Atmospheric aerosols can significantly cool down climate

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It is possible to significantly slow down and even temporarily stop the progression of global warming by increasing the atmospheric aerosol concentration, shows a new study from the University of Eastern Finland. However, climate engineering does not remove the need to reduce greenhouse gas emissions.

The study used global climate models to analyse the ability of atmospheric aerosols to cool down the climate, as well as the consequences of their use.. The study focused on methods of climate engineering, which intentionally and artificially increase the atmospheric aerosol concentration in order to cool down the climate. Furthermore, the cooling effects of current atmospheric aerosol emissions were analysed. The study found that aerosol particles injected into the stratosphere proved extremely efficient in cooling down the climate. The method mimics massive volcanic eruptions which release aerosol particles into the stratosphere that reflect solar radiation back into space, thus cooling down the climate even up to years. Atmospheric aerosols injected into the troposphere, on the other hand, can effectively impact the climate through cloud formation. Atmospheric aerosols increase the number of cloud droplets in clouds and make them whiter, which means that they can more effectively reflect solar radiation back into space.

The study also showed that current traffic and industry induced aerosol emissions cool down the climate. However, their cooling effect on the global temperature is significantly smaller than the warming effect of current greenhouse gas emissions. Nevertheless, it would be possible to

harness, for example, global airline traffic and ship traffic for the purposes of atmospheric temperature regulation by increasing the sulphuric concentrations of fuels. This would make it possible to significantly increase stratospheric aerosol concentrations and cloud reflectivity in open sea. However, sulphuric concentrations of fuels would have to be increased beyond the levels defined in international agreements. In addition, the cooling effect would mainly be targeted at the northern hemisphere, which is responsible for a far greater share of global traffic than the southern hemisphere.

Climate engineering not enough, greenhouse gas restrictions vital

The study also shows that not even the most promising methods of climate engineering can cool down the climate, unless the growth of greenhouse gas emissions can be brought under control. This is indicated by a study that analysed the climate effects of a volcanic eruption at a time when aerosol concentrations in the stratosphere were increased for climate engineering purposes. The cooling effect of the volcanic eruption was significantly smaller than it would have been under normal circumstances. The sulphur dioxide released in the volcanic eruption combined with the sulphur dioxide injected into the stratosphere for climate engineering purposes leads to relatively larger particle sizes in comparison to a volcanic eruption in current conditions. The ability of large particles to reflect solar radiation is weaker and their life cycle in the atmosphere shorter than those of smaller particles.

In practice, the consequences would be similar in a situation where the stratospheric aerosol concentration is increased for climate engineering purposes. If greenhouse gas emissions continue to grow, reversing the resulting global warming by climate engineering would require the injection of increasingly large amounts of aerosols into the atmosphere.

The consequence would be increasingly large relative particle sizes with a smaller cooling effect, thus weakening the relative effect of climate engineering. This means that climate engineering is not able, not even in theory, to reverse global warming caused by growing greenhouse emissions, if they continue to increase at the current rate also in the future. Moreover, climate engineering can't fully reverse all consequences of increased atmospheric carbon dioxide concentrations, such as changes in rainfall. Climate change should be mitigated by reducing greenhouse gases, while climate engineering – even at its best – could provide only temporary relief in situations calling for extreme measures.

The findings were originally published in *Geophysical Research Letters*, *Journal of Geophysical Research*, *Atmospheric Chemistry and Physics*, and *Environmental Research Letters*.

More information: The doctoral dissertation by Anton Laakso, MSc, entitled Modelling radiative and climate effects of aerosols: from Anthropogenic emissions to geoengineering, is available for download at: helda.helsinki.fi/handle/10138/161360

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