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# Winter haze over North China Plain: influence from emission and meteorology

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Analysis of PM2.5 readings taken at the US embassy in Beijing since 2009 reveals that winter haze over North China Plain (NCP) peaked in 2012 and 2013 and there was an improvement in air quality until 2016. The variation of wintertime PM2.5 from 2009 to 2016 is influenced by both emission changes and meteorology conditions, and in this study we quantified the relative contributions from these two aspects. The sensitivity simulation by the GEOS-Chem model suggested that the emission reductions over NCP in 2013-2017 caused a 10% decrease of the regional mean PM2.5 concentration in 2016 winter compared to the 2012 winter level. We removed the emission influence on PM2.5 concentration to get the PM2.5 that influenced by meteorology (met-influenced PM2.5). For the met-influenced PM2.5, compared to the original observation, the percentage of clean days (daily PM2.5 concentration less than 75 $\mu$g/m3) decreases while that of the polluted (daily PM2.5 concentration between 75 $\mu$g/m3 and 150 $\mu$g/m3) and heavily polluted (daily PM2.5 concentration between 150 $\mu$g/m3and 250 $\mu$g/m3) days increases. However, proportion of the extremely polluted (daily PM2.5 concentration exceeds 250 $\mu$g/m3) days stays unchanged, even if the emission reduction is doubled, indicating that the extremely polluted situation over NCP is dominated by the meteorological conditions, and the emission control from 2013 to 2017 has little effects on the extremely polluted days. We developed an effective haze day index (HDI) to represent the weather conditions conducive to haze days. HDI is constructed based on the normalized near surface meridional wind (V850), temperature difference ($\delta$T) between near surface (850hPa) and upper atmosphere (250hPa), and the relative humidity on 1000hPa (RH1000). HDI correlates well with daily PM2.5 with the correlation coefficient of 0.65, and is skillful to detect 72% of the severe haze days (daily PM2.5 concentration exceeds 150 $\mu$g/m3), ranging 48% in 2014 winter to 94% in 2012 winter. The components of HDI can also reveal the relative importance of the three meteorological variables in haze days. On average, the anomalously high meridional winds is the main cause of severe haze these years, while in 2012 winter, the relative humidity favorable for secondary aerosols formation is the largest contributor to haze.