

Tracking nitrogen oxides, nitrous acid, and nitric acid from biomass burning

Jiajue Chai
David Miller
Meredith Hastings

Biomass burning emissions are an important source of atmospheric nitrogen oxides ($\text{NO}_x = \text{NO} + \text{NO}_2$) and nitrous acid (HONO), which play important roles in atmosphere oxidation capacity and have severe impacts on air quality and climate. However, tracking NO_x and HONO and their chemistry in the atmosphere based on concentration alone is challenging. Isotopic analysis provides a potential tracking tool. In this study, we measured the nitrogen isotopic composition ($\delta^{15}\text{N}$) of NO_x and HONO during the Fire Influence on Regional and Global Environments Experiment (FIREX) laboratory experiments at the Missoula Fire Laboratory.

Our newly developed and validated annular denuder system (ADS) enabled us to effectively trap HONO a previously prior to a NO_x collection system in a train series for isotopic analysis. In total we investigated 25 “stack” fires of various biomass materials where the emissions were measured within a few seconds of production from the fire. $\delta^{15}\text{N}\text{-NO}_x$ ranged from -4.3 ‰ to +7.0 ‰ with a median of 0.7 ‰. We found the $\delta^{15}\text{N}\text{-NO}_x$ follows a linear relationship with $\delta^{15}\text{N}\text{-biomass}$ ($\delta^{15}\text{N}\text{-NO}_x = 0.94 \delta^{15}\text{N}\text{-biomass} + 1.98$; $R^2=0.72$). $\delta^{15}\text{N}\text{-HONO}$ ranged from -5.3 to +8.3 ‰ with a median of 1.4 ‰. While both HONO and NO_x are sourced from N in the biomass fuel, the secondary formation of HONO likely induces fractionation of the N that leads to the difference between $\delta^{15}\text{N}\text{-NO}_x$ and $\delta^{15}\text{N}\text{-HONO}$. We found a correlation of $\delta^{15}\text{N}\text{-HONO} = 0.86 \times \delta^{15}\text{N}\text{-NO}_x + 0.52$ ($R^2=0.55$), which can potentially be used to track the chemistry of HONO formation following fire emissions.