OZONE AND UV SOLAR RADIATION TIME VARIATIONS AT LISBON

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ABSTRACT — Observations of atmospheric ozone, including total and layered from the Dobson No. 13 spectrophotometer and direct sondings with the Brewer-Mast Ozonesonde are being made at Lisbon (38° 46′ N; 09° 09′ W; 105 m m.s.l.) covering almost three decades. In addition, as from December 1982 observations of the UV solar radiation at surface started at the same location, including the UV-B spectrum between 290 nm and 330 nm with the Berger's Sunburning Ultraviolet Meter, as a contribution to radiation and ozone studies.

Analysis of both total and layered ozone and UV radiation will be presented aiming mainly to show their annual cycle and the local time correlations between both parameters. The maximum of the daily mean UV-B of 15.0 SU (Sunburn Unit) was observed in June, and the minimum of 1.4 SU was observed in December. These values compare well with the results of other observers in places of similar latitudes.

1 – INTRODUCTION

The concern of the scientific community as regards the environmental impact of ozone field variations in relation to UV-B (290 nm to 330 nm) solar radiation increases in the biosphere has been stressed mainly in the second half of this century and is well illustrated by [5, 10, 11] and in other papers presented in the Meeting of Experts on the Ozone Layer, organized by UNEP in Washington DC, 1-9 March 1977. On the light of observations, it was possible to indicate [5, 9, 11] that 10 % reduction in total

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ozone leads to increases of UV-B radiation at near surface air that may be almost twice the percent ozone reduction. In addition, analysis of Aspendale data [1] on both erythemally effective ultraviolet radiation and total ozone pointed towards a higher percent UV-B increase near ground than a simultaneous percent total ozone change in the mean, although the dispersion of individual cases is large.

Being aware of this problem and taking advantage of the ozone observations available in Lisbon, a preliminary analysis of UV-B and ozone variations was undertaken and the results will be reported here, but it is understood that the interpretation of the results is subject to severe limitations, which was not the case of other larger networks [2, 4].

2 — THE DATA AND THEIR ANALYSIS

The results of the observations used in this paper include total and layered ozone both obtained with the Dobson ozone spectrophotometer No. 13 of the IOC located in Lisbon and operated by the Portuguese National Institute for Meteorology and Geophysics, the vertical distribution of ozone being derived from the Umkher method on C wavelength. In addition, in December 1982 a program of observations of solar UV-B radiation was initiated in the same location using the Berger's Sunburning Ultraviolet Meter [3] which allows the detection of the solar spectrum between 290 nm and 330 nm by means of the Sunburn Effect. This implies, as it is well known, that the results may not be expressed as absolute energy, the reason why the computed parameter was the power of the radiation, that is, Sunburn Units per hour. On the time when the relative air mass $\mu = 2.5$ on clear sky without mist, fog, smoke or dust, leading to conditions of very good horizontal visibility, simultaneous special total ozone observations were made and a set of 70 observation pairs was selected for analysis.

The analysis of the UV-B data aiming to compare observation and theory is given in Fig. 1, which shows the annual cycle of this parameter for 1983, with the maximum in June and the minimum in December, as it should be for the Northern Hemisphere when the daily mean is computed from all times of any day.

Therefore, it may be accepted that the data set has internal consistency. In the same figure it is included the annual cycle of the total ozone for the years 1973 and 1983 at the same location, just to illustrate the mainly positive correlation of both parameters, which is not supported by theory on the grounds of absorption laws. This behaviour only stresses that the search for correlations

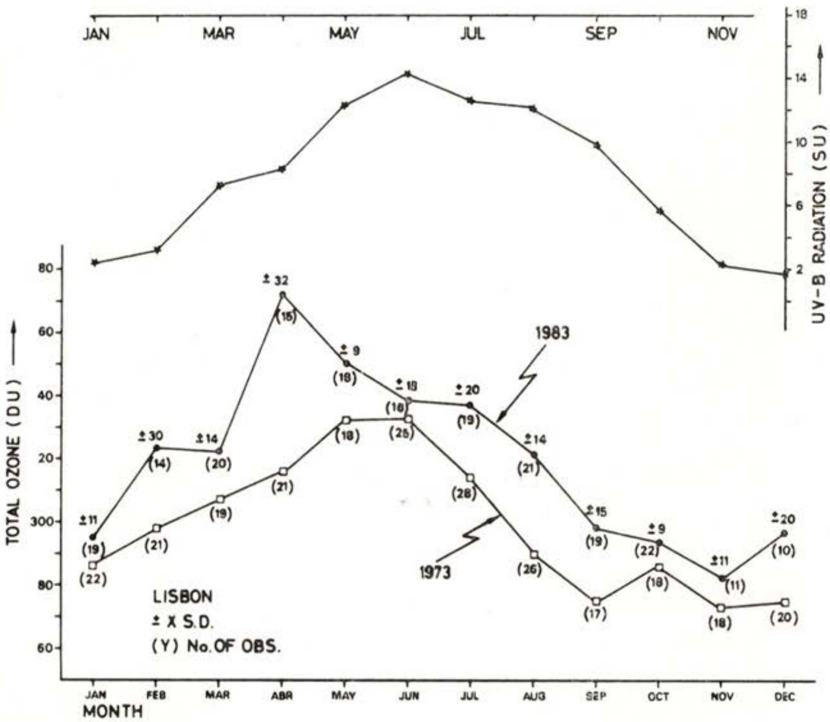

Fig. 1 — Monthly means of total ozone for 1973 and 1983 (lower) and daily means of UV-B solar radiation for 1983 (upper) at Lisbon.

