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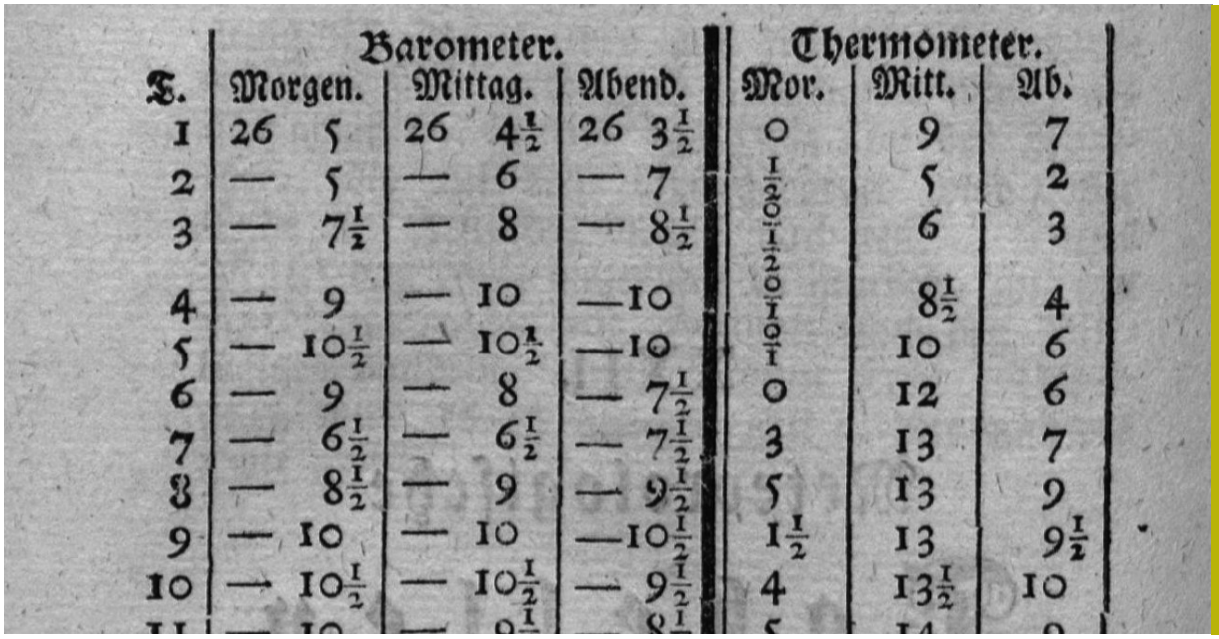
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Early Instrumental Meteorological Series



T.	Barometer. Morgen.	Mittag.	Abend.	Thermometer. Mor.	Mitt.	Ab.
1	26 5	26 4½	26 3½	0	9	7
2	— 5	— 6	— 7	½	5	2
3	— 7½	— 8	— 8½	½	6	3
4	— 9	— 10	—10	½	8½	4
5	— 10½	— 10½	—10	½	10	6
6	— 9	— 8	— 7½	0	12	6
7	— 6½	— 6½	— 7½	3	13	7
8	— 8½	— 9	— 9½	5	13	9
9	— 10	— 10	—10½	1½	13	9½
10	— 10½	— 10½	— 9½	4	13½	10

18 – 21 June 2018, University of Bern, Switzerland

Hosted by Stefan Brönnimann, Institute of Geography
Christian Rohr, Institute of History

Supported by

FNSNF Swiss National Science Foundation

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Akademie der Naturwissenschaften
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ASG Verband Geographie Schweiz
Association Suisse de Géographie
Associazione Svizzera di Geografia

Dear Workshop Participants

We would like to extend a very warm welcome to all of you at the Early Instrumental Meteorological Series Workshop here in Bern.

The goal of this workshop is to get an overview of current activities, and then to compile an inventory of pre-1850 records. Thanks to your excellent contributions, we are able to present a broad and comprehensive conference programme that covers various aspects of early meteorological series. This booklet contains all conference abstracts. The abstracts are in chronological order of the conference programme.

We would like to thank the Swiss National Science Foundation, the Swiss Academy of Sciences, and the Verband Geographie Schweiz for their generous support, and the Oeschger Centre for Climate Change Research for the logistics and administration.

We look forward to many interesting presentations, lively discussions and a hopefully large inventory.

Stefan Brönnimann and Christian Rohr

Venue

Conference Programme

Monday 18 June

09:15-09:30	Stefan Bröninmann	Welcome and Introduction
09:30-10:00	Phil Jones	Digitizing early instrumental data: which sites to digitize and what to do with the digitized data?
10:00-10:30	Franz Mauelshagen	Humboldt's Isotherms
10:30-11:00	Mathias Deutsch	Meteorological observations in Weimar during the first half of the 19th century
11:00-11:30	*Coffee break*	
11:30-12:00	Heli Huhtamaa	Tracing pre-1850s instrumental series from Finland
12:00-12:30	Oyvind Nordli	Esmark's observations, 1816-1838 – The first reliable Norwegian climatological time series? Swedish and Norwegian observations before 1860 - an overview.
12:30-13:00	Rajmund Przbylak	Early instrumental meteorological data from the Arctic and the area of Poland
13:00-14:00	*Lunch Break*	
14:00-14:30	Janusz Filipiak	The longest one-man weather chronicle (1721 to 1786) by Gottfried Reyger for Gdańsk, Poland as a source for improved understanding of past climate variability
14:30-15:00	Rudolf Brazdil	Early instrumental meteorological observations in the Czech Lands
15:00-15:30	Barbara Chimani	Long-time series of Austria and the Alpine region
15:30-16:00	Yuri Brugnara/Lucas Pfister	Early Instrumental Data from Switzerland
16:00-16:30	*Coffee Break & Posters*	
17:00-17:30	Richard Cornes	The London and Paris Sub-daily Pressure series: an indicator of storm activity over the last 300 years
17:30-18:00	Robert Rohde	Early instrumental data in Berkeley Earth temperagture products
18:00-19:00	*Icebreaker & Posters*	

