N95- 10636

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TOTAL OZONE TRENDS OVER THE U.S.A. DURING 1979-1991 FROM DOBSON SPECTROPHOTOMETER OBSERVATIONS

Walter D. Komhyr, Robert D. Grass, Gloria L. Koenig
NOAA/ERL Climate Monitoring and Diagnostics Laboratory
Boulder, Colorado 80303

Dorothy M. Quincy, Robert D. Evans, R. Kent Leonard
Cooperative Institute for Research in Environmental Sciences
Boulder, Colorado 80309

ABSTRACT

Ozone trends for 1979-1991, determined from Dobson spectrophotometer observations made at eight stations in the United States, are augmented with trend data from four foreign cooperative stations operated by NOAA/CMDL. Results are based on provisional data archived routinely throughout the years at the World Ozone Data Center in Toronto, Canada, with calibration corrections applied to some of the data. Trends through 1990 exhibit values of -0.3% to -0.5% yr^{-1} at mid-to-high latitudes in the northern hemisphere. With the addition of 1991 data, however, the trends become less negative, indicating that ozone increased in many parts of the world during 1991. Stations located within the ±20°N-S latitude band exhibit no ozone trends. Early 1992 data show decreased ozone values at some of the stations. At South Pole, Antarctica, October ozone values have remained low during the past 3 years.

1. INTRODUCTION

NOAA's Climate Monitoring and Diagnostics Laboratory (CMDL) currently operates 16 Dobson spectrophotometer stations, some of which have records dating back to the early 1960's. Since inception of the program, all field instruments have been calibrated relative to a single "world standard" Dobson spectrophotometer No. 83, whose long-term ozone measurement precision has been maintained at better than ±1% [Komhyr et al., 1989]. Of the 16 operating stations, 4 are foreign cooperatives: Haute Provence, France; Huancayo, Peru; Lauder, New Zealand; and Perth, Australia. We present trend data for 12 of the stations for 1979-1991, a time interval approximating that of the operating interval of the National Aeronautics and Space Administration's TOMS and SBUV ozone spectrometers aboard the Nimbus 7 satellite. Also presented are total ozone data for South Pole, Antarctica, for October months of 1962-1991. Results are expressed in the new Bass-Paur [1985] ozone absorption coefficient scale adopted for use world-wide January 1, 1992 [Hudson et al., 1991]. The new scale yields ozone values about 2.6% smaller than did the Vigroux [1953] ozone absorption coefficient scale used during July 1, 1957-December 31, 1991.

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2. OZONE TRENDS

Figures 1 and 2 plot total ozone anomaly data (i.e., monthly mean ozone deviations from monthly normals for the periods of record shown) for five stations on the United States mainland; two stations in Alaska; Mauna Loa Observatory, Hawaii; American Samoa, South Pacific; and three foreign cooperative stations. Data used in the analysis are provisional, archived at the World Ozone data Center in Toronto, Canada, except that Mauna Loa and Samoa data were provisionally reprocessed in the past through July 1987, and corrections of 0 to -1.7% were applied to Wallops Island data for May 1985 to September 1991 based on recalibration of the instrument in Boulder in 1991. (Provisionally reprocessed data have mean calibration corrections applied; additional small corrections that are air mass dependent may be necessary for portions of the record). Not used in the analysis are available data from Nashville, Tennessee, and Perth, Australia, which require re-evaluation, as well as data from Tallahassee, Florida, where observations were terminated in late 1989, but resumed in April 1992. Data shown in Figures 1 and 2 are de-seasonalized. No attempt has been made to remove from the data ozone variations due to the 11-year solar cycle, the Quasi-biennial Oscillation (QBO), and El Niño phenomena, or the effects of volcanic stratospheric aerosols.

