Overview of the ERA-CLIM2 project

Roberto Buizza and ERA-CLIM2 colleagues

ERA-CLIM2 Symposium
University of Bern, 14 December 2017

ERA-CLIM2 followed ERA-CLIM

ERA-CLIM (European Reanalysis of Global Climate Observations) run between 2011 and 2013, and involved 9 partners.

ERA-CLIM main goal was to prepare input data and assimilation systems for a new global atmospheric reanalysis of the 20th century.

ERA-CLIM was part of an EU larger effort to:

- Improve climate data access, data quality, and transparency
- Develop a sustainable capability for data recovery and reanalysis
- Develop core resources for future climate services

Since 2014 the EU funded 5 related projects

All 5 projects aimed to contribute to the establishment of the Copernicus Services:

- ERA-CLIM2 (European Reanalysis of the Global Climate System)
- UERRA (Uncertainties in Ensembles of Regional Reanalyses)
- QA4ECV (Quality Assurance for Essential Climate Variables)
- EUCLEIA (European Climate and weather events: interpretation and attribution)
- CLIPC (Climate Information Portal for Copernicus)

The EU projects in reanalysis

UERRA (Uncertainties in Ensembles of Regional ReAnalysis, 2014-2018) main objectives are:

- To produce ensembles of European regional meteorological reanalyses of Essential Climate Variables (ECVs).
- To recovery of historical (last century) data and creation of user friendly data services.

QA4ECV (Quality Assurance for Essential Climate Variables) main objectives are:

- To develop quality assurance methods for ECVs, satellite retrievals, data products, and in situ retrievals.
- To generate multi-decadal satellite-derived global ECV records, including multi-decadal Climate Data Records (CDR) for terrestrial ECVs.

The EU projects in reanalysis

EUCLEIA (European Climate and weather Events: Interpretation and Attribution) aimed:

- To provide assessments of the extent to which weather-related risks have changed due to human influences on climate
- To identify those types of weather events where the science is still too uncertain to make a robust assessment of attributable risk.

CLIPC (Climate Information Portal for Copernicus) provides access to climate information.

Its main objective is to build a “one-stop-shop” platform that allows to find answers to questions related to climate and includes data from satellite and in-situ observations, climate models, data re-analyses, and transformed data products enabling impact assessments

ERA-CLIM2 Consortium has 17 partners

1 (C)	European Centre for Medium-Range Weather Forecasts	ECMWF	International
2	Met Office	METO	United Kingdom
3	The European Organisation for the Exploitation of Meteorological Satellites	EUMST	International
4	Universitaet Bern	UBERN	Switzerland
5	Universitaet Wien	UNIVIE	Austria
6	Associação para a Investigação e Desenvolvimento de Ciencias	FCIENCIAS.ID	Portugal
7	All-Russian Research Institute of Hydrometeorological Information-World Data Centre	RIHMI	Russia
8	Mercator Ocean	MERCO	France
9	Meteo-France	METFR	France
10	Deutscher Wetterdienst	DWD	Germany
11	Centre European de Recherche et de Formation Avancee en Calcul Scientifique	CERFAC	France
12	Centro Euro-Mediterraneo Sui Cambiamenti Climatici Scarl	CMCC	Italy
13	Ilmatieteen Laitos	FMI	Finland
14	The University of Reading	UREAD	United Kingdom
15	Institut National de Recherche en Informatique et en Automatique	INRIA	France
16	Universite de Versailles Saint-Quentin-en-Yvelines	UVSQ	France

The FP7 ERA-CLIM2 project (2014-2017)

ERA-CLIM2 involved ~ 50 people (budget was 17M€, with 7M€ from EU).

GA2, EUMETSAT, Dec 2016

GA3, Univ. Vienna, Jan 2017

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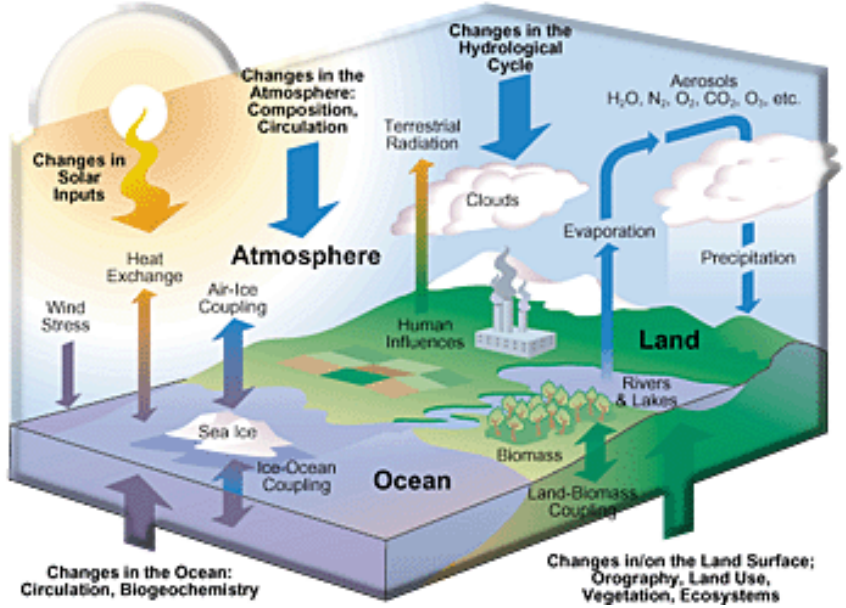
The FP7 ERA-CLIM2 project (2014-2017)

