb) from a diverse number of climate sources around the world. The CDMP has scanned a multitude of collections of data, maps and descriptions of meteorological settings (with emphasis on intense meteorological events) and made them available to the public (http://docs.lib.noaa.gov/rescue/data_rescue_home.html). For the southern Mediterranean, these documents are reports/assessments issued by local meteorological services, initially organised by European ex-colonial countries such as France and Italy, and in many cases constitute components of multi-country meteorological collections published by European countries.

Another web-repository is maintained by BADC (the British Atmospheric Data Centre; being available at http://badc.nerc.ac.uk/browse/badc/corral/images/metobs) and comprises images of data-pages scanned in the framework of Atmospheric Circulation Reconstructions over the Earth Initiative (ACRE: http://www.met-acre.org/) from various sources of historical weather observations (mainly from the 'Climatological Returns' and 'Daily Weather Reports'), which are held by the National Meteorological Archives of the UK Met Office (http://www.metoffice.gov.uk/corporate/library/). For the southern Mediterranean, a handful of daily climate series for Cyprus, Egypt and Morocco are available from BADC.

For both CDMP and BADC data repositories, the most extensive southern Mediterranean sites are for major towns/cities, e.g. Oran, Algiers, Tunis, Cairo, Beirut, Nicosia (from 1870s up to 1970s). Meteorological records were taken at observatories, civil/military administration buildings, hospitals, hotels, sea ports, and airports. However, rural and remote places were also covered by stations set up by the various state meteorological services to cover the whole territory of their country/region (often sparsely, but particularly densely in agricultural regions, i.e. the Nile Delta), and also where companies, services and foreign missions were activated such as construction companies (e.g. Suez Canal), lighthouses (semaphores), educational institutions (schools/universities), etc.

Data from all these sorts of stations can be found in the online repositories, either at daily/sub-daily resolution and also as annual tables of monthly-mean values of specific meteorological parameters: morning temperature and sea level pressure (SLP) recordings, daily precipitation totals, and often daily maximum, minimum, dew-point, and sub-daily temperatures, sub-daily and mean daily SLP records, vapour pressure, humidity, evaporation, cloudiness, sunshine duration, wind direction and strength, description of the daily weather state (often the sea state too), and references on specific phenomena: dew and frost incidents, fogs, storms, heavy rainfall, hail, characteristic winds (e.g. sirocco/ghibli).

The overall daily-data coverage for the southern Mediterranean is summarised in Tables 1 and 2. The various data book collections are provided, together with the countries and periods covered. Note that several data gaps are found within the earliest and latest years mentioned, and these gaps could be of daily, monthly, annual, or multi-annual length. The World War II period 1941–1944 is a common data-poor interval. However, monthly data summaries (often constituting year-round monthly-means of certain meteorological parameters) are provided for more stations than the daily-scale documented stations and extend in periods not covered by daily records.

Under the framework of the European Union (EU)-funded EUropean Reanalysis and Observations for (4) Monitoring (EURO4M: http://www.euro4m.eu/index.html) project in connection with the WMO/MEditerranean DAta REscue (MEDARE) Initiative (http://www.omm.urv.cat/MEDARE/index.html) data are being digitised and long series reconstructed from long daily maximum and minimum temperatures and precipitation totals, along with sub-daily data for surface air pressure over North African and Middle East Mediterranean countries. Figure 1 gives details of the locations and variables being digitised, quality controlled and homogenised after the records are merged with recent parts of the data recorded by the relevant Mediterranean NMSs, while Table 3 gives a detailed account of the stations, variables and periods recovered, digitised and quality controlled at the daily scale for temperature (maxima and minima) and precipitation (daily amounts) and at the sub-daily scales for air surface pressure parameters.

This DARE exercise, enabled by the European Commission funds, will extend further back in time some of the longest surface temperature, precipitation and air pressure time series at the daily and sub-daily scales, respectively, which will allow scientists and policy-makers analyses to assess climate variability and change impacts over one of the poorest documented regions of the world. The EURO4M project intend to also share the data rescued under this effort with appropriate global and regional databanks [e.g. ECA&D (European Climate Assessment and Dataset), CRU (Climatic Research Unit –data sets), ISTI (International Surface Temperature Initiative)], as has been the case for a set of air pressure records already provided to the ISPD (International Surface Pressure Databank). However, note that this exercise for

Table 1. Collections of climatic data books being available from NOAA (all collections, but the last one) and BADC (just the last collection, i.e. UK-CR/DWR) and the year range (limits) which is covered with daily data for the South Mediterranean (North Africa and Middle East).

Abbreviated name	Data book series	Year range
ABCM-France	Annales du Bureau Central Météorologique de France	1878–1913
BM-Algerie	Bulletin Météorologique de l'Algerie	1877–1938
BQRM-Maroc	Bulletin quotidien de reseignements météorologique du Maroc	1953–1978
SM-Tunis	Service Météorologique de Tunis	1907–1932
BM-Cirenaica	Bolletino Meteorologico della Cirenaica	1928–1931
BMA-Italiana	Bollettino Meteorologico dell'Africa Italiana	1932–1936
MR-Egypt	Meteorological Report. Cairo Daily Weather Report. Egypt Monthly Weather Report. Egypt Helwan Observatory	1900–1963
MWR-Israel	Monthly Weather Report. Israel	1947–1975
AULO-Beirut	American University–Lee Observatory. Beirut.	1891–1975
BCM-Lebanon	Bulletin Climatologique Mensuel. Lebanon	1928–1970
AO-Ksara	Annales de l' Observatoire de Ksara	1921–1971
MCD-Syria	Monthly Climatological Data. Syria	1955–1975
UK-CR/DWR	UK-Climatological Returns UK-Daily Weather Reports	1881–1920

Table 2. Periods covered with daily data for each country of the South Mediterranean by NOAA- and BADC-available data books (see Table 1 for details of book collections).

