Seasonal characteristics of chemical and dynamical transports into the extratropical upper troposphere/lower stratosphere

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To characterize chemical distributions in the extratropical upper troposphere and lower stratosphere (Ex-UTLS) together with the stratosphere-troposphere exchange (STE) processes, in particular, transport from (1) the stratosphere, (2) tropical troposphere, (3) mid-latitude lower troposphere (LT), (4) high-latitude LT into the Ex-UTLS, the mixing fraction of air masses originated from above (1)−(4) including (5) Ex-UTLS remaining for at least 90 days is estimated by using the 90-day backward trajectories with European Centre For Medium-Range Weather Forecasts (ECMWF) ERA-Interim data as the meteorological input. Furthermore, the time-series of chemical tracers obtained at ground-based observatories and those measured on board commercial airliners between France/Russia and Japan by the Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL) project are incorporated into the estimated mixing fractions, hereby, spatio-temporal distributions of chemical tracers in the Ex-UTLS are reconstructed. Though the analysis period extends from January 2012 to December 2016, the all tracers data are incorporated after detrending to focus exclusively on their seasonal characteristics. The mixing fractions and reconstructions of CO, N_2O, and SF_6 show the following seasonal characteristics. In winter, stratospheric air mass with low-CO/not-low-N_2O/low-SF_6 mixing ratios is transported down to ~330K potential temperature level in association with the Brewer-Dobson circulation. In spring, deeper stratospheric air with low-CO/low-N_2O/low-SF_6 mixing ratios reaches to the Ex-UTLS region. In summer, the high-latitude LT air mass with high-CO/high-N_2O/high-SF_6 mixing ratios is lifted up to ~330K. In autumn, while the tropical tropospheric air mass dominates the latitudinal lower region of Ex-UTLS, the stratospheric air mass occupy the latitudinal higher region where is, however, tinged with tropospheric character in some degree, i.e., the composition shows low-CO/high-N_2O/not-low-SF_6 mixing ratios; it may be remains of monsoon activity which supplies tropospheric air mass to the LS region in summer.

Key words: extratropical UTLS, stratosphere-troposphere exchange (STE), aircraft measurement, trajectory analysis, mixing fraction (maximum 5)