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Evaluation of Aura MLS capacity for resolving water vapour variability in the Tropical Tropopause Layer using balloon and airborne in situ measurements

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Aura Microwave Limb Sounder (MLS) provides a great deal of crucial information on the structure and composition of the Tropical Tropopause Layer (TTL), although its coarse vertical resolution (2.5 - 3 km) complicates the detection of important physical processes controlling stratospheric water entry. This study aims at evaluating the actual capacity of MLS in capturing vertical and horizontal variability of TTL water vapour through comparisons against high-quality in situ measurements. As reference, we use balloon- and airborne FLASH Lyman-alpha hygrometer measurements from a series of field campaigns at various tropical regions (Asian monsoon, South and Central Americas, western Africa).

Deep overshooting convection may lead to a reduction or an enhancement of water entering the stratosphere depending on various parameters such as cold point tropopause (CPT) temperature and the timescale of vertical transport. Fast updrafts, characteristic to continental convection, often result in a cooling/dehydration at the CPT level and concurrent hydration above, producing kink-curved vertical profiles of water vapour. Since both processes are reversible, overshooting convection is expected to lead to an enhanced variance of water vapour in the TTL and LS, irrespectively of the net effect of convection on global stratospheric water. The query is thus a) how sensitive is MLS to the kinked curvature of a convectively-perturbed vapour profile and b) can MLS detect the convectively-induced H_2O variance?

The comparison of MLS versus FLASH in situ profiles shows good agreement at coarse resolution and, in particular cases, MLS appears to trustworthily reflect structures at height scales shorter than nominal vertical resolution (defined as half-power width of the corresponding averaging kernels). We provide some examples where MLS captures dehydration and/or hydration features and correctly reproduces spatial and temporal variability inferred from in situ measurements in the TTL.

Next, we examine the H_2O variance profiles derived from various sets of collocated FLASH and MLS measurements, noting the altitude where the variance drops to unperturbed stratospheric values. The analysis reveals that at a given spatiotemporal grid (typically, 10 ° x 5° x 2 weeks), the MLS variance profiles are largely consistent with those derived from balloon or airborne water vapour soundings at a given location. Finally, we construct and discuss the global geographical distribution of water vapour variance at TTL/LS pressure levels for different seasons. In addition, an idea is put forth that the limited sensitivity of MLS to vertical structures may serve for assessing the bulk contributions of convectively-induced LS hydration at regional and hemispheric scales.