CERA-SAT ocean component and further developments

Eric de Boisséson,
Dinand Schepers, Patrick Laloyaux, Per Dahlgren, Yuki Kosaka, Giovanna De Chiara, Marcin Chrust, Magdalena Balmaseda, Phil Browne, Patricia de Rosnay, Michael Mayer, Roberto Buizza

ECMWF

ERA CLIM2

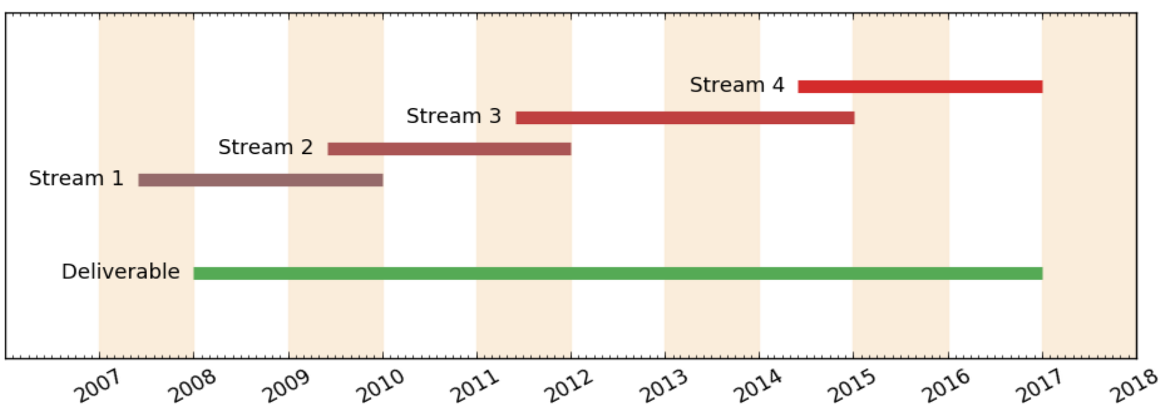
ERA-CLIM2 General Assembly, University of Bern 12-15 December 2017

Introduction

- From CERA-20C ocean to CERA-SAT ocean:

	CERA-20C	CERA-SAT
Resolution	ORCA1_Z42	ORCA025_Z75
Ocean IC	10 ensemble members from ORA-20C	2x5 ensemble members from ORAS5
Assimilation	EN4.0.2 T/S profiles	EN4.1 T/S profiles AVISO along-track SLA (using ORAS5 MDT) OSTIA sea-ice
SST relaxation	HadISST2.1.1 ¼ degree monthly	OSTIA 1/20 degree daily
Period	1901-2010	2008-2016

- CERA-SAT ocean has been produced in 4 separate streams (6-month overlap) that cover 2008-2016:

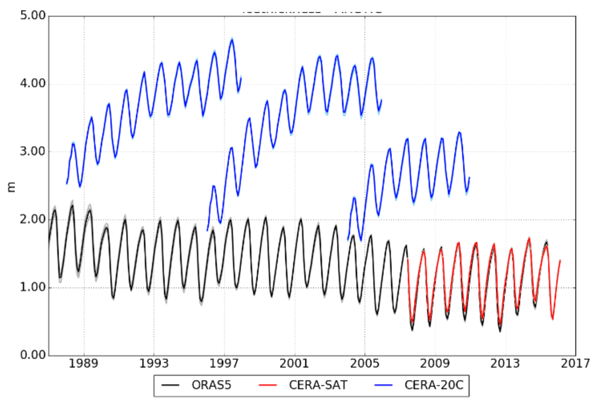


Courtesy of D. Schepers

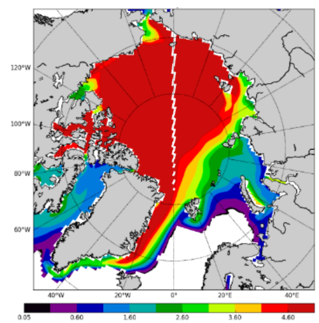
CERA-SAT ocean vs ORAS5

- The sea-ice issues in CERA-20C were “solved” in CERA-SAT: problems with settings for sea-ice albedo and temperature in coupled mode.

