ECMWF reanalysis activities update

Hans Hersbach

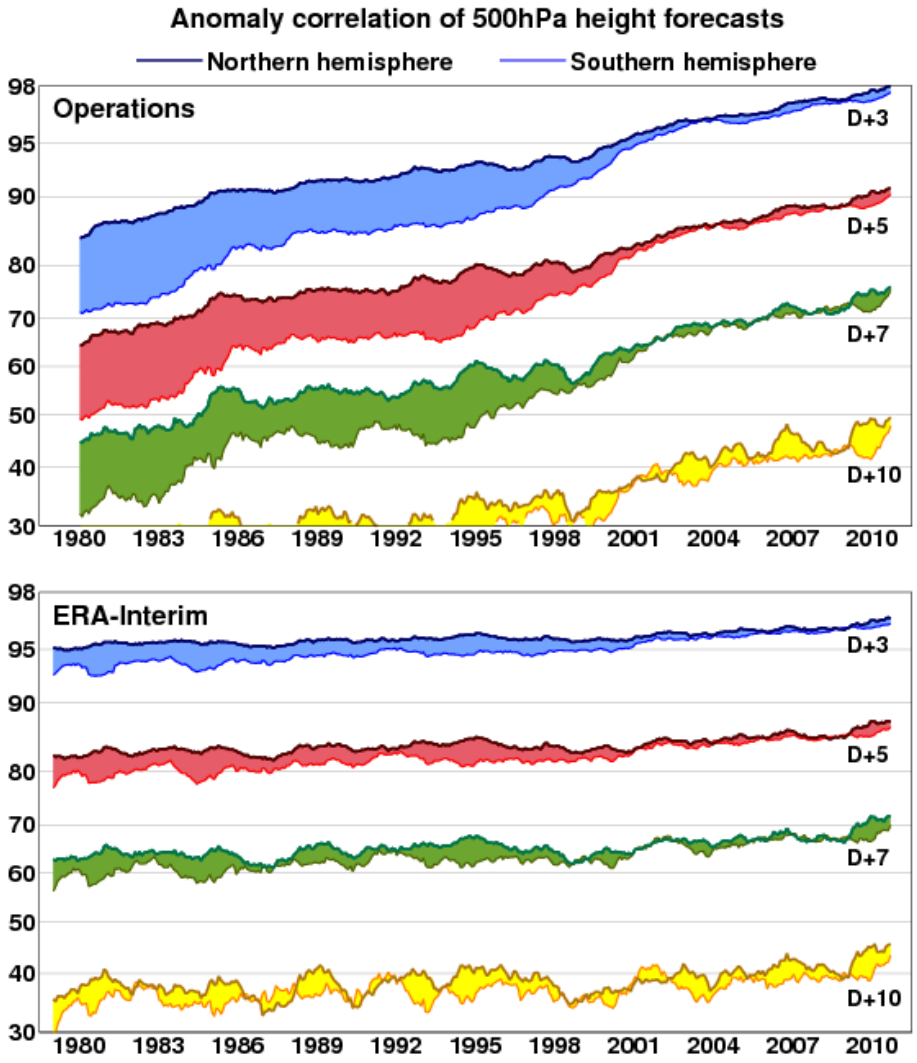
and many colleagues

Rationale behind reanalysis

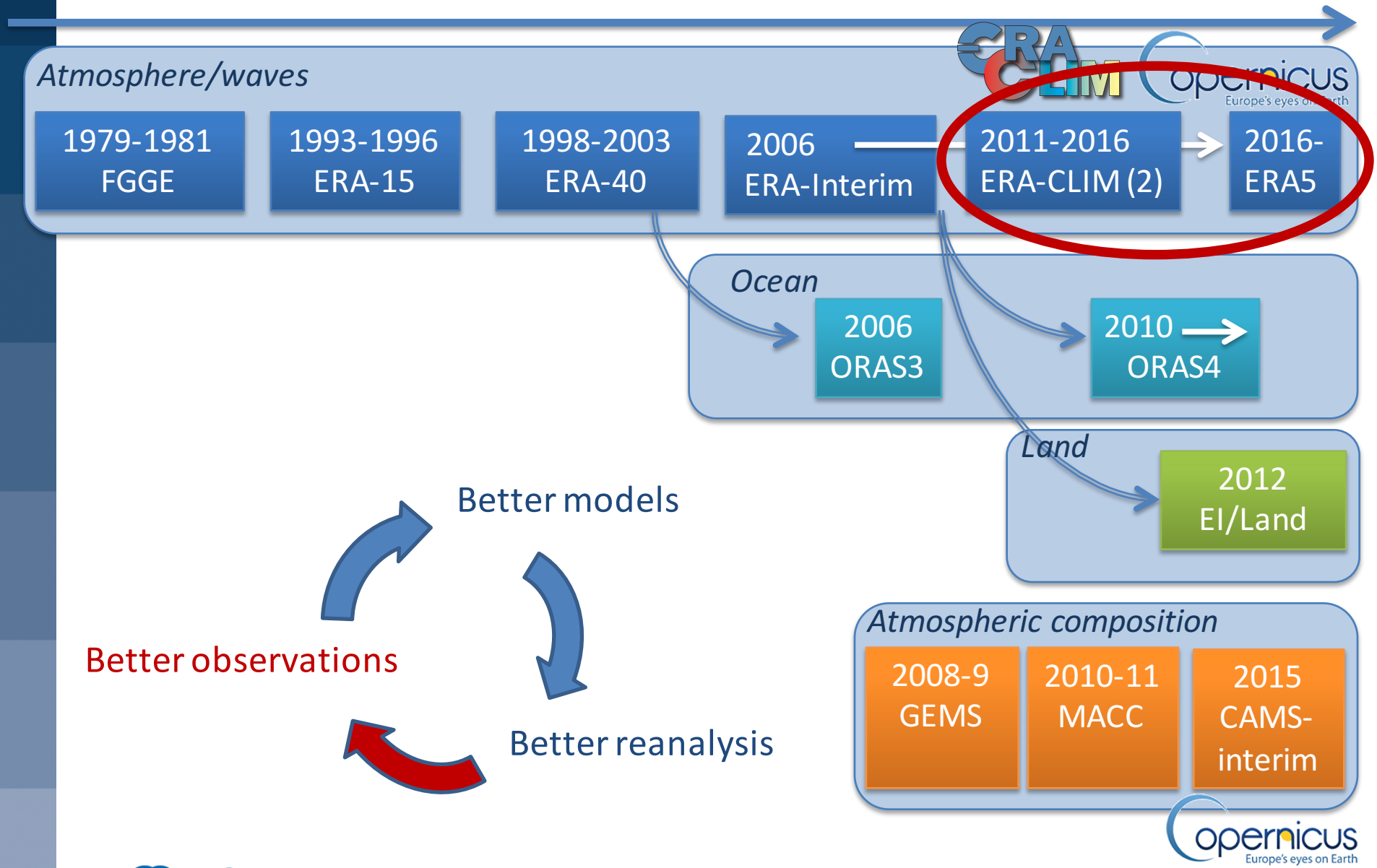
Consistent reconstruction of the atmosphere (and ocean):

