

The Coupled Earth Reanalysis system [CERA]

Patrick Laloux

Acknowledgments: Eric de Boisséson, Magdalena Balmaseda, Dick Dee, Peter Janssen, Kristian Mogensen, Jean-Noël Thépaut and Reanalysis Section

November 19, 2014



- 1 Operational ECMWF reanalysis system
- 2 Coupled earth reanalysis system
- 3 Assessment of the performance
- 4 Test run for CERA20C
- 5 Conclusions and future steps

1 Operational ECMWF reanalysis system

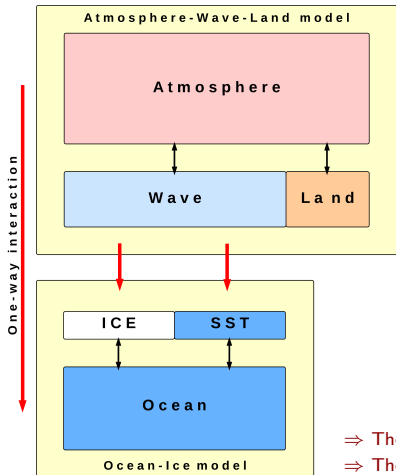
2 Coupled earth reanalysis system

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Uncoupled assimilation system



Atmospheric reanalysis [ERA-INTERIM]:
consistent with the atmospheric-wave-land model
air-sea interface is prescribed

Ocean reanalysis [ORAS4]:
consistent with the ocean-ice model
forced by the atmospheric reanalysis

- ⇒ The atmos reanalysis has a limited effect on the ocean reanalysis
- ⇒ The ocean reanalysis has no effect on the atmos reanalysis

Observations considered in reanalysis production

Extended Climate Reanalysis

Ocean observation type	Ocean variable
CTD/ARGO/Moorings	Temperature Salinity
XBT	Temperature
HADISST2	Sea surface temperature

Atmospheric observation type	Atmospheric variable
Weather stations	Surface pressure
Ships and buoys	Surface pressure 10m wind direction/force

Wave observation type	Wave variable
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Land observation type	Land variable
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Satellite Era Reanalysis

Ocean observation type	Ocean variable
CTD/ARGO/Moorings	Temperature Salinity
XBT	Temperature
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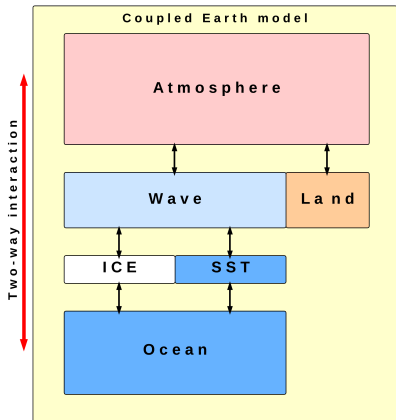
Atmospheric observation type	Atmospheric variable
Weather stations	Surface pressure
Ships and buoys	Surface pressure 10m wind direction/force
Radiosondes and profilers	upper air wind direction/force upper air temperature Specific humidity
Aircraft report	Upper air wind direction/force Temperature
Satellite sounding	Radiance Radio occultation bending angle 10m wind direction/force Atmospheric motion winds

Wave observation type	Wave variable
Altimeters	Wave height

Land observation type	Land variable
Weather stations	2m Temperature 2m relative humidity Snow depth
Satellite sounding	Snow cover

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CERA system



Coupled earth model:

1-hour atmosphere-ocean coupling frequency

Atmosphere: 1.125° with 137 levels

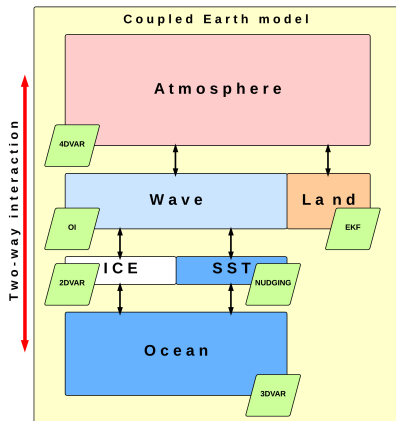
Ocean: 1° with 42 levels (first layer of 10 meters)

