Geodetic data assimilation for crustal activity modeling

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We have been working on a simulation model for crustal activity forecast around the Japanese islands. We have successfully calculated the steady surface deformation pattern by introducing dislocation sources representing relative plate motions on the modeled plate boundaries in the elastic lithosphere overlying the viscoelastic asthenosphere (Hashimoto et al., 2002).

Assimilation of observation data into a simulation model is indispensable when we aim at forecasting crustal activities of the real Japanese islands. Fortunately, the nationwide permanent GPS array enables us to monitor surface deformation of the Japanese islands continuously as well as very precisely. The goal of our simulation can be achieved by introducing GPS data into the simulation model.

We first estimated a displacement rate at each GPS station based on daily coordinate data. Those displacement rate data contain effects of interplate coupling in addition to the steady deformation due to the plate subduction. We subtract the calculated steady deformation rate from the observational displacement rate, and inverted the residual displacement rate to estimate interplate coupling (slip deficit) distribution on the plate boundary interface. The result shows heterogeneous distribution of interplate coupling around the Japanese islands. Daily residuals after the correction of displacement rates reflect spatio-temporal changes of slip or slip-deficit distribution on the plate boundary, which is monitored by applying the Kalman filtering technique. The resultant slip (slip-deficit) distribution is fed back into the model calculation of interseismic tectonic loading.