

ACRE Drought and Flood meeting

**The Corfu Summer Institute for Theoretical Physics and Gravity,**

**Corfu, Greece, 23rd September to 27th September 2024.**

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**Introduction and Overview.**

Since its inception in mid-2007, the International Atmospheric Circulation Reconstructions over the Earth (ACRE) Initiative has worked to strengthen the ties and flow of data recovered from international historical terrestrial and marine instrumental data rescue activities through to international data holdings and their ingestion into improving historical dynamical reanalyses, for their ultimate use in enhancing the quality and temporal extent of such products for the full range of global to regional scale climate services, applications and management needs.

The ACRE Meeting held in Corfu, Greece, 23rd September 2024 to 27th September at the Summer Institute for Theoretical Physics and Gravity brought together leading scientists and practitioners from around the world – including those ‘on-line’. These scientists are working in the fields of applications and reanalysis of historical climate and weather data sets in drought and flood analyses together with many historians, geographers, hydrologists, meteorologists, and climatologists who are undertaking the painstaking task of ‘rescuing’, collecting and collating critical observations from our past. These observations can provide important detail on past drought and flood frequencies, histories, and return periods as well as feeding critical data into reanalysis methods that then create past and recent weather systems and upper-level dynamics important for weather and climate forecasting, as well as in disaster risk reduction and attribution.

A key outcome from ACRE Corfu was in the presentation and *elucidation of clear pathways in the use and value of data rescue in development of long-term drought data bases, especially in the development of methods of using rescued data from as far back as the 14th Century in the consequent development of long-term records of the Standardised Precipitation Index (SPI. Such initiatives may provide greatly improved input into drought policy development that would then include improved understanding of drought (and flood) return periods, frequencies, and intensities.*

Below is an executive summary and listing of recommendations arising from this recent ACRE Corfu Meeting on Droughts and Floods. Details aspects of ACRE, together with extensive information relating to the program, speakers and subject matter presented follows in the detailed text.

**Executive Summary, Key Messages and Recommendations:**

* Droughts and floods have long been significant climatic events, with historical documentation through data rescue and reanalysis techniques shedding light on multi-centennial trends.
* It is possible to extend drought (and flood) data bases back many centuries (e.g. 14th Century in China, 16th Century in Europe) and these data bases can be invaluable in assessing long-term return frequencies of severe drought and flood events. This detailed historical information can be especially valuable in drought policy formulation (e.g. drought relief payments for farmers).
* Historical data-rescue remains crucial for understanding long-term climate variability and trends, especially those related to droughts and floods, with efforts focusing on diverse sources such as ship logbooks, diaries, farm records, and other sources.
* Data Rescue and Reanalysis Methods greatly enhance our understanding of climate change over many centuries.
* It is possible to reconstruct key drought indices such as the Standardised Precipitation Index (SPI) as far back as the 14th Century in some regions.
* Use of reanalysis methods (e.g. 20th Century Reanalysis, ERA-5) greatly expands the value of data rescue through the identification of long-term historical systems such as drought and floods, especially their return periods and long-term trends. These techniques can aid attribution studies of severe events, including drought and floods of special importance in insurance and litigation needs.
* Medicanes (cyclones) and other extreme weather events underscore the importance of improved early warning systems and use of historical documentation to better understand return frequencies and other aspects of extreme events.
* Utilisation of farm records and other similar observations is important for a more enhanced understanding of historical droughts and their trends.
* Collaborative projects like ACRE and online tools (e.g., ReaderMapper) are essential for expanding access to rescued climate data related to droughts and floods and supporting global research initiatives.

**Recommendations**.

* There is a need to enhance data rescue and Reanalysis Systems to improve our understanding of long-term trends in droughts and floods, especially in aspects related to climate change.
* Efforts need to be made to extend drought (and flood) data bases back many centuries, taking note of the efforts already made for China and Europe. This detailed historical information can be especially valuable in drought policy formulation (e.g. drought relief payments for farmers).
* Enhanced work needs to be undertaken to retrieve information from such as farm records and ship logbooks to gain an enhanced understanding of trends in drought and major weather systems.
* Effort needs to be made to extend valuable drought indices such as the SPI back in history to gain an improved understanding of changes and trends in drought in all world regions.
* Use of reanalysis methods (e.g. 20th Century Reanalysis, ERA-5) should be greatly expanded to aid attribution studies of extreme weather and climate including events such as flash floods and flash droughts.
* Collaborative projects like ACRE and online tools (e.g., ReaderMapper) need to be promoted in order to enhance the rescue of data related to droughts and floods and supporting global research initiatives.
* There is a need to more clearly illustrate the clear linkages and opportunities for applications of long-term data rescue in such as drought policy development.

