The science of landscapes: Earth and planetary surface processes
Winter 2019
Problem set 4

Due in class Monday 18 Feb, 10:30am. Office hours 11:30a-12:30p, or by arrangement (kite@uchicago.edu).

Collaboration policy. You may discuss homework questions with each other, but you should not be in the same room as another student when you are writing up the answers. Questions in this problem set are "open book" and may draw on concepts in the required reading.

Question 1.
Mississippi River velocity structure and sediment transport. Consider the following measurements of the flow velocity within a profile of the Mississippi River, at this time and place flowing with a flow depth of 8.5 m. The measurements are as follows:

z (m above bed), U_{avg} (m/s)
7.7, 1.25
5.2, 1.20
3.2, 1.05
1.8, 1.00
0.9, 0.90
0.6, 0.80

a) Recalling the law of the wall, what is your best estimate of the shear velocity, u_*? What is the roughness length of the flow, z_0? (Hint: Recall von Karman's constant, k = 0.4). Plot your results in both linear-linear and log-linear fashion (linear in U as the x-axis and log of z on the y-axis), showing both the data and your predicted velocity structure, using your best estimates for u_* and z_0.
b) Given this, what is the slope of the river in this reach? You will have to use definition of the shear velocity, $u_* = \sqrt{g*H*S}$, where S is slope.

(Based on Anderson & Anderson problem 12.4).

Question 2. Consider a steep-walled river channel with width = 50m, bankfull depth of 3m (to the levee tops) and a slope of 0.5 m/km. The bed of the river is made of coarse sand, organized into ripples that result in an effective roughness length (z_0) of 3 mm. The river at the moment is flooding at a stage of 0.5 m above bankfull. Recall that the shear velocity u_* is defined

as $u_* = \sqrt{}$(tau_b/rho), or $u_* = \sqrt{}$(gHS). Calculate the water discharge in the channel, in m3/s:

(a) at bankfull;

(b) at 0.5 m above bankfull.

(Note that in both cases you may ignore the frictional effects of the banks). In the latter calculation, ignore the contribution from that flow that escapes over the floodplain.

[No Question 3 this week as we have not yet covered sediment transport.]