

CERA-SAT: A coupled reanalysis at higher resolution (WP1)



ERA-CLIM2 General assembly
Dinand Schepers
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Coupled reanalyses to be produced at ECMWF

CERA-20C: A coupled reanalysis of the 20th century

- based on conventional surface and subsurface observations
- deliver long timeseries of Essential Climate Variables (ECVs)

CERA-SAT: A coupled reanalysis at higher resolution

- based on *conventional and satellite observations*
- to evaluate the impact of a *higher resolution* on the coupled processes
- Includes *land surface and wave analyses*



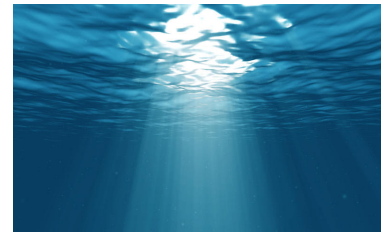
Atmosphere



Land



Wave



Ocean



Sea ice

Outline

- Introduction – Coupled data assimilation & the CERA system
- CERA-SAT – A an overview of the assimilation system
 - Special topic: Sea ice
 - Special topic: Sea level anomaly (SLA) assimilation
- CERA-SAT – Current status & future activities

CERA-SAT – Atmosphere

- Increased resolution (TL319; L137)
 - ~60 Kilometre; 137 levels
- Full observing system
 - Reprocessed datasets; ERA-5 observation usage
- Diagnostics as in ERA-5



Model: IFS (CY42R1_esuite, April 2016)

Observation: ERA5 observing system (except prescribed sea-ice & SST)

Assimilation: 10-member ensemble hybrid DA; 24-hour window)

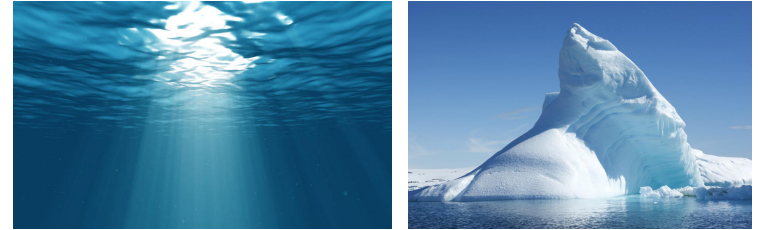
Resolution: TL319L137

Initialisation: ERA-Interim

Analyses: Archived 3-hourly

CERA-SAT – Ocean/Sea ice

- Increased resolution (1/4 degree ;ORCA025)
 - ~30 km; 72 levels
- Ice model (Lim2) coupling
 - Bug fix w.r.t. CERA-20C
- Sea Level Anomaly (SLA) assimilation
 - Using ‘uncoupled’ Mean Dynamic Topography (MDT)



Model: NEMO / LIM2 (CY42r1_nemo_E28)

Forcing: SST nudged (OSTIA 1/20th degree analysis)

Observation: salinity and temperature profiles, SSA, Sea-ice analysis

Assimilation: 10-member ensemble; 24-hour window 3Dvar FGAT; Direct initialisation (DI)

Resolution: ORCA0.25 Z75

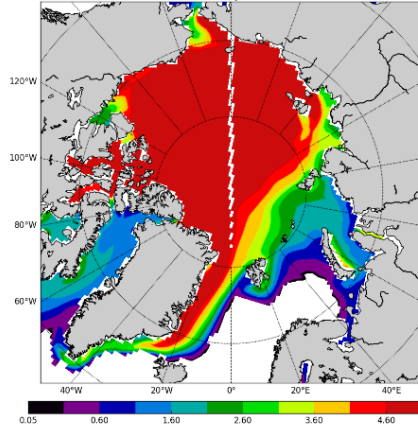
Initialisation: ORAS5

CERA-20C (sea ice thickness)

