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Potential impacts of Arctic warming on Northern Hemisphere mid-latitude aerosol optical depth

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The specific weather and climate conditions is superimposed on the emission of aerosol particles from human activities, providing a favorable atmospheric background for the maintenance and development of haze events in some regions. To enhance the understanding of climate impact on haze events, this study investigates the potential impacts of Arctic warming on the variation of North Hemisphere mid-latitude aerosol optical depth (AOD) in winter when haze often occurs. We first analyze the spatio-temporal variability of wintertime AOD (WA) in mid-latitudes of Northern Hemisphere from NASA MERRA-2 for the period of 1980-2016 using the empirical orthogonal function analysis and morlet wavelet analysis. The results indicate that WA had anti-phase oscillations in East Asia and India, compared with that in Europe and North America. It showed inter-decadal fluctuations but rising trend for WA in East China and North India, while the WA decreased in Europe and North America during last 37 years. In addition to the temporal trends of WA, it had two major change modes with periods of 12 and 7 years during last 37 years and the inter-decadal variation was dominant, which implies the potential impacts from natural variabilities. Further canonical correlation analysis shows high correlations between the mid-latitude WA and Arctic summer (May and June) surface temperature (T56). Moreover, the Arctic summer surface temperature demonstrates similar periodic variations with periods of about 7-9 and 11-13 years. Both of these indicate the potential impacts of Arctic summer warming on mid-latitude winter pollution. We then analyze the temporal correlations between Arctic summer temperature and mid-latitude winter AOD in different regions. Averaged Arctic T56 has a clear teleconnection with WA in mid-latitudes of the Northern Hemisphere. Arctic T56 correlated positively with WA in Europe and North America, and negatively with that in East Asia, North India and Middle East. Particularly, T56 in the eastern sea (Kara sea) of Novaya Zemlya has the most prominent correlation with the WA in mid-latitudes of the northern hemisphere, especially in East China. This implies that Arctic T56 could be used for rough estimates of winter AOD in mid-latitudes of Northern Hemisphere.