Least squares linear regression lines fitted to the ozone anomaly data of Figures 1 and 2 through 1991 exhibit several interesting features. The two most northerly stations, Point Barrow and Poker Flat show non-significant downward ozone trends of -0.3 and -0.5% yr^{-1}, based on sparse data obtained during spring to autumn seasons of years when observations were made. Stations Bismarck, Caribou, Haute Provence Observatory, and Boulder, located between 40° and 50°N latitudes show downward ozone trends of about -0.4% yr^{-1}, statistically significant at the 95% confidence level (t-statistic) except in the case of the short Haute Provence Observatory record. At Wallops Island (38°N), the downward ozone trend

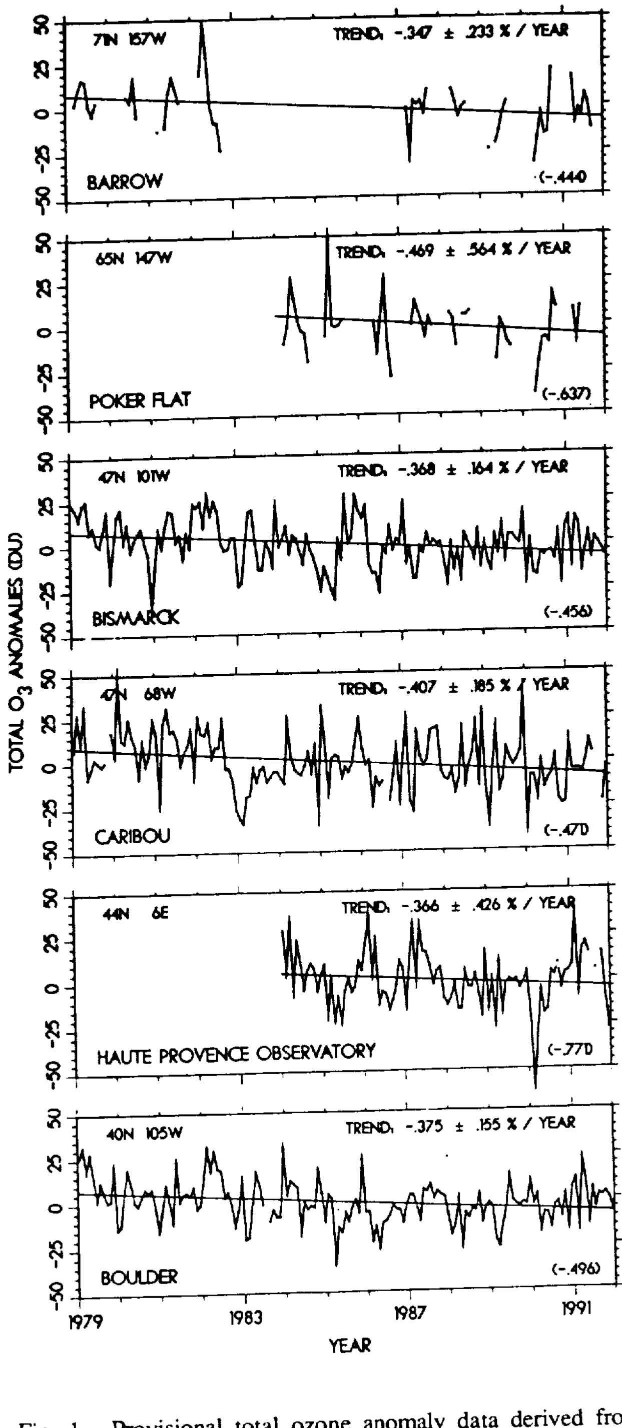

Fig. 1. Provisional total ozone anomaly data derived from Dobson spectrophotometer observations made at BRW, Poker Flat, Caribou, Bismarck, Boulder, and Haute Provence observatories. Least-squares linear regression lines are fitted to data obtained through 1991. Uncertainties in indicated ozone trends are 95% confidence intervals (t-statistic). The values in brackets in the lower right-hand corner of each plot is the ozone trend derived from data obtained only through 1990.

