Seasonal characteristics of trace gas transport in the extratropical upper troposphere/lower stratosphere

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Radio-active chemical species, clouds, and aerosols in the extratropical upper troposphere and lower stratosphere (Ex-UTLS) affect the Arctic climate via their radiative effects; the distributions of such substances are largely controlled by atmospheric transport processes. For instance, stratospheric air mass which has less tropospheric trace gases descend into the Ex-UTLS associated with the stratospheric residual circulation, while tropospheric air mass with tropospheric trace gases is irreversibly transported into the Ex-UTLS by Rosbby wave breaking in the subtropical jet and monsoon activity etc. As the air mass has a distinctive composition depending on own origin, relative strength of transport processes should affect chemical abundance in the Ex-UTLS. In this regard, however, the both typical composition of some air mass transported from some origin and strength of the transport process have large seasonal variations, hence it is difficult to understand the nature of trace gas transport into the Ex-UTLS. This study focuses on mixing fraction of air masses in the Ex-UTLS originated from, e.g., the stratosphere, tropical UTLS, tropical lower troposphere, and extratropical lower troposphere, to figure out seasonal variations in the transport processes. The backward trajectories launched in the Ex-UTLS are used for this analysis with European Centre For Medium-Range Weather Forecasts (ECMWF) ERA-Interim data as meteorological input. Based on the estimated mixing fractions, the spatio-temporal distributions as well as transported amount of several trace gases from each original region are estimated by the aid of continual aircraft measurement data by the Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL) project. This project has conducted air samplings once a month from April 2012 with Japan Airlines flight between France/Russia and Japan at spatial intervals of 10° or 15° in longitude along individual flight track at around 11 km over Siberia. As a tentative result for estimates of CO and N_2O, the following seasonal characteristics ware obtained. In winter, stratospheric air mass with low-CO/not-low-N_2O mixing ratios is transported down to ~330K potential temperature level associated with the Brewer-Dobson circulation in the stratosphere. In spring, deeper stratospheric air with low-CO/low-N_2O mixing ratios reaches to the Ex-UTLS region. In summer, the tropical UTLS air mass with low-CO/high-N_2O mixing ratios is transported into Arctic region over ~350K, the lower tropospheric air mass with high-CO/high-N_2O mixing ratios is lifted up to ~330K. In autumn, the upper region of Ex-UTLS is tinged with tropospheric character in some degree, i.e., the composition shows low-CO/high-N_2O mixing ratios; it may be remains of monsoon activity which supplies tropospheric air mass to the LS region in summer.

Keywords: upper troposphere , lower stratosphere, STE, aircraft measurement, trajectory

