Geophysical Research Abstracts
Vol. 19, EGU2017-14021, 2017
EGU General Assembly 2017

A proposal of monitoring and forecasting system for crustal activity in and around Japan using a large-scale high-fidelity finite element simulation codes

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Here we propose a system for monitoring and forecasting of crustal activity, such as spatio-temporal variation in slip velocity on the plate interface including earthquakes, seismic wave propagation, and crustal deformation. Although, we can obtain continuous dense surface deformation data on land and partly on the sea floor, the obtained data are not fully utilized for monitoring and forecasting. It is necessary to develop a physics-based data analysis system including (1) a structural model with the 3D geometry of the plate interface and the material property such as elasticity and viscosity, (2) calculation code for crustal deformation and seismic wave propagation using (1), (3) inverse analysis or data assimilation code both for structure and fault slip using (1) & (2). To accomplish this, it is at least necessary to develop highly reliable large-scale simulation code to calculate crustal deformation and seismic wave propagation for 3D heterogeneous structure. Actually, Ichimura et al. (2015, SC15) has developed unstructured FE non-linear seismic wave simulation code, which achieved physics-based urban earthquake simulation enhanced by 1.08 T DOF x 6.6 K time-step. Ichimura et al. (2013, GJI) has developed high fidelity FEM simulation code with mesh generator to calculate crustal deformation in and around Japan with complicated surface topography and subducting plate geometry for 1km mesh. Fujita et al. (2016, SC16) has improved the code for crustal deformation and achieved 2.05 T-DOF with 45m resolution on the plate interface. This high-resolution analysis enables computation of change of stress acting on the plate interface. Further, for inverse analyses, Errol et al. (2012, BSSA) has developed waveform inversion code for modeling 3D crustal structure, and Agata et al. (2015, AGU Fall Meeting) has improved the high-fidelity FEM code to apply an adjoint method for estimating fault slip and asthenosphere viscosity. Hence, we have large-scale simulation and analysis tools for monitoring. Furthermore, we are developing the methods for forecasting the slip velocity variation on the plate interface. Basic concept is given in Hori et al. (2014, Oceanography) introducing ensemble based sequential data assimilation procedure. Although the prototype described there is for elastic half space model, we are applying it for 3D heterogeneous structure with the high-fidelity FE model.