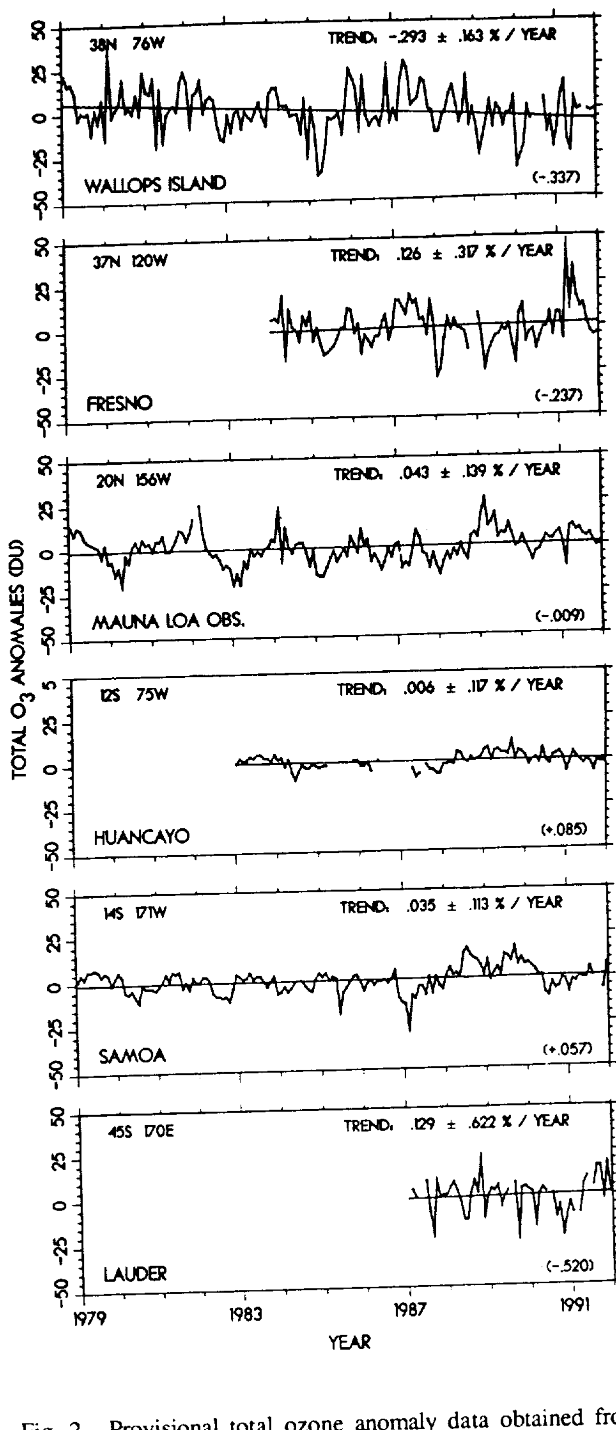

Fig. 2. Provisional total ozone anomaly data obtained from Dobson spectrophotometer observations made at Wallops Island, Fresno, MLO, Huancayo, Samoa, and Lauder. Least-square linear regression lines are fitted to the data obtained through 1991. Uncertainties in indicated ozone trends are 95% confidence intervals (t-statistic). The value in brackets in the lower right-hand corner of each plot is the ozone trend derived from data obtained only through 1990.

