3-D visco-elastic FEM modeling of kinematic earthquake cycle in Southwest Japan

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Introduction

In Southwest Japan, the Philippine Sea plate (PH) is subducting northwestward beneath the Amurian plate (AM) along the Nankai Trough. The subduction of PH slab has created repeatedly great thrust-type interplate earthquakes (M～8) with a recurrence interval of about 100～150 years. The most recent major interplate events were the 1944 Tonankai (M 8.0) and the 1946 Nankai (M 8.1) earthquakes. However, historical documents and liquefaction imprinted at archaeological sites show that spatial distributions of source region and recurrence intervals were quite different each earthquake cycle. In general, the fault region along the Nankai Trough is divided into several segments. The two segments (which is called A and B) located from the western part of Kii Peninsula to off-Shikoku correspond to the fault plane of Nankai earthquakes, and other two segments (called C and D) located from the eastern part of Kii Peninsula to off-Aichi prefecture correspond to Tonankai earthquakes. Segments AB always rupture together, and segments CD rupture together, sometimes with segment E located in Suruga Bay.

This segmentation is probably due to the difference in friction which is concerned with laterally changing dip angles of subducting PH slab, and the transfer of stress between fault segments may possibly have created and controlled a complicated sequence of earthquakes along the Nankai Trough. Hence, the purpose of this study is to model earthquake cycles at the Nankai Trough and quantitatively estimate the stress transfer between fault segments using available historical data sets. As a future work, it is necessary to evaluate the effects of eastward motion of AM and collision to northeast arc.

For the purpose of simulating earthquake cycle, interseismic deformation rate due to plate subduction is also necessary. *Miyazaki and Heki* [1] changed the kinematic reference frame of GPS velocity data from Eurasian plate to stable part of AM and re-determined AM-PH Euler vector and its angular velocity using velocity data of the GEONET observation points which are placed on the stable part of Philippine Sea plate. The obtained Euler vector and angular velocity predict the AM-PH convergence rate at Nankai Trough of 63-68mm/yr toward ～N55W.

In this study, we assume that this convergence rate is constant with respect to time, and plate coupling strength is 100% with depths of about 5-25km, and linearly decrease with depth in the deeper transition zone at about 25-35km, based on a thermal model of *Hyndman et al.* [2]

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In order to simulate earthquake cycle associated with AM-PH interaction, we constructed 3-D visco-elastic FEM model (Figure 1) in Southwest Japan consisting of elastic crust and visco-elastic upper mantle including the subducting PH slab with a complicated 3-D configuration based on the distribution of sub-crustal earthquakes, and utilized GeoFEM visco-elastic module now developing under the collaborative work between Nagoya University and RIST. This is a first application of GeoFEM to solid earth problems. As a first step, our calculation was performed with 1 PE adopting relatively coarse FEM mesh. However, much small division of mesh (corresponds to a few millions DOFs) will be adopted for parallel computations in near future. In calculating earthquake cycle, we prescribed amounts of fault slip based on the data of actual earthquake sequence along the Nankai trough and, for interseismic period, constant backslip (*Savage* [3]) deduced from GPS data using split-node technique (*Melosh and Raefsky* [4]). Though our model is only kinematic, it may offer the key to an understanding of earthquake cycles at the Nankai Trough.

In the presentation, we will show the calculated and stress field (such as ΔCFF) along the plate interface and their variations with respect to time.