- glue together observations from different nature and origin into *global fields,*
- using the *laws of physics* of the atmosphere
- with an appropriate *bias correction* scheme
- using the *same system* over the entire reanalysis period.

At lower resolution to *keep affordable*



Global reanalyses produced at ECMWF

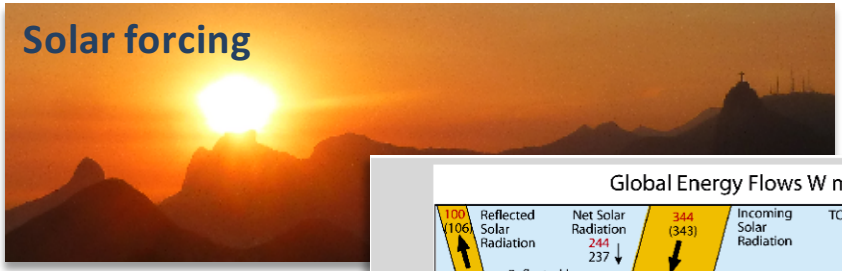


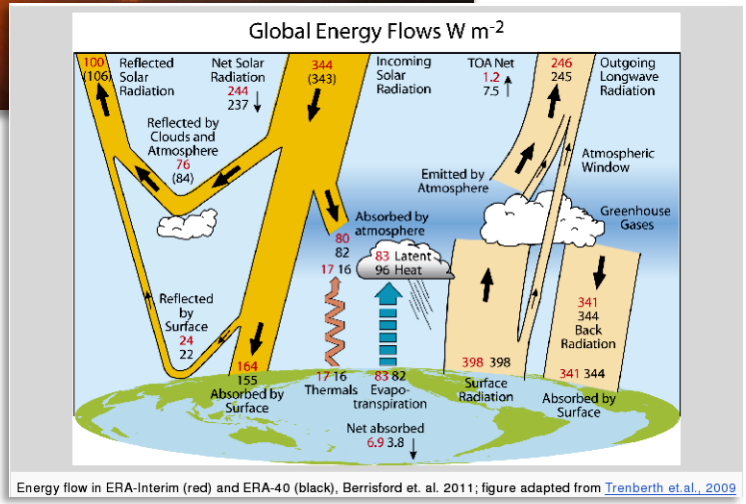
ERA-20C climate reanalysis forcing:

You need realistic energy budgets for the atmosphere

And it needs to reflect the 20th century evolution

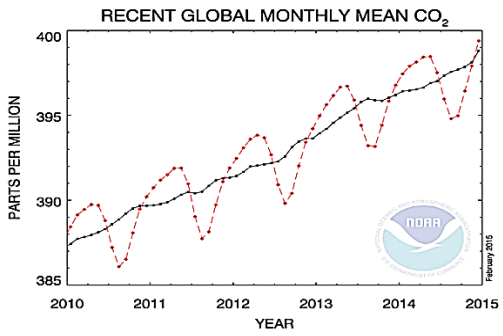
Solar forcing



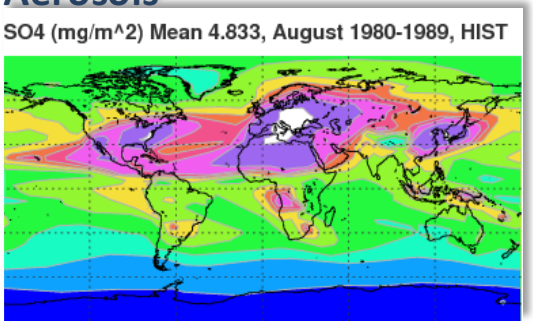


Energy flow in ERA-Interim (red) and ERA-40 (black), Berrisford et. al. 2011; figure adapted from Trenberth et.al., 2009