Goal: *Production of a consistent 20th-century reanalysis of the coupled Earth-system: atmosphere, land surface, ocean, sea-ice, and the carbon cycle*



Main components:

- Production of coupled reanalyses **(WP1)**
- Research and development in coupled data assimilation **(WP2)**
- Earth system observations for extended climate reanalyses **(WP3)**
- Evaluation of uncertainties in observations and reanalyses **(WP4)**
- Improving access to reanalysis data and input observations **(WP5)**

ERA-CLIM2 main objectives

1. Improvement of **observational data sets** needed for reanalysis, with a focus on temporal consistency and reduction of uncertainties;

2. Coherent **research and development in coupled data assimilation** targeted for climate reanalysis;

3. **Production of coupled reanalyses** (atmosphere, land, ocean, cryosphere, and, for the first time, the carbon cycle across these domains);

4. Development of tools and resources for users to help **assess uncertainties** in reanalysis products.

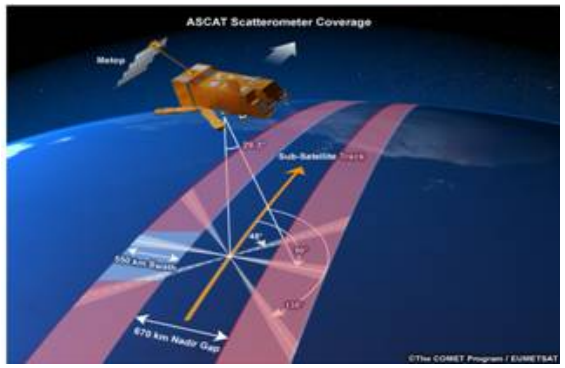
Observation data rescue

Upper-air data have been rescued, digitised and formatted in ERA-CLIM and ERA-CLIM2 by all partners (Map created within the registry).

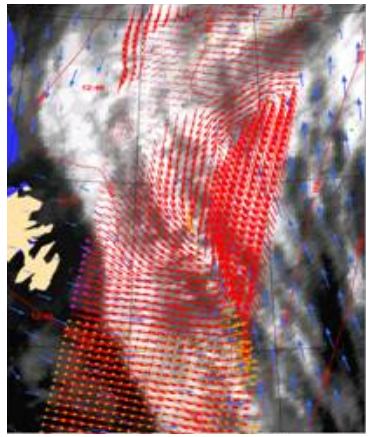
(From L Haimberger)

