

Aggregated Watershed Modeling

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Project Abstract:

We are pursuing several research directions to quantify water and biogeochemical cycling at the aggregated watershed scale using various modeling approaches. Within this modeling effort, so-called watershed Functional Zones play a key role insofar as they are the basis for various reduced order/dimension models for water and biogeochemical cycling. The elements of this research component include:

- *Zone-based transect modeling:* The functional zones that have been identified each represent a hillslope having distinct characteristics in both surface and subsurface features relative to neighboring parcels. For each intensive zone, we are creating a hillslope scale model (typically in 2D) and compare its response to early snowmelt relative to an average water year.
- *3D HPC modeling of surface+subsurface flow and biogeochemistry:* Using the software platform Amanzi-ATS, we are developing models for flow and biogeochemistry at the sub-catchment scale, initially focusing on the Lower Triangle. The HPC modeling makes use of adaptive mesh refinement to resolve smaller scale features (e.g., floodplains) that have an outsized impact on system behavior. This is one component of the Scale Aware Watershed Simulation Capability (SAWaSC).
- *Functional Zone refinement with HPC distributed computing:* High performance computing distributed modeling is being performed in select regions of the watershed to evaluate and refine the Functional Zone concept and to optimize the placement of sensor networks and other characterization data. A combination of ParFlow-CLM for hydrology and Amanzi-ATS for hydrology + biogeochemistry (both of which solve the for integrated surface-subsurface hydrology) are being used to determine whether various zones defined initially actually have similar functional responses as regards water and nitrogen export to various forcings and transients, especially as related to snow dynamics. Where this is not the case, the Functional Zones will be refined accordingly.
- *Reduced Order/Dimension SAWASC:* Building on insights from the HPC modeling task, a reduced-order (or semi-distributed) SAWaSC modeling approach is being developed to predict aggregated watershed discharge and nitrogen export as a function of snow dynamics. The approach is based on a residence time analysis within stretches of the river system, with lateral bedrock and hyporheic exchange taken from machine learning-based training on the high resolution distributed HPC sub-catchment simulations of biogeochemical cycling and fluxes and/or 1D stream tube reactive flow and transport simulations. The reduced order models will be further tested by synoptic sampling of stretches of the river system for discharge and concentration, with a focus on nitrogen. The zonation will be used to provide time-dependent lateral fluxes of water and biogeochemical species to the river system, i.e., C-Q relationships.