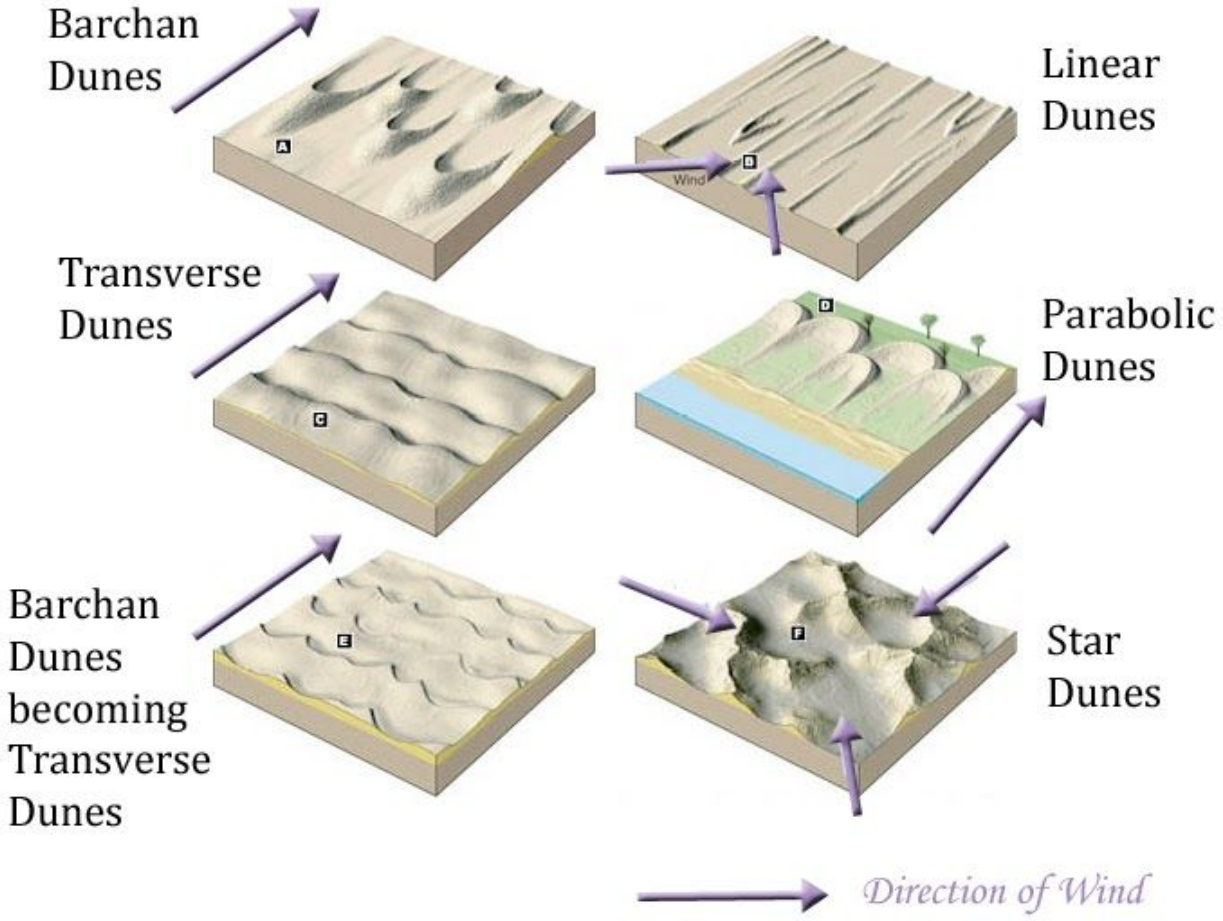
Background Material

[1] **Aeolian processes** pertain to wind activity in the study of geology and weather and specifically to the wind's ability to shape the surface of the Earth (or other planets). Winds may erode, transport, and deposit materials and are effective agents in regions with sparse vegetation, a lack of soil moisture and a large supply of unconsolidated sediments. Although water is a much more powerful eroding force than wind, aeolian processes are important in arid environments such as deserts.