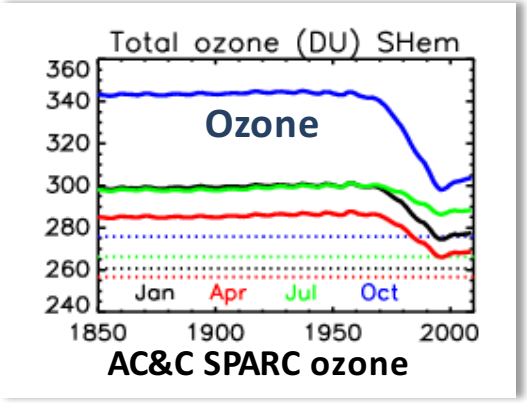
Greenhouse gases



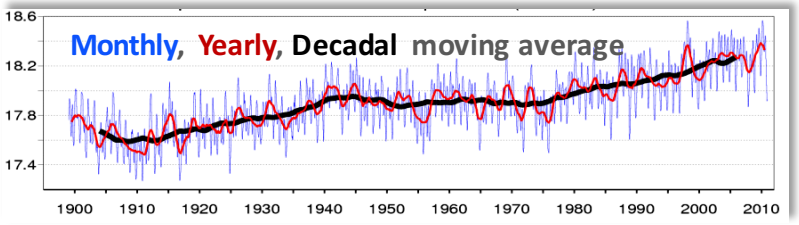
Aerosols



Volcanic eruptions



SST and sea ice



ERA-CLIM climate pilot reanalyses

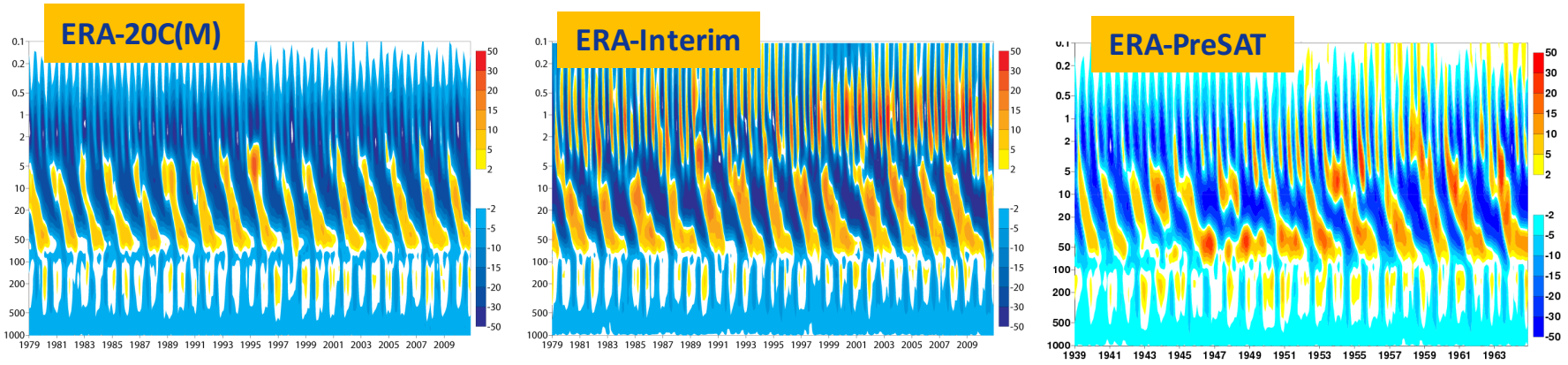
Configuration

- ✓ **IFS Cy38r1:** Atmosphere and ocean-wave component
- ✓ **T159** (~125km), **91 levels** in the vertical (up to 1 Pa)
- ✓ **CMIP5** forcing
- ✓ 10-member ensemble
- ✓ 1900-2010

ERA-20CM: *model only*
ERA-20C: *surface observations only*
ERA-PreSAT: *in addition early upper-air data (*1939-1967 only)

