

Reanalysis Needs for Reference Data



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Reanalysis Section

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Key points

- **Reference-quality observational data are essential for many aspects of reanalysis**
- **Useful for validation and/or assimilation, but also via their contribution to improving satellite-based products**
- **Priority 1 and 2 ECVs all highly relevant**
- **Look forward to jointly making progress via WG-ARO & GRUAN**

Outline

- **Current reanalysis activities**
- **ESA's Climate Change Initiative**
- **Recap, outlook, ways to work together**

Stating the obvious

- There's no such thing as the perfect dataset – applies to observations, models and reanalyses
- Caution should be applied when using any dataset
- Especially true when examining trends in reanalyses
- At any point in time, we can improve on what we've got – via better instruments and/or reprocessing

Outline

- **Current reanalysis activities**

- Expanding the ERA-Interim reanalysis



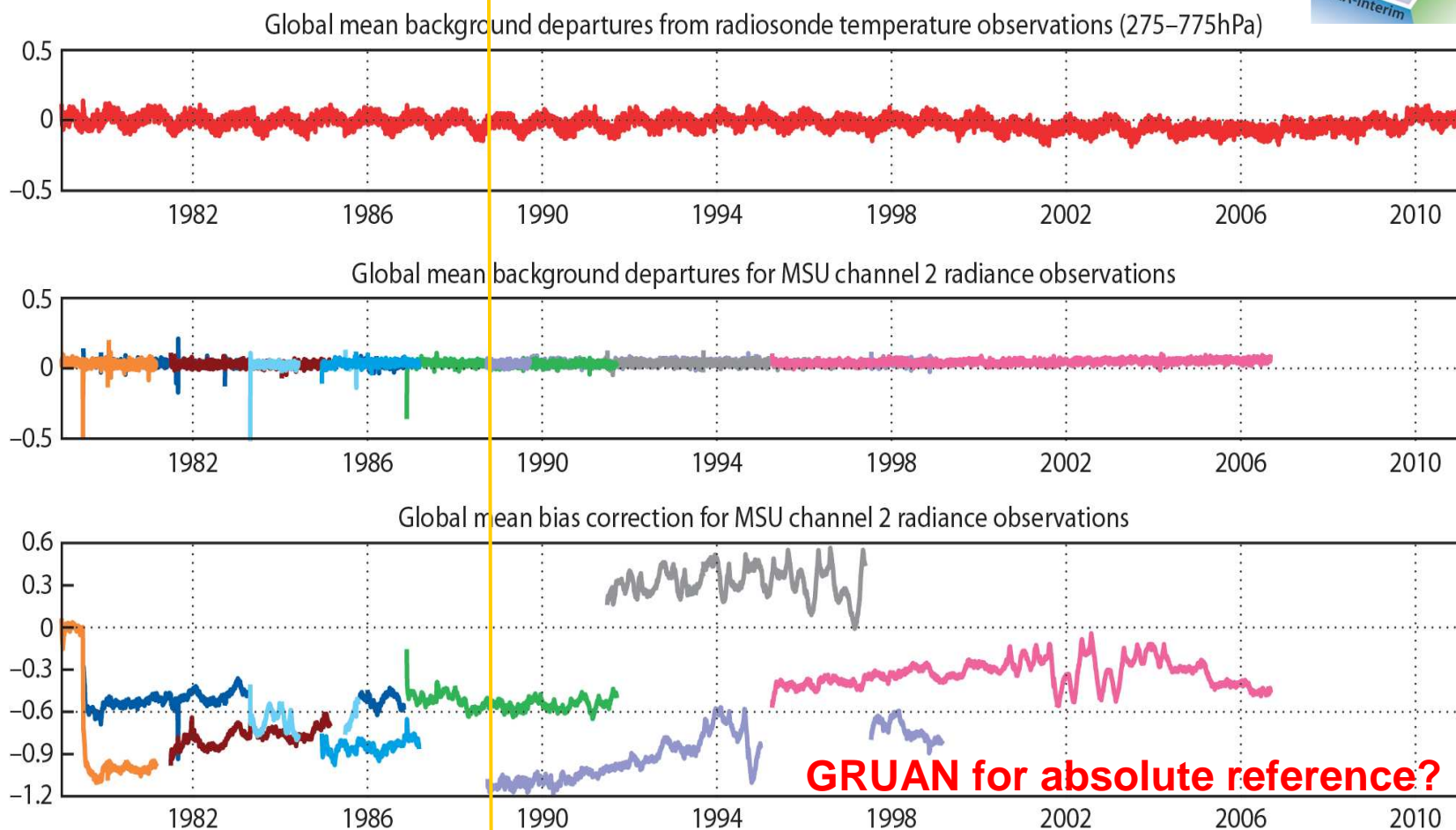
- Developing the ERA-CLIM reanalyses
- MACC-II for atmospheric composition – operational + reanalysis
- Ocean reanalyses



- **ESA's Climate Change Initiative**

- **Recap, outlook, ways to work together**

Expanding the ERA-Interim reanalysis



Back-extension

Services: access, diagnostics, ...

ERA-Interim full-resolution data server



ERA Interim, Daily Fields

http://data-portal.ecmwf.int/data/d/interim_full_daily/

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About Us Overview Getting here Committees Products Forecasts Order Data Order Software Services Computing Archive PreplFS Research Modelling Reanalysis Seasonal Publications Newsletters Manuals Library News&Events Calendar Employment Open Tenders

ERA Interim, Daily Fields >

ERA Interim, Daily Fields

Note: In order to retrieve data from this server, you first have to accept the [conditions of use](#).

Type of level
Model levels
Potential temperature
Potential vorticity
Pressure levels
Surface

Personal
Your Requests

Data usage
Conditions

See also...
Data FAQ
Data Servers
Data Services
GRIB decoder

Select date
Select a date range between
Start date: 1979-01-01
Select a list of month:

	Jan	Feb	Mar	Apr	May	Jun	Jul
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2011	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Select All or Clear

Select Time
☐ 00:00:00 ☐ 06:00:00
Select All or Clear

Select parameter
☐ 10 metre U wind component
☐ 10 metre surface wind

ECMWF Data Frequently Asked Questions
Most Frequently Asked Questions

1. How can I obtain ECMWF data?
2. What is MARS?
3. What is the format of the data?
4. What is the resolution of the data?
5. Can I get the data for a specific location?
6. What is the time range of the data?
7. What is the time resolution of the data?
8. What is the time resolution of the data?
9. How can I get the data for a specific location?
10. Where can I find the data?

Grid for retrieval1

Default (as archived) Custom... 0.75x0.75

ERA Project

27. Where can I find general documentation of ERA Reanalysis data?
28. What is the resolution of ERA data?
29. Where can I find documentation on the scientific aspects of ERA data?
30. What are the 'steps' for the surface daily fields in ERA-Interim?
31. What is the best forecast period to use for accumulating fields in ERA-Interim?
32. What observations were assimilated in ERA-Interim?
33. In ERA-Interim, how can I get the monthly means of the daily means of accumulated fields (e.g., precipitation)?
34. What is the accumulation period in ERA-40?
35. What observations were assimilated in ERA-40?
36. Which satellites are used in assimilation for ERA-40?