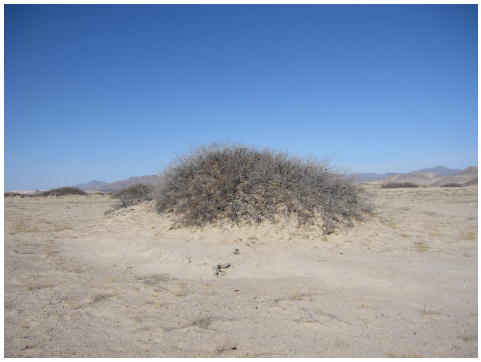
[2] **Dunes** are large masses of wind-blown sand, and are most common in deserted environments, such as the Sahara, and also near beaches. An area with dunes is called a **dune system**.

[3] **Types of sand dunes**

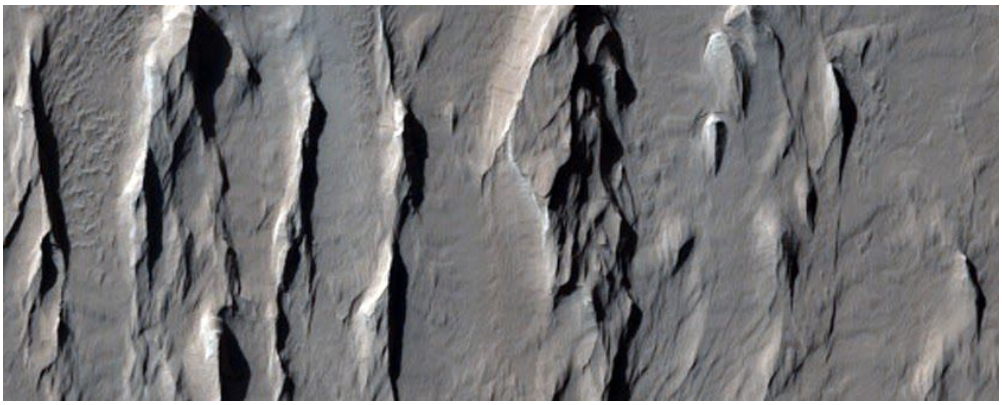


More sand dunes:

1. Nabhka: In simplest terms, a nabkha is a sand dune that forms around vegetation. [5]



2. A **yardang** is a streamlined protuberance carved from bedrock or any consolidated or semiconsolidated material by the dual action of wind abrasion by dust and sand, and deflation which is the removal of loose material by wind turbulence. [6]



[4]

Sand Movements

Saltation

Sand grains bound, land, and rebound, imparting renewed impetus to other sand grains. Such motion is confined to short distances and heights of about 2 m.

Reptation

On hitting the surface, saltating grains release a small splash-like shower of particles that make small hops from the point of impact. This process is known as reptation.

Avalanching, Creep and related near-surface activity

Coarse sand and small pebbles inch forwards by rolling and sliding with the momentum gained from the impact of jumping sand particles and down the tiny crater-slopes produced by an impacting particle.

Suspension
Particles of silt and clay lifted into the atmosphere become suspended and may be carried great distances. Sand particles may be lifted into the lower layers of the atmosphere, as in sandstorms, but will fall out near the point of takeoff. Dust particles may be carried around the globe.
Note: This phenomenon does not seem to be modelled in the existing Desertscape Simulation

AEOLIAN LANDSCAPES

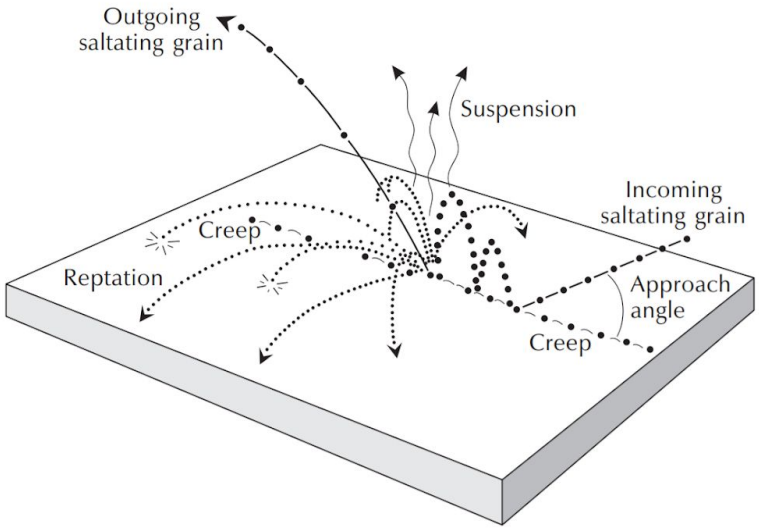


Figure 10.3 Modes of grain transport by wind.
Source: Adapted from Livingstone and Warren (1996, 13)

[4]

Sand Generation

Bedrock Abrasion
Exposed bedrock is susceptible to ‘sand blasting’ wherein deflated sand erodes the exposed surface of the rock creating more sand particles prone to deflation (sand movement).