TABLE 1. Comparison of Ozone Trends Through 1990 and 1991, for Data Shown in Figures 1 and 2

Station	Lat./Long.	O_3 Trend* (% yr^{-1}) 1979-1991	O_3 Trend* (% yr^{-1}) 1979-1990
Pt. Barrow	71°N, 157°W	-.35 ± .23	-.44 ± .27
Poker Flat	65°N, 147°W	-.47 ± .56	-.64 ± .63
Bismarck	47°N, 101°W	-.37 ± .16	-.46 ± .19
Caribou	47°N, 68°W	-.41 ± .19	-.47 ± .21
Haute Prov.	44°N, 6°E	-.37 ± .43	-.77 ± .47
Boulder	40°N, 105°W	-.38 ± .16	-.50 ± .17
Wallops Is.	38°N, 76°W	-.29 ± .16	-.34 ± .18
Fresno	37°N, 120°W	+.13 ± .32	-.24 ± .33
Mauna Loa	20°N, 75°W	+.04 ± .14	-.01 ± .16
Huancayo	12°S, 75°W	+.01 ± .12	+.09 ± .14
Samoa	14°S, 171°W	+.04 ± .11	+.06 ± .13
Lauder	45°S, 170°E	+.13 ± .62	-.52 ± .80

*Indicated uncertainties are 95% confidence interval errors (t-statistic). The records are not all of uniform length.

TABLE 2. Percent Ozone Changes in 1992 January-April Monthly Means Relative to Monthly "Normals" Based on Data Records of Figures 1 and 2

Station	Latitude	Jan.	1992 Feb.	March	April
Pt. Barrow	71°N	-	-	-3.7	-2.5
Poker Flat	64°N	-	-	[-5.9]	-3.9
Bismarck	47°N	-1.7	-5.1	-4.6	-5.4
Caribou	47°N	-2.9	-7.1	-4.7	-2.4
Haute Prov.	44°N	[-11.8]	-4.0	-7.9	-3.6
Boulder	40°N	+2.4	-0.8	-3.0	-7.4
Wallops Is.	38°N	-1.6	-2.2	-2.3	-7.5
Fresno	37°N	+2.0	+1.6	+4.2	[-8.5]
Mauna Loa	20°N	-1.3	+4.7	+1.3	-0.4
Huancayo	12°S	-2.6	-1.3	[-2.1]	-
Samoa	14°S	+2.2	+2.7	+1.7	-2.5
Lauder	45°S	+3.4	+1.9	+3.4	-3.4

Values in brackets in the body of the table represent record ozone lows.

is about -0.3% yr^{-1}. Mauna Loa Observatory, Huancayo, and Samoa, located within the ±20°N-S latitude band, exhibit essentially zero trends in ozone. At Lauder (45°S), where the record length is only 5 years, the trend is slightly positive, through not statistically significant.

We are currently engaged in a program to reprocess total ozone data from our stations, with application of detailed instrument calibration corrections. Trends computed from recently reprocessed 1979-1991 data from Caribou, Fresno, and Wallops Island, are not different from values shown in Figures 1 and 2 by more than ±0.1% yr^{-1}.

Numbers in brackets in the lower right-hand corners of the plots of Figures 1 and 2 are the ozone trends computed only through 1990. Note that through 1990 (see also Table 1), computed trends are in most cases considerably more negative than trends determined through 1991. The large downward trend through 1990 at Haute Provence Observatory resulted largely from unusually low ozone values at Haute Provence in February 1990. Most stations (see especially Fresno and Lauder) show more ozone in 1991 than in 1990, indicating that ozone increased over many parts of the world in 1991.

Because of high ClO values reported at mid-to-high latitudes of the northern hemisphere in early 1992 [NASA headquarters, 1992], as well as possible ozone destruction by Mt. Pinatubo stratospheric aerosols, there has been considerable speculation about a possible increase in ozone depletion rate early in 1992. In Table 2, we present percent changes in ozone for the NOAA/CMDL station network for the months of January-April 1992 relative to "normal" values for these months derived from the data records depicted in Figures 1 and 2. Record low monthly means in Table 2 are denoted by bracketed percent changes in ozone. Thus, the March 1992 monthly mean total ozone at Poker Flat was nearly 6% lower than March values observed in the past, though this result may not be significant due to the sparsity of the Poker Flat data. The January 1992 Haute Provence Observatory ozone value was lower by nearly 12% than the average of 1984-1991 January values. (Contrast this with the Haute Provence February 1990 ozone mean (not shown) which was 18% lower than the 1984-1991 "normal" value). The Fresno April 1992 monthly mean ozone value was nearly 9% lower than the mean 1984-1991 April ozone value. But in 1991 (not shown), March total ozone was higher at Fresno than the 1984-1991 "normal" March value by 13%. Note also (Table 2) that relatively low ozone values occurred during April 1992 at Bismarck, Boulder, and Wallops Island. These resulted most likely from anomalous air flow patterns, which brought ozone-poor air from equatorial regions during April 1992 northward to higher latitudes.