Collections of climatic data books	Morocco	Algeria	Tunisia	Libya	Egypt	Israel/Palestine	Lebanon	Syria	Cyprus
ABCM-France	1878–1912	1878–1913	1888–1913	–	1888–1913	1906–1913	1895–1913	–	–
BM-Algerie	1909–1934	1877–1938	1877–1938	–	–	–	–	–	–
BQRM-Maroc	1953–1978	1953–1978	–	–	–	–	–	–	–
SM-Tunis	–	–	1907–1932	–	–	–	–	–	–
BM-Cirenaica	–	–	–	1928–1931	–	–	–	–	–
BMA-Italiana	–	–	–	1932–1936	–	–	–	–	–
MR-Egypt	–	–	–	–	1900–1963	1924–1933	–	–	–
MWR-Israel	–	–	–	–	–	1947–1975	–	–	–
AULO-Beirut	–	–	–	–	–	1912–1915	1891–1975	1912–1915	–
BCM-Lebanon	–	–	–	–	–	–	1928–1970	1928–1956	–
AO-Ksara	–	–	–	–	–	–	1921–1971		–
MCD-Syria	–	–	–	–	–	–	–	1955–1975	–
UK-CR/DWR	1894–1920	–	–	–	1900–1904	–	–	–	1881–1920

recovering and bringing long-term and high-quality climate variables into the future only encompasses three of the measured climate variables, while the other climatic parameters contained in the sources will remain undigitised until some other opportunity for digitising them emerge. Therefore, there is still much scope for undertaking further DARE activities for the southern Mediterranean sub-region.

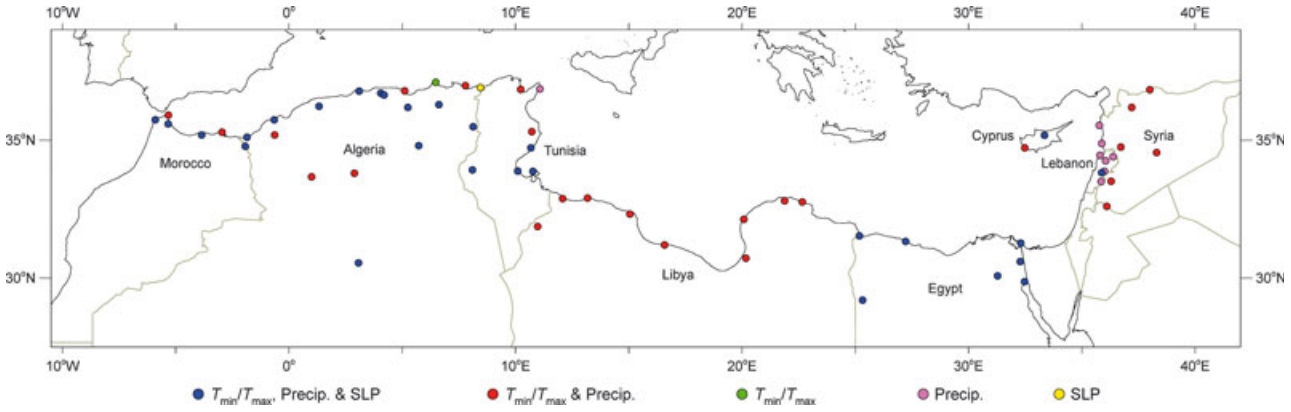

Figure 1. Location of a number of sites and climate parameters for which station records are being digitised and quality controlled under the EU-funded EURO4M project in its component of data archaeology in the Mediterranean region (http://www.euro4m.eu/Data_archaeology_in_the_Mediterranean_region.html).

1.2 Holdings of Mediterranean historical climate data at French archives

France has a very long and wealthy meteorological history, going back several centuries with a very significant legacy of climate data. Regular meteorological instrumental measurements have been recorded since the end of the 17th century onwards. Instrumental observations have been carried out by astronomers, doctors, Jesuits during the 17th and the 18th centuries (Jourdain *et al.*, 2008). In the 19th century the observations were organised by several institutions and administrations (e.g. Education Ministry through primary schools and observatories networks, Public Works Ministry for flood warning, lighthouses and river navigation networks, Telegraph with the le Verrier telegraphic network) and the Navy with the semaphore network and meteorological association (Fierro, 1991; Locher, 2008).

French climate data are consequently hidden in many places in France. Today the most important holdings for earlier climate instrumental data are as follows: Météo-France as the NMS in France responsible for climate data recording and archiving. Other institutions also keep historical climate data, such as archive institutions (i.e. national, territorial, departmental, and local archives), scientific institution archives (e.g. Academy of Sciences, Academy of Medicine, research centres, universities, learned societies), local and national libraries, the Ministry of Defence archives and from other several governmental administrations.

Pichard and Roucaute (2009) explore in their study the availability of historical climate data for the Provence Department (located in southern France and belonging to the Mediterranean region) and state that scientific archives in France are disseminated in a 'pleiade' of institutions with their own status and methods of preservation. Auffray *et al.* (2009) also illustrates the difficulties in recovering and gathering data of climate extreme events due to the wide dispersion of sources in France.

