Isotopic composition of water-soluble nitrate in bulk atmospheric deposition at Dongsha Island: Sources and implications of external N supply to the northern South China Sea

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Increased reactive nitrogen (Nr) emission from Asian continent poses profound threats on ecosystem safety from terrestrial throughout the ocean proper. To quantify atmospheric Nr input, diagnose its sources, and evaluate influence on marine N cycle of the South China Sea (SCS), an oligotrophic marginal sea adjacent to the emission hotspot China, we conducted measurements of concentrations of nitrate and ammonium, and dual isotopes of nitrate ($\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$) in atmospheric deposition collected from Dongsha Island off south China. The $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$ for dry deposition averaged at –2.8‰ and +58.8‰, with a range from –7.5‰ to +3.7‰ and from ~+17‰ to +88‰, respectively. The dual isotope ratios showed an anti-correlation and an inverse seasonality; the $\delta^{15}N_{NO3}$ values were higher in summer compared to those in winter, and the $\delta^{18}O_{NO3}$ values were higher in winter than those in summer. In winter, not only isotope composition of nitrate but also the ammonium and nitrate dry deposition fluxes were relatively uniform, demonstrating a persistent influence of fossil fuel combustion dominated Asian continental outflows via the northeasterly monsoon winds. More variable isotopic values in summer suggest the likelihoods of varying sources and dynamical formation processes of atmospheric nitrate. Biomass burning and lightning are suggested to be responsible for the observed higher $\delta^{15}N_{NO3}$ values in summer. Atmospheric nitrate and ammonium deposition was estimated to be ~50 mmol N m^{-2} $year^{-1}$, with the dominance of nitrate in dry deposition but slightly dominance of ammonium in wet deposition. If without this additional fertilization of atmospheric Nr deposition to enhance the carbon sequestration, CO_2 release out of the SCS would be doubled of the present amount. Our study demonstrates that atmospheric deposition may serve as an important external Nr supplier to the SCS yet difficult to separate the isotopic signal from N-fixation due to their similarity in $\delta^{15}N_{NO3}$.