Measurements of the Stable Isotopologues of Water Vapor at Mauna Loa for Monitoring the Atmospheric Water Cycle

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Measurements of the isotopic composition of water vapor reflect the history of air mass mixing and cloud processes influencing the vapor as it moves through evaporation and transpiration. This comes about because heavy isotopologues of water (i.e, HDO and $H_2^{18}O$) have a different vapor pressure than normal (lighter) H_2O, and as such they prefer to remain in the condensed phase during both condensation and evaporation. Continuous measurements of H_2O $H_2^{18}O$ and HDO were made at Mauna Loa for four weeks in October 2008 using three laser-based spectroscopic analyzers. Figure 1 shows that at Mauna Loa the isotopic composition dramatically captures the dramatic diurnal transition between air influenced by the marine boundary layer during day and free troposphere air at night. Closer examination shows that this transition is almost reversible, yet the isotopic signature of clouds is evident and suggests cloud processes play a role in the energy budget that maintains the MBL. The very dry and isotopically depleted free-troposphere air indicates that the humidity is set though ice cloud processes either in the midlatitudes or in the upper troposphere within the Inter-Tropical Convergence Zone. Moistening of the troposphere near Mauna Loa occurs in association with detrainment from warm convection, as is exemplified by an “atmospheric river” event that was observed in the second half of the field period. This work establishes that commercially available isotopic vapor analyzers are both capable of monitoring the isotopic composition at NOAA baseline stations, that the calibrated measurements are of remarkable high precision, and that the data can be used to establish new understanding of the atmospheric water cycle.

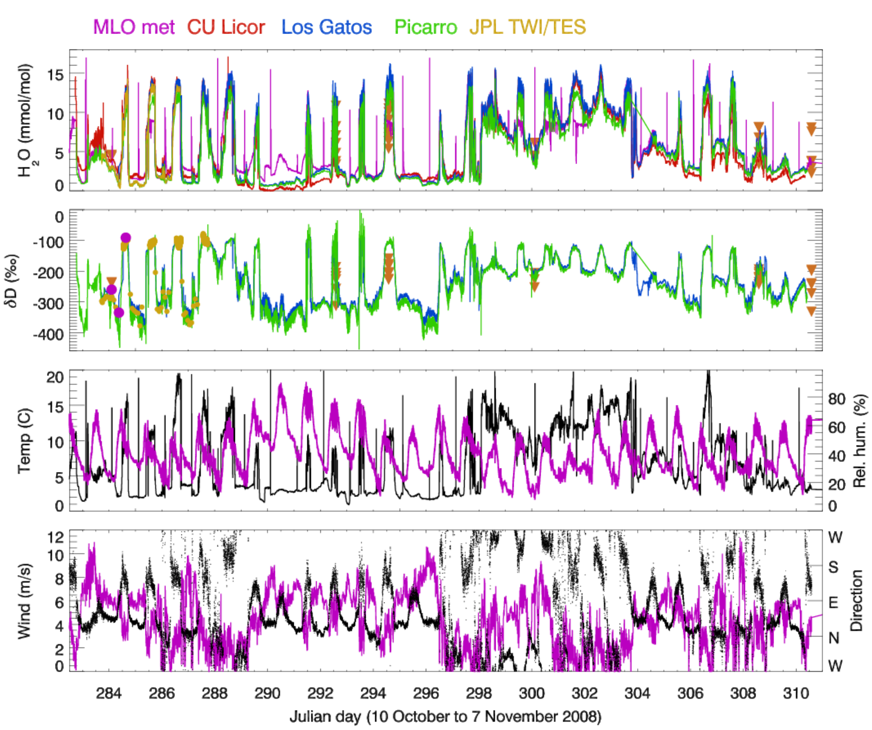

Figure 1. Time series of a) water vapor volume mixing ratio, b) dD of water vapor c) station temperature (magenta) and relative humidity (black) and d) wind speed (magenta) and direction (black dots) at Mauna Loa from 10 October to 6 November 2008. Panel a and b include all observations from station meteorological dew point hygrometer (magenta), Licor 7000 IRGA (red), LGR WVIA (blue), Picarro IWVA (green), JPL-TWI (orange circles), TES satellite FTIR (gold triangles) and 3 flasks (magenta circles).