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Exploring the impact of aerosol radiative forcing uncertainty on shifts in ITCZ position and tropical rainfall in the near-term future

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Anthropogenic aerosol emissions over the industrial period have caused a negative but highly uncertain radiative forcing. This negative radiative forcing has had a cooling effect mainly over the northern hemisphere, affecting the atmospheric interhemispheric energy balance. Consequently aerosols have been linked to observed dynamical responses over the industrial period that depend on the atmospheric interhemispheric energy balance, such as changes in the position of the Intertropical Convergence Zone (ITCZ) and resultant tropical precipitation shifts. However, over the course of the 21st century anthropogenic aerosol emissions are predicted to decline. The reduction in anthropogenic aerosol emissions will cause a positive radiative forcing relative to present day, creating a warming effect in the northern hemisphere. Hence, if the strength of aerosol radiative forcing modulates the magnitude of shifts in the ITCZ, then the large uncertainty in aerosol radiative forcing will limit our understanding of how tropical precipitation will shift in the near-term future.

We use a perturbed parameter ensemble (PPE) of a global coupled climate model to investigate the link between aerosol radiative forcing and ITCZ and tropical rainfall shifts in the near-term future. The PPE consists of 20 simulations of the UK Met Office's GC3.05 model with parameters perturbed from a range of model schemes. The ensemble was designed to sample uncertainties in future changes, and as a result spans a range of aerosol radiative forcings.

The PPE reveals both northward and southwards shifts in the ITCZ position across the ensemble in the latter half of the 20th century and first half of the 21st century, as well as changes in width and intensity of the ITCZ. We find a correlation between the shift in the ITCZ position and the magnitude of aerosol radiative forcing and AOD trends. However, the correlations in our ensemble are not as strong as those cited in previous studies that use multi-model ensembles. The potential causes of this difference are investigated. We also compare our model output to aerosol, cloud and radiation observations in attempt to identify the most plausible future aerosol-driven climate responses.