

## ACRE and ACRE-facilitated 20CR Overview

### ACRE

The international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative (<http://www.met-acre.org>), undertakes and facilitates historical global surface terrestrial and marine weather data recovery, imaging and digitisation, feeding these data into the international repositories (International Comprehensive Ocean Atmosphere Data Set [ICOADS], International Surface Temperature Initiative [ISTI], Global Precipitation Climatology Centre [GPCC] and the International Surface Pressure Databank [ISPD]) responsible for such material, seeing that these repositories provide the best quality and quantity of surface weather observations for assimilation into all reanalyses, and ensuring that reanalyses outputs are freely available and feed seamlessly into the climate science, climate applications, impacts, risks and extremes communities (Allan *et al.*, 2011 - <http://dx.doi.org/10.1175/2011BAMS3218.1>). ACRE is also expanding to develop an integrated cross-disciplinary focus (climate science melding with social sciences and humanities) on historical reanalyses and weather reconstructions, ensuring that the global historical weather observations and reanalyses outputs are analysed and assessed in a longer historical context, and tailored to the needs of educators, students and the general public.

ACRE is run from the Met Office Hadley Centre, but relies on the continuation of ‘grassroots’ support from the international weather/climate data community and some funding and in kind support from a core consortium of nine partners: the University of Southern Queensland in Australia; the US National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) and Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado; The National Climatic Data Center (NCDC) of NOAA; the International Environmental Data Rescue Organization (IEDRO); the University of Sussex in the UK, the British Library; the University of Giessen in Germany and the University of Bern in Switzerland.

### Regional Data Rescue Foci

Under ACRE’s broad international focus, it has worked to develop various regional data rescue foci, such as in Chile, the Pacific, China, Canada, Meso-America, India, SE Asia, Africa, the Arctic, and Antarctica, all of which are at various stages of development (See latest details at <http://www.met-acre.org/Home/2014%20ACRE.docx?attredirects=0&d=1>).

### ACRE-facilitated 20CR

The ACRE-facilitated 20th Century Reanalysis Project (1871-2012) (20CR) ([http://www.esrl.noaa.gov/psd/data/20thC\\_Rean/](http://www.esrl.noaa.gov/psd/data/20thC_Rean/)) is an ongoing international project led by NOAA and CIRES in the US to produce global, gridded 4-dimensional weather reanalysis\* products (dynamical reconstructions of major weather variables) for climate applications extending back to the 19th century using an Ensemble Kalman Filter and only surface synoptic pressure observations (Compo *et al.*, 2011 - <http://dx.doi.org/10.1002/qj.776>). The monthly sea surface temperature (SST) and sea-ice data are provided by Met Office Hadley Centre HadISST dataset as boundary conditions for 20CR. The pressure observations dataset, held by the International Surface Pressure Databank (ISPD) (<http://reanalyses.org/observations/international-surface-pressure-databank>), has been assembled through international cooperation under the auspices of the international ACRE initiative, and working groups of GCOS ([http://www.esrl.noaa.gov/psd/gcos\\_wgsp/](http://www.esrl.noaa.gov/psd/gcos_wgsp/)) and WCRP.

The currently available 20CRv2 from 1871-2012 will be enhanced temporally and dynamically by 20CRv3 1850-2015 (in 2016) and then by the NOAA Climate Reanalyses 1816-2019 (in 2019)

The 20CR provides the first-ever estimates of long historical near-surface to tropopause level 6-hourly fields of weather variables and derived quantities (e.g., storm tracks) extending back into the 19th Century plus additional estimates of uncertainties, via a 56 member ensemble of realizations at each 6-hourly time step.

*\*In reanalyses, observations and a numerical model that simulates one or more aspects of the Earth system are combined objectively to generate a synthesized estimate of the state of the system. A reanalysis typically extends over several decades or longer, and covers the entire globe from the Earth's surface to well above the stratosphere.*

### **Dynamical Downscaling of 20CR**

Dynamical downscaling by the Met Office Providing REgional Climates for Impacts Studies (PRECIS) (<http://www.metoffice.gov.uk/precis>) regional climate modelling system is being used to take 20CR output down to finer resolution (25 km to 100 m), to enhance the value of this output for the climate science community, wide ranging climate applications and services, policy makers, planners, environmental managers, educational and public sectors. So far this has taken the form of a study of the 1894 flooding of the River Thames (See pages 13-17 of <https://docs.google.com/viewer?a=v&pid=sites&srcid=bWV0LWFjcmUub3JnfGFjcmV8Z3g6MWEwMTRjMzI0ZmEOZTEwNg>) and analyses of 20CR for key climate events of relevance to agriculture in Central America to assess both how 20CR validates against observations, and how PRECIS downscaling of 20CR performs over the region (<https://sites.google.com/a/met-acre.org/acre/meetings-and-workshops-1/MESO-AMERICA%20FLYER-1.pdf?revision=1>).

