Using MERRA-2 and M2AMIP to characterize the energy links between El Niño SST and tropical land drought

The El Niño Southern Oscillation (ENSO) is a coupled Earth system circulation phenomena that reaches all around the globe. The heat added to the atmosphere by increased precipitation produces circulation changes that have global reach and, over time, warms the entire tropical band, and much of the Earth. Many studies have noted that El Niño causes warm and dry (and sometimes drought) conditions over tropical land masses. We develop a composite analysis of El Niño to identify the predominate features of tropical land response. This analysis shows that the land’s lagged response is related to a reduction clouds that leads to increase surface shortwave radiation that increases the surface temperature. The precipitation lag is somewhat longer, and then leads to a reduction in soil water and, in concert with increased SW induced surface warming, leads to increased sensible heating of the atmosphere above. The M2AMIP simulation generally captures these features, but the response is strongest with increased temporal and spatial proximity to the El Niño peak warming. The regionality of these features is also discussed, and it is noted that even the strongest individual El Niño events can vary from this composite mechanistic paradigm.

Tropical global monsoon land areas (30S-30N) composite El Niño anomaly time series for MERRA-2 (left) and M2AMIP (right) for several key quantities listed on the figure. The solid line indicates the composite average and shading indicates ±1 standard deviation of the composite mean. Scales are color coded for each line. Dots indicate anomalies significantly different from zero (at 90% confidence). The variables are near surface air temperature (T2m), precipitation, SWCRE, vertical velocity (ω, directed positive for upward motion, at the 500hPa level), surface temperature (Ts), sensible heat flux (Hs), downward longwave radiation (LW↓) and net surface longwave radiation (LWnet, directed downward positive), dry static energy (DSE) divergence (∇•CpT+∇•gZ+∇•KE), heating due to water vapor divergence (∇•Lqv), surface evaporation (Evap) and surface soil wetness. DSE and water vapor divergence are computed from the model output fluxes of qv, CpT and gZ, and do not include mass corrections to the wind.

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