Ice thickness in March 1950

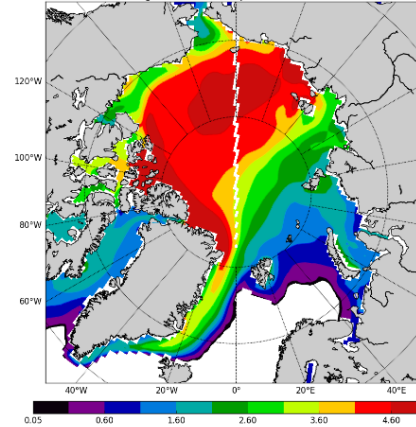
CERA-20C

2372 icethic: npstere 195003

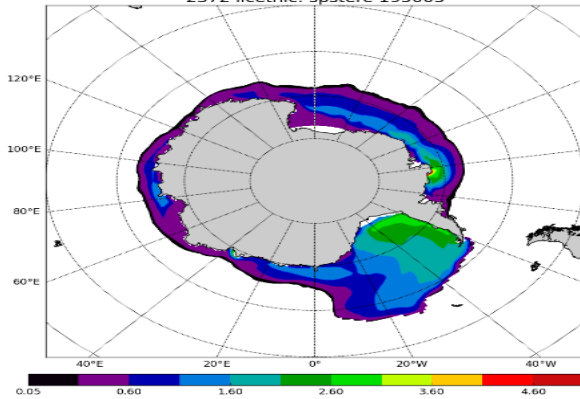


ORA-20C

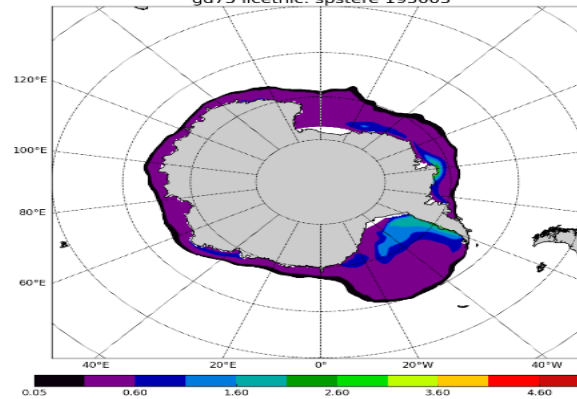
gd75 icethic: npstere 195003



2372 icethic: spstere 195003



gd75 icethic: spstere 195003



→ in CERA-20C, sea-ice getting very thick in the Arctic with an increase in the Antarctic as well