**ACRE Background**

Since its inception in mid-2007, the International Atmospheric Circulation Reconstructions over the Earth (ACRE) Initiative has worked to strengthen the ties and flow of data recovered from international historical terrestrial and marine instrumental data rescue activities through to international data holdings and their ingestion into improving historical dynamical reanalyses, for their ultimate use in enhancing the quality and temporal extent of such products for the full range of global to regional scale climate services, applications and management needs.

During the above time, ACRE has held full meetings and workshops in Switzerland (2008), Australia (2009), the USA (2010), the Netherlands (2011), France (2012), Portugal (2013), Canada (2014), Chile (2015-linked to ICSHMO 11), Ireland (2016), New Zealand (2017), Japan (2018) and Argentina (2019).

Data visualisation and multidisciplinary meetings were also held in Italy (2009), the UK (2009; 2014), New Zealand (2011), Costa Rica (2016), and most recently ACRE presentations were made in Greece (on Crete in 2022 at IMS, and in Athens as part of COMECAP 2023).

Regionally-focused ACRE Southeast Asia, China and Japan workshops took place in Malaysia (2014), Indonesia (2014), China (2016; 2019), and Hong Kong (2017), along with the INDARE initiative in the Indian Ocean (meetings in Geneva in 2014, Mozambique in 2014, and on Mauritius in 2015; 2016), while ACRE was also present at the 10ICSHMO conference held on New Caledonia (2013).

ACRE has participated in various EU-funded projects under EC FP7, ERA-CLIM 1 & 2, MEDARE, UERRA, EURO4M, C3SDRS, C3S2, and held a side event at the CoP26 conference in Scotland, England in 2021.

The above ACRE meetings, workshops and conferences were variously supported and funded by contributions from WDCM, WMO, GCOS, WCRP, the Met Office Hadley Centre, APN, Environment Canada, CSIRO, UK AHRC, MeteoFrance, KNMI, FONDS PACIFIC, CATIE Costa Rica, University of Malaysia, National University and SMU Singapore, SACA&D, CSSP China, WCSSP South Africa, MeteoSwiss, FCUL, CMA, Verisk Climate, Hong Kong Maritime Museum, CMOC, GFCS, IOWC.

Following COVID, and two online meetings of ACRE, face-to-face meetings were resumed with the first topic-specific ACRE meeting on Drought & Flood held at the Mon Repos Estate on Corfu in Greece in September 2024.

Group photographs during the ACRE Drought and Flood meeting:

<https://photos.app.goo.gl/it1K3CVZhqygZacR9>

**Program**

*\*Before name = remote presentation*

*Presentation time 30 minutes, with recommendation of last 5 minutes for questions.*

# Monday Sept 23rd:

2000**: Registration & Welcome reception** outside the Mon Repos Museum (ex-Royal summer Palace) (meal included) with informal discussions if we want

# Tuesday Sept 24th:

0900: **Registration if needed**

# Introduction and Opening

## Rob Allan

## Christos Zerefos/Dimitra Founda

0930: **Rob Allan**: Short overview of ACRE (<https://physics.ntua.gr/corfu2024/Talks/allarob@gmail_com_01.pptx>)

# Data & Data Rescue

**(Session Chair: Roger Stone Online Presentation Coordinator: Ed Hawkins Rapporteur: Praveen Teleti)**

0945: **Andrea Kiss**: Documentary evidence based multi-centennial flood and drought series in Europe: an overview (<https://www.dropbox.com/scl/fi/ohtdal4pqvtw7sytiq6hu/File-16-10-2024-07-35-46?rlkey=ijq6n0taanxaplutomkftqjg4&st=41vtgwqf&dl=0>)

1015: **Dimitra Founda**: The historical sub-daily climatic observations in Greece - Efforts to improve access and exploitation (<https://physics.ntua.gr/corfu2024/Talks/founda@noa_gr_01.pptx>)

1045: **Morning Tea.**

1115: Presentation of the bi-annual WMO Professor Mariolopoulos Trust Fund Award for young scientists who made exceptional contributions to meteorology and climatology in 2024. Video of the Award Ceremony: <https://youtu.be/VjXVtAjl-j0>

1130: **\*Stefan Grab**: The use of documentary and digitized farm rainfall [records](http://www.apple.com/uk) to place central Karoo droughts in perspective (<https://www.dropbox.com/scl/fi/i0h7sw4ejieyyy2q6yoqo/ACRE-202024.pptx?rlkey=w9o8uw3j00sbu3281aj8sh32u&st=3r3zskwl&dl=0>)

1200: **\*Richard Cornes**: Marine data pipelines (getting recovered data into global international repositories) (<https://www.dropbox.com/scl/fi/b4e5t7vfc6ecr5vm5sz2c/ACRE_marine_pipeline_sep24.pptx?rlkey=9ev28b8c8jzwbsn5xxoj9otc1&st=ken87svn&dl=0>)

