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A network approach to evaluate ecosystem vulnerability

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Ecohydrologic systems exhibit shifts in behavior due to natural or human induced perturbations or stresses. These shifts result from changes in dependencies between many interacting components. A framework that defines a system based on these shifting interactions is needed to holistically evaluate properties such as resilience, vulnerability, or health that cannot be reached through the isolated study of component behaviors. This study uses a network approach in which ecohydrologic time-series data are nodes, and information theoretic measures that capture various aspects of time dependencies are links. It has been shown that an information decomposition approach can be used to determine the relative redundant (shared by multiple source nodes to a target), synergistic (arising only from the knowledge of multiple source nodes), or unique (only provided by an individual source node) information within a given detected link. We construct networks from flux tower and ecohydrologic model output nodes and evaluate how these evolve in terms of connectivity, dominant time scales of interactions, link uniqueness, and link stability over time windows ranging from several hours to several weeks as ecosystems respond to shifting environmental conditions. We associate these network properties with simulated and observed vegetation responses, and show that a network framework can be used to detect critical interactions that dictate ecosystem vulnerabilities to extremes.