Building Open-Source Software to Better Understand the Impact of Soot on Global Warming

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Introduction

As carbon levels continue to increase globally, it is rapidly becoming more important to improve our understanding of climate change. Scientists regularly monitor the atmosphere and use current trends to predict how the climate will evolve. The next step in climate forecasting involves developing a predictive model that uses current data and numerous parameters to simulate different outcomes.

Soot exists as a group of elemental carbon nanospheres welded together by the incomplete combustion of fossil fuels. Soot significantly contributes to climate change because elemental carbon efficiently absorbs the sunlight's energy. A major uncertainty in soot optical properties is the limited knowledge on how the shape of soot will change as it interacts with light.

Objectives

This project aims to improve the accuracy of an available open-source software application that builds soot aggregates. At the time of beginning this project the program, FracMAP, created soot aggregates without the elemental carbon nanospheres overlapping. To better understand how light interacts with soot aggregates, the main goal of this project is to implement overlap into FracMAP's fractal-building algorithm. To verify that the results are correct, we will use qualitative analysis to visually check that the aggregate looks how we would expect. We can then use quantitative analysis to check that the positions of the nanospheres in the aggregate reflect the overlap parameter that was used for that trial.

When overlap has been inserted into FracMAP's algorithm, the data will need to be tested to determine its legitimacy and ultimately analyzed to come to conclusions on the impact of soot on global warming. To accomplish this, the command line interface will need to be expanded to accept more parameters, run customized batch runs and log useful information to the user interface as well as logging files. In this program, it was determined that implementing a dedicated logging library would be the best option due to the high quality of available C++ logging libraries and the efficiency over building the logging capabilities from scratch.

Screenshots

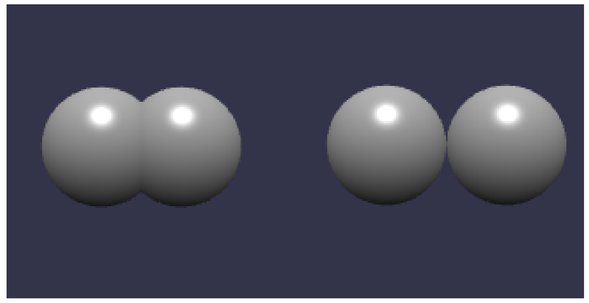

Figure 1: On the left side are two nanospheres with an overlap. On the right side are two nanospheres that are not overlapping. Elemental Carbon nanospheres in soot will over overlap due to sintering.

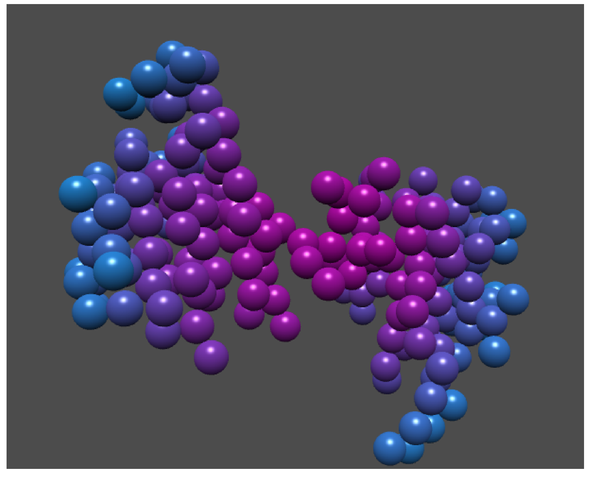

Figure 2: During development a temporary 3D visualizer was used to quickly verify the results until the final interface was completed.

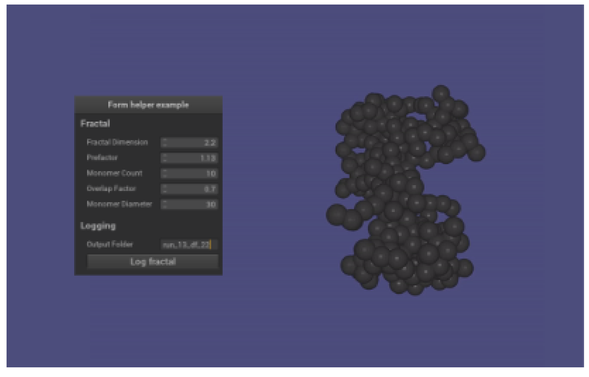

Figure 3: The finalized user interface with parameters that update the model live.

Results

Using the algorithm we developed to apply overlap using the parameter, k, we were able to successfully produce a fractal that would visually overlap as expected. Different degrees of overlap were tested. Parameter k values of 0.5, 0.6, 0.75, 0.9, and 1.0 were tested. A value of 0.5 represents an overlap of 50%, and a value of 1.0 represents no overlap at all. Using software to visualize the shape of the fractal, the qualitative visual results appear as expected.

Discussion

The results appear to be expected. The qualitative analysis indicates that the result is good. However, it is difficult to know with absolute certainty whether the algorithm is producing good results. The algorithm used to build the fractal is a monte-carlo algorithm. Testing whether the result is good would mean testing if the results are completely random by running a large number of trials and checking for anomalies. This type of exhaustive testing is something that we did not have time for, but we would like to continue to work on following SURF.

References

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