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Effects of surface roughness on evaporation from porous surfaces into turbulent airflows

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The ubiquitous and energy intensive mass transfer between wet porous surfaces and turbulent airflows is of great importance for various natural and industrial applications. The roughness of natural surfaces is likely to influence the structure of adjacent boundary layer and thus affecting heat and mass fluxes from surfaces. These links were formalized in a new model that considers the intermittent turbulence-induced boundary layer with local mass and energy exchange rates. We conducted experiments with regular surface roughness patterns subjected to constant turbulent airflows and monitored mass loss and thermal signatures of localized evaporative fluxes using infrared thermography. The resulting patterns were in good agreement with model predictions for local and surface averaged turbulent exchange rates. Preliminary results obtained for evaporation from sinusoidal wavy soil surfaces reveal that evaporative fluxes can be either enhanced or suppressed (relative to a flat surface) owing to relative contribution of downstream (separation zone) and rising (reattachment zone) surfaces of the wave with thick and thin viscous sublayer thicknesses, respectively. For isolated roughness elements (bluff bodies) over a flat evaporating surface, the resulting fluxes are enhanced (relative to a smooth surface) due to formation of vortices that induce thinner boundary layer. Potential benefits of the study for interpretation and upscaling of evaporative and heat fluxes from natural (rough) terrestrial surfaces will be discussed.

Keywords: Turbulent Evaporation, Porous Media, Surface Roughness, Infrared Thermography.