Temporal Information Partitioning Networks reveal ecohydrologic responses to rainfall pulses and drought

Allison Goodwell and Praveen Kumar
University of Colorado, Denver

Abstract. Ecohydrologic fluxes within atmosphere, canopy and soil systems exhibit complex and joint variability. This complexity arises from direct and indirect forcing and feedback interactions that can cause fluctuations to propagate between water, energy, and nutrient fluxes at various time scales. When an ecosystem is perturbed in the form of a single storm event, an accumulating drought, or changes in climate and land cover, this aspect of joint variability may dictate responsiveness and resilience of the entire system. A characterization of the time-dependent and multivariate connectivity between processes, fluxes, and states is necessary to identify and understand these aspects of ecohydrologic systems. We construct Temporal Information Partitioning Networks (TIPNets), based on information theory and information decomposition measures, to identify time-dependencies between variables measured at flux towers along elevation and climate gradients in relation to their responses to moisture-related perturbations. Along a flux tower transect in the Reynolds Creek Critical Zone Observatory (CZO) in Idaho, we detect a significant network response to a large 2015 dry season rainfall event that enhances microbial respiration and latent heat fluxes. At a transect in the Southern Sierra CZO in California, we explore network properties in relation to drought responses from 2011 to 2015. We find that high and low elevation sites exhibit decreased connectivity between atmospheric and soil variables and latent heat fluxes, but the high elevation site is less sensitive to this altered connectivity in terms of average monthly heat fluxes. This work presents a novel use of information theoretic measures to gage the responsiveness of ecosystem fluxes to shifts in connectivity, and aids our understanding of ecohydrologic responses to disturbances. This study is relevant to ecosystem resilience under a changing climate, and can lead to a greater understanding of shifting behaviors in many types of complex systems.