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SOWER (Soundings of Ozone and Water in the Equatorial Region): Variability of temperature structure around the tropical tropopause

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Tropical tropopause temperature is one of the most important factors which control water vapor mixing ratio in the lower stratosphere. There exist low temperatures over the Indian Ocean and the Western Pacific during the whole season, and they form a horseshoe-shaped structure accompanied with convective activity. The structure resembles a stationary wave response called the Matsuno-Gill pattern, which is a superposition of the Rossby response in the western part and the Kelvin response in the eastern part. The purpose of this study is to investigate variability of the horseshoe-shaped temperature structure around the tropical tropopause using the ERA-40 temperature data at 100hPa and the outgoing longwave radiation (OLR) data for the proxy of deep convection. We use the monthly mean data for about 23 years. Paying attention to the horseshoe-shaped structure, we first define two indices. One is calculated for a meridional curvature of the tropopause temperature at each longitude over the equator (HSI-R). When it is negative, the structure would be representative of the Rossby response. The other is calculated for a zonal gradient of the tropopause temperature at each longitude along the equator (HSI-K). When it is negative, the structure would be representative of the Kelvin response. Strong negative values of HSI-R and HSI-K are located in the eastern hemisphere, where they have a good positive correlation. When a phase of HSI-K is shifted eastward by 15 degrees of longitude relative to HSI-R, the correlation coefficient is most significant (r=0.52). After adopting the longitudinal shift to HSI-R, an empirical orthogonal function (EOF) analysis was performed using the values of HSI-R and HSI-K in the eastern hemisphere. The first EOF features a positive linear relation, and its score (hereafter HSI-1) represents the strength of the horseshoe-shaped structure. The values of HSI-1 are negative during northern and southern summer. During northern summer the negative values exist in two regions; one is located between 60E and 75E (region NH-W) adjacent to the South Asian monsoon area. However, the correlation coefficient between the area mean value of HSI-1 in the NH-W region and the mean OLR in the monsoon area is not high, but the relation to the ENSO cycle is evident. The other is located between 110E and 150E (region NH-E) adjacent to the North Pacific monsoon area, and the relation to the convective activity in the monsoon area is significant. During southern summer the negative values of HSI-1 are located between 90E and 120E (region SH) adjacent to the Australian monsoon region. The variation in the SH region is large in comparison with those in the NH-W and NH-E regions, and the relation to convective activity in the monsoon region is clear. The interannual variation is also large, and it is closely related to the ENSO cycle.