Observation re-processing

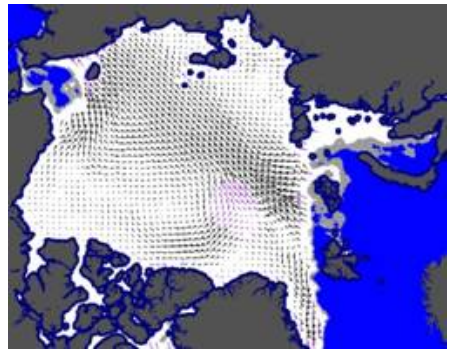
ASCAT



Ocean winds



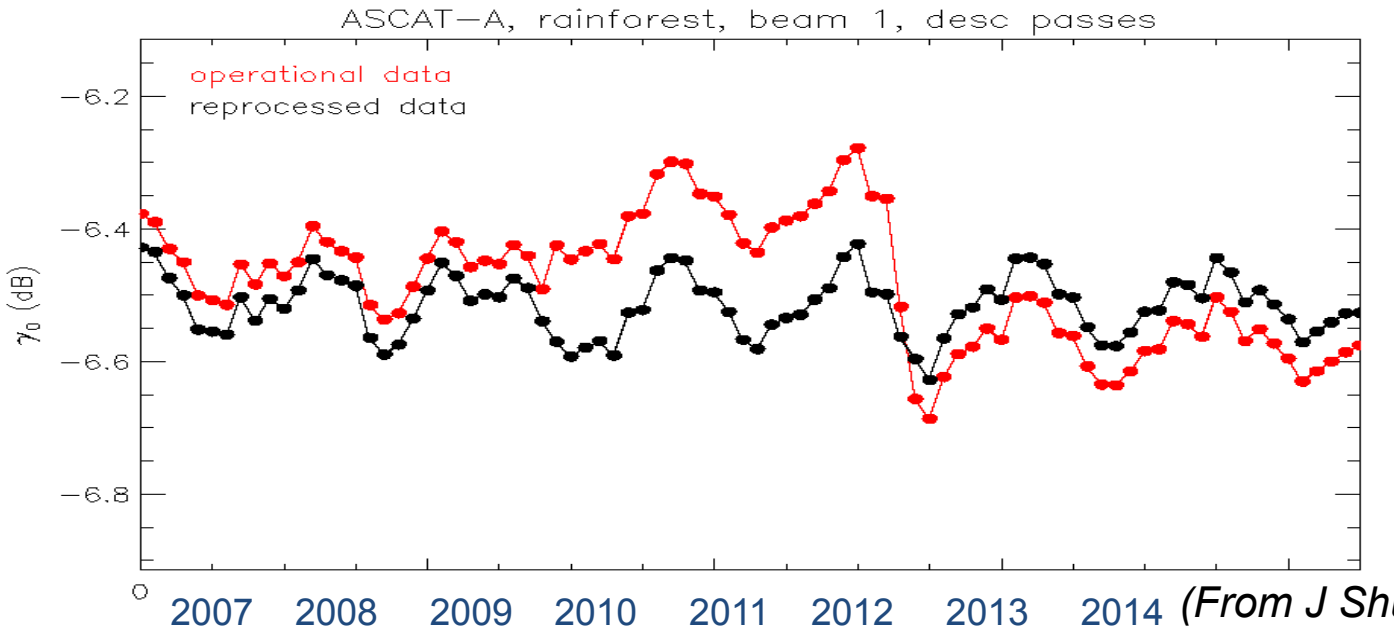
Sea ice drift



Soil moisture

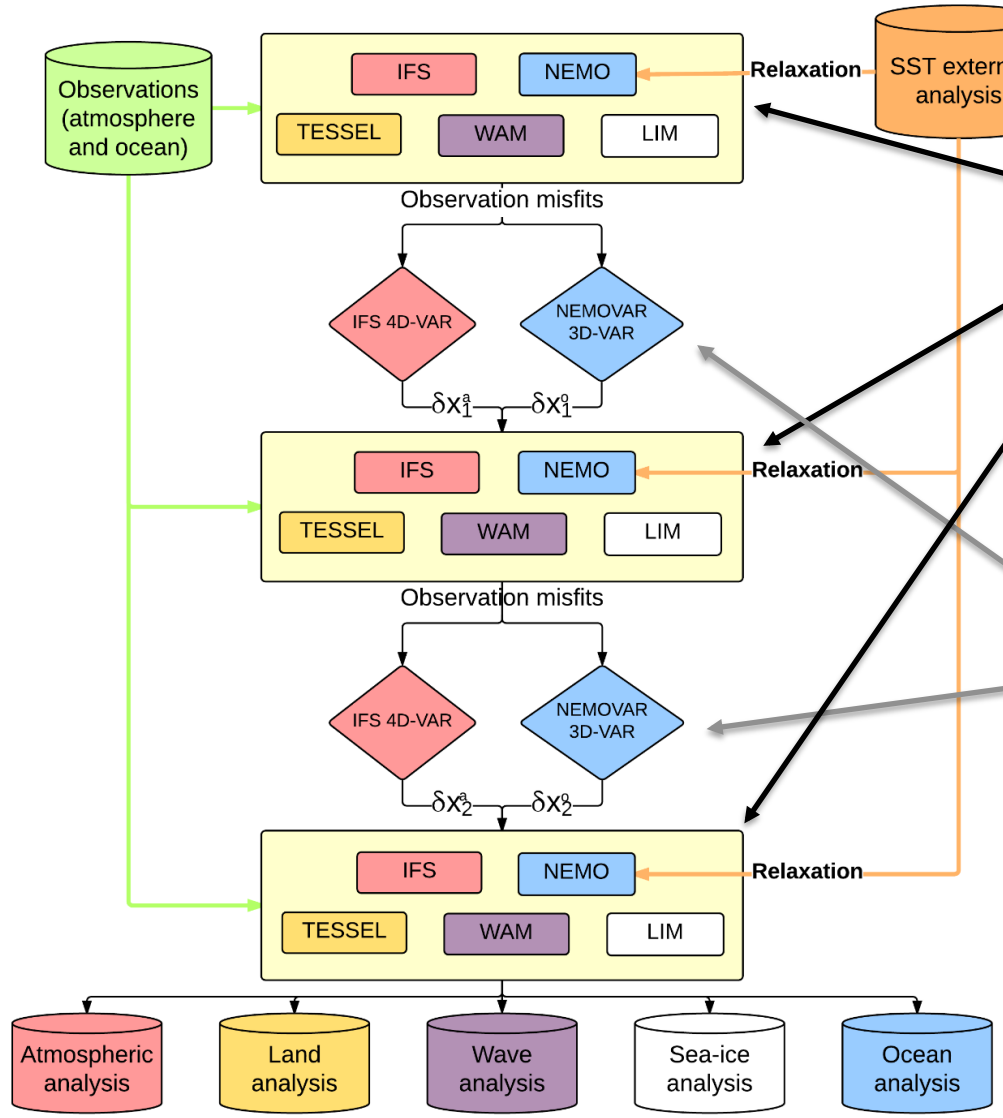
One example: radar backscatter signature of tropical rainforest;

- Recalibration eliminates drifts and jumps in the time series;
- Reflects only natural variations of backscatter of the forest canopy.



