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Evaporation-Condensation Dynamics on Rough Surfaces

E. Shahraeeni and D. Or
ETH Zurich, Mechanical Engineering, Zurich, Switzerland (e.shahraeeni@env.ethz.ch)

Evaporation-condensation is an important process for vapor transport through unsaturated porous media, and in a wide array of other applications such as mobilization of dust particles and behavior of aerosols in the atmosphere. As a primary building block we resolved the combined mass and energy transformations involved with evaporation-condensation on capillary rough surfaces. Dynamics of the phenomena at the micro scale are described by a quasi analytical model for air-water interface evolution in a wedge-shaped channel. This dynamics of phase change is coupled with an analytical model for temperature evolution associated energy exchange during phase change and subsequent conduction and/or convection. The solution was applied to random distributions of roughness elements found on surfaces of soil or dust grains and describes rates of mass accumulation or loss as a function of ambient temperature and relative humidity. Results show vastly different rates of mass accumulation (or loss) based on capillary characteristics of the roughness and boundary conditions. These results provide estimates of porous media wetting dynamics via vapor transport into initially dry packs of grains and may be extended to provide estimates for residence time of initially dry suspended particles in the atmosphere.