Taking into account granular bed resistance in turbulent bedload transport with arbitrary slope (and particle shapes)

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Abstract: Turbulent bedload transport has a major influence for riverbed evolution and is still lacking a general understanding for realistic configurations with arbitrary slopes and sediments shapes. In this contribution, we explore the importance of the granular bed resistance to the fluid flow. Maurin et al. (2018) have shown that a generalized version of the repose angle of the granular material can be defined, and is able to characterize the slope influence on sediment transport rate for particle scale simulations (Maurin et al., 2015) over a large range of slopes and fluid forcing (i.e. Shields number). Extending the configuration to arbitrary particle shapes, the sediment transport rate can be shown to be correlated to the variation of the granular media repose angle (Monthiller, 2019).

\[ \theta = \frac{\tau_b}{(\rho_p - \rho_f)gd \cos(\alpha)} \]

From a granular point of view, the bedload transport observed is the result of a competition between:

**Driving transport mechanisms**
- Fluid surface shear stress: \( \tau_b \)
- Fluid flow inside the bed: Gravity-driven fluid flow: depends on the slope
- Slope (streamwise weight): \( \rho_p g d \sin(\alpha) \)

**Resisting transport mechanisms**
- Granular buoyant weight: \( (\rho_p - \rho_f)gd \cos(\alpha) \)

\[ Q_s = \sqrt{\frac{(\rho_p - \rho_f)gd}{\rho_p g d \sin(\alpha)}} \cdot \theta \]

DEM bedload transport simulations with variation of slope and density

From analytical and dimensional analysis:
\[ Q_s \sim \sqrt{\rho_p g d \sin(\alpha) \tan(\alpha)} \cdot \frac{\mu_s}{1 + [((\rho_p - \rho_f)gd/\mu_s)^{3/2}]} \]

**Perspectives**
- Avalanche angle or repose angle?
- Generalization? Limits?

**References**

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