# ERA-CLIM2 WP4 Session Starter

## DWD, ECMWF , FFCUL, RIHMI, UNIBE, UNIVIE, UVSQ

Leopold Haimberger

**Thursday 10 December 2015**

# Main tasks

- Making optimal use of observations in reanalysis, and providing end users with meaningful information about uncertainties in reanalysis products.
- Range of activities,
  - quality control and error estimation for input observations,
  - work on bias correction and homogenisation of data records,
  - quality assessments of reanalysis products based on independent observations and comparisons with other reanalyses and high-level observational products.

# From ERA-CLIM2 proposal

- Additional information about the usage and assimilation of observations is fundamental to a full understanding of uncertainties in many applications. Nevertheless, it has always been very difficult, if not impossible, for users to access this type of information.
- The ERA-CLIM project has addressed this shortcoming by developing the **Observation Feedback Archive** (OFA).
- It **will continue to be maintained, developed, and supported in ERA-CLIM2**, and will provide a permanent source of information about the quality of the observational record.

# Current status

- OFA is great for surface data
- The OFA for upper air data is scattered over many places, incomplete, hard to access
- Responsibility for ingestion of newly digitized data is currently unclear
- Using upper air background departure statistics for QC is still too challenging, especially if they have not been assimilated
- Could that be changed until the end of ERA-CLIM2?

**Global Reanalyses**

- ERA-20C (Jan 1900 - Dec 2010)
- ERA-Interim (Jan 1979 - present)
- ERA-Interim/LAND (Jan 1979 - Dec 2010)
- ERA-20CM (Jan 1900 - Dec 2010)
  - Final
  - Experimental
- ERA-40 (Sep 1957 - Aug 2002)
- ERA-15 (Jan 1979 - Dec 1993)

**Observation Feedback**

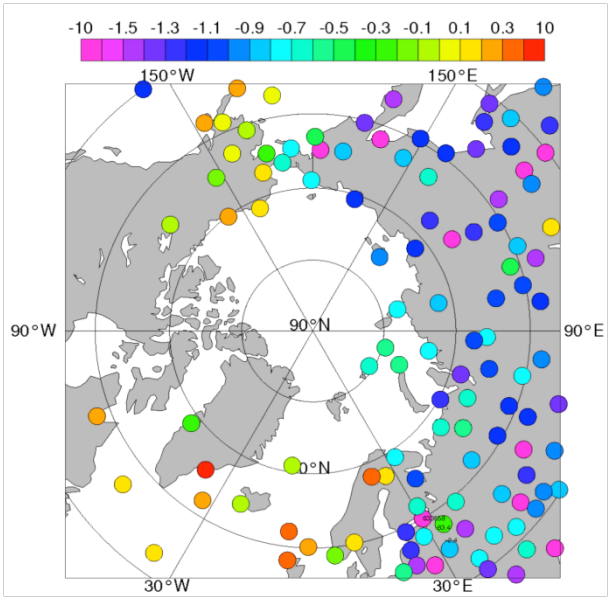
- ERA-20C (Jan 1900 - Dec 2010)
- ISPD v2.2
- ICOADS v2.5.1 with interpolated NOAA 20CR feedback

**Multi-model**

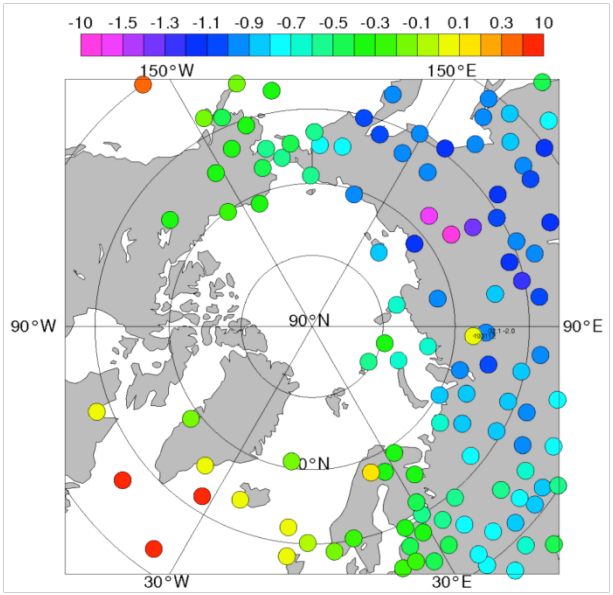
- S2S (NEW: Reforecasts added)
- TIGGE
- TIGGE LAM

