Final Report Summary - ERA-CLIM (European Re-Analysis of global CLIMate observations)

Executive Summary:

This report summarizes the scientific outcomes of the collaborative research project entitled "European reanalysis of global climate observations" (ERA-CLIM), carried out within the Framework Programme 7 of the European Union under Grant Agreement No. 265229.

The project set out to develop observational datasets suitable for global climate reanalysis, with a focus on the past 100 years. These include atmospheric, terrestrial and oceanic observations from a variety of sources, global reanalyses of the observations, and various uncertainty indicators needed for climate applications.

In-situ data rescue efforts conducted within the project have led to a large improvement of the digital instrumental record for the early 20th century. The number of pre-1957 weather observations from kites and early radiosondes available for climate reanalysis has more than doubled as a result of these efforts.

ERA-CLIM has provided initial impetus for an important international activity in satellite data rescue by investigating the availability of data records from pre-operational satellites and their potential use in future climate reanalyses. This has led to a first comprehensive survey of early satellite data for reanalysis, including priorities for data rescue and information about next steps.

Several satellite data records important for climate reanalysis have been reprocessed during the project. These activities have helped develop and solidify a comprehensive programme for reprocessing of satellite data holdings at the Organisation for the Exploitation of
The UK Met Office Hadley Centre (UKMET) has developed improved global gridded estimates of the evolution of sea-surface temperature and sea-ice concentration during the 20th century, together with meaningful information about uncertainties in these estimates (HadISST.2). In addition, important new data collections containing high-quality sub-surface and surface ocean observations have been developed (EN4, HadIOD).

Using many of the observational data sets developed in ERA-CLIM, a set of climate model integrations (ERA-20CM) and several pilot reanalyses for the 20th century (ERA-20C, ERA-20CL) have been produced at ECMWF. These datasets, with a combined volume of hundreds of terabytes, will be made freely available via the internet during 2014. A first test reanalysis for the period 1939-1949 has been conducted using newly recovered upper-air observations from the project.

Several project activities have contributed to the estimation and reduction of uncertainties, in climate observations as well as gridded products derived from them. A permanent Observation Feedback Archive facility has been developed by the project to allow users easy access to the input observations used in climate reanalyses, and to information about uncertainties associated with the observations.

The impact on science of the global climate data produced in ERA-CLIM will be substantial. The 20th-century reanalysis data sets (ERA-20CM, ERA-20C, ERA-20CL) will be made available on the internet in stages during 2014.

A follow-up project (ERA-CLIM2, Grant Agreement No. 607029) will continue to strengthen data rescue, data reprocessing, and climate reanalysis. ERA-CLIM2 will introduce an added focus on development of consistent reanalyses of the coupled Earth system, including atmosphere, ocean, land and carbon. The combined results of the two successive ERA-CLIM projects will provide key resources and capabilities needed to implement Copernicus Climate Change Services.

Project Context and Objectives:

European Reanalysis of Global Climate Observations (ERA-CLIM)

ERA-CLIM is a collaborative research project involving 9 partners, funded by the European Commission for a three-year period beginning January 2011. The overall goal of the project is to prepare input data and assimilation systems for a future global atmospheric reanalysis of the 20th century. This involves recovery and digitization of early meteorological observations, reprocessing and recalibration of radiance observations from satellites, and preparation of climate-quality atmospheric forcing data and boundary conditions. These input data sets are used in several pilot reanalyses, including an exploratory climate reanalysis of the 20th century based on surface observations only; a corresponding high-resolution reanalysis of land-surface parameters, and a new atmospheric reanalysis of the satellite era from 1979 to present. Access to the ERA-CLIM pilot reanalyses, and to all observations used to produce them, will be provided via the internet.

Key objectives:

- Improve the available observational record for the early 20th century
- Prepare data sets and assimilation tools needed for global reanalysis
- Provide information about data quality by means of pilot reanalyses
- Develop an Observation Feedback Archive facility for users
- Assess and reduce uncertainties in reanalysis data

Policy relevance:

The project addresses policy objectives underlying the Commission's Copernicus programme, by developing core information products for future Copernicus Climate Change Services. These include global atmospheric reanalyses to support climate monitoring, to serve as boundary conditions for high-resolution regional reanalyses and other specialized products, and as benchmark datasets for calibration and validation of climate models.

Project Results:
Potential Impact:

Impact on climate science

The impact of atmospheric reanalysis on climate science is best grasped by examining the citations of the journal articles that describe previous reanalysis datasets. These are among the highest-cited literature in the geosciences, with (according to Google Scholar at the time of this writing) 1681 articles citing Dee et al 2011 (on the ERA-Interim reanalysis) and 4531 articles citing Uppala et al 2005 (on the earlier ERA-40 reanalysis). The work reported in those articles includes a broad range of subjects in atmospheric science, oceanography, climate science, and many applied fields e.g. in energy, health, environmental science, etc.

International awareness and interest in the ERA-CLIM project has grown proportionally, with numerous users in the science community inquiring about availability and characterization of future data products. The full impact of the outcomes of this project on climate science will occur after the major datasets have been published, later in 2014.

