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Past, present and future aerosol forcing derived from CMIP6

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Aerosol forcing remains the most uncertain component of the total climate forcing on the Earth system. RFMIP and AerChemMIP contained experiments that allow us to determine time-slice present day (2014 minus 1850) from 17 CMIP6 models, and transient (1850 to 2014, or 2100) aerosol forcing from 11 models. In CMIP6, aerosol present-day aerosol forcing is -1.01 (full range -1.37 to -0.63) W m^{-2}, a range considerably narrower than comprehensive assessments of aerosol forcing from multiple lines of evidence such as AR5 (-1.9 to -0.1 W m^{-2}) or Bellouin et al. 2020 (-2.0 to -0.35 W m^{-2}). The transient experiments also show a diversity in time histories, with most models showing a peak negative aerosol forcing at some time between 1975 and 2010, and recent trends varying from strongly recovering to slightly strengthening aerosol forcing. Models that were run to 2100 under SSP2-4.5 all show a projected weakening aerosol forcing.

By fitting a simple relationship of how globally integrated emissions of black carbon, organic carbon and SO_2 relate to effective radiative forcing from aerosol-radiation interactions (ERFari) and aerosol-cloud interactions (ERFaci), an emissions to forcing relationship can be determined for these 11 RFMIP and AerChemMIP models. Using a 100,000 member Monte Carlo ensemble of historical aerosol time series, where coefficients are drawn from these model-derived distributions, and total 1850 to 2014 aerosol forcing is taken from the wider distributions of Bellouin et al. (2020), we create a best estimate historical time series for aerosol forcing (with uncertainty) that is constrained to historical warming and observed ocean heat uptake using a simple climate model. This method can also be used to predict aerosol forcing from future emissions scenarios, such as the SSPs and those derived from integrated assessment models, and provides estimates of the likely ranges for equilibrium climate sensitivity and transient climate response based on the historical aerosol forcing.