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Effects of grain-scale sediment-bed roughness on surface-subsurface mass exchange GUANGCHEN SHEN, JUNLIN YUAN, MANTHA PHANIKUMAR, Michigan State University — In aquatic environments such as rivers, the exchange of solutes across the interface between the sediment and the overlying water plays a significant role in controlling biogeochemical processes. Most previous studies on characterizing this exchange are focused on flows with sediment bedforms much larger than individual sediment grains. Detailed understanding of the effects of grain-scale bed roughness on the exchange is limited. Our recent pore-resolved simulations of interface turbulence (Shen, Yuan and Phanikumar, JFM, 2020, 892: A20) revealed that, even in the absence of bed form, the grain-scale roughness of a flat river bed may lead to significant mass flux into the sediment. Here, we quantify the important macroscopic exchange quantities such as the exchange flux, subsurface flow paths characteristics, and the residence-time distribution. Results show that (1) grain-scale bed roughness generates multiscale subsurface flow paths that reach scales much larger than the grain diameter and (2) the roughness-induced hyporheic storage is dependent on the roughness characteristics. These observations indicate that, despite its small scale, the bed roughness can induce significant hyporheic exchange similar to that induced by a larger-scale bedform.

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