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BALLOON-BORNE MEASUREMENTS OF POLAR STRATOSPHERIC OZONE

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Research Objectives:

The objective was to provide high-resolution measurements of the vertical structure of stratospheric ozone at high northern and southern latitudes, as part of a series of studies of stratospheric ozone losses over polar regions.

Summary of Progress and Results:

Fifty-seven balloon-borne ozonesonde soundings were conducted from Palmer Station, Antarctica (65°S, 64°W), between September 3 and October 31, 1988. Although the 1988 austral-springtime ozone depletion over most of Antarctica was generally not as deep as during the record year of 1987, much of the activity centered over Palmer Station. The losses in total ozone overburden at this location were nearly as great during the 1988 season as during 1987. Starting at about 325 DU in early September, the column ozone amount had dropped to 200 DU before mid-October.

While the decrease in column ozone amounts over Palmer Station during 1988 was similar to that of 1987, the vertical profiles had quite different characteristics. During 1987 there were layers, at altitudes of about 17 km, in which ozone depletion was essentially complete - over 95 percent. Such deeply-depleted layers were absent over Palmer Station in 1988.

As an element of the AASE mission, thirty-seven ozonesonde soundings were made from Lerwick, Shetland Islands (61°N, 2°W), between January 7 and February 13, 1989. During this same time period, the Danish Meteorological Institute launched three sondes per week from each of two sites in East Greenland, using sondes provided by NASA. These data are currently being analyzed.

Journal Publications:

Torres, Arnold L., and George Brothers, "Ozone Profiles over Palmer Station, Antarctica," submitted to Journal of Geophysical Research, 1989.

Margitan, J. J., G. Brothers, E. V. Browell, D. Cariolle, M. T. Coffey, J. C. Farman, C. B. Farmer, G. L. Gregory, J. W. Harder, D. J. Hofmann, W. Hypes, S. Ismail, R. O. Jakoubek,

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W. Komhyr, S. Kooi, M. H. Proffitt, A. R. Ravishankara, A. L. Schmeltekoph, W. L. Starr, G. C. Toon, A. Torres, A. F. Tuck, A. Wahner, and I. Watterson, "Intercomparison of Ozone Measurements over Antarctica," J. Geophys. Res., in press.

TITLE : DEVELOPMENT OF A FAST RESPONSE ATMOSPHERIC METHANE MONITOR FOR THE NASA ER-2 AIRCRAFT

INVESTIGATORS : J. B. McManus, P.L. Kebabian, C.E. Kolb

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ABSTRACT OF RESEARCH OBJECTIVES :

It has been the objective of this project, under contract number NASW-4345, to develop the core of an infrared-laser based atmospheric measurement instrument that is intended for eventual deployment on the NASA ER-2 high altitude research aircraft. The goal of this phase of development is to construct and test the optical core of the instrument, which will demonstrate the basic instrument performance in terms of sensitivity, stability and automatic operation. The ARI Stratospheric Methane Monitor is based on a magnetically broadened HeNe laser operating at 3.39 microns, which is coincident with a methane absorption line. The instrument utilizes a compact, fast flow response, multipass absorption cell, with over 50 meters of pathlength. The instrument is completely microprocessor-controlled, for signal processing and automatic laser stabilization. The goal for instrument sensitivity is 5 ppb methane (0.3% of ambient), with a cell flushing time of 3 seconds.

SUMMARY OF PROGRESS AND RESULTS :

Aerodyne Research has successfully completed the development of the core of an infrared laser-based atmospheric methane instrument, which with further development should be suitable for deployment on the NASA ER-2 aircraft. The measurement of methane in the stratosphere is important because methane is, through photochemical processes, the main source of water wapor and hydroxyl radicals in the statosphere. Thus it plays important roles in the chemical cycles of the upper atmosphere, including the cycles leading to ozone depletion. We have constructed and tested a methane measurement instrument which includes the following subsystems: a magnetically-broadened infrared HeNe laser, laser control and signal processing electronics, an optical system with a low pressure, fast response multipass absorption cell, and a gas handling system for bench testing. A flight qualified instrument will require a more robust mechanical structure and enclosure, a more complete gas sampling system, an enlarged data processing and control system, and extensive pre-flight testing.

Tests to date indicate that we have met our goals for the basic instrument performance. The current minimum detectable level of change in methane concentration is 5 ppb (RMS noise, one second time constant), out of an ambient concentration of 1680 ppb. The baseline drift has been demonstrated as low as 15 ppb (peak to peak) over 5 hours. The instrument automatically locks onto the laser line at turnon, controls the laser intensity and records methane measurements, all without operator intervention, which is essential for the ER-2 mission. The existing control system can be expanded, using the same computer (Harris RTX 2000), to allow automatic calibration cycles, as well as logging of methane concentration and housekeeping data.

At the heart of the Aerodyne Stratospheric Methane Monitor is a unique infrared HeNe laser, which was invented at Aerodyne Research. This laser acts as an amplitude and frequency controlled light source that can be tuned on and off the center of a methane absorption line (near 2947 wavenumbers). This laser offers advantages in terms of reliability, weight and power consumption over tunable diode-lasers as a source for optical absorption measurements of methane. The ability to tune this gas laser over a range of .015 wavenumbers, with nearly uniform output, is derived from the application of a non-uniform transverse magnetic field to the laser plasma. The laser frequency is scanned over the methane line twenty times per second, while the output power is held constant to within one part in ~10,000. This allows us to detect the small fluctuations in transmission through an optical obsorption cell that are caused by changes in atmospheric methane concentration. The laser output is actively controlled to compensate for ambient levels of methane by means of a column matching reference cell. Once calibrated, the system automatically detects deviations from the ambient methane level.

The methane monitor employs a fast flow response multipass optical obsorption cell of the off-axis resonator (Herriott cell) design. With an effective gas volume of 1.5 liters, we obtain an optical absorption length of over 50 meters, which gives an absorption due to ambient methane at 40 Torr pressure of ~10%. The optical train also includes a column matching reference cell for laser amplitude control, and a high concentration methane cell for laser line locking.

JOURNAL PUBLICATIONS:

We plan to publish a description of this work at a later time. We have written a paper describing a related laser-based methane instrument, which was developed for the NASA-ABLE3A experiment. That paper is scheduled to appear in Applied Optics on December 1, 1989.