AMOC analyses for decadal climate predictions: a multiple timescale coupled atmosphere-ocean data assimilation perspective

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Abstract:

Enhancing predictions of AMOC variability and hence of decadal-scale climate variability is partly an initial-value problem. The ability to initialize the multi-frequency AMOC under varying levels of observation availability is assessed in an idealized low-dimensional analogue of the coupled atmosphere-ocean North Atlantic climate system. A multi-timescale fully coupled data assimilation (DA) scheme assimilating instantaneous high-frequency and/or time-averaged observations is proposed, along with a simplification involving climatological covariances estimated from a single long model simulation. This cost-effective simplification is tested using a simplified low-order coupled model, while the multiscale approach is characterized using CMIP5 data from a comprehensive coupled atmosphere-ocean global climate model. The skill of AMOC analyses from idealized DA experiments is characterized in scenarios where progressively fewer observables are assimilated: from combinations of upper subpolar, subtropical and deep ocean temperature and salinity to the extreme case of observations in the atmosphere only. Results suggest that skillful AMOC analyses can be obtained using the more cost-effective DA alternative while a clear benefit of multi-time-scale assimilation is found for initializing the fast and slow components of the AMOC. Recovery of decadal-scale AMOC variability using atmosphere-only observations appears feasible provided that time-averages of properly chosen observables are assimilated within the coupled DA scheme.