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Attribution of the relative contributions of anthropogenic aerosols and decadal variability to the mid-20th century global "cooling": a focus on tropospheric temperature latitudinal gradient

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The global mean surface temperature went through a cooling period during the mid-20th century despite the continuous increase in greenhouse gas concentration. This generates a renewed interest to look at the multi-decadal climate variabilities across the 20th century, which are often believed to be related to the internal variabilities caused by ocean-atmosphere interaction.

At the same time, an obvious interhemispheric tropospheric temperature trend asymmetry is found in both reanalysis datasets and model simulations during this time. Considering the rapid increase of industrial activities in North America and Europe, it generates another possibility that anthropogenic emissions play a role during this period. And if anthropogenic emissions do have significant effects, then the relative contributions of anthropogenic emissions and internal variabilities to the mid-20th-century cooling is worth understanding because of the increasing importance of human activities to the natural environment.

To test this hypothesis, we did a detailed analysis on the global temperature trend and the interhemispheric temperature trend asymmetry from the surface to the mid-troposphere based on Coupled Model Intercomparison Project phase 5 (CMIP5) multi-model ensemble and multiple reanalysis datasets. Our results show that the anthropogenic aerosol emissions contribute to global cooling and particularly asymmetry during the mid-20th century, and the fingerprint of anthropogenic emissions is more obvious in the mid-troposphere compared with the surface.

By different attribution methods (such as multi-linear regression and pattern correlation), we quantified the relative contributions of Anthropogenic Emissions and Internal variabilities based on single forcing simulations of seven CMIP5 models. We conclude that a superposition of Internal Variabilities originating from the Atlantic Ocean and anthropogenic aerosol emissions overwhelms the warming influence of GHGs and lead to the mid-20th century cooling period.