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Understanding seasonal uncertainty in CMIP5 tropical precipitation projections

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Greenhouse-gas-driven changes in the magnitude and distribution of tropical rainfall have the potential to severely impact communities and ecosystems in already vulnerable regions. However, despite improvements in many areas of GCM performance between CMIP3 and CMIP5, uncertainty in regional tropical rainfall projections remains stubbornly large. Inter-model regional tropical precipitation uncertainty is not strongly related to the range of climate sensitivities exhibited by different models. Instead, other mechanisms that are not directly related to climate sensitivity produce a variety of different precipitation pattern responses across models.

CMIP5 seasonal rainfall projections were separated into components corresponding to different driving processes, e.g. thermodynamic moisture increase, a weakening tropical circulation, and shifts in convective regions. The inter-model variance and co-variances of each of these components were examined, across the tropics and for the regional example of East Africa. The dominant cause of inter-model uncertainty across the tropics is the range of different responses in spatial shifts in convection. Over the oceans these appear to be associated with SST pattern change, though the picture over land is more complex, with land-sea temperature contrasts likely to be important.

For the case study of the MAM rainy season in East Africa, an interesting picture emerged where convective shifts cause most of the inter-model uncertainty, but the multi-model mean shift component is nearly zero. A multi-model mean wettening signal in total precipitation change results from the positive residual of the thermodynamic and weakening circulation components.

To further understand the drivers of CMIP5 uncertainty, a series of idealised AMIP experiments have been examined. These were used to examine separately the range of GCM responses to CO_2 forcing, a uniform SST increase, and a specified SST pattern perturbation. For most land regions, the greatest precipitation uncertainty arises from the response of convective shifts to a uniform SST increase.