Tuesday 19 June

08:30-09:00	Drew Lorrey (remote)	Data rescue activities in New Zealand
09:00-09:30	Rob Allan	Some observations on evolving and potential terrestrial historical station records around the globe
09:30-10:00	Stefan Grab	Early instrumental weather records in South Africa: an overview
10:00-10:30	Sharon Nicholson	Early rainfall observations in Africa and on islands of the Atlantic and Indian Oceans
10:30-11:00	*Coffee break*	
11:00-11:30	Victoria Slonosky	Historical climate data in Canada and calibration of early instrumental observations
11:30-12:00	Jürg Luterbacher	Preliminary analysis of subdaily pressure and temperature variations of Old Arkhangel (1813-1831) and old Russia (1837-1880)
12:00-12:30	Kathleen Pribyl	Early instrumental data from the Mascarene Islands
12:30-13:00	Pablo Canziani (remote)	Data rescue activities in Argentina
13:00-14:00	*Lunch Break*	
14:00-14:30	José Manuel Vaquero	Recovery of early instrumental meteorological data in the Iberian and former colonies context: a review
14:30-15:00	Mariano Barriendos	Early instrumental observations in Spain, 1780-1860. State of research and data applications
15:00-15:30	Nicolas Maughan	The amateur weather-observing networks in the South-East of France and the production of early instrumental meteorological data (18th c.)
15:30-16:00	*Coffee Break*	
16:00-16:30	Ricardo Garcia-Herrera	Ship's logbooks historical wind observations for the open oceans
16:30-17:00	Rob Allan	Unlocking long historical weather observations from marine sources
17:00-17:30		Discussion
19:00	*Conference Dinner*	Restaurant Rosengarten

Posters

Ulrich Foelsche	Extending the instrumental record of the meteorological station in Graz, Austria back into the late 18th century
Lisa Hannak	Analysis of parallel measurements of manual and automatic measurement systems at German climate reference stations
Sylvie Jourdain	Early instrumental series: Climate data rescue activities at Meteo-France
Nicolas Maughan	HISTRHONE. A multi-secular database (A.D. 1300-2000) on the historical flood variability in the Lower Rhône Valley
Simon Noone	The Copernicus Climate Change Service Global Land and Marine Observations Database
Kristín Björg Ólafsdóttir	Early instrumental meteorological series from Iceland
Dubravka Rasol	Data rescue activities in Croatia
Julian Flückiger	The meteorological series from Bern, Switzerland
Stefan Brönnimann	The Copernicus Climate Change Service Data Rescue Services
Christian Rohr	EUROCLIMHIST
Kim Jacobson	Climate data rescue from the Belgian colonial archives : helping to close the data-gap for Central Africa
Barbara Chimano	EUMETNET Data Rescue Actvities
Fernando Sanchez Rodrigo	Early meteorological data in southern Spain, 1778-1830

Workshops Programme

Wednesday 20 June

08:30-09:30		C3S side meeting
09:30-10:00	Stefan Brönnimann	Introduction / Discussion with remote participants
10:00-10:30	Antonia Valente	Metadata Inventories of Historical Meteorological Series
10:30-12:00		Work in groups
	Lunch (individual)	
13:00-14:00		C3S side meeting
13:00-16:00		Work in groups
16:00-17:00		Discussion, incl. remote participants
19.30	*Public evening event*	

Thursday 21 June

08:30-09:30		Discussion, incl. remote participants
09:30-12:00		Work in groups
	Lunch (individual)	
13:00-15:00		Work in groups
15:00-16:00		Discussion, incl. remote participants
16:00	End	

Group assignments

Group 1: Mediterranean

Manola Brunet

Mariano Barriendos

Maurizio Maugeri

José Manuel Vaquero

Nicolas Maughan

Dubravka Rasol

Fernando S. Rodrigo

Remote: Dimitra Founda

Group 2: Rest of Europe

Rudolf Brázdil

Barbara Chimani

Richard Cornes

Sebastian Eggenberger

Janusz Filipiak

Ulrich Foelsche

Lisa Hannak

Heli Huhtamaa

Philip Jones

Elin Lundstad

Jürg Luterbacher

Franz Mauelshagen

Øyvind Nordli

Kristín Björg Ólafsdóttir

Christian Pfister

Christian Rohr

Remote: Anders Moberg

Group 4: Rest of world

Stefan Brönnimann

Kathleen Prybil

Rob Allan

Stefan Grab

Sharon Nicholson

Sylvie Jourdain

Remote: Drew Lorrey

Remote: Antonia Valente

Group 3: Americas

Vicky Slonosky

Robert Rohde

Yuri Brugnara

Raphael Neukom

Ricardo Garcia-Herrera

Remote: Pablo Canziani

Remote: Nancy Westcott

Public Event

PROGRAMM

Simona Boscani Leoni
Zwischen London und den Alpen: Die ersten meteorologischen Messungen in der Schweiz

Christian Rohr
Wenn instrumentelle Messreihen irreführend werden – oder: Ortskenntnis und Quellenkritik schaden nicht

Stefan Brönnimann
Wetterrekonstruktion aus historischen Messungen

Olivia Romppainen-Martius
Wetterrisiken in der Schweiz – eine Übersicht und Einordnung

Moderation: Heinz Wanner

REFERENTINNEN UND REFERENTEN

Simona Boscani Leoni ist SNF-Förderprofessorin am Historischen Institut der Universität Bern und leitet das Projekt: «Kulturen der Naturforschung online: Akteure, Netzwerke, Themen in der longue durée (1550-ca. 1830)». Ihre Forschungsschwerpunkte liegen auf der Wissens-, Wissenschafts- und Umweltgeschichte der Frühen Neuzeit sowie auf der Alpenwahrnemung zwischen der Renaissance und dem 19. Jahrhhundert.

Christian Rohr ist Ordentlicher Professor für Umwelt- und Klimageschichte am Historischen Institut der Universität Bern sowie am Oeschger-Zentrum für Klimaforschung tätig. Seine Forschungsschwerpunkte liegen auf der Klimageschichte des Mittelalters und der Frühen Neuzeit sowie auf der Wahrnehmung, Deutung, Bewältigung und Erinnerung von extremen Naturereignissen in der Geschichte.

Stefan Brönnimann ist Professor für Klimatologie am Geographischen Institut und Oeschger-Zentrum der Universität Bern. Er rekonstruiert das weltweite Wetter und Klima der Vergangeneheit anhand von historischen Messungen und Klimamodellen.

Olivia Romppainen-Martius ist Professorin für Klimafolgenforschung am Mobiliar Lab für Naturrisiken, am Oeschger-Zentrum für Klimaforschung und am Geographischen Institut der Universität Bern. Sie beschäftigt sich in ihrer Forschung mit Wetterrisiken (Starkniederschläge, Hagel und Stürme) in der Schweiz.