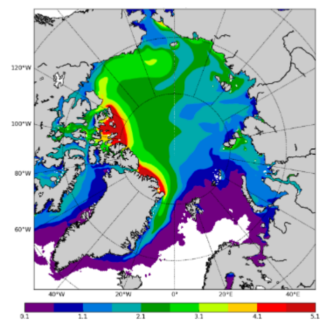
Arctic ice thickness



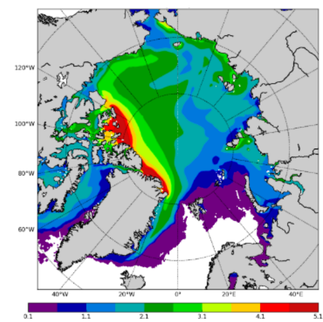
March 2002 ice thick. CERA-20C



March 2014 ice thick. CERA-SAT



March 2014 ice thick. ORA-S5

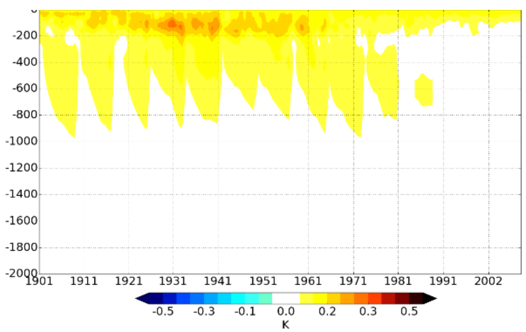


- Drift in sea-ice thickness seen in CERA-20C contained. No signs of sea-ice accumulation in the Arctic. CERA-SAT sea-ice similar to ORAS5 sea-ice.

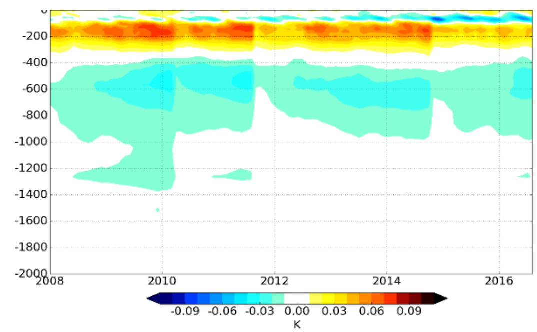
CERA-SAT ocean vs ORAS5

- CERA-SAT streams restart from ORA-S5 ICs. Like in CERA-20C, CERA-SAT is drifting from its baseline.

Temp. CERA-20C minus ORA-20C - Global

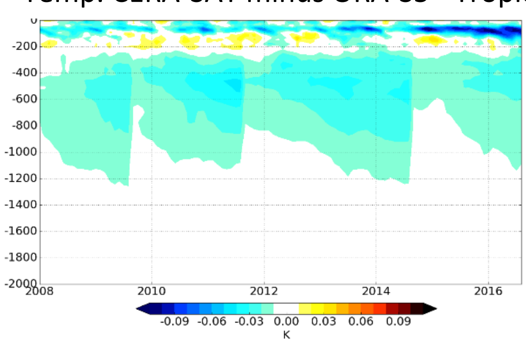


Temp. CERA-SAT minus ORA-S5 - Global

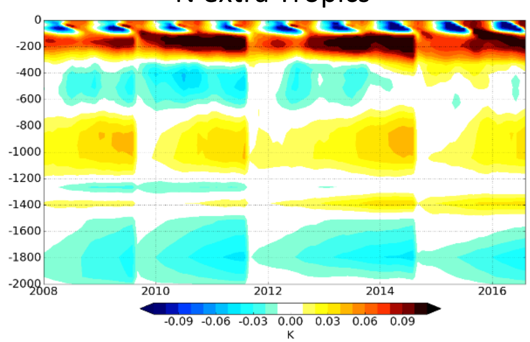


- CERA-20C was gaining heat wrt ORA-20C from the start of each stream. In CERA-SAT, differences are smaller, but things are less straightforward. Differences associated with stratification but also AMOC adjustment.