Upper air

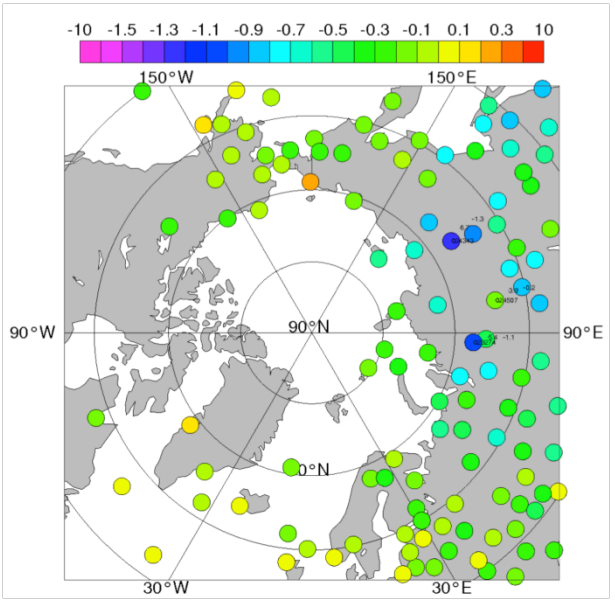
# Adjustment of early radiosonde temperatures




Unadjusted




RAOBCORE adjusted

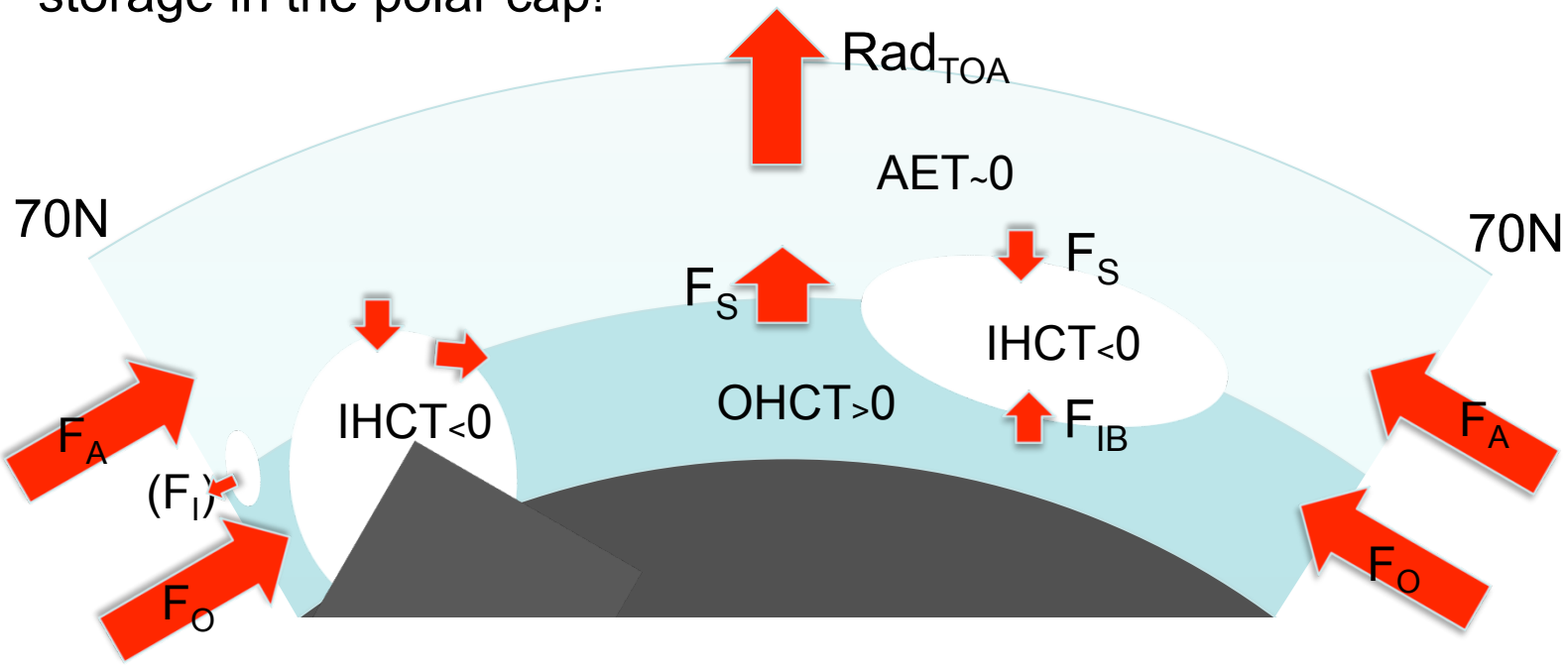



RICH adjusted

- Radiosonde T-trends 1954-1974, at 300 hPa.
- Reference Series ERA-preSAT (-1967), JRA55 (1968-1979)
- Improvements due to digitized FSU data, ERA-preSAT observation feedback archive
- Part of D4.1

# Mean energy budget of the polar cap

- Main balance between horizontal energy transport and radiative energy loss at TOA
- Observed ocean warming and ice melt rates are small residual of large fluxes
- → Sum of the fluxes across 70N and TOA should yield mean energy storage in the polar cap!



