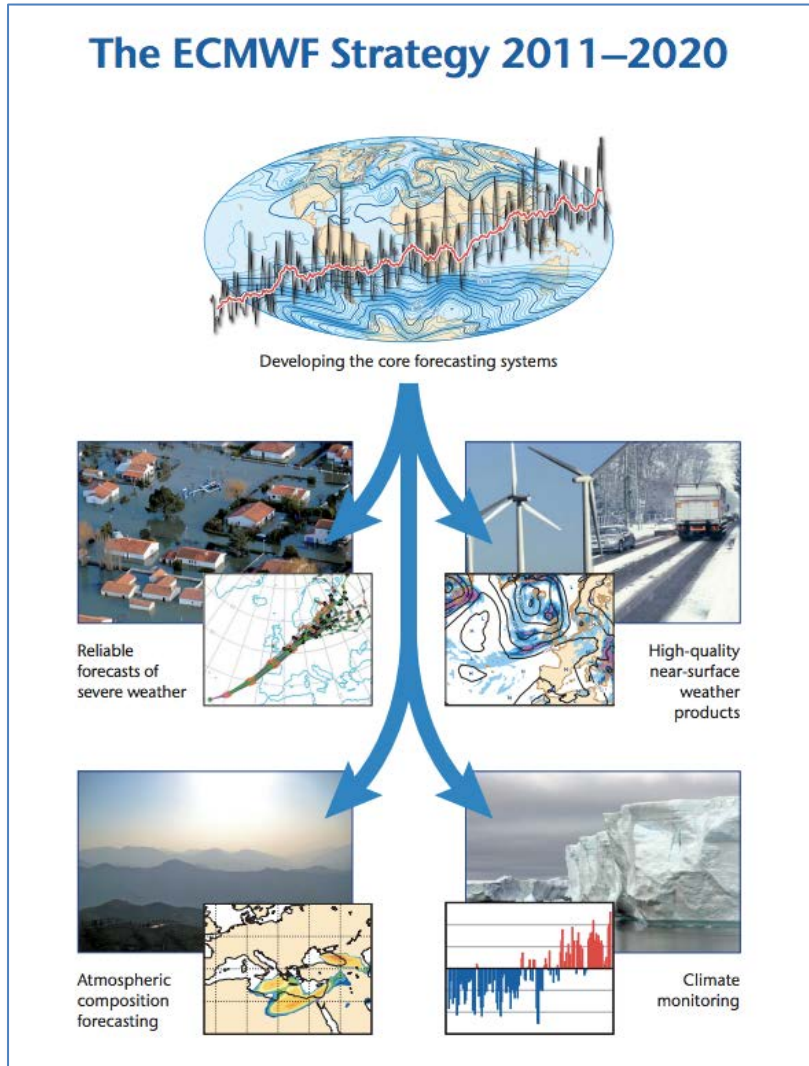


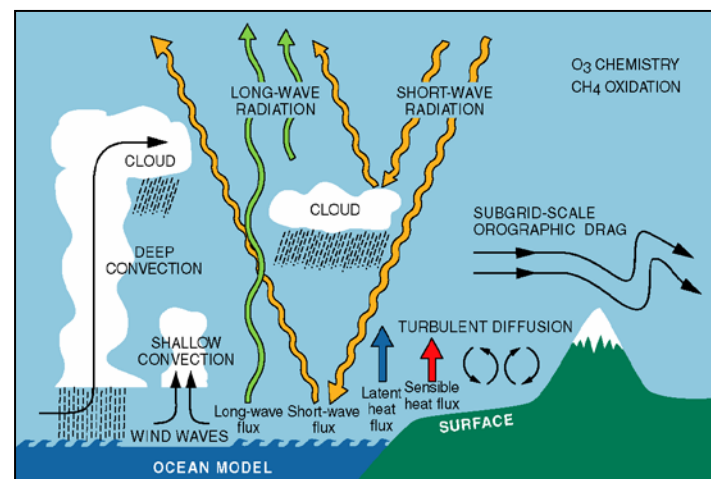
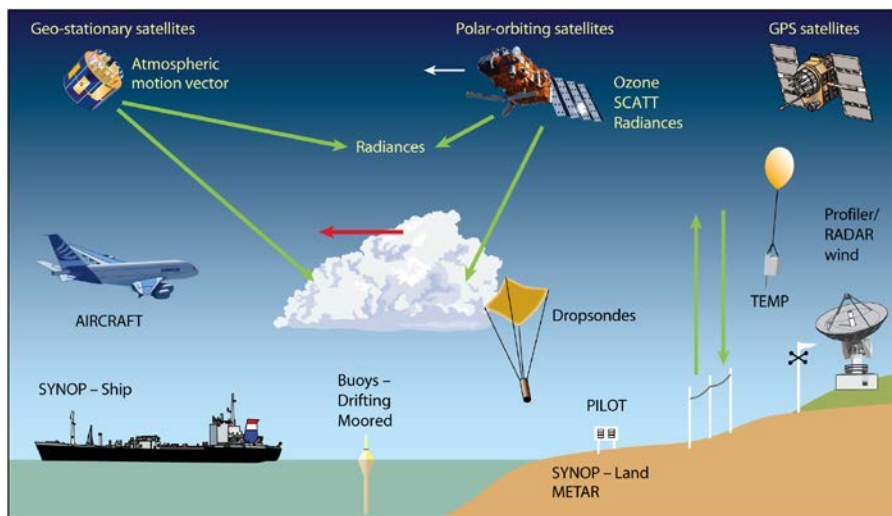
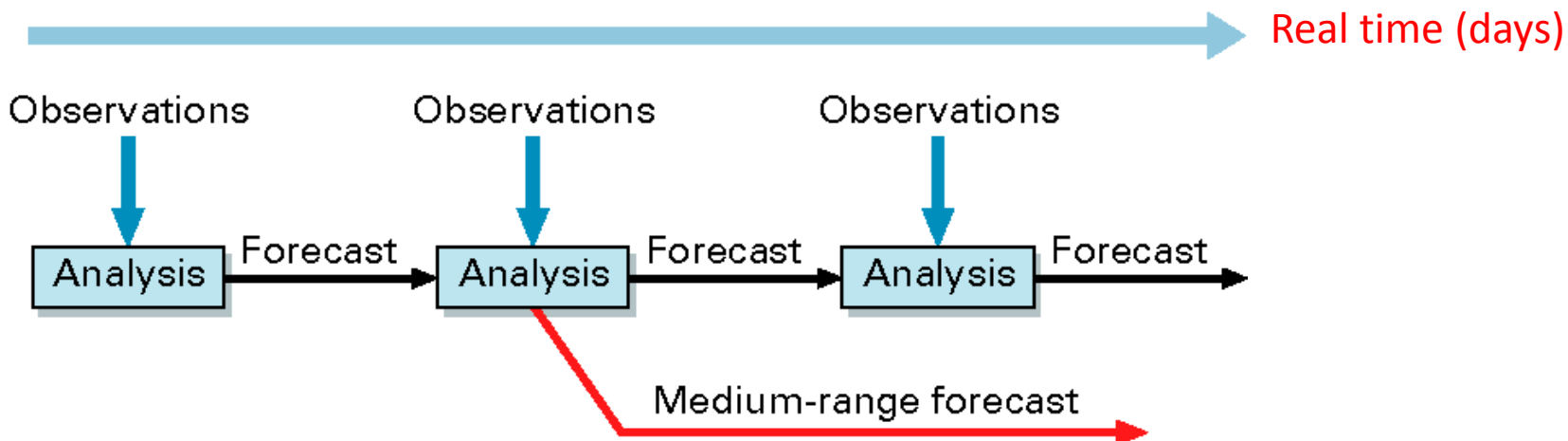
ECMWF Atmospheric Reanalysis (ERA) products