1230: **Vicky Slonosky**: Canadian floods and droughts in meteorological observations and newspaper reports: the Canada-Wx historical database and DRAW (<https://physics.ntua.gr/corfu2024/Talks/victoria_slonosky@mail_mcgill_ca_01.pptx>)

1300: **Rob Allan:** Historical Medicanes: Data Requirements (<https://physics.ntua.gr/corfu2024/Talks/allarob@gmail_com_02.pptx>)

1330: **Lunch & offline discussions (at the venue).**

1530: **Catherine Ross**: Rainfall Data Rescue activities at the UK Met Office National Meteorological Archive – current activities, use in climate monitoring, and next steps (<https://physics.ntua.gr/corfu2024/Talks/catherine_ross@metoffice_gov_uk_01.pptx>)

1600: **\*Mariela Vasquez**: ACRE Chile, efforts and advances (<https://www.dropbox.com/scl/fi/q18dc5i51pff10sba8smp/ACRE-2024.pdf?rlkey=i7qvms3acpt8xvf9c9z13a2os&st=h8deb6j9&dl=0>)

1630:  **\*Stefan Bronnimann:** Atlantic-European Jet Variability from Rescued Daily Pressure Series (<https://www.dropbox.com/scl/fi/8eqwaqkvxzllyhf9rj6ll/Presentation_117_ACRE.ppt?rlkey=vq6vu6z9oye8r0sjjxa4yceie&st=g1nr8gh0&dl=0>)

1700: **Afternoon Tea.**

1730: **Day One Close**

**Day One Summary (**<https://www.dropbox.com/scl/fi/ej0cbokht6rmhis0m3tqd/9th_ACRE_Meeting_Summary_Day1.docx?rlkey=p4qluf4wphp4u9ead42a4l1bu&st=tybporrx&dl=0>**)**

**Press Conference** (<https://www.ertnews.gr/perifereiakoi-stathmoi/kerkira/kerkyra-i-klimatiki-krisi-kai-ta-meteorologika-ergaleia-antikeimeno-diethnous-synantisis/>

<https://www.youtube.com/watch?v=MIGu1mW49Gs>)

# Wednesday Sept 25th:

0900: **Registration if needed**

# Data & Data Rescue (continued)

**(Session Chair: Gil Compo Online Presentation Coordinator: Vicky Slonosky Rapporteur: Christa Pudmenzky)**

0930: **Praveen Teleti**: Roadmap to discover, transcribe, and analyse early 20th Century weather observations from Singapore, West Malaysia, and northern Sumatra (<https://physics.ntua.gr/corfu2024/Talks/praveen_teleti@ncas_ac_uk_01.pptx>)

1000: **Christa Pudmenzky:** Weather Detective (<https://physics.ntua.gr/corfu2024/Talks/christa_pudmenzky@unisq_edu_au_01.pptx>)

1030: **Togo Tsukahara, Hisayuki Kubota, Jun Matsumoto, Alice de Jong, Masumi Zaiki, Ikumi Akasaka and Atushi Ota:** Preliminary result of research into Dutch Naval Logbook and weather related datasets (<https://physics.ntua.gr/corfu2024/Talks/byz06433@nifty_com_01.pptx>)

1100:  **Morning Tea.**

1130: **Theo Brandsma:** Digitization of the Royal Netherlands Navy logbooks in the 1813-1960 period for climate reconstruction (<https://physics.ntua.gr/corfu2024/Talks/theo_brandsma@knmi_nl_01.pdf>)

1200: \***Matt Hannaford, David Nash and Bárbara Direito:** Documentary reconstruction of rainfall variability in Mozambique during the nineteenth century (<https://www.dropbox.com/scl/fi/fg1oqvypn6x2i3sn54n20/Hannaford-ACRE.pptx?rlkey=prl07a33a5hfabzzj6368gst1&st=6nmo5n4q&dl=0>)

1230:  **Chih-Hsuan Chang, Elaine Kuanhui Lin, Yu-Shiang Lin and Wan-Ling Tseng:** Adjusting Standardized Precipitation Index to reconstruct 0.5° x 0.5° drought data from documentary records in the Chinese dynasties since the mid-14th century (<https://physics.ntua.gr/corfu2024/Talks/keepgoingjustdoit@gmail_com_01.pptx>)

1300: \***Peter Thorne:** Global Land and Marine Observations Database **(**GLAMOD) (<https://www.dropbox.com/scl/fi/kwym96w9u769wf0786evv/ACRE_Talk_Peter_Thorne_C3S_service.pptx?rlkey=4g8v6wasq50e4qpsypwnyaavj&st=ozra1ulr&dl=0>)

