Agreement Between Dobson Spectrophotometer and Filter Ozonometer Measurements of Total Ozone

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1. Introduction

In his comparison of the Dobson spectrophotometer with the M-83 filter ozonometer, Bojkov (1969) concluded that the M-83 filter ozonometer gives misleading results and introduced intolerable errors outside certain ranges of airmass μ and visibility.

A filter instrument developed by the University of Canterbury, Physics Department, Christchurch (43°31′S), was taken some 350 miles to Invercargill (46°25′S) for comparison with Dobson spectrophotometer No. 17 operated by the New Zealand Meteorological Service at that site. This initial comparison period was from 5–16 February 1971.

Parallel measurements were made on each instrument at intervals during the day, on those days when there were clear skies for several hours. Many additional measurements were made with the filter instrument to check the internal consistency of these measurements. Many workers have previously checked the internal consistency of the Dobson spectrophotometer measurements and it was therefore considered unnecessary to take a large number of readings with this instrument. It was assumed that No. 17 behaved as other instruments of this type have been reported to behave.

The results of this comparison provide the basis for this note.

The filter instrument uses selective transmission filters to allow the passage of the wavelength bands used in ozonometric calculations. The two pairs of filters have transmission peaks at 3254 and 3055 Å and 3398 and 3176 Å, with corresponding half-power bandwidths of 28, 46, 23 and 32 Å.

The Dobson spectrophotometer uses quartz prisms and plates to provide this function. The bandwidths of the corresponding pairs in the Dobson instrument are 9 and 19 Å respectively (Vigroux, 1967).

2. Data

Data used in this comparison were collected for an airmass range $1.2<\mu<3.5$, but, because of the limited observation period, comparison on a seasonal basis is not possible. However, because of the variability in ozone content within any month, it has been possible to compare data collected on days with very different absolute amounts of ozone.[1] In fact, the 50 units difference represents 70% of the average seasonal variation for New Zealand (Farkas, 1970). However, it is the intention of this note to give a brief presentation of results and a fuller description will be published later.

Fig. 1 shows the values of total ozone between 0730 and 1730 New Zealand Standard Time on the five days during the comparison period when direct sun measurements were possible for several hours.

Complete data were not available for each day of the days shown because of intermittent cloud. For example, complete cloud cover on the afternoon of 10 February made further direct sun measurements impossible, whereas a cloudless day on 16 February enabled a complete data set to be obtained. Data collected between 1130 and 1230 NZST on 15 February on the filter instrument were affected by passing cloud, but have been included here for completeness. Unfortunately, no Dobson data were available during this interval. However, the Dobson data at 1530 on this day seem similarly affected.

The correlation between the values obtained from the two instruments is remarkable. In every case the values obtained from the filter instrument agree with the Dobson values well within experimental accuracy for the complete range of airmass available. The standard deviations in each case also show excellent agreement and the magnitude of this standard deviation can therefore be used as an ozone stability factor for each day. It is to be emphasized that the filter instrument was calibrated independently.

In the filter instrument the intensity of each wavelength is recorded on some arbitrary, but absolute, intensity scale from which differences are calculated. A photomultiplier and logarithmic electronic amplifier convert the solar ultraviolet into usable intensity data, rather than the calibrated graduated density wedge used in the null method of the Dobson.

This system, that is, the measurement of absolute levels, allows the easy detection of data obtained when

[1] The use of direct sun measurement with AD wavelengths over a wide range of ozone amounts is in accord with the International Ozone Commision recommendation for comparison of ozone measuring devices with the Dobson spectrophotometer (IAMAP, 1963; World Meteorological Orgainzation, 1965).

