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Effect of climate variability and change on winter haze over eastern China in recent decades

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In recent years, eastern China has frequently experienced persistent and severe winter haze pollution episodes with high aerosol concentrations, which have affected half of the 1.3 billion people in China. In this work, the increases in wintertime aerosol concentrations and severe haze events in eastern China over 1985-2015 were quantified by using observed atmospheric visibility from the National Climatic Data Center Global Summary of Day database, observed PM2.5 concentrations from the network of China National Environmental Monitoring Centre (CNEMC), and simulated PM2.5 concentrations from the Goddard Earth-Observing System (GEOS) chemical transport model (GEOS-Chem). Observed winter haze days (defined as days with atmospheric visibility less than 10 km and relative humidity less than 80%) averaged over eastern China (105–122.5°E, 20–45°N) increased from 21 days in 1980 to 42 days in 2014. Observed severe haze days (defined as days with PM2.5 >150 μg m-3) occurred mainly over Northern China. Considering variations in both anthropogenic emissions and meteorological parameters, the GEOS-Chem model simulated an increasing trend in wintertime surface-layer PM2.5 concentrations of 10.5 ($\pm$6.2) μg m-3 decade-1 over eastern China in the past decades. Sensitivity studies showed that changes in anthropogenic emissions and in climate contributed 87% and 17% to this increasing trend, respectively. Wintertime severe haze events over eastern China showed large interannual variations, driven by climate variability. Process analyses were performed to identify the key meteorological parameters that determined the interannual variations of wintertime severe haze events.