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Understanding and Interpreting Climate Model Ensembles

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The CMIP3 multi-model ensemble has been widely utilised for climate research and probabilistic prediction, but the properties and behaviour of the ensemble are not well understood. Here we present a simple paradigm for probabilistic interpretation of the ensemble and show that the ensemble performs well under this paradigm, at least in terms of the model climatologies.

We contrast the widely-adopted paradigm in climate science, of an ensemble sampled from a distribution centred on the truth, with the paradigm of a statistically indistinguishable ensemble, which has been more commonly adopted in other fields. This latter interpretation (which supports the natural probabilistic interpretation of ensemble outputs) leads to new insights about the evaluation of ensemble performance which refute several recent claims regarding the purported inadequacy of the ensemble. Using the well-known rank histogram method of analysis and data from current and paleo climates, we find that, for climatological averages over the globe, the CMIP3 ensemble generally provides a good sample under the statistically indistinguishable paradigm, although it appears marginally over-dispersive and exhibits some modest biases. These results contrast strongly with the incompatibility of the ensemble with the truth-centred paradigm.

We will also address the long-standing question of why the multi-model mean performs significantly better than the ensemble members on average, and investigate and identify the key properties of the distribution which control how likely the mean is to out-perform all individual models.