# The state of the coupled Arctic energy budget (70-90N)

- Add up atmosphere, ocean, ice equations and integrate over polar cap

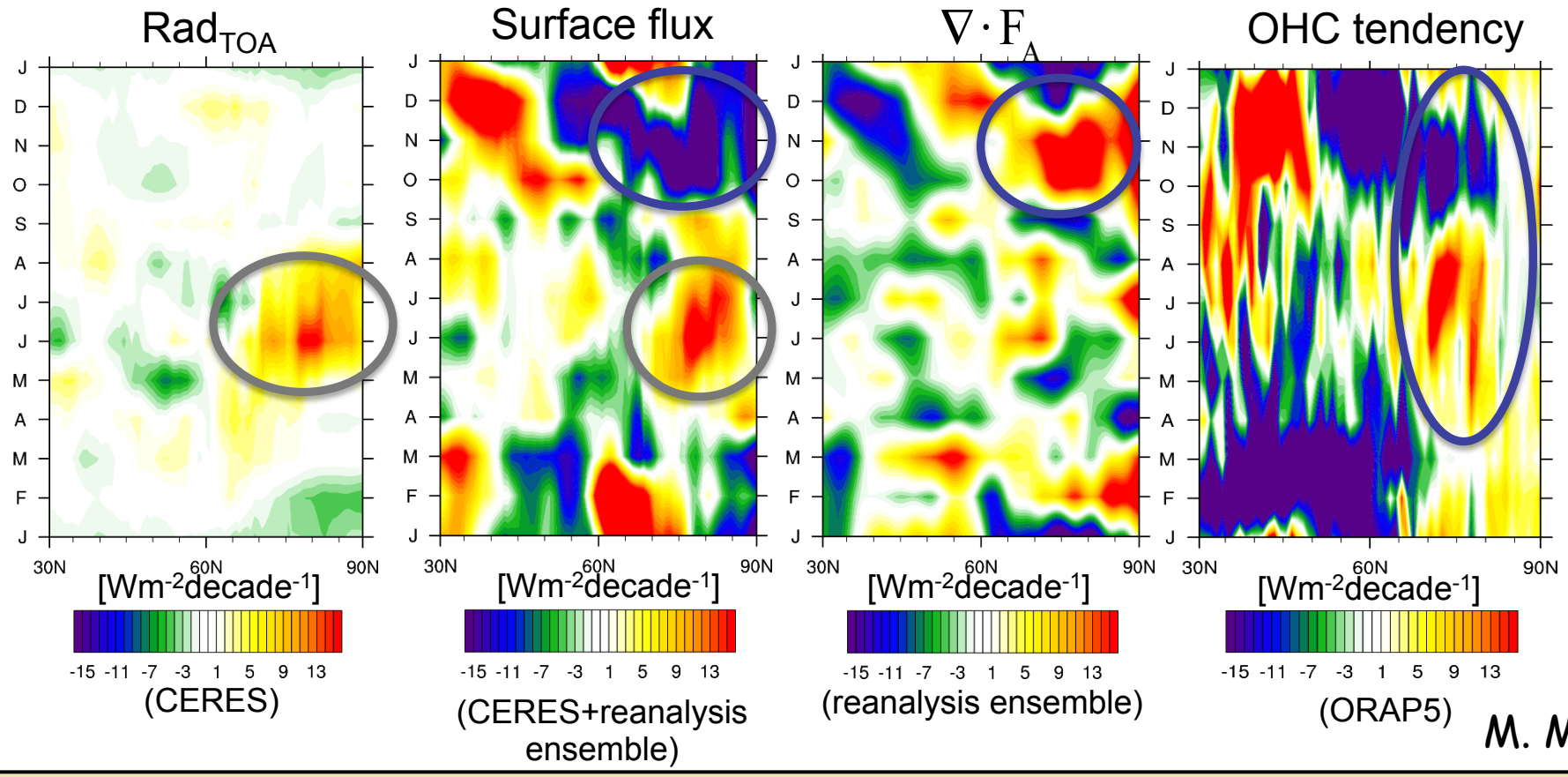
$$\{\mathrm{Rad_{TOA}}\} + \mathrm{F_A}(70\mathrm{N}) + \mathrm{F_O}(70\mathrm{N}) + \mathrm{F_I}(70\mathrm{N}) = \{\mathrm{OHCT}\} + \{\mathrm{IHCT}\} + \{\mathrm{AET}\} + \\ + \mathrm{imbalance}$$

- 2000-2014 averages (CERES, ERA-I, ORAP5, JRA55,…):

| Net heat flux into polar cap [$Wm^{-2}$] | | Heat storage [$Wm^{-2}$] | |
|---|---|---|---|
| $Rad_{TOA}$ (CERES) | -116.1±0.4 | | |
| $F_A$ across 70N | 95.3 (92.3,98.7) | atmosphere | 0.1±0.1 |
| $F_O$ across 70N | 18.5±0.4 | Ice melt | 0.3±0.3 |
| $F_I$ across 70N | ≈3 (Serreze et al 2007) | Ocean heat content | 0.7±0.5 |
| **Sum of fluxes** | **0.3±0.9** | **Storage sum** | **1.1±0.6** |

