Toward Integrated BioEPIC, Data Management and Assimilation Capabilities Supporting Watershed Research

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Abstract:

The extreme complexity of natural ecosystems poses significant challenges in the quantitative understanding of critical processes driving system functioning and predictability. Field-scale studies of coupled processes are hindered by our limited capabilities to characterize, monitor, manipulate, and model systems to derive scalable causal functions beyond a local context. We present emerging capabilities for sensing, experimentation, data management and assimilation into models driven by scientific needs to tackle these challenges.

The BioEPIC (Biological and Environmental Program Integration Center) capability developments in support of ecosystem science are centered on challenges and needs driven by community input. Coupled plant-soil-microbial processes represent a key theme, while new sensing capabilities, and manipulative platforms that represent field-scale, yet manageable complexity, are needed. The SMART (Sensors at Mesoscale with Autonomous Remote Telemetry) Soils testbed and EcoSENSE program are developing capabilities to quantify complex causal interactions across plant-soil-microbial-atmosphere interfaces with novel sensing technologies that are transferable from lab to field. Integrating >70 continuous data streams from existing and novel EcoSENSE technologies, the SMARTSoils testbed demonstrated the power of joint utilization of multi-scale and multi-physics datasets in elucidating underlying mechanisms driving ecosystem dynamics. The testbed is used to validate and improve models to quantify evapotranspiration (ET), a major source of uncertainty in the water budget, for the Watershed Function Science Focus Area (WFSFA). With the first prototype completed and fully functioning,

the design and construction of SMARTSoils 2.0 aims to be modularized and standardized to allow easier community adoption.

The WFSFA data management and assimilation framework provides infrastructure to establish field-to-lab connectivity, perform automated data quality checks, and enable data integration. An ongoing effort in partnership with the DOE's ESNet user facility involves establishing telemetric connectivity between Berkeley Lab and the East River watershed observatory via advanced wireless communication (5G and satellite) networks. In parallel, a variety of ML and statistical algorithms are being explored for data screening from field and lab in near real-time. An open source brokering service tool BASIN-3D enables integration of diverse field, lab and external datasets on-demand from distributed data sources into a common format based on the Open Geospatial Consortium's Observations and Measurements.

Together these technologies will enable a rapid, interactive feedback loop between the SMARTSoils platform, the East River watershed observatory, and associated models and data systems. These capabilities are needed to complete the cycle of field-informed experiment execution, lab-informed model parameterization, and optimal model-driven measurement adaptation in the field.