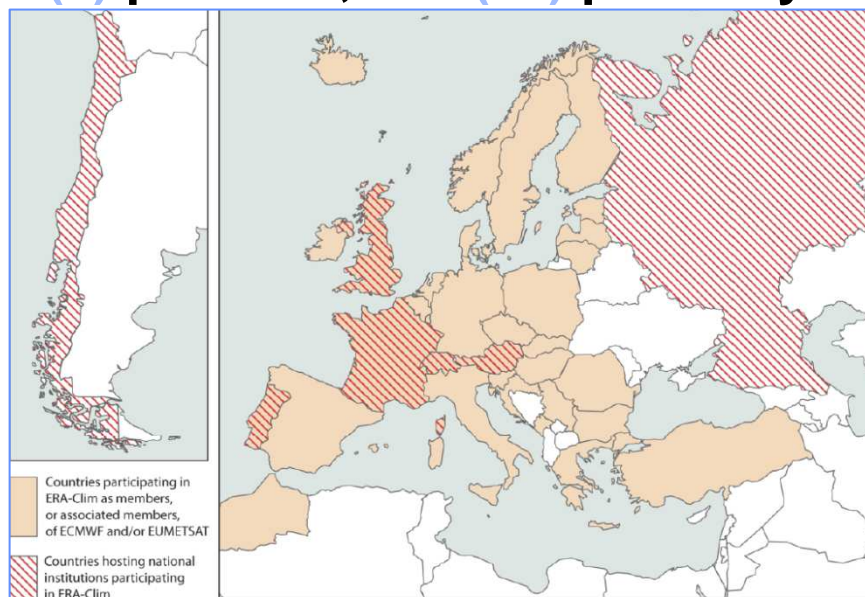
If you experience any difficulties, please check our [data FAQ](#) first



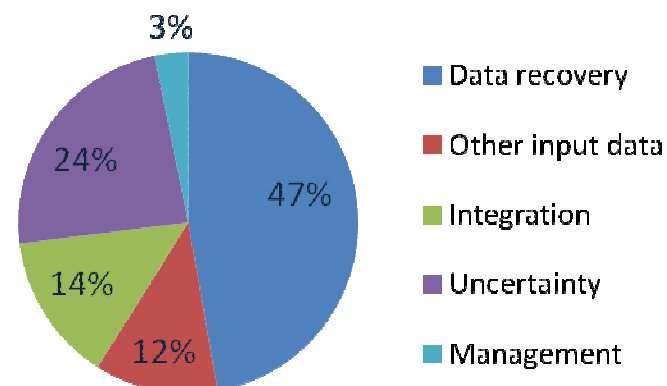
Newsletter 129
Autumn 2011

The ERA-CLIM Project

- ERA-CLIM: European Reanalysis of Global Climate Observations
- 3-year collaborative research project, start date 01/01/2011
- Funded by EU research FP7, Environment theme
- Total cost €4.9M; EC contribution €3.5M
- 8(9) partners, 47.5(59) person-years, 50 deliverables



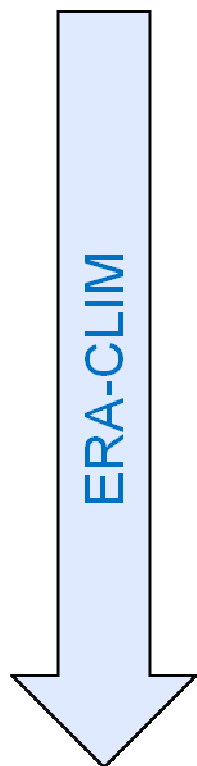
Work packages:



ERA-CLIM Deliverables

Objectives	Key deliverables	
Development of the observational record for the early 20 th century	Inventories; database for metadata, web-based digitising tools	WP1
	Digitized, quality-controlled instrumental records for the early 20 th century	
	Access to observations and metadata via international data centres	
Preparation of reprocessed satellite observations, boundary conditions, and forcing data	Reprocessed satellite data sets for input to reanalysis; early satellite records	WP2
	Ensemble of consistent sea-surface boundary conditions for the 20 th -century	
	Atmospheric forcing data (solar, aerosols, GHG, land surface...) for ERA-20C	
Development of an Observation Feedback Archive (OFA)	Database facility for input observations with quality feedback from reanalyses	WP3
Production of pilot reanalyses and data quality information	A series of long test reanalyses at various resolutions to prepare for ERA-20C	
	All reanalysis products and input observations available via web services	
Assessment and reduction of data uncertainties	Homogenized in-situ data and bias correction techniques	WP4
	Improved ocean observations for reanalysis	
	Tools for quality assessment of reanalysis products	

ERA-CLIM pilot reanalyses



	What	Period	Resolution	Ens	When	Vol
ERA-Int	Interim reanalysis	1989-NRT	T255L60	1	ongoing	33 Tb
ERA-P0	AMIP ensemble	1900-2011	T159L91	10	Jun 2011 (9M)	
ERA-P1	EDA using sfc obs only	1900-2011	T159L91	10	Sep 2011 (15M)	655 Tb
ERA-S1	Land surface using ERA-P1	1900-2011	T799	1	Sep 2012 (9M)	77 Tb
ERA-P2	Reanalysis using all obs	2 early decades	T511L91	1	Sep 2012 (9M)	180 Tb
ERA-E2	As ERA-P2 but with SST/sea-ice perturbations	2 early decades	T159L91	10	Jan 2013 (9M)	180 Tb
ERA-P3	To replace ERA-Interim	1979-NRT	T511L91	1	Jan 2012 (24M+)	234 Tb
ERA-20C	20 th -century reanalysis	1900-NRT	T511L91	1	2014 (36M+)	1062 Tb

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- **ESA's Climate Change Initiative**

