In which height does the ozone deficit occur over the Tibetan Plateau in summer? : Comparison of balloon-borne and satellite observations

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Observations by the Total Ozone Mapping Spectrometer (TOMS) instruments on board satellites have demonstrated that total ozone over the Tibetan Plateau shows noticeable minimum in summer, compared with that of other similar-latitude regions (e.g., Zhou and Luo, 1994; Zou, 1996). This low-ozone event is called 'ozone valley', and it has been focused for the past several decades.

However, because of technical difficulties, information on vertical ozone profiles over the Tibetan Plateau and adjacent regions is limited to very few examples. Here we had conducted balloon-borne and satellite observations of atmospheric ozone over the Tibetan Plateau in the summer and autumn of 1999. Balloon-borne ozone measurements were made at Lhasa (29.4°N, 91.1°E, 3,650 m a.s.l.); twice in June, seven times in August, five times in September, and six times in October, 1999. The ozonesonde used here employed electrochemical concentration cell (ECC) technique, and it was combined with radiosonde (Vaisala RS80) to measure simultaneously with air pressure, temperature, and so on. Satellite observations of total ozone in June to October 1999 were from Earth Probe/Total Ozone Mapping Spectrometer (EP/TOMS) version 8 data operated by National Aeronautics Space Administration/Goddard Space Flight Center (NASA/GSFC).

Figure 1 shows the day-to-day variations of column ozone from the EP/TOMS and ozonesonde datasets. The ozonesonde datasets indicate the existence of low-ozone layers below ~50 hPa altitudes at Lhasa during the ozone valley periods (**Figures 1b** and **1c**), not above ~50 hPa. In particular, the distinct low-ozone concentrations appear throughout the upper-troposphere and lowermost-stratosphere (200-50 hPa). However, there are few notable differences in the column ozone below ~50 hPa in the middle of September and October at both stations. These results suggest that the ozone loss in height discussed here strongly reflects the seasonal trend of total ozone.

Figure 2 illustrates the correspondence of ozone mixing ratios to temperatures in the vicinity of the tropopause regions (averaged at 100-70 hPa). This result indicates that the ozone concentrations are clearly sensitive to the temperature changes. The important point in this figure is that the temperatures at Lhasa lie below ~200 K and ozone concentrations also show lower values in the observations of June and August, although those of Kagoshima (and also zonal mean temperatures) indicate above ~200 K on average.

Ozonesonde observations in the mid-summer revealed existence of distinct low-ozone layers in the vicinity of tropopause, and showed appearance of cold-tropopause layers (< ~200 K temperatures at 100-70 hPa altitude) which would be caused by adiabatic expansions of air parcels from the lower-atmosphere over the Tibetan Plateau. The observed ozone concentrations depended strongly upon variations of the temperatures near the tropopause. At the same time, the expected atmospheric

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condition inferred that temperatures in the summertime tropopause are frequently low enough to initiate chlorine-catalyzed heterogeneous chemistry on supercooled aerosols.

These suggest a possible important contribution of temperature-dependent ozone depletion in the vicinity of the cold-tropopause, in addition to transport process of tropospheric ozone-poor air that have been considered, to the observed low-ozone events (i.e., ozone valley) over the Tibetan Plateau.

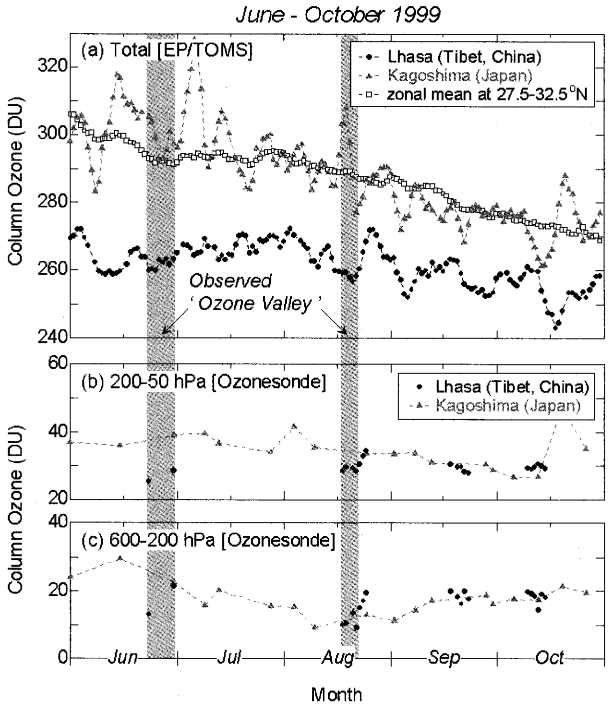

Figure 1 Seasonal variation of (a) total ozone at Lhasa (29.4°N, 91.1°E), Kagoshima (31.6°N, 130.6°E), and zonal mean at 27.5-32.5°N from ER/TOMS satellite, and column ozone in (b) 200-50 hPa and (c) 600-200 hPa at Lhasa and Kagoshima from ozonesonde during June and October 1999.

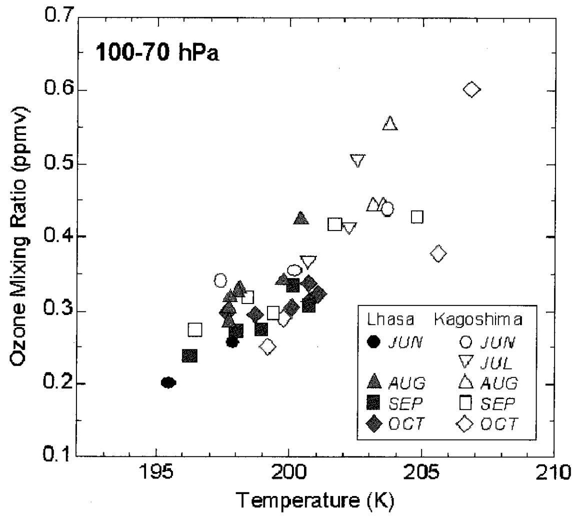

Figure 2 Correspondence of ozone mixing ratio to temperature in 100-70 hPa. Each mark is the data from one sonde measurement made in each month and station, as indicated in the frame.

References

Zhou, X., Luo, C., 1994. Ozone valley over Tibetan Plateau. Acta Meteorol. Sinica 8(4), 505-506.

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