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Comparison of Indian ozonesonde and Umkehr profiles at New Delhi 1989-97

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सार – डॉबसन स्पेक्ट्रोफोटोमीटर सं. 112 से लिए गए उमखेर प्रेक्षणों की तुलना नई दिल्ली स्थित भारतीय ओजोन सौंदे के साथ की गई है। उमखेर आँकडों की तुलना उमखेर प्रोफाइलों के सतह औसत फार्मेट में परिवर्तित ओजोन सौंदे के साथ की गई है। मौसमी, वार्षिक और दीर्घ अवधि औसत आँकड़ों की तुलनाएँ की गई है। प्रत्येक ऋतु में प्रतिवर्ष इन तुलनाओं के परिणाम भिन्न पाए गए हैं। किन्तु इनमें से कोई भी प्रवृति लंबे समय तक नहीं देखी गई है।

ABSTRACT. Umkehr observations made with Dobson Spectrophotometer no.112 have been compared with Indian ozonesondes at New Delhi. Umkehr data are compared with ozone sonde data converted to the layer averaged format of the Umkehr profiles. Comparisons are made for seasonally, annually and long term averaged data. Results of comparison are shown to differ from season to season and year to year, but there is no long-term trend.

Key words – Dobson ozone spectrophotometer, Ozonesonde , Umkehr, Ozone layer.

1. Introduction

Previous studies (Bojkov, 1966; Craig *et al.*, 1967; Dütsch and Ling 1969; DeLuisi and Mateer, 1971) have compared ozone profile data taken *in situ* by MAST (Brewer) or chemiluminescent ozonesondes with ozone profile data produced by the indirect Umkehr observation method. A common recommendation of these investigators was that the use of empirical data be increased to improve the first guess profiles for Umkehr reduction algorithm. Inaccuracies in early sonde data and low sonde burst heights have limited the usefulness of past Umkehr - sonde comparisons.

Dobson Spectrophotometer observations are also used to obtain the vertical distribution of ozone.This is known as Umkehr method. In this series of observations are made with the spectrophotometer to obtain the ratio of intensities of the zenith scattered ultraviolet light from clear blue sky at one pair of wavelength, as the zenith angle of the sun increases from 60° to 90° .The commonly used wavelength pair is the “C” *viz*. 3114 A° and 3324 A°. If the intensities obtained are plotted against the zenith angle of the sun, the curve descends with increasing zenith angle until a minimum point occurs near 86°-88° and then the curve ascends. Because of the occurrence of this inversion, the method has been called the Umkehr or reversal method.

The atmosphere has been divided into nine layers *viz*.:

Layer I	upto 10.3 km
Layer II	10.3-14.8 km
Layer III	14.8-19.2 km
Layer IV	19.2-23.7 km
Layer V	23.7-28.2 km
Layer VI	28.2-32.7 km
Layer VII	32.7-37.5 km
Layer VIII	37.5-42.6 km
Layer IX	42.6-47.8 km

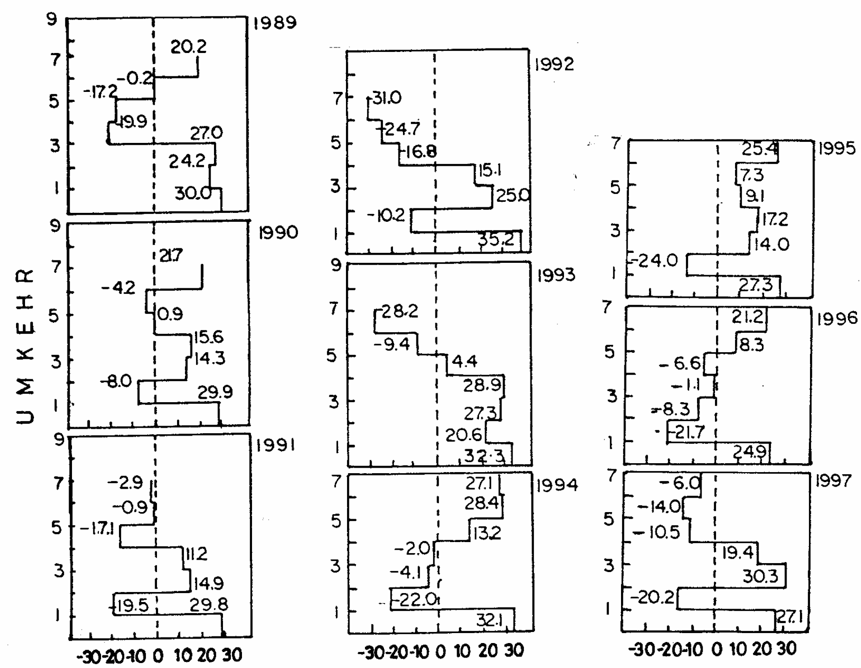

Fig. 1. Annual long term percentage difference 100 × (Umkehr-sonde)/Umkehr for New Delhi