CERA (to be started soon; Cy41r2): coupling with the ocean

The QBO in ERA-CLIM

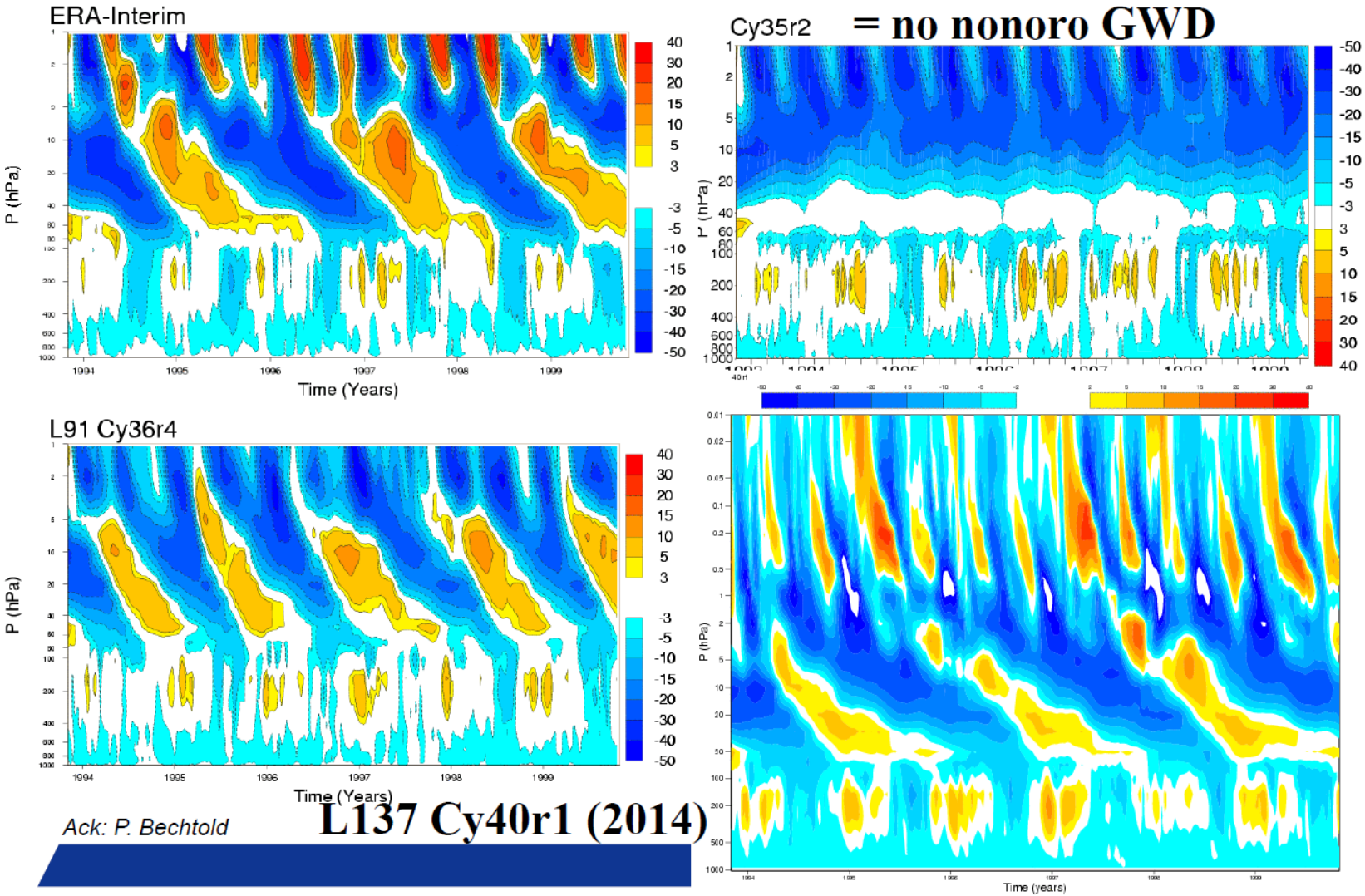


ERA5: the ERA-Interim replacement

	ERA-Interim	ERA5
Start of production	August 2006 IFS Cy31r2	End 2015, reach NRT end before 2017 IFS **Cy41r2**
Model input (radiation and surface)	As in operations, currently OSTIA *(inconsistent SST)*	Appropriate for climate (CMIP5 including **AC&C SPARC ozone**, blend HadISST.2.1.0 and OSTIA)
Analysis method	12h 4D-Var	12h 4D-Var on **10-member EDA (T319, 63km)**
Spatial resolution	79 km global 60 levels to 10 Pa	31 km global (**T639**) 137 levels to 1 Pa
Output frequency	6-hourly Analysis fields	**Hourly** (three-hourly for the EDA), Extended list of parameters ~ 5 Peta Byte
Time period	1979 - present	**1979 - present**
Extra Observations	Mostly ERA-40, GTS	Various reprocessed CDRs, including for ozone
Radiative transfer	RTTOV7	RTTOV11 + CO2, SSU cell-pressure correction
Variational bias corrections	Satellite radiances	Also ozone, aircraft, surface pressure

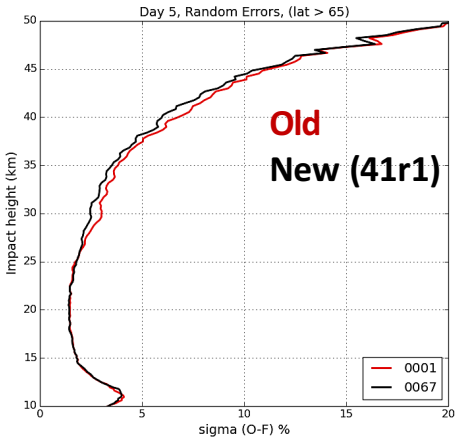
ERA5 will use 137 levels in the vertical

