Nimbus 3 IRIS Ozone Measurements over Southeast Asia and Africa during June and July 1969

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ABSTRACT

Remote soundings of total ozone made by the Infrared Interferometer Spectrometer onboard the Nimbus 3 satellite, during June and July 1969, show the presence of ozone minima over northeast India and north Africa where summertime upper air high pressure systems exist. The easterly jet stream is revealed by ozone maxima observed along its path over southeast Asia and Africa during the summer monsoon period.

1. Introduction

The meteorological significance of changes in atmospheric ozone, contained primarily in the stratosphere, was realized since the early studies of Dobson et al. (1927). The manner in which ozone is transported by atmospheric motions was quantitatively studied by
Fig. 1. Distribution of total ozone (10⁻³ cm STP) derived from Nimbus 3 IRIS using a 10° latitude by 10° longitude grid for the periods 30 May–18 June 1969, a., 19 June–4 July 1969, b., and 5–22 July 1969, c.
many investigators (e.g., Newell, 1963). As a result of ozone being recognized as a useful tracer of the circulation in the lower stratosphere. The total ozone measurements (Prabhakara and Salomonson, 1971) made by the Infrared Interferometer Spectrometer (IRIS) on board the Nimbus 3 satellite have significantly promoted our understanding of the behavior of this tracer in tropical regions. In this study we show a close correspondence between the upper air circulation and the patterns of ozone over southeast Asia and Africa [see Prabhakara et al. (1971) for complete details] during the early summer of 1969 (June and July) when the southwest monsoon was developing over that area.

2. Analysis procedure

The Nimbus 3 satellite had a sun-synchronous orbit, spanning 80N to 80S, with a period of 107 min. The successive orbits were spaced 26° of longitude apart at the equator. This orbital configuration leads to sparse daily coverage of IRIS ozone data as this instrument only had a field of view of about 150 km along the subsatellite path over the earth. To overcome this difficulty we have composited the data over two to three week periods and spatially averaged the data on a 10° latitude by 10° longitude grid. The IRIS functioned well until 22 July 1969, so that we were able to choose three successive periods, 30 May–18 June, 19 June–4 July, and 5–22 July, suitable for the present study. The corresponding ozone maps over the region of southeast Asia and Africa are shown in Figs. 1a–c.

3. Discussion of the ozone maps

In Fig. 1a, a broad minimum of ozone, extending from somewhat north of the equator at 135°E to 105°E at 15°E can be noticed. There are two “troughs” of ozone—one on the west near 15°E and 5–20N, and another on the east at 90°E and 5–20N.

In Fig. 1b, the ozone minimum along the equator has weakened and moved slightly south of its previous position. Corresponding to the trough on the west we now notice a well-defined minimum over north Africa. The ozone trough on the east has moved northward beyond 20N, and further east over China and the Philippines there exists an ozone minimum.

In Fig. 1c, the equatorial minimum is generally south of the equator. The minimum over north Africa has persisted. The minimum on the east is now over northeast India somewhat south of the Tibetan plateau.

The orderly progression in time of these macroscale ozone features is associated with the changes in the circulation present in the lower stratosphere and upper troposphere. For instance, the southward movement of the equatorial minimum from 30 May to 22 July reflects the winter intensification of the Hadley cell in the lower stratosphere of the Southern Hemisphere (Murgatroyd and Singleton, 1961). Krishnamurti (1970) has shown that two anticyclonic cells exist over northern Africa and the Tibetan plateau area during the summer months. The position of these persistent features corresponds very closely to the position of the ozone minima on the west and east shown in Figs. 1b and c. It is noteworthy that the African ozone minimum is displaced somewhat further south than the minimum over northeast India. This observation is also in agreement with the relative location of anticyclonic centers in the upper air shown by Krishnamurti and by Koteswaram (1958) (see Fig. 2).

The equatorial ozone minimum is produced by rising and horizontally diverging winds. We contend that the ozone minima over north Africa and northeast India (Prabhakara et al., 1971) are produced by the net divergence of ozone resulting from the outward flow present in the upper air high pressure systems located over these geographic areas.

Another significant feature that may be noticed in Fig. 1c is the belt of ozone-rich air on the southern boundary of the ozone minimum over northeast India. A similar, but less obvious, feature is also present around the ozone minimum over the Sahara. The positions of these ozone-rich belts correspond very closely to the locations of the easterly jet during this time period.

![Fig. 2. Streamlines and isolaths (knots, negative sign denotes east component) at 200 mb, 25 July 1955, 0300 GCT (Koteswaram, 1958). A denotes anticyclonic circulation, C cyclonic circulation. Heavy dashed lines are easterly and westerly jet stream axes.](image-url)
believe that these maxima are produced by advective and subsidence motions associated with the easterly jet.

4. Conclusion

The Nimbus 3 IRIS ozone measurements, primarily because of their satisfactory geographic coverage as compared to sparse Dobson ozone measurements over the tropical regions, give new insight into the characteristics of the upper air flow over the tropics.

We have shown that satellite ozone observations can be useful in studying atmospheric motions in the lower stratosphere and upper troposphere over wide geographic areas of the tropics. The intensification of the Hadley cell in the lower stratosphere as winter sets over the Southern Hemisphere is reflected by our ozone measurements. The development of minima of ozone over northeast India and north Africa during June and July 1969 lead us to infer the existence of net divergence of ozone associated with the high pressure systems in the lower stratosphere over those areas. For the first time these ozone measurements have suggested that the dynamics associated with the tropical easterly jet significantly enhance the ozone amounts along its path over southeast Asia and Africa.

As the meteorology of the vast regions of the tropics is not as yet fully explored, we believe satellite measurements of ozone could be immensely valuable in understanding and interpreting the circulations over the tropics.

REFERENCES