The Indian ozonesonde has been compared in the various international intercomparisons (1970, 1982, 1991, 1996). The comparison was found reasonably good (WMO, 1996; Smit *et al*., 1996)

2. Measurement program

Measurements are made with Dobson Spectrophotometer on zenith skylight while the sun's zenith angle changes between 60 and 90 in the morning or afternoon. The measurements are taken at different pair of wavelengths, A (305.5 and 325.4 nm), C(311.4, 332.4 nm), D(317.6 and 339.8 nm). A plot of these measurements *vs*. the solar zenith angle has a characteristic reversal (or Umkehr) in its shape that is related to the effective scattering height in the atmosphere of the light being observed at the time of the measurement. An observer may terminate an Umkehr observation set or select to cancel the next possible Umkehr observation if observing conditions are poor. Observers also make several daily observations of the ozone total column content, used in the reduction of the Umkehr observations. Calibration checks on the spectrophotometer are made on a bi-weekly basis using spectral and reference lamps. Other calibration checks are done on a longer time scale, both with lamps and by direct comparison with a standard Dobson instrument. The standard Dobson Ozone Spectrophotometer no # 112 participates regularly in the international intercomparison of ozone. The last intercomparison was made at Tsukuba, Japan (Peshin *et al*.,1998).

A modified electrochemical Brewer bubbler ozone sensor (B-M sonde) has been used in the ozonesonde (Sreedharan, 1968) for the measurement of ozone profile. The advantage of the B-M sonde (Indian sonde) over B-M sonde (Brewer and Milford, 1960) is the use of non-reactive teflon pump. Ozonesonde sensor consists of an electrotype cell containing a solution of buffered potassium iodide through which ambient ozone containing air is sucked in by a small pump. The electrodes of the cell are immersed in solution. The ozone in the air reacts with the KI solution. The reaction results in the liberation of ionic iodine in proportion to the ozone molecules present in the pumped air. This sets up a small current in the electrotype. By applying potential between the electrodes, the current is amplified and transmitted to ground equipment (401-MHz) for continuous recording of temperature, pressure and ozone concentration. It is flown with standard meteorological radiosonde for measurement of ozone and temperature at different pressure levels. The ozone profiles after integrating vertically are normalized with the total ozone measured by Dobson Spectrophotometer.

3. Data processing

The data presented here are ozone vertical distributions (profiles), retrieved from the observations of the Umkehr effect described above. The observation sets were converted to a standard format and sent to the WMO (world ozone data centre operated by the Atmospheric

Environment Service, Downsview, Canada) for reducing to ozone profiles. There are two methods for reduction of the observations to ozone profiles , the conventional (Mateer and Dutsch, 1964) and (Mateer and Deluisi, 1980). Only the profiles retrieved by the conventional method (measurement on C wavelengths) are described in this paper. An additional criterion was used in selecting the final Umkehr profile data set: only profiles with a root mean square difference (the "residual") of less than 0.7 between the observations at the various zenith angles and the observations as reconstructed from the derived profile are included. +All data used in this paper have been submitted for publication in Ozone Data for the World, available from World Ozone Data Centre, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4.

In processing the ozonesonde data, the integrated column ozone amounts were calculated above the burst heights by assuming the mixing ratio to be constant from 7.8 hPa to 0.1 hPa. The sonde data were then normalized to the Dobson total ozone. Only those data from sonde with normalization factors of 1.000 ± 0.150 were used in the comparison group.

4. Results and discussion

(*i*) *Annual mean differences*

In Fig. 1 we have shown the annual mean difference for all the layers 1 to 7 from 1989 to 1997. The variations of this mean difference in layers 7 to 1 are –31 to +27.1, –24.7 to +28.4, –17.1 to +17.2, –19.9 to +28.9, –8.3 to +30.3, –22 to +24.9 to +35.2% respectively. Note that in all the layers, except layer 1, variation of differences goes from negative and positive values indicating thereby that sometimes Umkehr values are greater and sometimes smaller than the sondes values. If we calculate the mean values for all the layers during this period then they come out to be ; +5.28, –1.00, –4.51, +9.38, +15.60, –8.98 and +29.84% in layers 7, 6, 5, 4, 3, 2 and 1 respectively. It is to be noted that in layers 3 and 4, where ozone concentration is the maximum, Umkehr values are higher than the sondes values.

(*ii*) *Seasonal differences*

In Fig. 2 we have plotted the mean difference for four seasons *viz*. pre monsoon, monsoon, post monsoon and winter. The months considered for these seasons are : pre monsoon-March, April and May, monsoon-July, August and September, post monsoon-September, October and November and winter- December and January. It demonstrates the variability of the Umkehr sonde comparisons by season. More variation from season to season in each layers Umkehr-sonde difference is found in layers 1 through 4 than in layer 5 through 7,whereas in layers 1 through 4 individual layer difference vary –21 to +33% over four seasons while layers 5 through 7 vary at most –16 to +13%.

