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Airborne in situ tracer and age of air observations in the UTLS during the rare Antarctic sudden stratospheric warming 2019

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In September 2019 a rare sudden stratospheric warming occurred in the Antarctic region. During the course of this event the airborne campaign SouthTRAC (Transport and composition of the Southern Hemisphere UTLS) was conducted with the main goal of studying the impact of the Antarctic vortex on the southern hemisphere upper troposphere / lower stratosphere (UTLS). SouthTRAC deployed the German High Altitude and LOng range research aircraft (HALO) in two phases (September/early October and November) based in Rio Grande, Argentina. The mission comprised 23 scientific flights including transfer flights to/from Argentina and local flights from Rio Grande. During several of these flights HALO flew over the Antarctic Peninsula and adjacent regions, thus probing the bottom of the Antarctic vortex, and crossing vortex streamers and thin filaments.

We present and analyse in situ measurements of CO_2 and various other long-lived tracers obtained by the University of Wuppertal's 5-channel High Altitude Gas AnalyzeR (HAGAR-V) along with N_2O measured by the University of Mainz's UMAQS (University of Mainz Airborne QCL Spectrometer) using laser absorption techniques. For our analysis we use mixing ratios of CO_2, SF_6, CFC-11, CFC-12, N_2O, and age of air (AoA) derived from CO_2 and SF_6.

Vertical and meridional distributions as well as tracer correlations show differences between phase 1 and phase 2 of the mission. During September the distributions at mid-latitudes indicate stronger isentropic transport of vortex and subtropical air than during November. The CO_2-N_2O correlation also changed between September and November due to isentropic mixing at 330-400 K potential temperature. The oldest observed AoA as derived from CO_2 was about 4.5 years at 390 K, while significantly older AoA is derived from SF_6, but is presumably an overestimate due to mesospheric loss of SF_6. We have compared the tracer distributions and AoA during SouthTRAC with those of the undisturbed 1999 Antarctic vortex sampled by the M55 Geophysica aircraft during the Antarctic campaign APE-GAIA. For September/October we find similar distributions and age values in both years, which would suggest that net tracer descent trough isentropes in the disturbed 2019 lower Antarctic vortex was not substantially different from that occurring in a typical undisturbed winter.