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"Supermodelling" by Adaptive Synchronization of Different Climate Models

Gregory Duane (1,6), Frank Selten (2), Noel Keenlyside (3), Wim Wiegerinck (4), Juergen Kurths (5), and Ljupco Kocarev (6)

(1) University of Colorado, Boulder, United States (gregory.duane@colorado.edu), (2) Royal Netherlands Meteorological Institute (KNMI), The Netherlands (selten@knmi.nl), (3) Leibniz-Institut Fuer Meereswissenschaften An Der Universitaet Kiel (IFM-GEOMAR), Kiel, Germany (nkeenlyside@ifm-geomar.de), (4) Radboud University Nijmegen, The Netherlands (w.wiegerinck@science.ru.nl), (5) Potsdam Institute for Climate Impact Research, Potsdam, Germany (Juergen.Kurths@pik-potsdam.de), (6) Macedonian Academy of Sciences and Arts, Skopje, Republic of Macedonia (sumo@manu.edu.mk)

Climate models of the class used by the IPCC give divergent results in regard to the magnitude of average temperature change in response to increased greenhouse gas levels, and in regard to regional projections. One would like to surpass the skill of averaged model outputs by using the best features of each model in run time. The supermodelling approach extends the "interactive ensemble" previously used for ENSO prediction, by introducing a set of connections between select pairs of corresponding variables in a small suite of different models. With weights on these connections obtained by training on 20th century data, the models tend to synchronize with one another as well as with reality.

Supermodelling has been tested with simple systems of ODE's and with quasigeostrophic models. It was previously shown that quasigeostrophic models with forcing in different sectors could be fused as a supermodel of a "real" system with a combination of forcings. Here we show that the weights needed to produce the correct supermodel can be found adaptively using a "real" training set. The advantage of the approach is that only a small set of trainable connections need be considered (as compared to the large number of parameters in each model) but such connections can be selected in a naive manner.

The approach is controversial in part because, even for a simple set of ODE's, the connections found by the learning procedure may define a skillful supermodel with no clear physical interpretation. That situation arises from a simple degeneracy: Even if one model has a perfect equation for a given dynamical variable, the learning scheme may choose to combine other models to reproduce the "perfect" behavior. A learning scheme that favors binary-valued weights can generate a more interpretable supermodel. The tradeoff between flexibility and the possibility of physical interpretation is studied.

The approach is also controversial because it is not clear that training on 20th century data will define connections that are optimal for 21st century greenhouse gas levels. It is shown with simple models that connections found by the learning procedure tend to be robust against large variations in the parameters of individual models and resulting bifurcations. Also, it is demonstrated that the approach applies to systems with widely different intrinsic time scales, such as atmosphere-ocean models. Supermodelling will therefore be useful for at least a significant fraction of the 21st century, will counter tribalism in our

field, and will produce a verifiable consensus on details of climate change.