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Synchronization of Blocking Patterns in Diifferent Models, Connected So As to Form a “Supermodel” of Future Climate

Gregory Duane[1], Francine Schevenhoven[2], and Jeffrey Weiss[1]
[1]University of Colorado, Atmospheric and Oceanic Sciences, Boulder, Colorado, United States of America (gregory.duane@colorado.edu)
[2]Geophysical Institute, University of Bergen, Bergen, Norway

The established benefits of post-processing the results of multi-model ensembles, even by simple averaging, suggest a more radical approach: The models should be combined more frequently in run-time so as to form a single “supermodel”. Simple nudging of models to one another, as frequently as the models might assimilate data from observations, combines model fusion with a reasonable degree of model autonomy.

Key to the success of the supermodeling approach is the phenomenon of chaos synchronization, known in the field of nonlinear dynamics, wherein two chaotic systems synchronize when connected through only a few of their variables, despite sensitive dependence on initial conditions. Synchronization gives rise to consensus among models. The nudging coefficients can be trained so that that consensus agrees with observations, because the effective dynamics of the trained supermodel, regarded as a single dynamical system, matches the dynamics of nature. Yet the number of independent nudging coefficients that must be trained is far less than the number of trainable parameters in a typical climate model.

It is expected that supermodeling will be especially useful for improving the representation of localized structures, such as blocking patterns, which will wash out if de-synchronized output fields of different models are combined by averaging. We confirm a hypothesis that such coherent structures will synchronize even when the underlying fields do not, because the internal synchronization within each structure re-enforces synchronization between models: A configuration of CAM4 and CAM5 models, of different resolution, connected by nudging, exhibits correlated blocking activity even when the flows do not otherwise synchronize.

We further explore the basis for correlated blocking activity in a pair of coupled quasi-geostrophic channel models. The local synchronization error is lower in a region of the channels where blocks form than elsewhere in the channels. Blocking correlations emerge as a vestige of “chimera synchronization”, the phenomenon in which complete synchronization of two spatially extended systems is intermittent in space as well as time. Such partial synchronization of different models in the regions of blocks - and of other structures such as jets, fronts, and large-scale convection - would be particularly useful for projecting climate-change patterns in extreme events associated with those structures.