

STRATOSPHERIC OZONE MEASUREMENTS AT THE EQUATOR

Mohammad Ilyas

Astronomy and Atmospheric Research Unit
 University of Science Malaysia
 11800 Penang, Malaysia

ABSTRACT

A balloon-borne project for ozone layer measurements was undertaken using the MAST ozone sondes and ASTOR radiosondes. Previously published data on this series (Ilyas, 1984) was recently re-analysed using a rigorous technique to evaluate correction factors (ranging between 1.2 to 1.4). The revised data presented here, show that at the tropospheric and lower stratospheric levels, the ozone concentrations at the equator are much lower than the mid-latitude concentrations. The layer of peak concentration is found to be shifted upward compared to the mid-latitude profile and above this the two profiles get closer.

1. INTRODUCTION

Stratospheric ozone has assumed an enhanced importance since the realization that several human activities could lead to adverse biological and climatic effects including the increased erythemal ultraviolet (UV-B) dosage (Ilyas, 1979a). The UV-B problem could become serious in tropical countries because the annual incident solar radiation is already maximum and also the ozone cover is minimum at equatorial and tropical latitudes (cf yearly UV-B dosage at Malaysian latitudes is estimated to be about 15 times that at 60° latitudes) (Ilyas, 1989). This also means that the same relative increase in this UV flux (say 1%) could, in absolute terms, result in a tropical flux increase of about 15 times the flux increase at 60° latitude. In other words, a 1% ozone decrease over Malaysia and 15% ozone decrease over 60° latitude (say Scotland) would result in equal UV-B dosage increases in the two locations. Thus a seemingly small relative ozone decrease at the high latitudes may, in

absolute terms, be quite significant at the low latitudes.

2. NEED FOR EQUATORIAL-TROPICAL STUDIES

Observational data on tropospheric-stratospheric ozone is severely limited at the lower latitudes (Dutsch, 1978) and is almost non-existent near the equator. This region is however of very much interest because as we noted earlier, here the ozone production is maximum yet the ozone column depth is minimum. Owing to these considerations, a comprehensive observational program was organized at the University of Science at Penang. This included measurements of: erythemal ultraviolet dosage (UV-B) (Ilyas, 1991), solar ultraviolet (UV-A) flux (Ilyas et al., 1988), surface-level ozone (Ilyas, 1987) and a pilot study of balloon-borne ozone soundings besides a series of supportive meteorological data (Ilyas, 1979b). In this paper, we summarize the results from the re-analysis of data from the ozone soundings program (Ilyas, 1984).

3. EXPERIMENTAL AND DATA ANALYSIS

The project began in Mid 1977 and moved to the launching phase in 1981 (April) through phases comprising feasibility study, supplies and initial tests and electronic modifications. The soundings were conducted from Kuala Lumpur (3°N, 102°E).

The instrumentation consists of an ozone sonde (MAST Model), a meteorological radiosonde (ASTOR) together with appropriate electronics to convert ozone signals (uA) into audio frequencies for modulation to the radiosonde transmitter and time sharing with the meteorological signals (temperature, pressure, humidity and references). The modulated frequencies are received by a special meteorological ground receiver which separates the

modulation on to a chart. The output frequencies can then be converted back to ozone (and other) signals using preflight calibrations. The temperature and ozone, after retrieval from the chart, are then plotted as a function of atmospheric pressure on ozonogram charts. If the pre-flight sonde calibration is good, no further data processing is needed. However, the MAST sondes did not have a good calibration system (like the present Vaisala system). Therefore it was recognized that the retrieved data need to be further processed to determine correction factors and residue correction for each flight separately (Dutsch, 1974).

Normally if the burst level (Pb) is 17 mb or higher, the residual ozone content is determined directly. However, in the case of a lower burst level, mean value of correction factors (XR) is computed from a series of higher soundings with burst level at 17 mb or above. Total ozone (Dobson) data from Dobson photometer operated at Singapore was used in evaluating the correction factors for the soundings which are summarized below (Flight on 10/06/81 did not produce useful data):

<u>Date of flight</u>	<u>Total Ozone</u>	<u>Correction Factor</u>
31/03/81	256.00	1.39
10/06/81	-	-
29/06/81	260.00	1.31
15/07/81	257.00	1.45
12/08/81	261.00	1.38
16/09/81	266.00	1.43
21/10/81	256.00	1.32
23/11/81	243.00	1.31
23/12/81	241.00	1.22
16/06/82	257.00	1.27

4. RESULTS

The results from the present series are summarized in Figs. 1, 2 and 3. Although the basic profile-structure remains same as in the previously published report (Ilyas, 1984), the absolute concentrations are significantly higher. In Fig. 3, the average profile at Kuala Lumpur is compared with the one from a mid latitude station. We notice that the upward shift of tropopause from around 200 mb at mid latitudes to about 100 mb at the equator corresponds to a shift in the ozone profile as well. The concentrations at the equator are considerably lower upto the peak layer after which both profiles tend to be