The following epigraphs illustrate the most important holdings of French instrumental climate data. First, a description is provided of a selection of holdings for the 17th and 18th centuries; followed by the Météo-France data holdings extending back to 1800 and ends with the description exploring some of the departmental archives (italics are used for the French names of institutions).

1.2.1 Historical sources extending back to the early 18th century

From the French Institute Library (*Librairie de l'Institut de France*). The manuscripts of the first French instrumental oldest climate series made by Morin 1665–1709 in Paris is stored in this library (quotation Ms 1488). The manuscripts were imaged by the *Institut de France*. These pressure data have recently been analysed by Cornes *et al.* (2012) developing a long series (but with a few gaps) to the present.

From the Academy of Medicine Library (*Librairie de l'Académie de Médecine*). The Royal Society of Medicine in Paris created a meteorological network in 1776 and it continued until 1792. More than 200 doctors sent their daily observations to L. Cotte. The collection of the records, 13 800 pages of weather reports on daily basis over France, is kept in the Library archives. The meteorological collection has been imaged thanks to the French-funded project ANR-CHEDAR. The images are accessible via internet from the Academy of Medicine website: http://www.academie-medecine.fr/userfiles/file/SRM/index.html. The next step, managed by Météo-France, will be the digitisation of the data for relevant climate series.

From Marseille Observatory (*Observatoire Astronomique de Marseille-Provence – OAMP –*). The Marseille Observatory (OAMP) holds observations recorded in the Marseille observatories since 1761 and the data registered by Catelin le Cadet (1744–1787). A precise inventory of this asset is available at http://www.oamp.fr/patrimoine/archives-f.html. Microfilms of this collection are available at the departmental archives

Table 3. List of stations, along with their identifiers (station name, WMO code, and country), geographical details (coordinates and elevation), climatic variables and periods recovered, digitised and quality controlled under the EURO4M project.

Country	Location/Station name	WMO code	Latitude	Longitude	Altitude (m)	Variables	Length
Morocco	Tangier city	60100	35.78 deg N	5.82 deg W	86	TX, TN, RR, SLP	1912–1961
	Tangier airport	60101	35.73 deg N	5.90 deg W	15	TX, TN, RR, SLP	1961–1978
	Al Hoceima	60107	35.18 deg N	3.85 deg W	12	TX, TN, RR, SLP	1965–1978
	Oujda	60115	34.78 deg N	1.93 deg W	478	TX, TN, RR, SLP	1910–1978
	Tetuan	60318	35.58 deg N	5.33 deg W	10	TX, TN, RR, SLP	1920–1978
Spain	Ceuta	60320	35.89 deg N	5.35 deg W	87	TX, TN, RR	1933–1939
	Melilla	60338	35.28 deg N	2.96 deg W	47	TX, TN, RR	1899–1962
Algeria	Skikda-Cap Bougarouni	60355	37.08 deg N	6.47 deg E	195	TX, TN	1931–1938
	Annaba-Cap de Garde	60357	36.97 deg N	7.79 deg E	161	TX, TN, RR	1909–1937
	La Calle (El Kala)	60367	36.90 deg N	8.44 deg E	10	SLP	1877–1938
	Algiers-Ville/Université	60369	36.78 deg N	3.07 deg E	59	TX, TN, RR, SLP	1877–1938
	Algiers-Bouzareah	60372	36.80 deg N	3.03 deg E	344	TX, TN, RR	1893–1920
	Algiers-Cap Caxine	60374	36.80 deg N	3.04 deg E	38	TX, TN, RR	1878–1879
	Tizi Ouzou	60395	36.72 deg N	4.05 deg E	222	TX, TN, RR, SLP	1879–1838
	Fort National	60395	36.63 deg N	4.20 deg E	942	TX, TN, RR, SLP	1884–1938
	Bejaia-Cap Carbon	60400	36.78 deg N	5.10 deg E	225	TX, TN	1926–1938
	Bejaia-Bougie (Port)	60401	36.75 deg N	5.10 deg E	9	TX, TN, RR	1909–1926
	Constantine	60419	36.37 deg N	6.62 deg E	660	TX, TN, RR, SLP	1880–1938
	Orleansville (Chlef)	60425	36.17 deg N	1.34 deg E	112	TX, TN, RR, SLP	1879–1838
	Setif	60445	36.18 deg N	5.40 deg E	1081	TX, TN, RR, SLP	1878–1938
	Oran	60461	35.70 deg N	0.65 deg W	53	TX, TN, RR, SLP	1852–1966
	Oran-Cap Falcon	60485	35.77 deg N	0.80 deg W	78	TX, TN, RR	1896–1938
	Tebessa	60475	35.42 deg N	8.12 deg E	863	TX, TN, RR, SLP	1879–1938
	Nemours (Ghazaouet)	60517	35.10 deg N	1.85 deg W	83	TX, TN, RR, SLP	1878–1938
	Sidi-Bel-Abbés	60520	35.20 deg N	0.63 deg W	476	TX, TN, RR	1880–1938
	Biskra	60525	34.85 deg N	5.72 deg E	125	TX, TN, RR, SLP	1880–1938
	Laghouat	60545	33.80 deg N	2.89 deg E	767	TX, TN, RR	1888–1938
	Geryville (El-Bayadh)	60550	33.68 deg N	1.00 deg E	1320	TX, TN, RR	1888–1938
	El-Golea	60590	30.55 deg N	3.07 deg E	394	TX, TN, RR, SLP	1892–1938
Tunisia	Tunis	60715	36.80 deg N	10.17 deg E	36	TX, TN, RR	1886–1938
	Kelibia	60720	36.84 deg N	11.11 deg E	82	RR	1907–1932
	El Djem	60743[a]	35.33 deg N	10.70 deg E	112	TX, TN, RR	1900–1932
	Sfax	60750	34.72 deg N	10.72 deg E	23	TX, TN, RR, SLP	1886–1938
	Tozeur	60760	33.95 deg N	08.11 deg E	50	TX, TN, RR, SLP	1897–1938
	Gabes	60765	33.89 deg N	10.11 deg E	4	TX, TN, RR, SLP	1887–1930
	Djerba	60769	33.88 deg N	10.85 deg E	4	TX, TN, RR, SLP	1898–1912
Libya	Nalut	62002	31.87 deg N	10.98 deg E	621	TX, TN, RR	1932–1953
	Zuara	62007	32.88 deg N	12.08 deg E	3	TX, TN, RR	1920–1955
	Tripoli Airport	62010	32.67 deg N	13.15 deg E	81	TX, TN, RR	1943–1955
	Tripoli Sidi El Mesri	62010	32.87 deg N	13.22 deg E	25	TX, TN, RR	1916–2008
	Tripoli City	62010	32.90 deg N	13.18 deg E	25	TX, TN, RR	1932–1974
	Misurata	62016	32.41 deg N	15.05 deg E	32	TX, TN, RR	1925–1956
	Sirte	62019	31.20 deg N	16.58 deg E	13	TX, TN, RR	1925–1955
	Bengazi Benina	62053	32.08 deg N	20.27 deg E	129	TX, TN, RR	1944–1955
	Bengazi Regima	62053	32.67 deg N	20.67 deg E	322	TX, TN, RR	1922–1935
	Agedabia	62055	30.72 deg N	20.17 deg E	7	TX, TN, RR	1924–1955
	Shahat	62056	32.82 deg N	21.85 deg E	621	TX, TN, RR	1921–1955
	Derna	62059	32.78 deg N	22.58 deg E	26	TX, TN, RR	1928–1955
Egypt	Salloum	62300	31.55 deg N	25.18 deg E	4	TX, TN, RR, SLP	1919–1957
	Mersa Matruh	62306	31.33 deg N	27.22 deg E	25	TX, TN, RR, SLP	1920–1957
	Port Said	62333	31.28 deg N	32.23 deg E	6	TX, TN, RR, SLP	1884–1957
	Cairo Abbassia	62371	30.08 deg N	31.29 deg E	30	TX, TN, RR	1900–1908
	Cairo Ezbekiya	62374	30.05 deg N	31.25 deg E	20	TX, TN, RR	1909–1957
	Giza (Cairo)	62375	30.03 deg N	31.21 deg E	28	TX, TN, RR	1924–1957
	Helwan (Cairo)	62378	29.86 deg N	31.34 deg E	116	TX, TN, RR, SLP	1904–1957
	Siwa	62417	29.20 deg N	25.48 deg E	−15	TX, TN, RR, SLP	1912–1957

