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Simulations of the climate effects of European air quality legislation in Pegasos

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Pegasos is a large-scale, multiyear project that studies the interactions between air quality and climate employing laboratory and field measurements, and modelling studies from process level to global scale. Among the scientific questions addressed by Pegasos is that of how the reduction in particulate emissions resulting from the cumulative European air quality legislation (which has been progressively enacted since 1970) affects the climate system. To investigate this question, we have performed multi-decadal climate simulations using the coupled Max Planck Institute Earth System Model (MPI-ESM) together with the fully integrated aerosol model HAM, using purpose-built emission inventories representing (i) a best estimate of modern-day (here taken as the year 2010) emissions and (ii) a scenario in which no European Union (EU) air quality legislation had been enacted. The difference between the two amounts to a total anthropogenic emission of some 2.8 Tg/yr PM2.5.

The simulations were run using greenhouse gas concentrations fixed at 2010 levels and were each of 40 simulated years after spinup. As expected, the largest reductions in particulate matter concentrations are found over Europe. In contrast, the strongest climate signals are found in regions remote from the particulate emission sources. The global mean multiannual surface temperature does not show a strong response to the emission reductions, differing by less than 0.1°C between the simulations. However, this masks large regional differences, with the strongest signal not in the emission source regions, but in the Arctic and central Siberia, where the simluated temperature difference reaches over 1°C. Precipitation changes also show a stronger signal far from the source regions: tropical precipitation is affected to a greater degree than the extratropical, which seems to be due to the changes in the hemispherically asymmetric aerosol forcing influencing the location of the Intertropical Convergence Zone (ITCZ).

These results illustrate the need to better understand not only the links between air quality and climate change, but more generally the dynamics of the response of the climate system to localised short-lived forcings. Furthermore, they show that for the purposes of policy guidance, climate science needs to move beyond global means as metrics of climate change.