Sea ice model coupling in CERA-SAT

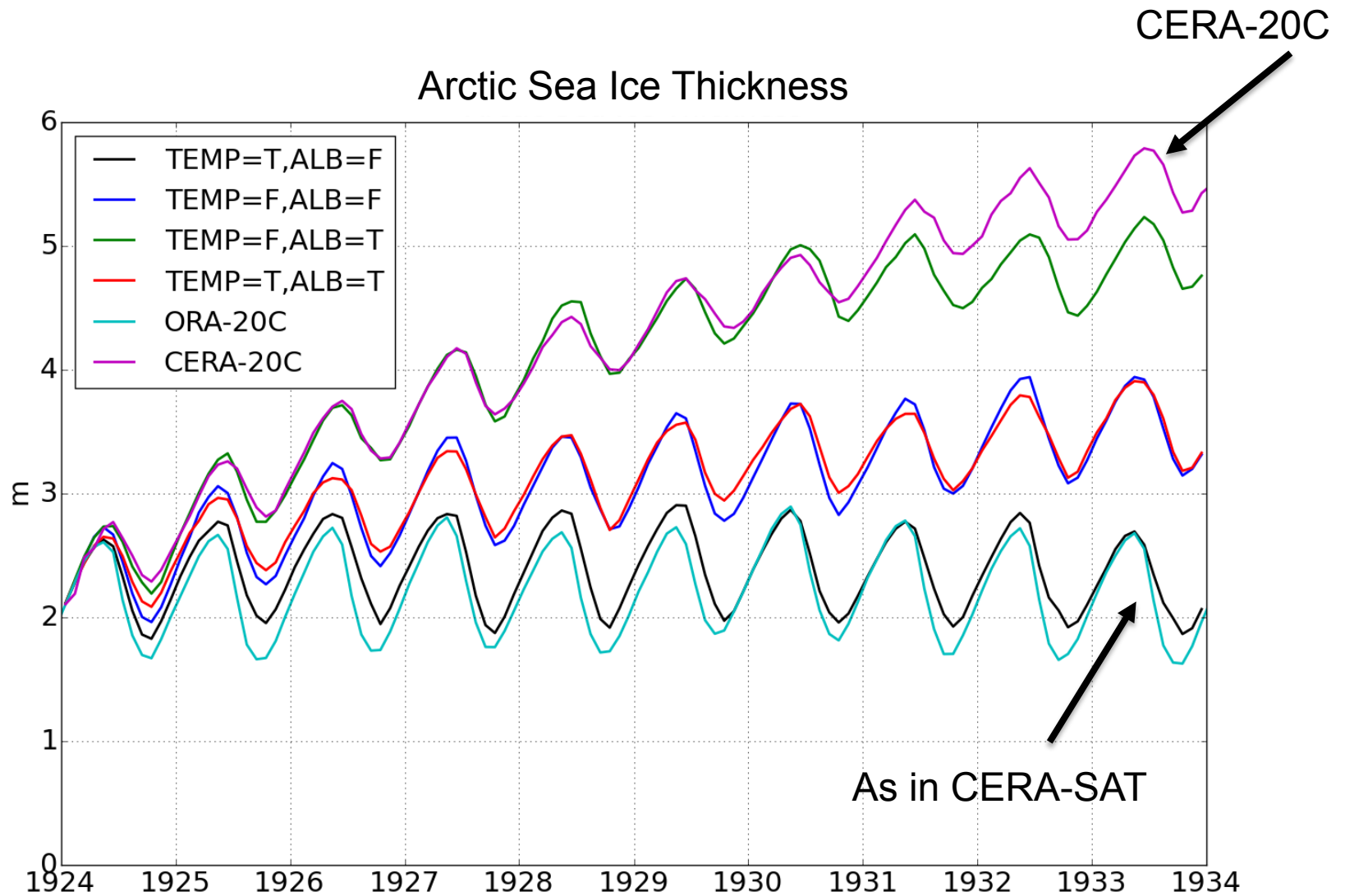


Figure courtesy of Eric de Boisseson

Sea surface anomaly (SLA) assimilation (I)

Sea surface height (CERA-SAT – ORAS5); Jan 22, 2012

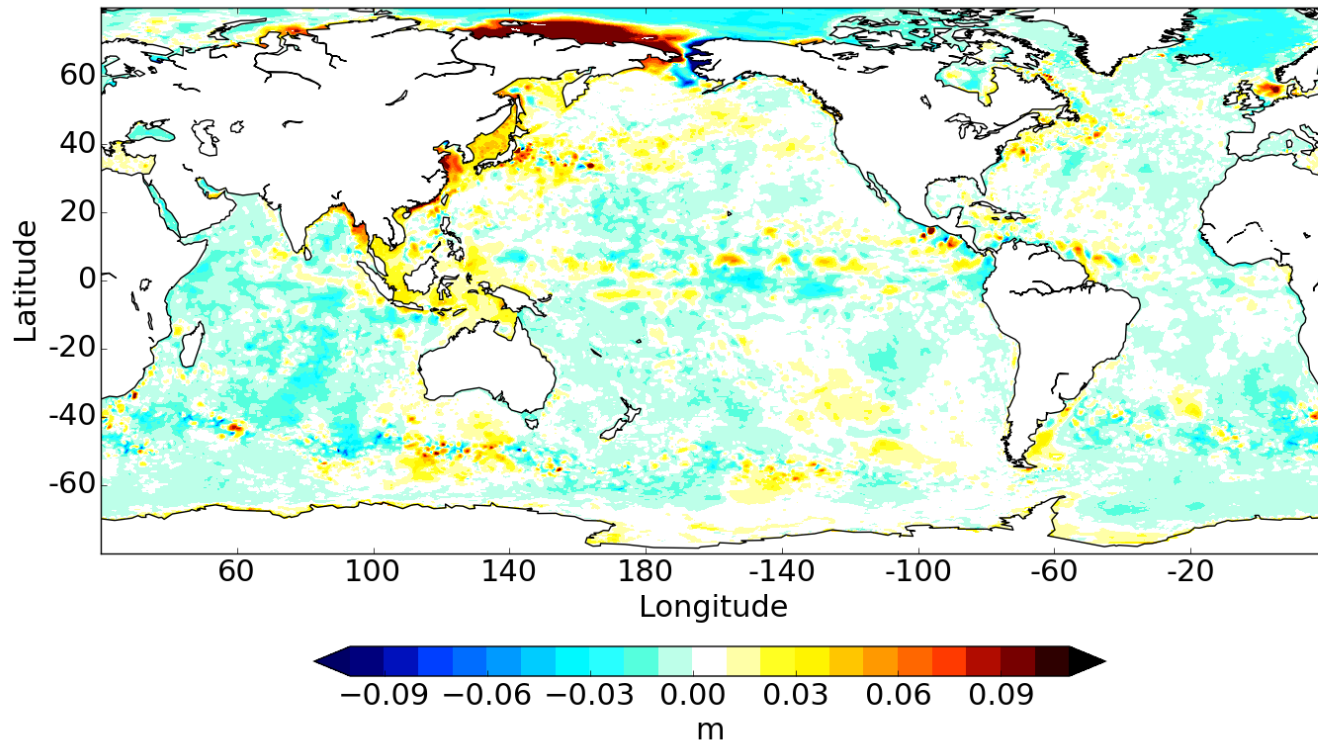


Figure courtesy of Eric de Boisseson

Sea surface anomaly (SLA) assimilation (II)

