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The stable water isotopic signature of ENSO: a new look at humidity controls

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Well known as a dominant mode of decadal climate variability, the El-Niño Southern Oscillation (ENSO) modifies distributions of atmospheric moisture over the Pacific and, by way of teleconnections, the Western U.S., where it alters risk of flood and drought for many American communities. This motivates a greater understanding of the processes that control specific humidity patterns during ENSO phases. Paired satellite retrievals of H2O and HDO from NASA's Tropospheric Emission Spectrometer are used to construct joint frequency distributions (JFDs) of specific humidity and the stable water isotope ratio D:H for the tropics and subtropics. Because the isotopic composition of atmospheric moisture records the condensational history of an air mass, the D:H ratio provides an opportunity to investigate mechanisms responsible for regional moistening or dehydration. JFDs during La Niña conditions (winters '07-'09 and '10-'11) are contrasted with weak warm phase winters ('06-'07, '09-'10) to estimate relative changes in hydrological processes (e.g. moist adiabatic, pseudoadiabatic). In addition, Principal Component Analysis (PCA) is performed on the JFD differences (La Niña minus El Niño-like winters), and the leading PCs are correlated with normalized variations in 500-hPa vertical velocity and geopotential height fields for the same period. These parameters are used as proxies for shifts in large-scale circulation. Eigenvectors associated with the remaining PCs are examined for changes in precipitation efficiency. JFDs are similarly analyzed for the Northwestern and Southwestern U.S., which experience precipitation anomalies of opposite sign during ENSO. The individual hydrological events that influence the 2010-2011 Northwestern JFD are examined in greater detail using ground-based isotopic measurements from the extreme northwest corner of Colorado, made during January-March 2011. These high frequency, continuous observations of water vapor and the D:H ratio provide a rare opportunity to analyze synoptic variability in the vapor isotope record that helps shape seasonal ENSO signatures.