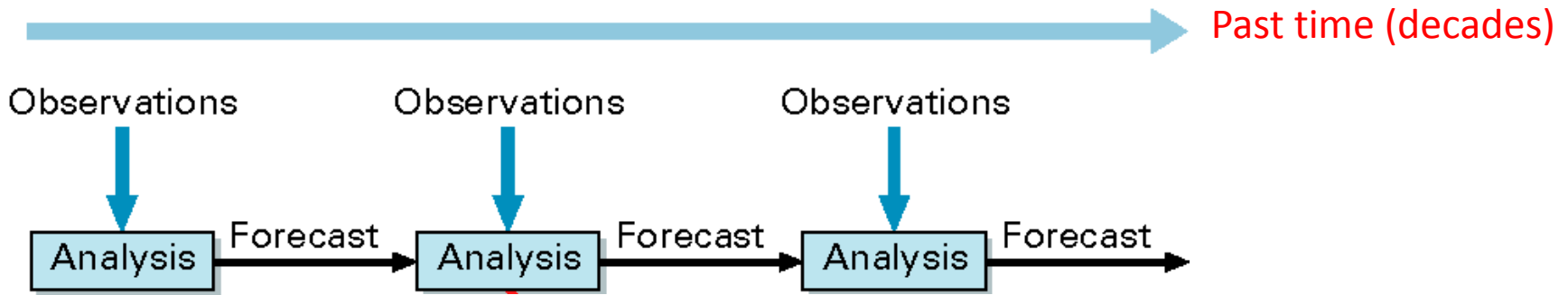
“From research datasets and observational feedback to societal services”

David Tan for Dick Dee and the Reanalysis Section

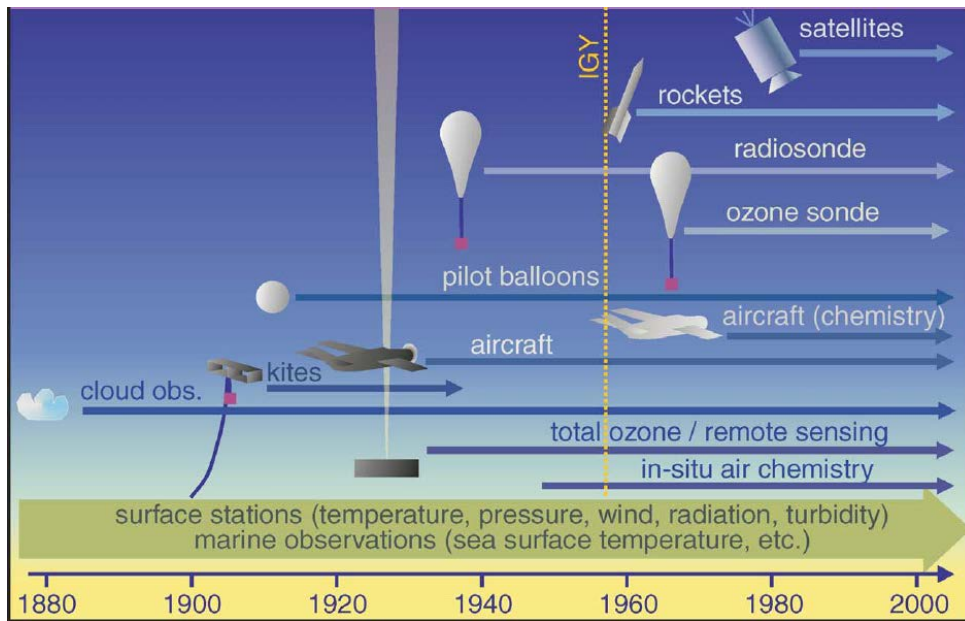
Weather forecasting: Data assimilation in real time



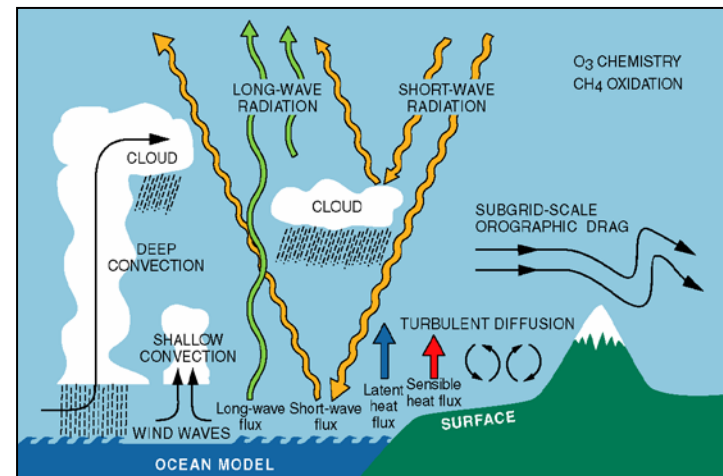
Reanalysis: Data assimilation in past time



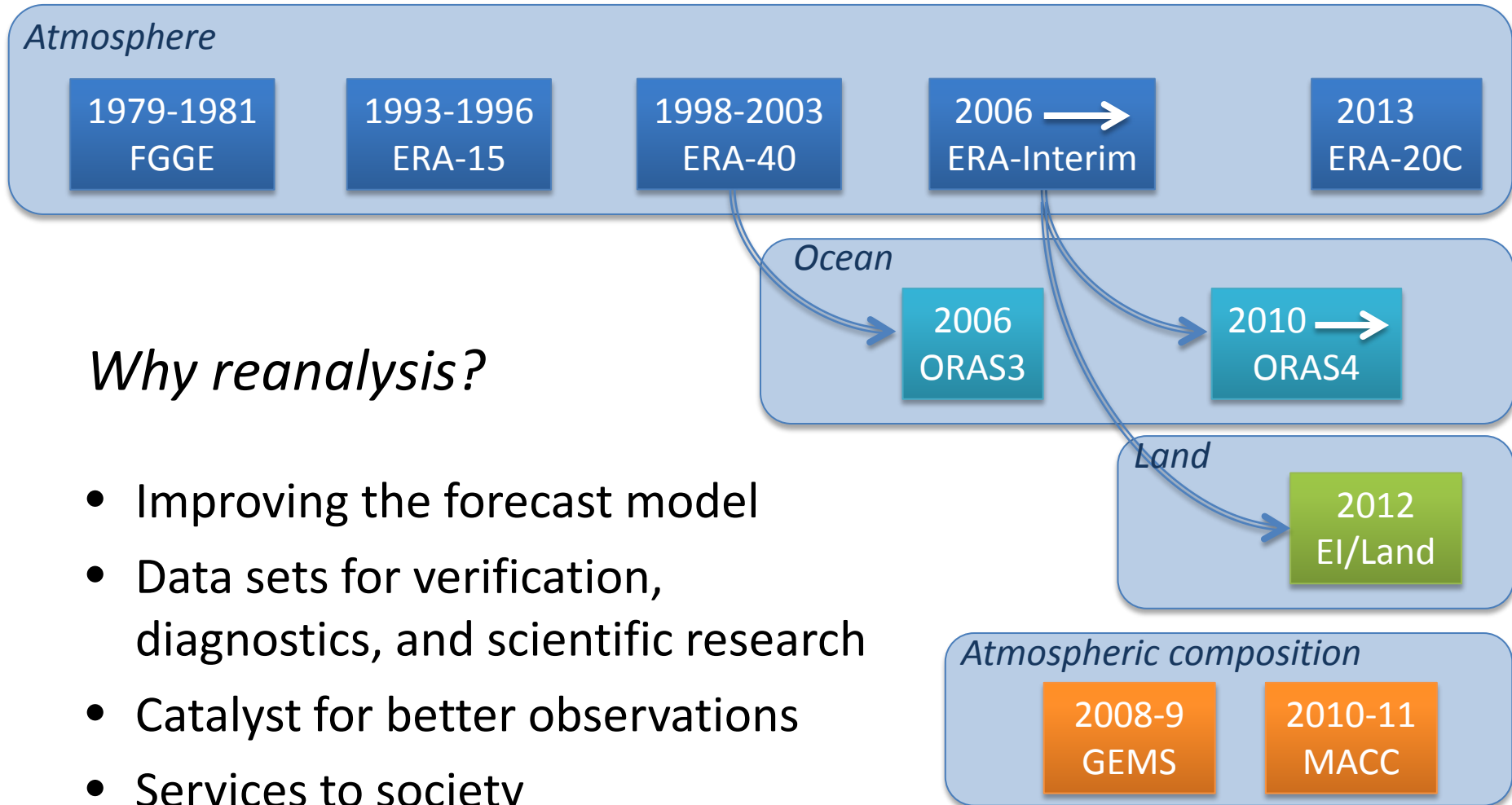
Observations – recovered/reprocessed
 Newer (but fixed) analysis systems
 Emphasis on consistent analyses, less
 on medium-range forecasts



