International workshop on seasonal to decadal prediction
Toulouse, France, 13-16 May, 2013

Importance of the deep ocean for model bias reduction and oceanic decadal predictability

Florian SEVELLEC

University of Southampton, UK, florian.sevellec@noc.soton.ac.uk
Alexey Fedorov, Yale University, United States, alexey.fedorov@yale.edu
Presenter : Alexey Fedorov

Assessing the limits of oceanic decadal predictability is critical for making progress in climate prediction. However, even when forced with the observed surface fluxes, ocean general circulation models develop biases in temperature and salinity fields. Typically, these biases amplify in coupled models. In the present study, we ask two complimentary questions related both to decadal prediction and the problem of model bias. (1) Can we temporarily reduce the bias and potentially improve prediction by slightly perturbing the initial conditions used for model initialisation ? (2) How much would such initial perturbations grow ? To answer these questions we conduct an optimization analysis of a realistic ocean GCM and compute optimal perturbations in temperature and salinity that can reduce the model bias most efficiently during a given time interval. We find that, in order to reduce this bias, especially pronounced near the ocean surface, initial perturbations should be imposed in the deep ocean (specifically, in the Southern Ocean). On decadal timescales, a 0.1 degree perturbation in the deep ocean can induce a temperature anomaly on the order of several degrees in the upper ocean, partially reducing the bias. The transient growth of such perturbations peaks after about 14 years. A corollary of these results is that very small errors in model initialization in the deep ocean can produce large errors in the upper-ocean temperature after a decade or two of numerical simulations, which can be interpreted as a decadal predictability barrier associated with ocean dynamics. The physical mechanism of the error growth includes the excitation of large-scale quasi-stationary waves (or eddies) in the Southern ocean. We show that a strong meridional temperature gradient in this region enhances the sensitivity of the upper ocean to deep-ocean perturbations through nonnormal dynamics facilitating the generation of these waves. Ultimately, our results emphasize the crucial role of the deep ocean for decadal climate prediction.