Progress report

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Introduction

The movements of sand have different patterns. How do these patterns, such as the waved pattern of sand moving along the shoreline, and sand dunes form? Are patterns of movements computable? Those are the enigma we are interested in. The objective of my research is to model and develop patterns of the movement of sand; namely to study sand dynamics. Sand dynamics is the study of the behavior of sand when there is a force (such as wind, or fluid) acting on it. We present a simple model of a box of sand (see figure 1.a and b[1]), and discuss its dynamics in terms of two cases: advection and avalanching respectively. These cases will be modeled with math-based computer code. (Matlab code)

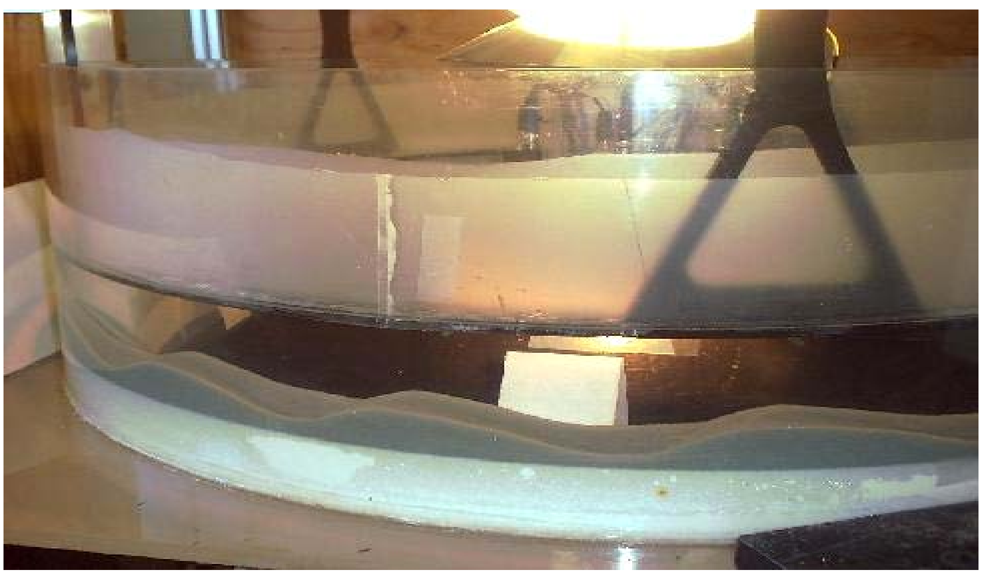

Figure 1.a

Figure 1. b

Approach

- **Advection**

Description of movements: Figure 2 shows a static pattern of sand. The value of the x-axis indicates the index of the position of sand particles before movements. Each column represents a column of sand particles, and the value of the y axis shows the number of particles in each column. When forces apply to each column, particles will move to different positions.

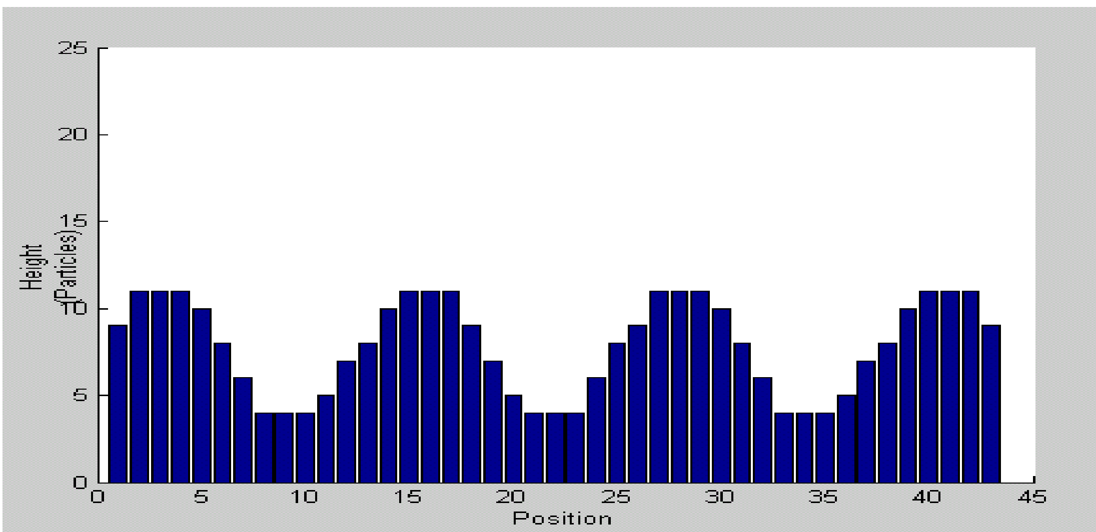

Figure 2

Force $\mathbf{F = \alpha \cdot h^p}$

α , a constant value; h, the height of sand particles in each column; p, power.

