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Seeking for efficiency in using a HPCC with high resolution models of oblique subduction

Mihai Pomeran, Luminita Zlagnean, and Lucian Besutiu
Institute of Geodynamics of the Romanian Academy, Solid Earth Dynamics, Bucharest, Romania
(mihai.pomeran@gmail.com)

With the ever increasing power of computer clusters employed for Earth's dynamics studies, new horizons of research arise with the use of large models. These models bring with them new challenges and this paper tries to rise awareness to an understated part of the parallelization process: the mapping phase, when the bulk computing load is distributed towards the individual processors of a computing cluster. Our work shows that the total computing time may decrease if the mapping stencil is built by taking into account the peculiarities of the simulation (e.g., gradients of the studied entity change).

The CYBERDYN Cybernetic Infrastructure (CCI) owned by the Solid Earth Dynamics Department at the Institute of Geodynamics of the Romanian Academy was employed to run our computations, and the CitcomS finite element software package was used to construct the models. ParaView visualization software was used to inspect the results.

The main elements of CCI are a Beowulf-type High Performance Computer Cluster (HPCC), a High Performance Visualization Cluster (HPVC) with a PowerWall and a 3D stereoscopic projection system: GeoWall. CCI's HPCC architecture was designed around 1344 central processing units (CPU) cores and 3TB of RAM. A Qlogic InfiniBand switch runs the high speed interconnect at speeds up to 40 Gbps. A Panasas network attached storage provides for CCI's HPCC 40 TB as model data storage. The HPVC nodes may also serve as HPCC computing nodes when needed.

To benchmark the numeric speed of the different mapping stencils, an oblique subduction process was considered. Initial conditions imposed two identical tectonic plates converging for a period of 30Myr (model time) at a constant latitude. Then an assumed pole jump of one plate changes the velocity vector field, increasing the lateral component of the velocity, relative to the trench.

The model space extends 11.46 degrees along latitude with 28.65 degrees along longitude and 1900 Km in depth. The computational mesh is irregular, with smaller size finite elements towards the middle of the model and at the surface.
Overall, the numerical simulation showed a sinking slab, flat on a side of the model and steep on the other side.

To reach at our conclusions, we used mapping stencils that attributed an equal number of finite elements to each CPU, but in a different way. The time for execution, and geological time got for different stencils allowed for choosing the optimum direction to distribute the maximum amount of CPUs on. This method proved to reduce significantly (by up to 30%) the computing time.

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