

Long-term variation in the mixing fraction of tropospheric and stratospheric air masses in the upper tropical tropopause layer

Yoichi INAI¹

¹ *Tohoku University, Sendai, Japan*

Observational records of the stratospheric mean age of air (AoA), the average residence time of an air parcel since entering the stratosphere, must reflect changes in the in-mixing from the extratropical lower stratosphere (LS) to the tropical tropopause layer (TTL). Focusing on the mixing fraction of tropospheric and stratospheric air masses in the upper TTL, the impact of mixing processes that occur prior to air masses entering the stratosphere separately from those that occur within the stratosphere are investigated. Using trajectory analysis, the mixing fraction during 1980–2016 is evaluated; and AoA and water vapor mixing ratios in the upper TTL are reconstructed. The interannual variation in the reconstructed water vapor shows good agreement with observations in the tropics. Furthermore, the reconstructed AoA exhibits long-term variation with a positive trend between 1980 and 1999. To compare the reconstructed AoA with the observed AoA in the mid-latitude stratosphere, the transit time spectra are estimated for the 1989–2016 period, and the AoA in the mid-latitude stratosphere is estimated by integration of the spectrum together with the AoA in the upper TTL. As a result, although the explicitly calculated transit time shows a clear underestimation compared with previous studies, it is suggested that the “aging” effects are 3.1–4.2 years for transit time in the stratosphere, 0.2–0.7 years for in-mixing prior to entering the stratosphere, 0.1 years for transit time from the troposphere to upper TTL, and 0.0–1.6 years for sub-grid scale mixing in the stratosphere.

Key words: tropical tropopause layer, age of air, in-mixing, trajectory analysis, mixing fraction