Halogen-containing Compounds in the Lower Stratosphere during the North American Summer Monsoon Season

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Intense convection occurs in summer within the North American Monsoon Anticyclone (NAMA) circulation, with over 100 storms penetrating the tropopause daily. These storms can inject water vapor and other chemicals into the lower stratosphere, with unknown effects on stratospheric ozone. The Dynamics and Chemistry of the Summer Stratosphere (DCOTSS) mission was designed to study this coupled dynamical and chemical system, and included deployments of the ER-2 aircraft from Salina, KS, along with radar, satellite and sonde observations of atmospheric structure and convection. We present measurements and analysis of organic and inorganic halogen-containing compounds from DCOTSS 2021. Long-lived anthropogenic halocarbons, such as CFCs and halons, are broken down at high altitudes before descending into the lower stratosphere. Shorter-lived compounds have both anthropogenic and natural sources, and can enter the stratosphere from the tropics or via direct injection by convection at mid-latitudes. Photochemical destruction of these compounds releases inorganic chlorine and bromine, which can lead to halogen-catalyzed ozone loss. The UAS Chromatograph for Atmospheric Trace Species (UCATS) measures several long- and short-lived organic chlorine species, accounting for about 2/3 of organic chlorine, and the Advanced Whole Air Sampler (AWAS) measures a comprehensive suite of trace gases, including most organic chlorinated and brominated halocarbons of interest, allowing an analysis of the organic chlorine budget of the lower stratosphere at the higher time resolution of the UCATS instrument, using AWAS samples to account for unmeasured species. We also calculate the approximate total amount of chlorine entering the stratosphere from the NOAA surface network and UCATS measurements of SF6, a tracer of mean age of air. From the difference between total chlorine and remaining organic chlorine, we estimate the amount of inorganic chlorine in each sample. We show results on total organic chlorine over North America in summer 2021, in background stratospheric air as well as in convectively influenced air and plumes of recent convection, with estimates of the amount of available inorganic chlorine and measurements of some of the important inorganic chlorine species.

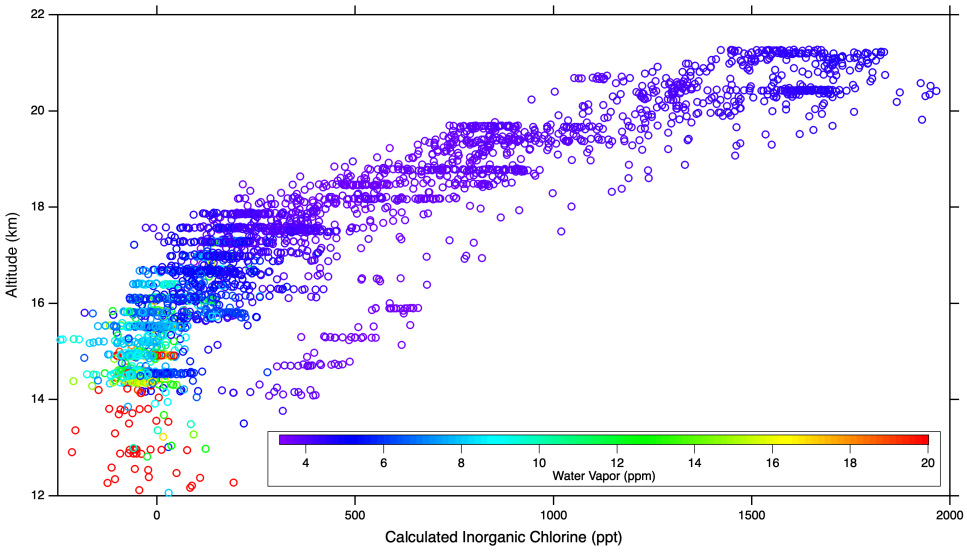

Figure 1. Calculated inorganic chlorine (Cly) in the stratosphere over the North American Monsoon circulation, color-coded by water vapor. Enhanced water vapor, which could activate chlorine, was only present in air parcels with low Cly measured in 2021.