Sea surface salinity (CERA-SAT – ORAS5); Jan 22, 2012

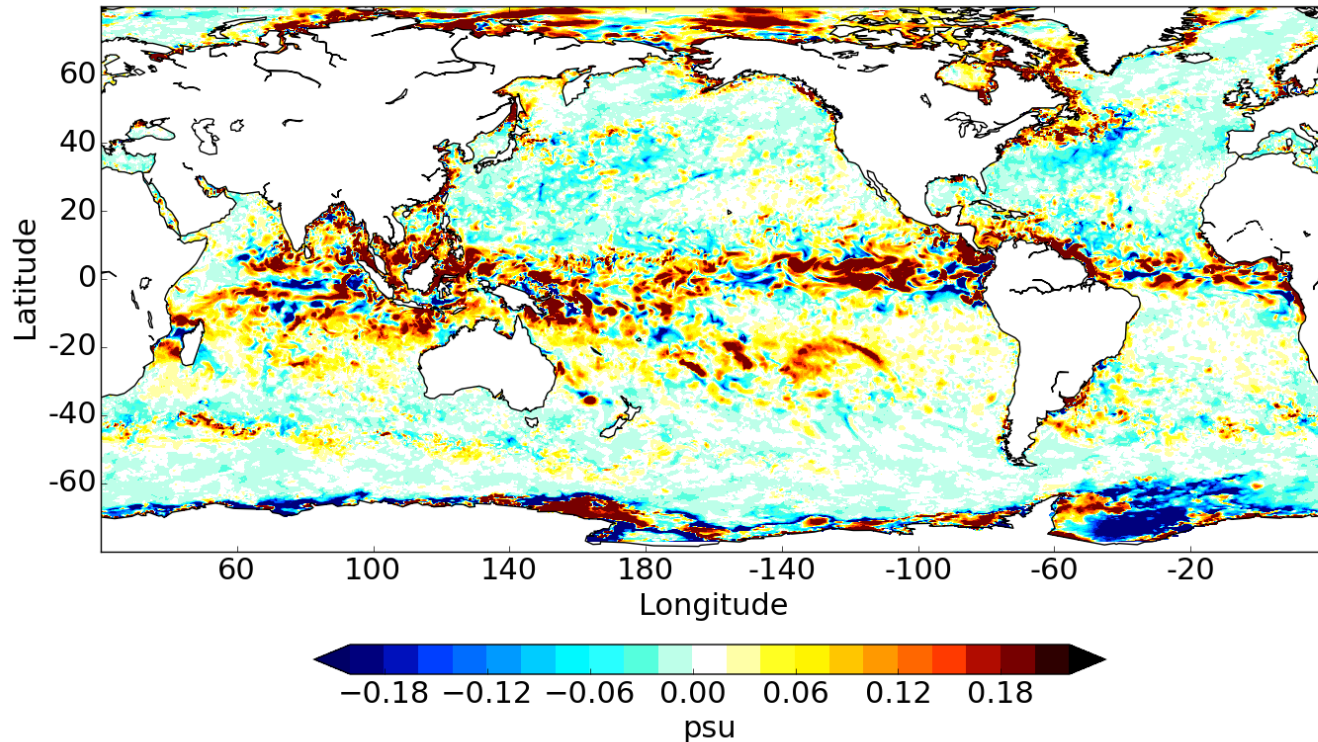


Figure courtesy of Eric de Boisseson

CERA-SAT land & wave



Model: IFS (CY42R1_esuite, April 2016)

Observation: SYNOP; ASCAT; NESDIS IMS

Assimilation: 2D-Optimal Interpolation (snow depth, screen level); SEKF (soil moisture)

Resolution: TL319

Analyses: Archived 3-hourly



Model: IFS (CY42R1_esuite, April 2016)

Observation: ERA5 observing system

Assimilation: 10-member ensemble hybrid DA; 24-hour window)