(continued)

Table 3. (continued).

Country	Location/Station name	WMO code	Latitude	Longitude	Altitude (m)	Variables	Length
	Ismailia	62441	30.60 deg N	32.23 deg E	10	TX, TN, RR, SLP	1884–1956
	El Suez	62450	29.93 deg N	32.55 deg E	10	TX, TN, RR, SLP	1907–1957
Lebanon	Rayack	40102	33.85 deg N	36.00 deg E	920	RR	1928–1970
	Tripoli	40103	34.45 deg N	35.82 deg E	20	RR	1931–1970
	Les Cedres (Al Arz)	40105	34.25 deg N	36.05 deg E	1925	RR	1939–1964
	Ksara	40106	33.82 deg N	35.89 deg E	918	TX, TN, RR, SLP	1912–1971
	Hermel	40108[a]	34.40 deg N	36.38 deg E	700	RR	1932–1970
	Rachaya	40109[a]	33.50 deg N	35.85 deg E	1235	RR	1933–1970
Syria	Jarablus	40005	36.82 deg N	38.00 deg E	350	TX, TN, RR	1928–1975
	Aleppo	40007	36.18 deg N	37.22 deg E	390	TX, TN, RR	1955–1975
	Lattakia	40007	35.50 deg N	35.78 deg E	7	RR	1928–1975
	Tartous	40050	34.90 deg N	35.87 deg E	5	RR	1928–1975
	Homs	40055	34.75 deg N	36.72 deg E	487	TX, TN, RR	1914–1959
	Palmyra	40061	34.55 deg N	38.30 deg E	404	TX, TN, RR	1928–1975
	Damascus	40079	33.48 deg N	36.23 deg E	720	TX, TN, RR	1928–1955
	Dara'a	40095	32.60 deg N	36.10 deg E	532	TX, TN, RR	1928–1933
Cyprus	Nicosia	17607	35.19 deg N	33.37 deg E	152	TX, TN, RR, SLP	1881–1922
	Paphos	17600	34.77 deg N	32.43 deg E	30	TX, TN, RR	1900–1922

TX, daily maximum temperature; TN, daily minimum temperature; RR, daily precipitation amounts; SLP, sub-daily sea level pressure observations.
[a]WMO pseudo-code.

(quotation 132J 1-244) and have been converted into electronic images by Météo-France.