QBO : Hovmöller U from free 6y integrations

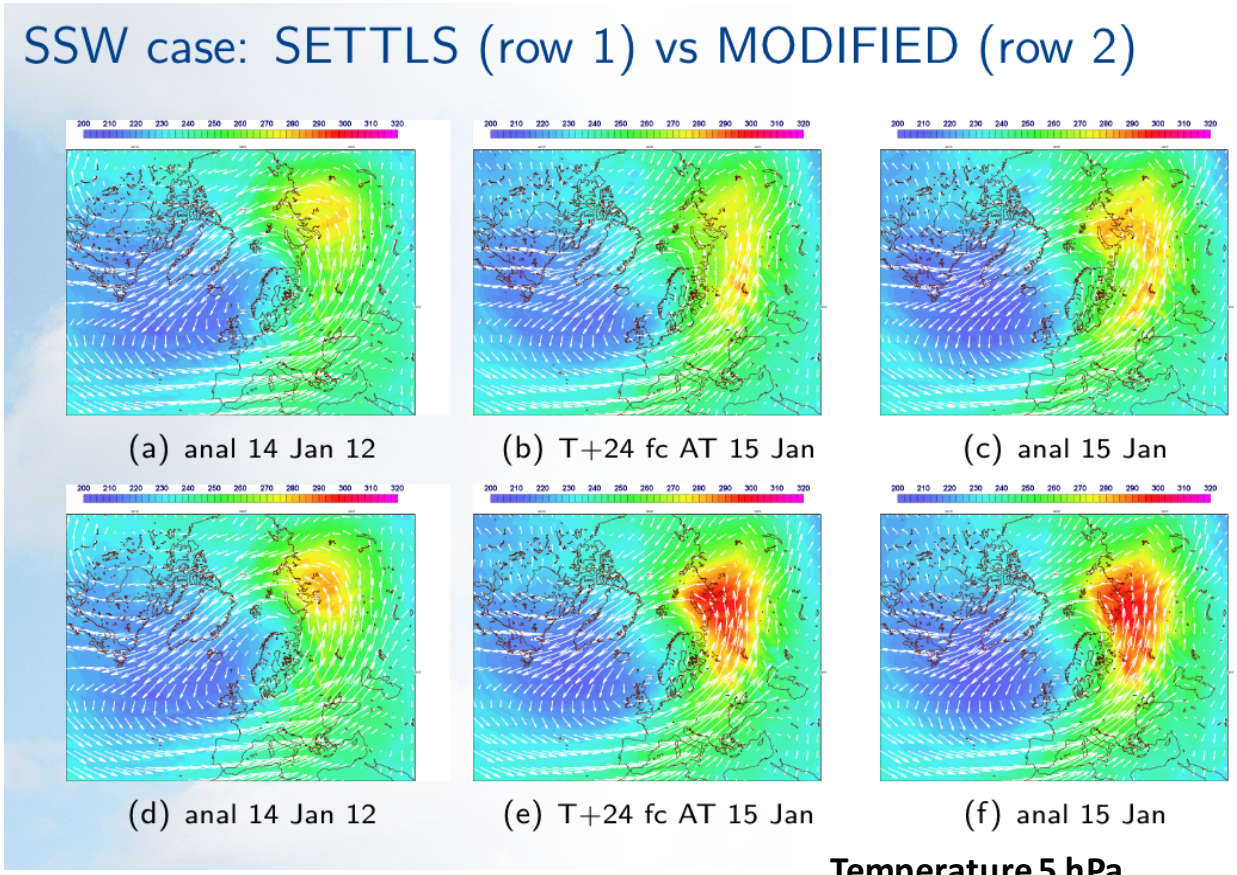


ERA5 will benefit from the latest IFS cycle 41r2

Example: *updated semi-Lagrangean departure scheme significantly improves the forecasts of sudden stratospheric warming events*