1330: **Lunch & offline discussions (at the venue).**

1530:  **Denis Stuber**: Meteo-France Data Rescue activities (<https://www.dropbox.com/scl/fi/6wf608jtisod0zxhzcazq/20240924_Meteo-France_ACRE_CORFOU-2024_DataRescue_V2.pdf?rlkey=1qujsd3funh58mymxfg136vns&st=w5mb5bxf&dl=0>)

1600: **\*Pablo Canziani and Gabriela Lakkis:** The four longest monthly precipitation time series (150+ years) for Argentina's Pampas and Mesopotamia regións: a preliminary analysis (<https://www.dropbox.com/scl/fi/j0uzpqm6q7lqdu971d96z/The-four-longest-monthly-precipitation-time-series.pdf?rlkey=tzzh7qycj3i1zpu80fju6sbdn&st=f1j1ajeu&dl=0>)

1630: **Afternoon Tea.**

1700: \***Maria Antonia Valente:** Data and metadata errors induced by publications of Instituto Geofísico do Infante D. Luiz (<https://www.dropbox.com/scl/fi/lmdwcbftfd89leaw2t7ct/ACRE2024_MariaAntoniaValente.pptx?rlkey=szou64hb9bowuvqphowandcdb&st=ug7oqpea&dl=0>)

1730: **Alessandro Ceppi**: The Dieci e Lode project - recovery of meteorological observations relating to the former Italian colonies (in particular Eritrea, Somalia, Ethiopia, Libya) (<https://physics.ntua.gr/corfu2024/Talks/diecielode@aisam_eu_01.pptx>)

1800: **Day Two Close.**

**Day Two Summary (**<https://www.dropbox.com/scl/fi/fw4g6s9wtxtd4sqbmj3zg/ACRE-Drought-and-Flood-meeting-Sep-2024-Rapporteur-Report-Christa-Pudmenzky.docx?rlkey=nkvvunww82rqt3xcbsm9eojax&st=shw38p2p&dl=0>)

***Guided tour of Corfu old town (catch local bus from Mon Repos).***

# Thursday 26th:

0900: **Registration if needed**

# Analysis & Reanalysis

**(Session Chair: Roger Stone Online Presentation Coordinator: Vicky Slonosky Rapporteur: Praveen Teleti)**

0930: **Hisayuki Kubota (Hokkaido University) and Masayoshi Ishii (Meteorological Research Institute):** Activities of ACRE Japan 2023-2024 - Ships around Japanese waters during the 18th and 19th centuries and new climate reanalysis “OCADA” (<https://physics.ntua.gr/corfu2024/Talks/hkubota@sci_hokudai_ac_jp_01.pptx>)

1000: **Gil Compo:** Developing reliable drought monitoring indices from a 200-yr atmospheric reanalysis dataset and future plans for the 20th Century Reanalysis (<https://physics.ntua.gr/corfu2024/Talks/compo@colorado_edu_01.pptx>)

1030: **Gil Compo:** The Great California Flood of 1861-1862 and the Great Mississippi Flood of 1874: Examples of Extremes in Precipitation (<https://physics.ntua.gr/corfu2024/Talks/compo@colorado_edu_02.pptx>)

1100:  **Morning Tea.**

1130: **Philip Brohan:** How to tame an evil variable: Machine Learning models of precipitation (<https://physics.ntua.gr/corfu2024/Talks/philip_brohan@metoffice_gov_uk_01.pptx>)

1200: **Ed Hawkins:** Translating extreme weather events into different climates (<https://www.dropbox.com/scl/fi/e15lm6kb3sjmez5dil4zh/ACRE-Corfu-24-forRob.pptx?rlkey=ckkde09ic1qzmk51dfuhk7dja&st=zlna71w8&dl=0>)

1230:  **\*Julie Jones/Richard Hall**: NERC project Decades (Decadal Changes in the Amundsen Sea) - Reconstructing the Amundsen Sea Low (<https://physics.ntua.gr/corfu2024/Talks/julie_jones@sheffield_ac_uk_01.pptx>)

1300: **Marlies van der Schee**: The new melded WMO IDARE and Copernicus Data Rescue Portal (<https://physics.ntua.gr/corfu2024/Talks/marlies_van_der_schee@knmi_nl_01.pptx>)

1330: **Lunch & offline discussions (at the venue).**

**Day Three First Session Summary** (<https://www.dropbox.com/scl/fi/mrgab6amm5fq56qcnsmo4/9th_ACRE_Meeting_Summary_Day3.docx?rlkey=ymc51otscfa2mjpki6usr5a6a&st=r15f34oz&dl=0>)

# Applications & Services

**(Session Chair: Philip Brohan Online Presentation Coordinator: Ed Hawkins Rapporteur: Denis Stuber)**

1530: **Roger Stone and Christa Pudmenzky:** Using modern reanalysis systems to improve understanding of atmospheric instability associated with severe

thunderstorms in southern Queensland and southern Victoria, Australia.

