Strategies for Forward Modelling of Infrared Radiative Transfer on GPUs

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Abstract. Satellite-based remote sensing in the mid-infrared spectral region can deliver a wealth of information on pressure, temperature, clouds and aerosols, and trace gas concentrations in the atmosphere. Interpreting the satellite measurements requires to solve an inverse modelling problem based on variational methods and a forward model evaluating the radiative transfer equations. As state-of-the-art satellite measurement campaigns require Petascale systems to process the data in due time, graphical processing units are employed for the high-throughput problem of computing the forward model for a given atmospheric state. We explore features of the considered architecture as well as relevant performance signatures of the different implementations to improve our understanding on opportunities for efficient exploitation of GPU-accelerated architectures based on the POWER[2]processor for this class of applications. Scalability is a key aspect as the application is known to scale well on massively-parallel architectures.

Keywords. IBM POWER8, NVIDIA P100, GPU acceleration, radiative transfer, atmospheric science, remote sensing, inverse modelling, forward modelling

1. Introduction

The Juelich Rapid Spectral Simulation Code (`JURASSIC`) [1,2] is a fast radiative transfer model for the analysis of atmospheric remote sensing measurements in the mid-infrared spectral region. The model has been used to retrieve geophysical data such as pressure, temperature, and trace gas concentrations from ESA and NASA satellite observations as well as aircraft measurements [1,2,3,4]. `JURASSIC` features a 3D raytracer for different observation geometries and to enable tomographic studies [5]. The model has also been extended to perform Mie-scattering calculations for aerosol and ice particles [6,7]. `JURASSIC` was carefully tested in inter-comparisons with the Karlsruhe Optimized and Precise Radiative Transfer Algorithm (KOPRA), the Reference Forward Model (RFM), and the Stand-alone AIRS Radiative Transfer Algorithm (SARTA).

The main aim of `JURASSIC` is to solve the Schwarzschild Equation, i.e. the radiative transfer equation for the mid-infrared spectral region,

$$I_\nu(z) = \int_0^z \mathrm{d}z'\, S_\nu(T(z'))\, \frac{\mathrm{d}\tau_\nu(z',z)}{\mathrm{d}z'}, \tag{1}$$

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