Variation in the mixing fraction of tropospheric and stratospheric air masses sharing the tropical lower stratosphere

*Yoichi Inai[1], Satoshi Sugawara[2], Shuji Aoki[1], Shinji Morimoto[1], Takakiyo Nakazawa[1]

1. Tohoku University, 2. Miyagi University of Education

Stratospheric abundance of tropospheric species is largely controlled by air mass transport into the stratosphere through the tropical tropopause layer (TTL) associated with the Brewer-Dobson circulation (BDC). In addition to this transport process, quasi-horizontally mixing process between the tropical and extra-tropical lower stratospheres is also affected the abundance of such species flowing into the mid and upper stratosphere. We focus on the mixing fraction of tropospheric and stratospheric air mass sharing the tropical lower stratosphere (TLS) and its temporal variation. To estimate the origins, i.e., tropospheric or stratospheric origins, for the TLS air masses, the backward trajectories are initialized between 20°S and 20°N with 1.5° x 5.0° latitude/longitude resolution at 400 K and 440 K potential temperature surface and are calculated every month for a maximum of 180 days over the period from January 1980 to December 2015 by using Era-Interim 3-dimentional wind field. The air mass origin is determined by history information along the backward trajectory, such as potential temperature, potential vorticity, and latitude, for each air parcel. By means of statistical analyses of such air mass origins in the TLS, it is shown that (1) the mixing fraction of tropospheric and stratospheric origins is almost consistent with that estimated by Sargent et al. (2014) based on aircraft campaigns in the comparison at the same temporal-spatial region, (2) the fractions of tropospheric/stratospheric origins have seasonal variations with the maxima in boreal spring/boreal summer-autumn, and (3) their annual averages have decreasing/increasing trends from 1980 to 1999 and have increasing/decreasing trends from 2000 to 2015, respectively. We examine how such long-term variation in the mixing fraction of the TLS air masses affects stratospheric abundance of tropospheric species and the stratospheric "age of air" (AOA) (Hall and Plumb, 1994). The results qualitatively agree with long-term variation of the AOA estimated from CO_2 mixing ratios that have been observed by the cryogenic whole air samplings in mid-latitude mid-stratosphere.

Keywords: stratosphere-troposphere exchange, trajectory analysis, age of air, air mass origin, tropical lower stratosphere

©2017. Japan Geoscience Union. All Right Reserved.