Unterstützt von:

FNSNF Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung

ASG Verband Geographie Schweiz
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Associazione Svizzera di Geografia

Burgergemeinde Bern

Digitizing early instrumental data: which sites to digitize and what to do with the digitized data?

Phil Jones

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1. Climatic Research Unit, University of East Anglia, Norwich, NR4 7TJ, UK

The earliest instrumental data (temperature, pressure and precipitation) were collected from Europe in the 17th century. At a few locations, near continuous series have been collected from a number of sites across Europe from the early-to-mid 18th century, with many sites being run by Universities. The EU IMPROVE project digitized nine sites and provided the original observations and the final series (after adjustments for changes to instruments, observation locations and times). The project illustrated that it is not just a case of digitizing the early data, but all the factors influencing the series (now called Metadata, or Station Histories) needs to be recorded as well. It also became obvious that not all the necessary metadata was recorded at the time, as some aspects of recording were not realized at the time or not thought to be important.

Instrumental recording expanded beyond Europe, with most recording beyond being initially dependent on instruments sent from Europe and was thus part of the European Colonization of many regions of the world. The first wave was scientific in nature, often organized through national scientific societies, but later waves were often linked to commercial activities related to trade, particularly agricultural, forestry and resource development. Instrumental readings were often sent back to Europe, but by the early 19th century readings were analysed and used locally.

Determining which sites to digitize before 1850 is often straightforward as in many regions there is little choice. In Europe, emphasis has been placed on the long series and those run under the auspices of the National Meteorological Services (NMS), which began to be formed from 1850 onwards. In some European countries, NMSs have paid little attention to series before the NMA was established.

There are numerous uses to which the data can be put. These include: input to reanalysis, additions to international datasets, extension of national records and pressure triangles to assess wind speeds over longer periods of time. In all of these, an individual record of observations is a small incremental addition to the sum of what's in a number of global datasets. Clearly some sites are more important, and the determinants are the remoteness of the location and the period from which the measurements come.

Humboldt's Isotherms

Franz Mauelshagen

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1.

Humboldt's isothermal map is considered a major achievement in climatology—and with good reason. In my paper, I will take a closer look into the early instrumental data he used and how he selected and evaluated those data. Contrary to common opinion, his main purpose cannot be reduced to a positivistic display of empiricism. Quite the contrary! Humboldt used measurements to indicate that calculations of solar climates, which had become somewhat popular at his time, were insufficient to explain geographical climatic variability and that climate was a much more complex physical phenomenon, with multiple causes influencing heat distribution.

Meteorological observations in Weimar during the first half of the 19th century

Mathias Deutsch

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1. Büro Deutsch, Erfurt (Thüringen)

The first state operated meteorological monitoring network in the German speaking world was operated between March 1818 and April 1831 with the setup of the so called *„Anstalten für Witterungskunde im Herzogtum Sachsen-Weimar-Eisenach“*. With at first 7 and later 9 stations daily measurements, which included temperature, atmospheric pressure and precipitation, were executed. These observation-data got released in the for example „Meteorologische Jahrbücher“ in Jena. The by duke Carl August and Johann Wolfgang von Goethe supported monitoring network only existed a few years though. Numerous publications established that, except in Jena, after 1831 and decades followed no further monitoring in the duchy Weimar-Eisenach was done. Recent discoveries at the Goethe-Schiller-Archive disprove this assumption. Meteorological observations at Weimar-Belvedere weren't stopped in 1831 but continued without interruptions until September 1857!

During the presentation the fully preserved meteorological measurement series starting August 1821 until September 1857 is being discussed. Furthermore will the as of yet unknown to science meteorological measurement series between January 1814 and December 1820 be presented. These data were compiled at the ducal library in Weimar city centre.

Tracing pre-1850s instrumental series from Finland

Heli Huhtamaa

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Jari Holopainen [2] jari.holopainen@uef.fi
Heli Huhtamaa [3] heli.huhtamaa@hist.unibe.ch
Samuli Helama [4] samuli.helama@luke.fi

1. Åbo Akademi, Finland
2. University of Eastern Finland, Finland
3. Utrecht University, Netherlands
4. Natural Resources Institute, Finland

Continuous and digitalized instrumental series from Finland extend barely prior the 1850. However, Finland has a long tradition of keeping meteorological measurements, extending to the first half of the 18th century. Various sources and archives hold fragmentary series of 18th and early-19th century temperature, precipitation, air pressure, and wind direction and strength measurements. This presentation reviews the state of the research, discusses the main challenges these fragmentary materials pose, and presents the most recent steps which have been taken in regards compiling and homogenizing continuous series extending to the mid-18th century.

Esmark's observations, 1816-1838 – The first reliable Norwegian climatological time series?

Øyvind Nordli

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1. Norwegian Meteorological Institute

Professor Jens Esmark (1762-1839) started observations in 1816 at his home in Oslo. As a student at the Copenhagen University he befriended the Swedish instrument maker Johan(nes) Ahl, and also followed the lectures of Christian Gottlieb Kratzenstein, a "hands-on" practical man who enjoyed crafting instruments. Esmark was therefore well educated for crafting his own instruments. He used barometers for measuring the heights of mountain tops, snow lines and vegetation zones in Norway, and his discovery of Ice Ages (published in 1824) is one of the most revolutionary advances made in Earth sciences.

Esmark's temperature observations (1816-1838) are tested for inhomogeneities. Three significant shifts were detected, but nevertheless the quality of Esmark's measurements seems to be better than for the other contemporary Norwegian time series.

