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A common fallacy in climate model evaluation

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We discuss the assessment of model ensembles such as that arising from the CMIP3 coordinated multi-model experiments. An important aspect of this is not merely the closeness of the models to observations in absolute terms but also the reliability of the ensemble spread as an indication of uncertainty. In this context, it has been widely argued that the multi-model ensemble of opportunity is insufficiently broad to adequately represent uncertainties regarding future climate change. For example, the IPCC AR4 summarises the consensus with the sentence: "Those studies also suggest that the current AOGCMs may not cover the full range of uncertainty for climate sensitivity." Similar claims have been made in the literature for other properties of the climate system, including the transient climate response and efficiency of ocean heat uptake.

Comparison of model outputs with observations of the climate system forms an essential component of model assessment and is crucial for building our confidence in model predictions. However, methods for undertaking this comparison are not always clearly justified and understood. Here we show that the popular approach which forms the basis for the above claims, of comparing the ensemble spread to a so-called "observationally-constrained pdf", can be highly misleading. Such a comparison will almost certainly result in disagreement, but in reality tells us little about the performance of the ensemble. We present an alternative approach based on an assessment of the predictive performance of the ensemble, and show how it may lead to very different, and rather more encouraging, conclusions. We additionally outline some necessary conditions for an ensemble (or more generally, a probabilistic prediction) to be challenged by an observation.