Transport of trace gases into the extratropical upper troposphere/lower stratosphere

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To investigate the seasonal characteristics of chemical tracer distributions in the extratropical upper troposphere and lower stratosphere (ExUTLS) as well as stratosphere–troposphere exchange processes, origin fractions of air masses originating in the stratosphere, tropical troposphere, mid-latitude lower troposphere (LT), and high-latitude LT in the ExUTLS are estimated using 10-year backward trajectories calculated with European Centre For Medium-Range Weather Forecasts (ECMWF) ERA-Interim data as the meteorological input. Time-series of chemical tracers obtained from ground-based and airborne observations are incorporated into the trajectories, thus reconstructing spatiotemporal distributions of chemical tracers in the ExUTLS. The reconstructed tracer distributions are analysed with the origin fractions and the stratospheric age of air (AoA) estimated using the same backward trajectory. The reconstructed distributions of CO and CO_2 in the ExUTLS are affected primarily by tropospheric air masses because of the short chemical lifetime of the former and large seasonal variations in the troposphere of the latter. Distributions of CH_4, N_2O, and SF_6 are controlled primarily by seasonally varying air masses transported from the stratosphere. For CH_4 and N_2O distributions, their seasonally varying photochemical decay along the average pathway from the source region are particularly important. This study developed and demonstrated a unique and effective method to exploit the advantages of observational data in combination with trajectory analysis. This method provides a means to understand both air mass transport and chemical decay for photochemical active substances from a new perspective.

Keywords: Transport, Earth atmosphere, Trajectory analysis

