8th International Conference on Fog, Fog Collection and Dew
Taipei, Taiwan, 14–19 July 2019
IFDA2019-149

Characterization of cloud water impacted by wildfire emissions in the western United States

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Clouds play an important role in processing trace gases and atmospheric aerosols by providing an abundant water medium for atmospheric aqueous-phase chemical reactions and through the potential to incorporate and deposit scavenged material directly or via precipitation. Relevant reactions include oxidation of volatile organic compounds to lower volatility products, thus contributing to secondary organic aerosol (SOA) formation and changing properties of aerosol released by evaporating clouds. One important source of gas and particulate emissions to the atmosphere is wildfires; however, direct sampling and measurements of the chemical composition of fog and cloud water impacted by wildfire plumes has been scarce. In order to improve understanding of the interaction between biomass burning smoke and clouds, cloud water was collected aboard the NSF/NCAR C-130 research aircraft during the WE-CAN (Western wildfire Experiment for Cloud chemistry, Aerosol absorption and Nitrogen) study in July and August 2018. 5 cloud water samples were collected from 4 research flights using the CSU/NCAR airborne cloud water collector and analyzed for major inorganic ions, total organic carbon (TOC), carboxylic and dicarboxylic acids, levoglucosan and other anhydrosugars, S(IV), formaldehyde and hydrogen peroxide.

The average pH value of collected cloud water was 3.85. The aqueous-phase concentrations of S(IV) and HCHO were higher than predicted from equilibrium partitioning of observed gas phase concentrations using Henry's Law. Due to abundant H_2O_2 (average concentration of 167.8 μM) and moderate pH, H_2O_2 was the dominant S(IV) oxidant in sampled clouds. Cloud composition was dominated by organic matter (OM) (TOC range = 15.9 – 131.7 mg C L-1), contributing approximately 85% of the measured solute load, inorganic species contribute the remaining 15%. The most abundant individual organic compounds measured were maleate, acetate, methylsulfonate, oxalate and formate. Measured organic acids and anhydrosugars contributed only 2-4% and <0.01-1%, respectively, of cloud water TOC. The composition of inorganic ions in collected cloud water varied considerably, with major species including ammonium, nitrate, sodium and chloride.