The longest one-man weather chronicle (1721 to 1786) by Gottfried Reyger for Gdańsk, Poland as a source for improved understanding of past climate variability

Janusz FILIPIAK

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3. Nicolaus Copernicus University, Faculty of History, Institute of History and Archival Sciences, Poland

In the paper we focus on the notes of botanist and meteorologist Gottfried Reyger on the weather conditions in Gdańsk, Poland. In our estimation, this chronicle, covering the period from December 1721 to June 1786 (the longest weather chronicle recorded by a single person), is a reliable source of information with the potential to contribute to the understanding of climate variability in 18th-century Gdańsk, the significant old Hanseatic city in Northern Poland. The temperature and precipitation series for all months, seasons and years of the period 1721–1786 were indexed against contemporary conditions according to the proposal of Pfister *et al*. (1994). The climate in the 18th century in Gdańsk was colder than nowadays; the springs were much cooler, as were the summers, while the autumns and winters were warmer. A few relatively cold periods and several warm periods were identified. The first half of the analyzed period was very humid, whereas the second was quite dry. The reconstructed indexed data series were compared to annual and seasonal mean values of air temperature and precipitation derived from regular instrumental observations made in Gdańsk since 1739. The linear regression method was applied to calibrate the reconstructed index series against anomalies from the 1961–1990 average. The correlation coefficient, standard error of estimate and the Root Mean Square Error statistics were used to diagnose the quality of calibration and verification. The highest correlation between the temperature indices and the observational series was found for winter. The reconstructed series for precipitation has a smaller variability than in reality. The reconstructed values for the years prior to 1739 indicates cold years for 1725–1732 and a wet period in the 1730s.

Early instrumental meteorological observations in the Czech Lands

Rudolf Brázdil

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Ladislava Řezníčková [1, 2] ladkar@sci.muni.cz

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2. Global Change Research Institute, Czech Academy of Sciences, Brno, Czech Republic

Creation of official meteorological station network in the Czech Lands (Czech Republic) is dated to 1851, when the Central Institute for Meteorology and Geomagnetism in Vienna was established (Czech Lands were a part of the Austrian empire in that time). But beginnings of instrumental meteorological observations go far beyond. The first such preserved observations come from Prague-Klementinum (Bohemia, the western part of the Czech Republic), where Josef Stepling measured air temperature, pressure and precipitation in 1752. Since 1 January 1775 started systematic meteorological observation there (precipitation from 1 May 1804), continuing up to the recent time. Antonín Strnad and Alois Davis, the third and fourth directors of the Prague-Klementinum observatory, were extremely enthusiastic for extension of meteorological observations to other places in Bohemia, what was subsequently realised. In Moravia, the oldest preserved instrumental records of several meteorological elements, provided by Alois Magg of Magg in Telč, exist between 7 May 1771 and 9 March 1775. Although these observations were done also before 1771 and after 1775, they were not yet found. Since May 1799 started continuous meteorological observation in Brno (precipitation from 1 January1803). A creation of economic societies with the aim to support a general economic development in the country was of a key importance for further development of instrumental meteorological observation in the Czech Lands. In Bohemia it was the I. R. Patriotic-Economic Society and in Moravia/Silesia the I. R. Moravian-Silesian Economic Society. During the first half of the 19th century, they organised network of meteorological stations and even published results of their observations. Some of these stations were included into a new Austrian meteorological network in 1851, but many stopped their observations already before this year.

Long-time series of Austria and the Alpine region

Barbara Chimani

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1. Zentralanstalt für Meteorologie und Geodynamik, Austria

Early instrumental measurements are important for climate research in different respects, e.g. to analyse the climate development and for evaluation purposes of paleoclimate proxy data and climate model performance. Nevertheless data from this time is sparse. Between 2002 and 2007 an international database on long-term, high quality climate data for the Alpine region was created (HISTALP) in order to facilitate further research on this topic. Therefore long term data sets on monthly bases for the Alpine area have been collected, quality controlled and homogenized for different meteorological parameters. For this area about 50 stations with data reaching back until 1850 or further have been identified.

Data in higher temporal resolution is significantly sparser. While on monthly resolution seven stations reach back to at least 1850 in Austria, on higher resolution this is only true for two stations (Vienna and Kremsmünster). The cause for the small number of available station before 1850 can be found in the founding year of the meteorological service in Austria: The Zentralanstalt für Meteorologie und Geophysik was founded in 1851, leading to a sharp increase in stations after that.

The London and Paris Sub-daily Pressure series: an indicator of storm activity over the last 300 years

Richard Cornes

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2. Climatic Research Unit, University of East Anglia, UK

In earlier work we assembled series of daily pressure for London and Paris back to the late seventeenth century through the recovery and correction of barometric pressure readings recorded by various learned institutions and individuals. These series represent two of the longest daily pressure series available, with the London and Paris observations extending back to 1692 and 1670 respectively. These data were used to analyse changes in the North Atlantic atmospheric circulation over the last 300 years through the calculation of a pressure-gradient series, in a similar manner to the widely used station-based North Atlantic Oscillation series. In this work we describe the construction of new versions of the London and Paris pressure series. These series contain several newly digitized and corrected data sequences. Notably a recently discovered series of readings was used to complete the London record during the period 1708-1722 - a period that was missing in the earlier version. In combination with a series of pressure from the Netherlands (consisting of readings from Zwanenburg, Utrecht and De Bilt) we have generated an index of geostrophic wind back to the late eighteenth century that is representative of storminess across the English Channel. The geostrophic wind index displays a statistically significant increase in storm activity over the 1850-2017 period during the winter season, although there is no such increase in storminess during the other seasons of the year.

Some observations on evolving and potential terrestrial historical station records around the globe

Rob Allan

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1. Met Office Hadley Centre, Exeter, Devon, UK

This presentation will provide an overview of the evolving and potential efforts under the international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative to recover, image and digitise a selection of long historical instrumental station weather observations from around the globe. These will include Exeter (UK), Madras and Calcutta (India), Baghdad and Basrah (Iraq), Mauritius (Indian Ocean), Sydney (Australia) and Hong Kong/Canton/Macau plus Beijing (China). It will complement similar efforts being reported at the meeting for locations such as Cape Town (South Africa) and, together with them, illustrate the scope of ongoing data rescue of this nature.

Early instrumental weather records in South Africa: an overview

Stefan Grab

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Jessica Picas [1] picasj5@gmail.com

1. School of Geography, Archaeology & Environmental Studies, University of the Witwatersrand, South Africa

Instrumental weather records for Africa are typically of short duration (< *ca* 60 years), with large data gaps and of poor quality. In addition, for many regions in Africa, the station network is spatially thin. This contrasts strongly with other continents and regions where instrumental records go back to the 18th and even 17th centuries. To this end, any long-term instrumental weather records found for parts of Africa, and especially those extending back in time prior to the 20th century, are of particular value.