Same physics but forcings can change, e.g. SST, GHG



Global reanalyses produced at ECMWF



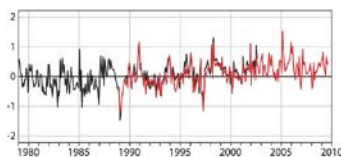
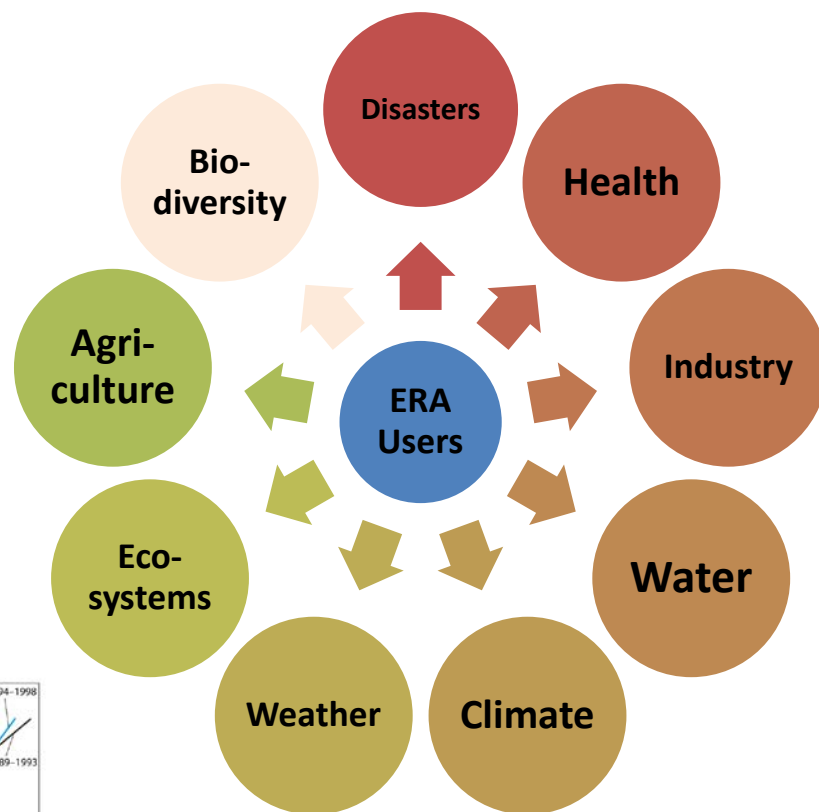
Why reanalysis?

- Improving the forecast model
- Data sets for verification, diagnostics, and scientific research
- Catalyst for better observations
- Services to society

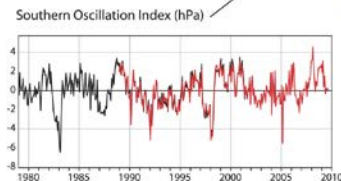
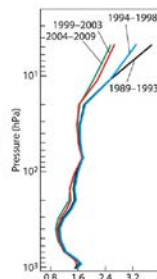
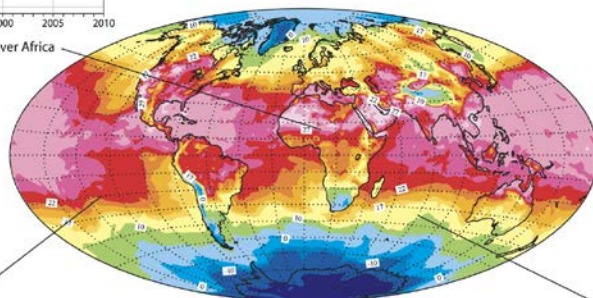
Related: US/Japanese global reanalyses, regional reanalyses

Use of reanalysis data is widespread

- Academic research, model validation
- Downstream modelling applications
- Climate change impact studies
- Assessment of wind energy potential
- Reinsurance risk analysis
- ... (more than 20,000 registered external users of ERA data servers)



ERA-Interim 2-metre temperature (°C)
15 August 2003 03 UTC

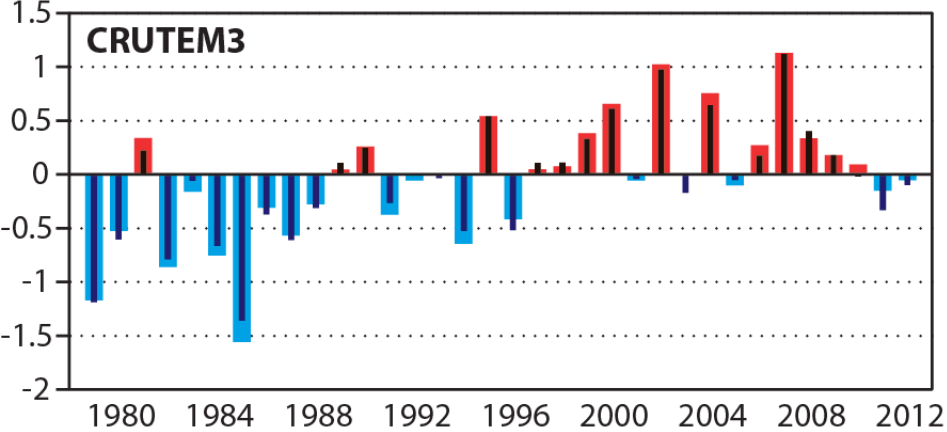


Completeness - gridded datasets, no gaps in space/time, multi-parameter
Consistency – to the extent imparted by assimilation method

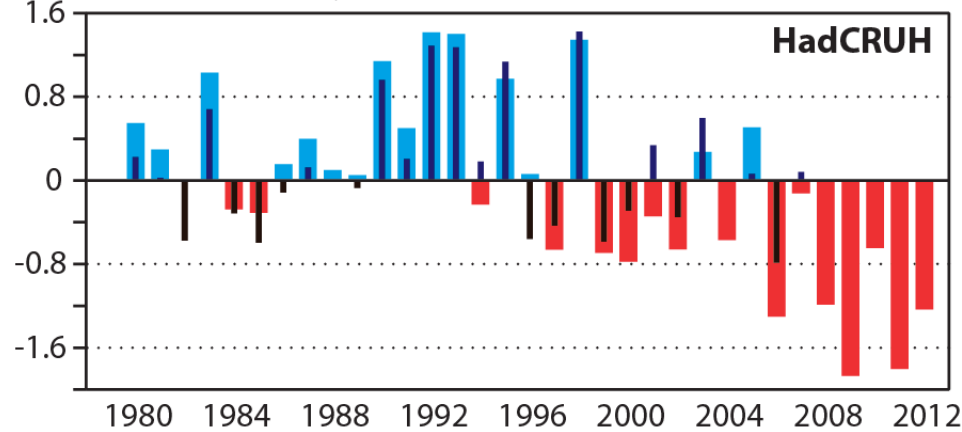
Reanalysis for climate monitoring

ERA-Interim: Extra-tropical northern hemisphere land anomalies (Dec-Mar)

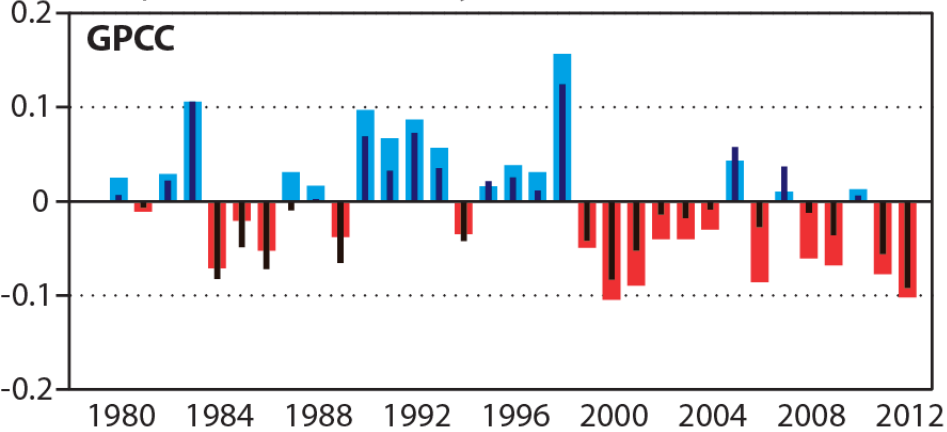
Temperature at 2m (K)



