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In-situ measurements of chlorine activation, nitric acid redistribution and ozone depletion in the Antarctic lower vortex aboard the German research aircraft HALO during TACTS/ESMVal

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In-situ measurements of stratospheric chlorine compounds are rare and exhibit the potential to gain insight into small scale mixing processes where stratospheric air masses of different origin and history interact. In addition, the relationship with chemically stable trace gases helps to identify regions that have been modified by chemical processing on polar stratospheric clouds.
To this end, in-situ measurements of $ClONO_2$, HCl, HNO_3, NO_y, N2O and O_3 have been performed in the Antarctic Polar Vortex in September 2012 aboard the German research aircraft HALO (High Altitude and Long Rang research aircraft) during the TACTS/ESMVal (Transport and Composition in the UTLS/Earth System Model Validation) mission. With take-off and landing in Capetown, HALO sampled vortex air with latitudes down to 65°S, at altitudes between 8 and 14.3 km and potential temperatures between 340 and 390 K. Before intering the vortex at 350 K potential temperature, HALO additionally sampled mid-latitude stratospheric air.
The trace gas distributions at the edge of the Antarctic polar vortex show distinct signatures of processed upper stratospheric vortex air and chemically different lower stratospheric / upper tropospheric air. Diabatic descend of the vortex transports processed air into the lower stratosphere. Here small scale filaments of only a few kilometers extension form at the lower vortex boundary due to shear stress, ultimately leading to transport and irreversible mixing. Comparison of trace gas relationships with those at the beginning of the polar winter reveals substantial chlorine activation, ozone depletion de- and renitrification with high resolution. Furthermore, the measurements are compared to the chemistry climate models EMAC and supported by ECMWF analysis.
Finally, we compare the Antarctic measurements with new measurements of $ClONO_2$, HCl and HNO_3 aboard HALO obtained during the Arctic mission POLSTRACC (POLar STratosphere in a Changing Climate) based in Kiruna (Sveden) and Oberpfaffenhofen (Germany) in winter 2015/16. Our measurements give new insights on the lower Arctic and Antarctic stratospheric composition impacted by polar stratospheric clouds and ozone depletion as well as mixing of mid- and high-latitude air.