

Frequently Asked Questions

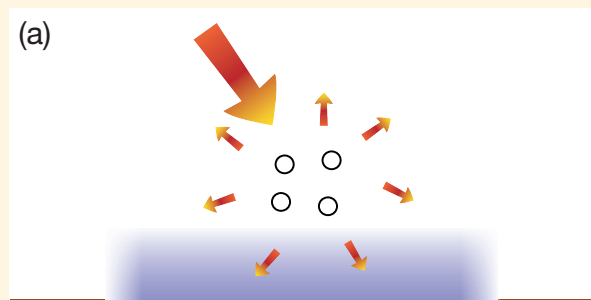
FAQ 7.2 | How Do Aerosols Affect Climate and Climate Change?

Atmospheric aerosols are composed of small liquid or solid particles suspended in the atmosphere, other than larger cloud and precipitation particles. They come from natural and anthropogenic sources, and can affect the climate in multiple and complex ways through their interactions with radiation and clouds. Overall, models and observations indicate that anthropogenic aerosols have exerted a cooling influence on the Earth since pre-industrial times, which has masked some of the global mean warming from greenhouse gases that would have occurred in their absence. The projected decrease in emissions of anthropogenic aerosols in the future, in response to air quality policies, would eventually unmask this warming.

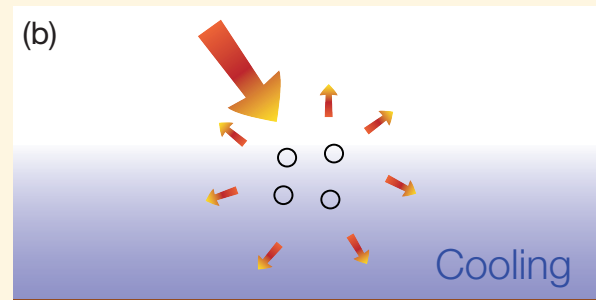
Atmospheric aerosols have a typical lifetime of one day to two weeks in the troposphere, and about one year in the stratosphere. They vary greatly in size, chemical composition and shape. Some aerosols, such as dust and sea spray, are mostly or entirely of natural origin, while other aerosols, such as sulphates and smoke, come from both natural and anthropogenic sources.

Aerosols affect climate in many ways. First, they scatter and absorb sunlight, which modifies the Earth's radiative balance (see FAQ.7.2, Figure 1). Aerosol scattering generally makes the planet more reflective, and tends to cool the climate, while aerosol absorption has the opposite effect, and tends to warm the climate system. The balance between cooling and warming depends on aerosol properties and environmental conditions. Many observational studies have quantified local radiative effects from anthropogenic and natural aerosols, but determining their

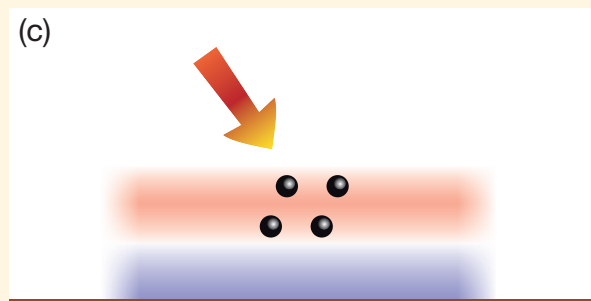
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Aerosol-radiation interactions**Scattering aerosols**

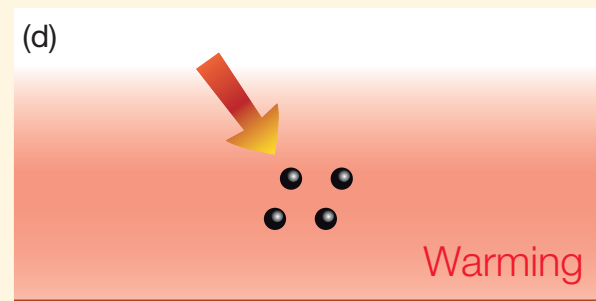
Aerosols scatter solar radiation. Less solar radiation reaches the surface, which leads to a localised cooling.



The atmospheric circulation and mixing processes spread the cooling regionally and in the vertical.

Absorbing aerosols

Aerosols absorb solar radiation. This heats the aerosol layer but the surface, which receives less solar radiation, can cool locally.



At the larger scale there is a net warming of the surface and atmosphere because the atmospheric circulation and mixing processes redistribute the thermal energy.

FAQ 7.2, Figure 1 | Overview of interactions between aerosols and solar radiation and their impact on climate. The left panels show the instantaneous radiative effects of aerosols, while the right panels show their overall impact after the climate system has responded to their radiative effects.

