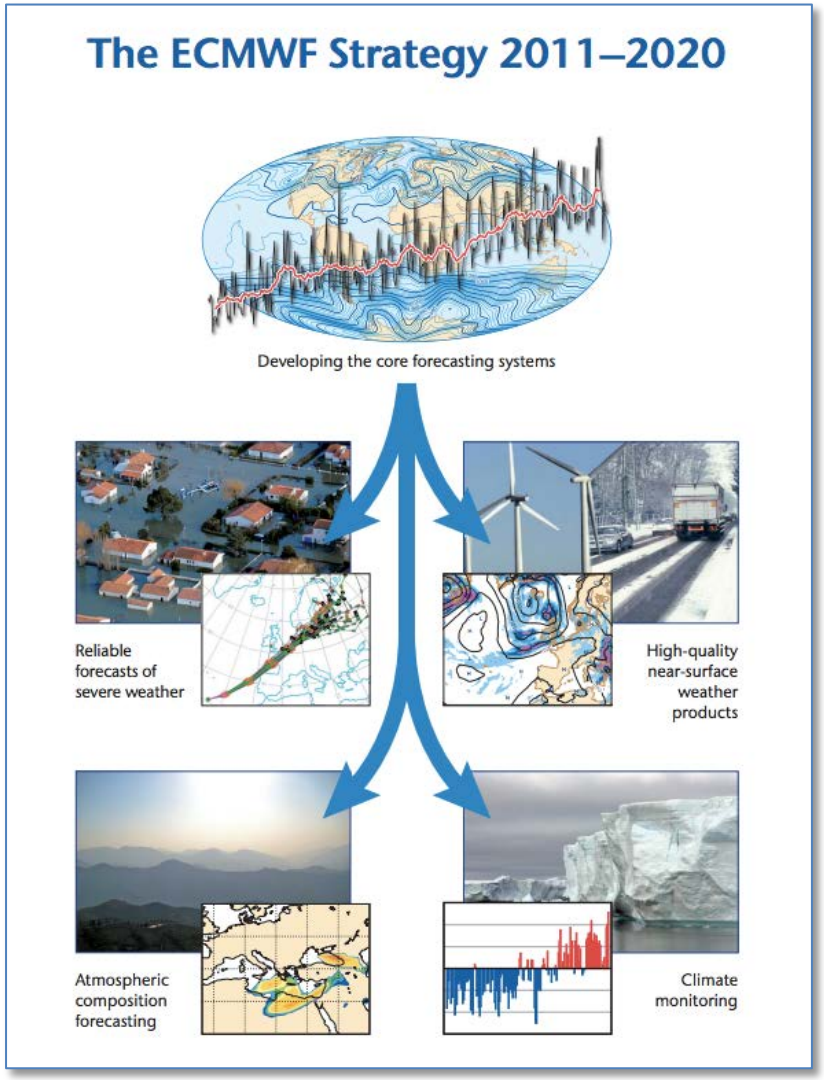
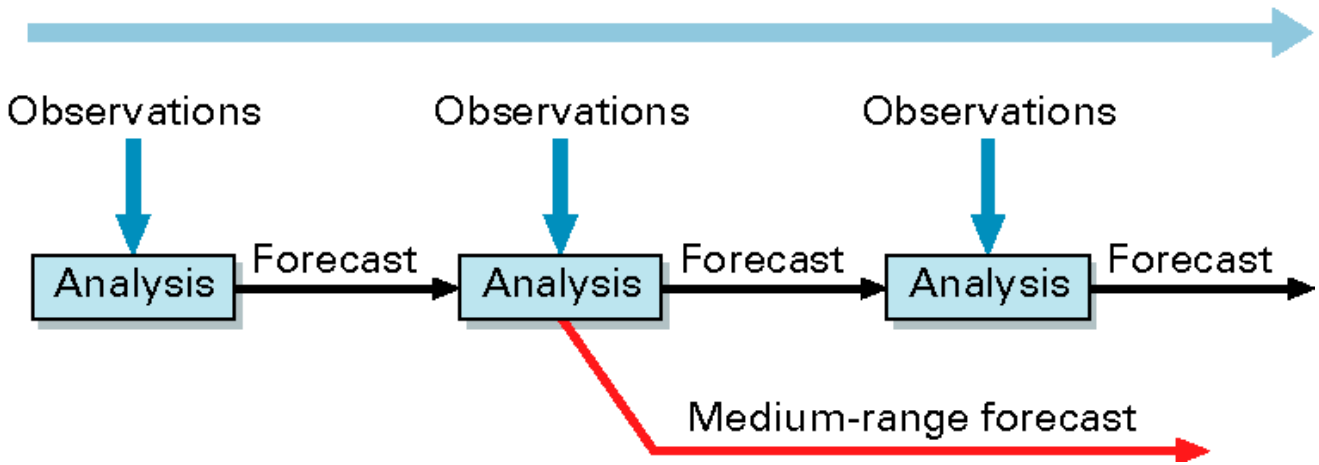
ECMWF Atmospheric Reanalysis (ERA) products

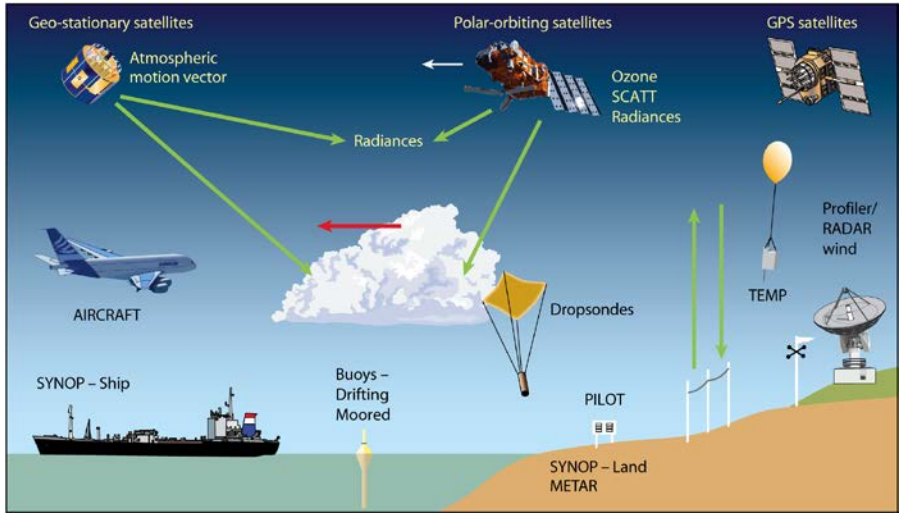


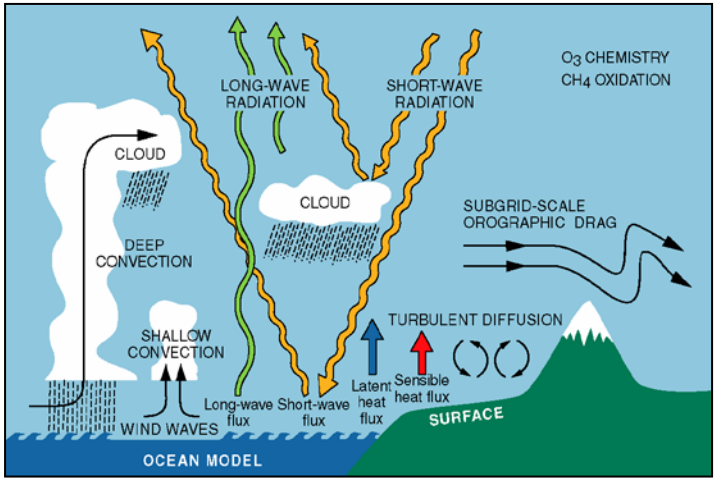
"From research datasets and observational feedback to societal services"

