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Toward An Automated Detection of Slow Slip Events with GPS Data

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Recently, slow slip events have been reported in various subduction zones such as Alaska, Cascadia, Mexico, New Zealand, and Japan. These exciting discoveries have been achieved through the operation of continuous GPS observation network. In Japan, the nationwide continuous GPS network operated by the Geographical Survey Institute, called GEONET, has contributed to detect slow slip events in several locations such as the Boso Peninsula, the Bungo Channel, and the Tokai District.
The increasing number of continuous GPS sites arises a new problem of how to find tiny displacements caused by slow slip events from vast amount of coordinate data. We devised a new technique to detect slow slip event from GPS coordinate data easily as well as efficiently. Our analysis is based on the daily routine coordinate solutions of GEONET provided by the Geographical Survey Institute. The data processing strategy is as follows. (1) A linear trend and seasonal signals are estimated from daily coordinate changes and subtracted from the original data to obtain residual time series. (2) The common residual is calculated by averaging the residual time series for all the stations in the network, and subtracted from each residual time series to reduce noise level (network filtering). (3) The time of a slow slip event is specified by the correlation analysis between the residual time series and a N-shape correlator. (4) Correlation values at GPS stations are plotted with different colors on the map. Spatially coherent color changes are candidates of slow slip events. Presently, human interaction is necessary to make a final judgment. But this step can be automated by evaluating spatial coherency of correlations and crosschecking the earthquake catalogue.
With this method, we can find slow slip events from temporally as well as spatially coherent pattern to correlation values. Artificial effects such as GPS antenna changes can be distinguished from slow slip events because spatial pattern is incoherent. As a result of our analysis, we detected slow slip events at Boso Peninsula and Bungo Channel, which have been reported previously. But the slow slip events at eastern Shikoku synchronized deep low-frequency tremors were not detected so far. A possible explanation is that the associated displacement is too small (less than 2mm). To solve the problem, it may be effective to change analysis region and to test various functions for the correlation analysis.

Keywords: slow slip; GPS; automatic detection; correlation analysis.