Cases	A Force applies once	Continued Forces
A Constant force (p = 0)	File name: checkcout.m	File name: changeIC.m
A Linear force (p=1)	checkcout.m	changeIC.m
A non-linear force	checkcout.m	changeIC.m

Note: The total number of particles in all movements does not change.

- **Avalanching**

No additional forces apply to sand particles in this case. Any movement is due to the critical angle θ, (the maximum angle of the steep of a sand dune). Figure 3 shows the sand particles before movements. The angle θ_1 is between the red lines and the black line (Figure 4). If $\theta_1 > \theta$, then the height of sand particles will come down.

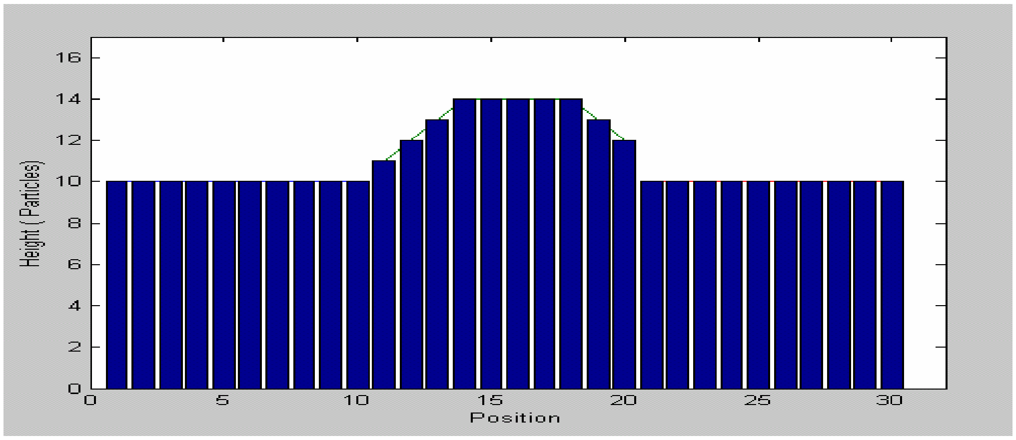

Figure 3.

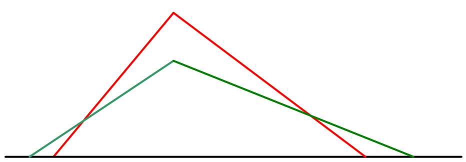

Figure 4.

The red area represents the sand particles before movements; the green area indicates the pattern after movements. (Matlab file: release.m)

Question

Is the system sensitive to initial conditions (does the system remember the initial conditions)?

Results

To answer the question, we study two types of perturbations via changing amplitude and the period. Then we observe sand patterns after applying a continuous force. (Matlab files: sandbumpsap.m /changing amplitude/ and sandbumpsT.m /changing period/)

So far, the conclusion is: If the force is very small (a force moves the number of particles a smaller distance than the height of each column), then the system remembers the initial condition; otherwise, it doesn't.

What are we going to do next?

Wavelength perturbation

Movement's description: Pick particles from the center of the sand bumps. Apply a force to make these particles move forward or backward. Then observe the pattern.

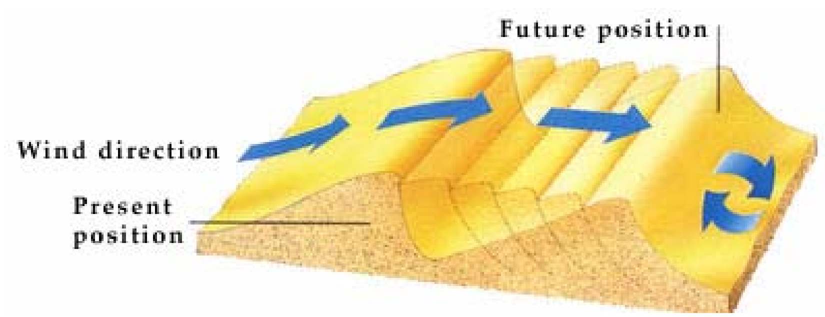

Figure 5. [2]

Reference:

[1] The figure a. and b. are from Prof. **Raymond Goldstein (**University of Arizona.2002).

[2] http://www.gridclub.com/fact_gadget/1001/earth/landscape/116.html