Resolution: 0.5 degree

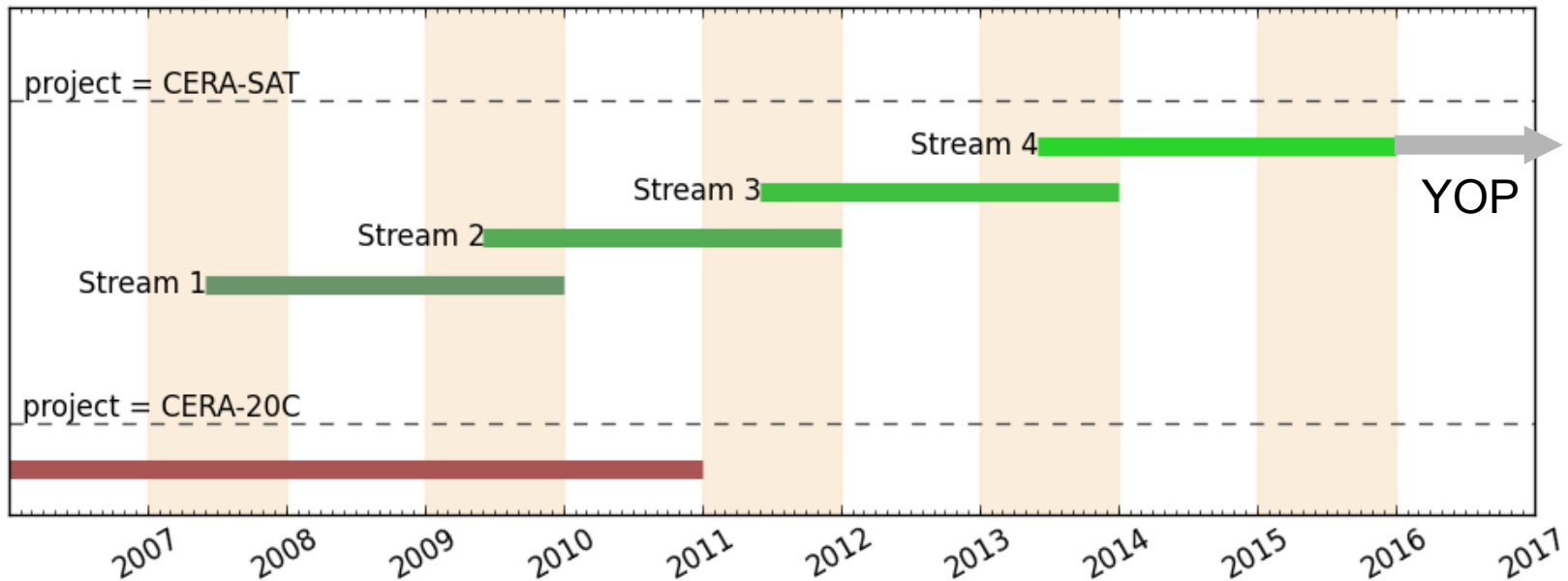
Analyses: Archived 3-hourly

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CERA-SAT Production

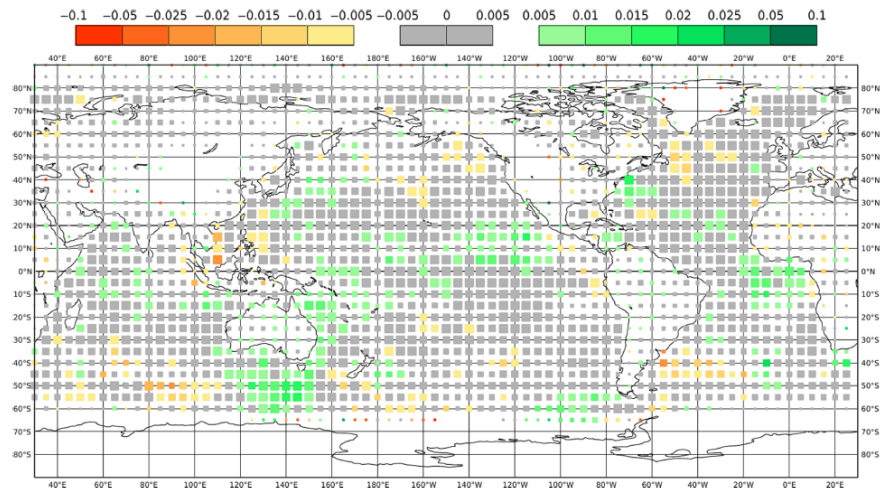
- Production started December 2016; Projected to finish July 2017
- 4 streams; 2.5+ years each (0.5+ year overlap)
- ~3 years overlap with CERA-20C, depending on spin-up



CERA-SAT Period covered: 2008 – 2016 + NRT extension (?)

