Why large ensembles? Exploration of an alternate strategy using small, synthetic ensembles of global climate models

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The advent of large initial condition ensembles of climate models (hereafter LEs) has led to an increased focus on internal variability as an irreducible uncertainty in future climate projections. There is a hope that LEs might enable a more robust quantification of both the response to projected anthropogenic forcings and the spread in that response due to internal variability. But LEs are nevertheless computationally expensive, and it is worth asking if there might be other means of achieving these goals without such a large investment of resources.

The work of Thompson et al. (2015) suggests that the uncertainty in future climate trends simulated by a given model can be effectively estimated using the statistics of a single, unforced control simulation of sufficient length. However, the magnitude of such trends and their range must still be determined from model simulations subject to presumed future forcings. But is a LE required for this, and if so, how large must it be? McKinnon et al. (2018) found that one GCM LE tended to overestimate the uncertainty in 50-year winter air temperature trends over North America compared to a resampled "observational LE."
Could it be the case that the largest ensembles are too much of a good thing?

Here we investigate a resampling strategy which uses N transient, forced simulations to construct N^2 future climate state anomalies, comparing the results with those from a straightforward application of a LE of size N^2. Specifically, we determine how and if these two ensembles can be distinguished statistically, for different climate variables, and at different spatial scales. We also examine differences in metrics of climate change (e.g., time of emergence) between the two strategies.

References

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