Atmospheric and Ocean reanalysis:

consistent with the coupled earth model

consistent air-sea interface

CERA system



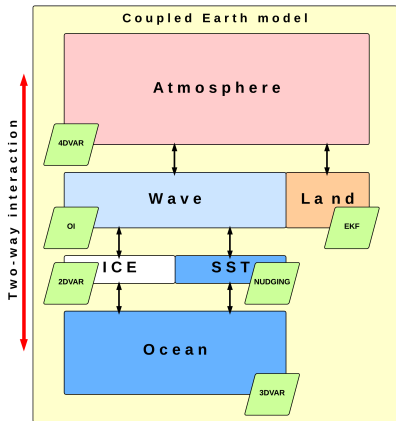
Sequential approach:

A common 24-hour assimilation window
observation misfits computed by the coupled model
Increments computed separately

Two outer iterations in 4DVAR and 3DVAR:

ocean-atmosphere correlations in the assimilation cycle

CERA system

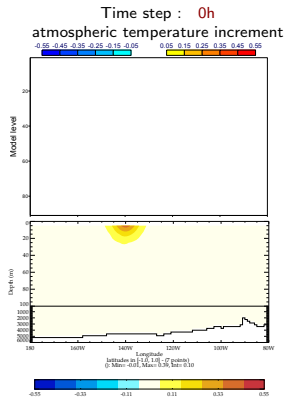


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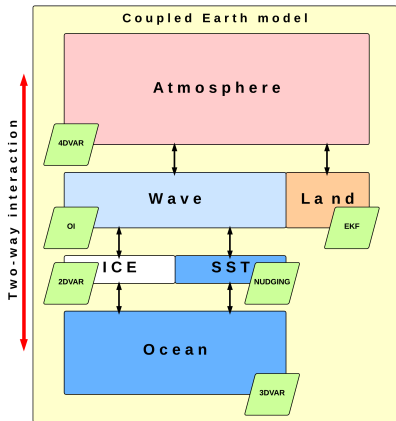
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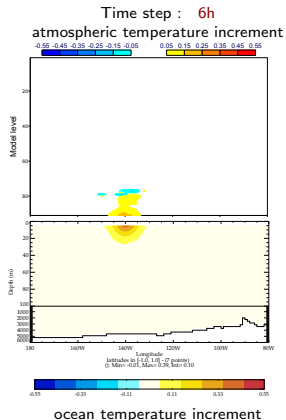


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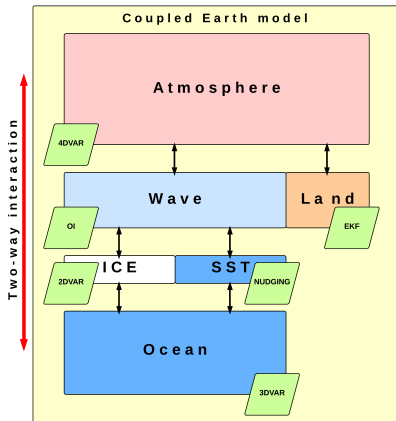
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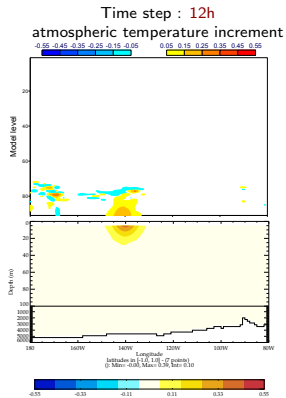


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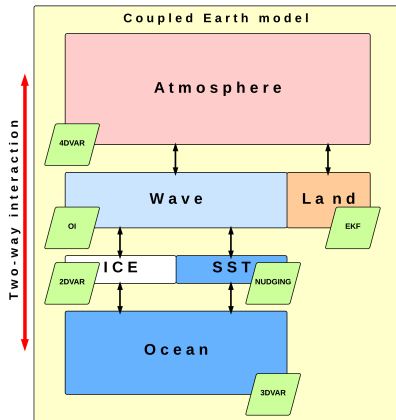
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CERA system