Further Planning

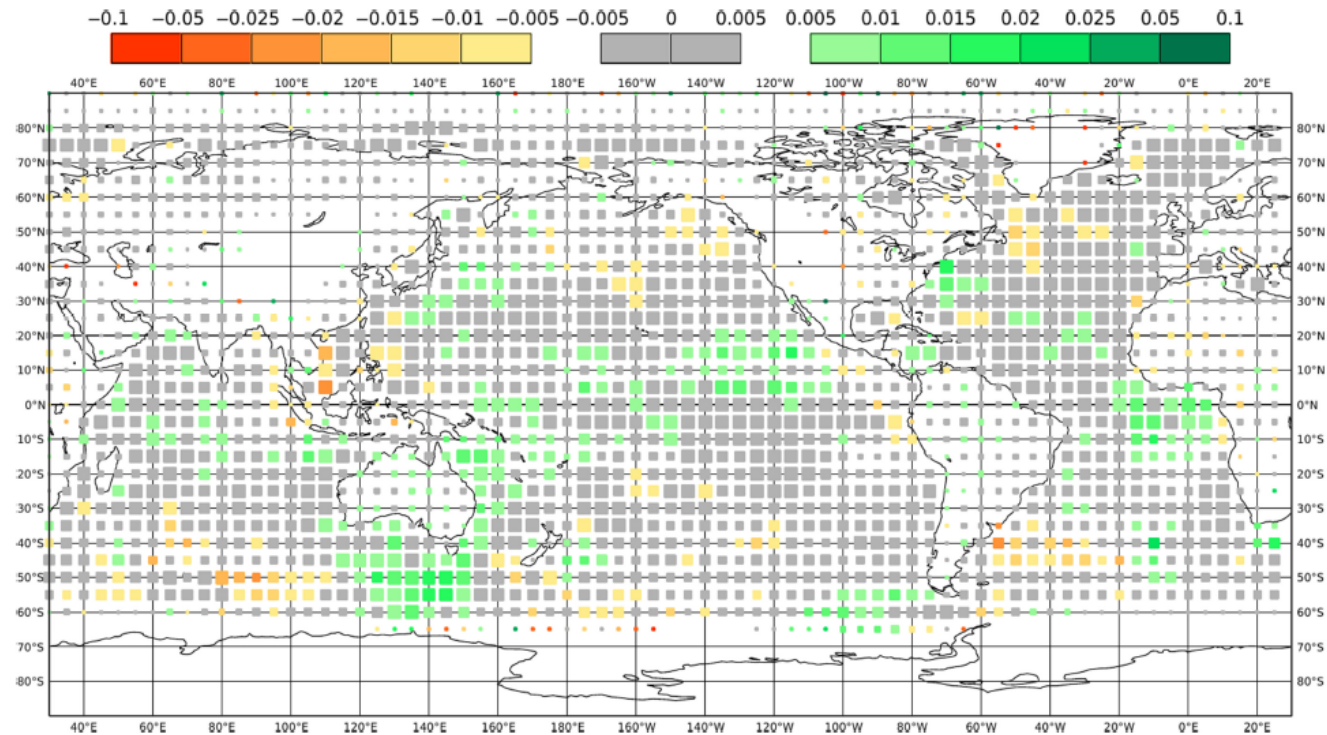
- Produce CERA-SAT
 - QA on the fly; if needed adapt the system
- Activities on satellite obs. assimilation in CERA-SAT
 - Investigate impact of coupling on assimilation of hyperspectral satellite instruments
 - Investigate the impact of the coupled SST field
 - Assessment of GSRO data reprocessed in ERA-CLIM2



Thank you.

Extra slides.

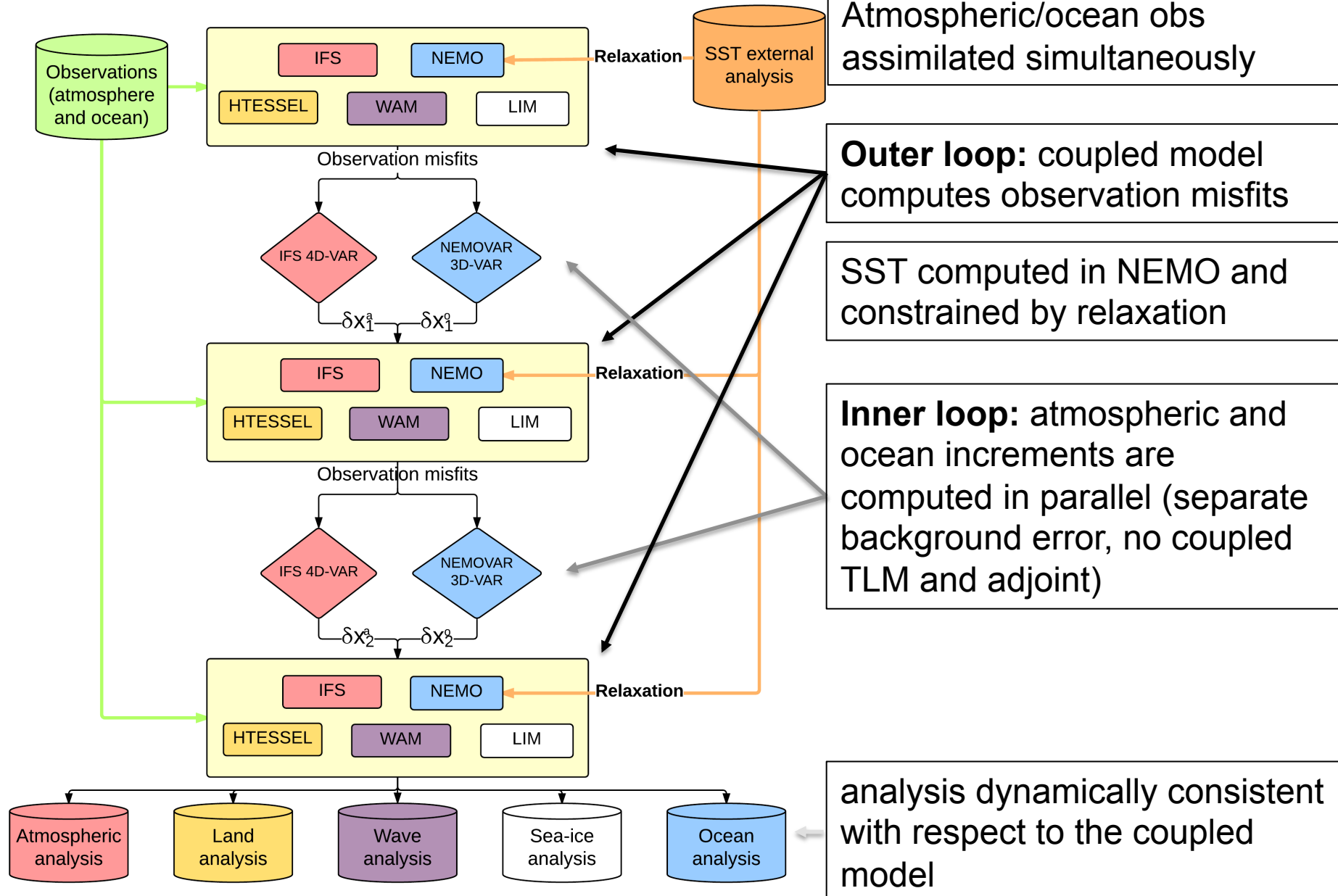
AMSU-A ch 5 – Background RMSE (UNCPL -CERA)