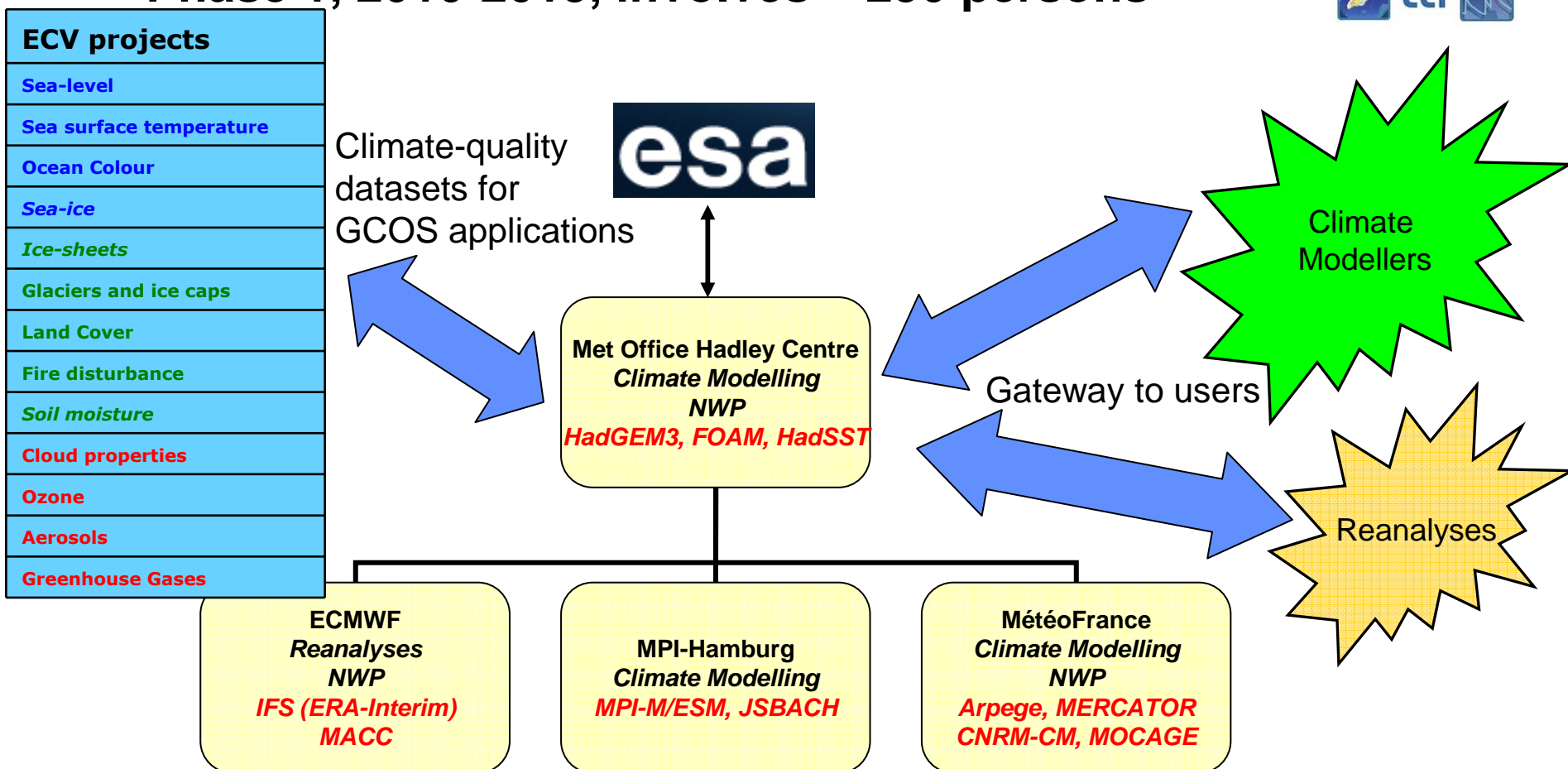


- Recap, outlook, ways to work together

ESA's CCI & Climate Modelling User Group



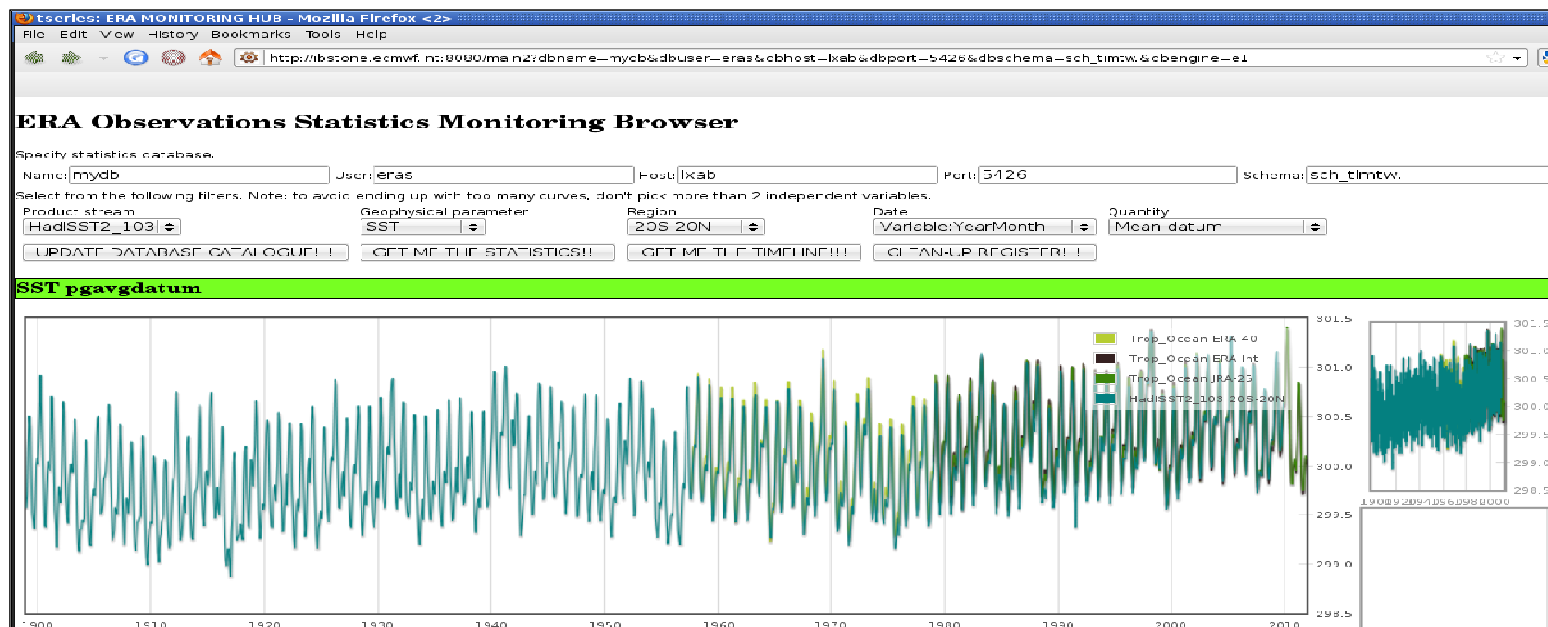
- 6 year program, 2010-2016, approx 75M Euros
- Phase 1, 2010-2013, involves ~ 250 persons



ECMWF within Climate Modelling User Group



- **Facilitate reanalysis usage** (ancillary input, comparison)
- **Our experience is contributing to product development:**
 - **Requirements, definitions, uncertainty characterization, consistency/homogeneity, validation – role for GRUAN!**
- **Building database system to evaluate L3 products**



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- ESA's Climate Change Initiative



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- Useful for validation and/or assimilation, but also via their contribution to improving satellite-based products
- Priority 1 and 2 ECVs all highly relevant
- Look forward to jointly making progress via WG-ARO & GRUAN
- Strengthen awareness and links between communities

