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Seasonal Prediction of Indian Wintertime Aerosol Pollution using the Ocean Memory Effect

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As China makes every effort to control air pollution, India emerges as the world's most polluted country, receiving worldwide attention with frequent winter haze extremes. In contrast with numerous studies linking haze in China with climate factors, the climate factors modulating Indian aerosol pollution have been less studied and are less understood. In this study, we decomposed the satellite observed historical spatial distribution of aerosol optical depth (AOD) over the 2003-2018 period, and found that the inter-annual variability of aerosol pollution over northern India is regulated mainly by a combination of El Niño and the Antarctic Oscillation (AAO). Both statistical analysis and numerical experiments using the Community Earth System Model version 2 (CESM 2) confirm that a strong El Niño condition excites a cyclone anomaly over northern India, reducing near surface wind speeds, thus aggravating aerosol pollution; positive AAO invigorates a meridional dipole sea surface temperature (SST) anomaly distributed over the Indian Ocean, and this feature enhances northerly winds over northcentral India, while weakening westerly winds over northeastern India, leading to a heterogeneous response in aerosol concentrations. Both El Niño SST anomalies and AAO induced Indian Ocean Meridional dipole SST anomalies can persist from autumn to winter, offering prospects for a prewinter forecast of wintertime aerosol pollution over northern India. We constructed a multi-variable regression model incorporating El Niño and AAO indices for autumn to predict wintertime AOD. The prediction exhibits a high degree of consistency with observation, with a correlation coefficient of 0.78 ($p<0.01$). This statistical model could allow the Indian government to forecast aerosol pollution conditions in winter, and accordingly improve plans for pollution control.