N89-14512

THE UW DIGITAL OZONESONDE: CHARACTERISTICS AND FLOW RATE CALIBRATION.

J.W. Harder
Cooperative Institute for Research in Environmental Sciences
University of Colorado/NOAA, Boulder, Colorado 80309-0449

D.J. Hofmann, J.M. Rosen, and N.T. Kjome
Department of Physics and Astronomy
University of Wyoming, Laramie, WY 82071

During the austral springs of 1986 and 1987, a series of balloon soundings were conducted to characterize the temporal and vertical development of Antarctic ozone depletion using the electrochemical concentration cell method (ECC). An important part of this study was to perform correlative studies between ozone and aerosol particles. In order to facilitate these simultaneous measurements, a digital ozonesonde system was developed to interface with aerosol counters. The ozone measurements will be described herein. The ozonesonde modification was accomplished by converting the current output of the sonde to a frequency and adding this digital signal to the serial data stream of a Vaisala Corporation RS-80 radiosonde under microprocessor control. This system has a number of advantages over the standard ozonesonde system currently in use, namely:

1) The high quality compensated operational amplifier used in the current-to-frequency conversion of the electrochemical current produces a linear cell response transfer function.

2) A measurement of pressure, temperature, humidity, ozone partial pressure, and (if present) aerosol concentration is transmitted every 5.24 seconds using a standard 403 MHz transmitter and FSK telemetry. Once the incoming signal has been received and decoded, IBM compatible computer hardware can store the data on floppy disk ready for detailed analysis.

3) A measurement of ozone partial pressure every 5.24 seconds permits complete resolution of electrochemical response time of the ECC (about 20 seconds).

4) Any sensor that has a TTL compatible frequency output can be interfaced to this system. But, the system can still be used as a stand-alone ozonesonde and is inexpensive enough to be used as a "throw away" instrument.

The multiple instrument capability of this system was utilized to study the response variability of two independent ozonesondes in the balloon flight environment prior to Antarctic deployment. These dual unit flights demonstrated that for pressures greater than about 50 mb (in the ozone hole region) agreement between units is quite good, on the order of 5%. However, for pressures less than 50 mb significant variations were observed, suggesting the need for individual pump efficiency calibration of each ozonesonde before balloon flight. The apparatus used to find the pump efficiency as a function of pressure is shown in Figure 1.

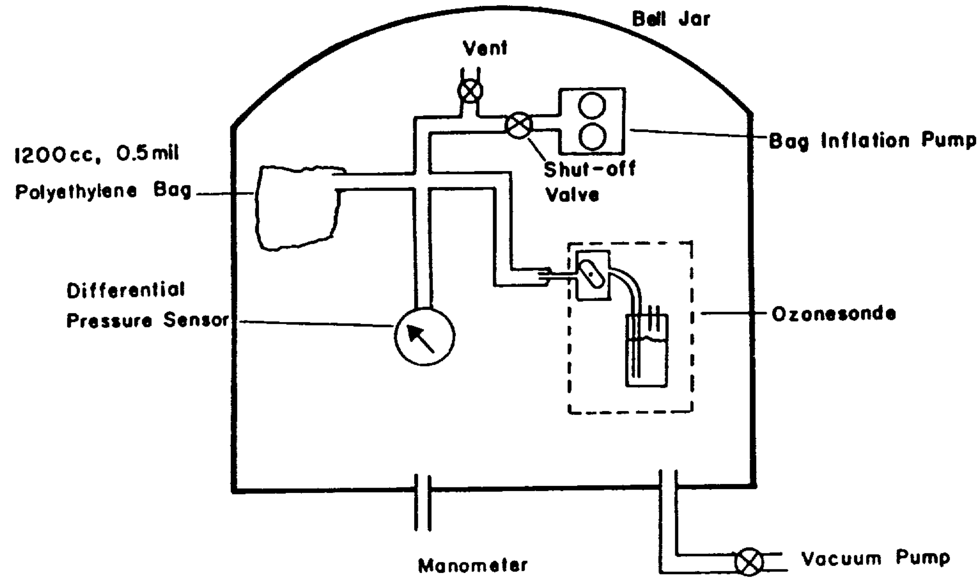

Figure 1. Apparatus used to perform ozonesonde pump calibrations.

This system essentially measures the length of time required to pump out a fixed volume of air. The differential pressure sensor measures the endpoints of when the bag is empty and full. The result of 45 individual ozonesonde pump calibrations is given in Figure 2.

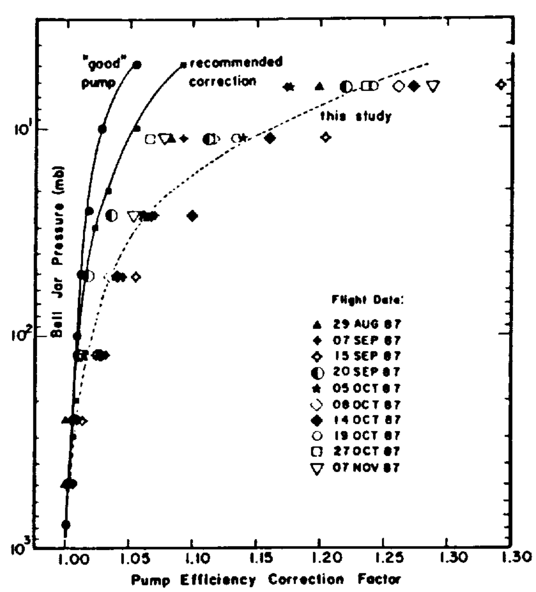

Figure 2. Measured flow rate correction as a function of pressure for the average of 45 ozonesondes (dashed curve), individual data for 10 sondes in this data set, the recommended pump calibration, and the calibration of a good pump. See text for details.

