In-situ measurements of total reactive nitrogen, total water vapor, and aerosols in Polar Stratospheric Clouds in the Antarctic Stratosphere

by

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Measurements of total reactive nitrogen, NOy, total water vapor, and aerosols were made as part of the Airborne Antarctic Ozone Experiment conducted in Punta Arenas, Chile during August and September 1987. The measurements were made using instruments located onboard the NASA ER-2 aircraft which conducted twelve flights over the Antarctic continent reaching altitudes of 18 km at 72 S latitude. Each instrument utilized an ambient air sample and provided a measurement up to 1 Hz or every 200 m of flight path.

The data presented focus on the flights of August 17th and 18th during which Polar Stratospheric Clouds(PSC's) were encountered containing concentrations of 0.5 - 1.0 micron diameter aerosols greater than 1 cm^{-3}. The temperature during these events ranged as low as 184 K near 75 mb pressure, with H_2O values near 3.5 parts per million by volume(ppmv). With the exception of two short periods, the PSC activity was observed at temperatures above the frost point of water over ice.

For analysis, the PSC aerosol is assumed to form from the co-deposition of HNO_3 and H_2O on pre-existing sub-micron aerosols as $HNO_3.3H_2O$, with saturation vapor pressures extrapolated from the freezing point of the equivalent liquid mixtures. The degree of saturation for HNO_3 and H_2O mixing ratios over $HNO_3.3H_2O$ was calculated for each point along the flight track using the ambient pressure and temperature measurements. If the calculated vapor pressures are reduced by a factor of 0.5 below 200 K, then saturation conditions coincide with a PSC as defined by elevated aerosol concentrations.

If the aerosol volume is assumed to be $HNO_3.3H_2O$ containing ~54% HNO_3 by mass, then the peak volume observed on the 17th was equivalent to ~4 ppbv of HNO_3. This represents nearly 50% of the NOy reservoir observed outside of the PSC region. The NOy level and the HNO_3 fraction both agree favorably with results from 2-D photochemical models.

The anisokinetic feature of the NOy sampling probe results in the enhancement of the concentration of aerosols in the inlet by a factor of ~6. NOy species incorporated in these aerosols evaporate in the heated inlet lines and add to the NOy gas phase level. The effective enhancement can be calculated along the flight track from the measured aerosol concentration and size distribution. This effective enhancement, the aerosol volume and assumed HNO3 mass fraction, and an estimate of the non-condensing fraction of the NOy reservoir can then be combined to predict the NOy signal. The resulting agreement between the measured and calculated NOy provides strong independent evidence that NOy species are incorporated in the PSC aerosol.