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Climate-driven changes in future aerosols and ozone using a machine learning method with multi-source data

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In recent decades, air pollutants have been changing considerably in various regions across the world. Since the mid-1990s, Asian regions have experienced the fastest near-surface ozone (O_3) increase rate of 2–8 ppb per decade across the world. Aerosols have been decreasing in North America and Europe since 1980s but increasing in Asia until the implementation of clean air actions in China after 2013. A deeper understanding of the long-term changes and causes of aerosols and tropospheric O_3 concentrations in a warming climate is of significance in both the environment and climate policy-making.

In this study, to quantify the impacts of future climate change on O_3 and aerosols, near-surface O_3 concentrations over Asia and global aerosol concentrations in 2020–2100 are projected using a machine learning (ML) method along with multi-source data. We showed that the climate penalty on O_3 is robust over most regions of Asia. The near-surface O_3 levels are projected to increase by 5%–20% over South China, Southeast Asia, and South India under the high-forcing scenarios in the last decade of 21st century, compared to the first decade of 2020–2100. In addition, driven by the climate change alone, $PM_{2.5}$ (particulate matter less than 2.5 μm in diameter) concentrations in 2091−2100 would increase by 10−25% in northern China and western U.S. and decrease by 0−25% in southern China, South Asia, and Europe under the high forcing scenario, compared to those in 2015−2024. Also, climate-driven global future aerosol changes are found to be comparable to those contributed by changes in anthropogenic emissions over many regions of the world in high forcing scenarios. Our results highlight the importance of climate change in regulating future air quality.