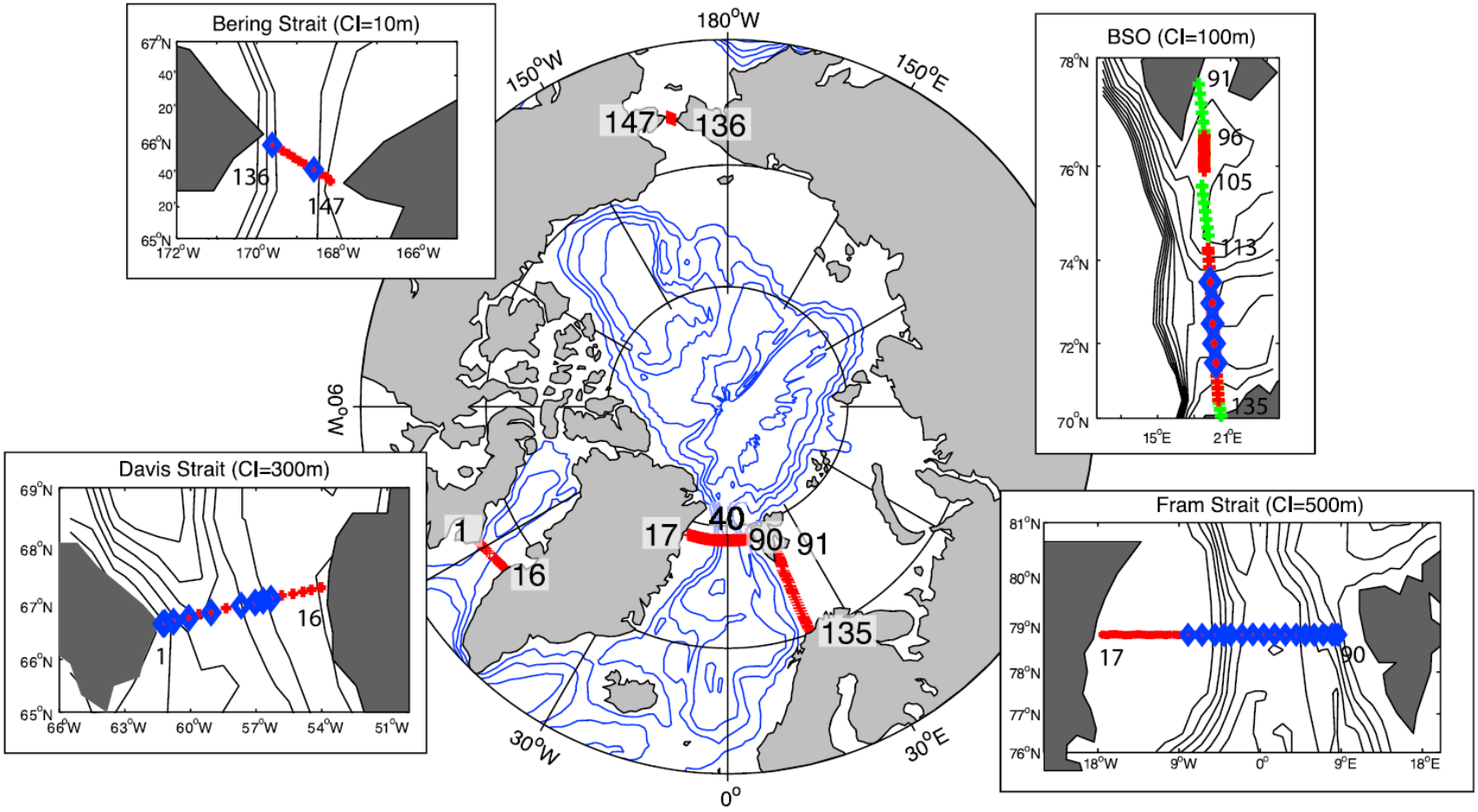
# Seasonal trends over polar region

- Positive summer trend of $F_S$ driven by $Rad_{TOA}$ → ice-albedo feedback
- Negative autumn trend of $F_S$ driven by atmospheric energy convergence – associated with decreased baroclinicity