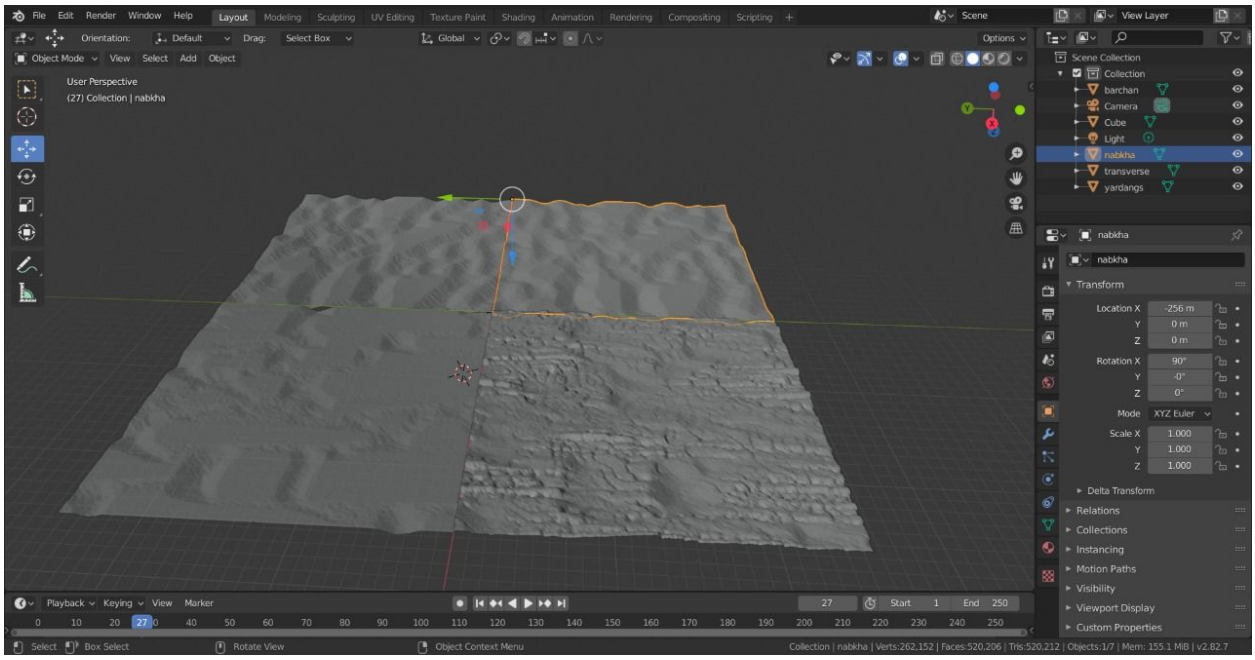
Current Workflow

We run the existing simulation to generate the obj files for 4 basic dune formations (these depend on the parameters such as high altitude wind field, vegetation etc.).

```
// Nabkha are created under the influence of vegetation
std::cout << "Nabkha" << std::endl;
DuneSediment dune = DuneSediment(Box2D(Vector2(0), Vector2(256)), 1.0, 3.0, Vector2(3, 0));
dune.SetVegetationMode(true);
```

The code is in C++. We are currently using Visual Studio 2019.

The obj files generated are viewed in blender 2.82



In the figure: You see 4 kind of sand dunes:

1. Barchan
2. Transverse
3. Nabkha
4. Yardang

References

[1] Aeolian processes: https://en.wikipedia.org/wiki/Aeolian_processes
[2] Dune: https://en.wikipedia.org/wiki/Dune
[3] https://socratic.org/questions/what-are-the-different-types-of-sand-dunes
[4] FUNDAMENTALS OF GEOMORPHOLOGY by Richard John Huggett
[5] Nabhka: https://en.wikipedia.org/wiki/Nabkha
[6] Yardang: https://en.wikipedia.org/wiki/Yardang

Original Proposal can be found here.

