Vertical profile observations of water vapor deuterium excess in the lower troposphere

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In a recent publication in *Atmospheric Chemistry and Physics* (Salmon et al., 2019), we use airborne measurements of water vapor (H_2O_v) stable isotopologues and complementary meteorological observations to examine how boundary layer dynamics, cloud processing, and atmospheric mixing influence the vertical structure of δD, $\delta^{18}O$, and deuterium-excess (d-excess $= \delta D - 8\times\delta^{18}O$) in the boundary layer, inversion layer, and lower free troposphere. Flights were conducted around two continental U.S. cities in February – March 2016 and included vertical profiles extending from near the surface to ≤2 km. We examine observations from three unique case study flights in detail. One case study shows observations that are consistent with Rayleigh isotopic distillation theory coinciding with clear skies, dry adiabatic lapse rates within the boundary layer, and relatively constant vertical profiles of wind speed and wind direction. This suggests that the air mass retained the isotopic fingerprint of dehydration during moist adiabatic processes upwind of the study area. Also, observed d-excess values in the free troposphere were sometimes larger than Rayleigh theory predicts, which may indicate mixing of extremely dehydrated air from higher altitudes. The two remaining case studies show isotopic anomalies in the d-excess signature relative to Rayleigh theory, and indicate cloud processes and complex boundary layer development. The most notable case study with stratocumulus clouds present had extremely low (negative) d-excess values at the interface of the inversion layer and the free troposphere, which is possibly indicative of cloud or rain droplet evaporation. We discuss how *in situ* H_2O_v stable isotope measurements, and d-excess in particular, could be useful for improving our understanding of water phase changes, transport, and mixing that occurs between the boundary layer, inversion layer, and free troposphere.