This figure shows the average of 45 pump efficiency factors (dashed curve), and the pump calibrations for ten ozonesondes in this data set (labeled according to the date that they were flown). Also shown in this figure is the efficiency of a "good" pump. This pump consists of a gear pump that has the bearings and gear teeth coated with vacuum grease to prevent any air leakage. This test demonstrates the response of a leak free pump and that the bag deflation technique gives reasonable results for a pump that behaves differently from the ozonesonde pump. Finally, the figure shows the pump efficiency correction factor quoted in the Ozonesonde Operations Handbook (NOAA Technical Memorandum ERL ARL-149). This pump correction factor is markedly different from the one found in this study. The differences are most significant at higher altitudes and can be as large as 15%. Figure 3 shows the differences between these two pump calibrations for two flights in Antarctica in 1987.

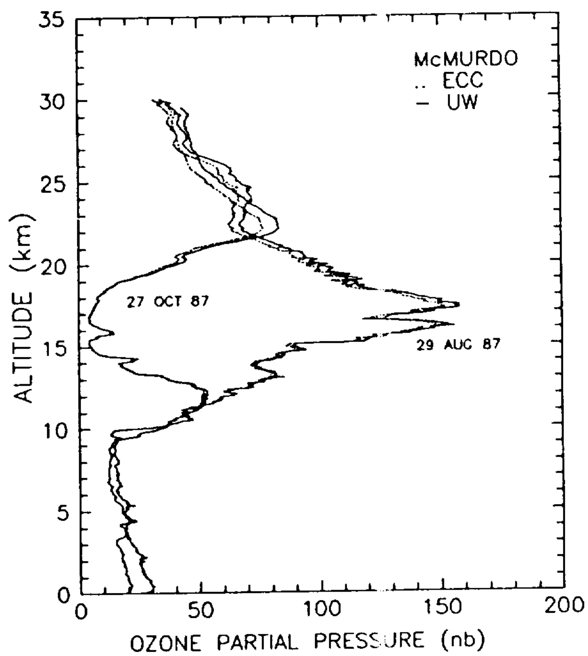

Figure 3. Comparison of pump correction factors for two flights in 1987. The dashed curve used the recommended flow rate correction factor, the solid curve used the pump calibrations found in this study.

In this figure, the profiles marked ECC are profiles derived from the recommended pump calibration, the profiles labeled UW are the profiles found using the individual pump corrections. Using the UW corrections, the integrated ozone was found to be 274 DU on August 29, and 148 DU on October 27. Using the standard correction, the derived integrated ozone columns would be 260 and 137 respectively. Figure 4 shows a comparison of the total ozone found from the Total Ozone Mapping Spectrometer and from integrated ozonesonde data in 1987. Agreement is generally quite good except for early in the season when the ozonesonde tends to give higher total ozone values.

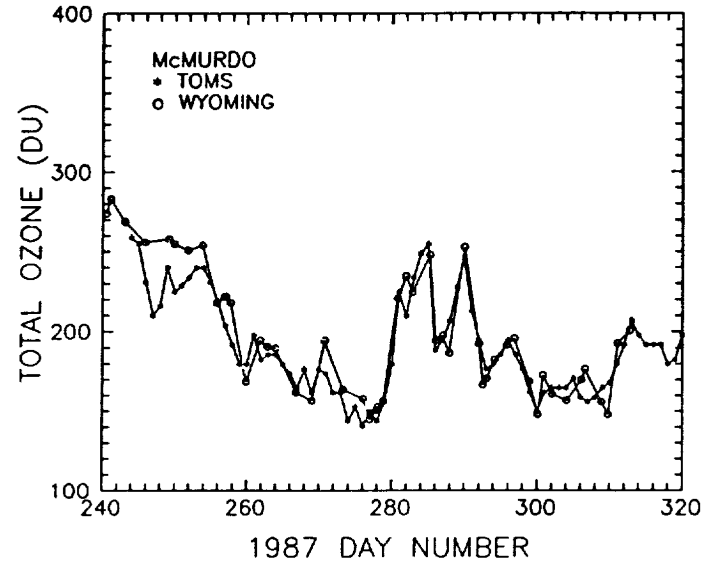

Figure 4. Comparison of total ozone as found by the Total Ozone Mapping Spectrometer, and that found by integrating the ozonesonde height profiles in 1987.

Acknowledgements. This research was supported by the National Science Foundation, Division of Polar Programs and Atmospheric Sciences and the National Aeronautics and Space Administration.