Day-5 verification vs GPSRO

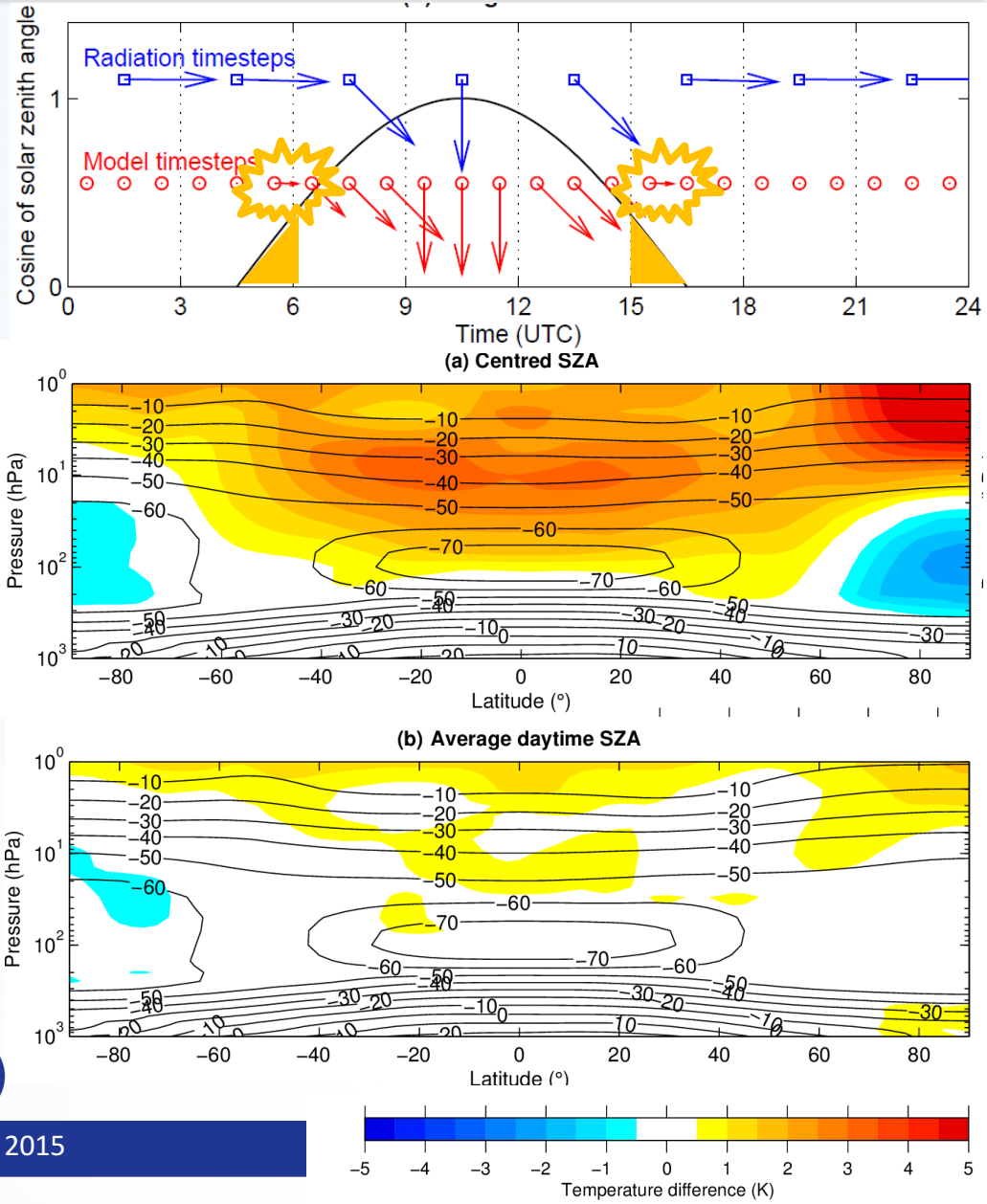


Temperature 5 hPa

Michail Diamantakis

Climate errors due to infrequent calls to radiation scheme

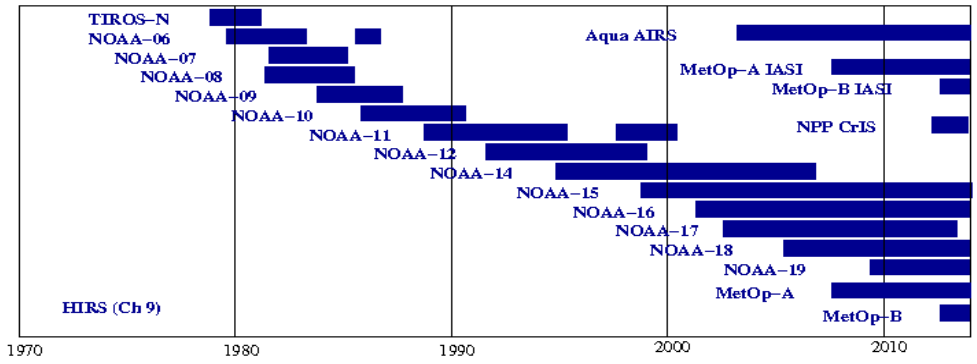
- All but one operational IFS configurations call radiation scheme only every 3 h
- At dawn & dusk, sun angle at centre of 3-h period too shallow: absorption *too high*
- Stratosphere too warm by 3-5 K (compared to running radiation scheme every timestep)
- "Wiggles" in mean fluxes versus longitude (Zhou et al 2015)
- Fix by averaging cosine of solar zenith angle over *sunlit part* of radiation timestep
- This is in 42R1, will be in ERA5



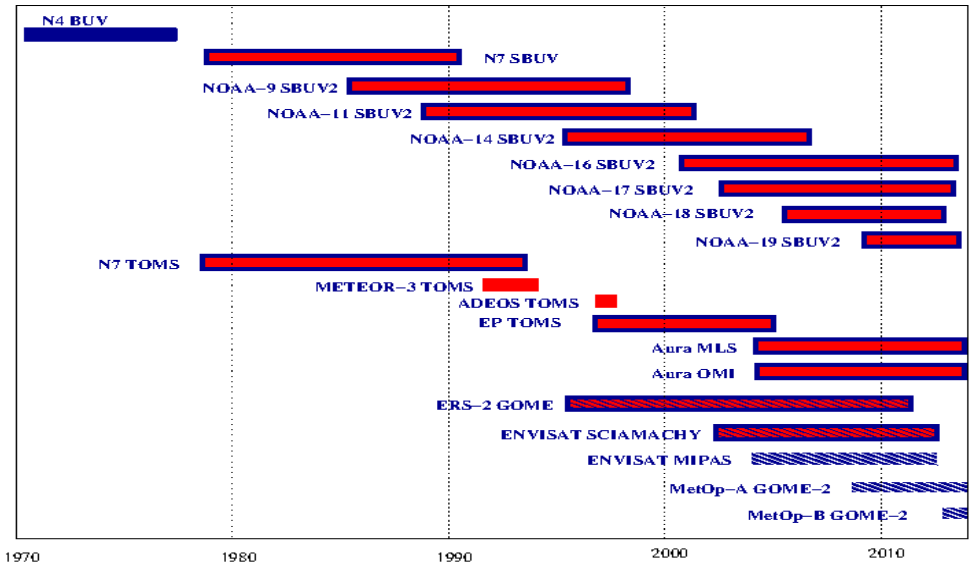
Hogan & Hirahara (ECMWF memo 2015)