Backup slides

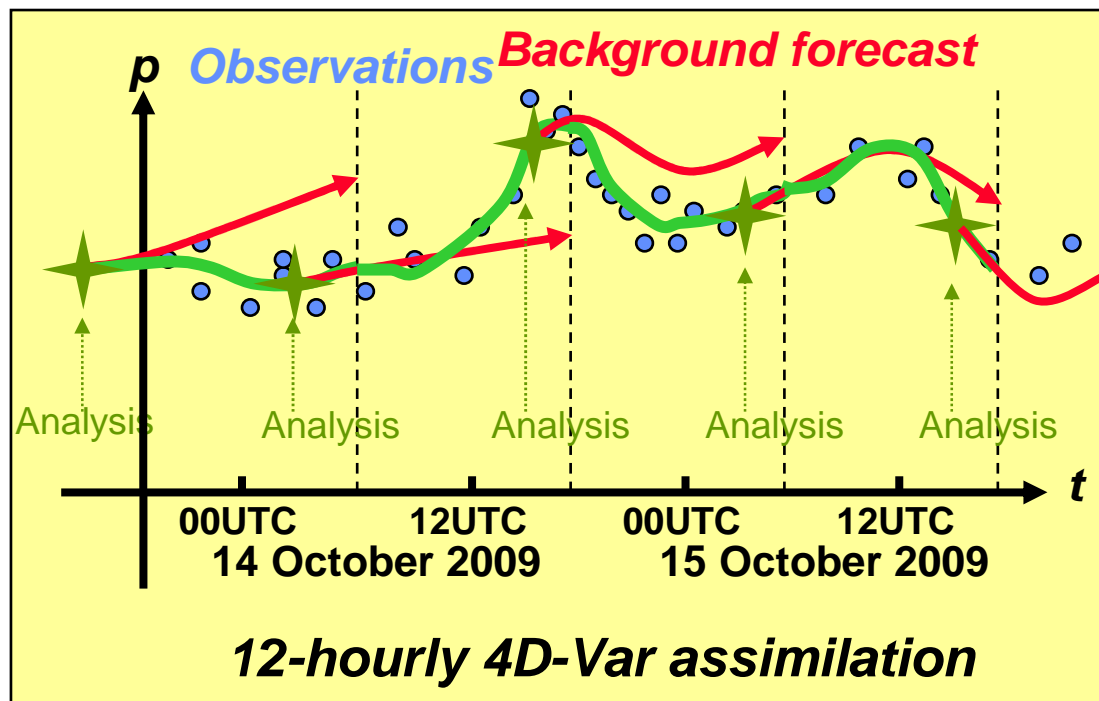
Brief Primer on Data Assimilation

- Combine information from

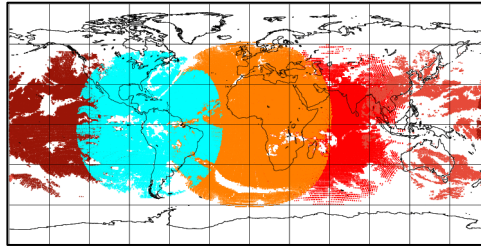
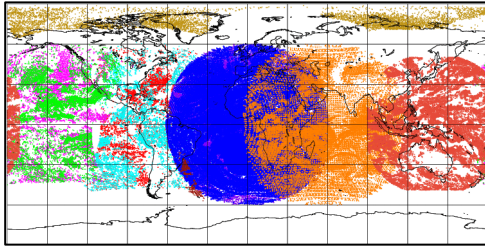
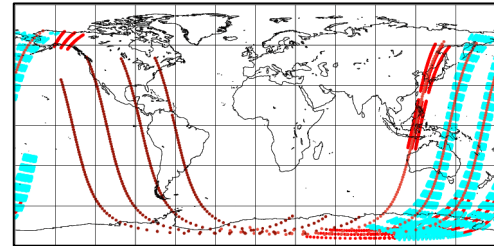
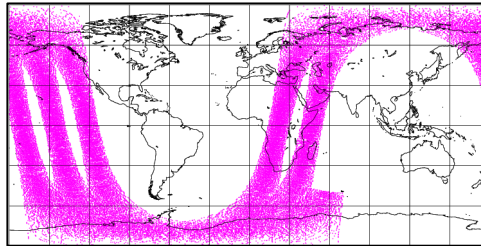
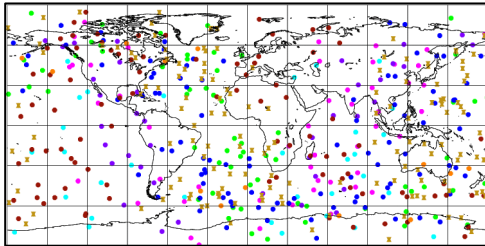
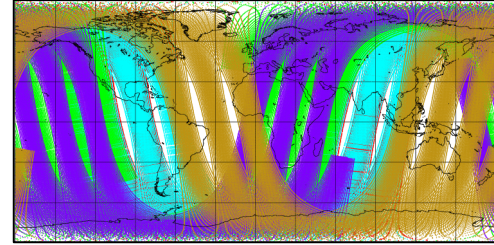
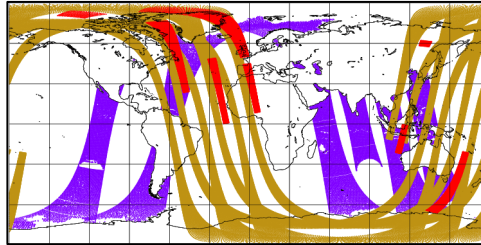
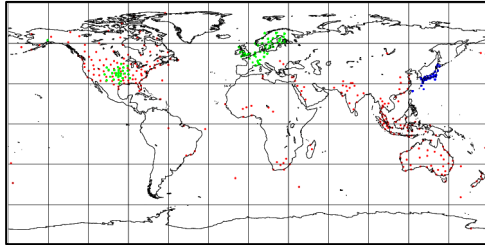
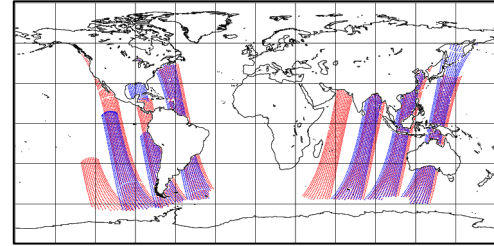
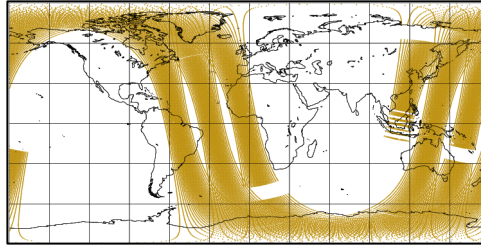
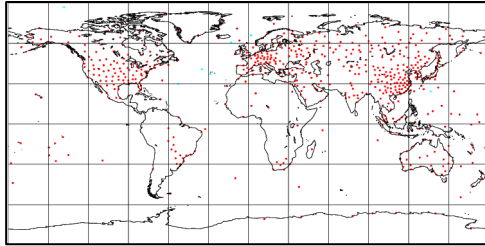
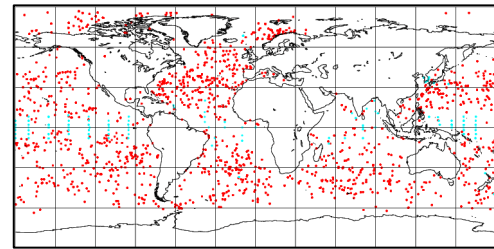
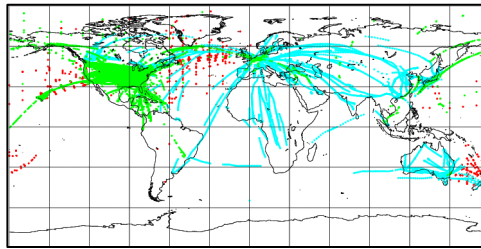
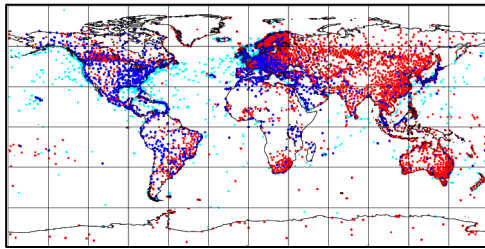
- Observations
- Background forecast (propagates the information extracted from prior observations)
- Error statistical models
- Relationships to build-in dynamical and physical consistency between various meteorological parameters