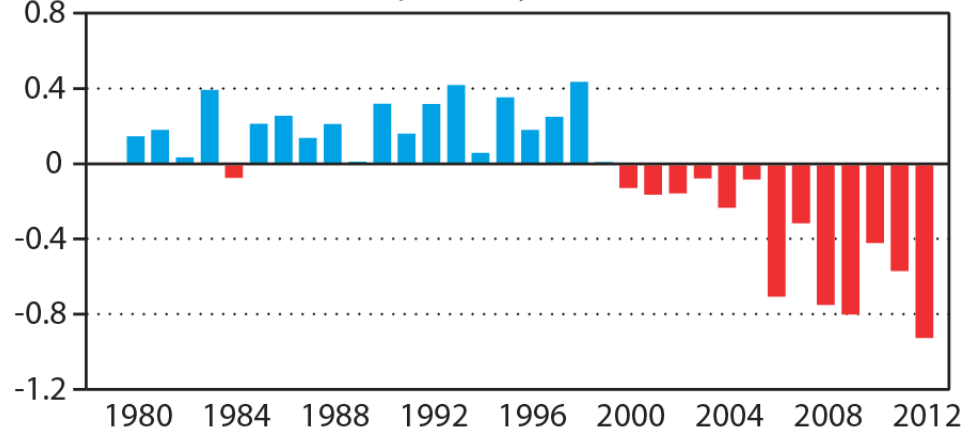
Relative humidity at 2m (%)



Precipitation rate (mm/day)



Volumetric model top-soil-layer water (%)



Variability good for some parameters, improving for others. Also for trends.

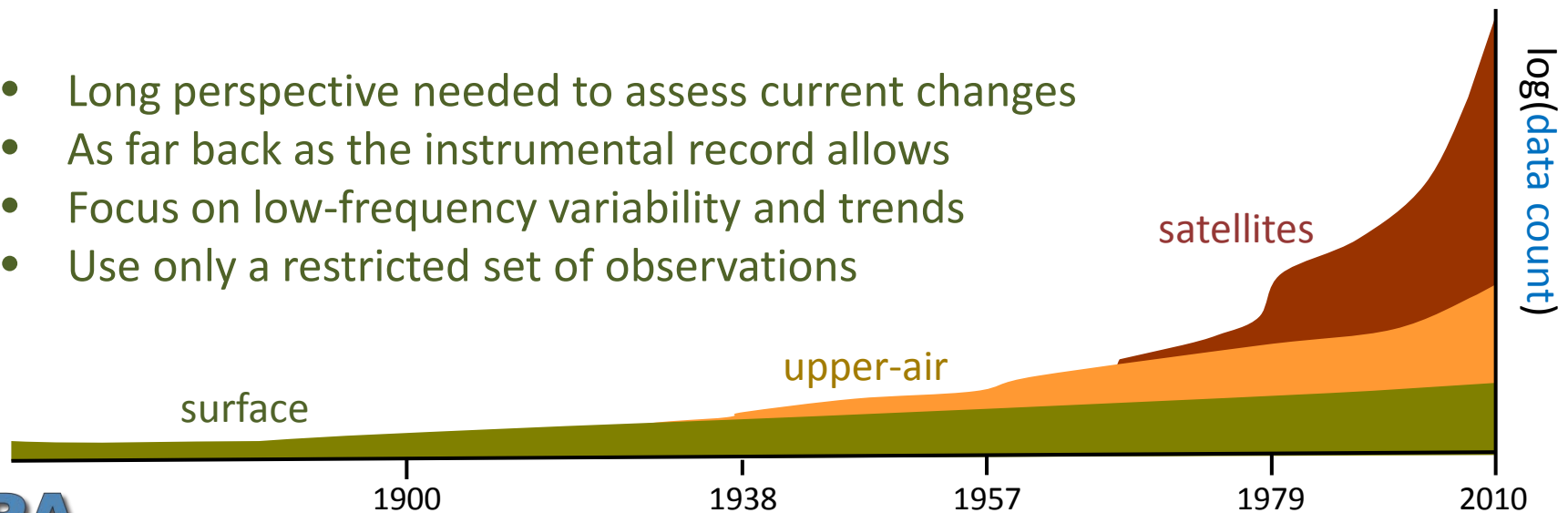
Climate reanalysis: Two types of products

Reanalyses of the modern observing period (~30-50 years):

- Produce the best state estimate at any given time
- Use as many observations as possible, including from satellites
- Closely tied to forecast system development (NWP and seasonal)
- Near-real time product updates

Extended climate reanalyses (~100-200 years):

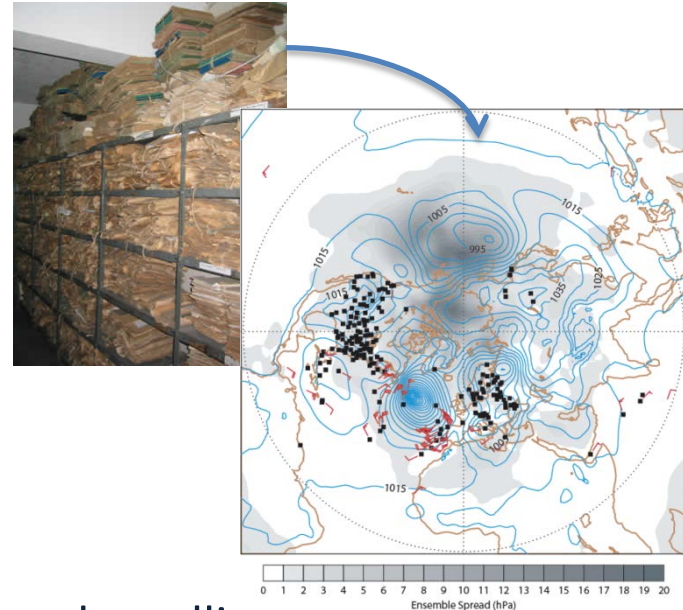
- Long perspective needed to assess current changes
- As far back as the instrumental record allows
- Focus on low-frequency variability and trends
- Use only a restricted set of observations



The ERA-CLIM project

ERA-CLIM: EU collaborative research project, 2011-2013, 9 global partners

Goal: Preparing input observations, model data, and data assimilation systems for a global atmospheric reanalysis of the 20th century

