O-02

Observations of turbulent mixing in Tropical Tropopause Layer (TTL)

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Introduction

The Tropical Tropopause Layer (TTL) is a transitional region between the troposphere and the stratosphere peculiar to the tropical zone. In recent years, the importance of elucidating the physical and chemical processes in TTL has attracted attention in terms of stratosphere-troposphere exchange (STE). Some previous studies show that there are thin (~1 km) intermittent turbulent layers in TTL, which may contribute to STE [e.g., Fujiwara et al., 2003]. However, the details of this layer have not yet been clarified because of the lack of direct observations. In this study, we (1) conducted observation campaign and analyzed turbulence and material transport as a case study and (2) investigated long-term variability of turbulent intensity using observation data from the Equatorial Atmospheric Radar (EAR).

Data

The observation campaign was conducted from November 21 to December 6, 2019, and ozone/GPS sonde observations were conducted at the Equatorial Atmosphere Observatory in West Sumatra, Indonesia. The observation data from EAR at the same station was also analyzed from 2001 to 2017. NCEP reanalysis data was used for identifying stratospheric Quasi-Biennial Oscillation (QBO) phase during the same period.

Result 1. Case study from campaign observation

During the observation campaign, turbulent layer was observed from EAR (Figure 1). From the sonde profiles (not shown), a structure thought to be equatorial Kelvin wave was found. The vertical wind shear increased as the wave amplitude increased, and the shear region also moved downward as the wave phase moved downward with time. The region of turbulent layer coincides with this shear region, and it is considered that turbulence is generated due to shear instability. At this time, the vertical distribution of ozone changed from a structure with a sharp peak to a structure that spreads vertically, so the turbulence seems to cause vertical mixing of ozone.

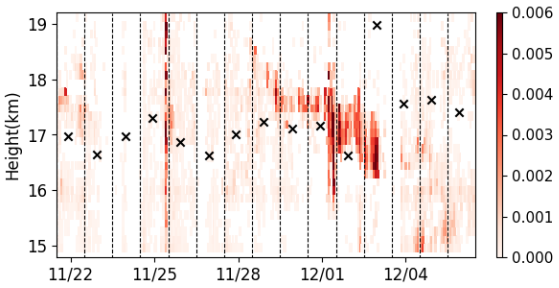

Figure 1. The eddy dissipation rate calculated from the EAR data during the observation campaign, which indicates the turbulent intensity. Cross signs indicate the tropopause height.

Result 2. Long-term analysis

Monthly average of the turbulence intensity obtained from EAR increases during winter in the northern hemisphere. On the other hand, average of the period divided according to the phase of QBO increases in the phase of westerly acceleration in upper troposphere. Both are consistent with the activity of equatorial Kelvin waves. The latter may be evidence of QBO westerly accelerating process.

References

[1] Fujiwara, M., et al., “Turbulence at the tropopause due to breaking Kelvin waves observed by the Equatorial Atmosphere Radar”, 2003, *Geophys. Res. Lett.*, 30, 1171, 2003.