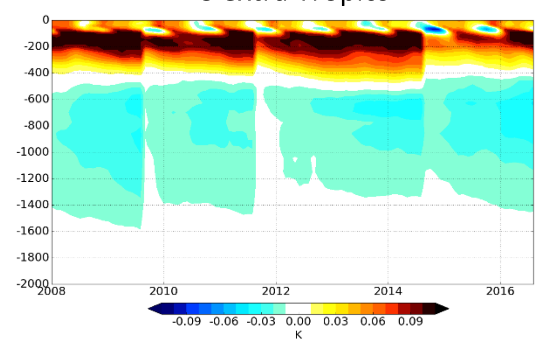
Temp. CERA-SAT minus ORA-S5 - Tropics



N extra Tropics

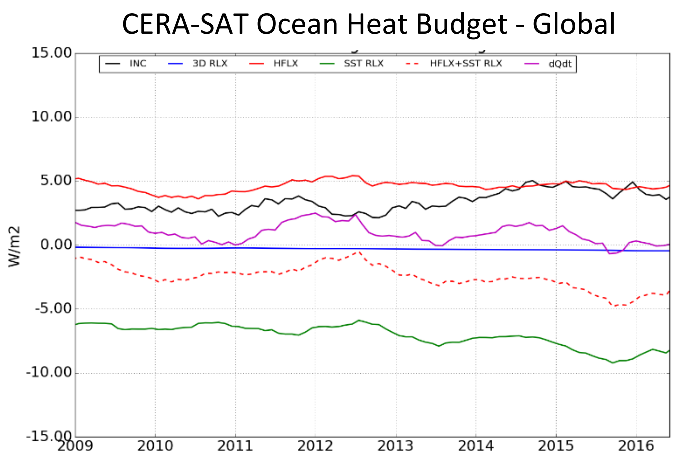


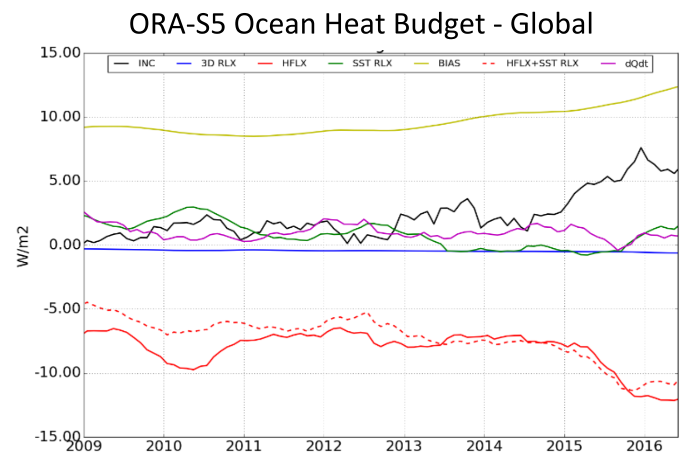
S extra Tropics



CERA-SAT ocean vs ORAS5

- Ocean heat budget analysis in CERA-SAT and ORA-S5





- In CERA-SAT, fluxes and increments tends to add heat to the ocean. The SST relaxation is cooling to stay close to OSTIA SST analysis.

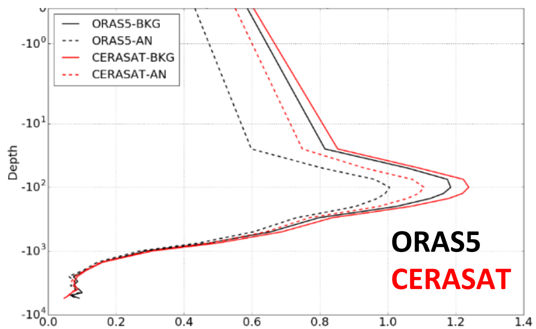
- Heat fluxes have opposite signs in CERA-SAT and ORA-S5. The contribution of the bias correction scheme in ORA-S5 is the largest and compensates for the large negative flux.

- Conclusions unclear. SST relaxation appropriate? Bias correction needed in CERA? (See Xiangbo's report)

CERA-SAT ocean vs ORAS5

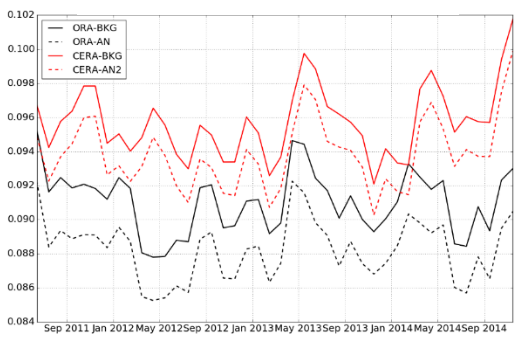
- Fit to observations:

RMS Temp vs profiles 2011-2014 - Global



- CERA-SAT does not fit profiles as well as ORAS5 in the upper ocean. Bias correction needed in CERA? Ocean assimilation settings to be revised in coupled mode?

RMS SSH vs satellite - Global



- The fit to altimeter is also slightly worse in CERA-SAT. Due to the use of uncoupled MDT for coupled run? The error is not growing though.

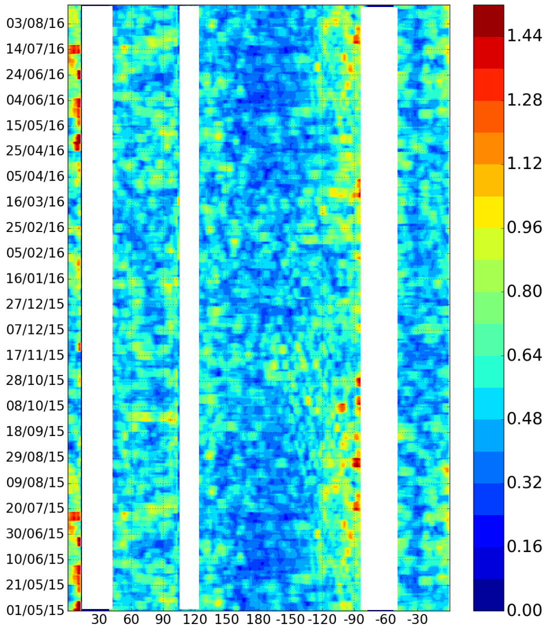
- The ocean assimilation in coupled mode needs revision when developing the next reanalysis based on CERA if we want to match ocean-only performances.