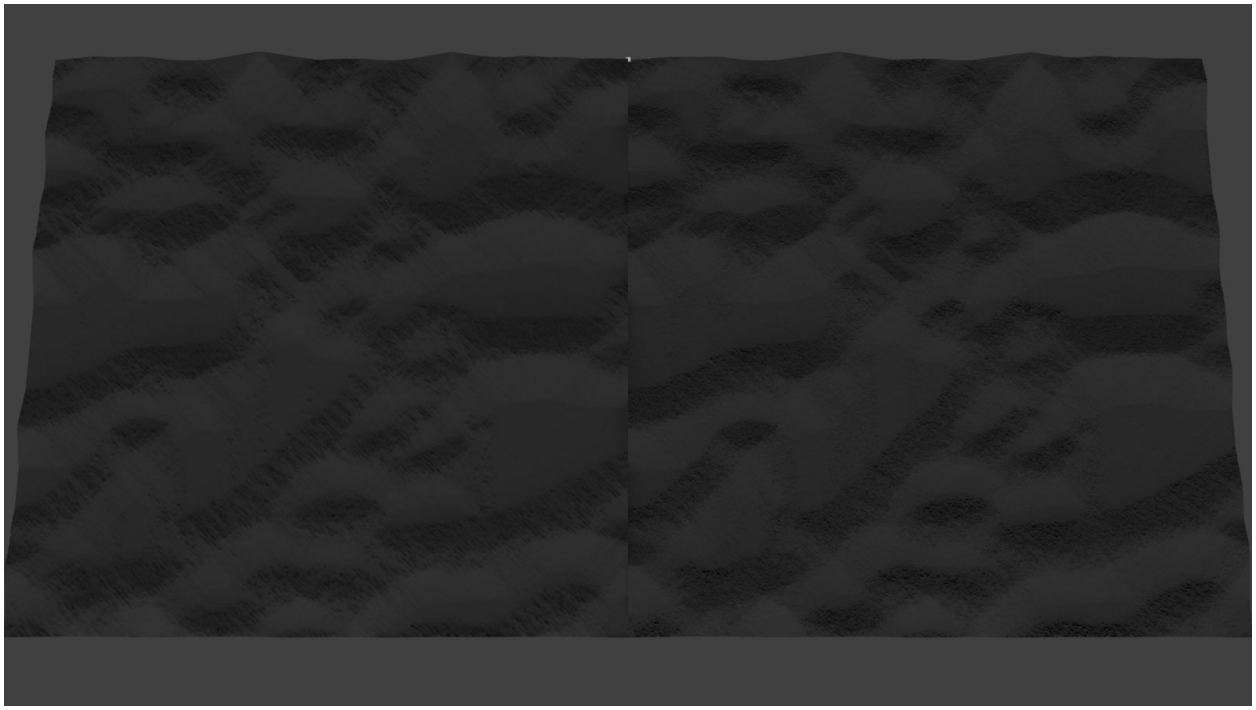
Checkpoint 2 Progress

(June 10)