David Tan for Dick Dee and the Reanalysis Section

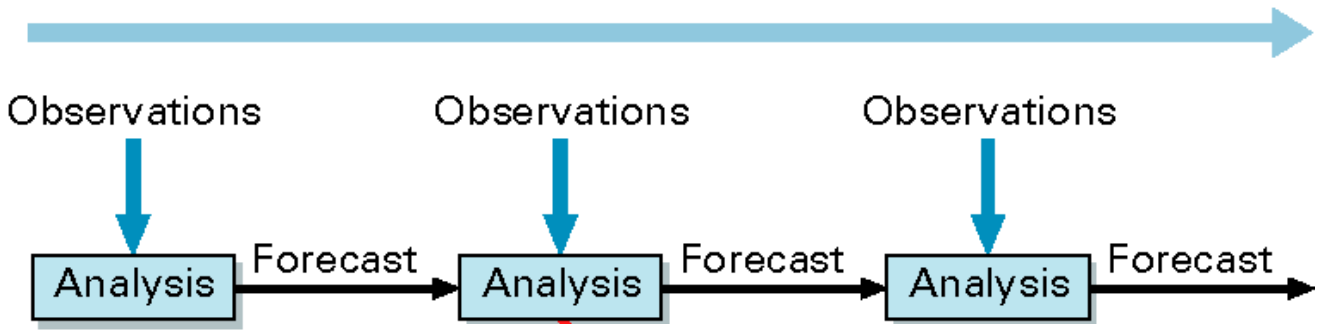
Weather forecasting: Data assimilation in real time

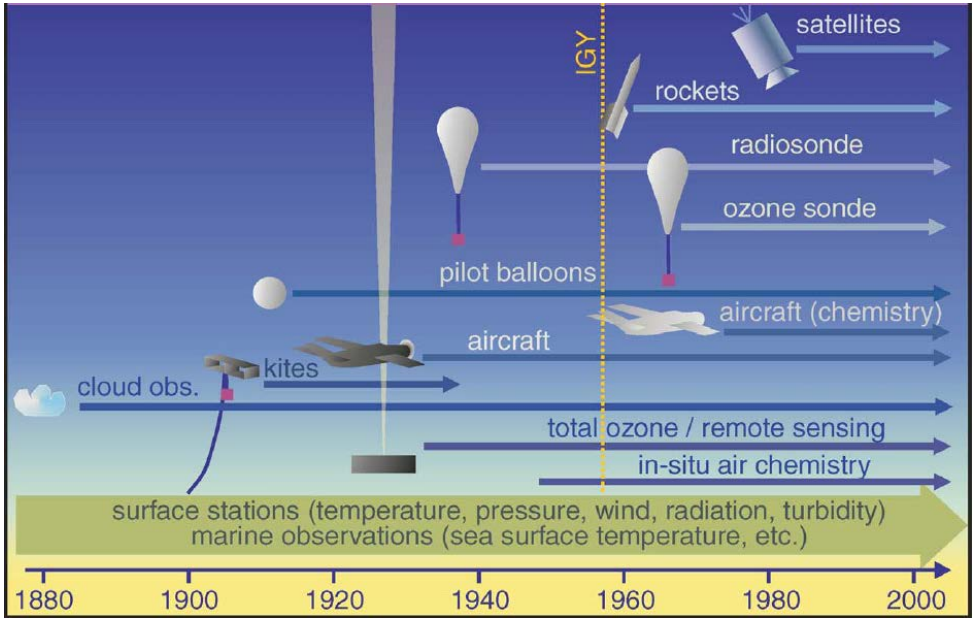






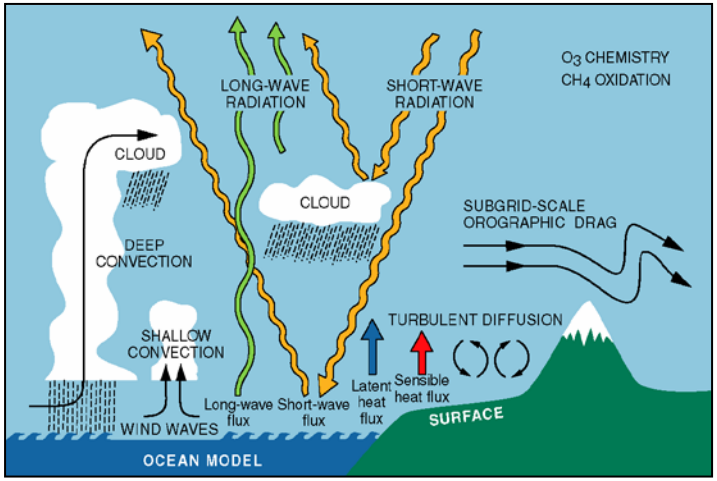
Reanalysis: Data assimilation in past time