### **Availability of 20CR output**

Global four-times-daily atmospheric and surface analysis fields spanning 1871 to 2012 from the 20CR Version 2 (V2) are available from ([http://www.esrl.noaa.gov/psd/data/gridded/data.20thC\\_ReanV2.html](http://www.esrl.noaa.gov/psd/data/gridded/data.20thC_ReanV2.html)) in Netcdf format, courtesy of the NOAA Earth System Research Laboratory, Physical Sciences Division (PSD), and University of Colorado CIRES. They are also available via our partners at the National Center for Atmospheric Research (<http://rda.ucar.edu/datasets/ds131.1/>) in GRIB format. Selected variables are available from the U.S. Dept. of Energy National Energy Research Scientific Computing Center Science Gateway (<http://portal.nersc.gov>) for every member in Netcdf4 format, and the complete 3 dimensional variables for every member in GRIB format are available from the NERSC Tape Science Gateway ([http://portal.nersc.gov/archive/home/projects/incite11/www/20C\\_Reanalysis/everymember\\_full\\_analysis\\_fields](http://portal.nersc.gov/archive/home/projects/incite11/www/20C_Reanalysis/everymember_full_analysis_fields)). The Hadley Centre assisted in making these data ready for distribution.

The entire 20CR output has been copied from tape in the US onto disk at the British Atmospheric Data Centre (BADC). This includes (i) all the original GRIB and binary files; (ii) original spectral resolution data; (iii) all 5-year streams and (iv) all ensemble members. All data have been unpacked, checked and ingested into the archive. Metadata records have been recorded and added to the BADC catalogue; these are visible at:

[http://badc.nerc.ac.uk/view/badc.nerc.ac.uk\\_ATOM\\_DE\\_6ae84cbc-177b-11e2-9c9c-00163e251233](http://badc.nerc.ac.uk/view/badc.nerc.ac.uk_ATOM_DE_6ae84cbc-177b-11e2-9c9c-00163e251233) BADC is working with ACRE to realise its ambition to convert the core data onto a 2 x 2 regular grid in Netcdf format for wider use.

### **ACRE Data and 20CR Visualisations**

Some 178 visualisations relating to ACRE and 20CR activities and output online at: <https://vimeo.com/user5027771>

Some specific examples are

- Tambora volcanic eruption: <https://vimeo.com/120228702>, <https://vimeo.com/120787915>, <https://vimeo.com/120792719>
- Krakatoa volcanic eruption <https://vimeo.com/117533217> volcanic eruptions
- Reconstructed atmospheric circulation before, during and after the Shackleton Imperial Trans-Antarctic Expedition (1914–17) and the loss of the Endurance in October 1915 (<https://vimeo.com/121803689>).

### Citizen Science

These are the main citizen science activities under/linked to ACRE:

*OldWeather*: OldWeather has completed the transcription of 350,000 pages of logbooks from the Royal Navy from the period 1914-1923 (<http://old.oldweather.org/>). These have provided more than 1.6 million new weather observations. Currently the project is working on US Government ship logs of Arctic voyages in the mid-19th century (<http://www.oldweather.org/>). Some 300,000 pages of such logs have been imaged so far, with more to come - transcription and analysis are ongoing.

*Australian Weather Detective*: With Weather Detective, citizen scientists uncover important weather records hidden in extracts from the logbooks of ships that sailed the seas around Australia in the 1890s and 1900s - <http://www.weatherdetective.net.au/about/> To date, some 375,000 lines of weather data have been digitised.

### Examples of Climate Applications and Climate Services

- Swiss Re announced late 2014 that their new European winter storm model will be based on 20CR, and that they will be the first reinsurance group to use it as a basis to model winter storm risk in Europe (<https://openminds.swissre.com/stories/722/> <http://meetingorganizer.copernicus.org/EGU2014/EGU2014-3448-1.pdf>)
- Assimilating no surface land temperatures, 20CR has reproduced both annual variations and centennial trends in land air temperatures, demonstrating the robustness of previous conclusions regarding global warming (Compo, G.P., P.D. Sardeshmukh, J.S. Whitaker, P.D. Jones, P. Brohan, and C. McColl, 2013: Independent confirmation of global land warming without the use of station temperatures. *Geophys. Res. Lett.*, **40**, **12**, 3170-3174, doi:10.1002/grl.50425.)
- The Met Office PRECIS team are part of the *Managing the Risks, Impacts and Uncertainties of drought and water Scarcity (MaRUIS)* project led by Oxford University (<http://www.mariusdroughtproject.org/>), in which at least one member of the 20CR ensemble output will be downscaled by the Met Office PRECIS regional climate modelling system to provide a high resolution baseline of UK droughts from 1850-2014
- An overview of various 20CR uses for climate services and applications, at least for Europe, is the following (Brönnimann, S. and O. Martius (Eds.), 2013: Weather extremes during the past 140 years. *Geographica Bernensia* **G89**, 108pp, DOI: 10.4480/GB2013.G89.01 - [http://boris.unibe.ch/40665/1/GB2013\\_G89%20Book.pdf](http://boris.unibe.ch/40665/1/GB2013_G89%20Book.pdf)) A more broader assessment of 20CR applications can be found at <https://docs.google.com/viewer?a=v&pid=sites&srcid=bWV0LWFjcmUub3JnfGFjcmV8Z3g6MWEwMTRjMzI0ZmE0ZTEwNg>