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# Effects of aerosol emission pathways on future warming and human health

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The peak global temperature is largely determined by cumulative emissions of long-lived greenhouse gases. However, anthropogenic emissions include also so-called short-lived climate forcers (SLCFs), which include aerosol particles and methane. Previous studies with simple models indicate that the timing of SLCF emission reductions has only a small effect on the rate of global warming and even less of an effect on global peak temperatures. However, these simple model analyses do not capture the spatial dynamics of aerosol-climate interactions, nor do they consider the additional effects of aerosol emissions on human health. There is therefore merit in assessing how the timing of aerosol emission reductions affects global temperature and premature mortality caused by elevated aerosol concentrations, using more comprehensive climate models.

Here, we used an aerosol-climate model ECHAM-HAMMOZ to simulate the direct and indirect radiative forcing resulting from aerosol emissions. We simulated Representative Concentration Pathway (RCP) scenarios, and we also designed idealized low and high aerosol emission pathways based on RCP4.5 scenario (LOW and HIGH, respectively). From these simulations, we calculated the Effective Radiative Forcing (ERF) from aerosol emissions between 1850 and 2100, as well as aerosol concentrations used to estimate the premature mortality caused by particulate pollution. We then use the University of Victoria Earth System Climate Model to simulate the spatial and temporal pattern of climate response to these aerosol-forcing scenarios, in combination with prescribed emissions of both short and long-lived greenhouse gases according to the RCP4.5 scenario.

In the RCP scenarios, global mean ERF declined during the 21st century from $-1.3$ W m$^{-2}$ to $-0.4$ W m$^{-2}$ (RCP8.5) and $-0.2$ W m$^{-2}$ (RCP2.6). In the sensitivity scenarios, the forcing at the end of the 21st century was $-1.6$ W m$^{-2}$ (HIGH) and practically zero (LOW).

The difference in global mean temperature at the year 2100 between LOW and HIGH was about 0.4 °C. The effect was even more significant on the global mean warming rate that reached 0.4 °C per decade in LOW and only 0.2 °C per decade in HIGH. The global temperature and warming rate were similar to each other in simulations using the aerosol emissions from standard RCP scenarios.

Anthropogenic aerosols caused significant premature mortality during the 21st century. In 2005, they caused 1.5 million deaths annually. The annual death rate dropped to 0.13 million per year in LOW and was 0.9 million per year in HIGH by 2100. Total premature mortality caused by anthropogenic aerosol particles between 2005 and 2100 was 27 million in LOW, 52-68 million in RCPs, and 113 million in HIGH.

Our results show that both climate and health effects of aerosols are fairly similar across RCP scenarios. However, RCPs share assumptions on effective air-quality policies. Our scenarios LOW and HIGH demonstrate that if strong aerosol policies are not enforced or even more ambitious cuts in aerosol emissions are made, the aerosol impacts on climate and health can differ significantly between scenarios.