needs to filter, as far as possible, the effect on UV-B variations not due to ozone variations. Before going to this, the reader can see in Fig. 2 how the mean yearly cycle of the UV-B at Lisbon compares with the yearly cycles at other locations on the Northern Hemisphere and conclude that a reasonably spacial consistency of the data exists, taking into account the differences in the length of the samples.

In order to examine the relation between the time variations of UV-B radiation at surface air and the total ozone it must be kept in mind that the ozone time and space variations arise from a complex action of mechanisms either on the basis of radiation

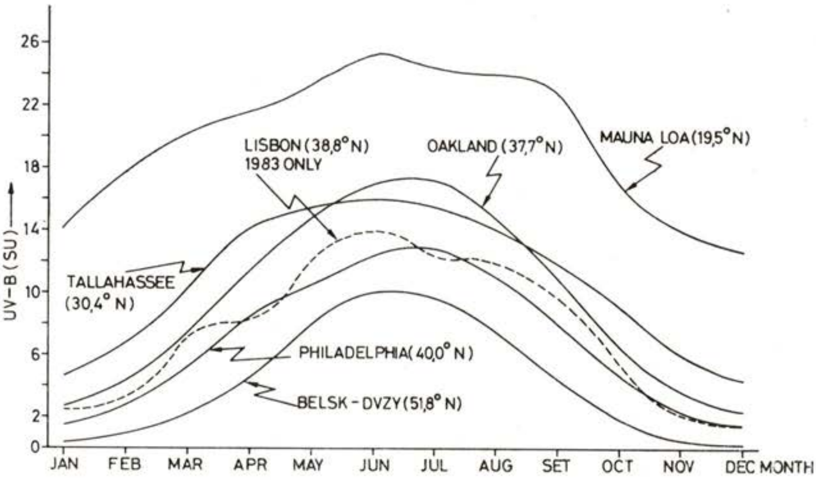

Fig. 2 — Daily mean (six years) of UV-B solar radiation for the indicated locations.

laws or of atmospheric dynamics, which has been dealt with by many authors and illustrated for the Lisbon station results in [6, 7, 8] both for the total and the layered ozone. Fig. 3 shows the effect of the tropospheric jet related circulations on the total ozone variations, which gives rise to ozone concentration gradients across and along the jet axis [6], with highest ozone contents to the left of jets looking downstream. Such large scale ozone transfer process originates significant vertical ozone redistribution mainly in the lower and middle stratosphere and upper troposphere with implications on solar radiation absorption mainly in the UV band of the spectrum. Within this context, the analysis made in Fig. 4 shows that the partial pressure of ozone over Lisbon for the same period of analysis of the UV-B contained in Fig. 1 and 2 was almost constant all over the year above about the 15 hPa level, which agrees with the observed distribution from ozonesondings at the same location in 1973; but the ozone maximum was, however, of the order of 18 mPa at 50 hPa level in February.

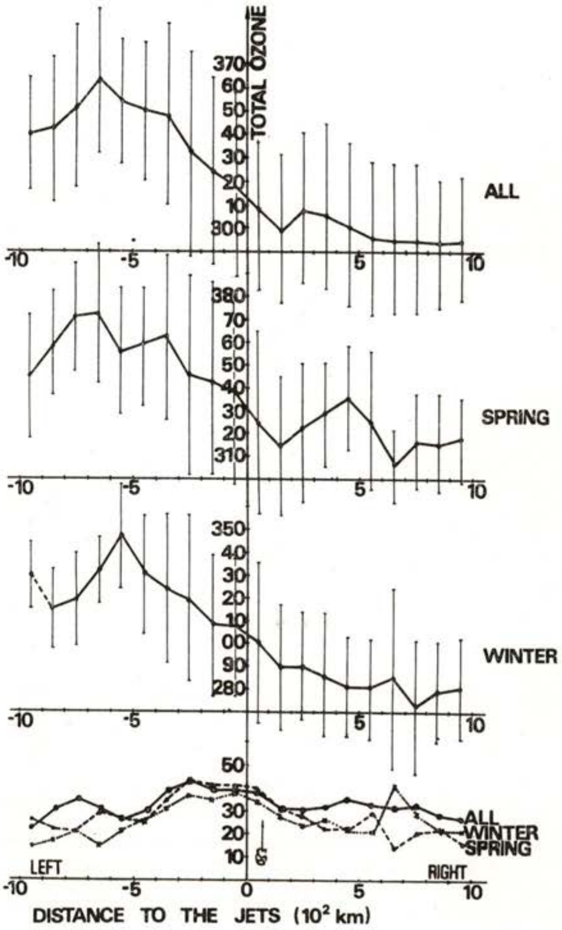

Fig. 3 — Ozone total, Ω, in relation to the jet axis position (Winter and Spring, 1968-1971) for Lisbon, with the standard deviations, σ_Ω, and their variations. (From Figueira, 1973).

