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Temporal evolution of composition and transport in the Arctic UTLS during PGS 2015/16

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The relation between transport and mixing in the Arctic upper troposphere and lower stratosphere (UTLS) during the POLSTRACC (The Polar Stratosphere in a Changing Climate) aircraft campaign in winter 2015/16 is investigated based on measurements of CO, N2O and CH4, performed by quantum cascade laser absorption spectroscopy onboard the German High Altitude and Long-Range Research Aircraft (HALO).
We focus on the role of transport and mixing between aged and potentially chemically processed air masses from the stratosphere with mid and low latitude air masses originating at the tropical lower stratosphere. By combining CO, N2O, CH4 and O_3 we estimate the evolution of their relative contribution to the UTLS composition over the course of the winter.
We found an increasing influence of aged stratospheric air partly from the vortex as indicated by decreasing N2O and SF6 values over the course of winter. Surprisingly we also found a mean increase of CO of (3.00 +/- 1.64 ppbV) from January to March relative to N2O in the lower stratosphere (PV > 7 PVU) which indicates an increase of tropospheric influence in the lower stratosphere over the course of the winter. This corresponds to an increase of up to 10% of tropospheric air in some regions of the lower stratosphere from January to March.
This increase of the tropospheric air fraction partly compensates for aging of the UTLS due to the diabatic descent of potentially vortex influenced air masses by horizontally mixed, tropospheric influenced air masses. This is consistent with simulated age spectra from the Chemical Lagrangian Model of the Stratosphere (CLaMS), which show an increase of young tropospheric air and a simultaneous increase of aged air from deep stratospheric and vortex regions.
We thus conclude, that the lowermost stratosphere in winter 2015/16 was dominated by aged air from the deep stratosphere and vortex region. These air masses were significantly affected by increased mixing from lower latitudes, which lead to a simultaneous increase of the fraction of young air in the arctic lowermost stratosphere over the course of winter.