FAQ 7.2 (continued)

global impact requires satellite data and models. One of the remaining uncertainties comes from black carbon, an absorbing aerosol that not only is more difficult to measure than scattering aerosols, but also induces a complicated cloud response. Most studies agree, however, that the overall radiative effect from anthropogenic aerosols is to cool the planet.

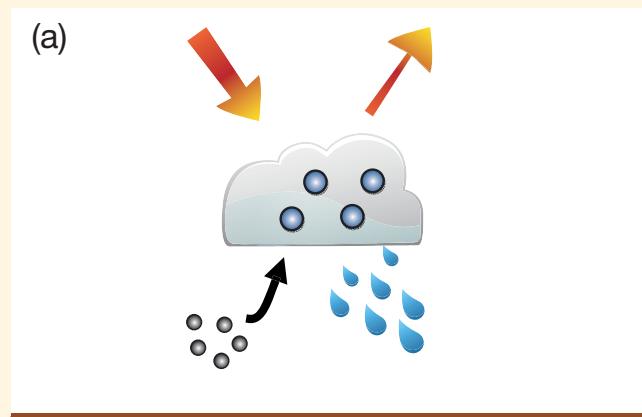
Aerosols also serve as condensation and ice nucleation sites, on which cloud droplets and ice particles can form (see FAQ.7.2, Figure 2). When influenced by more aerosol particles, clouds of liquid water droplets tend to have more, but smaller droplets, which causes these clouds to reflect more solar radiation. There are however many other pathways for aerosol–cloud interactions, particularly in ice—or mixed liquid and ice—clouds, where phase changes between liquid and ice water are sensitive to aerosol concentrations and properties. The initial view that an increase in aerosol concentration will also increase the amount of low clouds has been challenged because a number of counteracting processes come into play. Quantifying the overall impact of aerosols on cloud amounts and properties is understandably difficult. Available studies, based on climate models and satellite observations, generally indicate that the net effect of anthropogenic aerosols on clouds is to cool the climate system.

Because aerosols are distributed unevenly in the atmosphere, they can heat and cool the climate system in patterns that can drive changes in the weather. These effects are complex, and hard to simulate with current models, but several studies suggest significant effects on precipitation in certain regions.

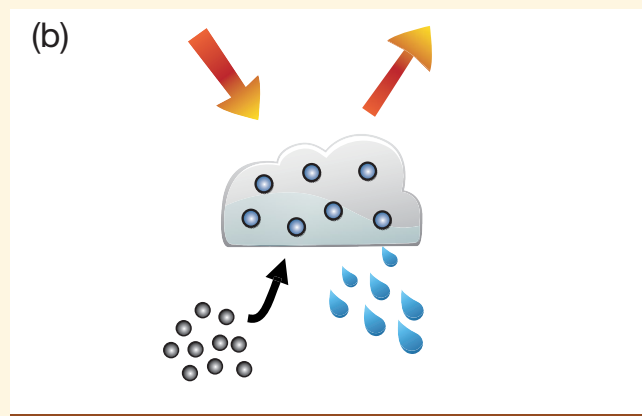
Because of their short lifetime, the abundance of aerosols—and their climate effects—have varied over time, in rough concert with anthropogenic emissions of aerosols and their precursors in the gas phase such as sulphur dioxide (SO₂) and some volatile organic compounds. Because anthropogenic aerosol emissions have increased substantially over the industrial period, this has counteracted some of the warming that would otherwise have occurred from increased concentrations of well mixed greenhouse gases. Aerosols from large volcanic eruptions that enter the stratosphere, such as those of El Chichón and Pinatubo, have also caused cooling periods that typically last a year or two.

Over the last two decades, anthropogenic aerosol emissions have decreased in some developed countries, but increased in many developing countries. The impact of aerosols on the global mean surface temperature over this particular period is therefore thought to be small. It is projected, however, that emissions of anthropogenic aerosols will ultimately decrease in response to air quality policies, which would suppress their cooling influence on the Earth’s surface, thus leading to increased warming.

Aerosol-cloud interactions



Aerosols serve as cloud condensation nuclei upon which liquid droplets can form.



More aerosols result in a larger concentration of smaller droplets, leading to a brighter cloud. However there are many other possible aerosol–cloud–precipitation processes which may amplify or dampen this effect.

FAQ 7.2, Figure 2 | Overview of aerosol–cloud interactions and their impact on climate. Panels (a) and (b) represent a clean and a polluted low-level cloud, respectively.