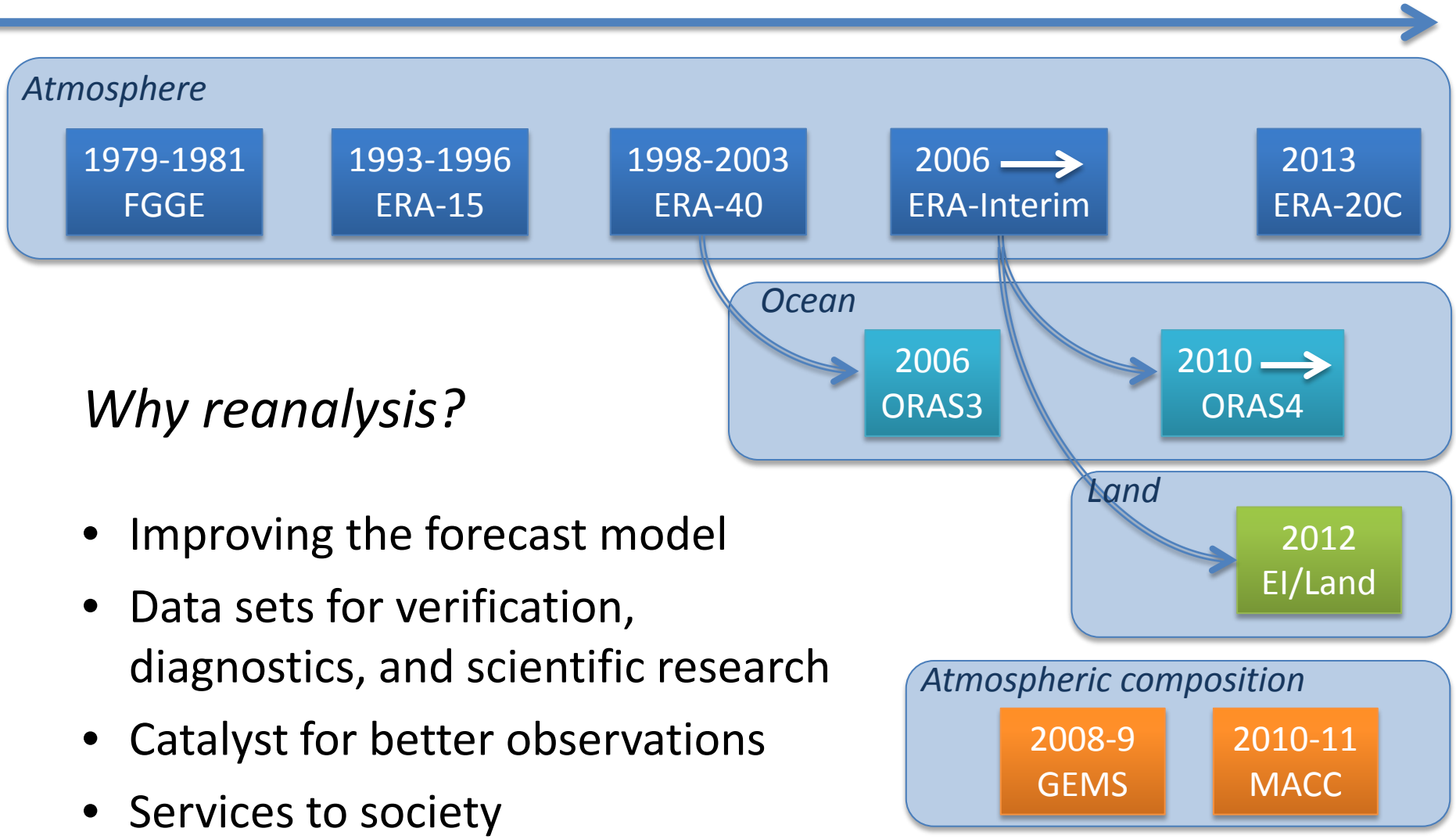


Same physics but forcings can change, e.g. SST, GHG

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



Global reanalyses produced at ECMWF



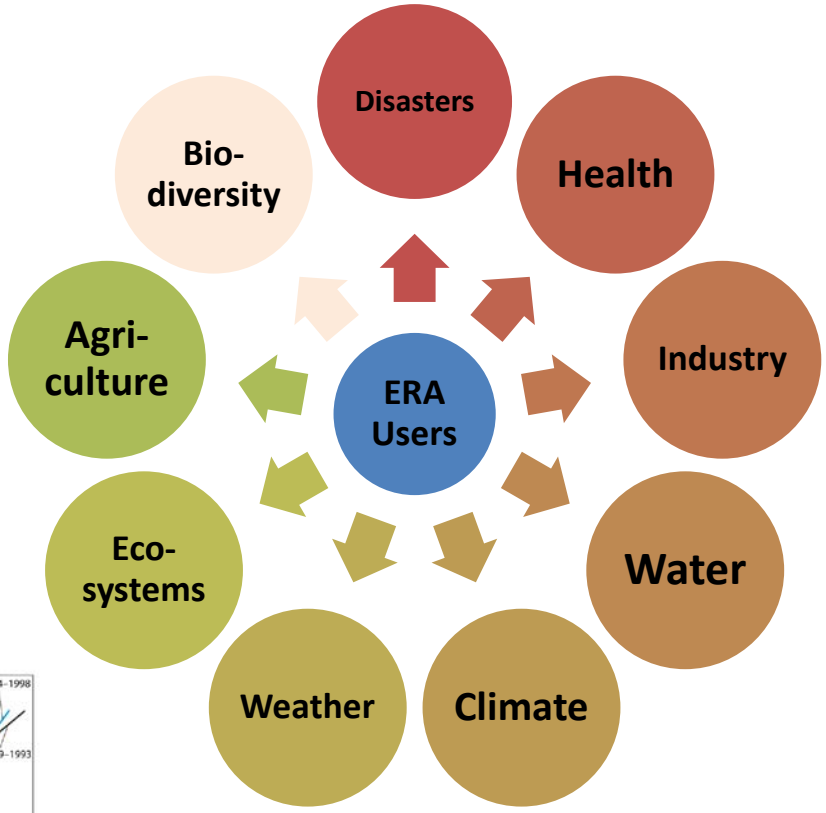
Why reanalysis?

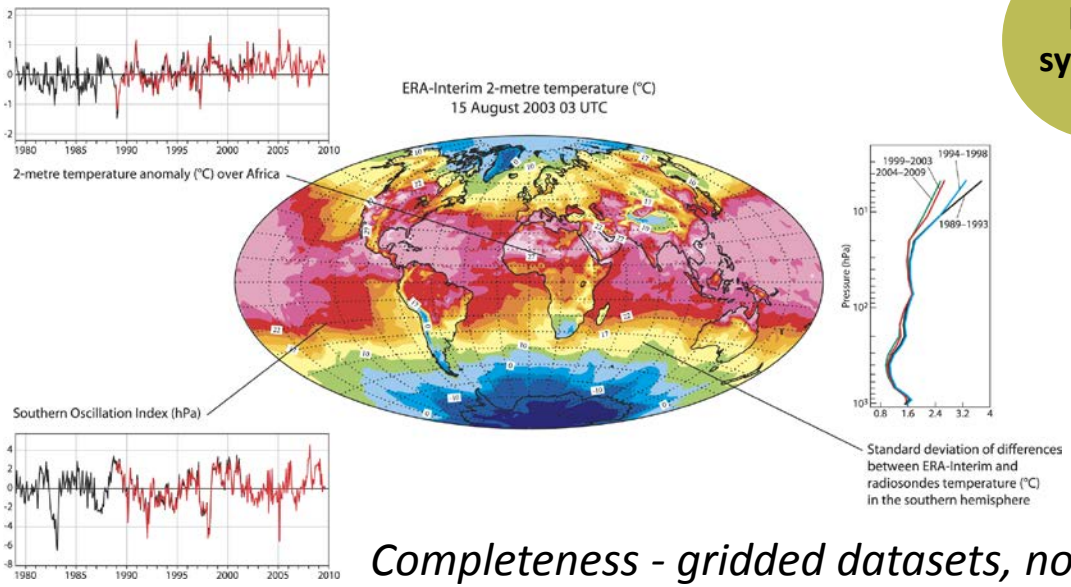
- Improving the forecast model
- Data sets for verification, diagnostics, and scientific research
- Catalyst for better observations
- Services to society

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)