(From J Shulz)

Advances in coupled data assimilation



Coupled model computes observation misfits in each outer iteration

SST computed in NEMO and constrained by relaxation

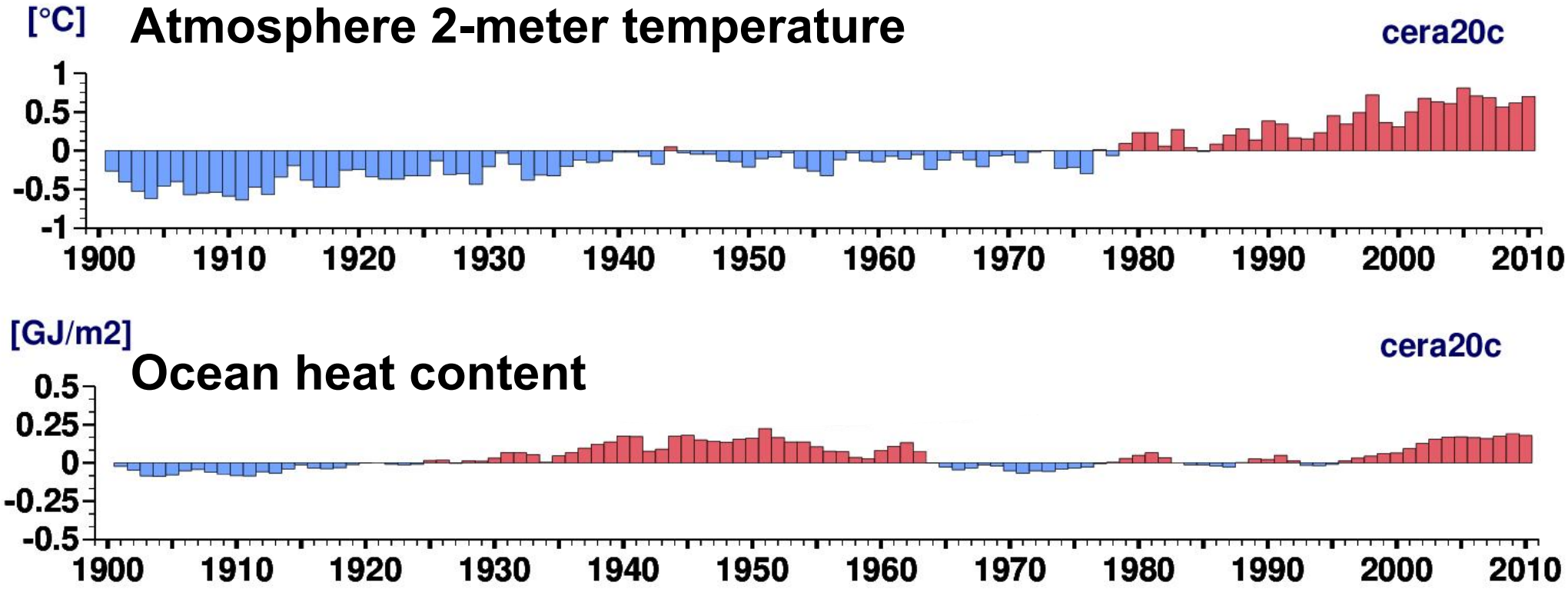
Atmospheric and ocean increments are computed in parallel to correct the initial state

Analysis dynamically consistent with respect to the coupled model

(From P Laloyaux)