1600: **Christa Pudmenzky:** 20th Century Reanalysis data underpins research into wind erosion in Australia (<https://www.dropbox.com/scl/fi/k2nga0cod2e4mngowze71/ACRE-Corfu-Presentation-CP.pptx?rlkey=25ejt6sktijulygw9r23b5u5d&st=pnap01kb&dl=0>)

1630:  **Ian Goodwin**: Australian East Coast Lows and Large-Scale Circulation from Documentary Evidence, the Natural Archive and Paleoclimate Data Assimilation (<https://physics.ntua.gr/corfu2024/Talks/goodwinclimate@gmail_com_01.pptx>)

1700:  **\*Cathy Smith**: The current status of the Web-based Reanalysis Inter-comparison tools (WRIT) and plans for the future (<https://docs.google.com/file/d/1epCYE6anaQtndA2-Sp8t13Iq53m-LeoT/edit?usp=docslist_api&filetype=mspresentation>)

1730: **Afternoon Tea.**

1800:  **Day Three Close.**

**Day Three Second Session Summary**

***Greek night (conference dinner) in taverna Trypas (we go by bus): Accompanying persons can join the social programme without extra charge***

# Friday 27th:

0900: **Registration if needed**

# Applications & Services (continued)

**(Session Chair: Rob Allan Rapporteur: Praveen Teleti)**

0930: **Stavros Solomos**: Modeling reconstruction of weather conditions during historical events. The examples of Salamis Battle in 480 B.C. and Arachova battle in 1826 (<https://physics.ntua.gr/corfu2024/Talks/ssolomos@academyofathens_gr_01.pptx>)

1000: **Presentation led Open Discussion: ACRE & the future**

1030:  **Philip Brohan:** Artificial Intelligence and Machine Learning for ACRE?  **(5–10-minute talk leading into discussions) (**<https://physics.ntua.gr/corfu2024/Talks/philip_brohan@metoffice_gov_uk_02.pptx>**)**

1100: **Ed Hawkins & Vicky Slonosky:** Making an impact through the press and social media. **(5 minute talks each leading into discussions)** (<https://www.dropbox.com/scl/fi/avb28zzafnpgrqe5xzncv/ACRE-Public-outreach.pdf?rlkey=5ac29hfbrke8zhy0smko1fz4r&st=kcxwwufe&dl=0>)

1130:  **Morning Tea.**

1200: **Gil Compo:** The future of reanalysis. **(5–10-minute talk leading into discussions) (**<https://physics.ntua.gr/corfu2024/Talks/compo@colorado_edu_03.pptx>**)**

1230: **Roger Stone:** Moving ACRE more towards applications. **(5–10-minute talk leading into discussions)** (Not presented or discussed due to illness)

1300: **Next Meeting thoughts then Close**

**Rob Allan:** Historical projects and series needing completion (<https://physics.ntua.gr/corfu2024/Talks/allarob@gmail_com_04.pptx>)

Video of the public talk of **Christos Zerefos** (in Greek): <https://youtu.be/xc3xuRmdJg8>

**Presentation summaries: ‘take-home’ messages**.

As a key illustration to the above points, opening keynote speaker at the ACRE Corfu meeting, Andrea Kiss, highlighted the core importance of ACRE applications, using ACRE principals, an **historical analysis of droughts and floods in Europe, defining various drought types, including meteorological, hydrological, and socio-economic droughts** was provided**.** Using diverse historical sources such as professional observations, diaries, and legal documents, major drought periods as far back as 1530 can be highlighted**.** This 1530 event was followed by major drought events in 1540, and other periods up to 1840. For floods, it was noted the relationship between cooler temperatures and flood occurrences, emphasizing the importance of quantifying severity through maximum water levels. From this, a European flood database is under development.

It was shown that it was obvious that careful historical analyses can lead to a far better understanding of return periods of major droughts and floods, not only in Europe but in other world regions where careful data recovery is carried out.

**Use of reanalysis methods (e.g. 20th Century Reanalysis) greatly expands the value of data rescue through the identification of complex historical weather systems,** including severe weather and climate patterns (especially drought and floods). Roger Stone, for instance, illustrated the **value of data rescue and reanalysis techniques in obtaining a better understanding of upper-air instability values and associated severe thunderstorm and flash flooding events** in Australia. It was pointed out that this understanding has considerable value in attribution studies related to severe climate patterns and which are of high importance for insurance and litigation aspects associated with severe weather and climate events. Similarly, Stefan Bronnimann (Switzerland) presented **information on long-term jet stream reconstructions associated with severe weather and climate events using multiple reanalysis products** (modE-RA, modE-Sim). The relationship between jet stream variability and patterns in Scotland and the UK has been explored, particularly winter rainfall and blocking events leading to droughts. These findings closely aligned with ERA5 data for the common period.

