TTL dehydration efficiency evaluated using in-situ data and back-trajectories

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Water in the stratosphere (SW) has a significant impact on Earth's climate, and on stratospheric chemistry. The efficiency with which tropospheric air parcels are dehydrated en route to the stratosphere exerts a dominant control on stratospheric water concentrations. The uniquely cold, clean, and dynamic environment in the upper troposphere where this dehydration takes place challenges our ability to predict how the physical processes involved in this dehydration lead to the observed SW. Predictions of how SW may change in the future will hinge on an accurate, process-level understanding of what currently controls it.

Here we use measurements from the ATTREX campaign to statistically constrain dehydration efficiency in the TTL. We use measurements of water vapor, ice water content, and ice crystal number and size distributions from the upper troposphere ($350 < \theta < 375$K) to examine how various processes (nucleation, deposition, settling) contribute to incomplete dehydration. We also use measurements of water vapor from the lowermost stratosphere ($375 < \theta < 390$K) and compare these data to the minimum saturation mixing ratios calculated along back-trajectories initiated from the water vapor measurement locations. These analyses lead to the conclusion that in the Pacific TTL regions sampled by the Global Hawk, dehydration inefficiency increases with decreasing temperatures below ~195K and is expected to result in a >10% higher entry value for WV transported into the stratosphere than would be the case if dehydration was completely efficient.