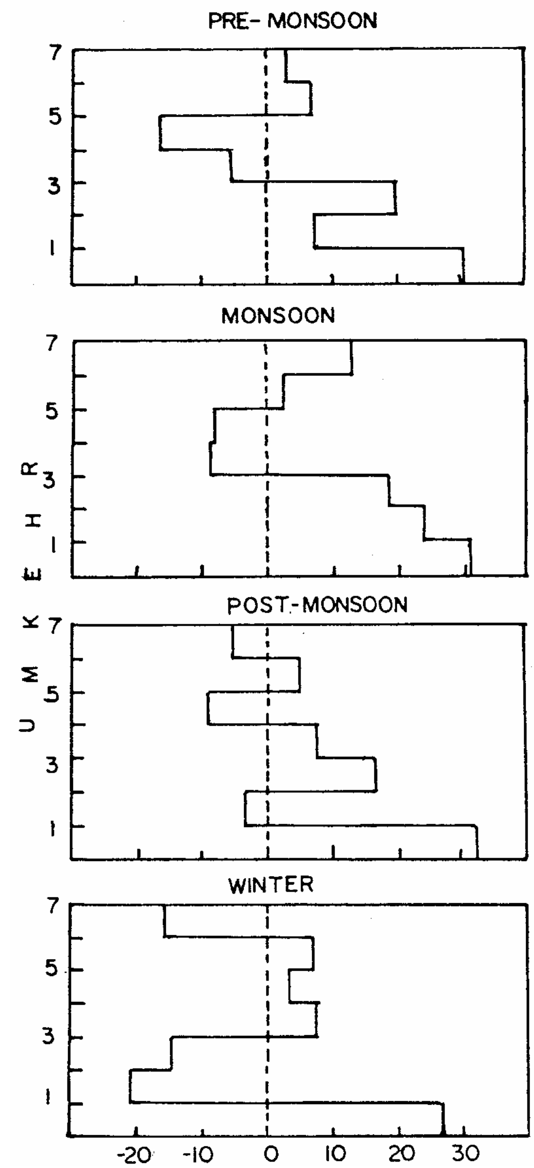

Fig. 2. Seasonal percentage difference 100 × (Umkehr-sonde)/Umkehr

(*iii*) *Long-term difference*

In Fig. 3, we have shown the long-term variation of Umkehr-sonde mean difference. We do not find any trend, the values however, fluctuate in both positive and negative directions.

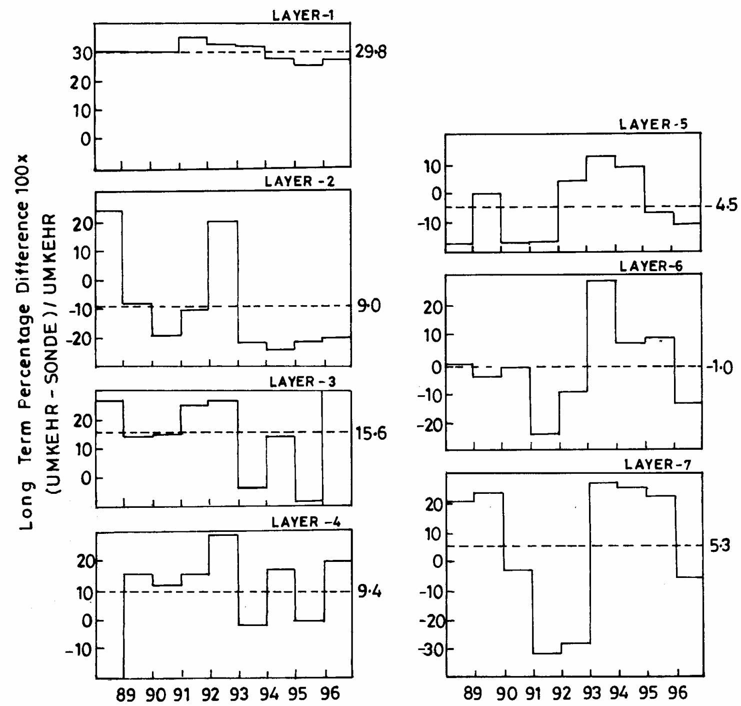

Fig. 3. Seasonal percentage difference 100 × (Umkehr-sonde)/Umkehr

5. Conclusions

This study demonstrates that the differences between ozone profiles retrieved by ozonesonde measurements and by Umkehr observations vary according to the season in which the observations are made. There are also year to year variations, but there is no long-term trend.

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