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The role of pore clusters (wet patches) on evaporation dynamics from drying porous surfaces

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Theoretical and experimental evidence suggests that the relationship between evaporative flux and porous surface water content is nonlinear (i.e. the reduction in flux is not proportional to reduction in water content). These nonlinearities are attributed to flux compensation due to interactions between evaporation from discrete pores whose spacing increases with surface drying and air boundary layer. Motivated by recent insights on the interplay between boundary layer thickness, pore size and spacing on surface fluxes, we examine effects of pore clustering on evaporation rates, addressing the question do pore clusters behave like large pores?
Evaporation rate from clustered surfaces was determined theoretically using analytical and numerical methods, and results were compared to experiments. We exposed porous surfaces with different pore clusters arranged in different patterns to prescribed evaporative conditions in a wind tunnel with air velocities between 1 and 4 m/s (to vary the thickness of viscous boundary layer). The water saturated porous plates were covered by impervious plates with fixed evaporating area distributed between 1 to 169 clusters. The evaporation rate (relative to free water evaporation) decreased with increasing cluster size ("big pores") and decreasing boundary layer thickness. Experimental findings suggest that clustering reduces evaporation rates relative to distributed pores, however this effect is limited to cluster sizes of about 10 mm (of the order of maximum boundary layer thickness studied). The results were in agreement with model predictions that yield a universal scaling function for estimation of evaporation reduction by pore clustering for different boundary conditions.