A significant effort has been dedicated to the **OCADA** **reanalysis project, which covers the period 1845-2015** (HisayukiKubota). Using the Local Ensemble Transform Kalman Filter (LETKF) technique for data assimilation and the MRI-AG global climate model (GCM), OCADA reanalysis incorporates inputs such as sea level pressure (SLP), tropical cyclone tracks, and sea surface temperatures (SST) from COBE-SST2. The inclusion of Japanese historical data has resulted in an increase in observations in the ISPD, enriching historical reanalyses and enabling better study of key weather events like the Muroto Typhoon of 1934 and cold periods in 20th-century Asia

An extensive update on the **20th Century Reanalysis version 3** (20CRv3), covering the period from 1806 to 2015 (Gil Compo) **demonstrated how the 20CRv3 dataset has improved** **reconstructions of major historical flood and drought events**, such as the 1900 Galveston Hurricane, compared to its predecessor, 20CRv2c. This **research emphasized the importance of reconstructing not only the means but also the variability and trends in climate**. One of the applications of 20CRv3 has involved wildfire research, showing how **wildfires** are linked to drought conditions such as high temperature, dry weather, and windy environments. This analysis used factors like net radiation, surface heat flux, vapor pressure deficit (VPD), temperature, and wind speed to explain wildfire occurrences. The 1871 Great Chicago Fire was one such example where extreme weather conditions were reproduced using the 20CRv3. The future goals for 20CRv3 were also discussed, including extending the dataset to 2023 and working towards 20CRv4, which will utilize more observations, a hybrid statistical-AI emulator, and NOAA’s UFS (Unified Forecast System).

**Aspects related to global rainfall trends using raw rainfall (RF) observations and 20CRv3 (**Phillip Brohan) highlighted the challenges in interpreting raw data, which can be misleading due to inconsistencies, and stressed the importance of fitting observations to gamma distributions for a clearer picture. This **analysis showed no significant global rainfall trend from 1850-1950 but revealed a positive trend in rainfall from 1950 to the present.** When comparing 20CRv3 and ERA5 datasets, this analysis showed that ERA5 contained observational biases, while 20CRv3 had biases in boundary conditions. It was concluded that although 20CRv3 performs better in most cases, it faces issues with sea-ice and 19th-century tropical observations. There were also noted performance drops between 1920-1950 in the dataset.

**GloSATref,** a new dataset using only Marine Air Temperature (MAT), as opposed to Sea Surface Temperature (SST), allows researchers to extend the dataset further back in time (Ed Hawkins). In the UK, rainfall data have been substantially expanded through data-rescue projects, with 4.9 million monthly observations now available compared to 3.4 million previously. **This analysis identified** **the wettest year in the UK as 1872 and the driest as 1855**. The role of the jet stream's latitude and speed in influencing UK rainfall patterns was highlighted, noting two significant drought periods: 1854-56 and 1887-89. This analysis showed the impacts of a warmer climate, projecting that storms like those seen in October 1903, **which was the wettest month on record in the UK, would now result in 17% more rainfall (and flooding) if occurring in the current/present climate regime.**

Results from the NERC Decades project on reconstructing the Amundsen Sea Low (ASL) (Julie Jones) showed that by using station SLP data, it was possible to construct ASL indices, showing a correlation between 20CRv3 and ERA5 of 0.63. This reconstruction work provides valuable insights into atmospheric circulation patterns over the Amundsen Sea region and their **impacts on Southern Hemisphere climate**.

**Aspects related to drought and wind erosion in Australia using 20CRv3 data** (Christa Pudmenzky)showed that Australia, with its large desert areas, experiences significant variability in dust storm frequency. The influence of ENSO on dust storms was highlighted including a case study on the Red Dawn dust storm in September 2009, which caused $438 million AUD in damage. This methodology involved comparing historical dust events (HDED) with ENSO and using a Climate Aridity Vegetation Index (CAVI) to further explore dust storm frequency.

The value of reanalyses techniques and data rescue in Australia was also highlighted (Ian Goodwin) especially in respect of **Australian east coast lows**, which are influenced by both tropical and extratropical air masses. Storm track data were presented, highlighting major storms in 1974 and 2007, which had devastating impacts on coastal regions.

The NOAA-WRIT plotting tools, **which allow users to analyze long-term gridded reanalysis datasets was provided (**Cathay Smith). **These tools can generate heat maps, correlation maps, and time-series plots, making them useful for tracking storm/flood trajectories** and analyzing climate risk parameters.