Coupled vs uncoupled spread

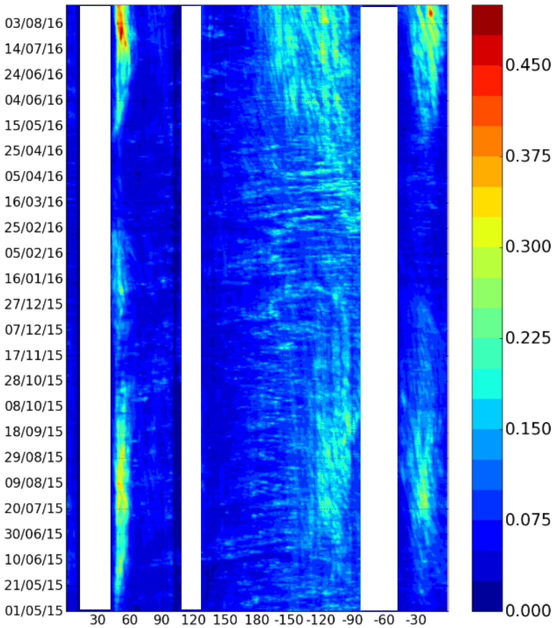
- In an uncoupled atmospheric reanalysis such as ERA5, the spread at the air-sea interface is generated by the scheme developed by Hirahara et al. (2016) that applies perturbations to SST and sea-ice using information from different reanalysis products. The spread is static.

- In CERA, the spread at the air-sea interface is flow-dependent resulting from the atmospheric EDA and the perturbations applied to the ocean.

SST spread 5S-5N – Uncoupled CERA-SAT



SST spread 5S-5N – CERA-SAT



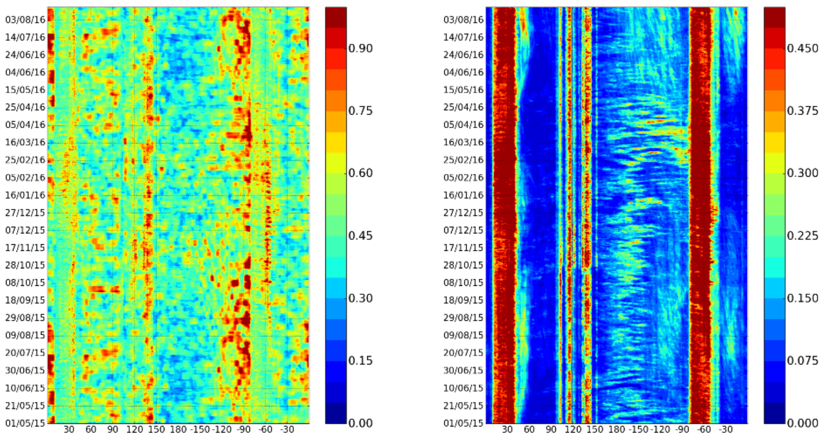
- The spread is larger in the uncoupled reanalysis. But the CERA-SAT spread is able to capture fine physical features associated to ENSO variability and TIWs

Coupled vs uncoupled spread

- The SST spread directly impacts the atmospheric variable that are closely associated

