On track to climate prediction

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In a new study published in *Tellus A*, Francois Counillon and co-authors at the Bjerknes Centre are testing seasonal-to-decadal prediction.

At the Bjerknes Centre, researchers are exploring the potential for seasonal to decadal climate prediction. This is a field still in its infancy, and a first attempt was made public for the latest Intergovernmental Panel on Climate Change (IPCC) report.

Apart from a few isolated regions, prediction skill was moderate, leaving room for improvement. In a new study published in Tellus A, seasonal-to-decadal prediction is tested with an advanced initialisation method that has proven successful in weather forecasting and operational oceanography.

"Ordinary" climate projections are designed to represent the persistent change induced by external forcings. Such "projections" start from initial conditions that are distant from today's climate and thus fail to "predict" the year-to-year variability and most of the decadal variability - such as the pause in the global temperature increase (hiatus) or the spate of harsh winter in the northern hemisphere. In contrast, weather predictions rely entirely on the accuracy of their initial state as the influence of the external forcing is almost imperceptible.

For seasonal-to-decadal time scales both the initial state and the external forcing influence the prediction. Starting a climate prediction from an initial state closer to the real climate is therefore necessary to yield better prediction than accounting only for external forcing. In our region of interest, decadal skill may be achieved by improving the representation of the heat content transiting into the Nordic Sea and in turn may influence the precipitation and temperature over Scandinavia.

The method employed to initialise/ correct a dynamical system is referred to as data assimilation. It estimates the initial state of a model knowing a set of sparse observations (much less than 1% of the ocean variables are observed). A relationship between the observations and the non-observed variables must be found to broaden the corrections.

Furthermore, the corrections must satisfy the model dynamics to avoid abrupt adjustments during the forecast. The Ensemble Kalman Filter uses statistics from an ensemble of predictions to estimate the relationship between the observations and all variables for their correction. This method is computationally intensive as it requires parallel integrations of the model but it ensures that the relationship evolve with the system, and that the corrections satisfy the dynamics of the model.

The Norwegian climate prediction model (NorCPM) combines the Norwegian Earth System model with the Ensemble Kalman Filter. In time, we intend to perform retrospective decadal predictions (hindcasts) over the last century, to test the skill of our system on disparate phases of the climate and shed light on the relative importance of internal and external influences on natural climate variability, including the significance of feedback mechanisms. Sea surface temperatures (SST) are the only observations available for such a long period of time and will be used for initialisation.

Our study investigates the potential skills of assimilating SST only, using an idealised framework, i.e. where the synthetic solution is taken from the same model at different times. This framework allows an extensive validation because the full solution is known and our system can be evaluated against the upper predictive skill (the case where observations would be available absolutely everywhere). NorCPM demonstrated decadal predictability for the Atlantic meridional overturning and heat content in the Nordic Seas that are close to the model's limit of predictability. Although these results are encouraging, the idealised framework assumes that the model is perfect and lower skill is expected in a real framework. This verification is currently ongoing.

More information: F. Counillon, I. Bethke, N. Keenlyside, M. Bentsen, L. Bertino, F. Zheng, "Seasonal-to-decadal predictions with the Ensemble Kalman Filter and the Norwegian Earth System Model: a twin experiment," *Tellus A* 2014, 66, 21074, dx.doi.org/10.3402/tellusa.v66.21074

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