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Direct numerical simulations of turbulent flows over a water saturated porous medium: How two phase pore flow forms roughness at a permeable surface

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Evaporation from a porous medium into a free flow is one of the fundamental processes in environmental systems (e.g. the evaporation of water from soil into the atmosphere [1]). In technical systems self-pumping transpiration cooling can be realized with the help of porous materials where the combination of capillary action and phase change is a promising approach to cool structures due to its high cooling efficiency [2]. The distribution of liquid in the porous material, namely the existence of continuous liquid pathways to the surface of the porous medium influences significantly the evaporation rate [3]. Furthermore, the condition of the turbulent boundary layer in which the vapor is transported away from the surface is of great importance.
Hybrid-dimensional models are successfully used for the efficient modeling of such systems under laminar flow conditions [4]. These models use coupling conditions to ensure the continuity of mass, momentum and energy between the pore network model (PNM) and the free-flow domain. But these coupling conditions comprise unknown parameters (e.g. the slip length) and their validity for turbulent flows is unclear. One possibility to evaluate the validity of coupling conditions and to derive closures for the unknown parameters is to fully resolve the Navier–Stokes equations in the free flow and the pore space.
In this talk results of such pore resolved calculations are presented for a porous medium with different water saturation levels. The focus will be on the momentum balance at the interface. It will be discussed (i) how the rough, permeable surface influences the turbulent boundary layer, (ii) how the fluid distribution will influence the effective roughness and (iii) how the pore wall wettability influences the fluid distribution.
Finally a possible approach for a coupling condition for the momentum balance of a turbulent flow with a porous medium under different saturation levels is presented.

Participation

In-Person

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