Improved observing system
Example: Ozone, ERA-Interim vs ERA5

Level 1b



Level 2



Used / same version

Used / new version

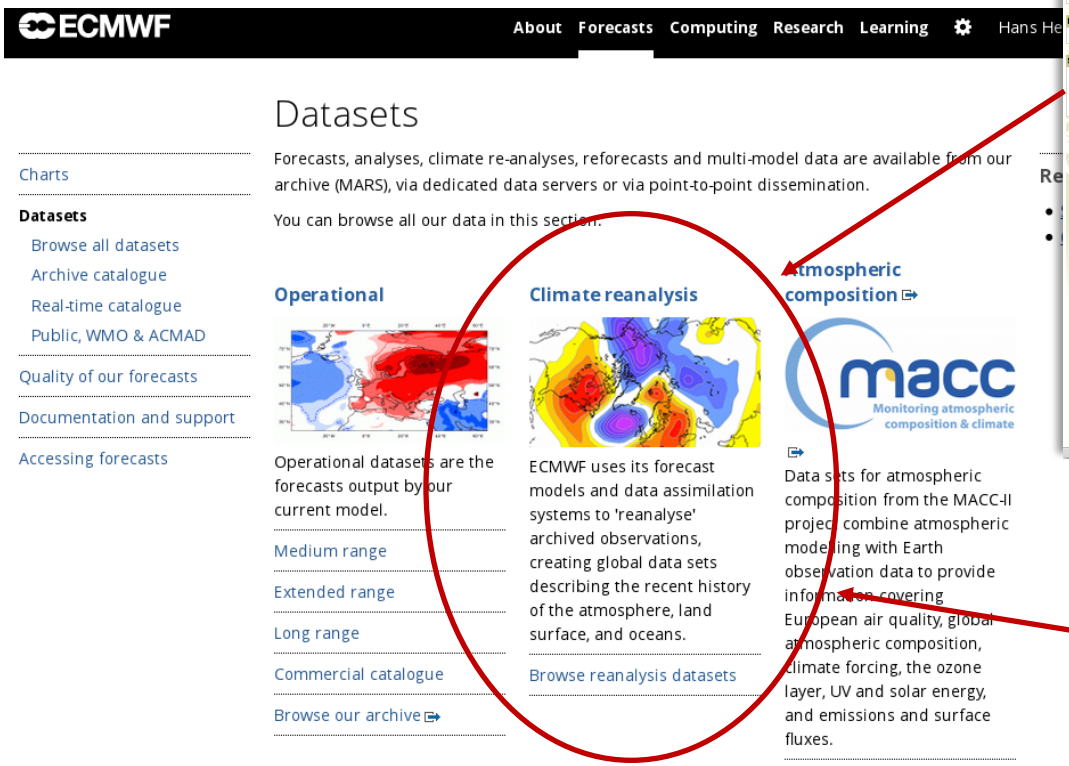
Never used

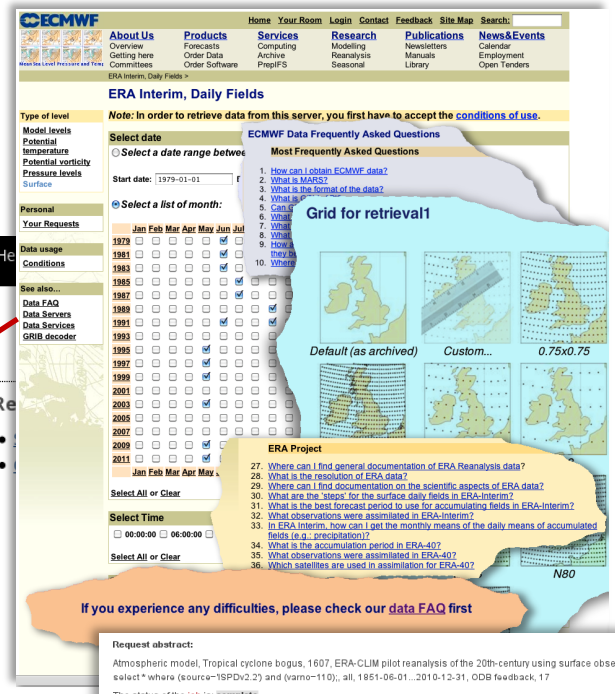
Available from CCI

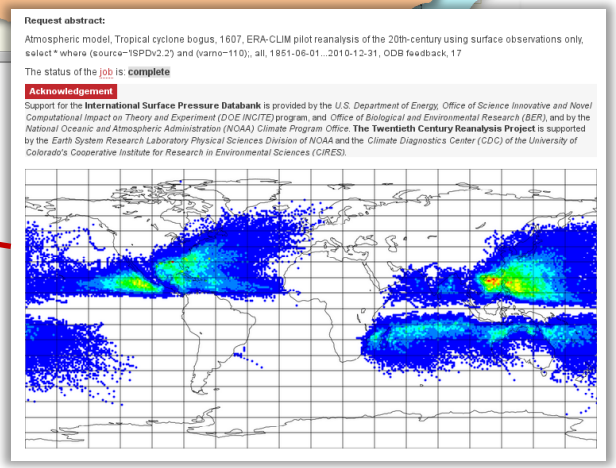
Rossana Dragani

Plus variational bias correction

Access to ECMWF reanalysis data





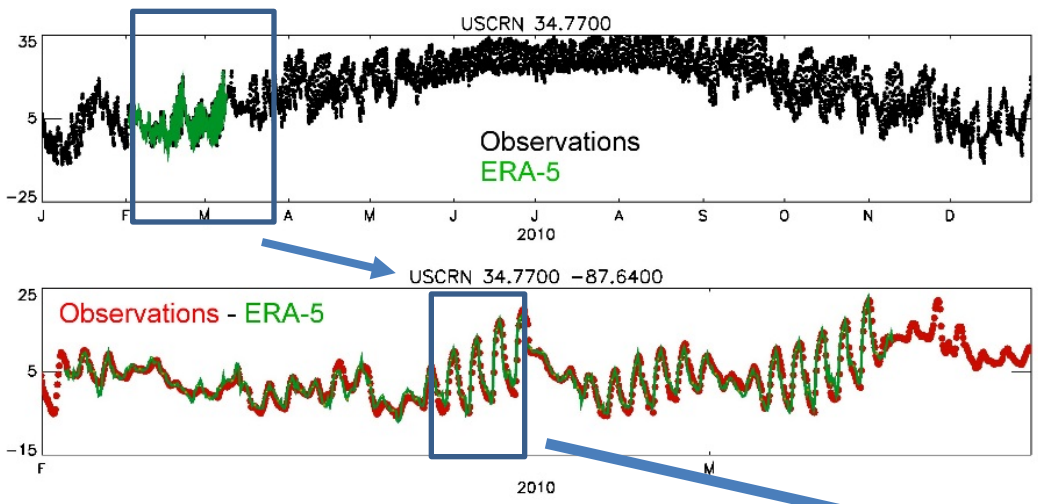


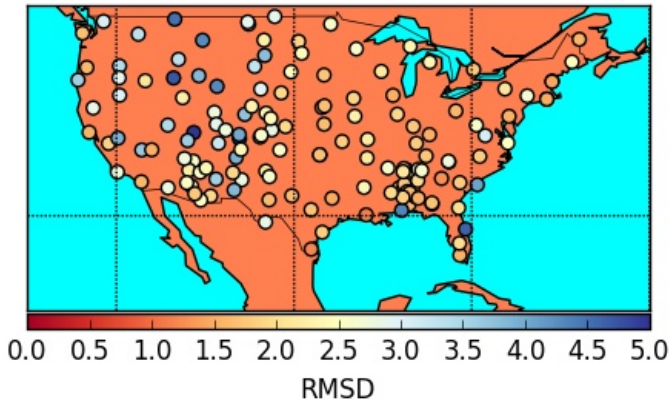
!New: access to observation feedback!

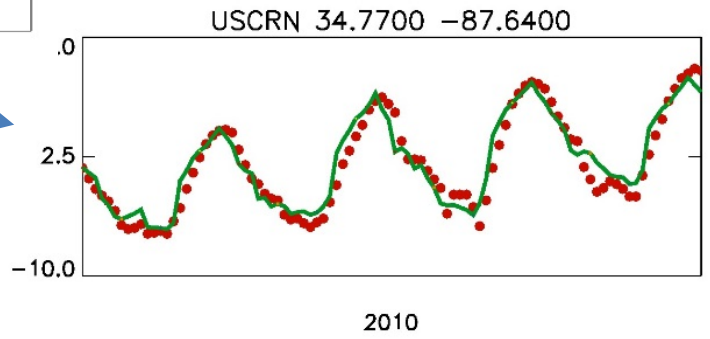
ECMWF

ERA5 will produce hourly archiving

Example: t2m vs. *Independent Observations* (from Clement Albergel)







Concluding remarks

On behalf of the European Commission ***ECMWF*** has been entrusted to operate the:

- ✓ Copernicus Atmosphere Monitoring Service ***CAMS***
- ✓ Copernicus Climate Change Service ***C3S***

within a newly formed Copernicus department at ECMWF

As part of ***C3S*** ECMWF will conduct ***ERA5*** (2016-2017)

- ✓ state-of-the art reanalysis, operational service, cycle ~5 years
- ✓ higher resolution, ensemble, latest model cycle, reprocessed data

As part of ***CAMS***, a reanalysis of atmospheric composition 2003-present will be produced

ERA-Interim is currently being continued

A number of century-long 'climate' reanalyses have been conducted within the **FP7** ***ERA-CLIM*** project and a coupled reanalysis, ***CERA***, is to be conducted soon within the ***ERA-CLIM2*** project.