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The response of European and Asian climate to global and regional aerosol emissions

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Asia has the world's highest anthropogenic aerosol loading and has experienced a dramatic increase in emissions since the 1950s, which has continued in the 21st century, in stark contrast with European (and North American) emissions which started to decrease in the 1970s.

We use a set of transient coupled model experiments (HadGEM2-GC2) to explore the regional climate effects of anthropogenic aerosol changes since the 1980s, with a focus on the European and Asian responses. Comparing simulations with globally varying aerosol emissions to an equivalent set with Asian emissions fixed at their 1971-1980 mean over Asia, we identify the contribution of Asian emissions to the total impact. Identifying thermodynamic and dynamic responses to global and regional aerosol changes, we diagnose atmospheric teleconnections and their interactions with local processes, and the mechanisms by which aerosol affects both European and Asian climate.

It is found that Asian aerosols led to substantial changes in Asian climate, weakening the summer monsoon, which is a key driver of the observed precipitation changes there in recent decades. Asian emissions are also able to induce planetary-scale teleconnection patterns in both winter and summer. The impact of the regional diabatic heating anomaly propagates remotely by exciting northern hemisphere wave-trains which, enhanced by regional feedbacks, cause changes in near-surface climate over Europe.

To examine the robustness of the mechanisms we identify in HadGEM2, we analyse similar sets of experiments from NorESM1-M and GFDL-CM3: models with very different climatologies and representations of aerosol processes.