Dissemination of scientific results

Various publications were prepared during the ERA-CLIM project reporting on important outcomes e.g. in data rescue, data analysis, data assimilation, and climate reanalysis. A selection of those publications is included in the list of references below.

An article by the project Coordinator (Dee et al. 2014) outlining the strategy for ERA-CLIM and beyond, targeted for a broad scientific audience, will appear in the widely read Bulletin of the American Meteorological Society in early 2014.

The Coordinator has presented the ERA-CLIM project vision and approach at major international conferences including the WCRP Open Science Conference in Denver (2011), the 4th WCRP International Conference on Reanalyses held in Silver Spring (2012) and the 13th Annual Meeting of the European Meteorological Society in Reading (2013). The Coordinator has also presented numerous seminars and lectures about the project at various institutes in Europe and elsewhere.

A complete list of publications, technical reports, presentations at international conferences and workshops has been submitted separately as part of the reporting required by the Commission.

Dissemination of data products

Several data collections with observations suitable for climate reanalysis have been developed and/or improved in ERA-CLIM:

• An ERA-CLIM extension of the Comprehensive Historic Upper-Air Network (CHUAN), available from the University of Bern and via the PANGAEA data repository at a permanent web location (doi.pangaea.de/10.1594/PANGAEA.821222).
• Additional in-situ surface observations recovered in ERA-CLIM; these are available directly from the ERA-CLIM project partners. These data are also supplied to the National Climate Data Centre at NOAA for inclusion in their data collections
• Several collections of ocean observations (EN4, HadIOD) to be made available via the Met Office Hadley Centre (after publication of a journal article describing each dataset)

Gridded products:

• HadISST.2: Global estimates of sea-surface temperature and sea-ice concentration from 1899-2010. These will become available via the UK Met Office Hadley Centre (after publication of a journal article describing the dataset).
• ERA-20C: Global atmospheric reanalysis from 1900-2010, 3-hourly data at 125 km spatial resolution and 91 vertical levels. The data are being prepared for public release via the internet at ECMWF, expected mid-2014.
• ERA-20CM: Global atmospheric model simulations from 1900-2010, monthly data at 125 km spatial resolution and 91 vertical levels. The data are being prepared for public release via the internet at ECMWF, expected mid-2014.
• ERA-20CL: Global land-surface reanalysis from 1900-2010, 3-hourly data at 25 km spatial resolution. The data are being prepared for public release via the internet at ECMWF, expected mid-2014.
Observation feedback:

• The Observation Feedback Archive (OFA) at ECMWF provides direct access to all input observations used in reanalysis, together with information such as quality indicators, bias estimates, and estimates of observation uncertainty.

ECMWF provides open access to ERA-CLIM reanalysis products and other research datasets at http://apps.ecmwf.int/datasets. This link also points to the Observation Feedback Archive (OFA), which is a permanent facility that will continue to be developed in support of future reanalysis projects.

The Met Office Hadley Centre provides internet access to observations data sets, including those developed in the ERA-CLIM project, via http://www.metoffice.gov.uk/hadobs.

The University of Bern Oeschger Centre for Climate Change Research has created a metadatabase for in-situ data rescue, which includes data inventories for various sources, at http://www.oeschger-data.unibe.ch/metads/

The University of Bern Oeschger Centre for Climate Change Research also maintains a data server for the CHUAN collection at http://www.oeschger.unibe.ch/research/projects/historicalupperair/index_en.html

Preparing for Copernicus Climate Change Services

Reanalysis developments have traditionally been motivated by the need to improve the use of observations for weather forecasting, and to provide datasets for research and education. The scientific user community has derived great value from global reanalyses of the atmosphere, ocean, land surface, and atmospheric composition, as evidenced by numerous publications that refer to these datasets. Increasingly, demand for reanalysis data products is driven by the need for accurate and comprehensive information on climate change and variability.

Different types of reanalyses will be needed to serve both climate science and climate change services in future. These include extended reanalyses spanning as much of the instrumental record as possible, and high-resolution reanalyses of the modern observing period that can be continuously updated in real-time. The ERA-CLIM project has made substantial contributions to the development of both types of reanalyses, and to the improvement of the instrumental observation record in general. The overarching goal is to make the best possible use of observations to serve the interest of society.

Global reanalysis generally, and the ERA-CLIM project specifically, has played an important role in ongoing discussions of a future Copernicus Climate Change Service, e.g. at the GMES and Climate Change conference held in Helsinki (2011). The success of ERA-CLIM has led to proposal for a follow-up ERA-CLIM2 project, which has now been funded by the European Commission until end 2016. ERA-CLIM2 will develop coupled data assimilation capability targeted for production of improved reanalyses of the coupled climate system, following the vision and approaches developed in ERA-CLIM. Further investments are needed to transform reanalysis from the valuable research activity it currently is into a dependable operational service. Resources for this purpose will likely become available through the Copernicus Climate Change Services about to be implemented by the European Commission.

List of Websites:

www.era-clim.eu

Contact details for Coordinator:

Dick Dee

e-mail: dick.dee@ecmwf.int

Postal: