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Interactive vs. Non-Interactive Ensembles for Weather Prediction and Climate Projection

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If the members of an ensemble of different models are allowed to interact with one another in run time, predictive skill can be improved as compared to that of any individual model or any average of indvidual model outputs. Inter-model connections in such an interactive ensemble can be trained, using historical data, so that the resulting "supermodel" synchronizes with reality when used in weather-prediction mode, where the individual models perform data assimilation from each other (with trainable inter-model "observation error") as well as from real observations. In climate-projection mode, parameters of the individual models are changed, as might occur from an increase in GHG levels, and one obtains relevant statistical properties of the new supermodel attractor. In simple cases, it has been shown that training of the inter-model connections with the old parameter values gives a supermodel that is still predictive when the parameter values are changed.

Here we inquire as to the circumstances under which supermodel performance can be expected to exceed that of the customary weighted average of model outputs. We consider a supermodel formed from quasigeostrophic channel models with different forcing coefficients, and introduce an effective training scheme for the inter-model connections. We show that the blocked-zonal index cycle is reproduced better by the supermodel than by any non-interactive ensemble in the extreme case where the forcing coefficients of the different models are very large or very small. With realistic differences in forcing coefficients, as would be representative of actual differences among IPCC-class models, the usual linearity assumption is justified and a weighted average of model outputs is adequate. It is therefore hypothesized that supermodeling is likely to be useful in situations where there are qualitative model differences, as arising from sub-gridscale parameterizations, that affect overall model behavior. Otherwise the usual ex post facto averaging will probably suffice.

Previous results from an ENSO-prediction supermodel [Kirtman et al.] are re-examined in light of the hypothesis about the importance of qualitative inter-model differences.