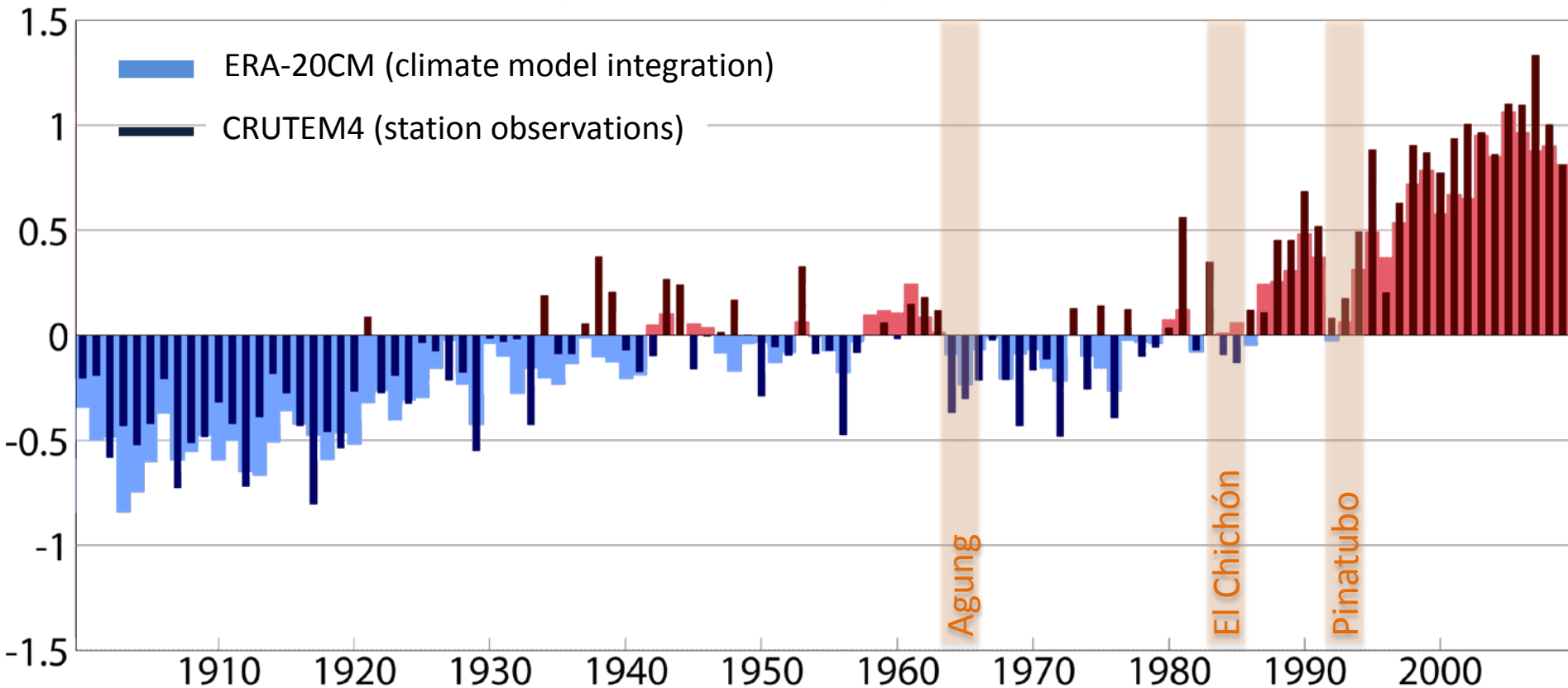


Main components:

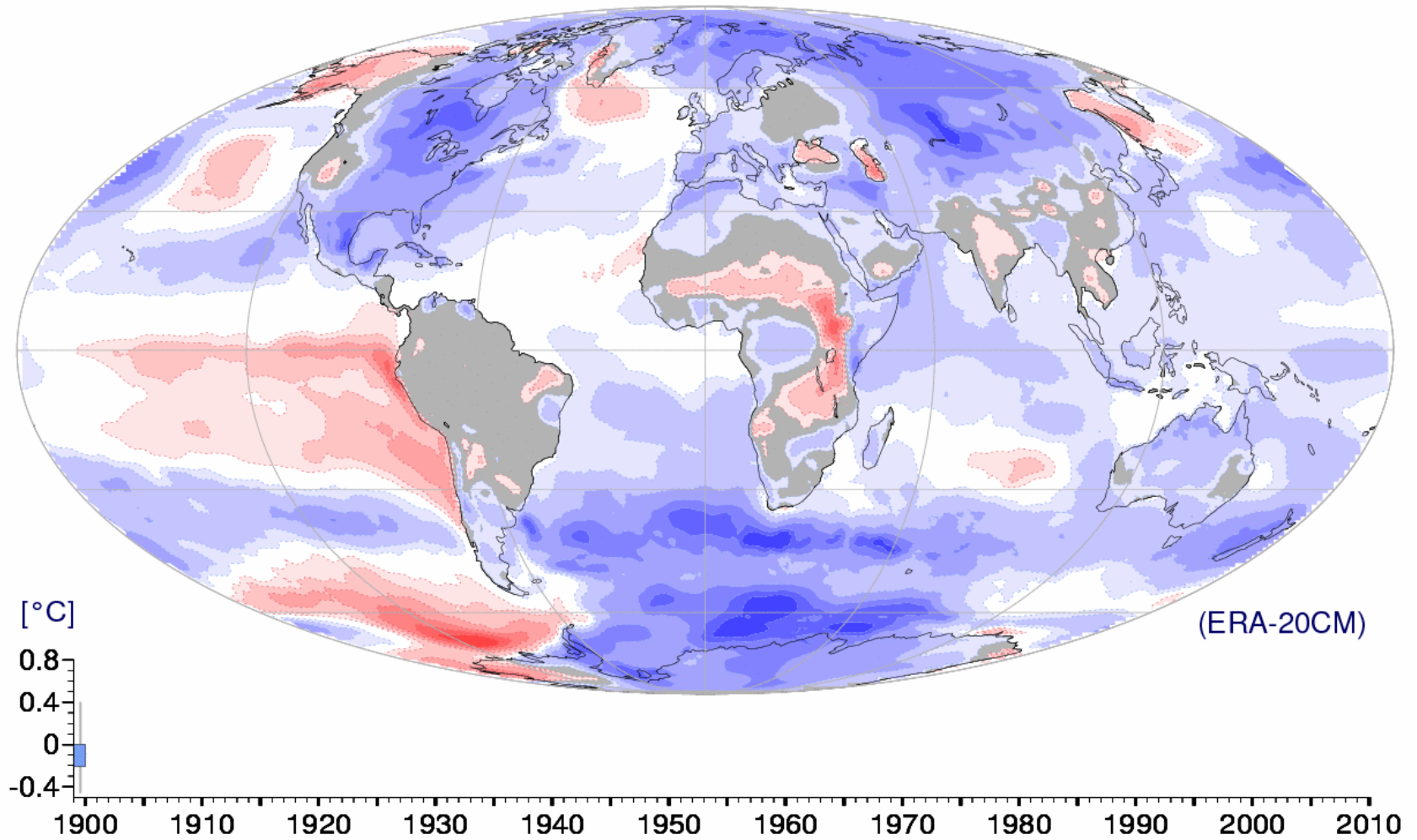
1. Data rescue efforts (in-situ upper-air and satellite observations)
2. Incremental development of new reanalysis products
3. Use of reanalysis feedback to improve the data record
4. Access to reanalysis data and observation quality information

ERA-20CM: Climate model integration

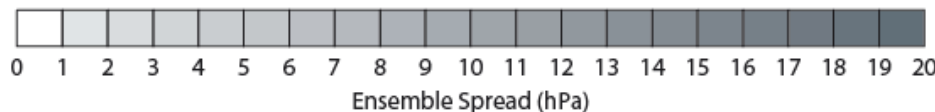
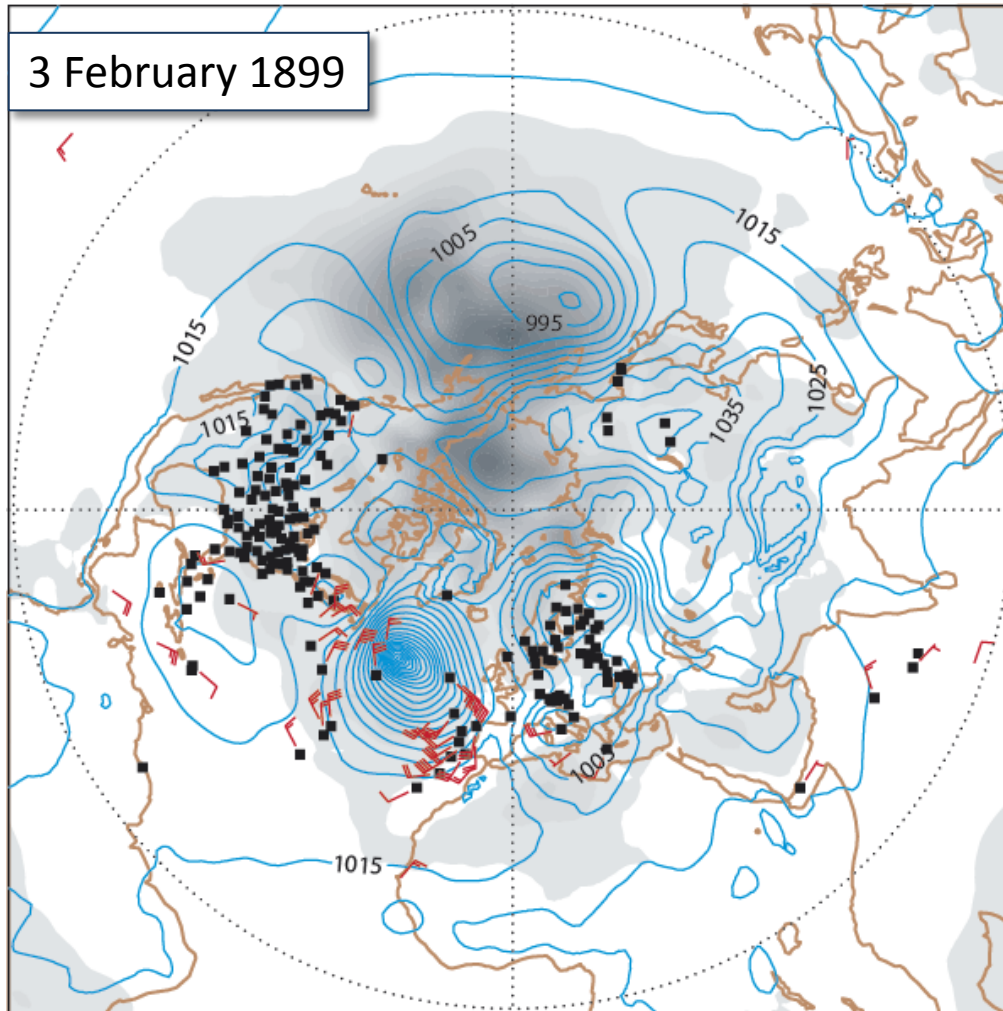
Annual-mean temperatures averaged over all CRUTEM4 grid boxes in extratropical northern hemisphere



Global warming relative to 20th-century average



ERA-20C: Assimilating surface observations



TERRIFIC STORMS AT SEA

Steamships from All Quarters Report Extremely Rough Voyages.

