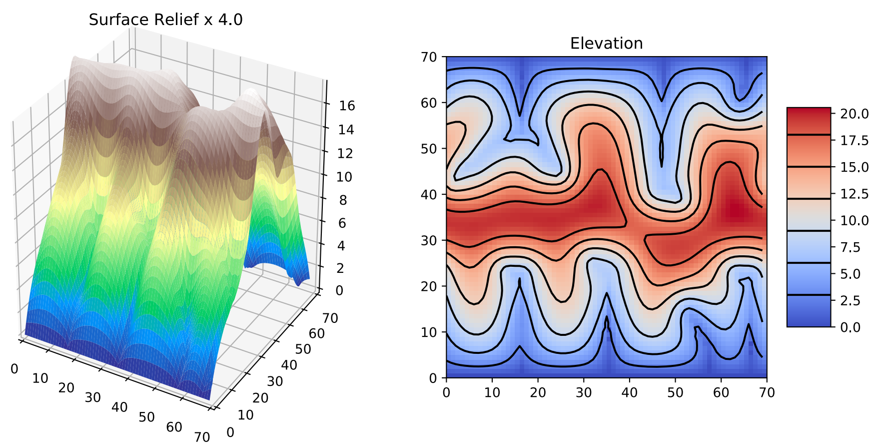
Computer Lab Assignment 9

Landscape Evolution Simulation

From bCourses, please download the article by Perron *et al.,* the Python file *landscape.py* and the Jupyter notebook *erosion_11.ipynb.* For this lab, you only need to edit the notebook file. The Python file should remain unchanged and will be imported into the notebook. We will guide you through a number of steps to obtain a working erosion code that follows the model by Perron *et al*. First you need to add a few crucial lines to the notebook and then you run it for various parameters and analyze the impact on the resulting landscape. Here is an example output:



(1) Work out the time step *dt*. Assume *dx=5* meters and D=5×10^{-3} meters^2/year. Remember for 2D diffusion problems, stable solutions require $\eta = D \times \Delta t / \Delta x^2 < \frac{1}{4}$. However, because of the additional fluvial erosion terms, we suggest using $\eta < \frac{1}{8}$.

(2) Compute the gradient $\left|\vec{\nabla} z\right|$ using the intermediate terms s_1, s_2, s_3, and s_4 as specified below equation 15 in the Perron paper.

(3) The equation for the elevation change includes two terms, $\Delta z = \Delta t \times [\Psi(\mathrm{z}) + \Phi(\mathrm{z})]$. First compute the fluvial erosion term $\Psi(\mathrm{z})$. It is the second term in equation 13 of Perron’s paper. It depends on the constants K, m, n, and θ_c as well as on the precomputed drainage area *A(i,j)* and your gradient. You need to enter the equation for $\Psi(\mathrm{z})$ on line 26 and repeat it on line 41 of your notebook. (Enable line numbers in the View menu.)

(4) Enter the mass diffusion term, $\Phi(\mathrm{z})$, on line 50 using the elevation *Z(i,j)* and diffusion constant *D.* Right below compute Znew[i,j]. Try running your code now! Hopefully it works.

(5) We want to perform 3 parameter modifications and analyze the effects. Please increase the stream stress threshold, θ_c, by factors of 10 until you see a noticeable change in the final landscape. Describe the change in shape and give an explanation!

(6) Go back to the original value of θ_c and increase the gradient exponent n in steps of 0.5. Please reduce the time step by a factor of 5 for this and the following part! Keep increasing n until you see a drastic change, describe the effect, and give an explanation!

(7) Go back to the original value of n and instead increase the area exponent m in steps of 0.05 until you see a change. Again describe the effect and give an explanation!