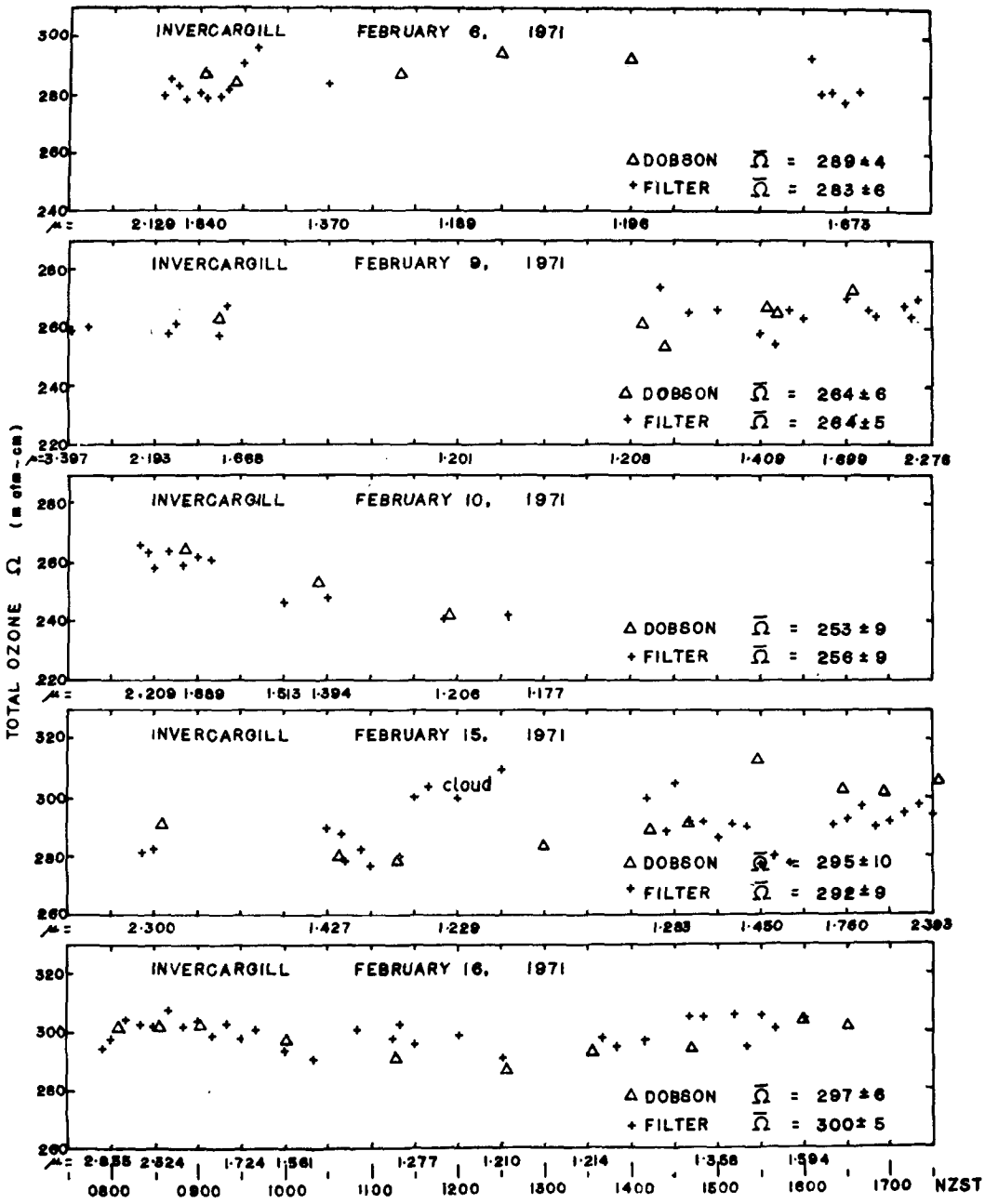

FIG. 1. Total ozone amounts observed with the Dobson spectrophotometer and filter ozonometer at Invercargill (46°25′S) on five of the comparison days.

clouds were passing in the field of view, simply by noting a drop in intensity levels. This function has been found to be particularly useful when the instrument is operating in the automatic mode as it does in Christchurch. In this mode data are recorded on both a chart recorder and, via a Digital Equipment Corporation PDP8 computer, on paper tape. To facilitate such automatic operation, the filter instrument is located on an equatorial mount together with a tracking telescope to maintain alignment on the sun.

3. Conclusion

The intention has been to show the possibility of constructing a filter system for measuring total ozone to an accuracy comparable to that of the Dobson spectrophotometer.

The filter instrument is relatively light, robust and cheaper than the conventional precision quartz spectrograph type, and can be made to operate automatically.

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