The significant roles of anthropogenic aerosols on surface temperature under carbon neutrality

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A new study finds that in the near future, the warming effect of anthropogenic aerosol reduction will superimpose on the cooling effect caused by the CO_2 reduction, leading to greater surface temperature increase, delayed start of temperature reduction, and a decelerated cooling rate.

This aerosol effect will not only extend the time required to achieve Paris Agreement targets, but also trigger a long-term cooling trend in the subpolar North Atlantic that is distinct from other regions.

The study was published in *Science Bulletin*. It was completed by Dr. Ma Xiaofan, Prof. Huang Gang, and Prof. Cao Junji from the Institute of Atmospheric Physics, Chinese Academy of Sciences.

Though atmospheric CO_2 makes an impact on surface temperature, the role of aerosols on the spatiotemporal changes of temperature cannot be ignored.

A large reduction in anthropogenic emissions is needed to achieve carbon neutrality and the low-warming target, which means that the concentration of CO_2 and aerosols in the atmosphere will jointly show a downward trend in the future.

However, the same trends in aerosols and CO_2 will cause opposite radiative effects. The warming effect produced by reduced aerosols works simultaneously with the cooling effect caused by reduced CO_2. In addition, aerosols can also affect the dynamic processes from the surface to the deep layer in the ocean, thereby altering regional features of ocean temperature.

To explore the impact of future reductions in anthropogenic aerosols on surface temperature, the researchers used the Community Earth System Model (CESM) to perform fixed-aerosol experiments over the 21st century under a low-emission scenario (RCP2.6) and compared the results with those in all-forcing simulations under the same scenario.

They found that the additional warming effect caused by the continued decline of aerosols in the 21st century will make the global mean surface temperature increase for a longer period of time, rather than a decrease

following the reduction of CO_2 (after ~2050).

They also found that under the low-emission scenario, when other regions have long-term warming trends in surface temperature, the subpolar North Atlantic (south of Greenland) shows long-term cooling trends. This phenomenon is dominated by aerosols while CO_2 plays a secondary role. The regional inconsistency of temperature changes is mainly due to the weakening of the Atlantic Meridional Overturning Circulation (AMOC).

Under the reduction of anthropogenic aerosols, the AMOC continues to weaken since the beginning of the 21st century, which causes the northward heat transport in the Atlantic continue to weaken. The anomalous cold signals gradually accumulate in the subpolar North Atlantic, leading to significant cooling trends in sea surface temperatures over this region in the second half of the century. The cooling of the sea surface further induces the local ocean to absorb more heat from the atmosphere through air-sea heat flux.

"Our study indicates that when planning a specific path to achieve carbon neutrality and low-warming targets, it is necessary to consider the important role of anthropogenic aerosols on the climate system," said Prof. Huang, the corresponding author of the study.

More information: Xiaofan Ma et al, The significant roles of anthropogenic aerosols on surface temperature under carbon neutrality, *Science Bulletin* (2021). DOI: 10.1016/j.scib.2021.10.022

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