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HAGAR-V: A new airborne five channel instrument for in situ measurements of tracers with a wide range of lifetimes to study UTLS transport

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Understanding transport and mixing processes in the UTLS (Upper Troposphere Lower Stratosphere) is crucial for accurate climate predictions. Highly resolved observations of trace gases with different chemical lifetimes provide complementary information on time scales of transport and mixing in the UTLS. In particular, measurements of chemical tracers covering a very wide range of lifetimes (days to many years) allow to discern and investigate transport processes on a wide range of spatial and temporal scales, including the global-scale Brewer-Dobson circulation, isentropic transport and mixing by synoptic-scale waves, to mesoscale convection. Conserved time-varying tracers like SF6 and CO_2 provide additional information on transport time scales, in particular the stratospheric mean age of the air.

We present a recently developed five-channel airborne instrument, HAGAR-V (High Altitude Gas AnalyzeR -V), capable of providing simultaneous high-resolution in situ observations of a suite of chemical tracers ranging from long-lived species like CH4, N2O and CFCs, to short-lived halocarbons and VOC with local lifetimes of days to months, along with the conserved age-of-air tracers CO_2 and SF6. The instrument comprises three measurement modules: a two channel GC/MS (Gas Chromatograph/Mass Spectrometer) and a two channel GC/ECD (Electron Capture Detector), with each channel measuring several species within 1 to 3 minutes; and finally a NDIR (non-differential IR absorption) analyzer measuring CO_2 at high time resolution (1-3 s) and precision ($\sim$0.1 ppm). Precisions for the species measured by GC vary from sub-percent to a few percent. For the GC/MS module a novel ultra-light cryogen-free preconcentration trap was developed and characterized for its temperature, adsorption and desorption behavior.

HAGAR-V was certified to fly on the German research aircraft HALO (High Altitude and LOng range) and has already been deployed on two HALO campaigns, namely PGS in winter 2015/2016 and WISE in autumn 2017. The instrument's characteristics and performance during these deployments will be discussed, and the observations will be presented demonstrating the high potential of HAGAR-V for the investigation of transport and mixing in the UTLS.