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Sensitivity of the climate response to regional aerosol emissions

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Short-lived emissions like aerosols and their precursors have inhomogeneous distributions in the atmosphere. As a result, aerosol radiative forcing of the climate is highly uneven, and depends on both the location of emission as well as circulation patterns. Unlike well-mixed greenhouse gases such as CO_2, the climate response to aerosol forcing may therefore be very dependent on the source region, and so understanding how the sensitivity of the climate varies with emission and forcing location has implications for the design of policy regarding short-lived climate forcers, as well as for understanding the coupling between radiative forcing and climate response.

Using the UK Met Office's HadGEM3 composition-climate model, we have performed a series of experiments to investigate the climate response to aerosol species from different key anthropogenic emission regions, in particular East Asia, South Asia, the USA, and the whole northern mid-latitude band. Recent results from these simulations will be presented, focusing in particular on the patterns of climate forcing due to Asian anthropogenic emissions, and the resulting responses in surface temperature and precipitation. Large-scale circulation changes, driven by regional temperature gradients, are found to play an important role in explaining the observed climate responses, which can be substantial even in in parts of the world far from the location of the forcing.

The correct magnitude of aerosol forcing remains, however, one of the greatest uncertainties in our current understanding of anthropogenic influences on climate. Aerosol radiative forcing varies considerably between different composition-climate models, and to explore the implications of this for climate responses we use the GISS Model-E2 and NCAR CESM1 models in addition to HadGEM3. These reveal a remarkable variation in the simulated climate response as a result of differences in the radiative forcing from identical perturbations to regional sulphate aerosol precursor emissions. The nature and underlying reason for the range of uncertainty in the forcing and response will be discussed. The comparison between these disparate models however also reveals aspects of the large-scale circulation response to localised mid-latitude forcings which may be robust across the models, and the implications of this finding will also be discussed.