Poster #21-42

4D Digital Watershed: Advanced Bedrock-to-Canopy Characterization across Watersheds

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Characterizing ecohydrological-biogeochemical processes over heterogeneous watersheds are critical for estimating and predicting integrated hydrological and biogeochemical responses – such as carbon and nutrient exports, water resources and quality – under climate changes and other perturbations. In the Watershed Function SFA, we develop novel watershed- characterization methodology to quantify complex watershed systems across scales, using advanced sensing, inversion, and machine learning approaches. Through explicitly bridging information derived from “on the ground" observations made at the East River Watershed and remote sensing data, we quantify fundamental scientific linkages among interacting processes in the watershed. We integrate multi-scale multi-type datasets, including hydrobiogeochemical point measurements as well as surface geophysics, airborne data and satellite/UAV images. Over the last few years, we have acquired an extensive suite of high-resolution airborne remote sensing data over the watershed, including LiDAR for ground and top-of-canopy elevations, time-lapse NASA Airborne Snow Observatory (ASO) for snow and SWE distributions, NEON hyperspectral mapping for leaf chemistry and plant physiology, and airborne electromagnetic (EM) survey for subsurface structure (jointly with USGS).

In this presentation, we present several key recent developments and findings. Examples include:

- Watershed-scale estimation of the shale bedrock porosity and fracture density, obtained through combining airborne electromagnetic data with borehole and surface-based geophysical data.
- Meter-scale mapping of meadow plant communities through the LiDAR/multispectral data fusion, and understanding of their spatial organization depending on soil/topographic characteristics
- Key drivers that regulate watershed vegetation sensitivity to droughts through historical Landsat datasets and random forest machine learning method
- The first watershed zonation map using hierarchical cluster analysis and spatial data layers, which delineates regions that have unique distributions of above-and-below ground properties that are likely to influence subsystem behavior, and thus aggregated watershed behavior
- A novel autonomous above-and-below ground coincident sensing system, tested at the East River Watershed hillslope intensive site to quantify how the relationships between soil moisture and vegetation density evolve during the growing season

By characterizing spatiotemporal (i.e., four-dimensional) variability of critical properties over the watershed, we aim to develop the new 4D Digital Watershed concept for model parameterization and validation of hydrological and biogeochemical simulations. In addition, we plan to use both model and data-driven approaches to co-design our characterization and monitoring network.