South Africa is an exception to the above expressed concerns for Africa, in almost every respect. A couple or more publications have addressed the climate of South Africa, drawing on available instrumental records extending as far back as the 1880s. However, the discovery of the original Cape of Good Hope, *Royal Astronomical Observatory* meteorological registers, which begin in 1834, was only made a few years back, and this has been the stimulus to search for, discover, photograph and digitize other early instrumental records from the sub-continent. This presentation provides an overview of: 1) what instrumental weather records have been found, 2) what has been achieved with these finds (photographed/digitised/analysed), and 3) the challenges, opportunities and work that lies ahead. Particular emphasis is placed on the *ca* 180-year Royal Observatory record in Cape Town, which includes several parameters including barometric pressure, temperature, precipitation and wind. This dataset likely represents one of the longest and oldest single station instrumental weather records for the southern hemisphere. Examples of shorter (several months) but even older (mid and late 18th century) instrumental datasets are presented – the earliest known for the African continent. Specific examples are provided on how these data, given their temporal and spatial limitations, may be used for a variety of historical climate reconstruction initiatives in South Africa.

Early rainfall observations in Africa and on islands of the Atlantic and Indian Oceans

Sharon Nicholson

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While observation networks commenced fairly late over most of Africa, numerous 19th-century and earlier observations are available in a handful of countries. Early observations are plentiful in Algeria, Tunisia, Senegal, Namibia, and South Africa. A few stations records are available in some other countries, notably in East Africa and in countries along the Guinea Coast. Unfortunately, few observations were taken prior to 1850. These exist mainly in Senegal, South Africa, Algeria, and Ghana. A handful of 19th century observations of rainfall were taken over islands, such as those in Cape Verde, Madeira, Canaries, Madagascar. On some islands of the Indian Ocean observations go back to the early 19th century. In the Atlantic, for some islands such as the Antilles, observations extend back to the 17th century. Many of the records were from French colonies and fortunately several authors have compiled summaries of the observations.

Historical climate data in Canada and calibration of early instrumental observations

Victoria Slonosky

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1. ACRE-Canada

The territory which is now known as Canada has been integrated into several international entities since the 16th century, including the French and British Empires and territory controlled by the Hudson's Bay Company. Historical weather and climatic observations can be found in a variety of different sources and formats from archival and bibliographic sources in Canada, Europe and the United States.

Observations discovered to date from before 1850 are mainly from three regions: Atlantic Canada, the St. Lawrence River and Great Lakes Region, and the areas surrounding Hudson's Bay. While multiple sources and overlapping records enable a nearly continuous reconstruction of the climate in the St. Lawrence Valley from the late 18th century onwards, the sporadic nature and wide geographical spread of the Hudson's Bay Company records pose difficulties for data calibration. Further, as yet mainly unexplored, potential sources of weather information may be found in ships' logs and scientific exploration journals.

Only a fraction of the known climatic records from before 1850 have been imaged, and an even smaller number have been transcribed. Citizen science transcription projects undertaken by ACRE—Canada have resulted in hundreds of thousands of individual weather observations transcribed from southern and Atlantic Canada, but many more, particularly from northern Canada, remain unusable in their current form. The interdisciplinary McGill University DRAW project is currently underway to enable citizen science transcription of weather data via a web app.

Many of the earliest observations in both Europe and Canada from the late 17th and first half of the 18th century were taken before instrumental scales were standardized, making the calibration and quality control of the observations an important issue. A method of comparing the frequency distribution of historical observations to modern data demonstrates that indications of overall quality can nevertheless be obtained.

Preliminary analysis of subdaily pressure and temperature variations of Old Arkhangel (1813-1831) and old Russia (1837-1880)

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We provide preliminary analysis of subdaily pressure and temperature variations for the period 1813-1831 from "Observations météorologiques faites à Arkhangel, communiquées par M. Kupffer (1842)". We also give first insights into the meteorological conditions in Northwestern Russia around the eruption of Mount Tambora in April 1815. We further present newly digitised subdaily pressure and temperature data from old Russian weather stations covering the period 1837-1880. The data stem from: (a) Annuaire magnétique et météorologique du corps des ingénieurs des mines de Russie (1837-1846); (b) Annales de l'observatoire physique central de Russie (1847-1861); (c) Svod'Nabliudenii proizvedennykh v Glavnoi fizichesko i podchinennykhi observatoriiâkh (1862-1864) and (d) Lietopisi Glavnoi fizicheskoi observatori (1865-1887). The dataset contains meteorological information from 150 stations though with a varying coverage of available years. A strong increase in the number of stations occurs after 1865 (from 6 to 67 stations). Meteorological variables were usually measured three times per day, predominantly (about 80% of the stations) at 7 a.m., 1 p.m. and 9 p.m. local time. The pressure observations have been corrected for temperature and gravity and reduced to mean sea level. Some stations (Barnaul 1841-1845, 1849-1862; St. Catherinenburg 1841-1862; St. Petersburg 1841-1862 and Tbilisi 1844-1846; 1852-1864) have hourly data which allow to study the diurnal cycle of meteorological variables. Long-term analyses are possible only with 7 stations that have observations longer than 30 years (Barnoul, Bogoslowsk, Nertchinsk, St. Catherinenburg, St. Petersburg, Tbilisi and Zlatouste). The data are part of the Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative (http://www.met-acre.org/). ACRE undertakes and facilitates the recovery, imaging and digitisation of historical instrumental surface terrestrial and marine global weather observations to underpin 3D weather reconstructions (reanalyses) spanning the last 200-250 years for climate applications, climate services, impacts, risks and extremes communities. All of the historical surface weather data and the reanalyses are freely available.

Early instrumental data from the Mascarene Islands

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Instrumental series from regions around the Indian Ocean rarely extend as far back in time as in Europe or North America. However, on the Mascarene Islands instrumental observations already began in the second half of the eighteenth century. Measurements were taken on Mauritius rather than Réunion, since this island had a natural port which made it a waypoint on the journey to India first for the Dutch, then for the French and finally for the British. Hence these observations arose in the colonial context; they were most likely begun in the 1770s by Jean-Nicolas Céré, the director of the botanical garden at Pamplemousses. In the 1780s Jean-Baptiste Lislet Geoffroy started his series which was continued until the 1830s. Renewed efforts for collecting meteorological data were undertaken by the Société Royale des Arts et Sciences de Maurice in the 1820s. However, most of these early data can not be located or are lost – due to the most impressive climatological feature of the Mascarene Islands which also was the primary factor of raising the interest in meteorology for local individuals as well as institutions: cyclones. With Charles Meldrum's appointment as government observer in 1862 and his influential work at the observatory in Port Louis begins a period for which at least monthly summaries survive in the Blue Books: Meldrum's extensive body of work on meteorology in general and (individual) cyclones in the Indian Ocean was not only based on data from the island, but also on observations collected from ship logs in the harbour of Port Louis. It seems that the cyclone devastating Mauritius in 1892 was responsible for the loss of the original unpublished records of earlier instrumental observations.