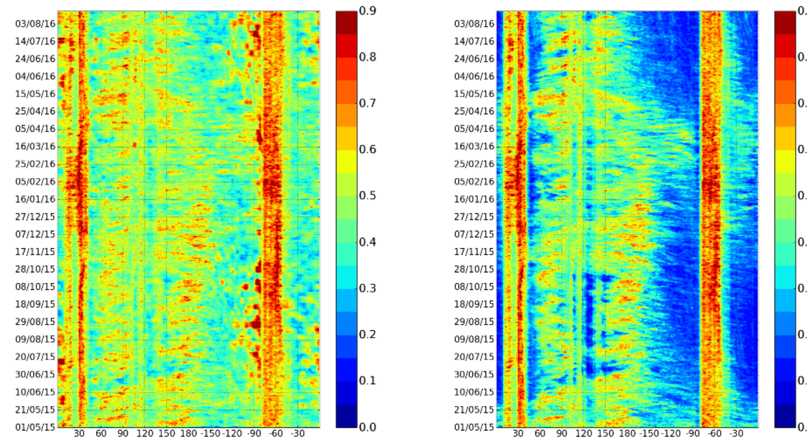
SKT spread 5S-5N

Uncoupled   CERA-SAT



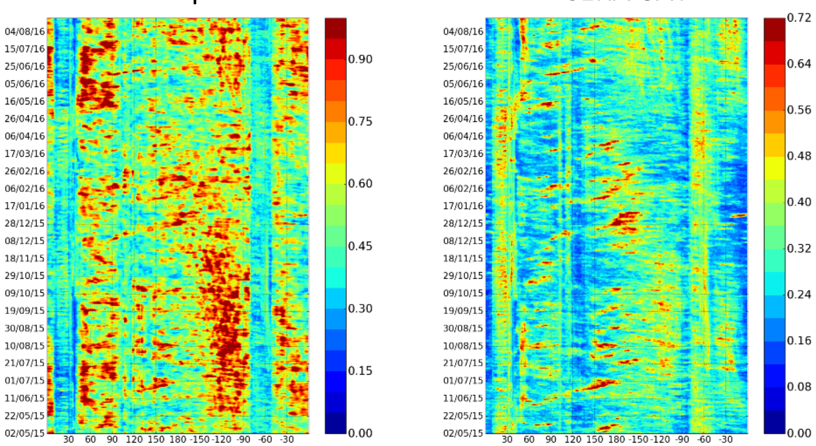
2T spread 5S-5N

Uncoupled   CERA-SAT



Evaporation spread 5S-5N

Uncoupled   CERA-SAT

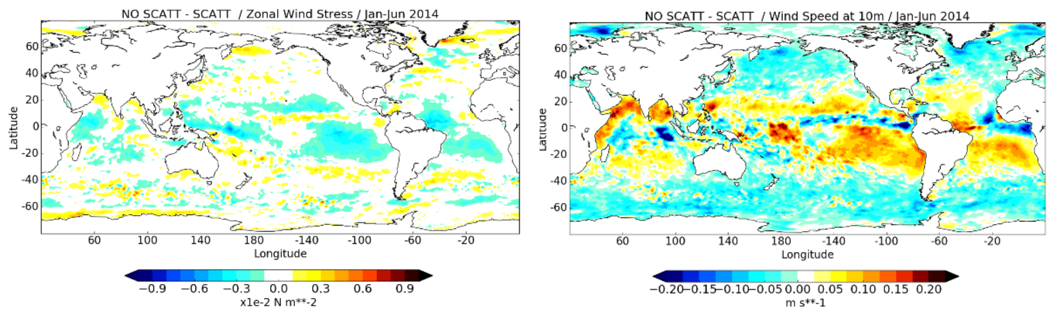


- The extent to which this impacts higher atmospheric levels and winds remains to be investigated as no direct impact is as obvious as for the parameters shown here...

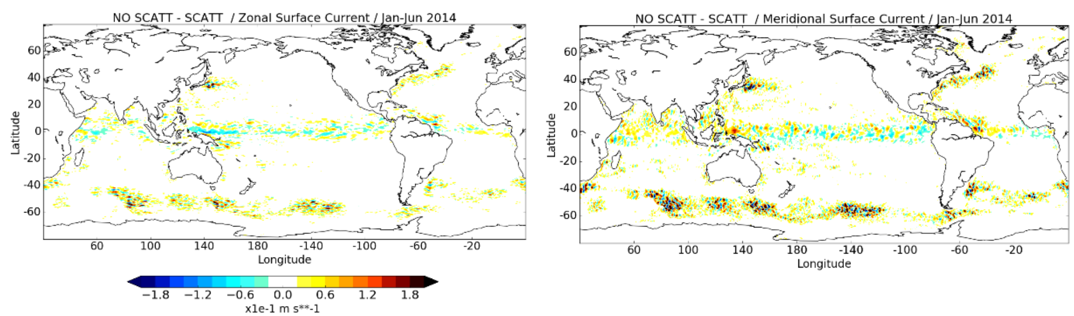
Impact of scatterometer data on the ocean

- Case study on the impact of assimilating scatterometer data in CERA-SAT:

Impact on surface winds



Impact on surface currents



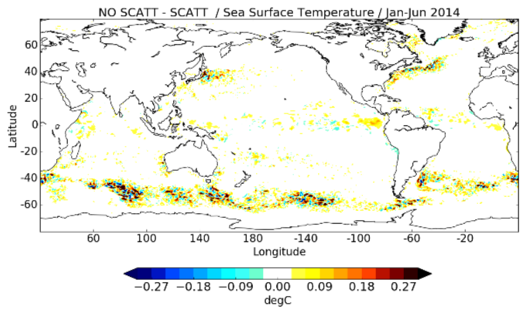
- Direct impact on the momentum forcing over the ocean. Ocean currents response.

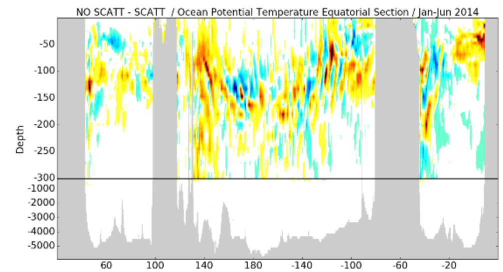
Courtesy of G. De Chiara

Impact of scatterometer data on the ocean

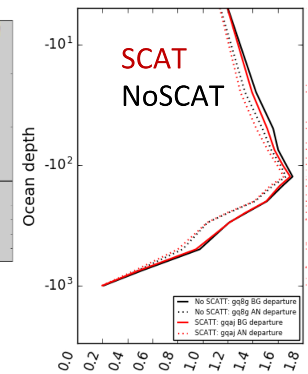
- Case study on the impact of assimilating scatterometer data in CERA-SAT:

Impact on ocean temperature

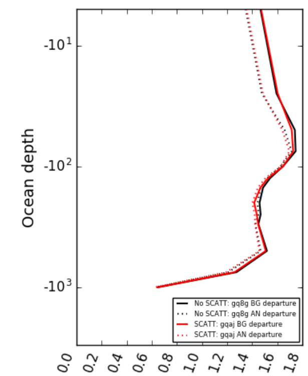




NW Pacific

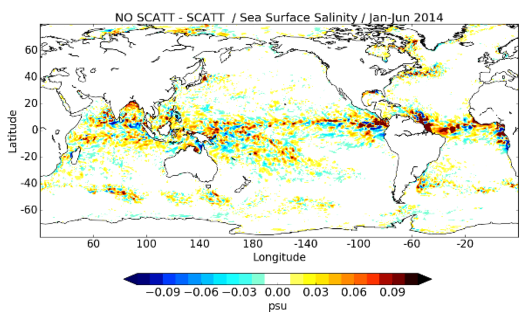


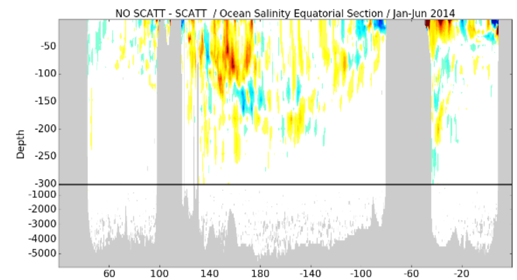
NW Atlantic



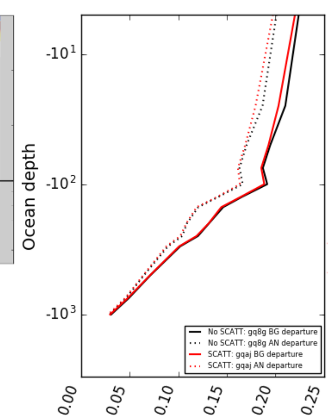
Impact on ocean salinity

SSS

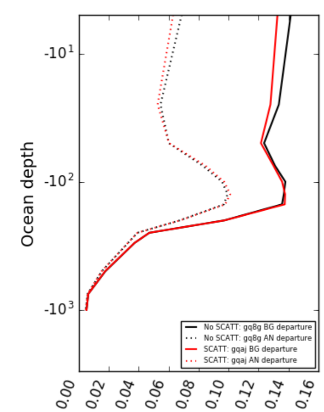




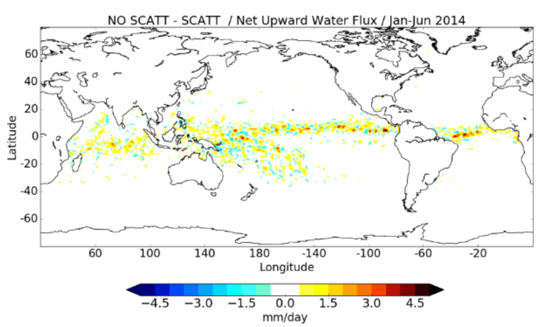
NW Pacific



Nino 3.4



E-P

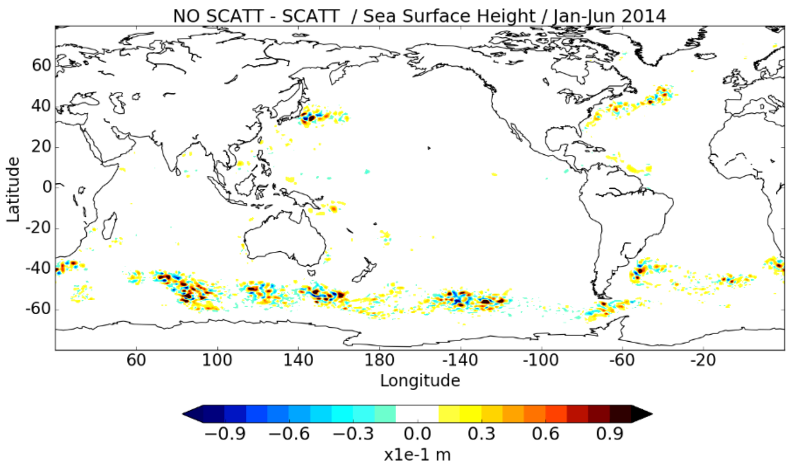


Courtesy of G. De Chiara

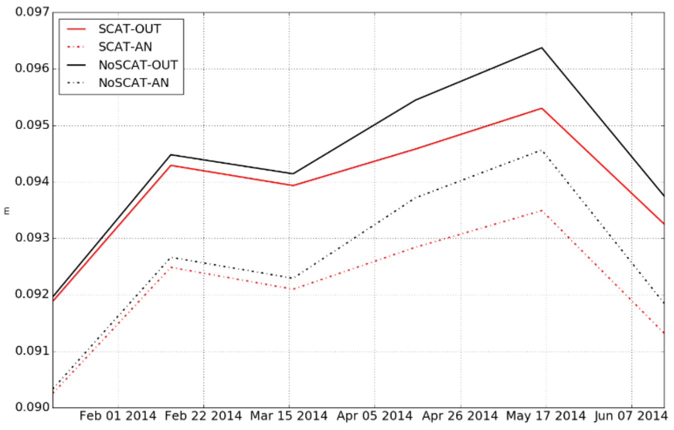
Impact of scatterometer data on the ocean

