Homework #5
Mathematical Modeling of Geological Processes
Due Monday, 11/27/2017
25 pts

In this homework, you will use Landlab to explore the interaction between hillslope and fluvial processes motivated by a framework presented in Perron et al. (2009), which is available on Blackboard. Perron et al. (2009) note that the equation commonly used in landscape evolution models, which combines diffusive hillslope processes with advective fluvial processes, takes the form of a nonlinear advection-dispersion equation. They nondimensionalize this equation to derive a Peclet Number, which quantifies the relative importance of hillslope and fluvial processes. They then hypothesize that the transition between hillslopes and channels (1^{st} order basins) will occur within the landscape at length scales that produce a Peclet Number near 1, where the timescales for diffusive and advective processes are equal. They use this hypothesis to derive a characteristic length scale at which they expect this transition to occur (L_c). In Figure 2, they demonstrate that this characteristic length scale is linearly proportional the spacing of first order valleys in landscape evolution models with a range of parameters.

Your goal is to reproduce the result shown in Figure 2 using a set of Landlab simulations. To do this, you should run a set of simulations that span a range of L_c values. Run these simulations to equilibrium, and then measure an average first order channel spacing in each simulation. You can manually measure these spacings, rather than trying to automate a measurement method in python. Show the output topography from all your simulation runs, determine L_c and valley spacing for each simulation, and then plot valley spacing versus L_c, as in Figure 2 of Perron et al. (2009). They run many simulations with different aspect ratios for each L_c value. You do not need to run many simulations for each L_c. However, you may find that as you change L_c you also have to change the aspect ratio of your grid to assure that you only have first order basins (no higher order basins). That is, your simulations should look qualitatively like the landscapes in the bottom right of Figure 2, not like the landscape in the upper left, which has second order basins.

To see how to set up this kind of landscape evolution model in Landlab, see the Tutorial on components (https://nbviewer.jupyter.org/github/landlab/tutorials/blob/master/component_tutorial/component_tutorial.ipynb). You will need to run models that are similar to the two-component diffusion and stream power model in this tutorial.