Background RMSE difference between the CERA system and the operational-like system with respect to AMSU-A channel 5 observations in September 2010.

Coupled atmosphere-ocean assimilation system (CERA)

Schematic for one assimilation cycle



CERA-SYSTEM

A Coupled system



EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

CERA CLIM2

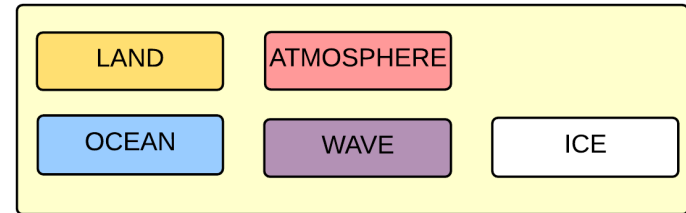
Earth system modelling at ECMWF

Diversity in coupling methodologies between the Earth system components

TYPE 1: fully integrated

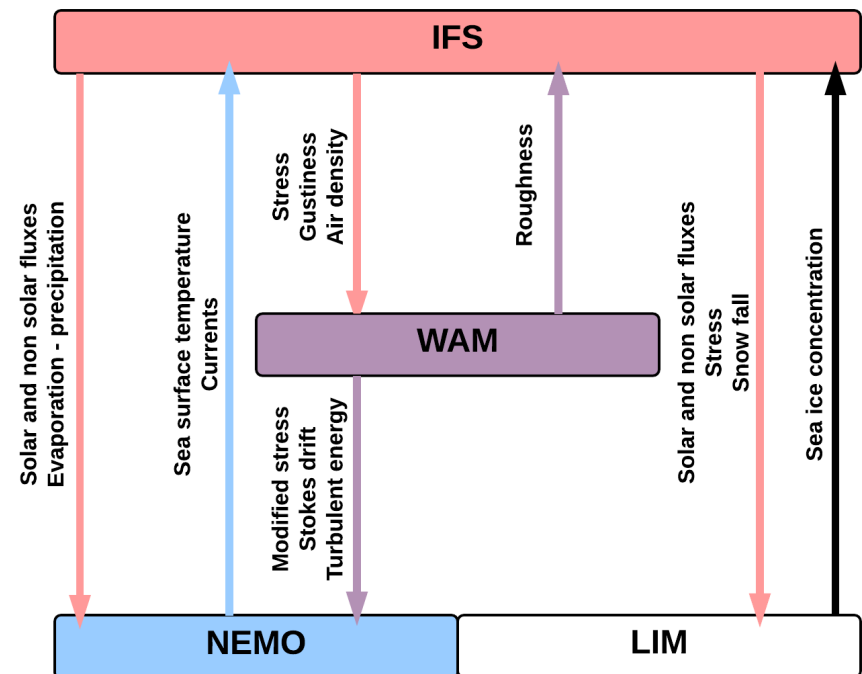
- atmosphere/composition
- composition rewritten for integration
- same grid and resolution

Medium, extended and long range



TYPE 2: single executable

- atmosphere/ocean/waves/sea ice
- sequential coupling
- different grids (interpolation)
- standalone models can be run off-line



TYPE 3: coupler

- information transferred by files
- not used anymore



CERA-20C: the first ECMWF coupled reanalysis of the 20th century



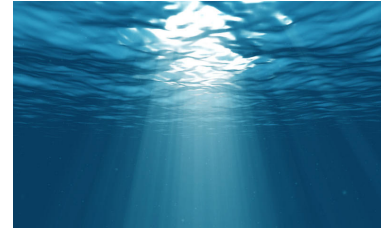
Atmosphere



Land



Wave



Ocean



Sea ice

Model: IFS/NEMO/LIM2 (CY41R2, Mar 2016)

Forcing: SST nudged (HADISST2)

Observation: surface conventional, salinity and temperature profiles

Assimilation: new CERA system (10-member ensemble coupled hybrid DA)

Resolution: T159L91/ORCA1 Z42

Period: 1901-2010

P. Laloyaux et al. A coupled data assimilation system for climate reanalysis. Quarterly Journal of the Royal Meteorological Society, 142(65-78), 2016.