CERA-20C: the 110y coupled reanalyses

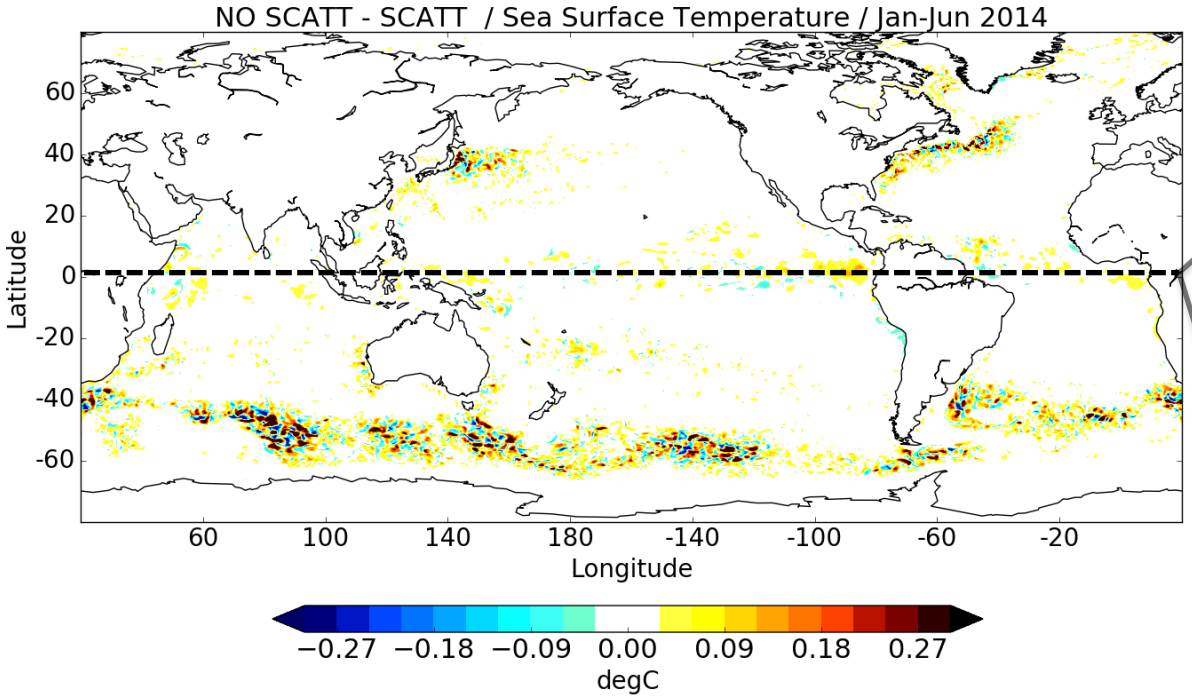
The ERA-CLIM2 coupled reanalyses give us a 4-dimensional Earth-system view of how its different components have been evolving.

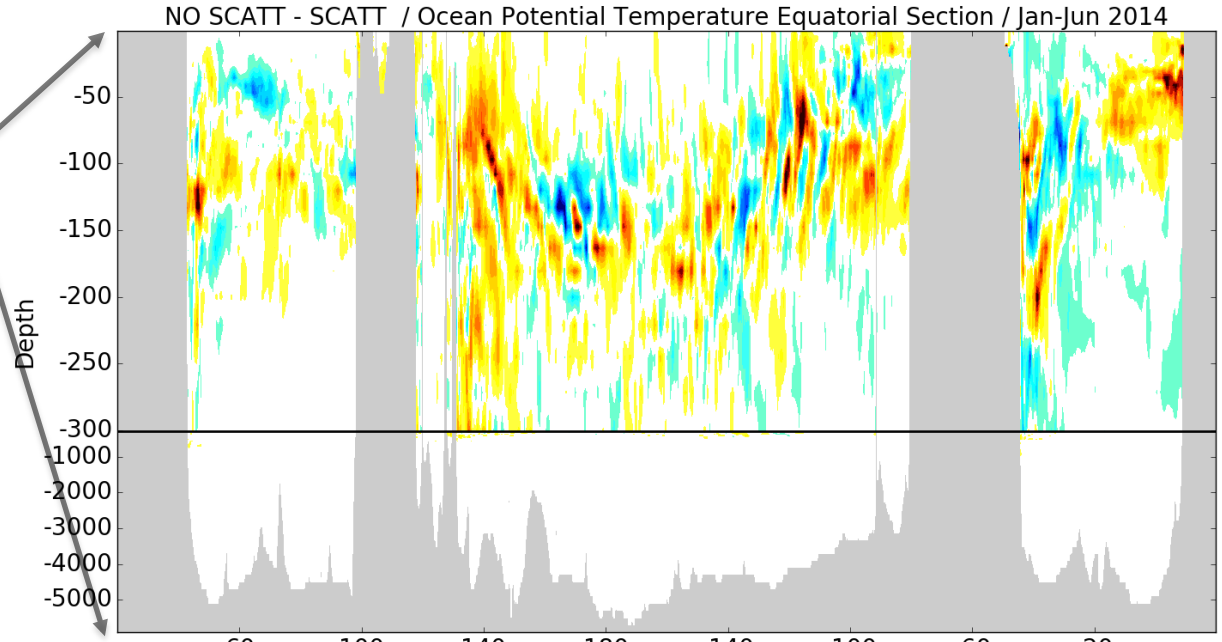


(From P Laloyaux)

The coupled reanalyses of the sat-era

In the CERA DA system, atmosphere wind observations have an impact on the state of the ocean (6 month of analysis, SCAT v NoSCAT data).

