Poster #1-46

Exploring the Complex Interactions among Land Use, Vegetation Dynamics, and Hydrology in the Tropics by Incorporating Preferential Flow into FATES-ELM

Maoyi Huang[1*], Yanyan Cheng[1], Ryan Knox[2], Charles Koven[2], Ruby Leung[1], and Michael Keller[3,4]

[1] Pacific Northwest National Laboratory, Richland, WA;
[2] Lawrence Berkeley National Laboratory, Berkeley, CA;
[3] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA;
[4] International Institute of Tropical Forestry, USDA Forest Service, Rio Piedras, PR

Contact: maoyi.huang@pnnl.gov

BER Program: TES
Project: NGEE -Tropics
Project Website: https://ngee-tropics.lbl.gov

Tropical forests play a major role in global water and carbon dynamics. Sustainable forest management by reduced impact logging and reforestation in tropical watersheds has the potential to improve the delivery of ecosystem services by improvement of water quality, increase of dry season base flow, reduction in floods, reduction in wildfire occurrence, reduction in soil erosion, and increase in carbon storage and timber production. These services depend upon the so-called *forest sponge effect*, a condition in which well- developed forest cover promotes high soil infiltrability and groundwater recharge during the wet season leading to increased streamflow during dry periods, despite the reduction in total annual runoff. Observations from tropical watersheds suggest that preferential flow (PF) is the mechanism responsible for the *sponge effect*. Preferential flow paths in soil pipes and macropores created by tree root growth and decay, soil macrofaunal burrowing, and soil shrinking/swelling significantly modulate root-zone moisture, groundwater recharge, evapotranspiration, and soil organic carbon. Preferential flow is absent in most hydrologic models and land models.

This study constitutes our first attempt to explicitly account for the influence of PF in the near- surface soil system into the FATES-ELM framework. Recent distributed hydrologic modeling studies suggest that although both lateral and vertical PF exists, the latter is more significant in magnitude and could explain the variations in streamflow patterns observed from paired catchments, where climate and substrate conditions are identical but land covers are distinct. Therefore, we have incorporated the most important feature of vertical PF by moving a fraction of water from infiltration directly to the bottom of the root zone at every time step to represent the effective contribution of PF. This fraction of quick flow is represented as a function of coarse root biomass (e.g., proportional to the mean diameter of coarse roots) that varies with land use patterns at different levels of disturbance (e.g., old-growth, clear-cut, various logging intensities), which can either by measured or calibrated depending on data availability. A set of single-point FATES-ELM simulations with and without PF will then be conducted at selected tropical sites, including Tapajos, Manaus, and Panama, and compared to observations. By using the simple parameterization of PF and improving its representation of the dynamics of water, carbon, and ecosystem demography constrained by observations, the enhanced FATES-ELM model will be a useful tool for exploring the complex interactions among land use, vegetation dynamics, and hydrology in the tropics.