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Rheology of mobile sediment beds sheared by viscous, pressure-driven flows. (English)

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Summary: We present a detailed comparison of the rheological behaviour of sheared sediment beds in a pressure-driven, straight channel configuration based on data that were generated by means of fully coupled, grain-resolved direct numerical simulations and experimental measurements previously published by P. Aussillous et al. [ibid. 736, 594–615 (2013; Zbl 1294.76263)]. The highly resolved simulation data allow us to compute the stress balance of the suspension in the streamwise and vertical directions and the stress exchange between the fluid and particle phases, which is information needed to infer the rheology, but has so far been unreachable in experiments. Applying this knowledge to the experimental and numerical data, we obtain the statistically stationary, depth-resolved profiles of the relevant rheological quantities. The scaling behaviour of rheological quantities such as the shear and normal viscosities and the effective friction coefficient are examined and compared to data coming from rheometry experiments and from widely used rheological correlations. We show that rheological properties that have previously been inferred for annular Couette-type shear flows with neutrally buoyant particles still hold for our set-up of sediment transport in a Poiseuille flow and in the dense regime we found good agreement with empirical relationships derived therefrom. Subdividing the total stress into parts from particle contact and hydrodynamics suggests a critical particle volume fraction of 0.3 to separate the dense from the dilute regime. In the dilute regime, i.e. the sediment transport layer, long-range hydrodynamic interactions are screened by the porous medium and the effective viscosity obeys the Einstein relation.

MSC:

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References:


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