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Transport of Antarctic stratospheric strongly dehydrated air into the troposphere observed during the HALO-ESMVal mission 2012

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Dehydration in the Antarctic winter stratosphere is a well-known phenomenon and occasionally observed by ballon-borne and satellite measurements. However, in-situ measurements of dehydration in the Antarctic vortex are very rare. Here, we present detailed in-situ observations with the FISH, HAI, FAIRO, TRIHOP, and GLORIA payload aboard the new German aircraft HALO. Strongly dehydrated air masses down to 1.6 ppmv were observed in a region up to 47°S and at 12 to 13 km altitude only, which has never been observed by satellites before. The dehydration can be traced back to individual ice formation events, where ice crystals sedimented out and water vapor was irreversibly removed. Within these dehydrated stratospheric air masses, filaments of moister air down to the tropopause are detected with the high resolution limb sounder GLORIA.

Furthermore, dehydrated air masses are observed with GLORIA in the Antarctic troposphere down to 7 km. With the help of a backward trajectory analysis, a tropospheric origin of the moist filaments in the vortex can be identified, while the dry air masses in the troposphere have stratospheric origin. The transport pathways of Antarctic stratosphere/troposphere exchange are investigated and the irrelevant role of the Antarctic thermal tropopause as a transport barrier is confirmed. Further, it is shown that the exchange process can be attributed to several successive Rossby wave events in combination with isentropic interchange of air masses crossing the weak tropopause and subsequent subsidence due to radiative cooling. Once transported to the troposphere, air masses are able to reach near surface levels within 1-2 months.