- Case study on the impact of assimilating scatterometer data in CERA-SAT:

Impact on sea level



Fit to altimeter – 50S-50N



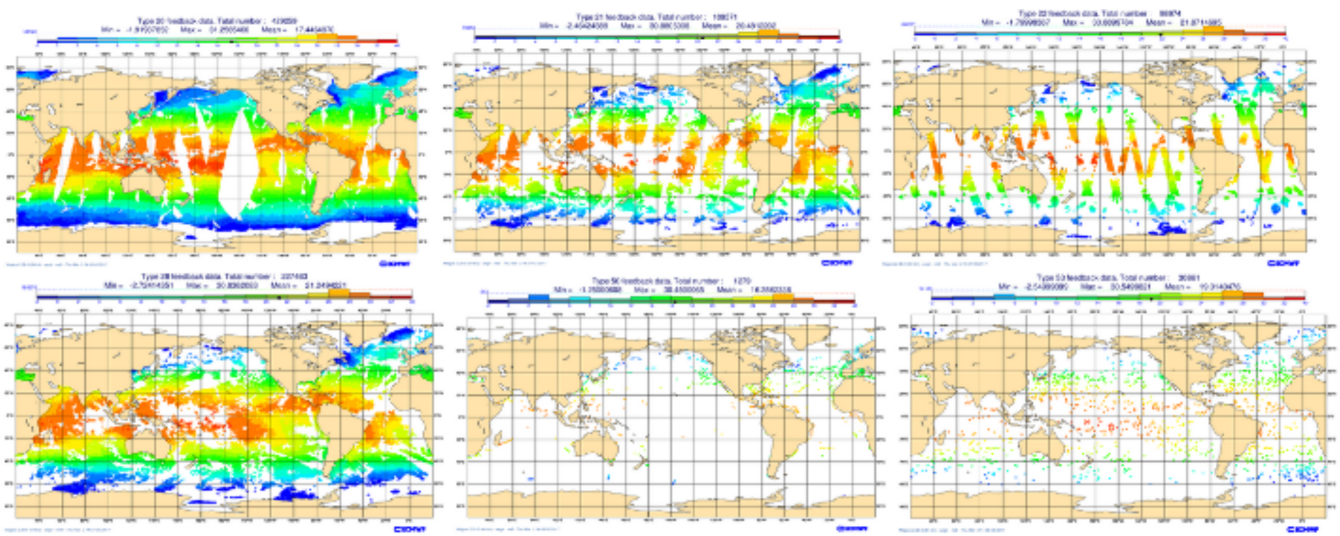
- Assimilating or not scatterometer impacts ocean parameters and the ability of the system to fit observations. Scatterometer data helps with the assimilation of T/S profiles and altimeter SLA

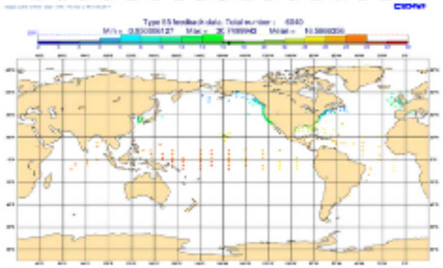
- On-going study that will further investigate the impact of scatterometer observations in the coupled system.

Courtesy of G. De Chiara

Future developments: SST assimilation

- Implementation of developments from project partners into the reanalysis system
- Assimilation of SST: using UKMO framework to replace the current SST relaxation scheme
- Test dataset provided by UKMO: one year of bias-corrected SST in-situ and satellite observations





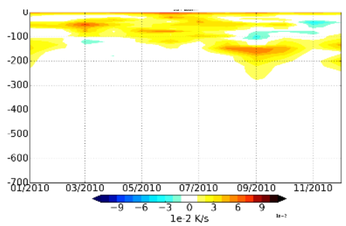
- Data from AMSRE, NOAA-AVHRR, AATSR, METOP-AVHRR, AMSR2, ships, drifters and moored buoys ~ 8e5 obs/day (3e4 for the profiles)

