Investigating Signatures of Large-Scale Advection and Microphysical Processes on Vertical Profiles of Water Vapor and Aerosols Near Mauna Loa and Mauna Kea

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While recent work suggests the isotopic composition of water vapor is controlled, to first order, by large-scale advection, other studies have proven isotopic measurements sensitive enough to investigate microphysical processes, such as rain recycling. On the one hand, this allows the stable isotope ratio 2H:1H (δD) to serve as an effective tracer of atmospheric constituents important for climate and air quality. On the other hand, it creates the possibility that isotopic measurements could aid studies of aqueous processing of aerosol and trace gases. In this work, we examine both the large-scale/advective and microphysical signatures in vertical profiles of δD on the Big Island of Hawaii, home to NOAA's Mauna Loa Observatory. Simultaneous measurements of aerosol size distributions and CO_2 are used to verify inferences made from the water isotope information. Profiles were constructed by continuously measuring water isotopologues, CO_2, aerosols (D<1000 nm), and temperature from a moving vehicle that was driven from sea-level to the summit of Mauna Kea several times daily. A total of nine profiles were obtained over three days, covering both the east- and west-facing slopes of the island. δD observations from this experiment clearly distinguish the moist marine boundary layer from the dry free troposphere, and also identify a transition layer in between, extending as much as 1000 meters above the trade wind inversion. Vapor mixing ratio and δD plots of the transition layer highlight the role of evaporation in mixing moisture upward from the top of the inversion cloud deck. Although air above the inversion is cloud-free, we are thus able to detect the traces of cloud-processing independent of aerosol number size distribution. Within the boundary layer, the isotopic profile is remarkably constant, except where falling precipitation is observed. In rainy conditions, strong isotopic depletion (lightening) is observed below the cloud layer, indicating the removal of heavier, condensed water. Conserved variable plots of total water and equivalent potential temperature are used to explore heating and cooling associated with rain removal and re-evaporation at lower altitudes.

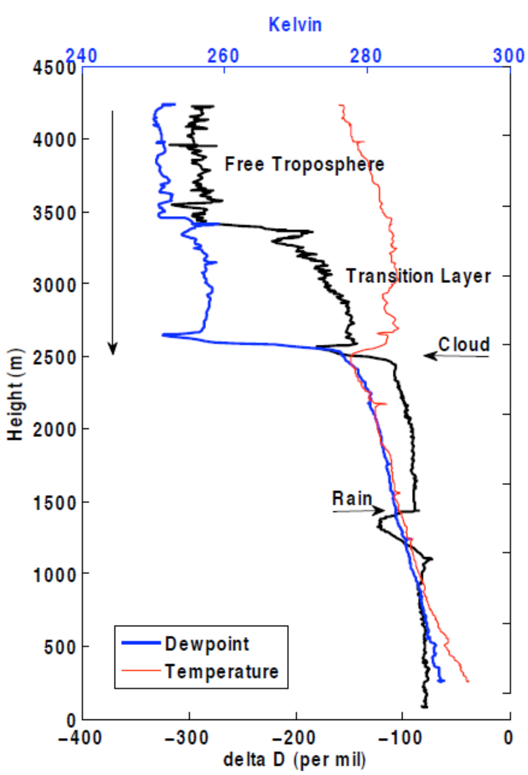

Figure 1. δD (black), dewpoint (blue) and ambient temperature (red) profiles measured while driving from Mauna Kea summit down to Hilo, Hawaii. First observations of rain and cloud are marked.