Recovery of early instrumental meteorological data in the Iberian and former colonies context: a review

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In the last years, several efforts have been made to recover early meteorological data of Spain and Portugal. This effort is especially relevant because Iberia is a territory where natural high-resolution proxies (annual or higher) are scarce. Therefore, the characterization of the climate and meteorological variability in the last centuries relies on a relatively limited number of evidences. Thus, early instrumental data, before the advent of Meteorological Services provide crucial information to fulfill this objective. On the other hand, the relationship of the Iberian countries with their former colonies has facilitated the access to this type of data from the Americas, as can be seen in Domínguez-Castro et al. (2017). In this presentation, we will show the more recent efforts undertaken in these topics. Alcoforado et al. (2012) recovered readings from Portugal of the 18th century and Domínguez-Castro et al. (2014) retrieved and digitized more than 100 000 meteorological observations prior to 1850 in Spain. Moreover, Domínguez-Castro et al. (2013) identified and analyzed the first systematic observations made in Iberia (city of Lisbon) between 1 November 1724 and 11 January 1725 by Diogo Nunes Ribeiro. Others efforts have been made to recover early data of others places in Iberia, including: Cádiz (Gallego et al., 2007; Rodrigo, 2012), Barcelona (Prohom et al., 2016), and Zafra (Fernández-Fernández et al., 2014). The data recovery has not been limited to temperature or precipitation, as some other studies have focused in cloudiness and solar radiation (Laken & Vaquero, 2015; Antón et al. 2014, 2017). Finally, we show the main results from a wide rescue exercise of early meteorological data in Southern and Central America, through the EMERLAC initiative (Domínguez-Castro et al., 2017) and Africa (Gallego et al., 2011).

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EARLY INSTRUMENTAL OBSERVATION IN SPAIN, 1780-1860. State of research and data applications

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Present state of research in Spain concerning early instrumental meteorological observation is very modest. A few number of large data series were detected and digitized by different european projects (Barcelona, Cadiz, Madrid, Valencia). Other short series or scattered observations also were detected and catalogued. At present, many cities have "traces" of possible old meteorological observations (Palma de Mallorca, Sevilla, Zaragoza), but research of them would require time and resources.

Meanwhile new resources are focused on detection adn rescue of old data, data available could be applied on historical climatology research.

Different spanish projects are promoting research on multi-proxy approach for study of severe climatic and meterological extremes. Thanks to systematic efforts, large databases are in construction for flood events and droughts. Old instrumental records can help for a better understanding of these events. Period under study is interesting because show atmosphere in a "pre-global warming" escenario but also during last period of "Little Ice Age".

Catalan Meteorological Survey has developped experience for data treatment and homogeneization of these old series in collaboration with research spanish and international groups. Pressure data are focusing effort because application in barometric indices and synoptic reconstructions.

Collaboration with other research groups at european scale could help in this effort to know about respective meteorological extreme events.

The amateur weather-observing networks in the South-East of France and the production of early instrumental meteorological data (18th c.)

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In the South-East of France, the first steps of experimental meteorology have really started in 1706 with temperature measurements made by the Count Luigi Ferdinando Marsili, eminent Italian scholar from Bologna, near the city of Marseille where he pioneered the use of the Florentin Thermometer. These observations have continued at the Marseille Astronomical Observatory, interspersed with more or less long intermissions, but only became systematic from the 1740's with a real expertise in observational procedures. Many other observers also made temperature, precipitation and atmospheric pressure measurements throughout the 18th c. in many Provençal stations like Arles, Aix-en-Provence, Cavaillon, Salon-de-Provence, Manosque or Toulon, but also in the Languedoc: in Nîmes, Viviers and Montpellier. For many of these cities, daily or monthly data are only available for some specific months or years. But, if these meteorological data are « intermittent series » over relatively short time periods they can be of great importance for studying past extreme climate events like the Great European Frost of 1709 or the 1730/31 drought in Southeastern France. However, although monthly instrumental series, dating back to the mid-18th century, for cities like Marseille or Montpellier are already online for several years in international climate databases, daily observational datasets (especially for the early 18th c.) for numerous stations are not still available and remain unexploited.

First, we will present an original and detailed synthesis of all existing early instrumental meteorological data (type of weather factor, frequency, quality and accuracy of records) for various stations in the South-East of France in the 18th century. Then, for stations with available daily instrumental observations, a state of progress in their extraction (from local weather dairies) and analysis will be given together with solutions to replace missing values.

Unlocking long historical weather observations from marine sources

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In historical climate studies, the rescue (discovery, recovery, imaging, digitisation, quality control and archiving) of historical marine weather observations has received much less consideration than its terrestrial data counterpart. The impetus for a change in this situation began in the mid-1980s, with successive Comprehensive Ocean-Atmosphere Data Set (COADS) and International Comprehensive Ocean-Atmosphere Data Set (ICOADS) programs (embodying the RECovery of Logbooks And International Marine data [RECLAIM] data rescue focus). In the last decade, with activities such as those under, and linked to, the international Atmospheric Circulation Reconstructions over the Earth (ACRE), this situation has begun to change dramatically. Several projects have led the way - CoRRaL: UK Colonial registers and Royal Naval Logbooks, those focusing on historical weather observations recorded in ship log books during World War 2 (1941-1946), an extended World War 1 period (1914-1923), the English East India Company (1780s-1830s), on circumnavigations and voyages of discovery (1700s-1850s), whaling voyages, 'stationary ships' anchored in colonial harbours, and late 19th-20th century Arctic and Antarctic expeditions, commercial vessels. The most recent of these have employed citizen science approaches, such as with OldWeather and Weather Detective.