Future developments: SST assimilation

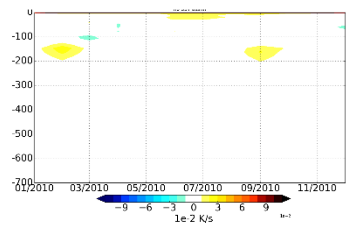
- Testing of the MLD parameterisation for the vertical correlation lengthscale to propagate the increment due to SST observations down to the thermocline

- Sensitivity tests with SST observation error sdv and thinning

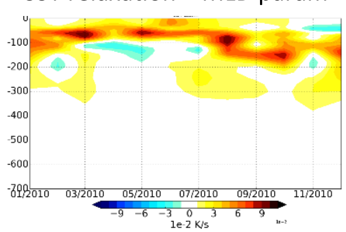
SST relaxation - std vert. lengthscales



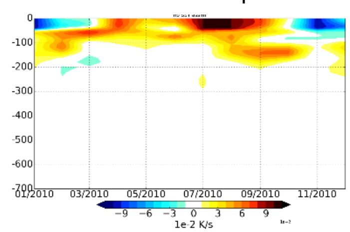
SST assim - std vert. lengthscales



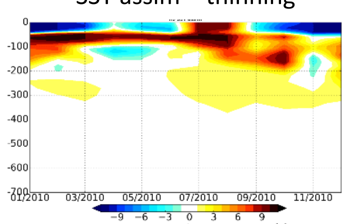
SST relaxation – MLD param



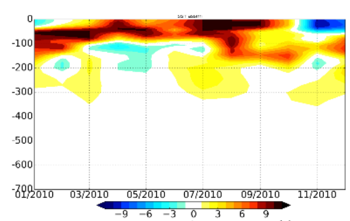
SST assim – MLD param



SST assim – thinning



SST assim – thin + OE increase



- MLD param allows the propagation of the T incr. down to the thermocline

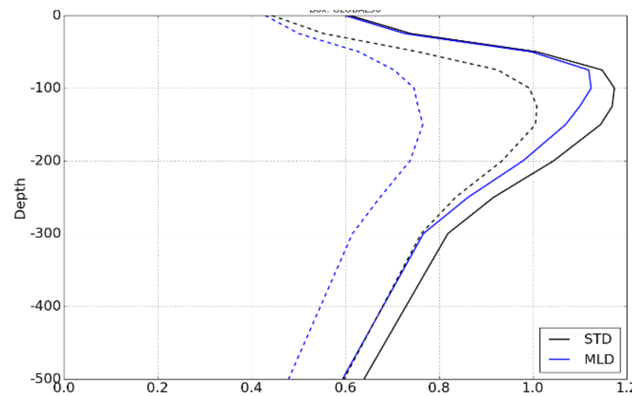
- Further thinning and increased SST OE reduce the weight given to SST obs. wrt to profiles

Future developments: SST assimilation

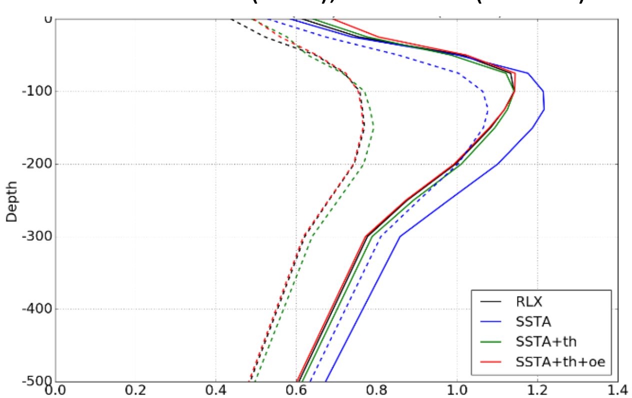
Fit to profile observations Jan-May 2010 – 50S-50N

- SST relaxation: fit to profiles greatly improved with MLD param. But much more expensive.

SST relaxation - std vert. lengthscales vs MLD param
BKG RMSE (solid), AN RMSE (dashed)



SST assim – MLD param
BKG RMSE (solid), AN RMSE (dashed)



- SST assim with MLD param: assimilating all the data improves the bkg in the first levels but degrades the fit in the thermocline and at depth. Thinning and increasing the OE sdv for SST help reducing the degradation at depth but first levels still worse.

- First results encouraging. Work still ongoing to find the best configuration: convergence, MLD param, OE, bias correction…

Conclusion

- CERA-SAT provides a ¼ degree 10-member ensemble of ocean reanalysis produced by a coupled system over 2008-2016

- CERA-SAT is being routinely compared to the ORA-S5 ocean-only reanalysis in terms of ocean parameters and fit to observations.

- Insights on potential improvements, impact of coupled/forced approaches

- The CERA-SAT framework is being used at ECMWF for observation studies in a coupled analysis system: example of scatterometer data

- CERA-SAT is only a milestone in the development of an Earth system approach to NWP and reanalysis: coupled system adapted for high-resolution NWP, baseline for ERA6…

- Crucial developments such as the assimilation of SST data are being tested for future implementation