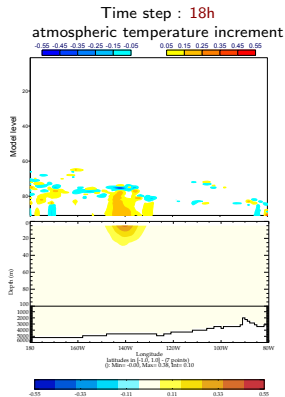


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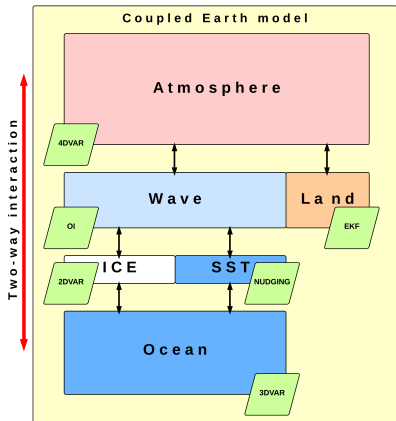
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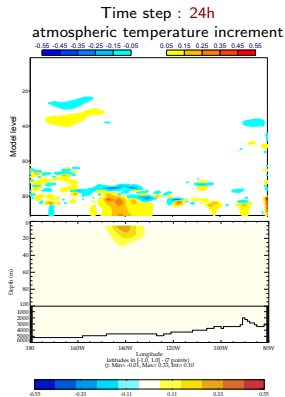


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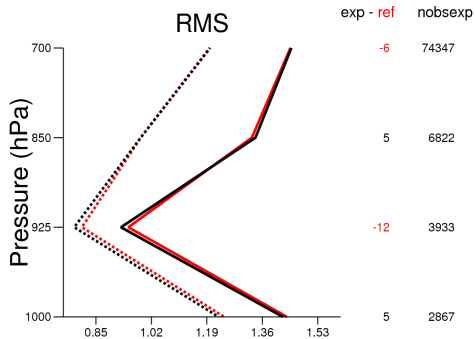
Two outer iterations in 4DVAR and 3DVAR:

ocean-atmosphere correlations in the assimilation cycle



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Performance of the CERA system in the Tropics for September 2010



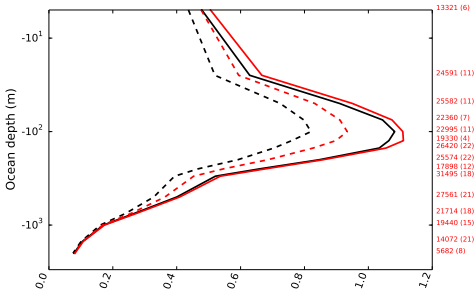
CERA system & Uncoupled assimilation system

Same resolution and code version

Temperature analysis RMSE (dashed lines)

Temperature background RMSE (solid lines)

⇒ Improved fit to radiosonde observations
(selected above ocean and coast)



⇒ Improved fit to buoy and probe observations

Impact of scatterometer data (10-meter wind observations) during the typhoon Phailin

The second-strongest tropical cyclone in India

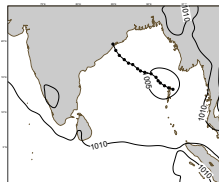
formed: 4 October 2013

dissipated: 14 October 2013

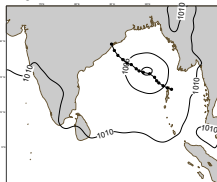
damage: \$696 million

fatalities: 45

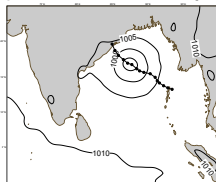
CERA analysis for mean sea level pressure over the bay of Bengal



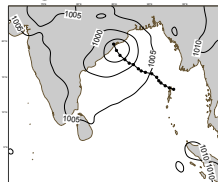
09 October 2013



10 October 2013



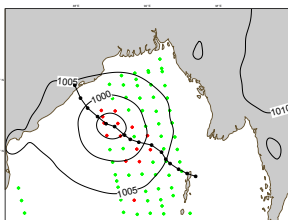
11 October 2013



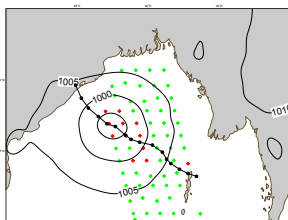
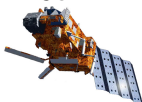
12 October 2013