CERA-SAT Progress and planning

CERA-SAT branch **Completed**

- cycle 42r1
- merge: Latest coupled model developments (E28 by Kristian)
- merge: DA coupling developments (CERA-20C inheritance)
- CERA-SAT prototype now running

CERA-SAT configuration **In progress**

- General verification
- Asses/implement 12hr vs 24hr 4DVAR (**Oct 2016 -**)

CERA-SAT production **Planned to start Jan 2017**

In summary

CERA-SAT

A pilot project for ocean-atmosphere coupled reanalysis of the satellite era is currently being developed within the ERA-CLIM2 project and will be produced at ECMWF next year.



EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

ERA-CLIM2

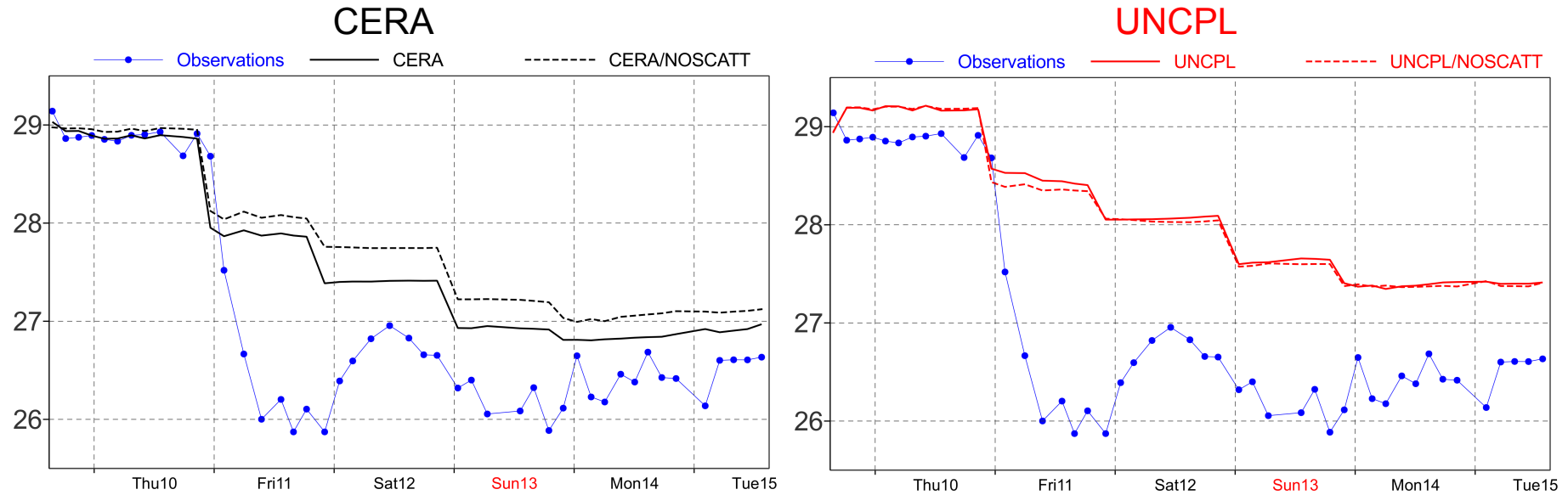
Outline

- ERA-CLIM2 – Coupled system – Century Reanalysis
- CERA-SAT –define against CERA-20C
 - Resolution upgrade
 - SLA assimilation
 - Sea ice assimilation (second try)
 - Full obs system as in ERA-5 (Also, diagnostics as per ERA5)
 - Current status - timeline
- Research plans:
 - Provide clean comparison coupled/uncoupled branches
 - 12hr vs 24 hr assimilation windows
 - Strong/weak constraint 4Dvar
 - [your input here]

Use of near surface measurements - Tropical cyclone

Phailin

Ocean temperature analysis at 40-meter depth (no scatterometer data in dashed)



- Crucial role of scatterometer data to estimate the ocean state in coupled assimilation
- Atmospheric observations have the potential to improve ocean analysis
- Fit to observations is not perfect (vertical resolution, nudge to a daily SST product)

Impact of scatterometer surface wind data in the ECMWF coupled assimilation system
P. Laloyaux, J-N Thépaut and D. Dee. MWR, 2016