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Ocean data assimilation in ICON-ESM for climate predictions

Project goal

The development of an ocean assimilation method for DWD´s next generation climate prediction system.

Introduction

The Deutscher Wetterdienst (DWD) develops a new initialization strategy for seasonal to decadal climate predictions based on the "Icosahedral Nonhydrostatic Earth System Model“ (ICON-ESM)[a,b] within its „Innovation in the Applied Research and Development" (IAFE) program. For this purpose, there is a close collaboration between the University of Hamburg and the Max Planck Institute for Meteorology.

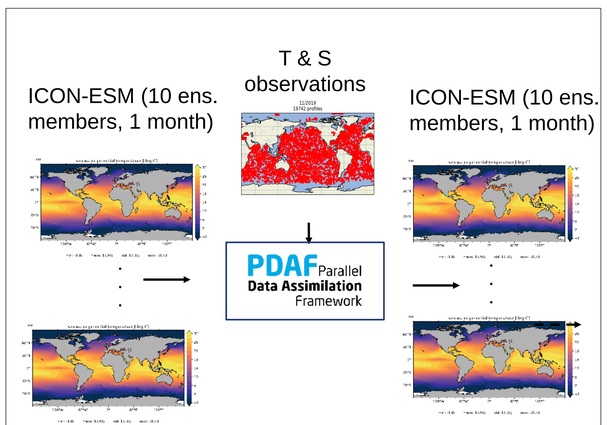

Fig. 1: Schematic of the assimilation system. The PDAF oceanic Ensemble Kalman Filter (EnKF) assimilates once a month temperature and salinity profiles into ICON-ESM; followed by a one month ICON-ESM run with 10 members.

Method

As a first step for a weakly coupled data assimilation only oceanic fields are assimilated into ICON-ESM. Monthly ocean temperature and salinity profiles from the EN4[c] data-set are assimilated with the method of the Parallel Data Assimilation Framework (PDAF)[d] Ensemble Kalman filter (EnKF) [Fig. 1]. An assimilation run with ICON-ESM is produced over the period 1960-2014. Various EnKF parameter settings are tested [Fig. 2]. While the local range spreads the observations to neighboring grid cells the error range determines its decay. For the following simulations, the local range of 5° and the error range of 1 K (PSU) is chosen. Anomalies added to the model climatology are used to avoid a too strong response of the oceanic circulation.

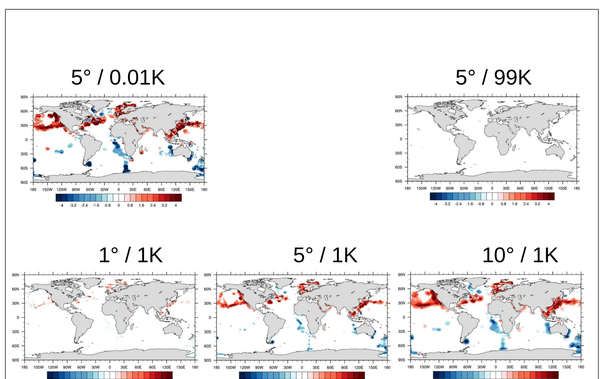

Fig. 2: Innovation of the ensemble mean temperature field at the surface after PDAF EnKF, depending on the choice of horizontal localization radius / error range for Jan 1960.

Results

The sea surface temperature (SST) variability of the assimilation run correlates well with observations and the Atlantic meridional overturning circulation is in the range of the observed strength [Fig. 3a,b]. The global mean SST is determined by the global warming trend. Hindcasts started from the assimilation run mainly follow this trend, but show also predictive skill over a couple of years when the trend is removed [Fig. 4a,b].

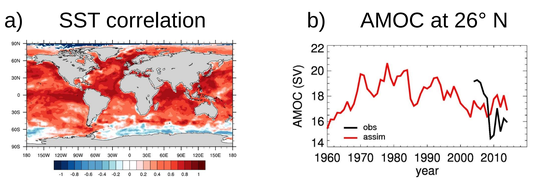

Fig. 3: Assimilation: (a) Correlation of annual mean sea surface temperature (SST) with observations from HadISST[e] and (b) Atlantic meridional overturning circulation together with RAPID-data[f].

Summary

- PDAF EnKF assimilates oceanic T & S observations into ICON
- ICON fills data-sparse regions
- anomalies keep the oceanic circulation realistic
- Next steps: assimilation of atmospheric observations / update of ICON

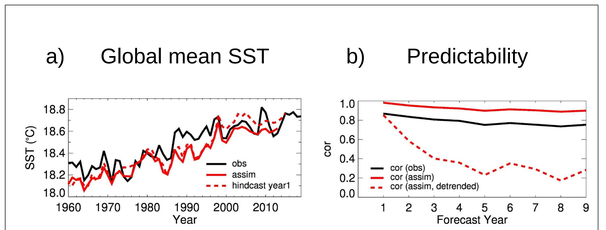

Fig. 4: Global mean SST: (a) Assimilation and first lead year of the hindcast simulations together with observations[e] and (b) their correlation for lead years 1-9.

References

[a]Giorgetta, M. et al., 2018, JAMES, 10, 1613-1637

[b]Korn, P., 2017, J. Comp. Phys., 339, 525-552

[c]Good, S. et al. 2013, J. Geophys. Res., 118(12), 6704-6716

[d]Nerger, L. and W. Hiller, 2013, Comp. and Geosci., 55, 110-118

Rayner, N., et al., 2003, JGR, 108, 4407

[f]Smeed D.A. et al. 2014, Ocean Sci 10(1): 29-38.

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