Ascending pass on the 11 October 2013

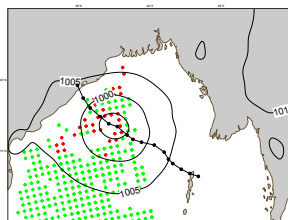
ASCAT-A



ASCAT-B



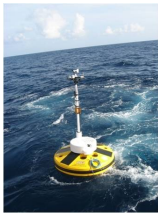
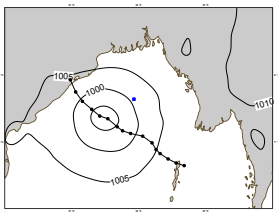
OSCAT



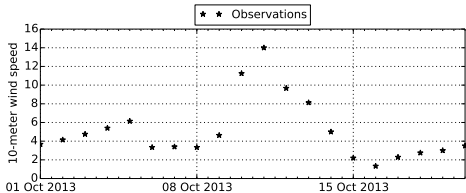
Wind observations assimilated by the CERA system

Wind observations rejected (first guess departure too large)

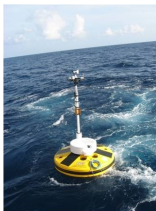
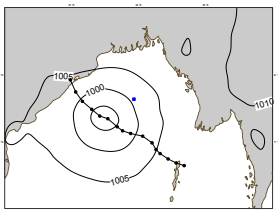
Impact of scatterometer data on 10-meter winds



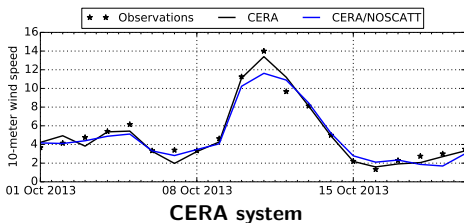
6 observations per day:
wind speed
wind direction



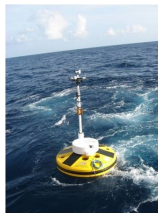
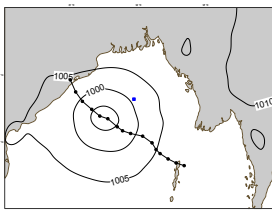
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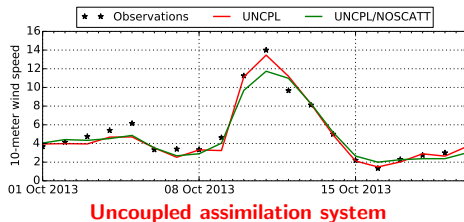
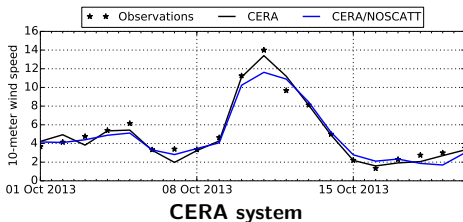
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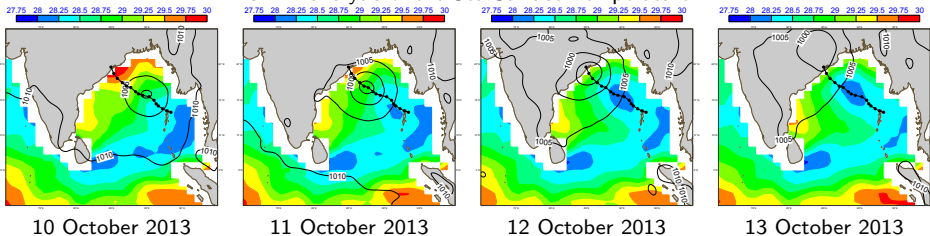


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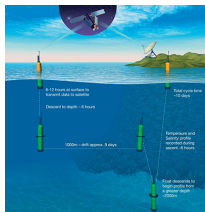
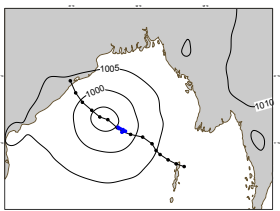
⇒ Positive and similar impacts of scatterometer data on atmospheric 10-meter winds