VERTICAL OZONE
OZONESONDE CORRECTED DATA
31/03/1981 - 16/06/1982

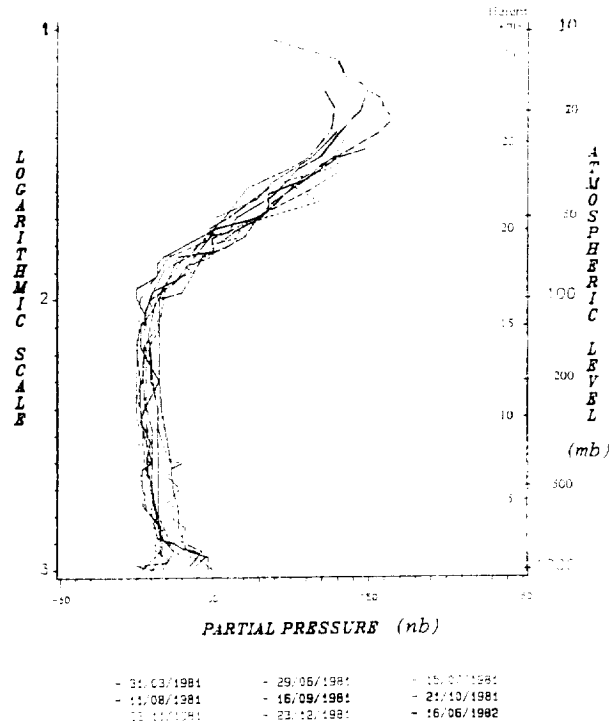


Figure 1

Ozone profiles measured at the Malaysian Station (1981 & 82). Seasonal variability is relatively small.

close.

There is little ozone content in the troposphere except for the small amounts in the surface layer. The results also confirm that the total ozone content of the layer is considerably less compared to mid and high latitudes. This means that the solar ultraviolet radiation (causing sunburn and skin cancer) can penetrate most near the equator.

The average profile in Fig. 2 exhibits the general tropospheric characteristics - ozone flux increasing over first 100-200 mb from the surface and then steadily decreasing with altitude to a minimum near the tropopause but with slightly varying slopes. Over the tropospheric region, the profiles indicate a build up from July (minimum) to December (maximum), decreasing in March and increasing in mid June (maximum as in December) and

**VERTICAL OZONE
OZONE & TEMPERATURE LEVEL
FOR MALAYSIA**

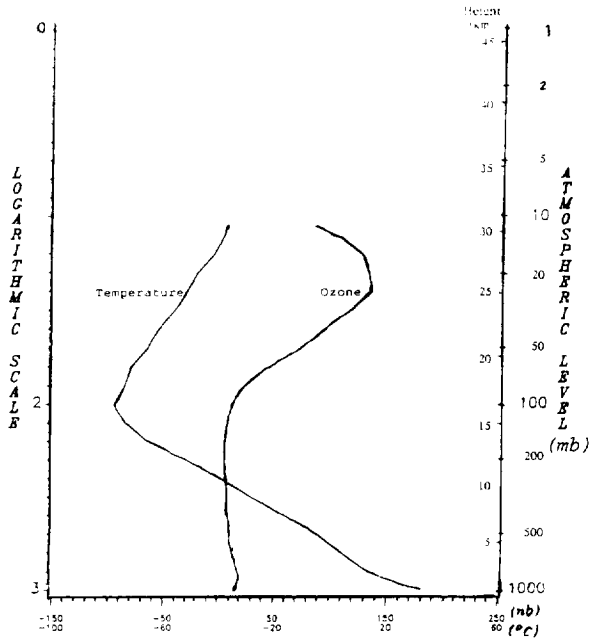


Figure 2

Average ozone and temperature profiles for Malaysia.

**VERTICAL OZONE
OZONE LEVEL COMPARISON
MALAYSIA & EUROPE**

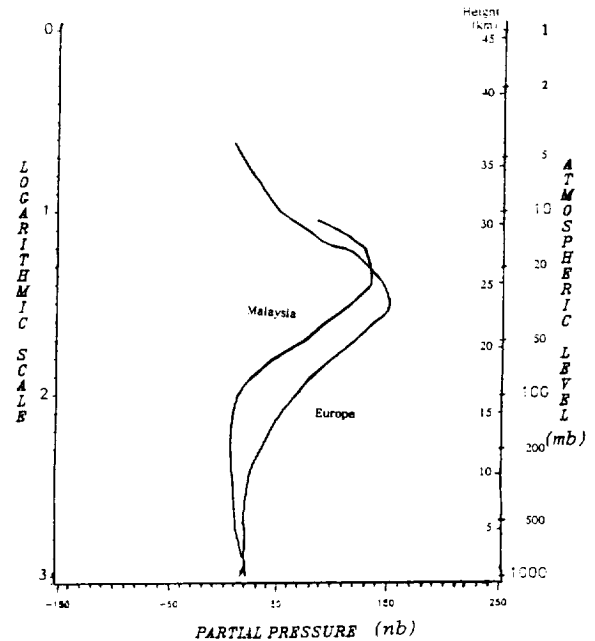


Figure 3

Comparison of the mean ozone profile for Malaysia with a mean profile for mid-latitude (from Dutsch, 1974).

