

Aerosol Changes over China and Their Impacts on Precipitation Based on CMIP5: Postprint

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Abstract

Based on aerosol optical depth (AOD) data and precipitation data from aerosol single-forcing historical experiments provided by the 5th phase of the Coupled Model Intercomparison Project (CMIP5), and employing linear trend analysis, correlation analysis, and Empirical Orthogonal Function (EOF) methods, this study analyzes the temporal and spatial variations of AOD over China since the Industrial Revolution and its impacts on precipitation. From 1860 to 2000, AOD over the China region exhibited a statistically significant increasing trend ($P < 0.001$). The increasing trend in AOD displayed an “east-high, west-low” spatial distribution pattern bounded by the Hu Huanyong Line, and the increasing trend after 1945 ($0.3807 \cdot (100a)^{-1}$) was significantly greater than that before 1945 ($0.0290 \cdot (100a)^{-1}$). In the aerosol single-forcing experiments, precipitation in 89.1% of China’s territory showed a statistically significant decreasing trend ($P < 0.001$), with the most pronounced precipitation reductions occurring in the southeastern region, the Sichuan Basin, and the southeastern Tibetan Plateau, while the decreasing trend was weaker in Northwest China. Moreover, the decreasing trend in precipitation after 1962 ($118.04 \text{ mm} \cdot (100a)^{-1}$) was significantly greater than that before 1962 ($26.67 \text{ mm} \cdot (100a)^{-1}$). Aerosols significantly reduced the frequency of precipitation events and precipitation intensity primarily by suppressing light precipitation, with reduction rates of $3.160 \text{ d} \cdot (100a)^{-1}$ and $0.1624 \text{ mm} \cdot \text{d}^{-1} \cdot (100a)^{-1}$, respectively. Investigating the climatic effects of aerosols on precipitation since the Industrial Revolution provides a scientific basis for better addressing regional climate change issues.

Full Text

Variation of Aerosol and Its Effects on Precipitation in China Based on CMIP5 Models

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Abstract

Aerosols play an important role in atmospheric physical and chemical processes. As human activities intensify and increasing amounts of aerosols are discharged into the atmosphere, climate issues caused by aerosol emissions have attracted widespread attention. This study aims to analyze changes in aerosol optical depth (AOD) and their effects on precipitation using linear trend analysis, correlation analysis, and empirical orthogonal function (EOF) methods. Based on multi-model experimental data from the Phase Five of the Coupled Model Intercomparison Project (CMIP5), we investigated the spatiotemporal variation of aerosols and their impacts on precipitation in China since the Industrial Revolution. The results demonstrate that AOD in China exhibited an increasing trend from 1860 to 2000 ($P < 0.001$), with a more pronounced increase east of the “Hu’ s Line” than to its west, particularly after 1945. The increasing rate after 1945 [$0.3807 \cdot (100a)^{-1}$] was significantly higher than that before 1945 [$0.0290 \cdot (100a)^{-1}$]. In experiments considering only aerosol changes, precipitation decreased significantly across 89.1% of China as aerosol emissions increased ($P < 0.001$). Precipitation reductions were most prominent across southeastern China, the Sichuan Basin, and the southeastern Tibetan Plateau, while the decreasing trend was moderate in northwestern China. The downward trend in precipitation was more significant after 1962 than before, with decreasing rates of $118.04 \text{ mm} \cdot (100a)^{-1}$ in the post-1962 period and $26.67 \text{ mm} \cdot (100a)^{-1}$ in the pre-1962 period. Increased aerosol emissions contributed to the reduction in rainfall frequency and precipitation intensity by suppressing light precipitation events, with reduction rates of $3.16 \text{ d} \cdot (100a)^{-1}$ and $0.1624 \text{ mm} \cdot \text{d}^{-1} \cdot (100a)^{-1}$, respectively. These findings provide an important scientific basis for understanding the climatic effects of AOD changes on precipitation since the Industrial Revolution and for better responding to future regional climate change.

Keywords: CMIP5; aerosol optical thickness (AOD); precipitation change; empirical orthogonal function (EOF); China

Note: Figure translations are in progress. See original paper for figures.

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