Nevertheless, significant repositories continue to be discovered or await the attention of the marine data rescue community - archives, museums and libraries in the UK, Scandinavian countries (Norway, Sweden, Denmark, Iceland and Finland), Russia and Chile with significant log book holdings for regions such as the Asia-Pacific, southern Africa, Antarctica and the Southern Ocean. In the UK, with ACRE Oceans, focusing on Royal Navy hydrographic and survey vessel Remarks Books (1759-1909), Convict Ships (18th-19th century), journals of Royal Navy surgeons (1793 to 1880), Cable Ships (from the 1850s – laying and maintaining telecommunication cables), Packet Ships (18th-19th century mail ships), UK and Norwegian Antarctic whaling plus circumnavigations (20th century).

Ship's logbooks historical wind observations for the open oceans

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Along the fifteenth century, Europeans started the open ocean navigation towards their colonies. This required the daily determination of longitude and latitude, which were recorded jointly with meteorological observations in the ships logbooks. Historical wind force observations were not instrumental but estimated and codified as “wind descriptors” in the logbooks. On the other hand, wind direction observations do not suffer from such limitation as they were measured with a compass and hence can be considered a truly instrumental observation, even for the oldest records. Millions of pages of such records have been preserved in different archives. They represent a valuable resource and provide unique information for an area of the globe poorly covered (the oceans) and for a period (c.1680-1900) when weather observations are sparse. We will show that logbooks extend back the instrumental record with observations of comparable quality to the modern ones, thus reducing the limitations derived from the shortness of current records. This has allowed building centennial series which allow a better characterization of weather extremes and unveiled multi-decadal variability previously unsuspected. We will provide examples as the steady enhancement of the Australian monsoon since the early 19th century, the non-stationary behavior of the Euro-Atlantic atmospheric circulation during the Late Maunder Minimum, the alternation of wet and dry multidecadal periods in the Sahel or the complex relationship between the Western North Pacific Summer Monsoon and the different ENSO modes. Finally, we will describe the status of the UPNAO project, which is currently recovering data from the Eastern Tropical North Atlantic.

Extending the instrumental record of the meteorological station in Graz, Austria back into the late 18th century

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The University of Graz hosts one of the long-term meteorological stations in Austria, which also contributes to the HISTALP dataset. The temperature time series goes currently back to the year 1836. The Austrian National Library has recently digitized several volumes of the newspaper "Grätzer Zeitung", which contain daily measurements (morning, noon and evening) of temperature and pressure, recorded in the historic center of Graz by Mr. Rospini (and later by his son and grandsons), a man of great interest in natural sciences. We have digitized the temperature data from 1816 onwards, and were able to construct an almost continuous time series up to the year 1837 (overlapping the "official" temperature series). Earlier volumes of the "Grätzer Zeitung" are currently only available on microfilm, but an initial screening shows that the temperature record can likely be extended back to the year 1795 - or even further (Mr. Rospini started his daily measurements in 1781).

Analysis of parallel measurements of manual and automatic measurement systems at German climate reference stations

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To study climate change, long and homogenous time series are required for a reliable research. Instrumental changes or site changes can affect the measurements and can be reason for breaks in long time series. To study the effect of changes in measurement systems, the German meteorological service (Deutscher Wetterdienst, DWD) operates climate reference stations where parallel measurements are taken with the old and new (operational) measurement system. Beside this, parallel measurements give the opportunity to evaluate historic observations.

As one example temperature measurements are done manually with a mercury-in-glass thermometer in a Stevenson screen. Automatic measurements are performed with an electronic PT100-sensor in a lamellar shelter LAM 630. The analysis of the differences shows small deviations between the two measurement systems at traditional observing times (which are used for the three daily manual observations: 6:30 UTC, 13:30 UTC, and 20:30 UTC). Formerly the traditional observing times were used to calculate daily mean values, with double weight on the evening value. Because of the increased temporal resolution of the automatic measurements, the formula was changed to an arithmetic mean over 24 hourly values. The comparison of the different equations show small differences in the mean but the standard deviation is larger than using the same equation to calculate daily mean values. Other parameters which are measured at German climate reference stations beside temperature are daily extreme temperature, soil temperature, relative humidity, pressure, sunshine duration and precipitation. In this presentation we will show some results of the statistical analysis of the differences between manual and automatic measurement systems.

Early instrumental series : Climate data rescue activities at Meteo-France

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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,2008).

French climate data are hidden in many places in France : Météo-France, National Archives, local archives, scientific institution archives, research centres, universities, learned societies, the Frennch National library, national libraies and the Defence Historical Service.

In 1897, the french climatologist Angot published the first catalog of meteorological observations made in France until 1850 giving the name of the observer , the parameters and the location of the archives. This leading publication is the key to search and locate the early instrumental series.

Météo-France has been involved in several targeted actions through collaborations with historians and researchers. The most important actions are presented :

- All the monthly rainfall made in France between 1704 and 1870, published by the scientist V. Raulin, have been imaged, digitised and integrated into the French National Climat Database.

- ANR Chedar project was the opportunity to image the collection of the records of weather reports made by 200 doctors on daily basis over France during the period 1776-1792 and to digitise some shorts series of sudaily pressure and temperature and daily precipitation data during the period 1783-1789.

- Bleuse (2010) describes the recovered long series of temperature, pressure and humidity measured in the Marine Hospital in Rochefort between 1815 and 1895.

- Surville et al. (2017) presents the series digitised by Météo-France for the city La Rochelle during the period 1776-1801.

HISTRHONE. A multi-secular database (A.D. 1300-2000) on the historical flood variability in the Lower Rhône Valley

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The recent HISTRHONE database (https://histrhone.cerege.fr) was built from a wide range of over a thousand different historical records from the 14th to the 20th century. A several-decades long collection of records related to past weather conditions, preserved in national and regional public or private archives and libraries, has been at the root of this project. The technical realization was conducted by the SIGéo laboratory, European Centre for Research and Education in Environmental Geosciences (CEREGE), in the Aix-Marseille University (France).

For the poster, we will strive to develop three major aspects:

1. The wide range of research in national or regional historical sources: narrative sources available since the 14th century, technical and engineering documents, or similar, since the 17-18th centuries and daily instrumental meteorological observations available since the late 18th c., and for specific years like 1816 or 1829, according to the place of observating stations.

2. An attempt to present a cross-historical analysis of the dataset. From the basis of an increasing intensity in river discharge, both Rhône and Durance river floods are classified in four distinct groups (1009 events in total in the series), the most severe events gathered in the last three groups (517 floods) can be subject to a safe statistical analysis since the 15th c.

