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Science for Environment Policy

Loss of cooling effect of aerosols can be offset by greenhouse gas reductions

The net cooling effect that aerosols have on the climate will be lost as emissions drop in the future, new research suggests. However, the consequent warming will ultimately be counter balanced if policies to reduce greenhouse gas (GHG) emissions are put in place.

Aerosols are fine particles or droplets suspended in the air that can affect the climate by altering the amount of the sun's energy that is reflected back into space. They can either cool or warm the atmosphere depending on the type of aerosol but overall aerosols in the atmosphere have a net cooling effect on the climate.

In this study researchers integrate historical emissions data and model projections to examine the impact of three aerosols, sulphates from sulphur dioxide (SO_2) emissions, black carbon and organic carbon, on the climate over 250 years from 1850 to 2100. Black carbon, formed by incomplete combustion of fossil fuels or biomass, absorbs the sun's energy and leads to warming. Both organic carbon and sulphate reflect the sun's energy and lead to an overall cooling effect.

Analysis of historical data shows that emissions of SO_2 increased from 1850, largely as a result of increased numbers of coal-fuelled power stations. Black carbon emissions, already significant in 1850 because of the use of coal and wood for domestic heating and cooking, rose due to increased emissions from a growing transport sector.

SO_2 emissions began to decline after 1970, as a result of controls, however black carbon continued to increase, although this was associated with some uncertainty. Organic carbon, produced mainly as a result of fires in forests and grasslands, increased between 1950 and 2000 because of increasing deforestation.

In order to predict future aerosol emissions and effects, researchers used the Global Change Assessment Model including both a 'reference' scenario, which included no actions to curb GHG emissions and a 'climate policy' scenario. This second scenario incorporates a price for carbon emissions across all sectors, assumed to drive adoption of low carbon technologies.

The results show that future emissions of the three aerosols dropped in both scenarios and were lower under the climate policy, rather than the reference scenario. This was a result of the assumption that lower carbon technologies would replace current types of fossil-powered technologies, and a projected reduction in deforestation, since this stored carbon was also assumed to increase in value.

The authors then examined the knock-on effects of these reductions on the overall warming or cooling effects. In order to account for the high uncertainty of radiative forcing estimates, the researchers defined high, medium and low estimates for key parameters and examined all outcomes.

The net cooling effect of the aerosols was reduced over the 21st century and total aerosol radiative forcing, increased from 0.1 to 0.8 watts per m^2 under the reference scenario. However, under the climate policy scenario, even when aerosols were assumed to have the strongest net cooling, therefore causing a greater warming effect when levels were reduced, the cooling effect of reduction in GHGs counter-balanced this and exceeded any warming effects by 2025.