decreasing in end June and July (minimum):

- * July, August & (end) June profiles showing very little variability among them and indicate lowest flux conditions [late summer to early autumn]
- * September, October & November profiles are close to each other and reflect medium ozone flux conditions [autumn to early winter]
- * March profile is very close to November profile reflecting medium flux condition [early spring & autumn]
- * December and Mid June profiles are identical and reflect highest flux condition [winter & summer]

However, over the stratospheric region, the profiles fall into two groups - a narrow band of summer profiles lying within a broader band of winter/spring/autumn profiles. The narrower band of summer-profiles begins to separate away around 50 mb level but

the upper level is rather restricted for this group of profiles. The profiles show summer maximum (June, July, August, September), winter minimum (November, December) and spring/autumn build up (October, March). The seasonal variability is very much less at the upper levels. The trend may be compared with similar analysis for mid latitudes (Dutsch, 1974).

5. DISCUSSION AND CONCLUSIONS

This pilot study had revealed a number of instrumental problems experienced in trying to cover the stratospheric altitudes at our location. One of the problems faced in this project was the extra strain placed on the balloon performance as a result of our equatorial location. This is due to two factors. Firstly, the upward (in altitude) shift of the layer (tropopause shift) means that the balloon needs to reach an extra height (equivalent of 8 to 10 km) at the equator to cover the whole layer (i.e. up to 35-40 km). Secondly, at our Malaysian location, we experience very strong easterly winds

all the way up to 25 to 30 km, most of the time. This means that the balloon cannot rise vertically up, rather it goes slanting and by the time it reaches about 20-25 km, it is a long way out from the receiver. This has led to signal fading. Also, a low elevation angle results in a non-perfect balloon performance resulting in an early burst.

During the course of this work, we have also experimented with several balloon sizes and we seem to have found a medium sized modified version that suits our situation best. Besides, we now know that there are periods during which the weather conditions are relatively better. Hence, this problem may be overcome, by working through a more strict launch schedule for which the organizational system has been re-structured for the forthcoming intensive campaign from the newly set up observatory in early 1993 under a National Project scheme.

We note that the correction factors for the soundings are relatively large, probably due to unsatisfactory calibration system/procedure available at the time of this series. Nevertheless, we believe that the results indicate a reasonably good estimate of the average ozone layer structure for the region under unperturbed conditions. The new series of launchings is aimed to provide a more detailed information on the layer structure and its variability.

ACKNOWLEDGEMENTS

The re-analysis of the data was made possible through a National IRPA Grant from the Ministry of Science, Technology and Environment, Malaysia. Special mention must be made of Dato' Prof. K.J. Ratnam, and Prof. R. Ratnalingam for their support of this project. A grant from the Alternative Fluorocarbons Environmental Acceptability Study (SPA-AFEAS) enabling the author's participation in the Symposium is gratefully acknowledged. Thanks are due

to Dr. W. Altmansphacher (Germany) for useful suggestions on the re-analysis procedure. Technical and textual help for this paper was provided by Balkis Abdul Rahman and Azlina Ali respectively.

REFERENCES

- Dutsch, H. U., 1974: Regular Ozone Soundings at the Aerological Station of the Swiss Meteorological Office at Payerne, Switzerland 1968-1972, LAPETH 10, Laboratory for Atmospheric Physics, ETH, Zurich, Switzerland. pp. 338.
- Dutsch, H. U., 1978: Vertical ozone distribution on a global scale, Pure & Appl. Geophys., 116, 512-529.
- Ilyas, M., 1979a: Adverse biological and climatic effects of ozone layer depleting activities (SST, Aerosol sprays, ...): an overview in Malaysia context, Sains Malaysiana, 8, 13-37.
- Ilyas, M. 1979b: Development of meteorological facilities at USM and some recent research work, In: Proc. Phys. Symp., Univ. Kebangsaan Malaysia: Bangi, pp. 30-37.
- Ilyas, M., 1984: An ozone soundings program at the eastern equator-preliminary results, In: Atmospheric Ozone, D. Reidel:Dordrech, 274-278.
- Ilyas, M., 1989: The danger of ozone depletion to the tropics, Search, 20, 148-149.
- Ilyas, M., 1987: Equatorial measurements of surface ozone, Atmosph. Env., 21, 1799-1803.
- Ilyas, M., 1991: Ozone depletion, ultraviolet-B and the Tropics, In: Ozone Depletion: Implications for the Tropics., (M. Ilyas, Ed.), University of Science Malaysia: Penang/United Nations Environment Programme: Nairobi, pp. 35-47.
- Ilyas, M., Aziz D. A. and Tajuddin M.R., 1988: Medically important solar ultraviolet - A radiation at the earth's surface, Photochem., Photobiol., 23, 179.