Strongly coupled data assimilation with the coupled ocean-atmosphere model AWI-CM: comparison with the weakly coupled data assimilation

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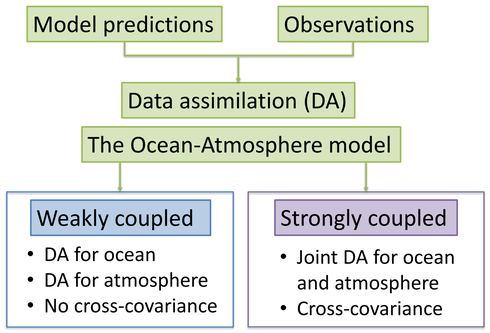
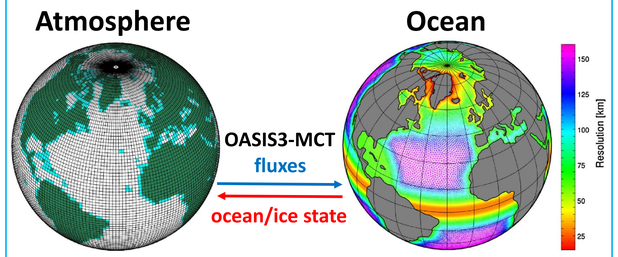
Overview



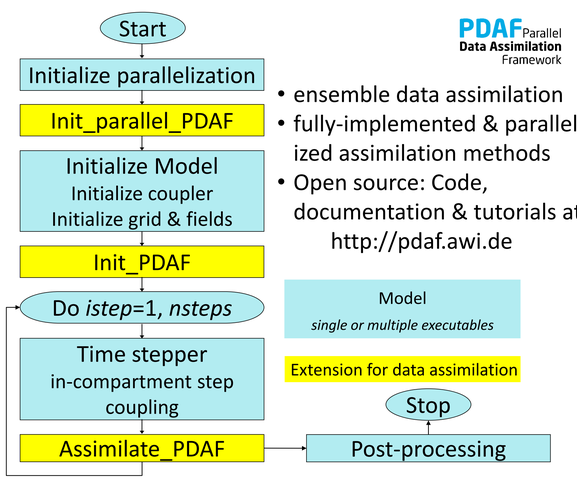
Coupled model: AWI-CM 1.4



- ECHAM6
- JSBACH land surface
- FESOM1.4
- includes sea ice

Coupler library: OASIS3-MCT
Two separate executables for atmosphere and ocean
D. Sidorenko et al., Clim. Dyn. 44 (2015) 757

Data assimilation with PDAF

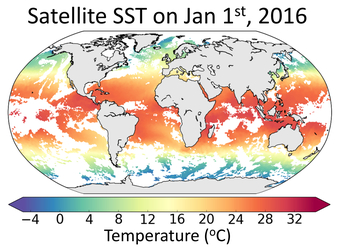


PDAF Parallel Data Assimilation Framework

- ensemble data assimilation
- fully-implemented & parallel-ized assimilation methods
- Open source: Code, documentation & tutorials at http://pdaf.awi.de

Observations

Sea surface temperature



- Satellite SST from EU Copernicus, level 3
- Daily data with data gaps due to clouds
- Original 0.1° X 0.1°, interpolated to unstructured ocean model grid

Numerical experiments

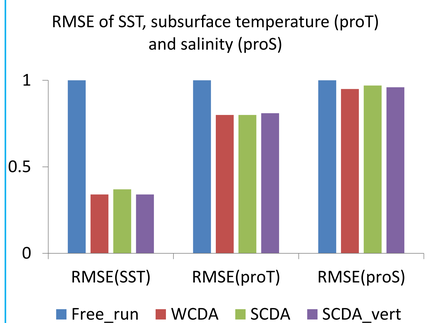
AWI-CM Model Setup

- Model resolution: 20-160 km for FESOM and T63L47 for ECHAM6
- Time step: 900s for FESOM, 400s for ECHAM6, coupling interval 1 hour

Data assimilation experiments

- Initial state and exchange fluxes: from long-term historical run
- Observation error: 0.5 °C
- Localization radius:
  - Horizontal: 300km
  - Vertical: until 600hPa
- Simulation period: full year 2016, daily assimilation update
- DA Method: Ensemble Kalman Filter (LESTKF), ensemble size = 46
- Run time: 3.5 hours, using 12,000 processor cores on HLRN and JUWELS
- Updated:
  - Weakly-coupled DA: ocean state (SSH, temperature, salinity and velocity)
  - Strongly-coupled DA: atmosphere state (temperature, surface pressure, vorticity, divergence, humidity and horizontal velocity) + ocean state

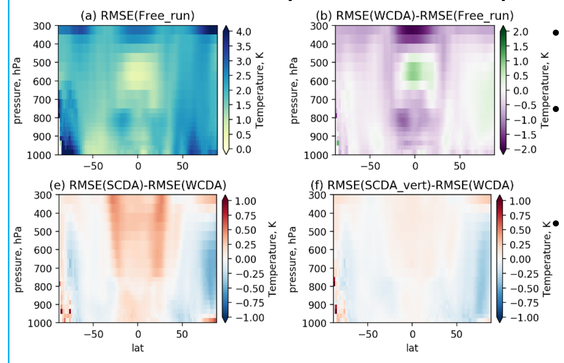
Results: Impact on the ocean



- Both WCDA and SCDA improve the prediction of the temperature.
- The SCDA run without vertical localization (SCDA) gives slightly larger (3%) RMSE(SST).
- The vertical localized SCDA run (SCDA_vert) gives the same RMSE(SST) as the WCDA.

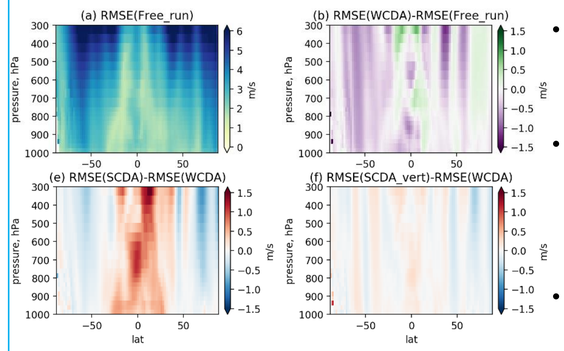
Results: Impact on the atmosphere

Zonal mean RMSE of temperature at different pressure levels



- 650hPa-1000hPa: RMSE is reduced everywhere by DA.
- 900hPa-500hPa: RMSE is slightly increased by WCDA in the Arctic; the two SCDA runs reduce it.
- SCDA gives up to 0.5 K larger RMSE between 25°N and 25°S compared to the WCDA, but smaller RMSE in the high latitude.

Zonal mean RMSE of wind velocity at different pressure levels



- 800hPa-1000hPa: RMSE in the equatorial region is reduced by WCDA and SCDA_vert.
- Up to 300hPa: SCDA shows larger RMSE between 25°N and 25°S; outside of the tropical region the velocity is improved.
- SCDA_vert gives similar results as WCDA.

Conclusion

- The SCDA of SST observations yielded a similar performance in simulating the ocean as the WCDA.
- For the atmosphere, the SCDA gives slightly worse results than the WCDA if no vertical localization is carried out. If vertical localization is implemented in the atmosphere, the difference between the SCDA and the WCDA is quite minor except in high latitudes.
- An exception is the Arctic region, where the SCDA with updates in the full atmosphere improves the atmospheric variables. However, the effect is similar to the case with vertical localization.
- The effect of the vertical localization in the tropical to mid-latitude regions implies that the SST has a strong influence on the lower troposphere.

Acknowledgement

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