M. Mayer

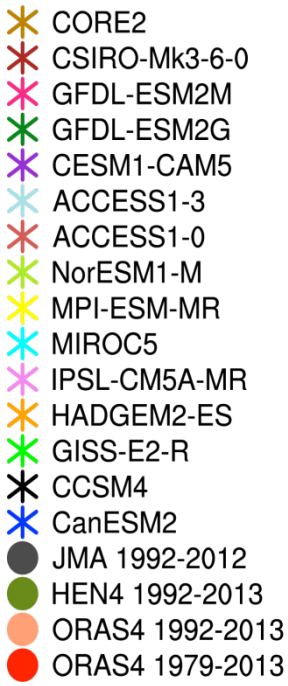
# Arctic gateway array (since 2004)

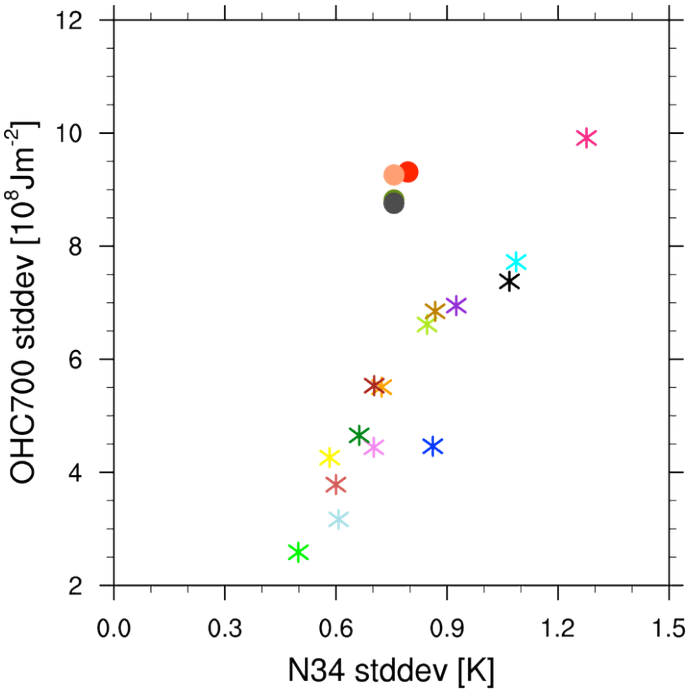


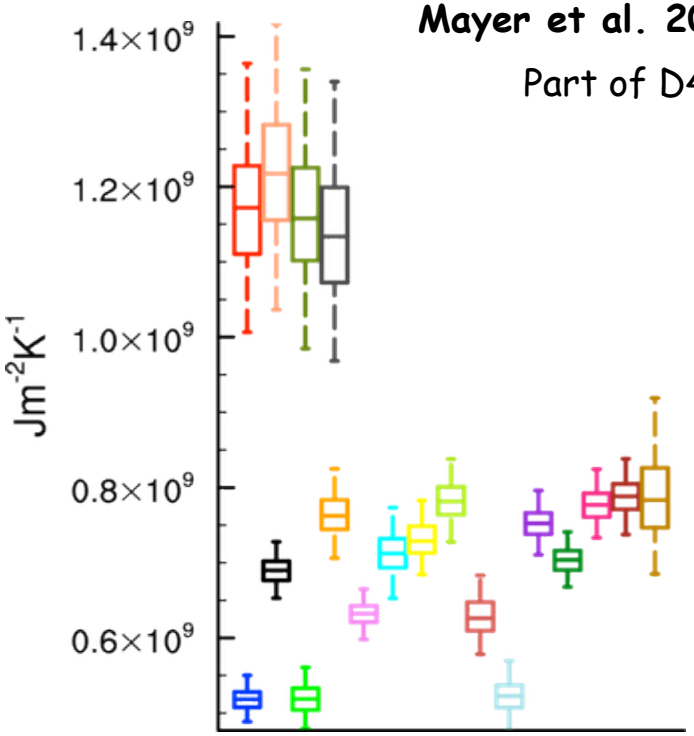

Tsubouchi et al. 2012

| Deliverable | Description (Lead beneficiary) | Delivery month | | Comment |
|---|---|---|---|---|
| | | Original | Amended | |
| D4.1 | RS bias adjustments (UNIVIE) | 12 | 20 | **delivered** |
| D4.2 | Updated RS bias adjustments (UNIVIE) | 36 | 48 | ERA5 and a ERA-preSAT rerun are expected to be much better reference than previous reanalyses but are not available in month 36. Value of deliverable would be significantly degraded |
| D4.3 | QC for obs from FFCUL (FFCUL) | 36 | 48 | FFCUL had difficulties in personnel recruitment and works hard on digitization of Chilean and other data. This has priority for now. QC aspect would improve a lot if 12 months more are available |
| D4.4 | Visualization tool for QC (FFCUL) | 12 | 12 | **delivered** |
| D4.5 | QC for upper-air, surface, and snow obs. (RIHMI) | 36 | 36 | no impact expected |
| D4.6 | Methodology for quantifying obs error (UBERN) | 36 | 36 | no impact expected |
| D4.7 | Verification of precipitation against GPCC (DWD) | 36 | 48 | Data set will be ready but validation of ERA5, CERA-20C would not be possible |
| D4.8 | Global energy, water, carbon cycles (ECMWF,UNIVIE, UVSQ) | 36 | 48 | Evaluations without ERA5, CERA-20C would be much less innovative |
| D4.9 | Upper air data qc (UBERN, RIHMI) | 24 | 24 | no impact expected |
| D4.10 | Comparison with other reanalyses (UNIVIE; ECMWF) | 36 | 48 | Comparisons without ERA5, CERA-20C would be much less innovative |
| D4.11 | Low frequency variability and trends (ALL) | 36 | 48 | Without completed ERA5, CERA-20C many evaluations would have to be based on data not created in ERA-CLIM2 |
| D4.12 | Uncertainty of input parameters for carbon budget (UVSQ) | 12 | 20 | **delivered** |
