Integrating Measurements and Models from Bedrock to Boundary Layer: A Strategy for Total Flux Measurement at the Hillslope Scale

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The use of meteorological flux towers to estimate evapotranspiration (ET)is complicated by the variable footprint of the observations, where wind speed, wind direction, turbulence and the surrounding terrain, affect the scale of the moisture-flux estimate. For hillslope-scale research or topographic transects where differences in water use by vegetation and the effects of terrain slope and aspect are critical, the impact of the changing atmospheric footprint on estimates of ET is not well constrained. In this research we are developing a new theory and experimental design for flux-inversion of ET at the hillslope scale using concurrent soil moisture, water table, sapflow, and meteorological observations. The experimental design requires sensor arrays to be deployed on an unstructured grid over the hillslope soil volume. For the model, a local, dynamic energy and water balance is formed by direct integration of Richards' and energy equations using a semi-discrete finite volume formulation of unsaturated-saturated moisture storage. The resulting dynamical system is continuous in time, discrete in space. Using field estimates of soil characteristic curves, the dynamical equations are solved numerically. Preliminary field examples from New Mexico, Utah, and Pennsylvania are presented: The first deals with seasonal phreatophyte water-use under shallow water table conditions. The second concerns long term soil moisture dynamics in a salt-flat playa setting, and the third is a humid temperate site.