From French National Library (*Bibliothèque Nationale de France – BNF –*). The French National Library (BNF) is intended to be the repository of all that is published in France. Gallica, the digital library maintained by BNF, is an access portal that holds collections from different public partners (e.g. institutions, learned societies, research centres, libraries). This digital library makes these French records freely available. Numerous imaged scientific annals and reports of academies and learned societies, newspapers in French extending back to 1700 are accessible via Gallica and are also very interesting sources to recover French ex-colonies data http://gallica.bnf.fr/

1.2.2 Météo-France archives and holdings

The Central Library of Météo-France (*Bibliothèque de Météo-France*). The first official French meteorological office, along with its central library, was created in 1878. The central library, relocated several months ago to Saint-Mandé near Paris, is gathering old collections from the Paris Observatory and the French Meteorological Society (*Société Météorologique de France*). It contains periodical collections beginning in the 18th century and periodical serials, including climatic publications for many countries, particularly the French ex-colonies.

French yearbooks and annals (e.g. *Annales du Bureau Central Météorologique, Annales de la Société Météorologique de France, Nouvelles Météorologiques*) contain overseas data for the Mediterranean basin. The French Daily Weather Bulletin (*Bulletin Quotidien du Bureau Central Météorologique*) contains regular Algerian daily data for pressure and temperature. The North African collections of yearbooks, annals and bulletins have been inventoried in the framework of the collaboration between North African NMSs and Météo-France: observations on daily basis can be found for Algeria (1881–1966), Tunisia (1929–1975), and Morocco (1922–1975).

The inventory of the publications stored in the library is available from the Météo-France web-site. Systematic imaging of historical publications such as annals and yearbooks is carried out by Météo-France and it is expected that free access to the pdf files via the library of Météo-France website http://bibliotheque.meteo.fr will occur.

1.2.3 Directorate of climatology (Direction de la Climatologie)

All the directorates for Climatology of the successive French meteorological services (*Bureau Central Météorologique, Office National de la Météorologie, Météorologie Nationale* and now Météo-France) collected climate data gathered from volunteer observers, professional stations and other institutions.

The Archives of Directorate for Climatology in Toulouse hold surface and upper-air data for the French mainland, overseas and French ex-colonies in hard copy and microfilms. The archives have been inventoried and are briefly summarised as follows:

French mainland records in paper form: Monthly climate reports, *Tableau Climatologique Mensuel (TCM)* from synoptic stations and semaphore stations since 1920 and monthly climate reports from all climatological stations since 1961.

French mainland records in microfilms: Daily Climate Report, *Compte Rendu Quotidien (CRQ)* with daily and sub-daily data from synoptic stations since 1955. The usage of these types of reports began in May 1923 in mainland France for all synoptic stations, but they were also used at synoptic stations of the French colonies from the end of World War II. These Daily Climate Reports, however, remained in the former colonies.

North African former colonies records in microfilms: The collection concerns 74 synoptic stations: TCM for Tunisia and Morocco from 1923 to 1962, TCM and CRQ for Algeria from 1924 to 1966, but with a big gap between 1937 and 1944.

1.2.4 National Archives (Archives Nationales)

The National Archives (AN) is a governmental agency in charge of preserving and communicating all information produced by the French Government and its administration. The Fontainebleau site mainly keeps archives going back in time to 1850.

In line with the French Public Archives Law, Météo-France deposited around 6300 boxes of climate and weather documents at the National Archives between 1976 and 1992. The Directorate of Climatology managed the deposit of 4287 boxes. A good idea of the content of these holdings is guaranteed thanks to the deposit forms delivered when archives were transferred. Boxes contain original manuscript of weather reports from 1800 to 1989 from surface and upper air stations for mainland France, French overseas and ex-colonies and from ships. The Table 4 gives details on the different collections.

Table 4. Description of the Météo-France holdings kept in Fontainebleau (AN).

Collections of Météo-France Climate data hold in National Archives site Fontainebleau	Number of boxes	Period of records
Marine (logbooks)	725	1879–1985
France surface climate with voluntary observers reports	790	1739–1972
France synoptic stations (CRQ)	1304	1923–1970
France semaphore and lighthouses	252	1868–1970
German observations WWII (logbooks)	53	1940–1944
France military stations (CRQ, original logbooks)	75	1913–1953
Primary school (TCM)	55	1865–1908
Overseas territories, Southern and Antarctic Lands	140	1833–1988
African ex-colonies and foreign countries (CRQ, TCM, …)	773	1833–1989
Others	100	–
Total	4287	–

Access to the documents was precluded during the first decade of the 21st century due to asbestos presence in the archives. A new project co-funded by Foundation BNP Paribas and managed by Météo-France and *Archives Nationales* started last year, which has as goals to clean up the archives from asbestos, to give full access to the archives in the best environment possible, to inventory and in detail assess the meteorological sources and its data content and digitise relevant documents and observations.

1.2.5 Departmental archives

Departmental public archives are in charge of the conservation and the communication of the documents produced by departmental administrations in France. The territorial separation of some administrations (e.g. Equipments, Education, Telegraphs, Météo-France) and the Public Archives Law has the effect of disseminating meteorological sources in all the departmental archives and different collections. These archives contain plenty of precipitation measurements, making them very useful and essential for flood studies (Naulet *et al.*, 2001).

