Fast Scalable Finite Element Analysis Method for Crustal Deformation using a 3D Island-scale High-fidelity Model

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Recently, three-dimensional high-fidelity crustal structure data in island-scale domains are becoming available due to the accumulation of high-resolution observation data. However, it has been difficult to use such data to perform crustal deformation analysis in an island-scale domain with quality assurance of the numerical simulation because of its huge analysis cost.
We propose a high-fidelity crustal structure finite element (FE) model construction method using high-fidelity crustal structure data, and a fast FE analysis method to reduce its huge analysis cost. These methods used an automatic FE model generation method for parallel computation, MPI and OpenMP hybrid parallel computation on a distributed memory super-computer, a geometric multigrid, variable preconditioning, and multiple-precision arithmetic. Using the proposed methods, we constructed 10 billion DOF high-fidelity crustal structure FE models including the whole Japanese Islands, and conducted elastic/viscoelastic crustal deformation analysis using this model with quality assurance of numerical simulation.
The proposed method can be applied for larger crust deformation problems and extended to nonlinear/dynamic problems. As illustrative examples, we present a crust deformation analysis with 2.05 trillion DOF and an implicit nonlinear wave analysis with 1.08 trillion DOF on 0.270 trillion unstructured finite elements.

Keywords: crust deformation, finite element method, fast scalable parallel computation