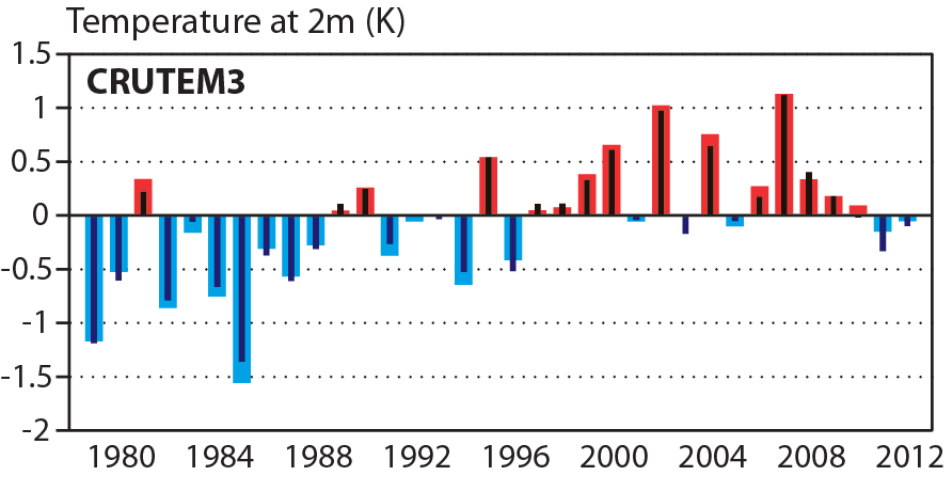


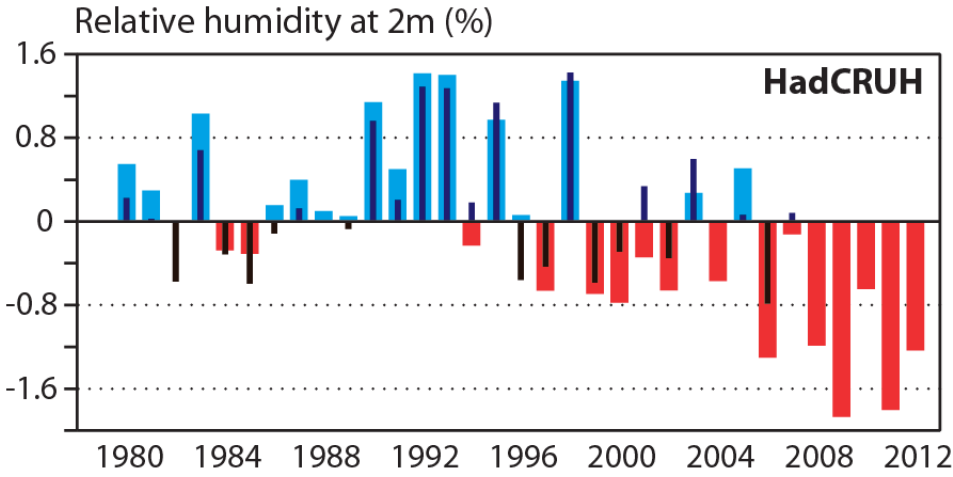


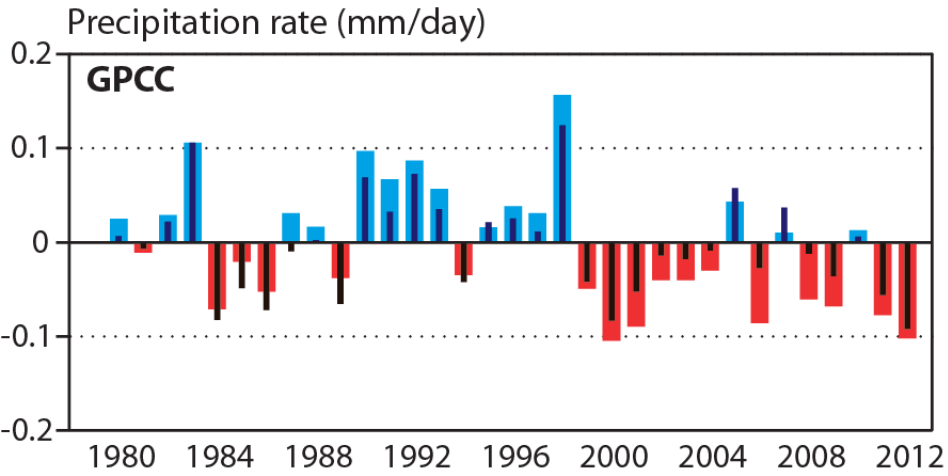
Completeness - gridded datasets, no gaps in space/time, multi-parameter
Consistency – to the extent imparted by assimilation method

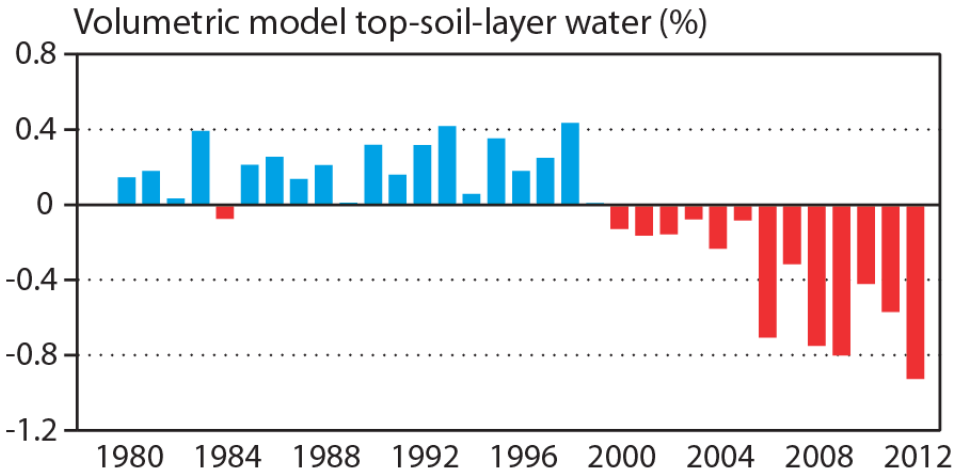
Reanalysis for climate monitoring

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









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

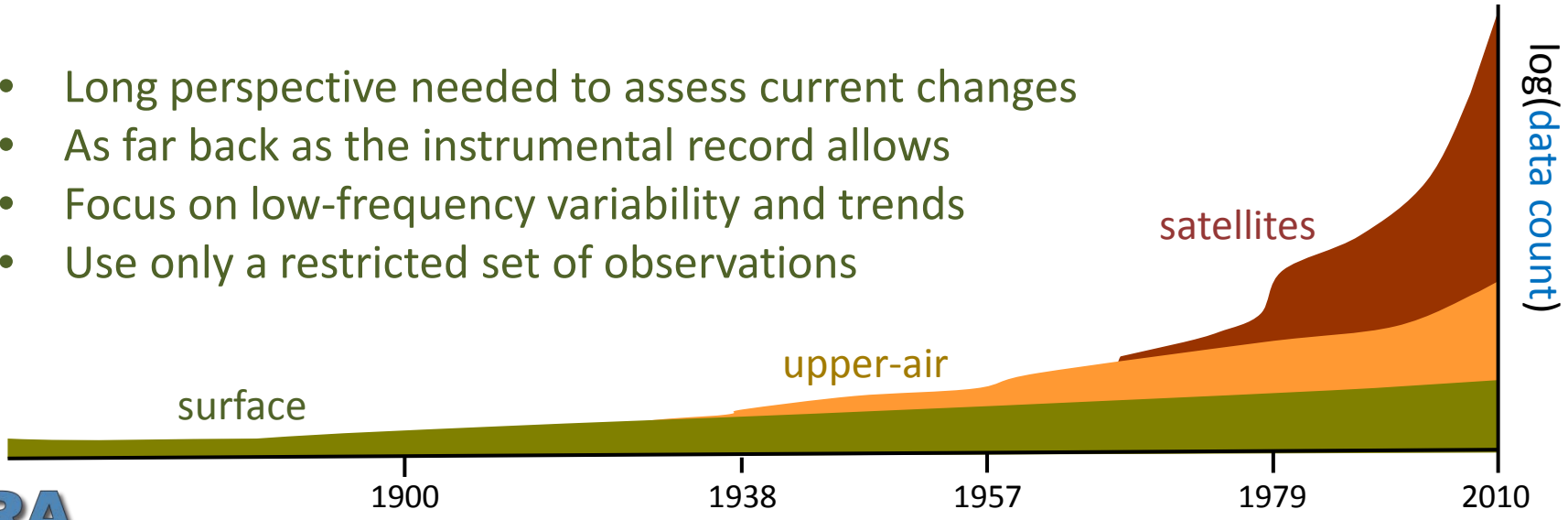
Climate reanalysis: Two types of products

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):