- To produce the “most probable” estimate of the atmospheric state

- And some estimate of uncertainty



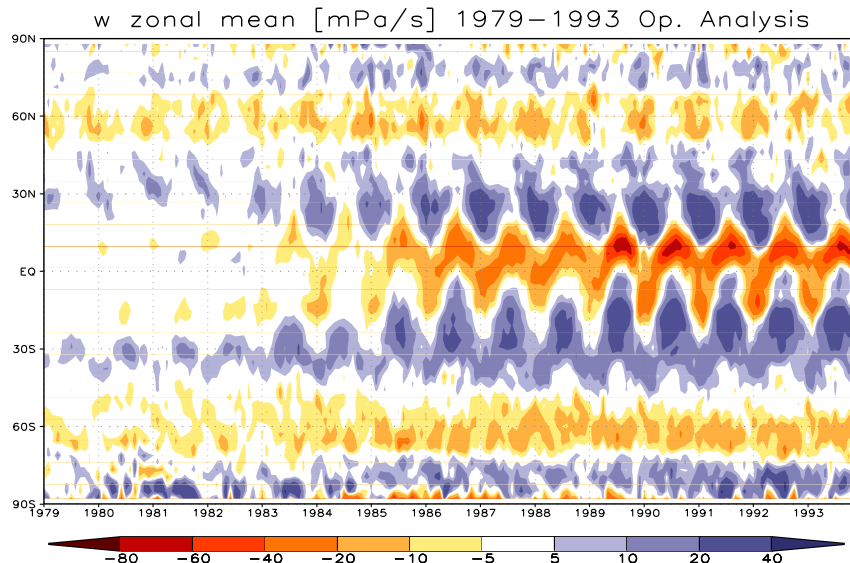
Data assimilation systems incorporate observations in an optimal way with a model to improve knowledge of the atmospheric state



Observation distributions
00UTC 6 February 2009 $\pm 3h$

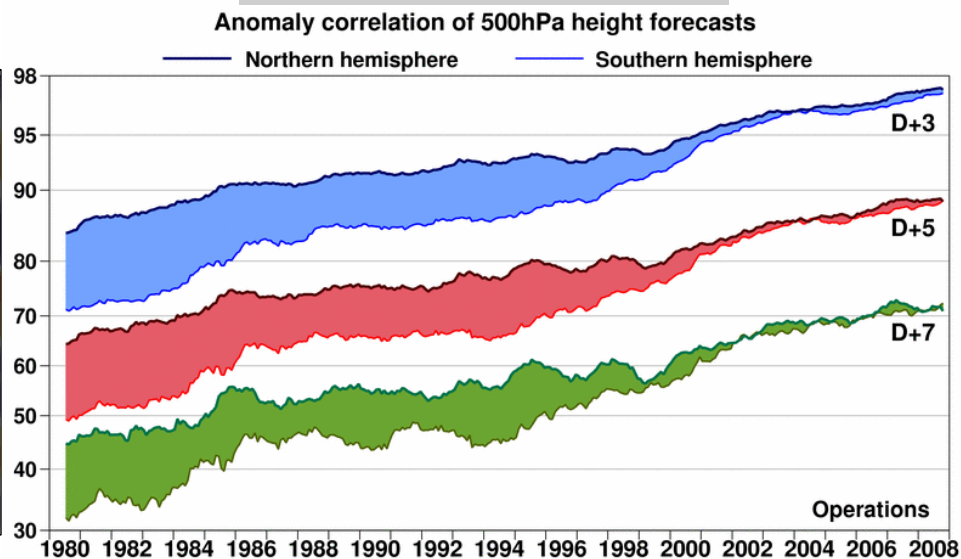
Why not use operational analysis products?

Zonal mean vertical velocity at 500 hPa



- ECMWF operational system
1979-1993

3 to 7-day Forecast skill



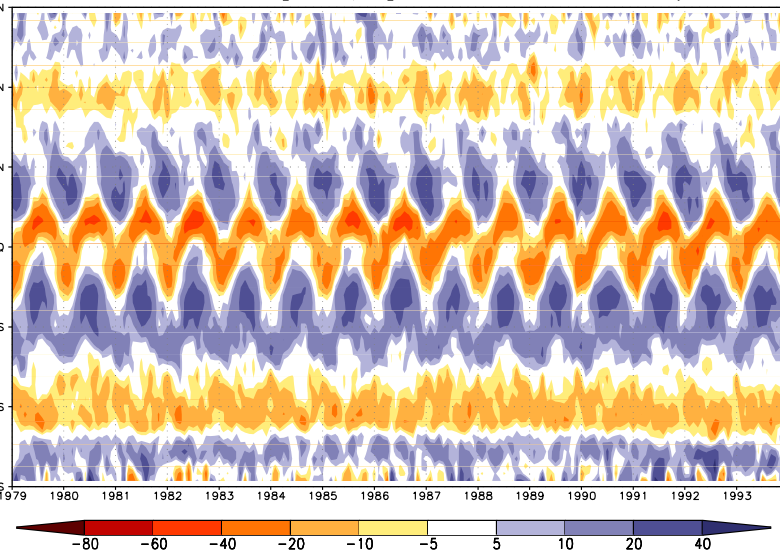
- ECMWF operational system
1979-2009

Quality of operational analysis products changes in time

ECMWF Reanalyses

Zonal mean vertical velocity at 500 hPa

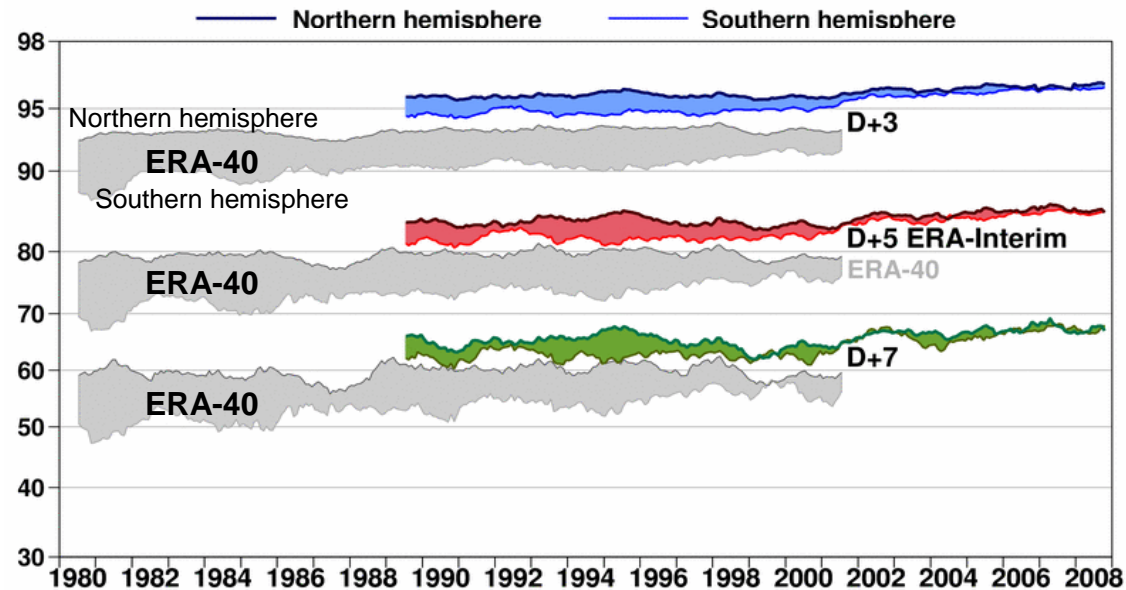
w zonal mean [mPa/s] 1979–1993 Reanalysis