CERA analysis of the Sea Surface Temperature

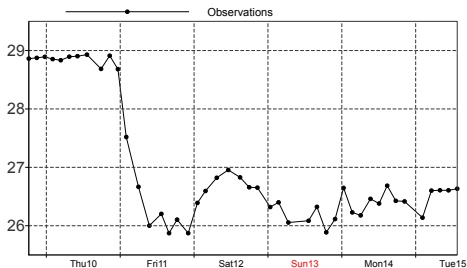


The CERA system (1°) produces the cold wake after the tropical cyclone

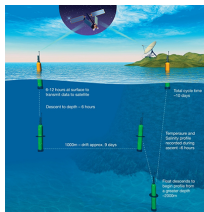
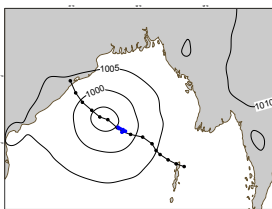
Impact of scatterometer data on ocean temperature at 40-meter depth



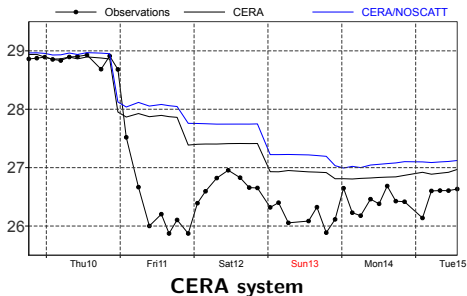
From a 10-day frequency (0-2000m)
to a 3-hour frequency (0-300m)



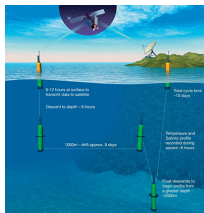
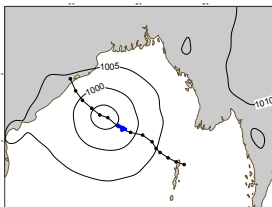
Impact of scatterometer data on ocean temperature at 40-meter depth



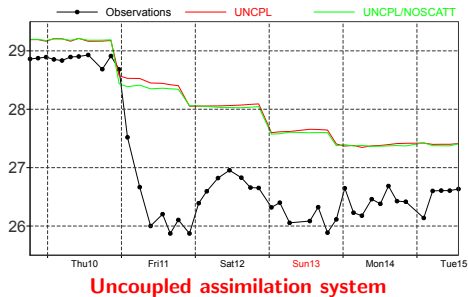
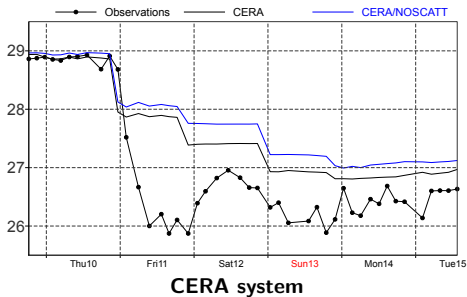
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Impact of scatterometer data on ocean temperature at 40-meter depth



From a 10-day frequency (0-2000m) to a 3-hour frequency (0-300m)



⇒ Positive impact of scatterometer data at 40-meter depth in the CERA system...
...but not perfect (10-meter layers, nudge to a daily SST product)

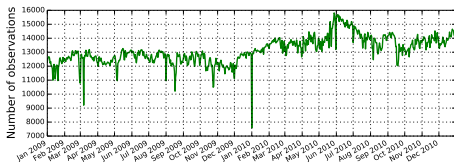
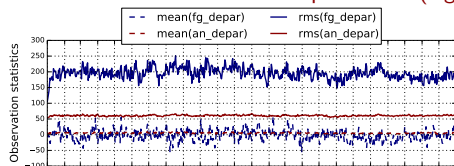
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Configuration:

- 1°CERA system
- assimilation of 10-meter winds, mspl, temperature and salinity profiles
- HadISST2 for the SST nudging
- from 1900 to 2010

Test run over 2 years (2009-2010) providing forcing fields for offline CARBON reanalyses

Tools to monitor the CERA20C production (e.g. mspl statistics from buoys)



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The CERA system:

- improves the fit to atmospheric and ocean temperature observations in the Tropics
- represents better the air-sea interaction during a typhoon
- encouraging results for the production of coupled reanalysis

Future steps:

- Cray migration
- Upgrade IFS to cycle 41R1
- Increase ocean vertical resolution
- Start production of CERA20C