



## Seasonal characteristics of trace gases transports 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, mixing fractions of air masses originating in the stratosphere, tropical troposphere, mid-latitude lower troposphere (LT), and high-latitude LT (hereafter, called as origin fractions) in the ExUTLS are estimated using 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 trajectory analysis, 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) that is also estimated using backward trajectory. The reconstructed distributions of CO and CO<sub>2</sub> 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<sub>4</sub>, N<sub>2</sub>O, and SF<sub>6</sub> are controlled primarily by seasonally varying air masses transported from the stratosphere. For CH<sub>4</sub> and N<sub>2</sub>O distributions, air masses transported via the deep branch of the Brewer–Dobson circulation are particularly important. This interpretation is qualitatively and quantitatively supported by the estimated spatiotemporal distributions of AoA.