- ERA-15 (1979-1994)

3 to 7-day Forecast skill

Anomaly correlation of 500hPa height forecasts

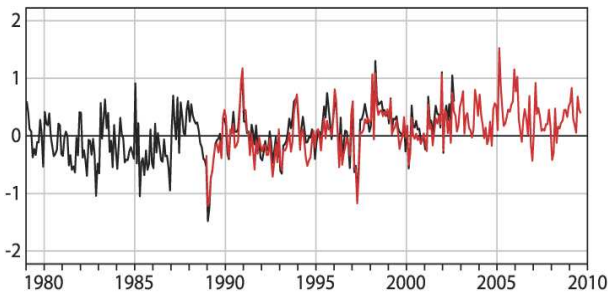


- ERA-40 (1957-2002)
- ERA-Interim: from 1989 to near-real-time

Reanalysis quality more “uniform” in time*

**** but still subject to changes in the observing system***

Reanalyses offer consistent multi-dimensional views of the atmosphere

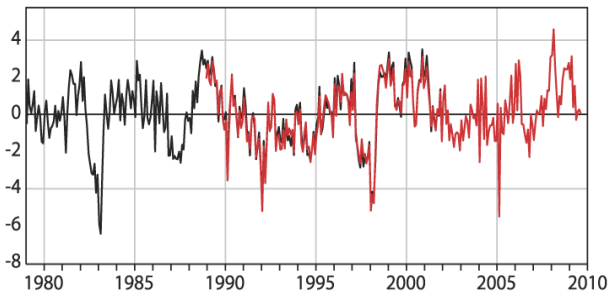


2-metre temperature anomaly (°C) over Africa

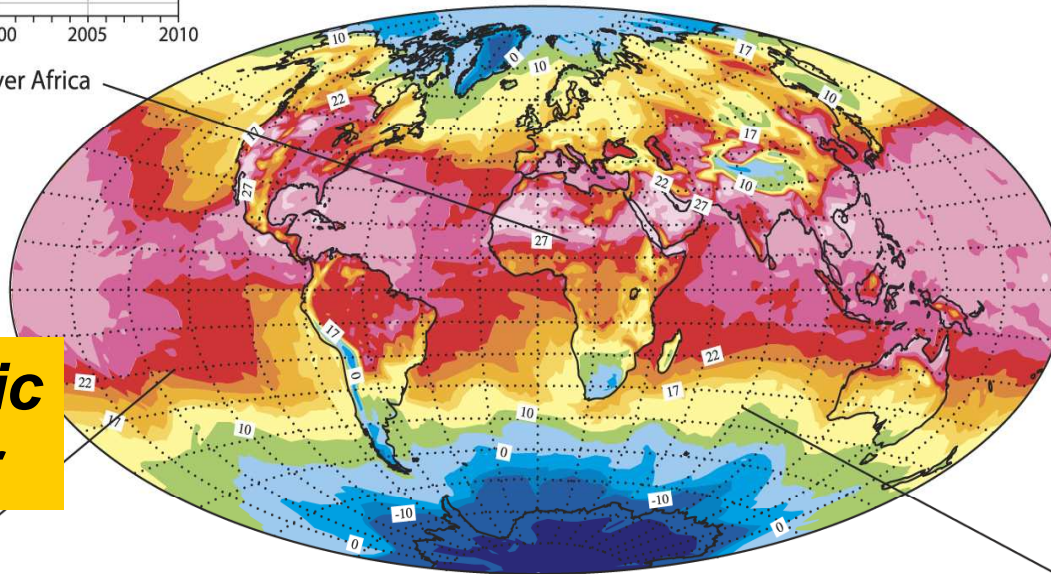
Time

**Atmospheric
parameter**

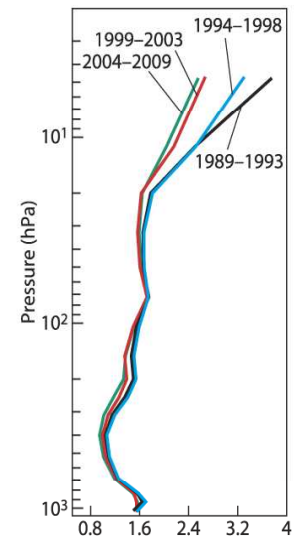
Southern Oscillation Index (hPa)



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



Horizontal



Standard deviation of differences
between ERA-Interim and
radiosondes temperature (°C)
in the southern hemisphere

Vertical

ERA-Interim products

- 20+-year period **January 1989- July 2009** completed
- Extending forward in time (5 days behind real-time)
- Monthly updates of the product archive
- Resolution: **T255L60, 6-hourly** (3-hourly for surface)
- Analysis + forecast products, and monthly averages
- Products from coupled ocean-wave and land-surface models
- Member state users: full access via MARS
- All users: web access via **ECMWF Data Server**

