Simulation of Orographic Clouds

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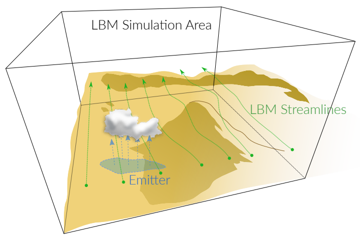
Abstract

Realistic cloud simulation is a hot topic in computer graphics research. Clouds play an important role in a plethora of different media, including movie and video game industries where cloudscapes span entire worlds. One area of their research is still quite untouched, that is the simulation of orographic clouds, i.e. clouds that are created in mountainous environments.

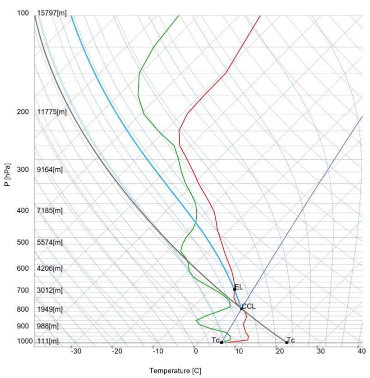
We present a physically-based method of simulating orographic clouds using **SkewT/LogP** diagrams as proposed by Duarte [1]. We extend this simulation with well-known **Lattice Boltzmann method** (LBM) to simulate wind. Lastly, we propose a simple enhancement of volumetric rendering method by Green [2] that uses phase functions to simulate more realistic anisotropic light scattering. All methods are parallelized on GPU using CUDA technology.

Contribution

The main contribution of this thesis lies in the created framework/application in which users can create new cloudscapes and run their simulation in real-time. The framework is easily extendable and can serve a purpose for further research on the topic.



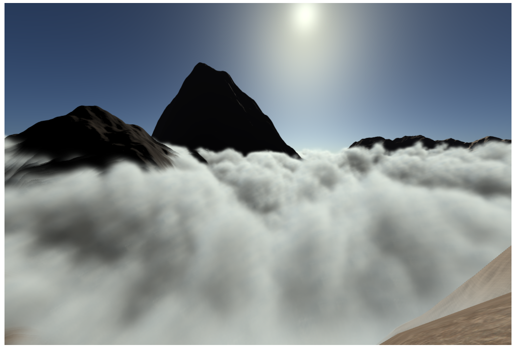
Framework



The framework uses a particle system to represent the clouds. Due to our selection of methods, no conversion to different data representations is necessary. The simulation then consists of particle advection on the vertical axis based on values computed from the SkewT/LogP diagram (shown on the left). LBM works in a grid called lattice, where velocity must be computed for each of its nodes. Then, based on the particle position, simple trilinear interpolation of the velocities of surrounding lattice nodes determines movement of the particle. Box of particles displaced by LBM simulation can be seen in the bottom image. Lastly, particles are ordered on the GPU using a helper index buffer. Particles are then rendered in batches to auxiliary framebuffer and the resulting image is composed into the final scene render.

Results

Since one of our main focuses was making all systems interactive and fully configurable, fundamentally different results can be obtained with a little bit of experimentation as shown below.



Conclusion and Future Work

We have demonstrated how the SkewT/LogP cloud simulation method can be coupled with the Lattice Boltzmann method to produce orographic clouds. An extensive framework was implemented that takes advantage of the GPU and exploits the parallelizability of the above-mentioned methods. Users can therefore freely experiment with cloud creation at real-time. In the future, the framework can be extended with more sophisticated time dependent emitters. Furthermore, a surface heating and cooling algorithm would be another major improvement.

References

[1] Duarte, R. P. M. A. *Realistic Simulation and Animation of Clouds using SkewT/LogP Diagrams*. PhD thesis, Universidade da Beira Interior, 2016.

[2] Green, S. Volumetric particle shadows. *NVIDIA Developer Zone* (2008).