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A process network based approach to model intercomparison using SUMMA ensembles

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The complexity of hydrologic systems has resulted in the proliferation of a large number of computational models spanning a wide range of process and spatiotemporal resolutions. Model intercomparison projects (MIPs) are an integral component for evaluating and understanding differences in these models. However, MIPs often report differences in model performance, rather than providing insights into deficiencies of model behavior. These shortcomings stem from several factors: differences in model implementations can obscure differences in conceptualization and parameterization, compensating errors due to differences in calibration and/or parameter values result in similar performance even when model structure differs, and MIPs often evaluate models on a narrow range of conditions.

We address several of these issues by simulating a wide range of hydrometeorological regimes using a large number of differing model configurations that have been constructed in a controlled fashion. To accomplish this we use the Structure for Unifying Multiple Modeling Alternatives (SUMMA) which provides a modeling framework that allows for flexible representations of spatial arrangements, flux parameterizations, and parameter values. SUMMA allows us to compare different model structures while keeping the same core implementation of numerical solvers and conservation equations.

We then use information theoretical analyses to determine model performance with an emphasis on process representation. First, we rank model performance for each of the simulations with respect to observations taken from FluxNet towers. Then, we compute process networks by analyzing the full set of energy and mass balance terms in a network-based fashion as a measure of model structure. Using the joint data from the process networks and performance analysis we are able identify the process interactions that are driving these differences in model performance.