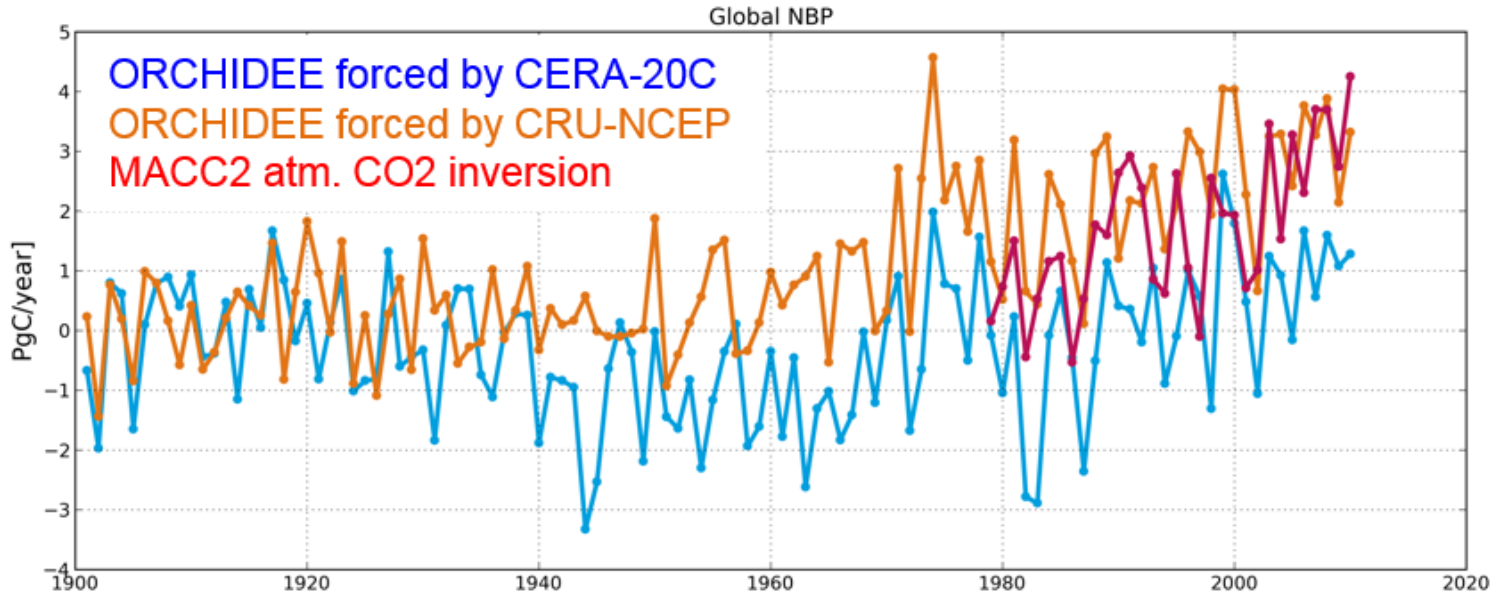




(From D Schepers)

The carbon cycle in the coupled reanalyses

The land carbon reanalysis produced by the ORCHIDEE model forced by CERA-20C shows a good agreement with other carbon estimates.



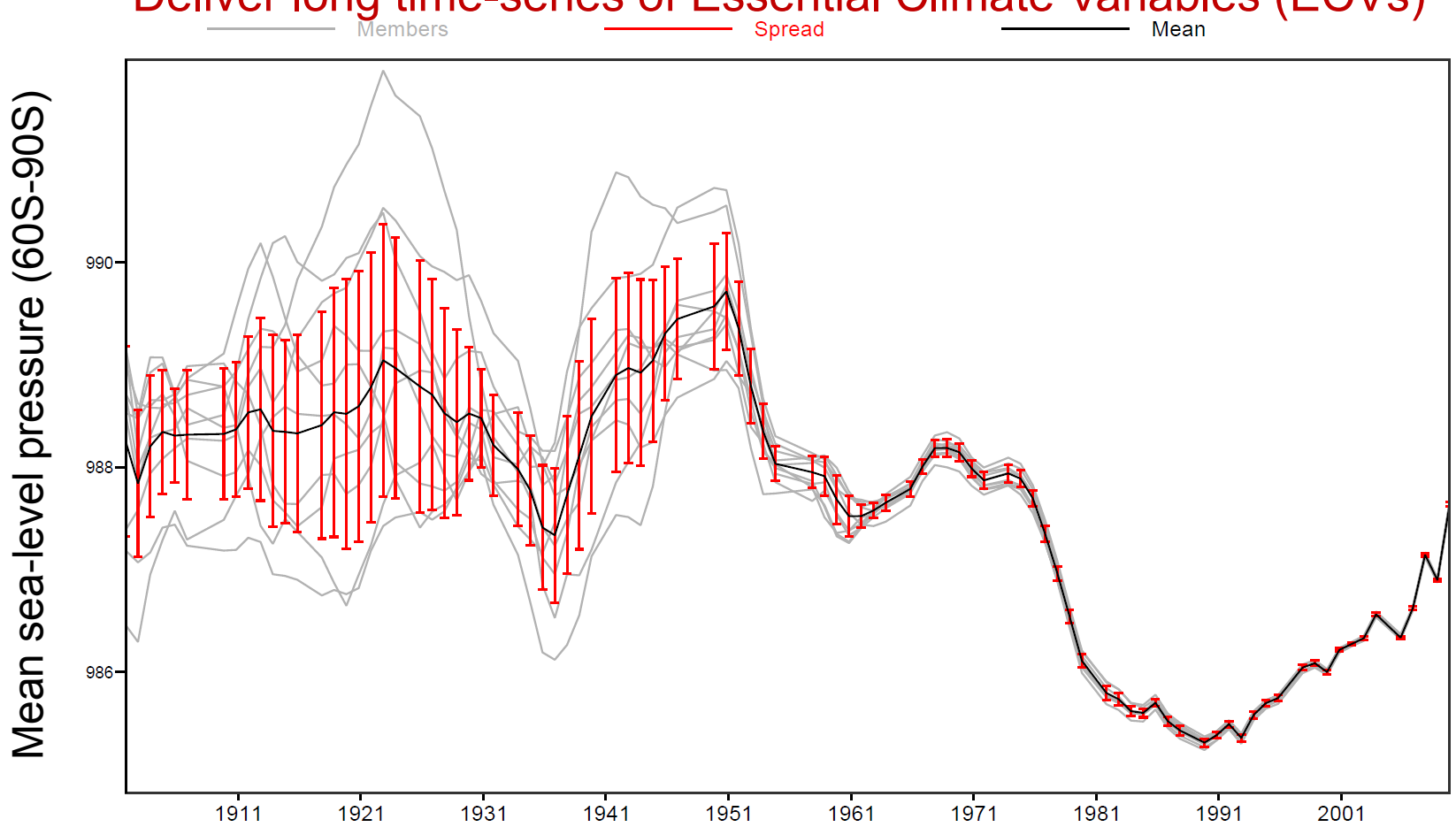
Global net carbon fluxes from the ORCHIDEE model forced by CERA-20C (blue) and by CRU-NCEP (orange), and from the MACC2 atmospheric CO2 inversion (red).

