

Exceptional emissions of NH₃, CO, HCN and C₂H₆ from the 2017 North American wildfires detected in the high-Arctic

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From August 17-22, 2017, simultaneous enhancements of ammonia (NH₃), carbon monoxide (CO), hydrogen cyanide (HCN) and ethane (C₂H₆) were detected from ground-based solar absorption Fourier-transform infrared (FTIR) spectroscopic measurements at two high-Arctic sites: Eureka, Nunavut (80.05°N, 86.42°W), and Thule, Greenland (76.53°N, 68.74°W). These enhancements were attributed to wildfires in British Columbia and the northwestern United States using FLEXPART back-trajectories and fire locations from the Moderate Resolution Imaging Spectroradiometer (MODIS) and found to be the greatest observed enhancements in more than a decade of measurements at Eureka (2006-present) and Thule (1999-present). Observations of gas-phase NH₃ from these wildfires illustrate that NH₃ may undergo long-range transport and, therefore, suggest that wildfires may be a considerable source of NH₃ in the summertime high-Arctic. However, the mechanisms leading to the long-range transport of wildfire emissions of NH₃ and its potential impacts on the biosphere, air quality and climate of the high-Arctic are not well understood.

In this study, enhancement ratios of NH₃, HCN and C₂H₆ with respect to CO are calculated for fire-affected measurements at Eureka and Thule. The enhancement ratios of HCN and C₂H₆ are found to be comparable between sites as these species are long-lived and act as tracers of wildfire emissions. For NH₃, differences in the enhancement ratios are observed between sites and are strongly dependent on the time of measurement, which suggests that transport patterns of the smoke plume and differences in burning phase may have a strong influence on the measured concentrations of NH₃. To further investigate these differences, satellite observations of NH₃ from the Infrared Atmospheric Sounding Instrument (IASI) and Cross-track Infrared Sounder (CrIS) are used to examine the spatial and temporal variability of NH₃ during transport. Comparisons of IASI and CrIS to high-resolution (0.25° × 0.3125°) GEOS-Chem model results using Global Fire Emissions Database (GFED4) 3-hourly biomass burning emissions are also performed to evaluate the emission inventories and investigate the physical and chemical properties influencing the long-range transport of NH₃ to the high-Arctic.