Real-time GPU-based Snow Simulations:
Adding Snow Drift, Terrain Voxelization & Weather Data

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A real-time realistic GPU-based snow simulation has been developed and enhanced by several NTNU HPC-Lab graduate students since 2006 [1][2]. The simulation simulates a wind field modeled as an incompressible fluid using computational fluid dynamics (CFD), and snowflakes modeled as particles. Stress in snow cover is used for avalanche release prediction [3].

We are continuing the work on the HPC-Lab Snow Simulator focusing on the following:

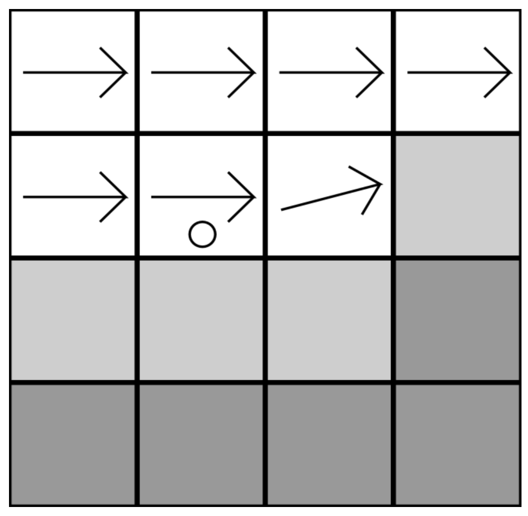
- Integrate simulator with real-world weather data
- Scaling the wind simulation resolution
- Adding dynamic snow drift inclusion

Atmospheric snow reintroduction

Some important dynamics of snow have that not previously been captured by the simulator are being implemented. These include

- Snow drift
- Snow dune formation

Forces acting on the ground snow layer from wind and local pressure give a probability of releasing a snow particle from the ground. The resulting free particle then drift in the air until it reaches a new place to stick.



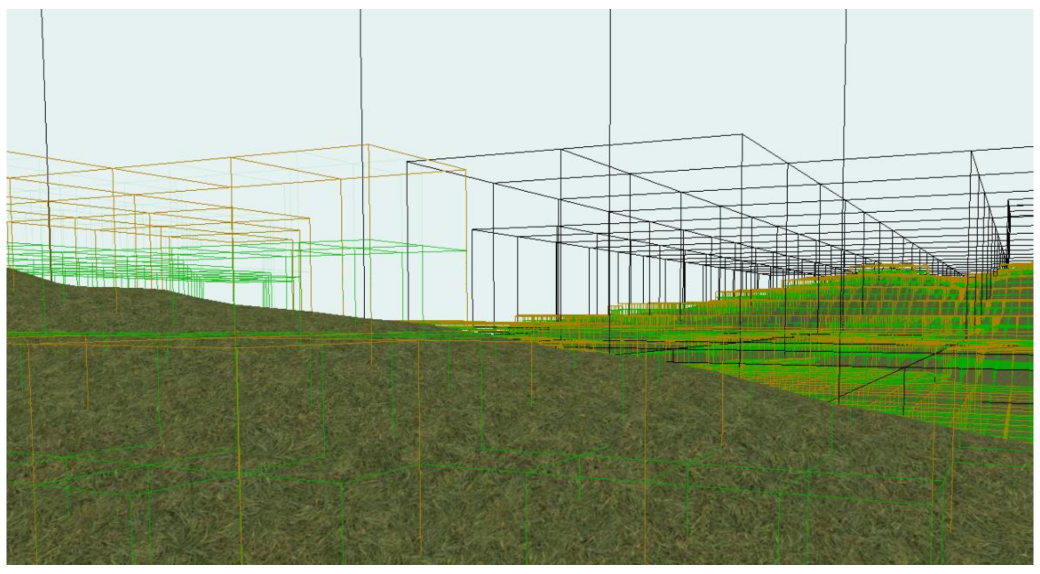
Wind loosens particles and reintroduces them into the simulation.

