Earth and Planetary Surface Processes
Winter 2017 - Lab 3. Sand dune formation.
Hinds 440, 10:30a-11:20a

Grades are not assigned for lab, but attendance is required.
If you are unable to make a lab, email kite@uchicago.edu to set up an alternate time.

This lab is based on the model in Werner's (1995) Geology paper, which was discussed in lecture. Download the pdf from the class website (listed under "Lab 3") and review the cellular-automaton rules that allow dunes to form in that model (read the ALGORITHM section).

Figure 1 of Werner's paper shows a 1-dimensional process. How do dunes with coherent 2D structure (as shown in the figures of Werner's paper) emerge in Werner's model?

We will now run a model that implements Werner's model. If you are interested in looking at the source code for such a model, google CSDMS, click on the first hit, go to models-→ terrestrial models → Pelletier's dune model, and download the C source. (Pelletier's text also has a code listing for the
Go to
http://web.ncf.ca/aa456/sand/dunefieldMorphology/sw/ , click 'Executable,' and download and launch. (Or, if you are on a Kite-group computer, go to the D: drive and launch setup.exe).

Set the dimensions to 256 x 1 (one-dimensional dunefield). Set L (hop) to 5 and sand height to 3. Leave everything else the same. (Note that changing pSand and pNoSand seems to have no effect. Note that the "von Neumann" vs "Moore" settings, which we will be leaving constant at "Moore, determinstic" but you might wish to play with, correspond to cells at Manhattan distance of 1 for von Neumann, and a Chebyshev distance of 1 for Moore – this is used for the avalanching step of the algorithm). Hit "tick" a few times. Note the initial conditions, and the shaded bands (corresponding to "shadowed" regions, less than 15 degrees "below" a dune crest - within which erosion is not permitted – a refinement on Werner's original model).

After you have hit 'tick' a few times, the interdunes (areas of zero height) get wider. Why is this?

Now hit "run" until the system has reached statistical steady state.

Why do smaller dunes move faster? Why

Now hit "stop", set L to 25, re-initialize, and run. You should see a radically different behavior.

What do you observe? What sets the spacing of these features?

(Research-project-hard question: Can you prove whether or not this is a statistically steady state, i.e., given enough time, will these features eventually converge on the same equilibrium as with L=3?)

Restore to L=3. Set sand height = 70. Run.

What controls the steady-state thickness of the interdunes? Note that the height scale is to the left of the main 1D display.
(Graduate students: can you write down an expression for steady-state interdune thickness in terms of the parameters of the model? What values of sand thickness, pSand, pNoSand, and model length would yield "one big dune", with no interdune at all?)

We will now switch to two dimensions. Stop the simulation, reduce sand thickness to 3, and set up a 256x256 grid. Run. Note that you can move the gray slider to adjust the position of the 1D cross section.

Why do barchans form? How are they destroyed?

Hit "stop" and observe the shadow region.

Compare the shadow map to the elevation map.

Now set sand thickness to 20 and re-run.

Describe (no need to explain) how the dunes interact – i.e. as dunes approach one another, how is sand fed from to another? In terms of the algorithm, why are taller dunes more "sticky"?

Now turn shadows off ("Model") toggle, rerun, and describe the change in results.

Explain the change in results.

Why are barchans unstable for high sand supply?

Bonus question:
Set sand height = 2, L = 3, but switch to "Von Neumann, deterministic" for the avalanching rule. Run.

Describe <u>and</u> explain the change in steady state pattern that results from switching between the Moore and the Von Neumann rules.