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Development of seismic tomography software for hybrid supercomputers

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Seismic tomography is a technique used for computing velocity model of geologic structure from first arrival travel times of seismic waves. The technique is used in processing of regional and global seismic data, in seismic exploration for prospecting and exploration of mineral and hydrocarbon deposits, and in seismic engineering for monitoring the condition of engineering structures and the surrounding host medium. As a consequence of development of seismic monitoring systems and increasing volume of seismic data, there is a growing need for new, more effective computational algorithms for use in seismic tomography applications with improved performance, accuracy and resolution. To achieve this goal, it is necessary to use modern high performance computing systems, such as supercomputers with hybrid architecture that use not only CPUs, but also accelerators and co-processors for computation.

The goal of this research is the development of parallel seismic tomography algorithms and software package for such systems, to be used in processing of large volumes of seismic data (hundreds of gigabytes and more). These algorithms and software package will be optimized for the most common computing devices used in modern hybrid supercomputers, such as Intel Xeon CPUs, NVIDIA Tesla accelerators and Intel Xeon Phi co-processors. In this work, the following general scheme of seismic tomography is utilized. Using the eikonal equation solver, arrival times of seismic waves are computed based on assumed velocity model of geologic structure being analyzed. In order to solve the linearized inverse problem, tomographic matrix is computed that connects model adjustments with travel time residuals, and the resulting system of linear equations is regularized and solved to adjust the model. The effectiveness of parallel implementations of existing algorithms on target architectures is considered. During the first stage of this work, algorithms were developed for execution on supercomputers using multicore CPUs only, with preliminary performance tests showing good parallel efficiency on large numerical grids. Porting of the algorithms to hybrid supercomputers is currently ongoing.