Terrain voxelization

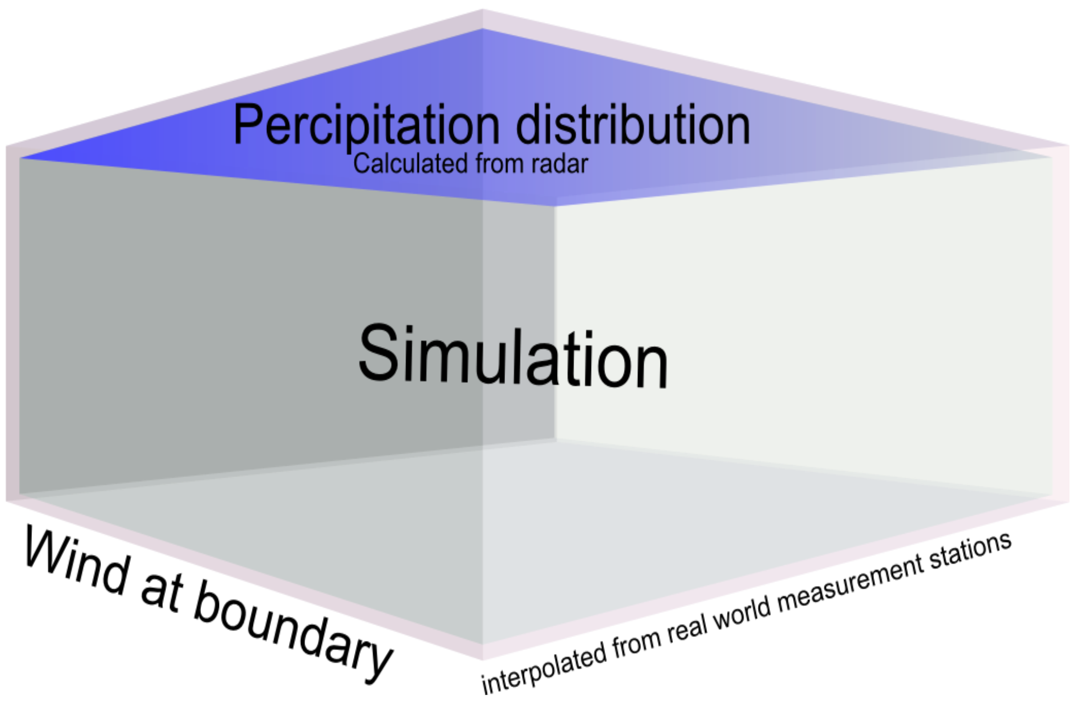
A full voxelization of the terrain is in progress. The resulting structure will store snow ground cover, dynamically capturing changes. Advantages include

- VDB tree: Shallow, sparse, and high resolution
- Support any terrain, and snow bridges
- Scaling of simulation

Though intended to store only terrain and snow data, the structure can be used as a basis for adaptively storing wind and pressure data.



Example of a sparse voxel structure



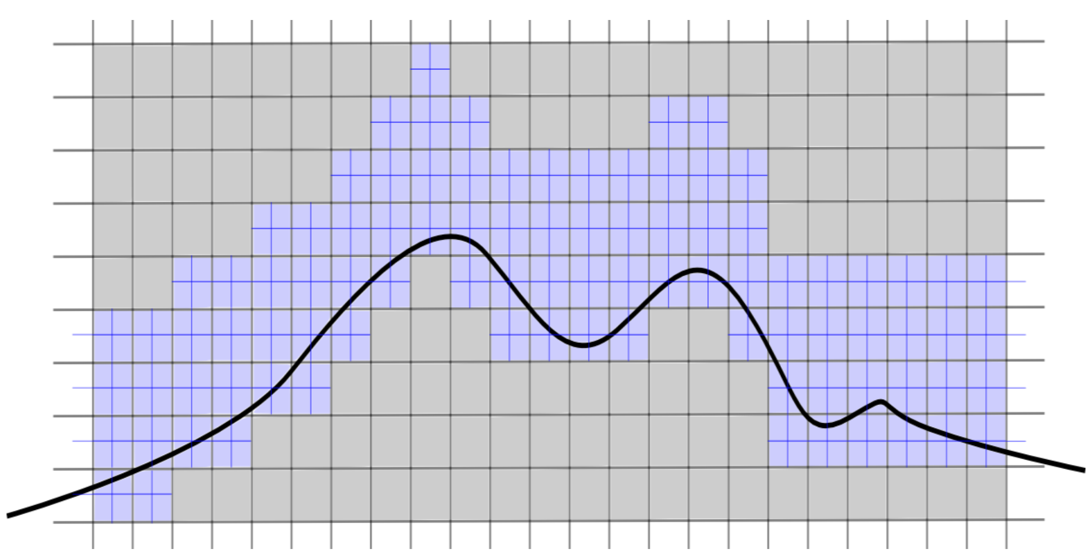
Real-world weather data stimulates simulation from boundaries

Real-world weather information

Previous extensions of the snow simulator included import of real world terrain. This is being extended to support importing weather information, such as:

- Varying wind velocity at the simulation boundaries
- Cloud coverage and density
- Precipitation distribution

Volumetric rendering of the cloud level for visualization is to be implemented.



Increased discretized resolution along ground. Volume is of constant size, but needs additional offset information to find neighbors.

Scaling simulation resolution

The simulator uses a uniform grid for wind simulation. We are investigating using higher resolution in interesting areas, such as near the ground or in designated areas. This will allow simulation of large areas while maintaining high quality of the simulation near target features without exploding memory cost.

REFERENCES

[1] Saltvik et al:"Parallel methods for real-time visualization of snow," PARA 2006, LNCS 4699, pp 218-227, 2007
[2] Eidissen: "Utilizing gpus for real-time visualization of snow," masters thesis, NTNU, 2009
[3] Boge: "Avalanche simulations using fracture mechanics on the gpu," masters thesis, NTNU, 2014