Poster #1-49

Improving Hydrological and Surface Energy Fluxes by Incorporating Plant Hydraulics and Hillslope Based Drainage Function in Earth System Models

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Spatial variability in water available for plant water use has an important control on how tropical forests respond to drought. Our previous simulations identified development needs for modeling surface and subsurface hydrology in Earth system models. First, the drought index formulation and the simplicity of treating root water uptake as a sink term in soil hydrology in the land component (ELM) of the Energy Exascale Earth System Model (E3SM) lack mechanistic representation of the interaction of soil-plant system. Second, subsurface lateral flow has been shown to have important control on surface hydrology and groundwater table depth. To address the limitation in representing hydrodynamics of the soil- plant system, we implemented in ELM the plant hydraulics scheme developed in the Functionally-Assembled Terrestrial Ecosystem Simulator (FATES). Simulations were performed at two tropical forest sites – Manaus, Brazil and Barro Colorado Island (BCI), Panama. The simulations showed that plants experience some water stress in the dry season at Manaus during the mega drought year, but the reduction in water availability is small. Combined with field characterization, simulations at BCI showed that trees experienced water stress during the 2015-16 El Niño event. We also identified the need of improvement of numerical accuracy for the plant hydraulics scheme in FATES.

To model subsurface lateral flow, we introduced a physics based representation of lateral fluxes as a drainage function using hillslopes to represent subgrid spatial variability in topography. This approach enables a realistic representation of lateral flow processes and their impacts on hydrological and surface energy fluxes, while keeping additional computational cost minimal for Earth system modeling. We coupled this model to ELM of E3SM and applied it at global scale. Simulations and analysis are used to understand (1) the role of subsurface lateral flow as a water source for river discharge; and (2) how lateral flow influences the spatial distributions of both soil moisture and water table dynamics. We will evaluate our simulations and investigate how surface heterogeneity modulates hydrological processes and the response of tropical forests to drought.