GPU-based Monte Carlo simulation of radiative transfer in a cloudy atmosphere

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The large amount of information provided by Earth-observing satellites and ground-based measurement stations calls for effective tools for data processing as well as for accurate and fast methods for simulating light propagation in the terrestrial atmosphere for real-time data interpretation. In atmospheric optics, the Monte Carlo method is one of the most powerful computing approaches, both due to its accuracy and flexibility in simulating light transport in complex environments (twilight, optically thick cumulus clouds, inhomogeneous and broken cloudiness, cirrus, etc.). However, the widespread use of Monte Carlo simulations is limited by their computational demand.

The development of software for supercomputers with parallel architecture applications opens new promising possibilities for mathematical modeling of radiative transfer. The vast majority of the existing radiative transfer codes are already adapted for clustered multi-processor systems. However, these are stationary, have to be constantly upgraded to support and improve the calculating efficiency: building capacities of these systems require considerable financial injections and complicated hardware settings.

Recent years have seen an increasing trend towards the transfer of scientific calculations to alternative platforms, specifically non-graphics computing on graphics processors. GPU-accelerated computing offloads compute-intensive portions of the application to the GPU (Graphics Processing Unit), while the remainder of the code still runs on the CPU (Central Processing Unit). The main advantage of GPU cards is a large number of processing cores. The current generation of GPU has enough flexible architecture; GPU cards are economical and easily replaced.

In this work, the GPU-based code for simulation of radiative transfer was developed. The solar irradiances in clear and cloudy (cumulus, stratocumulus, cirrus) atmospheres can be calculated for different altitudes of the Sun. We used CUDA-enabled (Compute Unified Device Architecture) NVIDIA processors (GeForce GTX 1080). The accelerated code was compared to the original single-threaded code. Our results show that GPU provides a substantial speedup over conventional CPUs by supporting the parallel computation of large numbers of independent radiative calculations and allows for a much higher computational performance at lower prices.

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