Seamless Sea Ice Prediction (SSIP)

Seamless sea ice prediction with AWI Climate Model

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In Short

- A first version of the seamless sea ice prediction system has been implemented successfully, and promising forecast skill has been demonstrated.
- The system has now been updated from AWI-CM v1.1 to the considerably more efficient AWI-CM v3.0, allowing larger assimilation and forecast ensembles.
- We aim to further improve the initial state estimates and sea ice forecasts, by assimilating more observations and introducing a hybrid approach with nudging in the atmospheric model component.

With Arctic sea ice continuously declining in recent decades, reliable sea ice prediction is urgently needed by stakeholders. Climate models equipped with initialization capabilities by data assimilation are suitable tools for sea ice predictions from daily to decadal time scales. Based on the AWI climate model (AWI-CM v1.1), we developed the first version of the seamless prediction system. The sea ice concentration, sea ice thickness, sea ice drift, and sea surface temperature is assimilated into the system. A comprehensive evaluation was summarized in a recently published paper in the Journal of Advances in Modeling Earth Systems [1]. As expected, the assimilation has strongly improved the ocean, sea ice, and atmosphere initial states.

With the newly developed AWI-CM 3.0, the ocean component has shifted from a finite element sea-ice ocean model (FESOM 1) to a finite volume sea-ice ocean model (FESOM 2); and the previous atmosphere component, ECHAM, has been replaced by OpenIFS from the European Centre for Medium-Range Weather Forecasts. The sea ice model is so far unchanged, although the next release of FESOM (FESOM2.1) will enable the use of a more sophisticated sea-ice model component. Using a similar resolution, AWI-CM v3.0 is about 3-5 times faster than its ancestor AWI-CM v1.1, enabling the use of larger ensembles at the same computational costs. This leads to a better representation of the cross-covariance matrix during multivariate data assimilation, and thus more accurate model updates. Therefore, the SSIP system has been migrated to the new AWI-CM v3.0. By default, the new system (SSIP2) now uses 30 ensemble members instead of 12 in the previous system [1].

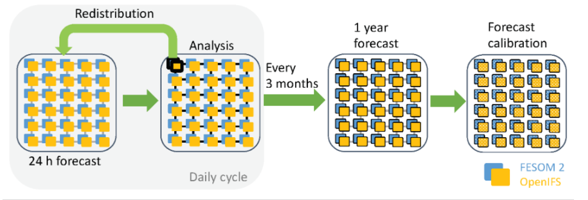

***Figure 1:** Schematic of the AWI Seamless Sea Ice Prediction System (version 2).*

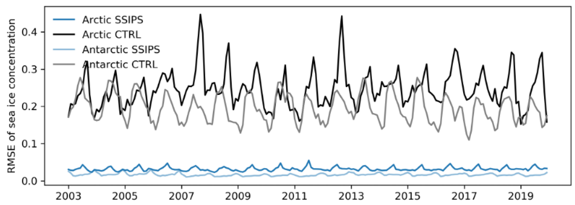

***Figure 2:** RMSE of monthly mean sea ice concentration in polar regions with respect to OSISAF observations. SSIP2 analysis is shown in blue, while the CTRL ensemble run without data assimilation is shown in black.*

Figure 1 shows a schematic of the SSIP2 system. After 24 hours of model integration, the MPI communicator for one realization conducts the analysis and distributes the analyzed states to all the ensemble members. Every 3 months, the forecast system is restarted from the analyzed states and integrated for 1-year long forecasts. A forecast calibration procedure is applied afterwards to remove systematic drift due to model biases that generally remain in climate models (including AWI-CM3) to achieve better forecast results. To start with, the calibration procedure has been applied only to sea ice concentration states. More observations such as sea surface height, sea surface salinity, and temperature and salinity profiles have been assimilated in the new system, complementing the previous set of observations. Analyses of assimilation runs and re-forecasts over two decades have been conducted and evaluated, showing promising accuracy of initial states (Figure 2) and forecast skill not only for sea ice and in polar regions, but also for other important modes of climate variability, including the El Nino-Southern Oscillation (ENSO) in the tropics.

Currently, the atmospheric state of the forecast system is not updated directly by the data assimilation. The atmospheric model trajectories are thus influenced by the ocean and sea-ice assimilation only indirectly via the coupling of the model components. Results of our current system show that the atmospheric ensemble spread is virtually as large as between completely independent free-running realizations, apart from near-surface temperatures close to the ocean surface. To initialize the atmospheric component â and also to improve the initialization of the ocean/ice component - an additional atmospheric constraint is required. We are now developing a hybrid system where the ensemble data assimilation in the ocean and sea ice is combined with nudging of the large-scale atmospheric dynamics based on reanalysis data.

WWW

https://www.awi.de/en/science/junior-groups/ssip.html

More Information

[1] L. Mu, L. Nerger, Q. Tang, S. N. Losa, D. Sidorenko, Q. Wang, T. Semmler, L. Zampieri, M. Losch, H .F. Goessling, Toward a data assimilation system for seamless sea ice prediction based on the AWI Climate Model. *Journal of Advances in Modeling Earth Systems* (2020). doi:10.1029/2019MS001937

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