The aforementioned significant differences in ozone contents must be the main source of time variations of near ground UV-B solar radiation on occasions of clear skies, but the search for such correlations requires the existence of sets of simultaneous ozone and UV-B observations at the same relative air mass values as referred to above. To this aim, $\mu = 2.5$ was selected and pairs

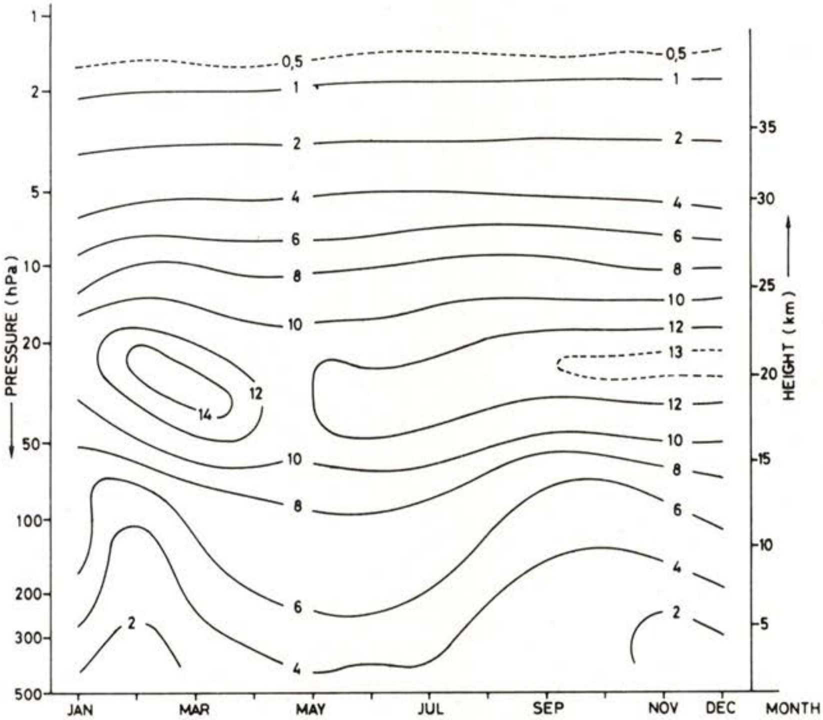

Fig. 4 — Mean time series of the vertical distribution of ozone over Lisbon for 1983, in mPa, from umkehr observations.

of observations were taken, separated in 7 groups of 10 values in chronological order; computed the mean value for the whole sample and for samples of 10 values, the percent deviations, $d\overline{O}_3$ (and $d\overline{UV\text{-}B}$)

$$d\overline{O}_3 = \{ [(\overline{O}_3)_{10} - (\overline{O}_3)_{70}] / (\overline{O}_3)_{70} \} . 100$$

where plotted in Fig. 5.

It may be seen from Fig. 5 a clear anticorrelation of the parameters in analysis as expected on theoretical basis, but there is little sign of a double increase of near ground UV-B relative to total ozone decrease as reported by some but not all other authors.

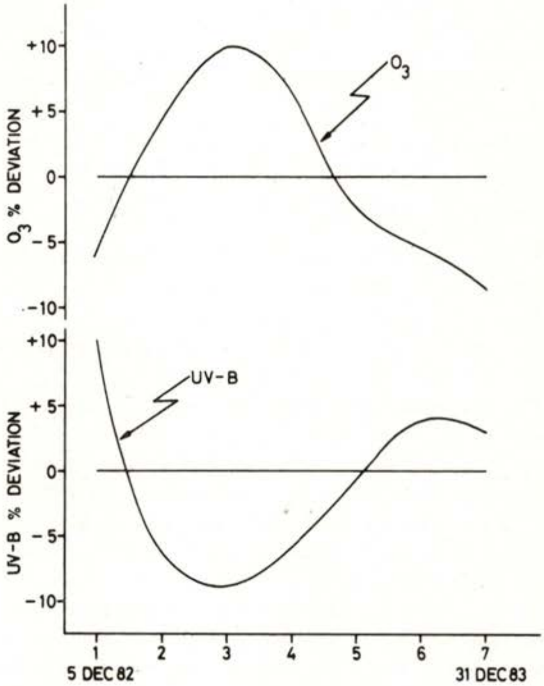

Fig. 5 — Time variations of total ozone and UV-B solar radiation at Lisbon for the indicated period.

3 – CONCLUSIONS

The preliminary study of the relations of total ozone and near ground UV-B solar radiation presented in this paper gives reasonable support that the methods of observation of the second parameter needs to be improved to obtain absolute values, but also that the equipment used so far is certainly very useful for this and other studies. In addition, the authors are aware of the need to extend the period of simultaneous observations and to improve the method of analysis of the time variations of both parameters with the aim of their better understanding.

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Miss Alice typewrote the manuscript and Mr. Carlos Alberto prepared the diagrams.

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