N91-25436

p. 2

Title: Airborne Lidar Measurements of Ozone during the 1989 Airborne Arctic Stratospheric Expedition

Authors: Edward V. Browell, NASA/Langley Research Center
Marta A. Fenn, ST Systems Corporation
Susan A. Kooi, ST Systems Corporation

ND210491
5Y768289

Discipline: Atmosphere

The NASA/NOAA Airborne Arctic Stratospheric Expedition (AASE) was conducted during the winter of 1988-89 to study the conditions leading to possible ozone (O_3) destruction in the wintertime Arctic stratosphere. The mission was based near Stavanger, Norway, and aircraft flights into the polar vortex were conducted between January 6 and February 15, 1989. As part of this experiment, the NASA-Langley Research Center's airborne differential absorption lidar (DIAL) system was configured for operation on the NASA Ames Research Center's (ARC) DC-8 aircraft to make measurements of O_3 profiles from about 1 km above the aircraft to altitudes of 22-26 km.

The airborne DIAL system remotely sensed ozone above the DC-8 by transmitting two laser beams at 10 Hz using wavelengths of 301.5 and 311 nm. Large-scale distributions of ozone were obtained on 15 long-range flights into the polar vortex during the AASE. Each flight lasted for an average of about 10 hours and covered about 8000 km. Over 150 hours of lidar data were collected on these flights which were conducted between Stavanger (59°N, 5°E) and the North Pole and between about the 40°W and 20°E meridians. These measurements were displayed in real time as false color images of ozone concentrations along the flight path. This poster presents selected data samples of O_3 observed during these flights, general trends observed in O_3 distributions, and correlations between these measurements and meteorological and chemical parameters.

The O_3 distribution observed on the first flight of the DC-8 into the polar vortex on January 6 reflected the result of diabatic cooling of the air inside the vortex during the winter compared to the warmer air outside the vortex. On a potential temperature (PT) surface, the O_3 mixing ratio generally increases when going from outside to inside the vortex. The trends in the O_3 mixing ratio and potential vorticity (PV) distributions were generally well correlated over the entire atmospheric cross section. Based on the location of the maximum gradient in PV on the 440-K PT surface on January 6, the edge of the vortex was estimated to be near 69°N, which also corresponded closely to the location of the maximum wind speed. The O_3 mixing ratio also showed a sharp gradient at this same location. Because of the good correlation in the gradients of O_3 and PV, the DIAL-derived O_3 distribution was used to determine the location of the edge of the polar vortex on each mission.

Post mission analysis of DIAL data extended the altitude range of ozone measurements at least an additional 3 km in range to provide data up to 30 km altitude. The extension technique utilized a single wavelength of lidar data, 311 nm, along with a modeled molecular return. Comparisons with ozonesonde data agree within 20%. These higher altitude data will be useful to investigators interested in mapping other chemical species on the ozone field.

The last AASE mission to be flown deep into the polar vortex was made on February 9. The O_3 distribution at latitudes above 80°N on the 460-K PT level was essentially constant to the Pole; however, between 71-80°N the O_3 mixing ratio was lower than at the higher latitudes within the vortex. This region of lower O_3 extended in the vertical across the PT range from ~420 to 580 K. The magnitude of the decrease was at a maximum at about 500 K (~20 km in altitude), and it represented a decrease of about 17% over the O_3 levels farther inside the vortex. A second large region of low O_3 was also observed on the transit flight from Stavanger to California across the polar vortex on February 15. It was also located near the edge of the vortex, and it had about the same relative O_3 decrease compared to O_3 levels farther inside the vortex, as was observed on February 9. Measurements of O_3 and nitrous oxide from the NASA ARC high-altitude (ER-2) aircraft on February 9 showed that the O_3 decrease at the bottom of this region was due to an in situ loss of O_3 and not due to transport processes. The O_3-depleted region observed by the lidar was correlated in vertical extent with the polar stratospheric cloud observations. This O_3 depletion is thought to be directly related to the chemical perturbation of the Arctic polar vortex that was observed during the AASE.

Acknowledgments

The authors would like to thank Syed Ismail, Patricia Robinette, Shane D. Mayor, Noah S. Higdon, James H. Siviter, Jr., M. Neale Mayo, Robert J. Allen, William J. McCabe, Jerry A. Williams, Loyd W. Overbay, Byron L. Meadows, Jaye A. Moen, and Ricky L. Martin of the Lidar Applications Group in the Atmospheric Sciences Division at the NASA Langley Research Center for their assistance in developing the comprehensive measurement capabilities of the airborne DIAL system, integrating the system into the DC-8, operating the lidar in the field, and reducing the lidar data after the mission. This research was supported by NASA's Upper Atmospheric Research Program.