(From P Peylin)

Ensemble-based uncertainty estimation

The use of ensembles allows us to estimate uncertainty.

Deliver long time-series of Essential Climate Variables (ECVs)

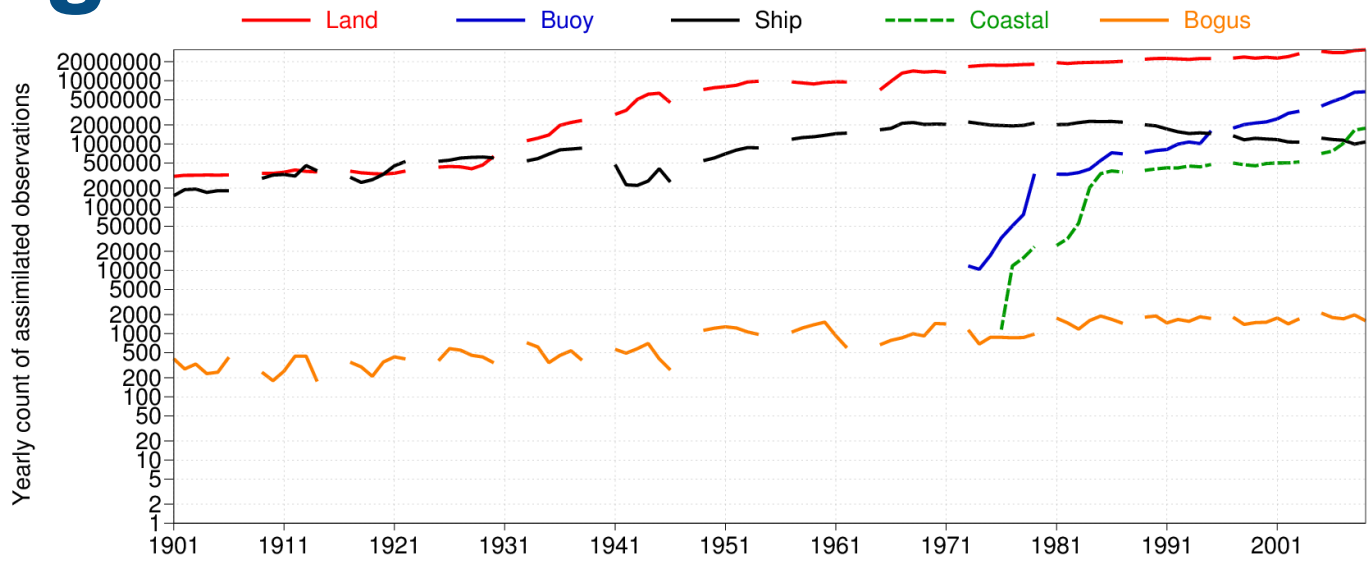


(From L Haimberger)

One of the challenges: data volume

Observation input

- up to 20,000,000 observations are assimilated per year



Archiving footprint:

- 1400 Tb of atmospheric data
- 200 Tb of ocean data

Manpower & teamwork

12/7 monitoring with required manual actions:

- related to observation inputs
- related to technical issues (HPC, filesystems, …)
- scientific monitoring

