ESCI 4701: GEOMORPHOLOGY

LAB: LANDSCAPE EVOLUTION WITH LANDLAB

1. Landscape Evolution Modeling

The field of landscape evolution modeling has developed with the goal of simulating landscape response – and therefore change – to external forcings. Such forcings could be climate, tectonics, land-use, ecology, etc., although the first two are most often considered in current and previous work.

We will evolve a landscape based around the core equation:

$$\frac{\partial z}{\partial t} = -K_{\mathrm{ch}} A^m S^n + K_{\mathrm{hs}} \frac{\partial^2 z}{\partial x^2} + U \tag{1}$$

Here, U is an externally-applied uplift field, and S is a positive scalar field of the slopes of steepest descent through a landscape.

Your goal in the class is to modify parameters to gain an intuition for processes that lead to landscape change.

We will be using Landlab; information (including download and installation instructions) and help may be obtained from `https://landlab.github.io`. Motivations and theory are provided in the Landlab paper, at `http://www.earth-surf-dynam-discuss.net/esurf-2016-45/`.

Please print out and hand in or email your assignments to me. They should include images of the plots exported by the code to highlight the observations you have made, as well as (where needed) slope/area plots.

QUESTIONS:

1. (10 pts) Hillslope vs. Fluvial Processes. Try changing K_{hs} and K_{ch}. How does this impact the form of the landscape, qualitatively? Next, use the plots of slope and area to estimate where the hillslope–fluvial transition is; measure this (by hand) for several sets of parameters (K_{hs} and K_{ch}) and produce a relationship between the scale of this break and your chosen K_{hs} and K_{ch}. For this second part of the question, feel free to work in groups and share your model runs to come up with enough results to plot a relationship.

2. (10 pts) Landscape equilibrium. Try changing the grid size and/or resolution (i.e. cell size), and/or the uplift rate. By watching the video of the model evolving in time, mark for each of these scenarios when you think the model has reached an equilibrium state (i.e. elevation is not changing in time: erosion equals uplift). Keep records of this, and likewise create a relationship. You may also combine in groups to gather enough model outputs to make a better plot. After doing this, change the total model runtime to capture snapshots of equilibrium and disequilibrium landscapes for a given (constant) set of inputs. Note any qualitative differences you see (or do not see) between them.

3. (10 pts) Uplift and erosion. Now, perform a similar set of exercises in which you vary uplift rate and different erosion efficiencies. Note the maximum equilibrium elevation that you attain for different values of U, K_{hs}, and K_{ch}.

4. (10 pts) Free-form exploration. Try changing the grid type, grid size, stream power exponents, distribution of uplift rate (e.g., what happens if you have just part of the landscape experience uplift), etc. Based on what you observe, create a consistent geomorphic history of the system. Creativity is expected here!