Iodine Detection in the Lower Stratosphere

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Iodine is emitted into the atmosphere mostly from marine sources, and in inorganic form. In the atmosphere, iodine participates in catalytic reaction cycles that destroy ozone and can form new particles. The impact on stratospheric ozone is currently not well established, in part due to the lack of quantitative measurements in the daytime lower stratosphere (LS). Previous stratospheric measurements detected iodine qualitatively in particles, establish low upper limits of iodine oxide (IO) radicals under twilight conditions, and small amounts of methyl iodide (CH_3I). Based on these observations, the WMO currently estimates an upper limit of <0.15 pptv I_y [total inorganic gas-phase iodine: sum of iodide atoms (I), IO, hypoiodous acid (HOI), higher iodine oxides (I_xO_y), iodine nitrate/nitrite (INO_x), CH_3I] are injected into the LS.

However, recent IO observations in the daytime tropical tropopause layer (TTL) challenge this view: 0.13±0.04 pptv IO in the Northern Hemisphere TTL; and 0.15±0.04 pptv IO in the Southern Hemisphere (Dix et al., 2013, 2016; Volkamer et al., 2015; Wang et al., 2015) suggest that between 0.25 to 0.70 pptv I_y are injected into the LS. This is 1.6 to 3.5 times the currently-established WMO upper limit (Saiz-Lopez et al., 2015). At these levels, gas-phase I_y is responsible for 30% of ozone destruction in the LS, which is comparable or larger to the effect of short-lived brominated species [i.e., bromoform ($CHBr_3$), dibromomethane (CH_2Br_2)]. A better understanding of iodine is needed.

Here, we present the first daytime IO detection from aircraft in the LS and TTL over the Western Pacific Ocean, also deemed the gateway to the stratosphere. These measurements were obtained using the University of Colorado Airborne MultiAxis Differential Optical Absorption Spectroscopy (CU AMAX-DOAS) instrument during the Convection Transport of Active Species in the Tropics (CONTRAST, Jan/Feb 2014) campaign (Pan et al., 2017). We also present the first quantification of iodine in LS submicron aerosol by the High Resolution Aerosol Mass Spectrometer (HR-AMS) from the Atmospheric Tomography Mission (ATom1, Jul/Aug 2016, ATom2, Jan/Feb 2017). Figure 1 shows the locations where iodine has been detected in the upper troposphere/lower stratosphere. We use these new data in conjunction with a global model to re-assess the I_y burden in the LS. The implications for lower stratospheric ozone destruction are also discussed.

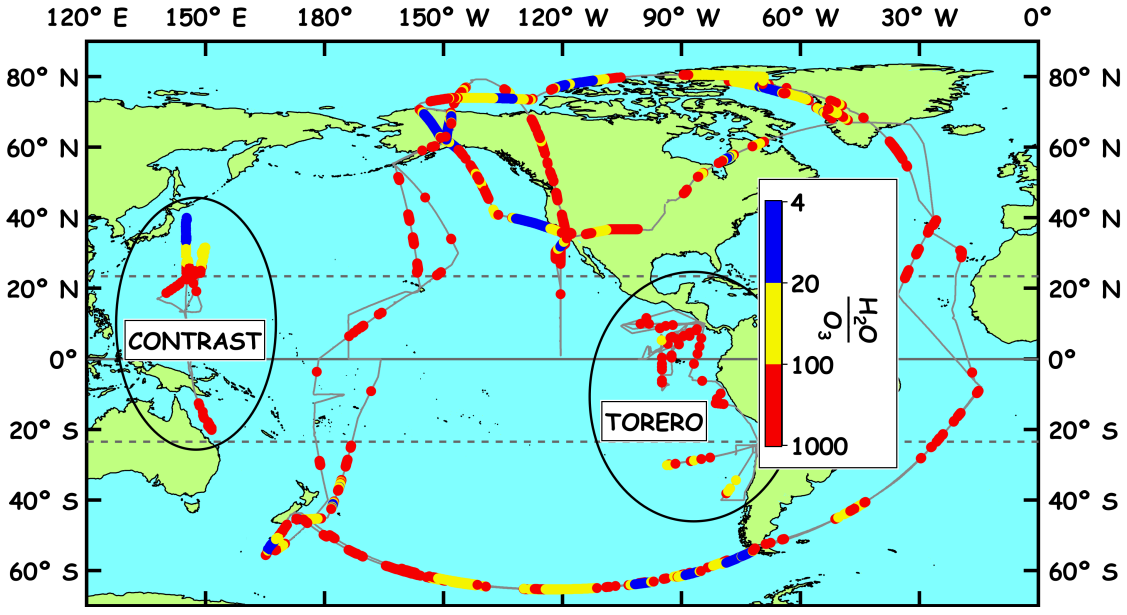

Figure 1. Selected flight tracks from the Tropical Ocean tRoposphere Exchange of Reactive halogen species and Oxygenated VOC (TORERO), CONTRAST, ATom1 and ATom2 field campaigns, and locations where iodine was detected in the upper troposphere and lower stratosphere.