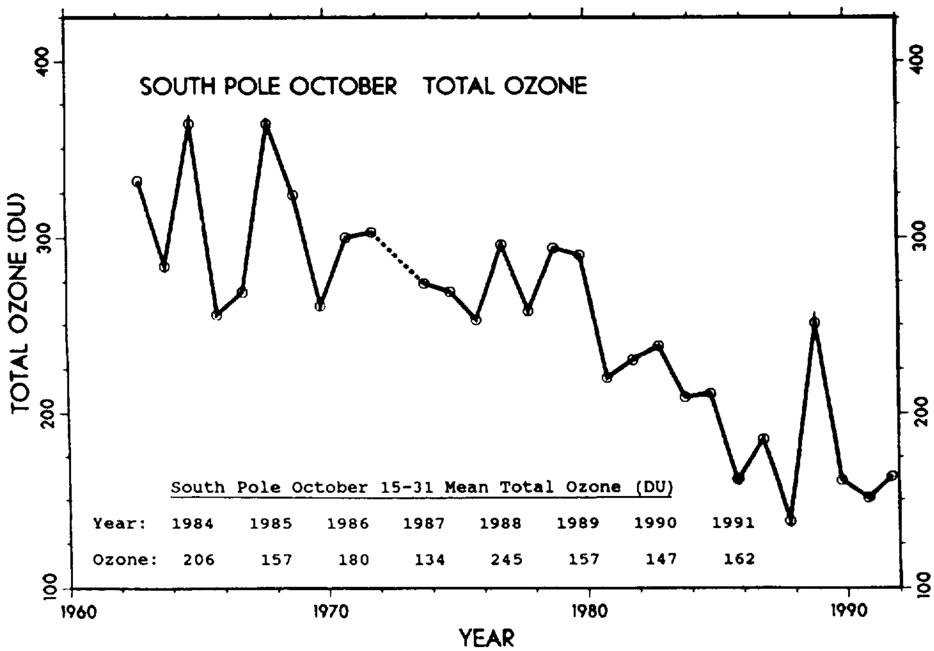

Fig. 3. South Pole mean total ozone amounts for October 15-31 time inervals of 1962-1991.

3. OCTOBER TOTAL OZONE AT SOUTH POLE

Figure 3 plots mean October 15-31 total ozone for South Pole, Antarctica, for 1962-1991. (October 15 is the time each spring when Dobson spectrophotometer observations first became possible following the polar night.) To date the record low October mean ozone value occurred at South Pole in 1987, though similar low ozone values occurred in succession also during the past 3 years. Komhyr et al. [1991] related low October South Pole total ozone values to anomalously warm sea surface temperatures in the eastern equatorial Pacific during June-August months. Considering that the current El Niño is still in progress, we expect a deep total ozone low at South Pole again in October 1992, barring undue atmospheric circulation perturbation effects by Mt. Pinatubo stratospheric aerosols.

4. ACKNOWLEDGMENTS

Appreciation is expressed to the observers at the various stations who made the observations throughout the years. Observations at the foreign cooperative stations of Haute Provence, Huancayo, and Lauder were conducted, respectively, under the supervision of Alain Barbe, Carlos Nickl Wanka, and W. Andrew Matthews.

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