Computational modeling of snow and glacier light transport

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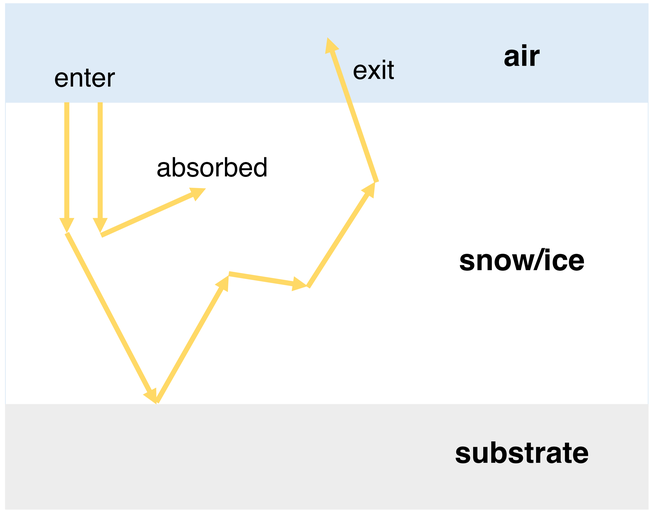
Introduction

Computational models are helpful for improving remote sensing of Earth's snow-covered regions. Models like the Snow Microwave Radiative Transfer (SMRT) model[2] use electromagnetic theories to predict temperature brightness from prescribed snowpack properties. The purpose of this project is to apply computer graphics methods to model snow light transport.

A portion of the Greenland ice sheet with high albedo on the left and low albedo on the right[1].

Methods



Our algorithm performs a Monte Carlo simulation of *N* photons entering the snowpack. The model outputs the total number of photons *M* which exit the snowpack and the aggregate albedo of the snowpack, *M/N*.

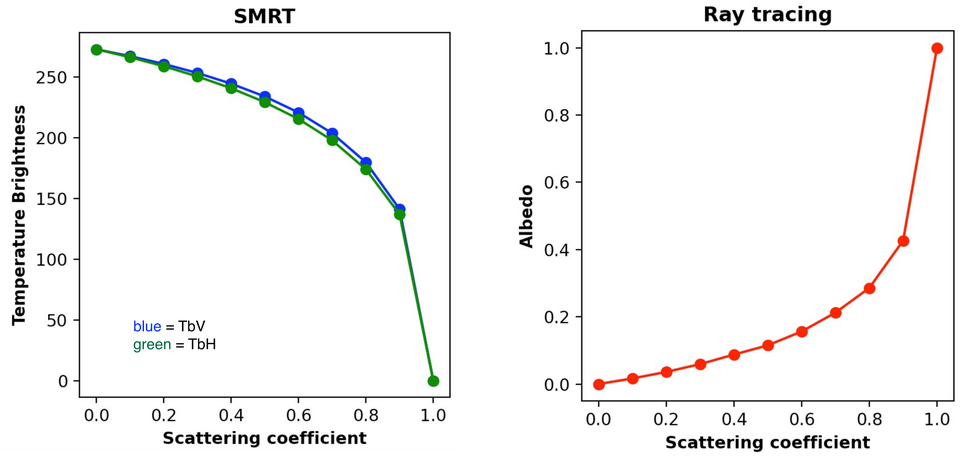
- We used the SMRT software package (written in Python) to run simulations of a simple single-layer snowpack with varying parameter values.
- We developed a ray tracing program in C++ with similar inputs and outputs as SMRT by building off the code from the *Ray Tracing in One Weekend* book series[2].
- We plotted our results using the Python Matplotlib library.

Results

- Our tests in SMRT validated our expectations of how various parameters (temperature, depth, scattering/absorption coefficients) should affect the output temperature brightness.
- We found that our ray tracing model produces very similar results as SMRT for a single layer of snow.

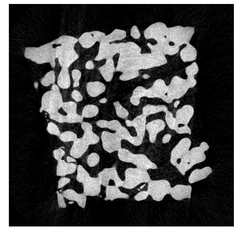
Comparing the SMRT and ray tracing models

varying scattering and absorption coefficients (k_s , k_a), with $k_s + k_a = 1$



Future work

This project is still in progress; future goals include resolving the discrepancy between the SMRT and ray tracing output types, simulating more complex snowpack, and using ray tracing to intersect snow microstructure obtained from micro-CT scans of real snow.



A micro-CT scan of snow.

References

1. Vena W. Chu. "Greenland ice sheet hydrology: A review." *Progress in Physical Geography* 38.1 (Nov. 2014), 19-54. doi: 10.1177/0309133313507075
2. Ghislain Picard, Melody Sandells, and Henning Löwe. "SMRT: an active–passive microwave radiative transfer model for snow with multiple microstructure and scattering formulations (v1.0)." *Geoscientific Model Development* 11.7 (Jul. 2018), 2763-2788. doi: 10.5194/gmd-11-2763-2018
3. Peter Shirley. *Ray tracing in one weekend.* https://raytracing.github.io/

Acknowledgements

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