Cross-tropopause transport of water in the Asian Summer monsoon from airborne and satellite observations

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The Asian Summer Monsoon (ASM) represents a dominant circulation feature in the Northern hemisphere and is considered to be the most important pathway by which water enters the stratosphere. Until recently, available observations of stratospheric water above ASM were exclusive to limb-viewing satellite sensors that may miss important physical processes controlling stratospheric water entry due to coarse spatial resolution. A great deal of high-resolution observations of ASM tropopause layer has recently become available from Russian high-altitude M55-Geophysica aircraft deployed in Nepal during summer 2017 within EU StratoClim project. The deployment comprised eight scientific flights, sampling a large diversity of meteorological conditions.

We make use of in-situ measurements of water by three hygrometers onboard Geophysica: FLASH, FISH and ChiWIS. A high quality of the measurements is ensured by close agreement between the instruments. The water data are complemented by particle backscatter measurements using airborne MAL lidars and MAS scatterometer. A regional-scale perspective is derived from Aura MLS and CALIOP satellite observations, which are shown to be fully consistent with airborne measurements. The airborne data evidence the complexity of processes driving horizontal and vertical distribution of water and provide some indications of convective impact up to 415 K potential temperature level. The flights above deep convection showed a remarkable variability of water vapour at and above the Cold Point Tropopause (CPT) on a scale of few tens of kilometers, associated with concurring dehydration and hydration processes. In certain flights that sampled a distant convective outflow, ice particles in subsaturated air and/or hydration features were observed well above the CPT level.

The presence of convective overshoots upwind is identified using MSG/Himawari brightness temperatures at two wavelengths, 6.2µm and 10.8µm, the first being sensitive to the water vapour emission at higher temperature in the lower stratosphere above the cloud in contrast to the colder cloud top. The analysis is followed by a discussion on the relative efficiency of physical processes controlling stratospheric water entry above ASM in comparison to other convective regions.

Key words: Asian monsoon, UTLS, water vapour, clouds, overshooting convection