ERA-Interim Public Data Server

Information: <http://www.ecmwf.int/research/era>

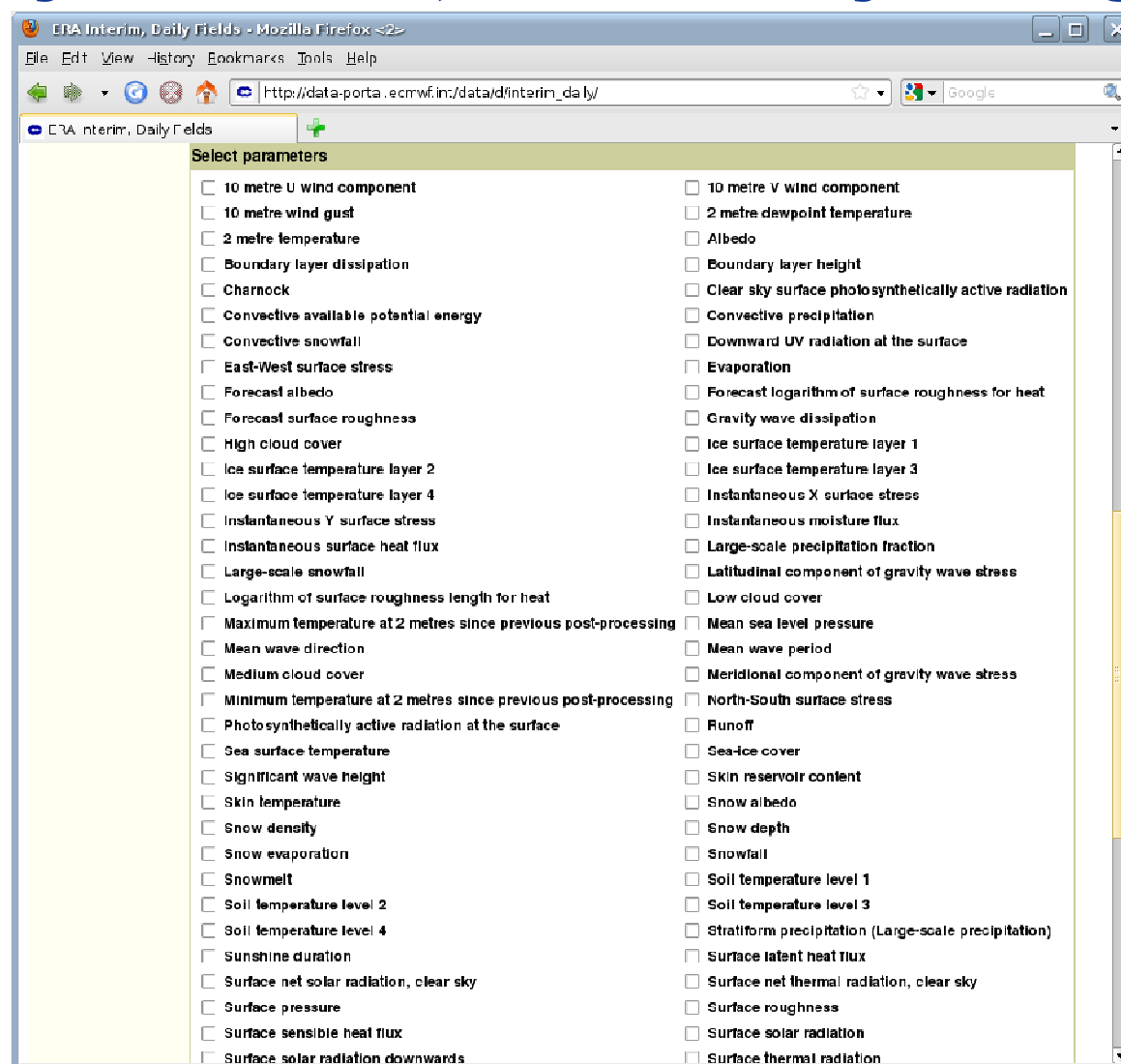
Products: http://data-portal.ecmwf.int/data/d/interim_daily/

From 1989 onwards.

Continued in near-real-time (monthly updates)

Surface (2D) parameters

3-hourly resolution, and monthly averages



Upper-air (3D) parameters

6-hourly resolution, and monthly averages

ERA Interim, Daily Fields - Mozilla Firefox <2>

File Edit View History Bookmarks Tools Help

http://data-portal.ecmwf.int/data/c/interim_daily/levtype=pl/

ERA Interim, Daily Fields

Select parameters

	1000	975	950	925	900	875	850	825	800	775	750	700	650	600	550	500	450	400	350	300	250	225	200	175	150	125	100	70	50	30	20	10	7	5	3	2	1
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Relative humidity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Specific humidity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Temperature	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
U velocity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
V velocity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Vertical velocity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Vorticity (relative)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	1000	975	950	925	900	875	850	825	800	775	750	700	650	600	550	500	450	400	350	300	250	225	200	175	150	125	100	70	50	30	20	10	7	5	3	2	1

Select All or Clear

Retrieve GRIB Retrieve NetCDF Plot data

Reanalyses are worth repeating

- All ingredients evolve thanks to research and development in the science community
 - Models are getting better
 - Dynamics, physics, resolution
 - Data assimilation methods are getting better
 - Optimal interpolation → 3DVAR → 4DVAR ...
 - Observations are getting better
 - Past observations are re-processed with new techniques, datasets can be homogeneized, ...
- Each new generation of reanalysis integrates all these efforts for the benefit of a wide user community

Potential role of reanalysis for integration and validation of ECV products

- Bring in products under one unified framework, to compare
 - with full reanalysis system
 - with other observations
- Identify / estimate uncertainties
- Assess impact via withholding experiments or sensitivity analyses
- Assess homogeneity and time consistency
- Identify discrepancies between physically-related parameters

Conclusions

- Most (if not all) of the ECV projects will require some information on the atmospheric parameters at the time and location of the satellite observation
- ECMWF already has a production system in place (based on the state of science as of 2006) to generate atmospheric auxiliary data in a time-continuous way
 - ERA-Interim reanalysis (1989-July 2009), continued in near-real-time
- These products are freely available on the web:
<http://www.ecmwf.int/research/era>
- Potential for integrating future ECV products in ECMWF reanalyses for evaluation and assessment

Some applications of reanalysis

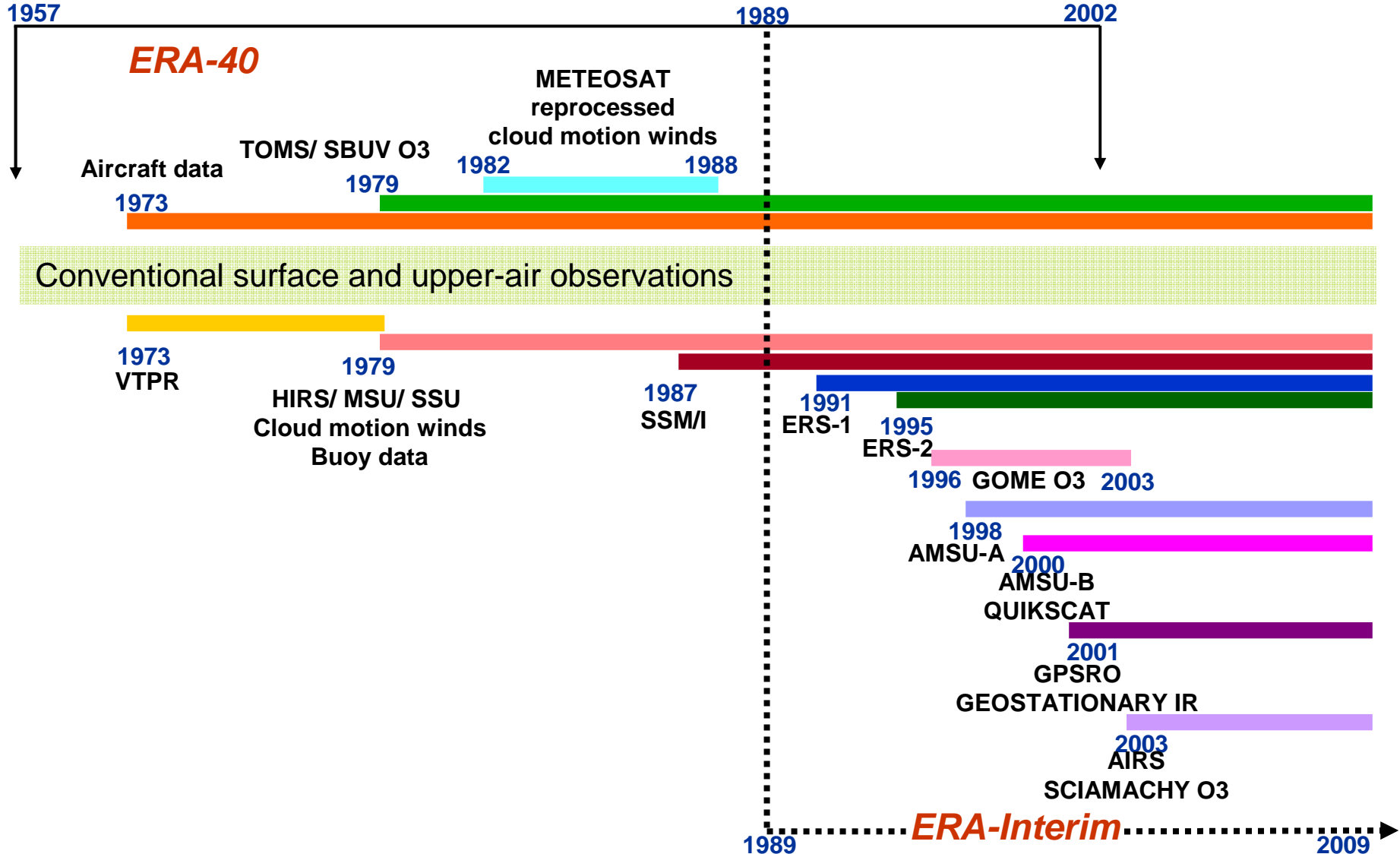
- **Gridded proxy for “Observations”, for verification and diagnosis**
 - Forecast model development, calibration of seasonal forecasting systems, climate model development; use of data assimilation increments for identifying model errors
- **Input data for model applications**
 - for smaller-scales (global→regional; regional→local), ocean circulation, chemical transport, nuclear dispersion, crop yield, health warnings, ...
- **Study of short-term atmospheric processes and influences**
 - process of drying of air entering stratosphere, bird migration, ...
- **Providing climatologies**
 - ocean waves, resources for wind and solar power generation, ...
- **Assessment of the observing system**
 - providing feedback on observational quality, bias corrections and a basis for homogenization studies; contributing to data reprocessing activities
- **Study of longer-term climate variability and trends**
 - used with caution in conjunction with observational studies

