What are aerosols and what impact do they have?

Atmospheric aerosols are microscopic particles, emitted from human and natural sources, suspended in the Earth’s atmosphere. They generally act to cool the climate by reflecting sunlight back to space and also by affecting clouds, but some specific types of aerosols have a warming effect (such as black carbon). Human sources of aerosols include industrial aerosols from emissions of gases such as sulphur and nitrogen oxides, as well as direct emissions of smoke and soot from fossil-fuel and biomass burning. They also have a negative impact on air quality and human health.

New research is revealing more information about the impacts of aerosols on recent global surface temperature trends, as well as how efforts to reduce emissions of some pollutants could benefit both the climate and human health. For example, reducing emissions of methane (which acts as a precursor to surface ozone) and black carbon could result in a ‘win-win’ by improving air quality, which has a positive benefit on human health, while also helping to tackle global warming.

The Met Office has been at the forefront of work to show the role aerosols play in masking some of the warming caused by greenhouse gases and in influencing our climate.

For the coming twenty to thirty years, changes in aerosols may have a stronger, more immediate influence than greenhouse gas emissions on some regional impacts and variations in global temperature.

Recent research suggests some regional impacts previously attributed to natural internal variability may be due to past emissions of aerosols. For example, Atlantic temperature changes, that have led to decadal shifts in Atlantic hurricane activity and extended sub-Saharan and Amazon drought, have been linked to industrial aerosol emissions.

This represents a new understanding of how aerosols as well as greenhouse gas emissions can influence climate and points to the importance of considering climate and air quality policies together.

![Figure 1](image)

**Figure 1.** The relative radiative forcing in watts per square metre caused by human emissions of selected greenhouse gases and aerosols, over the period 1750–2011 as per the IPCC’s AR5. Note that the methane forcing includes knock-on changes in ozone and stratospheric water vapour that approximately double the forcing from the methane itself. The black carbon forcing includes only the direct impact of the aerosol on radiation, whereas the all aerosols forcing includes both direct impacts on radiataion and its influence on clouds.
Aerosol links to the recent slowdown in global temperature rise

Recent research led by the Met Office has shown that changes in Pacific Ocean sea surface temperatures, which have been widely linked to the recent slowdown in global temperature rise, are associated with regional patterns of human aerosol emissions.

- Previous research suggests the cause of the observed ‘slow down’ in global mean temperature rise was linked to a negative phase of a long-term fluctuation in sea surface temperatures in the Pacific Ocean, known as the Pacific Decadal Oscillation (PDO). This was thought to be due to natural variability.

- New Met Office Hadley Centre research using models driven only by aerosols (no natural variability) also simulates a negative PDO that matches the timing and pattern of that observed in the real world.

- Whilst both aerosols and natural variability may have played a role in the recent negative PDO, there is a clear physical mechanism for forcing of the PDO by industrial aerosols.

- Recent large increases in global temperatures have occurred alongside a shift to a positive PDO and a decrease in Chinese aerosol emissions, combined with other factors. This adds further weight to the conclusion that aerosols could be linked to the PDO and global temperatures.

Tackling short-lived climate pollutants can have co-benefits for health and climate

Aerosols together with surface ozone are among the main contributors to poor air quality, which has a major impact on human health, agriculture and ecosystems around the world. Research shows policies to reduce air pollutants and mitigate climate change are interlinked. Understanding these interactions is important to predict near-term changes in air quality, climate and carbon budgets, as well as helping policymakers tackle these issues in an integrated approach.

- Air pollutants such as ozone and aerosols can have negative impacts on human health and ecosystem productivity. Short-lived Climate Pollutants (SLCPs) have a residence time in the atmosphere of days to years; they also have a warming effect on the global climate. SLCPs include black carbon (BC), methane (CH\textsubscript{4}), tropospheric ozone (O\textsubscript{3}), and hydrofluorocarbons (HFCs).

- Reducing SLCPs in the atmosphere can, therefore, offer a “win-win” outcome i.e. a “win” for air quality and a “win” for climate in the near term.

- Directly reducing emissions of methane is the most certain means of improving air quality and delivering a reduction in warming, as there is a larger scientific understanding of the climatic response of greenhouse gases (methane and tropospheric ozone) to emission reductions than for aerosol components, such as black carbon.

- Some actions to reduce greenhouse gas emissions could result in increased air pollution, for example the use of biomass and diesel vehicles, and tackling air quality issues could temporarily increase the rate of climate change. Well designed joint policies can minimise these adverse effects.