Session: C27 Poster: W158A

Sense and Sensitivity: improving regional climate simulation analysis with uncertainty-based diagnostics

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In the past years, climate-modeling research has evolved toward ensemble-based studies with the aim of obtaining more robust climate change projections as well as an estimation of uncertainty. International collaborations led to multi-model ensembles concentrated on quantifying inter-model uncertainty for both GCMs (Global Climate Modes) and RCMs (Regional Climate Models). At the same time, some regional modeling groups devoted themselves to producing smaller single-model ensembles to explore uncertainty sources that are specific to RCMs. These regional studies were performed over very few regions of the globe. For these simulation-rich areas, it is possible to take advantage of valuable uncertainty estimates to design diagnostic tools that can be helpful in the interpretation of regional climate model outputs. The first tool to be presented is based on internal variability (IV), natural variability (NV) and inter-model spread (IMS) estimates over a specific region for a given climate variable. An ad-hoc scale built using these estimates is useful to assess both the significance and the relevance of any modification made to the regional modeling system. When comparing the response of the modification to the IV, NV and IMS levels, the physical meaning of these thresholds becomes instrumental in determining whether the amplitude of the response is consistent with the nature of the model modification. Sensitivity experiments are a convenient and a widely used methodology to explore the effects of both internal and external sources of uncertainty in the estimation of the climate change signal. With a basic set of climate simulations (historical control, future control, historical perturbed and future perturbed), we can derive quantities such as the estimation of the control and perturbed climate change, as well as the climate sensitivity to the perturbation in both the historical and future periods. These results can be brought together on a single diagram, showing, for example, whether the effect of the perturbation on historical and future climates is similar, leaving the resulting climate change signal untouched, or conversely, whether it will dampen or amplify the climate change signal. These same four results can be combined in a different way to define three indices: the preponderance (Pr) of the greenhouse gas (GHG) forcing signal over that of the perturbation, the robustness (Ro) of the climate change estimate to a given perturbation, and the independence (In) of a perturbation to GHG conditions. This group of diagnostics becomes particularly useful at the time of discussing the different contributions of the various uncertainty sources. The development of these kinds of diagnostic tools is part of a general evolution towards a more mindful practice of regional climate modeling. At the stage of planning or analysis of climate simulations, such tools provide a practical way of examining the solidity of our working hypotheses.