Master’s thesis project in Space, Earth and Environment

Computer graphics tools for radiative transfer simulations

Radiative transfer calculations are a key element in e.g. astronomy, remote sensing, weather forecast models and climate simulations. That is, the source and path of the radiation observed by a telescope or satellite must be modeled, or the fact that solar and thermal radiation heat and cool the atmosphere and surface of a planet must be considered.

Essential parts of radiative transfer codes are how the medium is described and the efficiency of ray tracing. Different strategies are used. In codes used for our atmosphere the atmosphere is normally described by a rectangular grid. This is highly inefficient to e.g. describe the distribution of particles inside a cloud. The description of the cloud can require a grid spacing of 10 m, while the a horizontal grid of several kilometers suffice in clear-sky parts. A more flexible solution is to apply an irregular grid (e.g. of Voronoi type). Also surface topography (such as mountains) is also most efficiently described by an irregular grid. A drawback of using irregular grids is that the ray tracing algorithms can become more computationally demanding if not implemented properly.

The Atmospheric Radiative Transfer System (ARTS) is a broadly used simulation environment (C++, open source) developed by Chalmers together with University of Hamburg. Presently, ARTS handles only rectangular grids and the objective of this project is to introduce irregular grids. This will not be done from scratch, the basic features required should be found in existing libraries, either developed for computer graphics (e.g. CGAL) or related “tessalation” libraries (e.g. VORO++ or Qhull). A rough plan for the project is:

1. Understand the task and make a list of requirements. Carefully review the capabilities of existing relevant C++ libraries with respect to the requirements.
2. Select a library and add it to the ARTS environment. If needed, implement basic interface functions.
3. Create ARTS methods to perform ray tracing, using functions in the library.
4. Create ARTS methods to interpolate the irregularly gridded data, using functions in the library.
5. Add functionality to ARTS to map rectangularly gridded data to an irregular grid, with automatic generation of the irregular grid required to meet some accuracy criterion.
6. Link these features to the existing methods for performing radiative transfer, to demonstrate the new features for a scene including complex terrain.

Prerequisites: Experience of computer graphics and/or programming in C++; an interest in physics is beneficial.

Contact: Patrick Eriksson, patrick.eriksson@chalmers.se