| D4.13 | Confidence intervals on carbon fluxes (UVSQ) | 36 | 48 | Those would have to be based on existing ERA-20C, not new CERA-20C |
| D4.14 | Comparison of CTESSEL, ORCHIDEE flux estimates (ECMWF, UVSQ, UNIVIE) | 36 | 48 | This could be done partly with unfinished CERA-20C but much value would be added if complete CERA-20C set were available |

# Complex energy budget diagnostics




**Mayer et al. 2015**

Part of D4.8

- Key for comprehensive climate model validation
- Some terms missing in reanalysis output, should be complemented to comply with CMIP requirements

# What we have:

- **Atmosphere** $\nabla \cdot F_A = Rad_{TOA} - AET - F_S$
  - $Rad_{TOA}$: satellite data (CERES)
  - $\nabla \cdot F_A$: mass-corrected from atmospheric reanalyses
  - $F_S$: directly from model-forecasts (biased) or indirectly from other atmospheric fields (accumulated errors)
- **Ocean** $\nabla \cdot F_O = (1-f_i)F_S + f_i F_{IB} - OHCT$
  - $\nabla \cdot F_O$: directly computed from ORAS4 (soon: ARCGATE)
  - OHCT: from ocean reanalyses with very different data assimilation approaches
- **Sea ice** $\nabla \cdot F_I = f_i F_S - f_i F_{IB} - IHCT$
  - Sea ice mass from coupled ocean-ice reanalyses (ORAP5) or ice reanalyses (PIOMAS)
  - Sea ice extent to understand changes in fluxes

# From ERA-CLIM proposal

- Together with other in-situ and remote-sensing datasets available from existing data archives, **the observations collected for ERA-CLIM will be included in a newly developed Observation Feedback Archive.**
- **Quality feedback information** for this archive, including data departures and bias estimates, **will be generated during several new pilot reanalyses**, as well as from existing reanalysis datasets.
- The **pilot reanalyses** and the Observation Feedback Archive will be made available to users world-wide as a **unique resource for climate research** and observational studies of the Earth system.