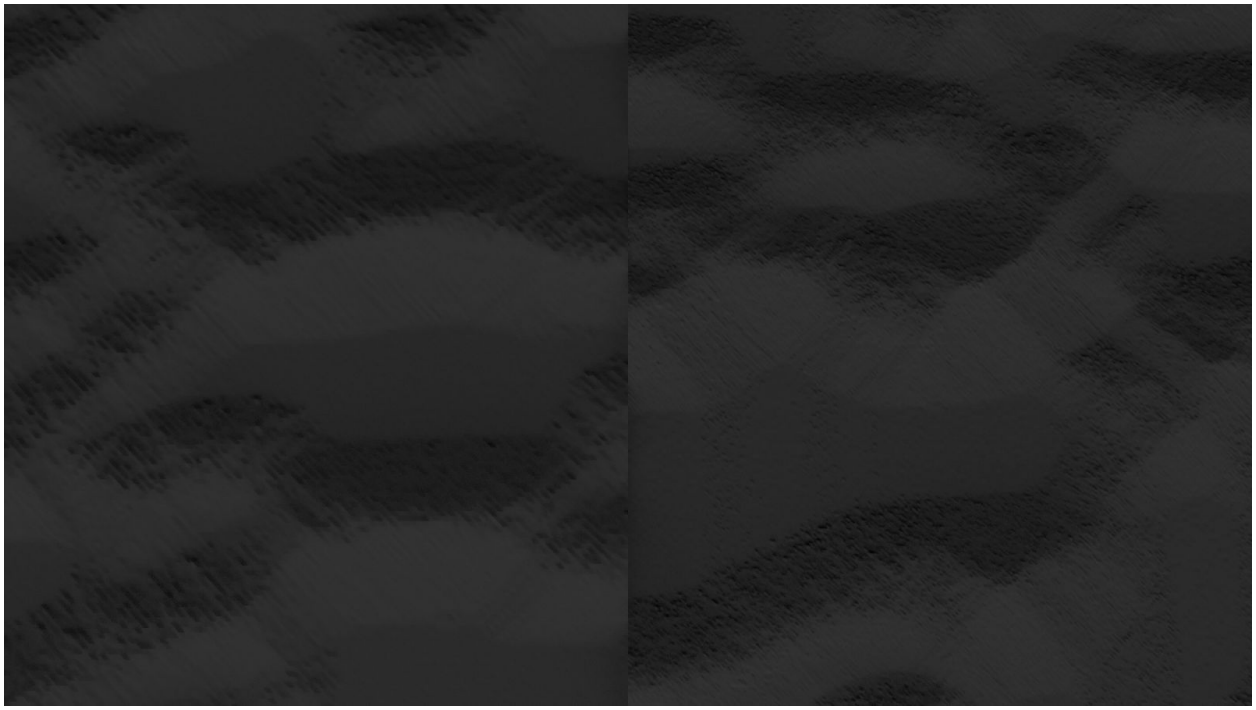
Premise

Say the simulation runs for 300 time steps on a grid resolution of 256X256 and we want to obtain sharp features corresponding to the simulation result at time step 300.

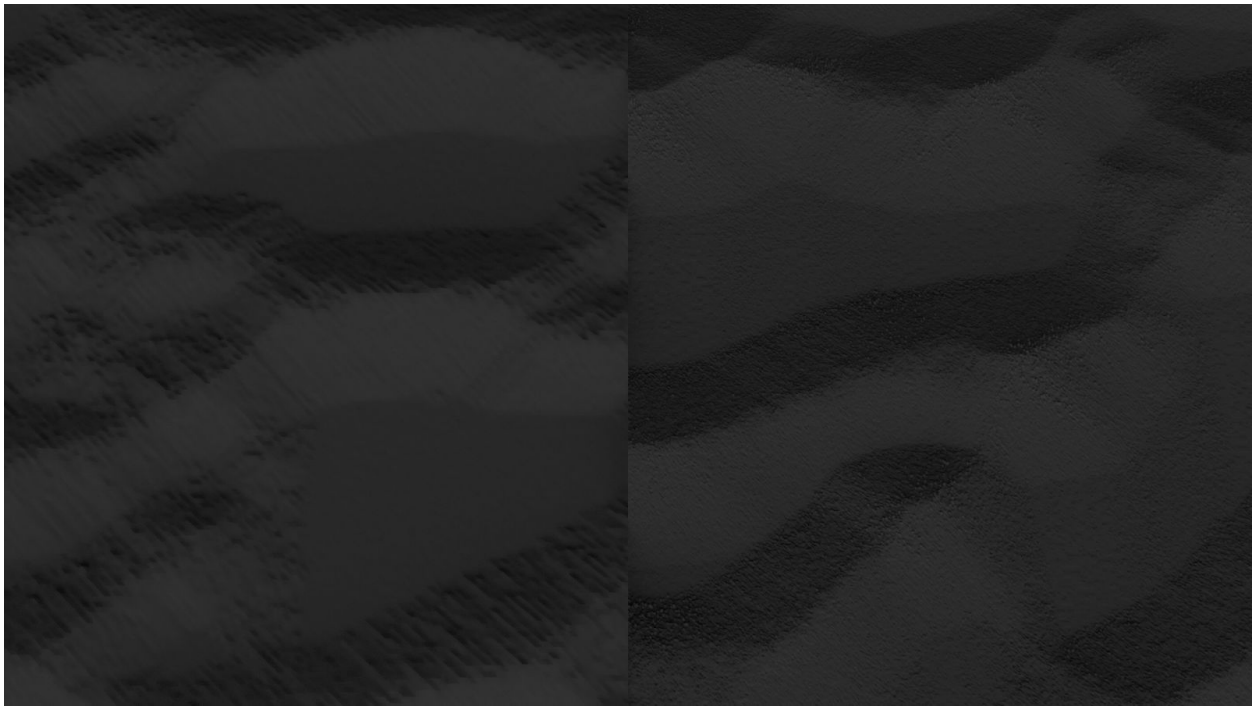
If we could somehow increase the resolution towards the end of the simulation to 512X512 or 1024X1024,the resulting coarse features should not differ too much from the original simulation as seen in the following figure:



However, the fine features would instead undergo a sharpening effect:



This sharpening should be more pronounced if the increase in resolution is more:



Implementation with known simulation time:

We implement this functionality by overloading the DuneSediments constructor to take an existing duneSediments object as argument and creating a new one with it's resolution increased by the given factor. For instance with a factor of 2, each grid cell will essentially get subdivided into 4 grid cells with copies of the original. The subsequent time steps would result in subtle differences which would present themselves as sharp features.

Implementation with unknown simulation time:

However there is a major drawback of the aforementioned approach: We should not be allowed to assume the time step at which the simulation ends. The design of the simulation facilitates real time interaction from the user and the user may stop the simulation at an arbitrary timestep and may wish to obtain the sharpened mesh corresponding to the one currently visible.

We try to overcome this problem by maintaining a queue of the previous n snapshots of the entire grid. As the newest timestep gets processed, we add the corresponding snapshot to the que and remove the oldest one on a FIFO basis.

As soon as the termination point of the low res simulation is arrived, the oldest low res snapshot still in the queue is subdivided and a corresponding high resolution simulation is run thereafter for exactly the number of remaining timesteps.

Therefore, at the memory cost of maintaining low resolution copies of the simulation parameters, we can sharpen the low res mesh at any point in the simulation.

Logs

A logging mechanism has been put in place to keep track of the time taken to run various operations.