**Future Steps for 20th Century Reanalysis (20CR) (Gil Compo) were highlighted at this meeting**. In particular, the upcoming Release: ISPD v5 (International Surface Pressure Databank) is expected to be released soon, offering new datasets for atmospheric reanalysis. Utilizing GLAMOD: 20CR will utilize GLAMOD (Global Land and Marine Observations Database), although uncertainties remain regarding the long-term fate of recently rescued observations. AI in Reanalysis: - The 20CR project is now running an AI-driven version, the Neural GCM (General Circulation Model), which is 20 times faster than traditional reanalysis models like Unified Forecast System (UFS). - 20CRv4 will introduce several improvements, including: - Hourly data availability for more granular analysis. - A list of user-required parameters to make the data more relevant to ongoing research. - Improved data assimilation using machine learning (ML) techniques to enhance the accuracy and reliability of the reanalysis products. A proposed user meeting or focus group will be held to gather input on these updates and future developments.

Many other examples presented at Corfu ACRE illustrated the value of data rescue and reanalysis techniques in better identifying historical drought and return periods than would otherwise have been the case. For instance, information from the Republic of South Africa (Stefan Grab) provided **insights into historical weather observations from the Karoo region through utilisation of farm records and missionary documentation to highlight long drought periods in the region**, especially during El Niño and La Niña events. For example, the level of severity of the droughts of 1859, 1872, and 1877-1878 was detailed. Likewise, information from Canada (Vicky Slonosky) outlined event detection methods such as newspaper searches and data analysis to **track changes in dry and wet periods over long-term historical periods.**

Many presentations discussed the intricacies of **data rescue** that is sorely needed in obtaining a better appreciation of drought and flood frequency and intensity (e.g. Data-Rescue Pipelines and Best Practices (e.g. Richard Cornes) on the challenges and progress in the data-rescue ‘pipeline’, which includes data extraction and quality control; the National Meteorological Archive (NMA) in Exeter, UK which holds an extensive collection of weather diaries, ship logbooks, and daily weather reports (DWR) (Catherine Ross); details of the efforts needed in rescuing naval logbooks, Chilean historical weather records, including ship logbooks (1843-1901) and coastal station data (1956-2005). She noted significant gaps in data from the Chilean Navy, with logbooks from 1901-1955 yet to be rescued. The potential of Catholic **church records and farm data as untapped sources** for historical climate information related to droughts in Chile was highlighted (Mariela Vasquez).

**Extensive efforts by Japanese universities under the ACRE Japan initiative to recover and utilize historical climate observations were highlighted** (Hisayuki Kubota). Again, as with many ACRE projects, the **aim has been to contribute to a better understanding of climate change, with recovered observations** being submitted to the International Surface Pressure Databank (ISPD). Kubota highlighted the historical voyages that passed through Japanese waters, including Captain Cook's third expedition in 1779, La Perouse in 1786, and US Navy fleets led by Captain Perry in 1853 and 1855. He also provided a detailed status report on the digitization of ship logs, including data from US, UK, Dutch, and Japanese fleets. Of note, the USN fleet’s logs, particularly from USS Mississippi (1852-1855), contain hourly weather data and could be instrumental in studying historical cyclones. Similarly, observations from the UK-Japan war of 1863 provided valuable weather data, including the Ansei-Edo Typhoon of 1856, which had a large, estimated radius of 400 km.

The WMO IDARE and Copernicus data rescue portals (Marlies Van der Schee) were discussed, emphasizing the **use of AI and machine learning for data rescue efforts**. It was highlighted that the release of WMO data rescue guidelines in 2024 and computer vision techniques were tested in a hackathon called ‘Dawsonia’, using over 2800 historical images, with promising results for automating data extraction.

The value of data rescue to better analyse historical drought and floods in many world regions has been highlighted at Corfu ACRE. These regions include SE Asia (e.g. West Malaysia, Singapore); former Italian colonies, and regions of Southern Africa). Practical aspects to do with uncovering data from the early 19th and 20th Century (e.g. from 1820) were provided as well as global records from World War 2 (Praveen Teleti). Other notable regions included Japan (Togo Tsukahara and colleagues) which covered recued data from 1813, and which originated in Dutch Naval logbooks. Indeed, much longer data bases are becoming available that originated with the **Dutch East India Company** and the Royal Netherlands Navy from the year 1600 (Theo Brandsma); for **Mozambique** (since 19th Century – Matt Hannaford – and in which 7 major drought periods have been identified during the 19th Century plus 6 major wet/flood periods during that century. Additionally, 28 major tropical cyclone periods have been identified. **The drought period of the early 1820s to 1830s appears to have been the most protracted in that region**.

