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On the turbulent mixing and ozone variations around the tropical tropopause associated with Kelvin waves

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We investigated the observed variations of ozone around the tropical tropopause in relation to large-scale waves both in the altitude and isentropic coordinates with ozonesondes provided by SHADOZ (Southern Hemisphere ADditional Ozonesondes) for period 1998-2009. Because ozone near this level can be used for the tracer of atmospheric motion, we regarded an ozone enhancement as the signal of a turbulent mixing. Global-model outputs (often $>$1.5 km) have difficulty analyzing the fine structure of ozone and temperature. Hence this study presents observed variations using ozonesondes ($<$0.2 km). Based on the signals of Kelvin waves (an eastward-traveling component of equatorial waves) which is filtered in the spectral-frequency domain using reanalysis data (ERA-Interim), we clarified the dependency of the observed profiles to phase evolution of the large-scale wave. In the phase-height cross sections or, in other words, the longitude-height cross sections for eastward-traveling Kelvin waves, the composite temperature and ozone profiles showed clear in-phase relationship. The phase line of temperature and ozone anomalies tilted eastward, indicating the undulation of isentropic surfaces associated with Kelvin waves. Finally, to avoid the influence of vertical advection accompanied by the waves, the ozone variation in the phase-isentrope cross sections were shown. The temperature anomalies still showed the phase progression associated with Kelvin waves. As for the ozone anomalies, however, the phase progression almost disappeared, but the enhancement of ozone was seen in the warm phase around 420 K level. Focusing on the positive ozone anomalies around 420 K level, the enhancement of ozone corresponded to the transition from warm to cold temperature anomalies. This suggests that the turbulent mixing may occur in the shear zone particularly for the warm anomaly. These observational results imply the connection between small-scale mixing and large-scale waves. May be there is the large shear zone near the maximum of temperature. Further research which is focused on the wave properties and the structure of temperature and wind is required.

Keywords: turbulence, equatorial wave, ozone