Initial Value Predictability of Upper Layer Temperature and AMOC

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When predicting the evolution of the climate system starting from a particular initial state, one must take into account that the climate system is chaotic and thus sensitive to even infinitesimal uncertainties in that state. Just as with weather forecasting, this sensitivity limits the range at which the influence of the initial state is detectable and potentially beneficial to the prediction. Using traditional perturbation ensemble methods as well as newly introduced techniques that can estimate predictability properties from the statistics of long control integrations, we have estimated the predictability limits of upper 300m ocean conditions as well as of AMOC for various comprehensive climate models including many that participated in CMIP5.

We find that for temperature in the upper 300m of the ocean, a typical initial state influences predictions for 5 to 10 years in the northern extratropics, but these limits vary substantially from model to model and from region to region. Indeed, model behavior suggests that the subpolar gyre of the North Atlantic, and possibly other regions, may be predictable for considerably longer. Surprisingly, AMOC predictability is not appreciably more predictable than the most predictable near-surface regions, perhaps because AMOC and the highly predictable regions are physically connected. When considering AMOC predictability it is useful to concentrate on the prominent leading mode of variability. For typical situations it may be no more predictable than generic patterns of AMOC variability. On the other hand using response operators derived from the fluctuation dissipation theorem we find for special patterns of near-surface buoyancy forcing it is possible to generate high amplitude events during which the leading AMOC mode, and associated SSTs, will be especially predictable. Representing processes well in the regions where these special forcing patterns are concentrated would appear to be crucial for taking advantage of this potential for enhanced predictability.