**The Dieci e Lode project** (Alessandro Ceppi) was presented in which the recovery of meteorological observations relating to the former Italian colonies (in particular Eritrea, Somalia, Ethiopia, Libya) was highlighted. Importantly, this showed the value of digitizing climatological data (e.g. from former Italian colonies) and which represents a significant step towards **understanding the climate of the past** in areas that still lack a dense monitoring network for detecting (and recording) meteorological phenomena. This process will permit a full utilization of the recovered values, which will be important for a **far a better understanding of climate change.**

**Data Rescue and Data bases** were discussed in length, including the comprehensive work involving the Global Land and Marine Observations Database **(**GLAMOD) (Peter Thorne), the rescue, preservation and serving of global historical in-situ land and marine surface observations, and aspects related to the management and uptake of the CDM-OBS data model used across the Copernicus C3S in-situ activities. It was strongly encouraged to log projects via the portal [**https://datarescue.climate.copernicus.eu/**](https://datarescue.climate.copernicus.eu/)**.**

Notably, over 4 million images are now stored by C3S. **Data Rescue at Météo-France** was highlighed by Denis Stuber who noted that drought-related climate archives mainly consist of weather observation charts, documentation on weather stations, and observation techniques and measuring instruments. 76% of the MétéoFrance’s climate archives have been catalogued and the public web portal [**http://archives-climat.fr/**](http://archives-climat.fr/)is available with a Catalogue of 88,748 archives and 700,000 images of meteorological observations for France and foreign territories.

The value of the **Weather Detective project which is an Australian Citizen Science** Project was highlighred by Christa Pudmenzky. Unusally, this data rescue project was funded by the Australian Broadcasting Corporation (media organisation) due to its importance in gaining a better understanding of long-term climate trends. The project started in August 2014 with 14,000 volunteers and is still going to this day. This work includes data rescue within 8,000 ships logbooks and images collected by Queensland State Meteorologist, Clement Wragge. These are collected are being digitized by volunteers and includes use of convict ship data. **It was noted this effort has been an enormous contribution to ACRE, not least through its value to the 20C Reanalysis work of NOAA to fully reconstruct weather and climate patterns of the past for climate change and attribution studies**.

The importance of recognising errros in data due to institutional management changes and prioroties in some meteorological agencies was highlighted by Maria Antonia Valente.

Of particular importance Chang Chih-Hsuan and colleagues utilized and adjusted the **Standardized Precipitation Index (SPI**) to reconstruct 0.5° x 0.5° drought data from documentary records in the **Chinese dynasties** since the **mid-14th century**. They discovered that the SPI could be used to connect modern data (CRU 1901-2023) and paleo data set (Reaches 1368-1911). Very importantly this work demonstrates the power of combining historical records with modern statistical methods to **reconstruct and analyse drought patterns over time.**

In **Argentina** (Pablo Canziani and Gabriela Lakkis), the four longest monthly precipitation time series (150+ years) for Argentina’s **Pampas and Mesopotamia regions have been created.** These include Corrientes since 1875, Bahia Blanca since 1860, Córdoba since 1873, and Buenos Aires since 1861. Importantly, a multiple linear regression (annual and seasonal) analysis was performed to analyse the dependence of the anomaly variable on climate indices such as AMO, PDO, TPI, SOI, El Niño and MPDI. **This method showed the number of wet and dry (drought)events per decade for each location and aspects related to key climate drivers addressed.**

**Summary and further recommendations from the meetings ‘wrap-up’ session.**

The session focused on enhancing the visibility of ACRE and related activities to a broader audience. The goals include raising the profile of scientific work, enhancing clear linkages to practical and policy focussed applications, promoting climate literacy, and ensuring science education for the public. A key development that was suggested to aid these efforts was to work towards developing an **ACRE Mission Statement**.

***Challenges & Opportunities:*** Illustrating clear linkages and opportunities for applications in such as drought policy development remained untapped. Additional linkages to climate change and climate variability studies related to extreme events and disaster risk reduction urgently need to be made. A key practical issue arising from this meeting was recognizing volunteers who contribute to data-rescue and historical climate research, emphasizing the importance of increasing visibility for their contributions to attract funding. Discussion on the lack of funding for core data sources like ICOADS despite its foundational role in sea surface temperature (SST) observations crucial for climate research.

***Proposal:*** Write an open letter to funders, highlighting the importance of historical observations and calling for increased support to preserve and utilize these data for future climate activities. Work towards developing an **ACRE Mission Statement**.

***Broader Impacts:*** Historical observations can improve weather forecasts, benefit machine learning models, and contribute to early warning systems and especially to disaster risk reduction and drought policy formulation. There was a broader discussion on how their research can address climate anxiety by emphasizing the societal relevance of their findings and contributing to scientific and cultural heritage.

***Media Engagement:*** The meeting discussed how to communicate effectively with the media, walking the fine line between reflecting on past climate events and projecting future scenarios if current climate inaction persists.

***Engagement with Cultural Institutions:*** Proposed collaboration with archives, libraries, and museums to further public engagement and preserve climate data for future generations.

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