ALL MORE OR LESS BATTERED

Vessels Sighted in Distress and Abandoned — Blinding Snow and Waves Like Mountains.

All the steamers that came in yesterday were coated with ice from the tops of the masts down to the water line, and all had passed through storms of blinding snow and mountainous waves. The British steamer *Ethelgonda*, from Bristol and Swansea, which left the latter port on Jan. 19, ran into a gale of hurricane force, and seas swept her decks repeatedly. So fierce was the wind that the boat drifted before the gales and was barely able to keep steerage way. She anchored outside the bar late Sunday afternoon. The cable parted and she lost her anchor, together with 100 fathoms of chain. Then the great snow-storm drove her 150 miles off the shore. She succeeded in getting back late on Tuesday night.

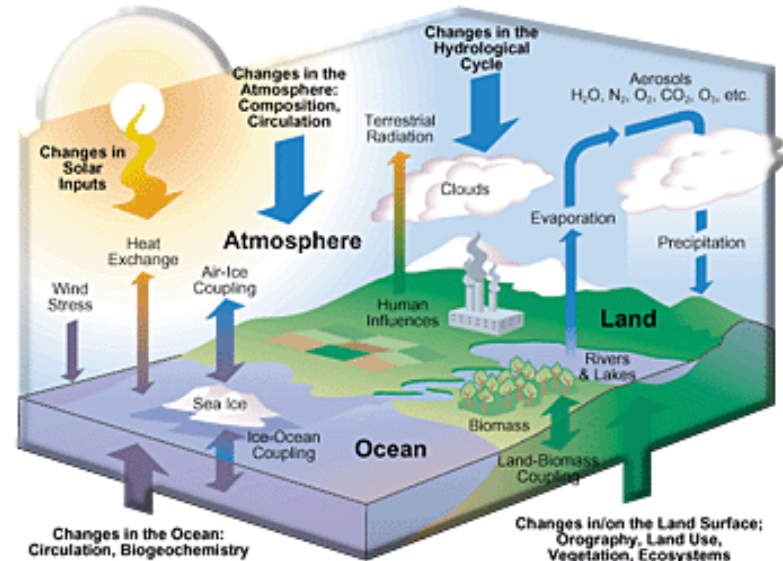
The French liner *La Bretagne*, from Havre, came in a little before noon yesterday, with 58 cabin and 225 steerage passen-

The New York Times

Published: February 16, 1899
Copyright © The New York Times

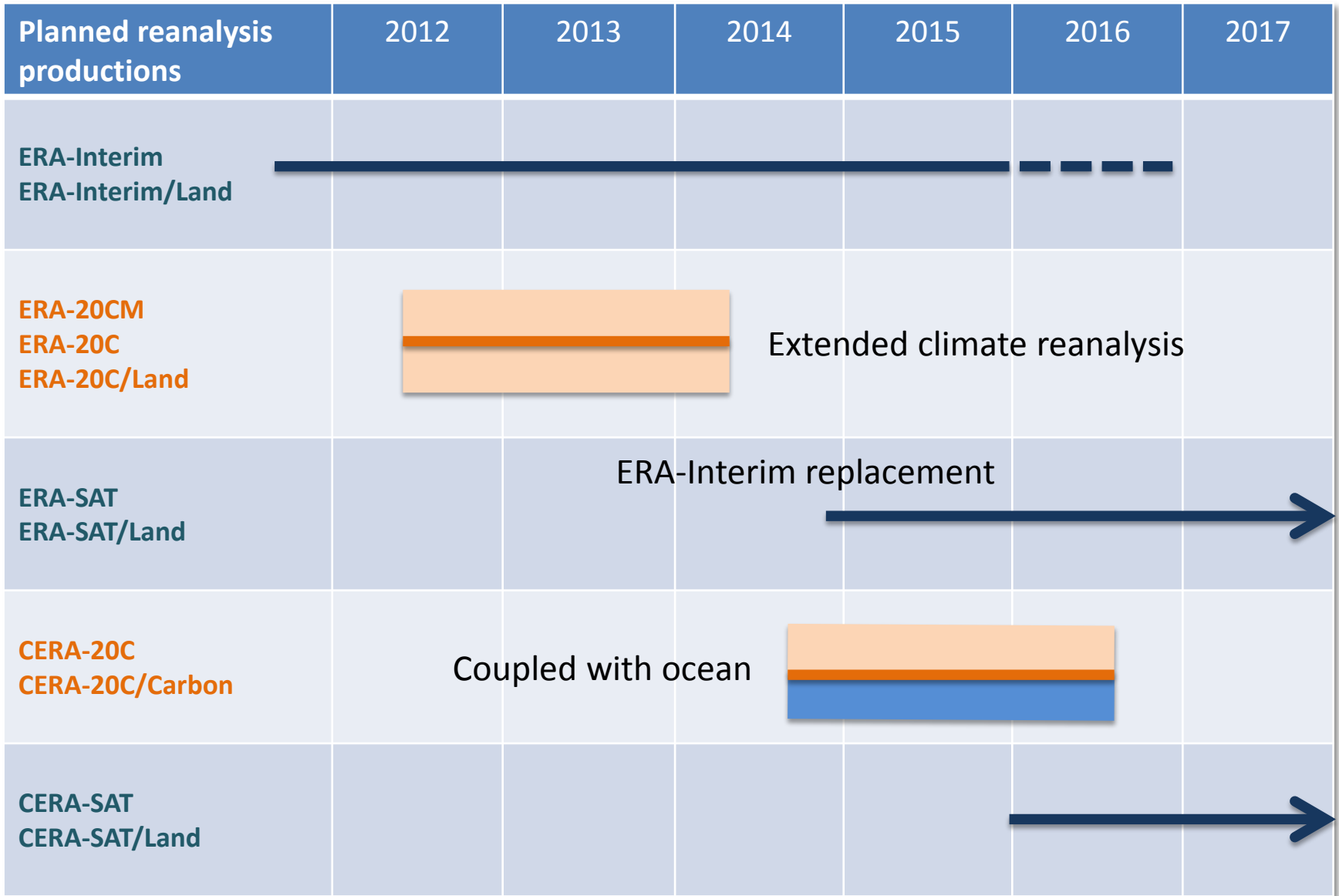
The ERA-CLIM2 project (2014-2016)

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



Main components:

1. Production of coupled reanalyses CERA-20C and CERA-SAT
2. Research and development in coupled data assimilation
3. Earth system observations for extended climate reanalysis
4. Quantifying and reducing uncertainties



Reanalysis information products

ECMWF's data policy:

- All gridded reanalysis products available, for research & commercial
- All input observations available, for research only