Figures

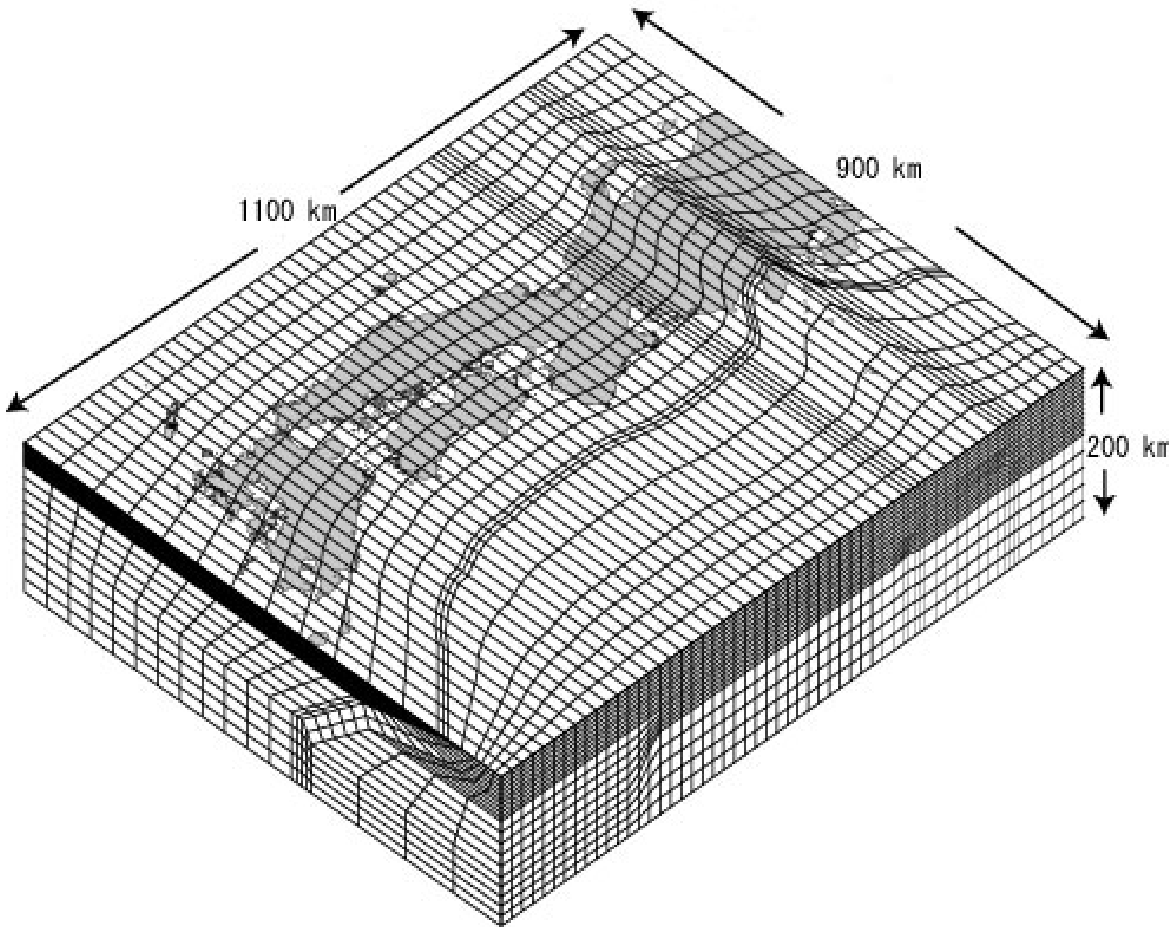

Figure 1: View of finite element mesh in Southwest Japan.

References

[1] Miyazaki, S. and K. Heki, 2000, *Crustal velocity field of southwest Japan: subduction and arc-arc collision*, Submitted to J. Geophys. Res.

[2] Hyndman, F. D., K. Wang and M. Yamano, 1995, *Thermal constrains on the seismogenic portion of southwest Japan subduction thrust*, J. Geophys. Res., **100**,15373-15392.

[3] Savage, J. C., 1983, *A dislocation model of strain accumulation and release at subduction zone*, J. Geophys. Res., **98**, 4553-4563.

[4] Melosh, H. J., and Raefsky, A., 1981, *A simple and efficient method for introducing faults into finite element computations*, Bull. Seismol. Soc. Am., **71**, 1391-1400.