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SOWER (Soundings of Ozone and Water in the Equatorial Region): Ozone variations associated with Kelvin waves in the tropical tropopause layer

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Trace gases entering the stratosphere from the troposphere usually path through the tropical tropopause layer (TTL). In this region it is known that equatorial waves can largely perturb the tropopause structure; one big perturbation is due to Kelvin waves. Recently, Flannaghan and Fueglistaler (2011) put a focus on turbulent mixing by shear-flow instability in connection with Kelvin waves. However, their discussion is based on the reanalysis dataset with a rather coarse vertical resolution (~1.5km), so it may not be appropriate to see realistic turbulent mixing. In this presentation, we analyze ozonesonde profiles with a much higher vertical resolution to depict a possible mixing process due to Kelvin waves. We used ozonesonde profiles between 10S and 10N at 10 observation stations; they are provided by SHADOZ (Southern Hemisphere ADditional OZonesondes). About 3000 vertical profiles of ozone and temperature are interpolated to 200 meter vertical bins. To categorize the phase of Kelvin waves, we used temperature (T) and zonal wind (U) data at 100 hPa level from the ERA Interim dataset provided by the ECMWF for the period 1998 to 2009. First, at each observation station we calculated the phase angle from the time series of T and U anomalies filtered by the Kelvin wave signature in the spectral-frequency domain (zonal wave numbers 1 to 10 and eastward moving period from 4 to 23 days). Because it is theoretically expected that the temperature anomaly (T') is in quadrature with zonal wind anomaly (U'), we can identify the phase of Kelvin waves. After we put the phases into 8 categories, we made composite analyses for the ozone and temperature profiles. In the phase-height cross section or, in other words, the longitude-height cross section for eastward traveling Kelvin waves, the composite temperature profiles show clear warm and cold anomalies in relation to the Kelvin wave. The phase line of temperature anomalies tilts eastward, indicating the downward phase propagation of the Kelvin wave structure. For the ozone composite, deviations from the height average also indicate the downward phase propagation. This in-phase relationship between temperature and ozone is probably due to vertical advection. Because the undulation of isentropes associated with Kelvin waves should not be negligible, we further described the ozone variations in the θ-coordinate in order to avoid this influence. In the θ-coordinate the temperature anomalies still show the phase progression associated with Kelvin waves. As for the ozone anomalies, however, the phase progression almost disappears, but the enhancement of ozone can be seen in the warm phase around 420 K level. Focusing on the positive ozone anomalies around 420 K level, the enhancement of ozone corresponds to the transition from positive to negative temperature anomalies. This suggests that the turbulent mixing may occur in the shear zone particularly for the warm anomaly. These results provide the consistent picture between diffusion process and ozone enhancement in connection to Kelvin waves.