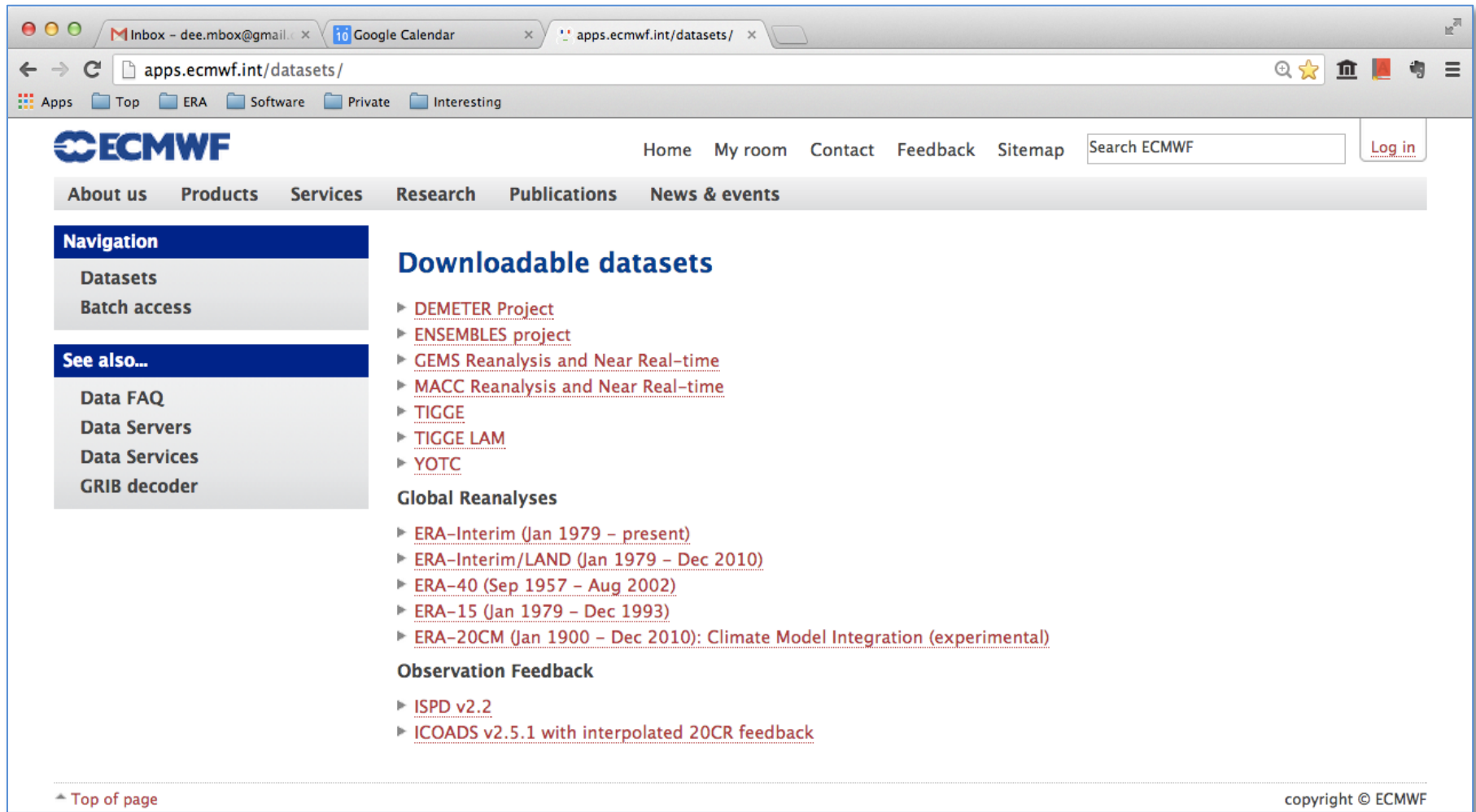
ERA Data Servers:

- All gridded reanalysis data and derived fields, at full resolution
- Based on ECMWF's Meteorological Archiving and Retrieval System (MARS)
- Currently >12,000 registered users of ERA-Interim data
- Interactive access via web servers; direct access from user applications
- See <http://apps.ecmwf.int/datasets/>

Climate Monitoring Facility:

- Interactive web tool for ECV time series visualization
- Prototype development (Web2013 project)
- Contains ERA data (real-time feeds), data from MACC, other reanalyses
- Additional functionality: User data overlays; superposition of data events

http://apps.ecmwf.int/datasets/



The screenshot shows a web browser window with the URL <http://apps.ecmwf.int/datasets/>. The browser tabs include 'Inbox - dee.mbox@gmail.com', 'Google Calendar', and the current page. The website header features the ECMWF logo, navigation links (Home, My room, Contact, Feedback, Sitemap), a search bar, and a 'Log in' button. A secondary navigation bar lists 'About us', 'Products', 'Services', 'Research', 'Publications', and 'News & events'. The main content area is titled 'Downloadable datasets' and includes a left sidebar with 'Navigation' (Datasets, Batch access) and 'See also...' (Data FAQ, Data Servers, Data Services, GRIB decoder). The main content lists several datasets under 'Global Reanalyses' and 'Observation Feedback'.

Navigation

- Datasets
- Batch access

See also...

- Data FAQ
- Data Servers
- Data Services
- GRIB decoder

Downloadable datasets

- ▶ [DEMETER Project](#)
- ▶ [ENSEMBLES project](#)
- ▶ [GEMS Reanalysis and Near Real-time](#)
- ▶ [MACC Reanalysis and Near Real-time](#)
- ▶ [TIGGE](#)
- ▶ [TIGGE LAM](#)
- ▶ [YOTC](#)

Global Reanalyses

- ▶ [ERA-Interim \(Jan 1979 - present\)](#)
- ▶ [ERA-Interim/LAND \(Jan 1979 - Dec 2010\)](#)
- ▶ [ERA-40 \(Sep 1957 - Aug 2002\)](#)
- ▶ [ERA-15 \(Jan 1979 - Dec 1993\)](#)
- ▶ [ERA-20CM \(Jan 1900 - Dec 2010\): Climate Model Integration \(experimental\)](#)

Observation Feedback

- ▶ [ISPD v2.2](#)
- ▶ [ICOADS v2.5.1 with interpolated 20CR feedback](#)