1.3 The Algerian NMS DARE program: an example to follow and learn from

The recovery, digitisation and reconstruction of the rich heritage of weather observations recorded in Algeria from the mid-19th century onwards is being explored through a related initiative carried out by the Office National de la Météorologie (Algerian NMS). This initiative has enabled the recovery of a dense network of precipitation time series at different temporal scales (from daily to monthly) for use in climate monitoring and prediction assessments and in the production of climate services, which will be useful for the national climate change adaptation program. Lessons learnt by the Algerian NMS related to the interoperability of the tools employed in its DARE program are worth discussing as they will prove useful to other countries. Both aspects are the focus of this sub-section.

As early as the first computer was purchased by the Algerian NMS in the 1970s and climate data management systems and other hardware and software were available thanks to the international cooperation fostered by the WMO Voluntary Cooperation Programme, the Climatological Branch started both the digitalisation and quality control of its recent weather observations and an early DARE program aimed at locating, organising and preserving the national historical assets and to image and digitise some of these assets for some of the essential climate variables (i.e. surface temperature and precipitation) measured anywhere at any time and date in the Algerian territory.

The recovery effort first emphasised the digitisation and quality control of the observations for 50 synoptic stations for the period 1953–1991, which include all

climatic variables and weather phenomena at sub-daily (eight observations per day) and daily scales. The digitised data were recorded and kept on magnetic tapes from the mid-1970s to early-1990s. These required later transfer of the data onto currently operable systems. From the mid- to late-1980s, the availability of new climate data management systems, such as the French DataStar (digitisation of precipitation and temperature) and the WMO/CLICOM (for digitising synoptic data before 1953 and after 1991) systems enabled the digitisation of the main and climatological stations for the six Algerian meteorological regions, which were then sent to the central climatological branch for quality control in delayed mode.

A problem with the digitised data related to the non-interoperability of the media where the data were kept (NORKS DATA) turned out to be a very time-consuming and intensive task. Transferring 1663 years of data from the 50 stations was required and this took 30 months of work. This points to the need to refresh the storage media as soon as new technology is available or at least every 10 years as recommended in the WMO guidance on climate DARE (Tan *et al.*, 2004). The task was completed between 1999 and 2001.

From 2000, a preservation and scanning effort of old historical data sources (e.g. the existing TCM and CRQ collections in the country – see Table 4 for details) was and is being carried out, since the microfilming of old data initiated in 1985 did not return sufficiently clear copies and was another time-consuming task. The old manuscripts and data sources were organised and archived before 2003 in the Oran archive and after that date in the Algiers national archives, allowing the centralisation of the historical sources kept in the country in a central archive that made it much easy to develop an inventory and ensure preservation.

The effort was and is being concentrated on the digitisation and quality controlling of a dense network of precipitation stations (about 790 rain gauge sites; ~25 of them going back in time to the mid 19th century, ~220 starting in the late 19th century, ~350 beginning around the early 20th century and the remaining from the 1960s and later). Figure 2 provides details (i.e. location and approximate length of the records) of the precipitation network that has been digitised and is being quality controlled by the Climatological Branch at the Algerian NMS.

At present, the DARE program has also scanned a large number of documents (272K daily reports with four images per day) containing climate daily data for 17 stations for the period 1949–2002, although it is still pending the scanning of the TCM source and other manuscripts with the oldest data sources for Algiers station with records going back to 1856. The effort is also being first put on digitising precipitation data (about 300 rain gauge stations have been digitised for different periods) and these records are being quality controlled to identify non-systematic bias in the series.

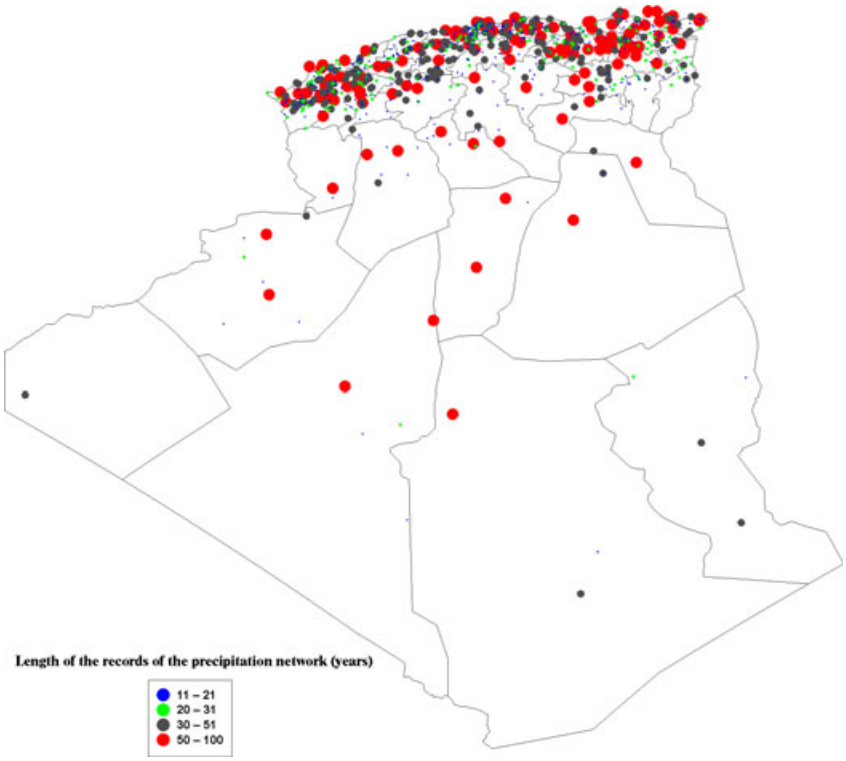

Figure 2. Location map of the Algerian precipitation network being recovered and quality controlled by the climatological branch at the Algerian NMS providing the approximate length of the records.

