A latitudinal dependence on the summer tropopause inversion layer and its seasonality

*Ryosuke Shibuya[1], Kaoru Sato[1], Shingo Watanabe[2], William Randel[3]

1. Graduate School of Science, The University of Tokyo, 2. JAMSTEC, 3. National Center for Atmospheric Research

The latitude-dependent structure of the summer tropopause inversion layer (TIL) and the seasonality of the mid-latitude TIL are examined using a general circulation model (GCM) with a vertical resolution of about 300m above a 10 km height and an offline column radiative transfer model (CRM). A comparison with GPS radio occultation temperature observations shows that the GCM successfully simulates the fine structure and seasonality of the TIL.
A gradient genesis analysis for the static stability at the TIL is performed. It is shown that a large negative tendency due to the stretching effect of the vertical velocity is balanced by a large positive tendency due to the radiative effect related to water vapor in the mid-latitude summer TIL. The negative stretching effect is caused by a shallow branch of the Brewer-Dobson circulation. Given that the radiative effect of water vapor is essential for the summer TIL as suggested by previous studies, this means that the stretching effect weakens the mid-latitude summer TIL. On the other hand, the polar summer TIL is balanced with a small tendency due to both the radiative and the stretching effects, suggesting that the polar TIL is not largely affected by the stretching effect. Using CRM, an idealized mid-latitude TIL without the stretching effect is estimated assuming that vertical velocities above the TIL are the same as that at the TIL height. The magnitude of the static stability of the idealized mid-latitude TIL is quite similar to that of the real polar summer TIL. This fact suggests that the latitude-dependence of the TIL structure is at least partly explained by the shallow branch of the stratospheric circulation. In contrast, it is shown that the TIL structure in the winter mid-latitude TIL is strengthened by the stretching effect. These results indicate that the stretching effect is essential to the seasonality of the mid-latitude TIL, although the TIL itself is mainly caused by the radiative effect of the water vapor.

Keywords: Tropopause Inversion Layer