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Considerations in the design of experiments to study and model mass and energy flux processes at the land-atmospheric interface in intermediate scale test systems

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IIntermediate scale laboratory test systems are at length scales intermediary between the scales of conventional laboratory column and small tank setups, and the field. This length scales generally defined to vary from ∼1 to ∼10 meters allow for experimental simulations to mimic field-scale processes under controlled conditions. As it is not possible to fully characterize the geologic heterogeneity at all relevant scales and conduct experiments under controlled conditions in the field, these test systems provide an effective alternative. A few examples of the use of intermediate testing reported in the literature are on the study of both saturated and unsaturated flow and transport, the behavior of multiphase fluids, subsurface remediation, and trapping, dissolution, and leakage of geologically stored carbon dioxide. In all these applications, the mass and thermal flux boundary conditions at the land surface are either known through observations or assumed. The characterization length scales of these subsurface studies are fully determined by the degree of geologic heterogeneity. Extending these testing methods to problems involving the interaction of the shallow vadose zone and the boundary layer is not straight forward. Examples of such problems are evaporation from soils, evapotranspiration, greenhouse gas and chemical vapor loading to the atmosphere from subsurface sources. In this class of problems where the flux occurs across the land-vegetation continuum, two domains have to be considered and characterized – the soil in the subsurface and the air in the atmospheric boundary layer. In addition to the differences in material properties, the fluid flow velocities in the two interacting domains are many orders of magnitude different. The characterization and observational length scales within the two domains are drastically different. The value of the data and findings based on early experimental studies where these differences were not fully recognized in selecting experimental systems is questionable. This paper discusses the important considerations that should be given in designing intermediate scale experiments for land-atmospheric interaction studies and issues that arise when developing and validating models. Recently completed experiments using a new test facility with a 7.15 m long soil tank interfaced with a climate-controlled, low-speed wind tunnel allows us to explore these issues. Data generated from experiments involving bare soil evaporation, different subsurface heterogeneity configurations, varying land surface microtopography and land surface obstructions are used in the presentation.