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Energy Balance Dynamics, Plant Water Use, and Subsurface Residence Times in the East River, Colorado

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Understanding the integrated water budget of mountainous watersheds requires knowledge of not only the distribution and partitioning of groundwater, surface water, and water used by vegetation, but also the inextricable link between energy fluxes with the atmosphere at the land surface. Given that evapotranspiration (ET) is the largest terrestrial water flux and transpiration often comprises 60% of ET, plant water use becomes a primary driver of these fluxes, moderating water availability for downstream use. A combination of models and observations are used here to understand the transient movement of water and energy across the earth's critical zone within the East River, Colorado. With the use of high performance computing, integrated hydrologic models enable a physically based representation of watershed hydrodynamics in high resolutions. Multi-year simulations of watershed behavior over the last decade at both local (i.e. hill slope transect) and regional (i.e. watershed) scales are performed with the integrated hydrologic model ParFlow-CLM. Results show the transient behavior of above and below ground storage vary drastically with water year, and can be directly used to inform the cascading bio-reactor model, HAN-SoMo, which shows excellent agreement in nitrogen cycling in the East River informed by residence times from the ParFlow-CLM simulations. Additionally, a new Lagrangian particle tracking technique is used to determine the transient movement of water, explicitly representing water source, age, and the associated flow pathways. Simulated fractionation of water with particles is quantified and directly compared to stream flow and depth-refined groundwater well samples. This new approach also enables novel comparisons of the degrees of water fractionation of evapotranspired water, enabling an improved knowledge of under what conditions vegetation water demands are met. Results show that ET residence times are very dynamic, demonstrating strong spatial patterns related to topography, land cover, and properties of the subsurface medium. Finally, the analysis of Eddy Coviance flux tower data shows excellent energy closure during the summer, but difficulties in the winter energy balance. Preliminary work shows that winter energy balance uncertainties are attributed to complex terrain and snowpack dynamics. Future work includes direct comparisons of model energy flux simulations with various land surface models (e.g. CLM and NOAH) and flux tower observation comparisons to determine energy loss seepage terms during the winter season, in addition to future instrumentation in various locations within the watershed.