Lecture 23—Bedforms and Bedload

There's a real problem coming—most bedload equations can't incorporate bedforms. Unfortunately, most of the time we care about bedload, there are bedforms. Go figure. Mercifully, there's a way to put bedforms into one class of bedload transport equations—the excess shear equations.

When we first talked about bedforms, I explained that bedforms act as a second source of drag, so that in addition to *grain drag* we also had *form drag*. This becomes an issue only because drag, in turn, affects shear stress. SO, we have two forms of shear stress, *skin friction* shear stress (caused by grain roughness) and *form drag* shear stress (caused by bedforms). The total shear stress in the system is the sum of the two:

$$\tau_t = \tau_{sf} + \tau_{fd}$$

So, here's how to think of this. There's only so much shear stress in the system, right?

$$\tau_t = \rho g h S$$

SOME of this shear stress is extracted by the bedforms, so there's only a *reduced* amount (τ_{sf}) left to actually move grains. In order to use bedload transport equations with bedforms, we'll need to calculate the total shear stress, subtract the form drag component, and use this *reduced* shear stress to calculate the bedload transport rate.

This is where things get a little hairy. At present, there are only expressions for the form drag of relatively simple shapes, like dunes. Perhaps the best-known expression (for dunes) is:

$$\frac{\tau_t}{\tau_{sf}} = 1 + \frac{C_D H}{2\kappa^2 \lambda}\left[\ln\left(\frac{H}{z_{0sf}}\right) - 1\right]^2 \qquad \text{(Wiberg and Nelson, 1992)}$$

where H is dune height, λ is dune wavelength, z_0 is the roughness element height (commonly taken to be $0.1D_{84}$) and C_D is the drag coefficient for dunes, often given as 0.212.

This allows for the form drag component to be removed, leaving only the skin friction component! Notice, however, that this only works where you have easy access to τ in an equation, and where τ and τ_c are clearly separated, as they are in all excess shear arguments. This helps to explain why excess shear equations remain popular.