

Zonally asymmetric temperature structure around the tropical tropopause and its relationship to deep convection in monsoon regions

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Tropical tropopause temperature is one of the most important factors which control the dehydration mechanism of air entering the lower stratosphere from the upper troposphere. Around the tropical tropopause during Northern Hemisphere (NH) summer and Southern Hemisphere (SH) summer, it is known that there exists zonally asymmetric temperature structure with ‘horseshoe’ shape, and it is theoretically interpreted as the Matsuno-Gill pattern, which is induced by near equatorial diabatic heating such as due to convection (*Highwood and Hoskins* [1998]). During NH summer, such a structure is coupled with deep convection within the Asian summer monsoon region, and is also associated with the distribution of minor constituents in the upper troposphere and the lower stratosphere (*Park et al.* [2007]). During SH summer, deep convection in the Australia summer monsoon region may also result in such a characteristic atmospheric structure. In this study, we investigate the climatological temperature structure around the tropical tropopause, and its variability associated with deep convection in monsoon regions. We use the reanalysis temperature data at 100hPa and the outgoing longwave radiation (OLR) data for the proxy of deep convection for about 23 years from January 1979 to August 2002. The southern oscillation index data are also examined because of the possible influence of the El Niño/Southern Oscillation (ENSO) on the interannual variation of deep convection.

Figure 1 shows the monthly-mean temperature climatology at 100hPa in August (NH summer) and February (SH summer) averaged over 23 years. In both months we find horseshoe-shaped zonal asymmetries; cold anomaly on the equator extends to north-west and south-west, surrounding warm anomaly in the west of it. Paying attention to this structure, we define the HorseShoe Index (HSI) as the difference between the mean temperature at 15N ($T(15N)$) and 15S ($T(15S)$) and that at the equator ($T(0)$): $HSI = (T(15N) + T(15S))/2 - T(0)$. Negative HSI values suggest that the horizontal distribution of cold anomalies represents a horseshoe shape. A longitude-time section for HSI shows two prominent HSI minima in NH summer (Jun-Oct) at 40E-120E and in SH summer (Dec-May) at 100E-120E. The NH summer minimum is extended more widely at longitude and has a larger absolute value than the SH summer one. We calculated correlation coefficients between HSI and OLR for each of the NH and SH summers. HSI at 40E-120E and that at 100E-120E are related to OLR within the Asia monsoon region (70E-140E, 5N-20N) in NH summer and the Australia monsoon region (110E-140E, 15S-5N) in SH summer, respectively. The interannual variation of HSI and OLR in the SH summer region is dominant, and it is found to be related to ENSO. We can conclude that deep convection within the Asian summer monsoon and the Australia summer monsoon regions could produce the characteristic temperature structure around the tropopause as a response of deep convective activity.

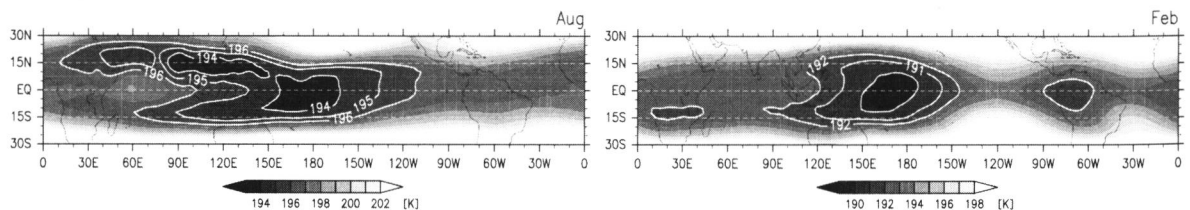


Figure 1: Climatological temperature (K) at 100hPa for (left) August and (right) February.

References

- [1] Highwood, E. J., and B. J. Hoskins (1998), *Q. J. R. Meteorol. Soc.*, *124*, 1579-1604.
- [2] Park, M., et al. (2007), *J. Geophys. Res.*, *112*, D16309, doi:10.1029/2006JD008294.