3. The historical flood data analysis is also related to a large amount of metadata. The ice of rivers (174 identified episodes), the droughts and the rains (HISTRHONE includes two additional databases dealing with ice events and drought episodes).

Cross-comparisons with data from other existing European databases on historical floods could be interesting to understand some specific extreme events in relation with the past climate variability.

The Copernicus Climate Change Service Global Land and Marine Observations Database

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This presentation shall outline the planned service provision for a new Copernicus Climate Change Service concerning the availability of in-situ fundamental climate data records. The service brings together a number of European parties working in tandem with NOAA NCEI to provide via the C3S Data Store improved access to land and marine surface meteorological records for climate research. This presentation shall provide a high-level overview of service aims, timelines and progress to date. On the marine side the service shall aim to improve the existing ICOADS holdings with improved quality flagging, duplicate removal etc. On the land side a set of integrated holdings across Essential Climate Variables and timescales is envisaged. Data shall be made available via the C3S data store under a common data model. The Service shall interact with sister lots concerned with data rescue, provision of baseline /reference network data, and provision of in-situ data products and the broader Copernicus Climate Change Service and Copernicus services. The Service aims to incorporate all available long and early instrumental series and make these available to users. I will outline the modalities of data ingestion and shall be urging you all to contribute the hugely valuable data that you have worked on. We shall ensure sharing and usage with e.g. reanalysis producers.

For full details on service please see link below:

http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-16-0165.1

Early instrumental meteorological series from Iceland

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The oldest known instrumental meteorological series in Iceland are the observations made in 1749 to 1751 at Bessastaðir, in Southwest Iceland. Several short discontinuous series of measurements exist from the late eighteenth century to early nineteenth century from various locations in the country. The observations were in hands of enthusiastic individuals during this time and the quality of them is very variable. The most valuable one were made under the auspices of the Danish Scientific Society, for example the daily observations of Jón Thorsteinsson made in Reykjavík from 1820 to 1854. On the initiative of the poet and naturalist Jónas Hallgrímsson a net of stations observing weather and measuring temperature was established in 1841 and 1842. The Icelandic Society of Letters distributed thermometers and detailed instructions on meteorological observations to around fifty ministers all over the country in cooperation with the Danish Scientific Society. During a period of a few years a considerable amount of observations was collected. A few of the ministers kept the effort going for more than thirty years but the majority slowly withered. The effort of the Icelandic Society of Letters on regular meteorological observations indirectly led to the establishment of observations in Stykkishólmur in West Iceland. These observations were made by a local merchant Árni Thorlacius. The observations started in September 1845 and mark a watershed in the history of meteorological observations in Iceland, with observations at the site continuing to the present. The Danish Meteorological Institute took over the formal observations in Iceland in 1872 and soon established a number of regular stations.

Data rescue activities in Croatia

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Meteorological measurements in Croatia date back to the middle of the 19th century. The first station with systematic measurements is Dubrovinik , founded in 1858, unfortunately there are longer gaps in measurements at that location. The station with the longest continuous measurements is Zagreb – Gric that has digitized data from December 1861 until now. The territory of the Republic of Croatia had a turbulent history and some regions belonged up to 6 different countries from the time of beginning of meteorological measurements.

The digital processing of climatological data started in 1981 and of precipitation data in 1991. Historical data are being digitized according mostly the priorities for climate monitoring needs. Recently, Croatia has joined several data rescue initiatives and programmes such as MEDARE, I-DARE, EUMETNET-DaRe etc. and some sporadical data rescue activities. The data rescue and digitalization is costly and time consuming task but more and more efforts are being made by the Meteorological and Hydrological Service of Croatia to find historical data logs and to scan and save those data that belong to the most important national and world heritage

Climate data rescue from the Belgian colonial archives : helping to close the data-gap over Central Africa

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During the first half of the twentieth century, climate data was rigorously collected throughout the Belgian Congo. Yet today this data is practically absent from (international) data repositories and not included in (re-analysis) climate models. The historical archives of La régie des plantations de la colonie (REPCO) and the Institut National d'Etudes Agronomique du Congo Belge (INEAC) archives hold vast amounts of (eco-) climatological data, with great potential and relevance for basic and applied research in the central Congo Basin. They are currently stored at the State Archives of Belgium, the Royal Museum for Central Africa and the Botanic Garden Meise in Belgium.

In 2017, the "Congo basin eco-climatological data recovery and valorization" (COBECORE) 4-year project was launched with the aim to valorize this legacy data by making it accessible for contemporary research through computer vision, machine learning and citizen science approaches. Here we report on the completion of scanning activities during the first year of data recovery for 575 climatological stations spread throughout the Congo Basin, equivalent to 4300 site-years (50 000 scans). We provide an overview of the climate stations where this data was collected during colonial times, as well as the parameters and timeframe for which we have data.

EARLY METEOROLOGICAL DATA IN SOUTHERN SPAIN, 1778-1830

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The objetive of this work is to present new data from southern Spain corresponding to the period 1778-1830. Data sources are early newspapers and medical studies interested in the influence of environment conditions on health and illness. Data correspond to some cities in the area (Sevilla, Cádiz, Málaga, Granada, Cartagena). Number of rainy days, temperature, pressure, wind direction, and qualitative statements of atmospheric events (rainfall, fog, cloudiness, storms) were recorded. Data base obtained to the date is a set of scattered meterorological series, with short periods of observation, fragmented and with no homogeneous characteristics. However, these data may offer interesting information on extreme events, as for instance floods in the 1780s decade, and the so-called ‘year without summer’ 1816.

Metadata Inventories of Historical Meteorological Series

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Data Rescue of Historical Meteorological Data has become a very important task for reconstructing the climate of the past. But rescuing only data itself is not enough, it's equally important to include the metadata details associated with observations. This information includes the site where the observations were taken, the observations time, instruments, procedures and other details that are crucial to analyse long time series or short time meteorological events that occurred in the past. In this presentation we will discuss the relevance of writing metadata inventories in Data Rescue initiatives. Taking into account the WIGOS Metadata Standard from WMO, we will show how we have been constructing metadata inventories for the ERA-CLIM2 FP7 project, which allowed for the recovery of Land Surface, Upper Air and Marine data in many world regions. We we'll also make the case for gathering the metadata inventories in a Global Registry such as the one developed in ERA-CLIM2 and the Registry in construction for the Copernicus Climate Change Service.