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Can metric-based approaches really improve multi-model climate projections? A perfect model framework applied to summer temperature change in France.

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Ensemble approaches for climate change projections have become ubiquitous. Because of large model-to-model variations and, generally, lack of rationale for the choice of a particular climate model against others, it is widely accepted that future climate change and its impacts should not be estimated based on a single climate model. Generally, as a default approach, the multi-model ensemble mean (MMEM) is considered to provide the best estimate of climate change signals. The MMEM approach is based on the implicit hypothesis that all the models provide equally credible projections of future climate change. This hypothesis is unlikely to be true and ideally one would want to give more weight to more realistic models.

A major issue with this alternative approach lies in the assessment of the relative credibility of future climate projections from different climate models, as they can only be evaluated against present-day observations: which present-day metric(s) should be used to decide which models are "good" and which models are "bad" in the future climate? Once a supposedly informative metric has been found, other issues arise. What is the best statistical method to combine multiple models results taking into account their relative credibility measured by a given metric? How to be sure in the end that the metric-based estimate of future climate change is not in fact less realistic than the MMEM?

It is impossible to provide strict answers to those questions in the climate change context. Yet, in this presentation, we propose a methodological approach based on a perfect model framework that could bring some useful elements of answer to the questions previously mentioned. The basic idea is to take a random climate model in the ensemble and treat it as if it were the truth (results of this model, in both past and future climate, are called "synthetic observations"). Then, all the other members from the multi-model ensemble are used to derive thanks to a metric-based approach a posterior estimate of climate change, based on the synthetic observation of the metric. Finally, it is possible to compare the posterior estimate to the synthetic observation of future climate change to evaluate the skill of the method.

The main objective of this presentation is to describe and apply this perfect model framework to test different methodological issues associated with non-uniform model weighting and similar metric-based approaches. The methodology presented is general, but will be applied to the specific case of summer temperature change in France, for which previous works have suggested potentially useful metrics associated with soil-atmosphere and cloud-temperature interactions. The relative performances of different simple statistical approaches to combine multiple model results based on metrics will be tested. The impact of ensemble size, observational errors, internal variability, and model similarity will be characterized. The potential improvements associated with metric-based approaches compared to the MMEM is terms of errors and uncertainties will be quantified.