Another effort carried out in parallel is a detailed inventorying of the rest of climatic variables on a monthly basis. Once finished, it will allow the Algerian NMS to undertake the digitisation and quality control of these data.

Despite constraints related to scarce human and technological resources at the Algerian NMS Climatological Branch and frequent changes in computer systems or software and the problems posed by deficient infrastructural capabilities, it is an exemplar to look at national DARE programs focused not only on making available current and historical weather observations but also to organise, inventory and preserve historical assets. This DARE program exemplifies both the difficulties encountered and hopefully will encourage other NMS in the region to follow the Algerian NMS effort.

2. Past and ongoing DARE activities over the GMR

The scarcity of long-term and high-quality climate records over the GMR is clearly made visible in many recent climatic studies (e.g. Xoplaki *et al.*, 2003, 2004; Kostopoulou & Jones, 2007a,b; Kuglitsch *et al.*, 2009, 2010; Hertig *et al.*, 2010; Toreti *et al.*, 2010), where different aspects of climate variability have been assessed using surface instrumental records. Figure 3 shows an example of the limited availability of long climate records over the GMR. The network of Mediterranean stations with maximum temperature records on a daily basis used in the study of Kuglitsch *et al.* (2009), whose time series were subjected by the authors to a homogenisation exercise to use the homogenised data in future climatic research over the GMR, is a clear example illustrating this shortcoming.

Figure 3 clearly shows the highly limited number of records in time (covering the last 50–100 years, but with more than half of the total stations, 174, just extending from 1940 onwards) and space (stations mainly located over northern, western and eastern parts of the GMR), which is particularly poignant over southern and Middle East Mediterranean countries.

Against this shortcoming, several activities at the international, European and national scales have been recently set up with the aim of enhancing climate data availability and accessibility over the GMR. This section assesses some of them, with the focus put on the WMO/MEDARE Initiative and other regional/European projects and initiatives.

Not only due to the disturbing lack of climate data but also to the urgent need for providing high-quality and long climate data to stakeholders (e.g. scientists and policy-makers), the WMO/MEDARE Initiative was defined and agreed at the first WMO International Workshop on Climate Data Rescue in the Mediterranean Basin (Tarragona, November 2007: http://www.omm.urv.cat/medare-tarragona/index.html) and was endorsed by the WMO Executive Council (EC)-60 (June 2008: http://www.omm.urv.cat/MEDARE/endorsement.html). The WMO/MEDARE Initiative aims to enhance climate data availability and accessibility over the GMR through promoting DARE activities among their members: the MEDARE Community (http://www.omm.urv.cat/MEDARE/medare-community.html), which brings together scientists from most of the Mediterranean NMSs, universities and research centres worldwide.

Among other recent organisational, dissemination, cooperation and raising awareness activities (Brunet, 2012), the MEDARE Community has set up a metadata portal (http://app.omm.urv.cat/urv/), which is being populated by the MEDARE Community with metadata for the longest and key climate records selected on a national basis. Up to 656 past and current observing sites from which key climate variables (e.g. surface temperature, precipitation, air pressure) are documented and available. Table 5 gives details of the total number of observing sites for which metadata exists in the MEDARE meta database and also provides the number of stations at the ECA&D (http://eca.knmi.nl/) project for comparison purposes with an emphasis on the southern Mediterranean and Middle East.

The MEDARE meta database gives information on station identifiers (i.e. local and WMO codes), geo-

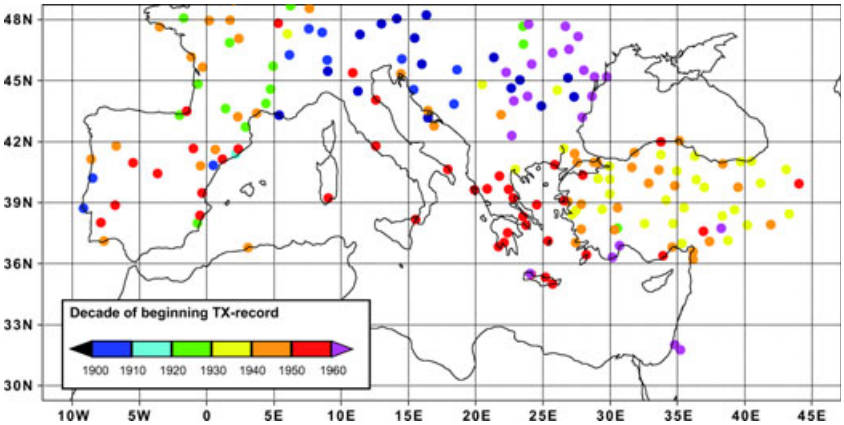

Figure 3. Location of the 174 Mediterranean stations used in Kuglitsch *et al.* (2009) study to homogenise daily maximum temperature series. The plot also gives details on the approximate length of these records. Adapted from Kuglitsch *et al.* (2009).

Table 5. Number of observing sites documented in the MEDARE and on the ECA&D data and metadata portals on a national basis.