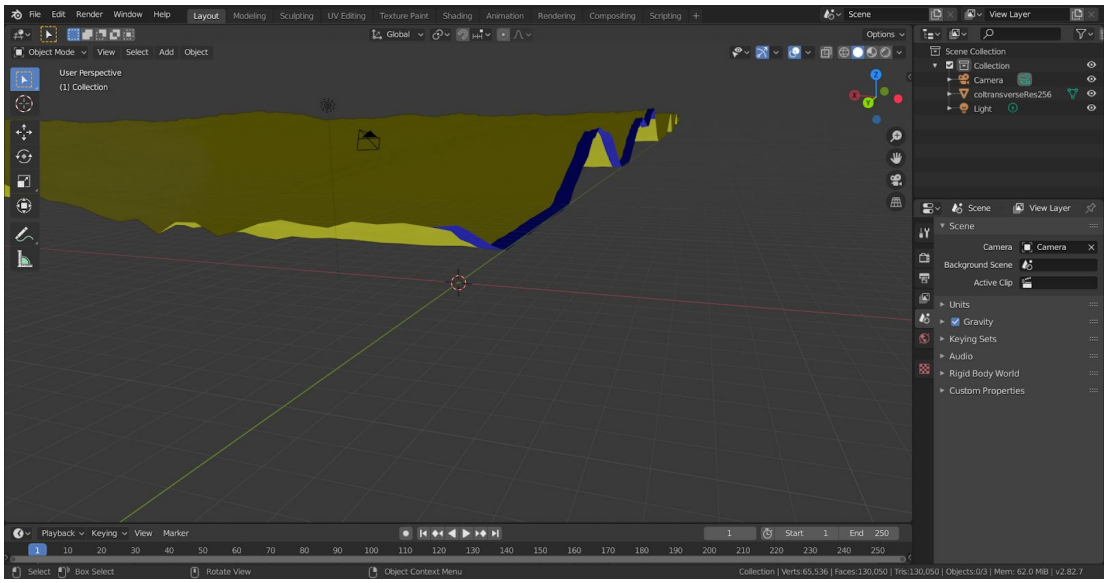
log_2020-06-09.txt - Notepad

File Edit Format View Help

```
2020-06-09 22:31:28     --- Fresh Run begins ----
2020-06-09 22:33:59     Low res dune done.
2020-06-09 22:33:59     Time required = 151.000000 seconds
2020-06-09 22:33:59     --- Start of next ---
2020-06-09 22:37:12     time hybrid dune with backsnaps done.
2020-06-09 22:37:12     Time required = 193.000000 seconds
2020-06-09 22:37:12     Total Time required = 344.000000 seconds
2020-06-09 22:37:12     --- Run Ends ----
2020-06-09 23:18:09     --- Fresh Run begins ----
2020-06-09 23:20:38     Low res dune done.
2020-06-09 23:20:38     Time required = 149.000000 seconds
2020-06-09 23:20:38     --- Start of next ---
2020-06-09 23:27:24     time hybrid (1024) dune with backsnaps done.
2020-06-09 23:27:24     Time required = 406.000000 seconds
2020-06-09 23:27:24     Total Time required = 555.000000 seconds
2020-06-09 23:27:24     --- Run Ends ----
```

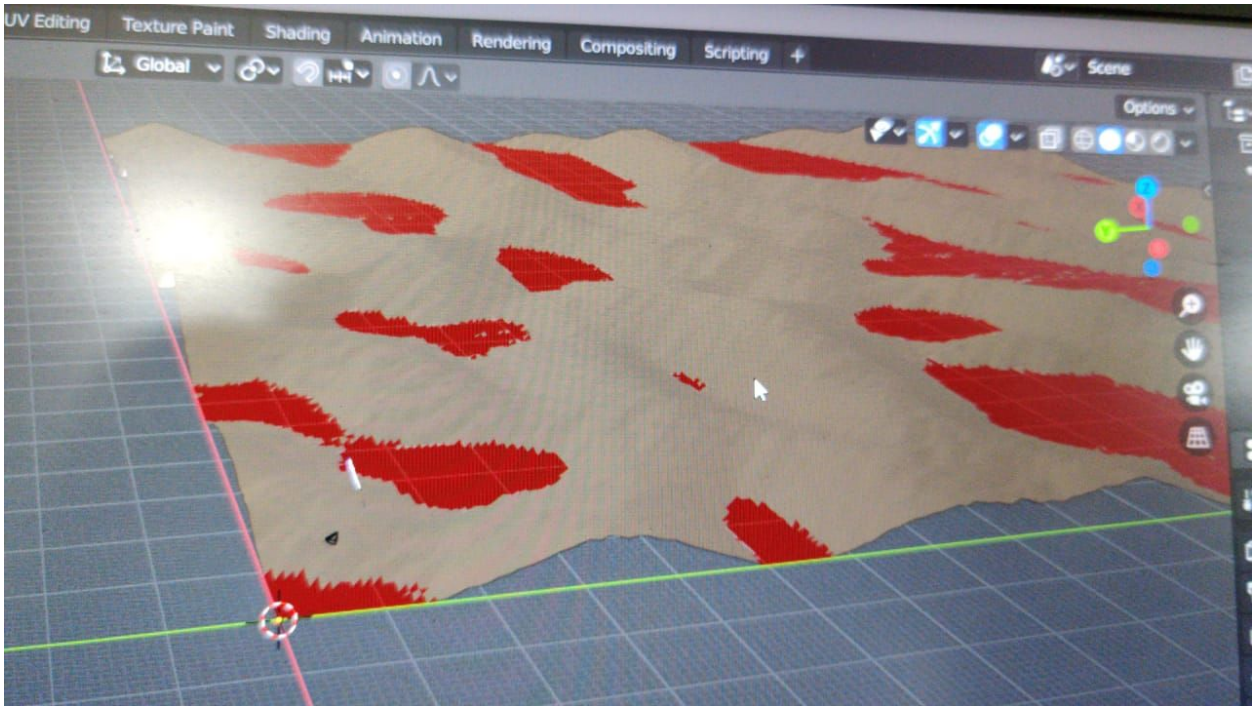
Highlighting Parts of Mesh

Next, we have implemented a mechanism for querying the grid and obtaining mesh faces associated with different materials as a result of the query.



The image above is a result of querying for the first few cells of the grid.

The next image shows results for querying the grid for certain sediment values.



This is to aid us in our subsequent task of sharpening only specific grid cells based on certain queries.