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Transport, mixing and ozone loss in the 2010 Arctic vortex region from in-situ tracer observations during RECONCILE

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The 2009/2010 Arctic stratospheric vortex was dynamically very active, splitting and reforming twice, first in mid December and then again in mid February. We use in-situ measurements of tracers and ozone both in- and outside the Arctic vortex during the 2010 RECONCILE campaign to investigate isentropic transport and irreversible mixing in the vortex region and to assess chemical ozone loss. N2O and CFC-11, along with CO_2, CFC-12, H-1211, CH4, SF6 and H2 were simultanously measured by the High Altitude Gas Analyser (HAGAR) during 13 Geophysica flights between mid January and mid March. Ozone was measured onboard the M55 Geophysica aircraft by the Fast Ozone Analyser (FOZAN). Early winter reference profiles for a number of tracers are provided by the satellite instrument ACE-FTS.

We derive an empirical "vortex index" from the observed isentropic distribution of N2O as an altitude-independent tracer of origin with respect to the vortex. This index is used to identify the origin of the observed air masses and to diagnose recent transport of air between distinct regions. Irreversible mixing of air masses, typically following such transport, is diagnosed from the evolution of the CFC-11/N2O correlation. Simulations with the Chemical Lagrangian Model of the Stratosphere (CLaMS) are used for comparison and to better understand the meteorological context of the observed transport and mixing.

Intrusions of extra-vortex air into the vortex are evident already during January, however much stronger effects are observed after the vortex split in late February and its reformation in early March. The N2O-derived "vortex index" suggests strong transport of subtropical air into the polar region above 470 K and a corresponding shift of the CFC-11/N2O correlation indicates that this air has already mixed irreversibly with high-latitude air. A further partial shift of the correlation is evidence for irreversible mixing of mid-latitude air inside the newly formed vortex. The CLaMS simulation captures these signatures of transport and mixing mostly well. We finally discuss the implications of the unusual transport situation on the derivation of ozone loss via the O_3-N2O correlation method.