Country name	Number of observing sites in MEDARE	Number of stations at ECA&D
Algeria	190	13
Andorra	7	–
Bulgaria	10	14
Croatia	13	10
Egypt	62	8
France	14	106
Greece	44	30
Israel	15	13
Italy	54	324
Jordan	12	–
Lebanon	3	1
Libya	28	4
Morocco	30	19
Macedonia	56	3
Slovenia	20	212
Spain	72	122
Tunisia	18	13
Turkey	8	35
Total	656	892

graphical data (i.e. coordinates and elevation), opening and closing dates, data source and owner/holder, station time series by variables distinguishing among the different time scales (i.e. monthly, daily, sub-daily) and station history. This information is being used by MEDARE members to target the longest climate records to be reconstructed (i.e. digitised, quality controlled and homogenised) under the umbrella of this WMO Initiative either at regional and sub-regional or national scales. In this regard and in connection with the EU-funded EURO4M project, 77 (82) maximum and minimum temperatures (precipitation) series are being reconstructed at the daily scale and 43 surface air pressure series at the sub-daily scale over the poorest documented Mediterranean regions of North Africa and Middle East, as shown in Figure 2, which will complement, extend back in time and significantly increase currently available stations at the ECA&D project over these regions.

The ECA&D project is one of the past and ongoing efforts for making available and accessible daily European climate observations for climate research, which is aimed at combining collations of observations at meteorological stations, analysing climate extremes and disseminating both the data and the resulting analysis. The current data set has been being contributed to by NMS and other projects and initiatives since its inception in 1998 and includes 4824 (26 112) meteorological stations (climate series) for 62 countries, which are provided by 58 participants (http://eca.knmi.nl/). This project is improving accessibility to high-quality climate series, which is mainly due to the involvement of most of the NMSs operating in the ECA&D European window (http://eca.knmi.nl/countries/country_overview.php). At present, the network of participants is being gradually extended to countries in the Middle East and North Africa, which is expected to result in a dramatically increased climate data availability and accessibility at the finest time scales for this region in conjunction with the EURO4M project and WMO/MEDARE Initiative efforts.

Several other initiatives attempting to directly or indirectly increase data availability or their accessibility are worth to mention. Thanks to the EU-funded Climate Change and Impact Research: the Mediterranean Environment (CIRCE) integrated project, a handful of southern Mediterranean climate series [i.e. for seven (six) Tunisian (Moroccan) locations have been added covering most of the 20th century for a few of the longest records]. Recently and under the framework of a local DARE project funded by the University of Giessen in Germany and supported by the ACRE Initiative to increase availability and accessibility of long historical observations series from Mediterranean and Middle East (Xoplaki *et al.*, 2012), four sites where air pressure, temperature and rainfall were measured since the late 18th and mid-19th centuries are being recovered, imaged, digitised and quality controlled.

Finally, a number of projects aimed at the establishment of data repositories or the implementation of high-performance computing (HPC) systems in the Eastern Mediterranean region have been recently set up. The EU-funded DARECLIMED project aims to identify, rescue, collect and disseminate regional data sets of interest for the climate, water and energy sectors over the eastern Mediterranean region through establishing a network of partners that have access to, own or have collected relevant data and implement a regional infrastructure for climate research (http://www.cyi.ac.cy/index.php/dareclimed-welcome.html). Another project, aimed at the implementation of a HPC ecosystem interlinking and coordinating regional computing, storage and visualisation resources to implement an integrated e-infrastructure, is the LinkSCEEM-2 project (http://www.linksceem.eu/ls2/project/about-us.html). It is expected that both projects improve data accessibility over the Eastern Mediterranean, a region where the need for long climate data is crucial.

3. Concluding remarks

Despite the wealthy heritage of historical climate records that have been taken across the GMR since the inception of instrumental data, current availability and accessibility to long-term and high-quality climate series are still largely inadequate. This shortcoming is impeding scientific progress on climate variability and change, along with its impacts in the Mediterranean socio-ecosystems, and it is obstructing the definition of the best strategies to adapt the countries to current and future climate change effects.

The study highlights the rich and still largely underexploited heritage of historical climate data over the GMR by means of assessing and describing the climate assets gathered and kept in various online repositories and physical archives around the world. Particularly, a revision is provided of the relevant Mediterranean data sources gathered and maintained by the NCDC/CDMP online repository. This is the largest repository of worldwide climatological data sources, which has recently seen a dramatic cut in funding in the 2012 financial exercise that could put in peril this valuable US-program. Also, the BADC repository and its potential for long climate DARE and reconstruction has been presented. Special emphasis has been placed on the French online and physical holdings containing not only French-mainland data, but also overseas former colonial data over the GMR with the focus put on southern and Middle East Mediterranean countries.

Several initiatives and projects intending to increase climate data availability and accessibility over the GMR have been analysed. The WMO/MEDARE Initiative along with the EU-funded EURO4M project have been the focus, since both ongoing activities in the DARE field are making valuable forward steps for ensuring that the rich heritage of Mediterranean climate records is not lost forever. Other EU- and national-funded projects have been also assessed. Some of the examples used in the article suggest that good coordination among data producers/holders (i.e. NMSs) and scholars (i.e. research centres, universities) in the DARE arena brings improved results when considering enhancing and accessing to crucial historical climate data that remain in unusable formats.

The analyses have shown the need and potential for continuing to promote and carry out DARE activities over this climate change hot spot and have given the necessary details pointing to the relevant climate data sources and holders. It has also assessed current efforts for recovering our historical climate past. Only after reconstructing long-term and high-quality climate series will it be possible to decipher what the long instrumental climate series can provide about past climate variations and the factors forcing them.

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