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Uncertainty in Future Tropical Precipitation Change

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This study aims to describe, and begin to understand, the substantial uncertainties in future changes in local precipitation due to differences in model formulation. Four multi-model ensembles (MMEs) are studied: a 268-member perturbed physics slab-model ensemble, two 17-member perturbed physics coupled-model ensembles (one with perturbed carbon cycle parameters), and a 16-member coupled-multi-model ensemble utilising the CMIP3 database. The focus is primarily on the vulnerable tropical regions.

An unbiased metric is developed to map the contribution made by uncertainties in model formulation to projected changes in local precipitation, relative to the contribution made by natural variability. This essentially provides a first attempt at evaluating the potential for reducing uncertainties in local precipitation change through model improvements. The role of modeling uncertainty is found to vary substantially, with a rich spatial structure being evident on a range of scales. Many key large-scale features are broadly similar between the different MMEs, suggesting that more detailed investigation of the large slab-model ensemble may have wider applicability. At regional scales, an important finding is that much larger spatial noise is apparent in the smaller MMEs, suggesting that 10s or 100s of model versions are required to robustly map the role of modeling uncertainty in local precipitation change.

The causes of some of these large-scale patterns in the role of modeling uncertainty are explored. The intention is that an enhanced understanding of uncertain physical processes will help develop observational constraints for regional uncertainty. In particular, it is found that the uncertainty due to model formulation is larger in equatorial regions than in the subtropics, and in the former always markedly exceeds that due to natural variability. This is consistent across the four MMEs, and is examined further, and separately, for tropical land and for each of the major tropical oceans. It is found that the physical mechanisms, and the resulting pattern and magnitude, of modeling uncertainty differs somewhat between these regions. Furthermore, throughout the tropics, uncertainty in global climate sensitivity contributes little to uncertainty in local precipitation changes. Subsequent analysis then estimates which of the model parameters contribute most to uncertainty in the large perturbed physics ensemble. It is found that there is considerable sensitivity to some parameters within the cloud scheme, and that over tropical land regions uncertainty in modeling the carbon cycle may be as important as uncertainties in modeling atmospheric processes. The importance of some other parameter uncertainties is more surprising, and these too are discussed
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