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# Local and remote impacts of aerosol species on Indian summer monsoon rainfall in a GCM

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The HadGEM2 AGCM is used to determine the most important anthropogenic aerosols in the Indian monsoon using experiments in which observed trends in individual aerosol species are imposed. Sulphur dioxide (SD) emissions are shown to impact rainfall more strongly than black carbon (BC) aerosols, causing reduced rainfall especially over northern India. Significant perturbations due to BC are not noted until its emissions are scaled up in a sensitivity test, in which rainfall increases over northern India as a result of the Elevated Heat Pump mechanism, enhancing convection during the pre-monsoon and bringing forward the monsoon onset. Secondly, the impact of anthropogenic aerosols is compared to that of increasing greenhouse-gas concentrations and observed sea-surface temperature (SST) warming. The tropospheric temperature gradient driving the monsoon shows weakening when forced by either SD or imposed SST trends. However the observed SST trend is dominated by warming in the deep tropics; when the component of SST trend related to aerosol emissions is removed, further warming is found in the extratropical northern hemisphere that tends to offset monsoon weakening. This suggests caution is needed when using SST forcing as a proxy for greenhouse warming. Finally, aerosol emissions are decomposed into those from the Indian region and those elsewhere, in pairs of experiments with SD and BC. Both local and remote aerosol emissions are found to lead to rainfall changes over India; for SD, remote aerosols contribute around 75% of the rainfall decrease over India, while for BC the remote forcing is even more dominant.