On the use of N\textsubscript{2}O as a tracer of stratosphere to troposphere flux of long-lived trace gases based on CARIBIC data.

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Stratosphere-troposphere exchange (STE) plays an important role in the distribution of several trace gases, with ozone and CO being commonly in use to study STE mixing structures and processes. Here we explore the use of N\textsubscript{2}O as a tracer of STE mixing proportions and the STE flux for long-lived gases, in particular CO\textsubscript{2} and CO\textsubscript{2} isotopes. N\textsubscript{2}O has a near uniform distribution in the troposphere, with little seasonal variation and the only sink in the stratosphere. Between 2005 and the present measurements of N\textsubscript{2}O in flasks collected as part of the CARIBIC project have resulted in a large data set with excellent N\textsubscript{2}O accuracy. N\textsubscript{2}O data for the UTLMS at mid- and high-latitudes (40-77 deg N) are found to demonstrate highly systematic STE mixing trends and compact distributions of the tropospheric end-member.

First, upper-tropospheric and STE-affected air can easily be distinguished using an N\textsubscript{2}O threshold based on the N\textsubscript{2}O distributions at NOAA stations. The threshold value is found to be the same for mid- and high-latitudes, with the data uncertainty being close to the seasonality. Second, as the UTLMS at mid-latitudes may contain both stratospheric air and a significant fraction of polar vortex air having experienced different degrees of chemical ozone losses, N\textsubscript{2}O can be used as a linear/additive tracer for long-lived gases, in particular when data are to be compared over different seasons and/or latitudes. Third, CARIBIC CO\textsubscript{2} isotope data for the UTLMS are found to agree well with the d18O(CO\textsubscript{2})/N\textsubscript{2}O slope estimated based on published stratospheric CO\textsubscript{2} isotope data, thus supporting our understanding of STE mixing and linear additive identity for N\textsubscript{2}O. We conclude that CARIBIC data coupled with N\textsubscript{2}O and CO\textsubscript{2} isotopic data published for the stratosphere and stations can be used as the frame of reference for d18O(CO\textsubscript{2}) and D17O(CO\textsubscript{2}) STE fluxes. The latter is of particular interest as it is thought to constrain global gross CO\textsubscript{2} fluxes. Our data can also help trace STE flux by deep stratospheric intrusions e.g. at mountain stations, an example of which will also be presented at the meeting.