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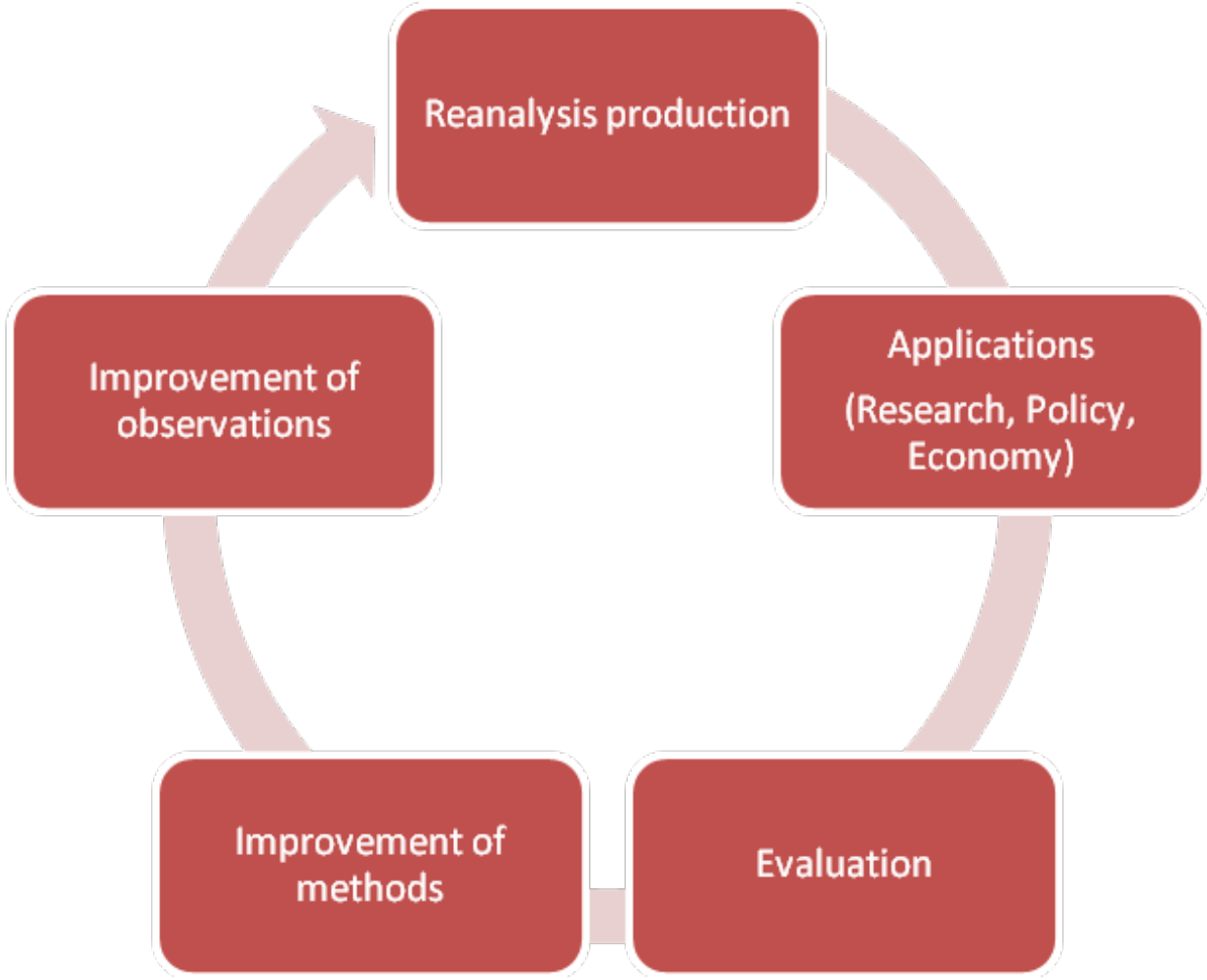
Final considerations: the reanalysis cycle



Few key recommendations

It is worth to list few key recommendations relevant for the five key areas of a reanalysis cycle:

Reanalysis production - As production centers move toward coupled Earth-system reanalyses, they should embrace the notion of families of products designed to support different applications. Reduced latency of data products (ideally real-time) should be aimed for.

Observations for reanalysis - More funding should be made available to support the rescue, reprocessing, recalibration, correction, quality control and use of observations for reanalysis.

ICR5: few key recommendations

Methods for reanalysis - There is a gap of research funding to improve the design of data assimilation methods for reanalysis.

Evaluation of reanalyses – Diagnostic/evaluation activities that look at the coupled atmosphere-ocean-land reanalyses should be promoted.

Applications of reanalyses –There is a need for better and more 'actionable' uncertainty characterization. Reanalyses should be promoted more as key resources in policy relevant documents (from the local scale to IPCC global assessments).

Conclusions

Reanalyses are key to monitor and understand the Earth-system climate.

The EU FP7 ERA-CLIM2 project gave an important contribution to observation rescue and recovery, assimilation methods, production, and uncertainty estimation.

ERA-CLIM2 has helped to consolidate the European leading role in this area.

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