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Modeling crustal deformation processes in the northeastern Japan island arc by considering subducting plate

Bunichiro Shibazaki[1]; Yoshihisa Iio[2]; Takaya Iwasaki[3]; Akiko Tanaka[4]

[1] IISEE, BRI; [2] DPRI, Kyoto Univ.; [3] ERI, Tokyo Univ.; [4] Geological Survey of Japan, AIST

To understand the tectonic loading processes of large inland earthquakes in Japan, it is necessary to clarify the loading processes caused by the subducting plate motion and the internal deformation in the island arc. To model the internal deformation, it is necessary to consider the effects of a realistic rheological structutre of the inland crust and upper mantle. Shibazaki et al. (2006) have succeeded in modelling stress concentration processes using the finite element method by considering the crust and upper mantle structures revealed by Iwasaki et al. (2003) and the temperature distribution inferred from the observed geothermal gradient. Shibazaki et al. (2006) have also modeled the crustal deformation of the inland crust by considering the subduction of the Pacific plate. In the present study, we have succeeded in modeling crustal deformation more reasonably by improving the assignment of boundary conditions.

To model long-term deformation processes, we need to consider an absolute stress state. In our model, along the upper part of the subducting plate boundary, slip occurs when the stress satisfies the Mohr-Coulomb yielding condition. Therefore, a certain stress level is maintained in the upper part of the subducting plate boundary. At the boundary between the subducting plate and the asthenosphere beneath the inland crust, viscous deformation can occur. We assign displacement boundary conditions so that the Pacific plate stationarily subducts beneath the island crust. We investigate how the inland crust deforms with the subduction of the Pacific plate. Around the aseismic front, the island lithosphere is thick since the temperature is low. Beneath the Ou Backbone Range, due to the high geothermal gradient, the lithosphere is thin. As a result, stress concentrates and an upward movement occurs. Numerical simulation reproduces an upward movement of around 1 cm/year. This value is considerably larger that that inferred from geological observations. We report the results of several numerical simulations by changing the model parameters and boundary conditions; we also discuss whether we can reproduce the long-term crustal deformation that is consistent with geological observations.