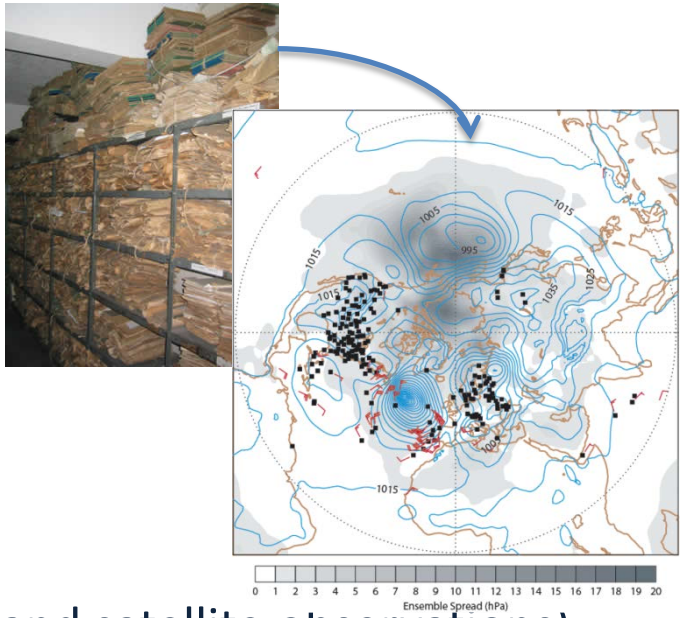
- Long perspective needed to assess current changes
- As far back as the instrumental record allows
- Focus on low-frequency variability and trends
- Use only a restricted set of observations



The ERA-CLIM project

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

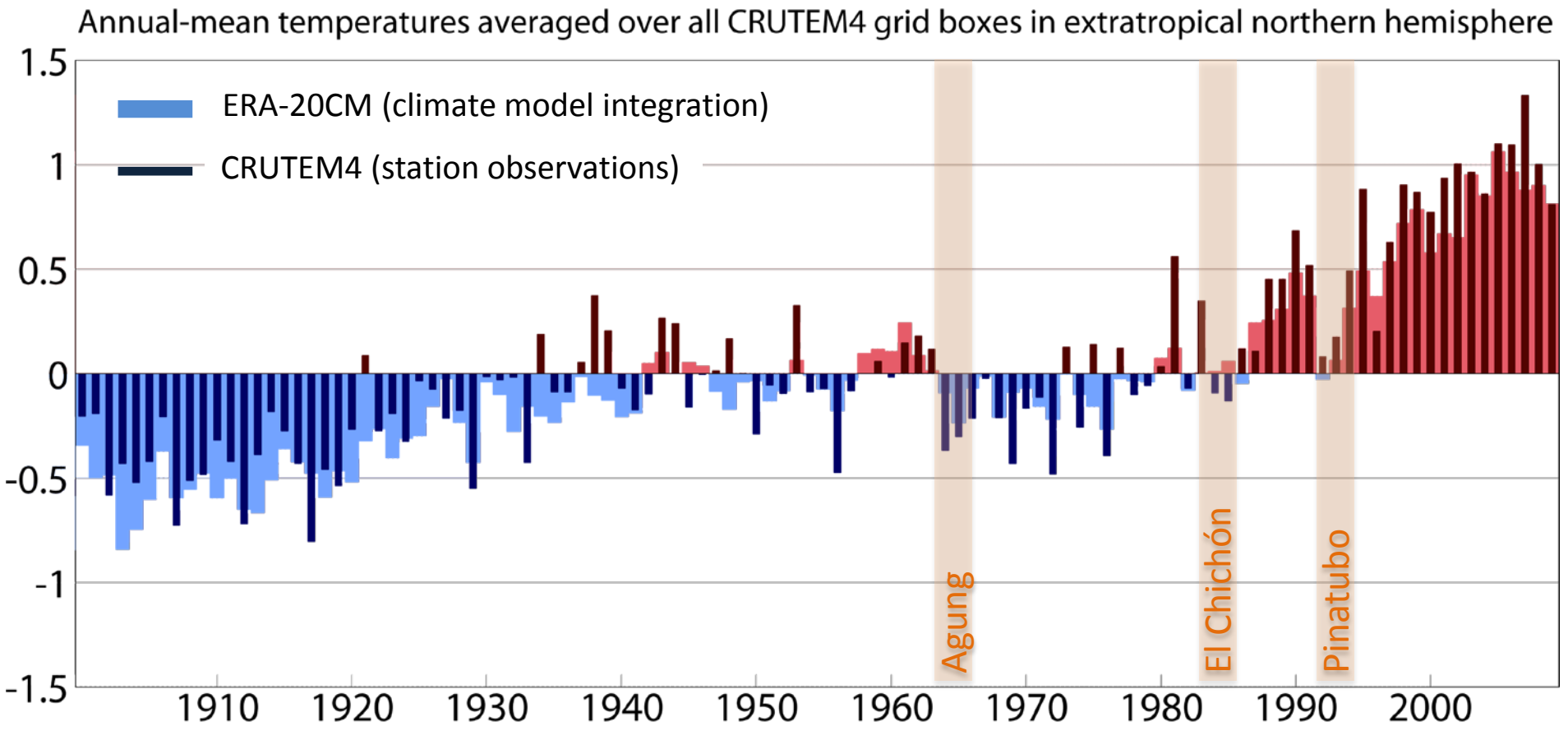
Goal: Preparing input observations, model data, and data assimilation systems for a global atmospheric reanalysis of the 20th century



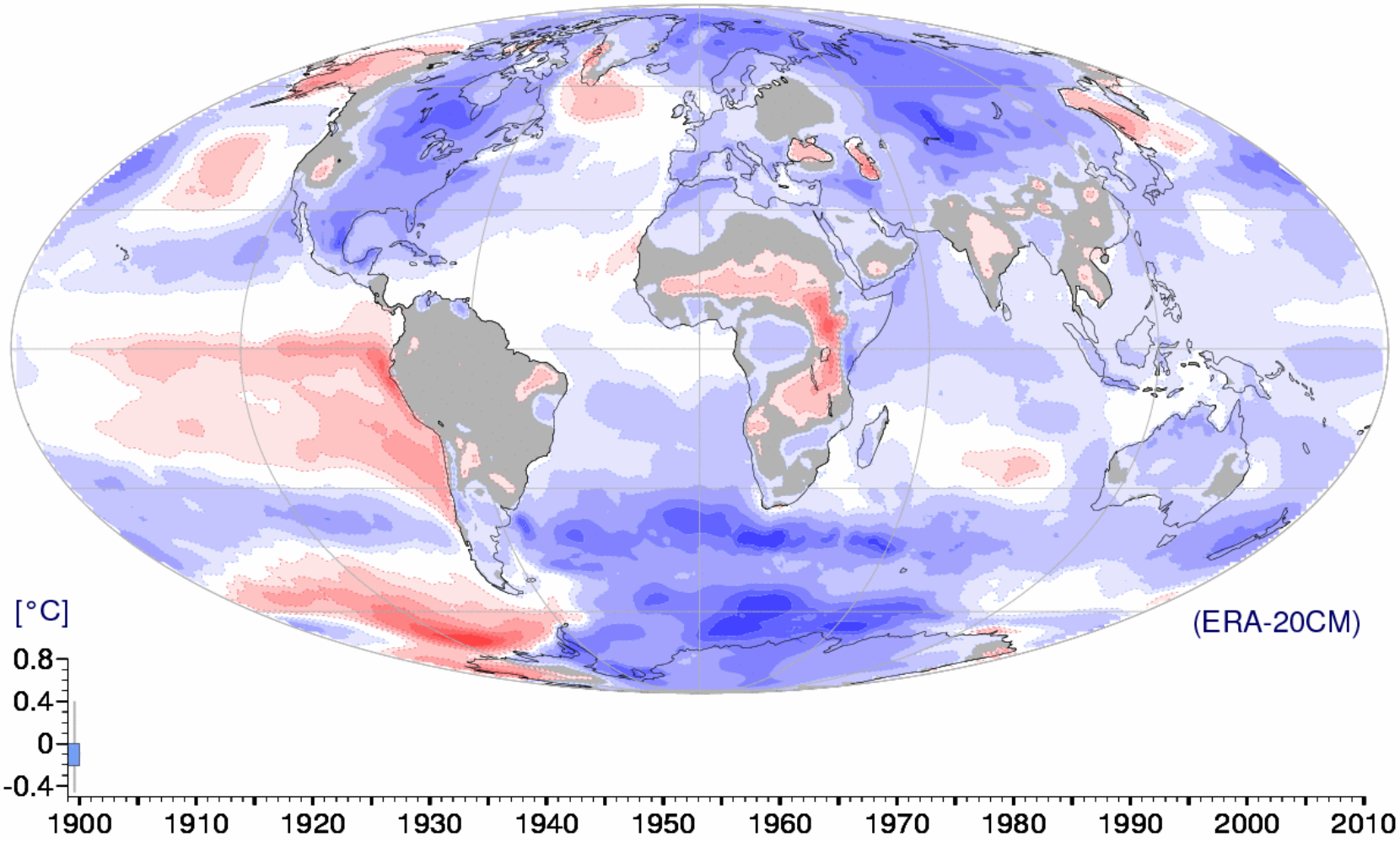
Main components:

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

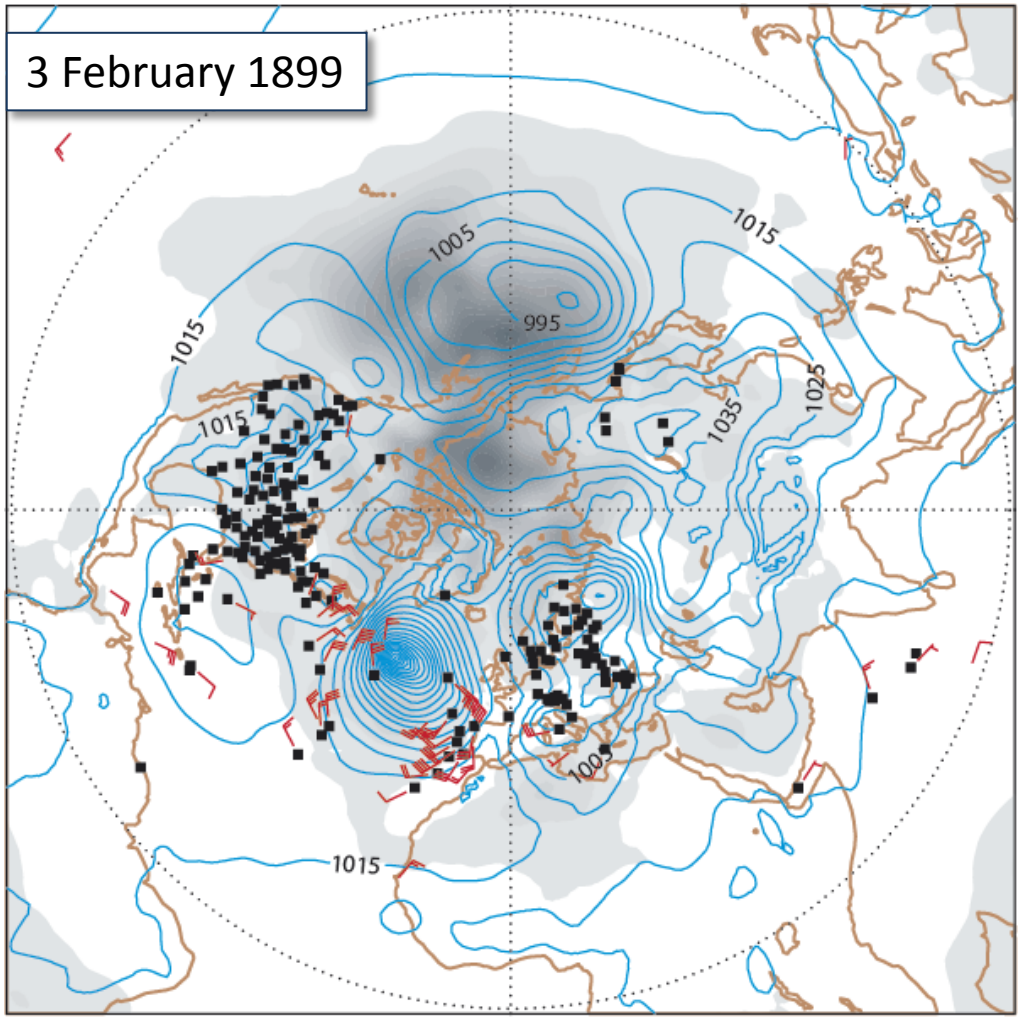
ERA-20CM: Climate model integration



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.

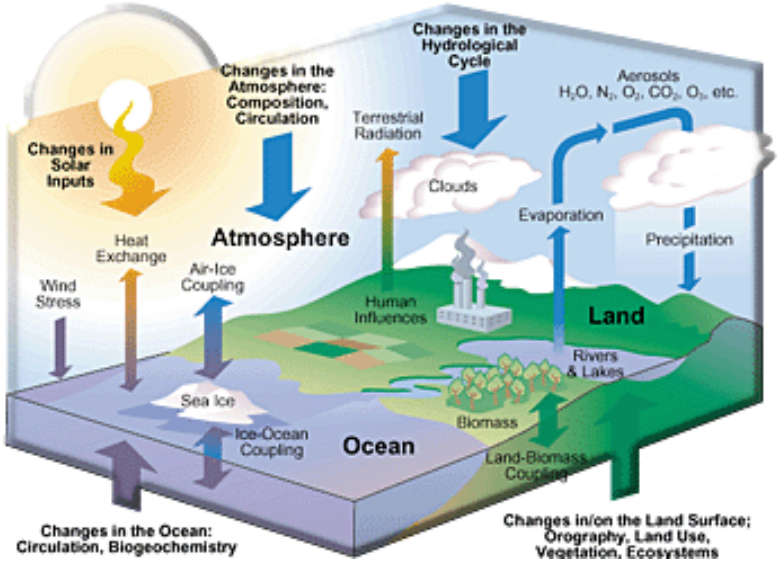
All the steamers that came in yesterday were coated with ice from the tops of the masts down to the water line, and all had passed through storms of blinding snow and mountainous waves. The British steamer Ethelgonda, from Bristol and Swansea, which left the latter port on Jan. 19, ran into a gale of 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 snowstorm 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

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

Planned reanalysis productions	2012	2013	2014	2015	2016	2017
ERA-Interim ERA-Interim/Land						
ERA-20CM ERA-20C ERA-20C/Land						
ERA-SAT ERA-SAT/Land						
CERA-20C CERA-20C/Carbon						
CERA-SAT CERA-SAT/Land						

Extended climate reanalysis

ERA-Interim replacement

Coupled with ocean

Reanalysis information products

ECMWF's data policy:

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

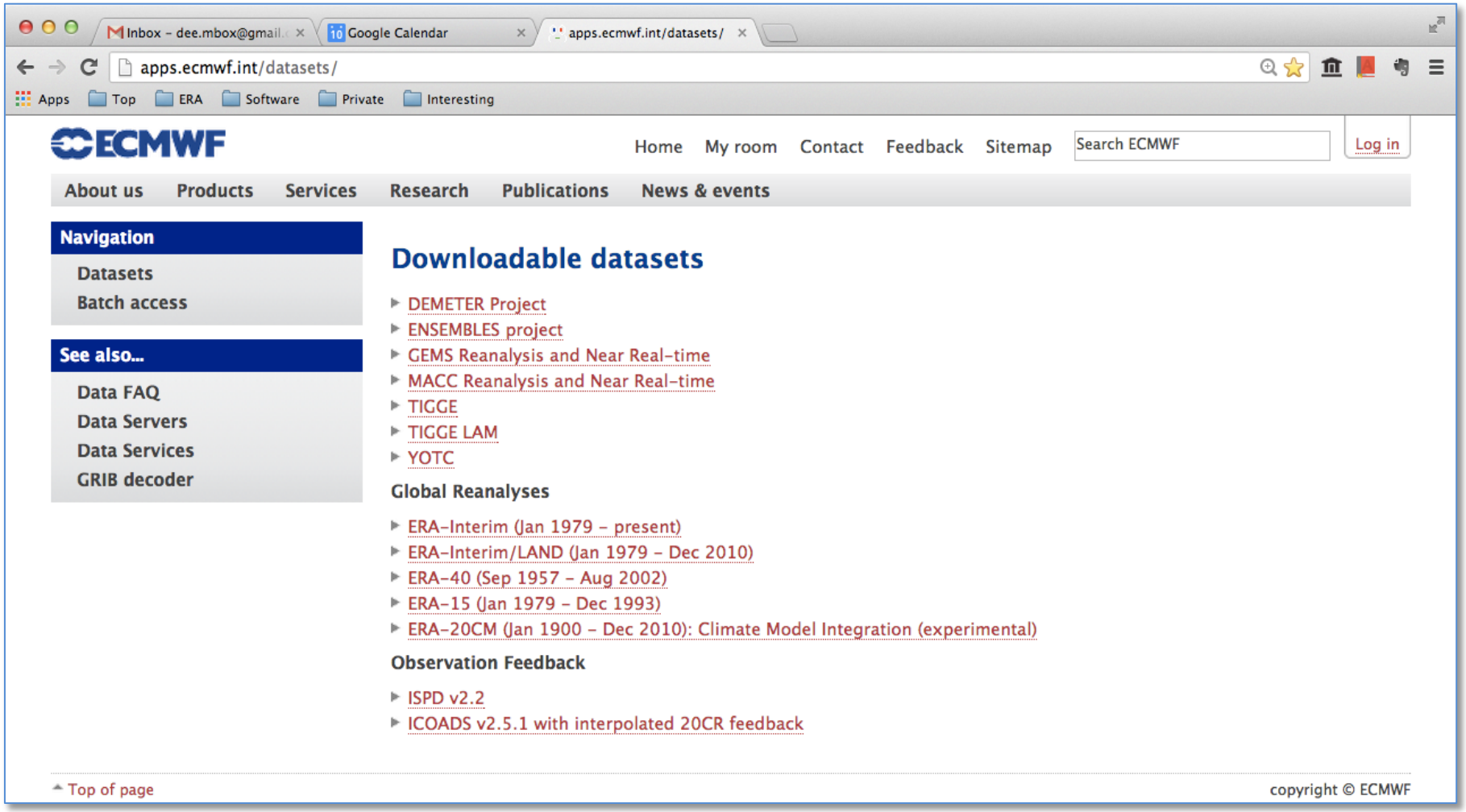
ERA Data Servers:

- 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/**

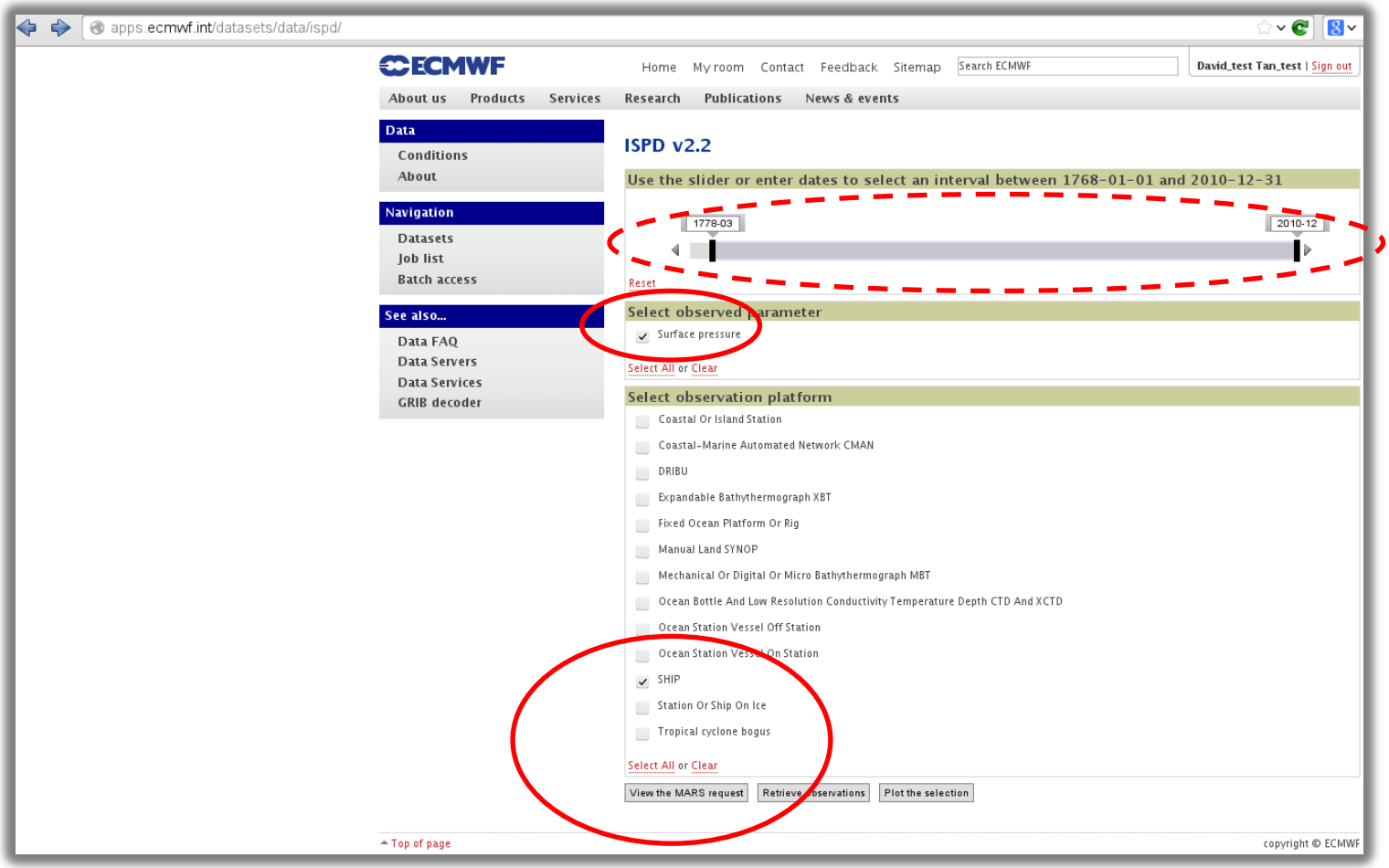
Climate Monitoring Facility:

- 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

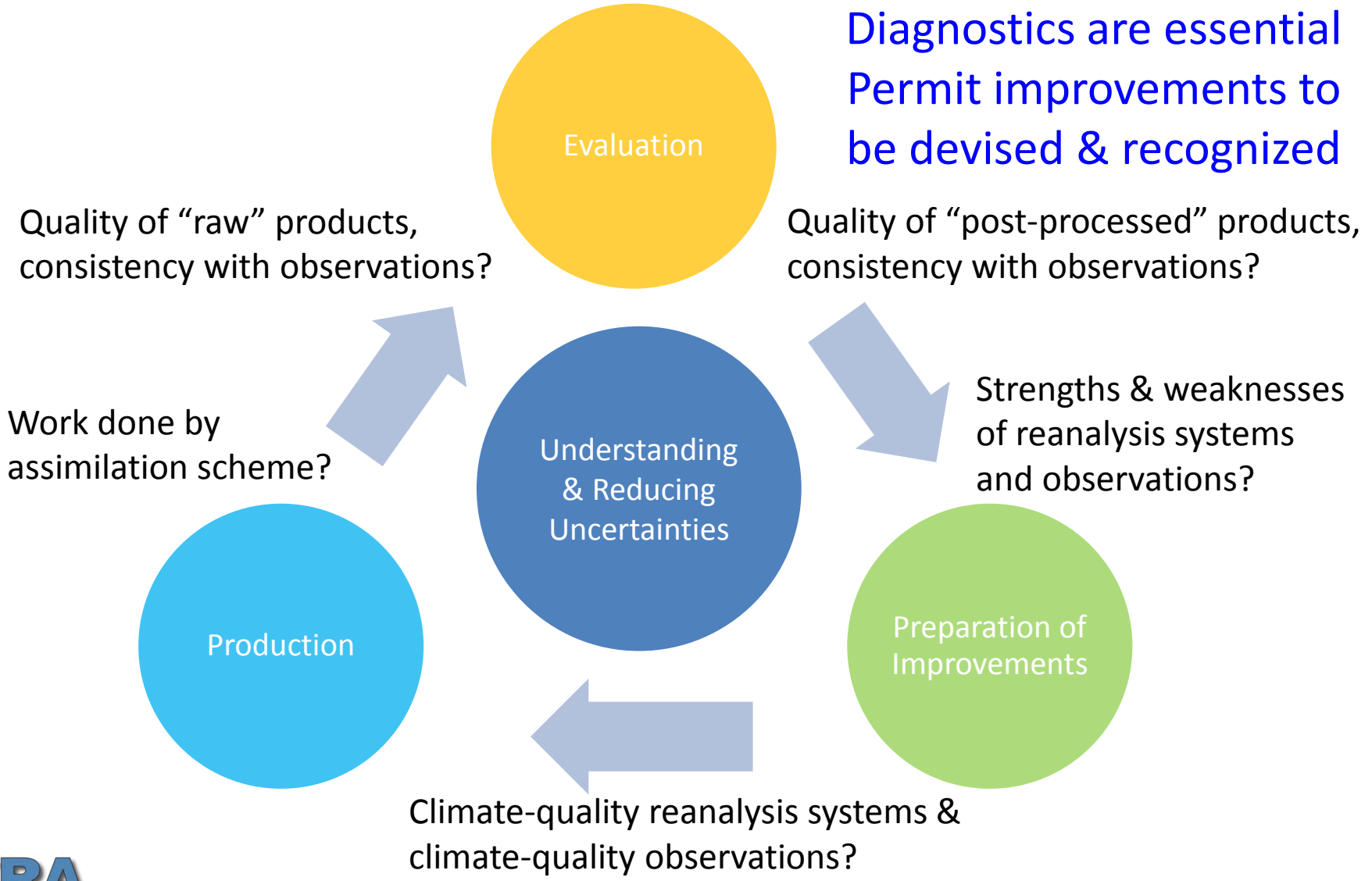
http://apps.ecmwf.int/datasets/



Observation Feedback from apps.ecmwf.int/datasets



Iterative progress: the reanalysis life-cycle

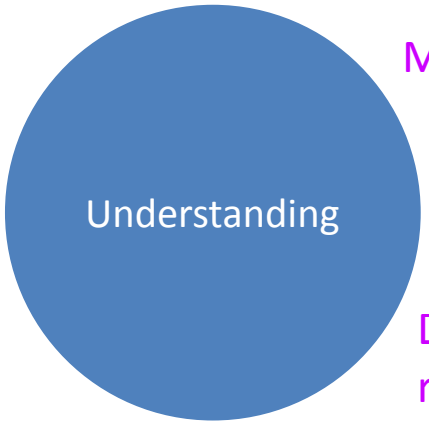


Diagnostics for Quality, Uncertainty & Confidence

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

Monthly means
Trends & anomalies
Budgets, e.g. energy/water cycles
Ensemble statistics
Downstream data, e.g. hydrology, renewable energy, agriculture, health

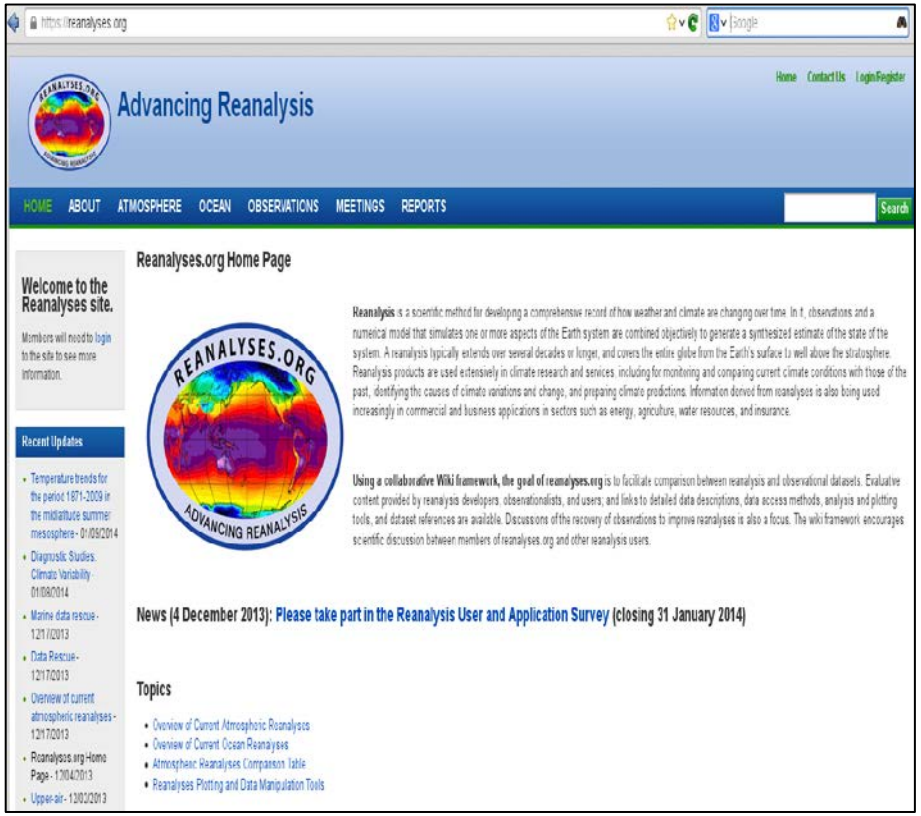
Work done by assimilation scheme?

Climate-quality reanalysis systems & climate-quality observations?

Strengths & weaknesses of reanalysis systems and observations?
Intercomparison projects, e.g. S-RIP

Reanalysis resources on the Web

reanalysis.org



UCAR/NCAR Climate Data Guide