When will ERA-Interim be replaced?

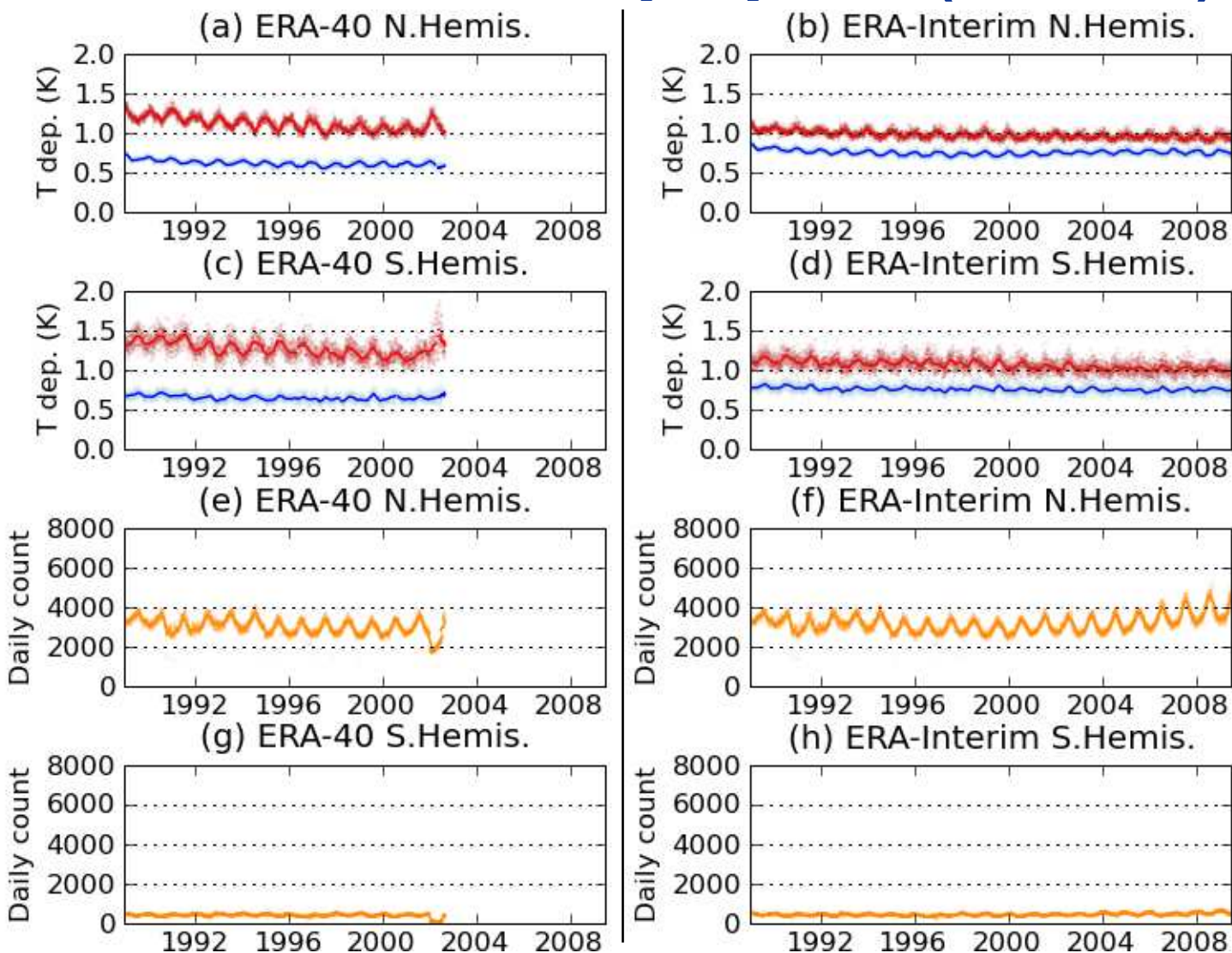
● Challenges for a future reanalysis project:

- An extended reanalysis project such as ERA-40 takes 7-10 years to complete
 - Complex technical and scientific adventure (computing, monitoring, archiving)
 - Integration of expertise of various communities
- Need to acquire 'new' observations
 - Not fully dealt with in ERA-Interim – few additional datasets
 - Several 'new' datasets now available after digitization and clean-up – more datasets coming up
- Scientific challenges:
 - Better handle the model error (bias)
 - Coupling with ocean
- Funding

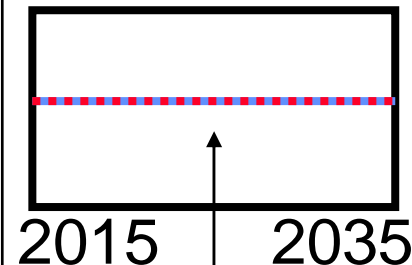
Observing systems used in ERA-40 and ERA-Interim



Validation with radiosonde temperatures at the “middle” of the troposphere (500 hPa)



Ideal case
(perfect model)



Analysis and a *priori* have the same statistics as compared to observations (observation error)