▲ Top of page

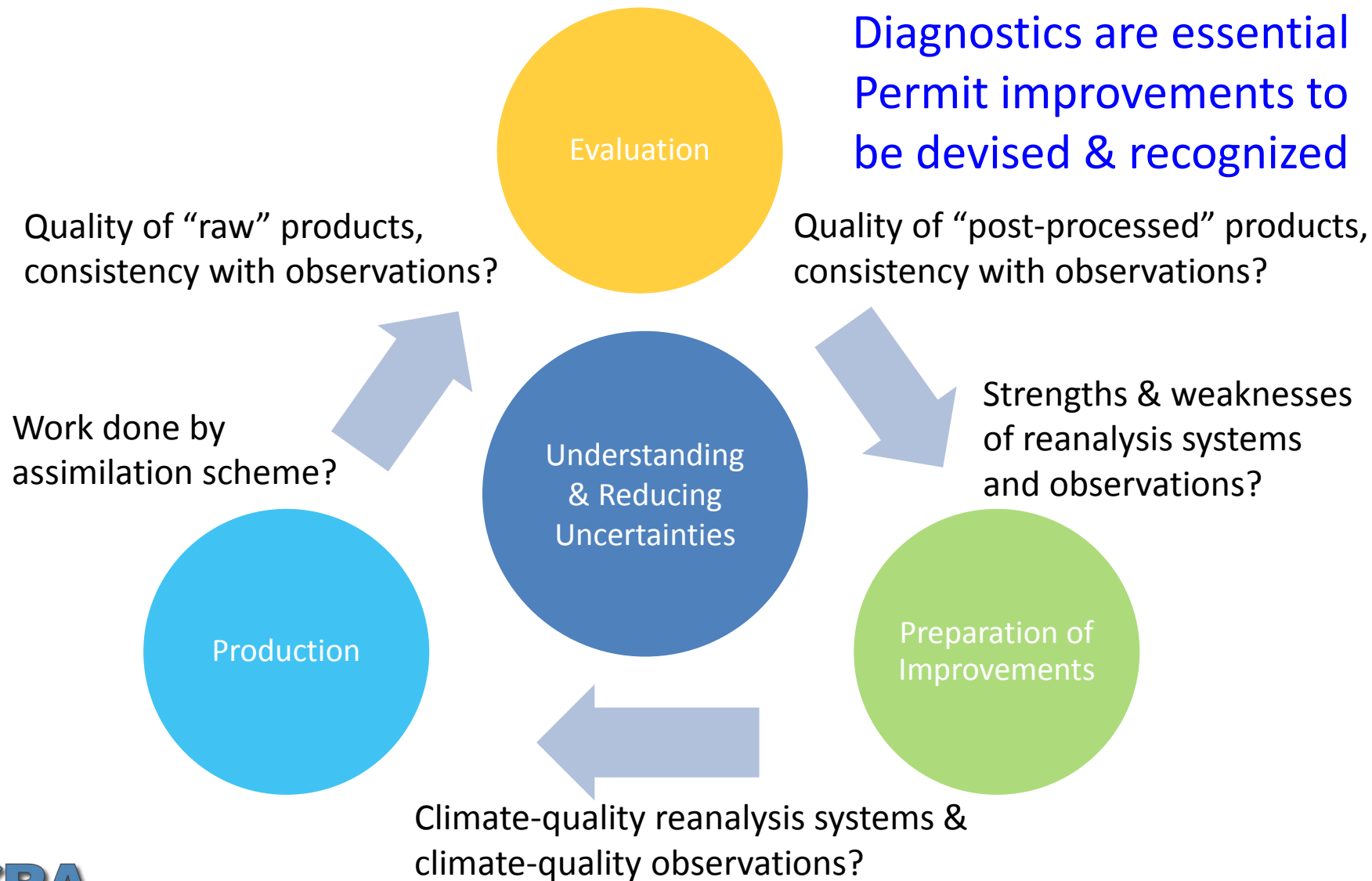
copyright © ECMWF



Observation Feedback from apps.ecmwf.int/datasets

The screenshot displays the web interface for the ISPD v2.2 dataset. The page title is "ISPD v2.2" and the URL is "apps.ecmwf.int/datasets/data/ispd/". The interface includes a navigation menu on the left with sections for "Data", "Navigation", and "See also...". The main content area features a date range selector (1778-03 to 2010-12) circled in red, a "Select observed parameter" section with "Surface pressure" selected, and a "Select observation platform" section with "SHIP" selected. Both sections are circled in red. The interface also includes a "Reset" button, "Select All or Clear" links, and buttons for "View the MARS request", "Retrieve observations", and "Plot the selection". The footer contains a "Top of page" link and "copyright © ECMWF".

Iterative progress: the reanalysis life-cycle



Diagnostics for Quality, Uncertainty & Confidence

INTERPRETATIVE METADATA

Abundant but much waiting to be discovered

Can be disjointed (grey-literature), not easy to synthesize

Quality of “raw” products,
consistency with L1/L2 observations?

Quality of “post-processed” products,
consistency with L2/L3/L4 observations?

Forecast scores

Bias corrections

Analysis departures

Analysis increments

Background departures

Cost function diagnostics

Work done by
assimilation scheme?

Climate-quality reanalysis systems &
climate-quality observations?

Monthly means

Trends & anomalies

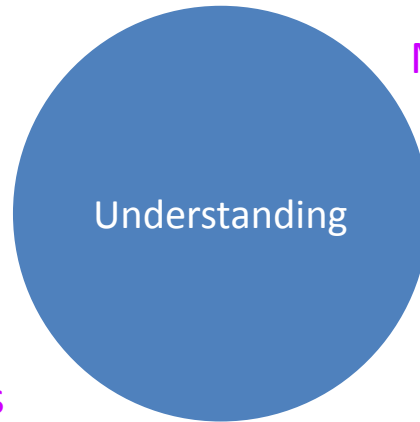
Budgets, e.g. energy/water cycles

Ensemble statistics

Downstream data, e.g. hydrology,
renewable energy, agriculture, health

Strengths & weaknesses
of reanalysis systems
and observations?

Intercomparison projects,
e.g. S-RIP



Reanalysis resources on the Web

reanalysis.org

The screenshot shows the homepage of reanalysis.org. At the top, there is a navigation bar with links for Home, Contact Us, and Login/Register. Below this is a search bar. The main content area features a large globe graphic with the text "REANALYSES.ORG" and "ADVANCING REANALYSIS". To the left, there is a "Welcome to the Reanalyses site." section and a "Recent Updates" section listing various articles and reports. The central text describes reanalysis as a scientific method for developing a comprehensive record of how weather and climate are changing over time. It mentions that reanalysis products are used extensively in climate research and services, including for monitoring and comparing current climate conditions with those of the past, identifying the causes of climate variations and change, and preparing climate predictions. Information derived from reanalysis is also being used increasingly in commercial and business applications in sectors such as energy, agriculture, water resources, and insurance. A call to action for a survey is also present.

reanalysis.org

Advancing Reanalysis

HOME ABOUT ATMOSPHERE OCEAN OBSERVATIONS MEETINGS REPORTS

Welcome to the Reanalyses site.

Members will need to login to the site to see more information.

Recent Updates

- Temperature trends for the period 1871-2009 in the midlatitude summer mesosphere - 01/08/2014
- Diagnostic Studies: Climate Variability - 01/08/2014
- Mainie data rescue - 12/17/2013
- Data Rescue - 12/17/2013
- Overview of current atmospheric reanalyses - 12/17/2013
- Reanalyses.org-Home Page - 13/04/2013
- Upper-air - 13/02/2013

Reanalyses.org Home Page

Reanalysis is a scientific method for developing a comprehensive record of how weather and climate are changing over time. In it, 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. Reanalysis products are used extensively in climate research and services, including for monitoring and comparing current climate conditions with those of the past, identifying the causes of climate variations and change, and preparing climate predictions. Information derived from reanalysis is also being used increasingly in commercial and business applications in sectors such as energy, agriculture, water resources, and insurance.

Using a collaborative Wiki framework, the goal of reanalyses.org is to facilitate comparison between reanalysis and observational datasets. Evaluative content provided by reanalysis developers, observationalists, and users; and links to detailed data descriptions, data access methods, analysis and plotting tools, and dataset references are available. Discussions of the recovery of observations to improve reanalyses is also a focus. The wiki framework encourages scientific discussion between members of reanalyses.org and other reanalysis users.

News (4 December 2013): Please take part in the Reanalysis User and Application Survey (closing 31 January 2014)

Topics

- Overview of Current Atmospheric Reanalyses
- Overview of Current Ocean Reanalyses
- Atmospheric Reanalyses Companion Table
- Reanalyses Plotting and Data Manipulation Tools

UCAR/NCAR Climate Data Guide

The screenshot shows the UCAR/NCAR Climate Data Guide website. The header includes the NCAR and UCAR logos, the title "Climate Data Guide", and the tagline "inform • compare • discover". Below the header is a navigation bar with links for CLIMATE DATA, ANALYSIS TOOLS, MODEL EVALUATION, EXPERT CONTRIBUTORS, ABOUT, and a search bar. The main content area is titled "Climate Data" and "ATMOSPHERIC REANALYSIS: OVERVIEW & COMPARISON TABLES". It features a summary section with two globe graphics showing atmospheric reanalysis data. The text describes reanalysis as a systematic approach to produce data sets for climate monitoring and research. It mentions that reanalyses are created via an unchanging ("frozen") data assimilation scheme and model(s) which ingest all available observations every 6-12 hours over the period being analyzed. This unchanging framework provides a dynamically consistent estimate of the climate state at each time step. The one component of this framework which does vary are the sources of the raw input data. This is unavoidable due to the ever-changing observational network which includes, but is not limited to, radiosonde, satellite, buoy, aircraft, and ship reports. Currently, approximately 7-9 million observations are ingested at each time step. Over the duration of each reanalysis product, the changing observation mix can produce artificial variability and spurious trends. Skill, the various reanalysis products have proven to be quite useful when used with appropriate care.

KEY STRENGTHS:

- Global data sets, consistent spatial and temporal resolution over 3 or more decades, hundreds of variables available; model resolution and biases have steadily improved
- Reanalyses incorporate millions of observations into a stable data assimilation system that would be nearly impossible for an individual to collect, analyze separately, enabling a number of climate processes to be studied
- Reanalysis data sets are relatively straightforward to handle from a processing standpoint (although file sizes can be very large)

KEY LIMITATIONS:

- Reanalysis data sets should not be equated with "observations" or "reality"

ATMOSPHERIC REANALYSIS: OVERVIEW & COMPARISON TABLES

Summary Expert Guidance Data Access References

Main variables:
Atmosphere
Data set collections
Diagnostic Data Sets
NCAR/UCAR/CSH | reanalysis | overview | summary page
Type of data product
Atmospheric Reanalysis

ABOUT THE EXPERTS

pages with Expert Guidance by Dr. Dick Dee at ECMWF

Atmospheric Reanalysis Overview & Comparison Tables

ERA-Interim

pages with Expert Guidance by