Quantifying the Impacts of Cold Airmass on Aerosol Concentrations Over North China Using Isentropic Analysis

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Winter air quality can vary markedly due to cold air activities. However, the impacts of the polar cold airmass on aerosol variations has not been clarified in a quantitative manner. Using an isentropic analysis method, we investigated changes in the cold airmass and sulfate aerosol distributions over North China during the winter of 2014/2015. The cold airmass and sulfate concentrations exhibited pronounced out-of-phase variations, with comparable amplitudes at subseasonal (30–60 days) and synoptic (4–6 days) scales. Subseasonal sulfate variations were closely associated with distribution of the polar cold airmass, as it shifted between zonal and meridional patterns, regulating cold airmass fluxes over North China. Typically, subseasonal surges in the cold airmass consisted of several synoptic disturbances, including one cold air outbreak event and 3–6 renewal/decay oscillations. These synoptic inflows of clean cold airmass repeatedly pushed the warm polluted airmass away from North China. Thus, spatio-temporal variations in sulfate better reflect cold airmass distributions and fluxes than northerly wind regimes. Using diagnostic equations derived herein, we estimated the contribution of various physical processes to aerosol variations during cold air anomalies. We found that the local changes in sulfate concentrations were mainly attributed to advection of warm airmasses, as well as advection and vertical displacement by horizontal convergence of the polar cold airmass. The latter two processes contributed most to sulfate decreases, leading to a relatively strong aerosol reductions during cold air outbreaks, while first two processes led to weaker aerosol reductions during cold air oscillations.

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