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Application of spatial filtering technique to GPS coordinates time series

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Coordinates time series of the continuous GPS stations provide us with various geophysical information such as the tectonic plate motion, source process of the earthquake, and magma behavior beneath the volcano. However, the time series often involve many spike-like daily scatters, periodic variations, and unexpected irregular changes, which degrade the extraction of desired information from the time series. It is well known that these errors are spatially highly correlated among the stations. These "common-mode errors" may be related with several conditions that are fixed in a day-by-day basis GPS data processing (precise satellite orbits, Earth rotation parameters, coordinate values of the reference stations, etc) or with the trade-off between coordinates solutions and other estimates such as tropospheric delay. On the other hand high spatial correlation of the common-mode errors is applicable to spatial filtering of the coordinates time series obtained in a specific GPS network (Wdowinski et al., 1997; Tabei and Amin, 2002). In this study we check characteristics of the common-mode errors involved in the final daily coordinates solutions of GEONET (F3 solutions). We select 43 stations in western Shikoku and eastern Kyushu, and analyze their coordinates time series from January 2002 to December 2004, which cover the 2003 slow slip event beneath the Bungo Canal.
At first we determine the best-fit linear trend for each component of coordinates time series. By subtracting the linear trends, residual time series are obtained. Next we calculate a daily common-mode bias by stacking residuals. Here we calculate the bias changing the combination of stations. Finally we subtract the common-mode bias from the observed position for each day and each site. The results show that common-mode errors of a specific station group are highly correlated with those from other group. And this is also true even when we change the number of stations for a group. Correlation coefficients obtained from the most distant (about 200 km) two groups are 0.83, 0.67, and 0.68 for the east, north and upward components, respectively.
It is impossible to estimate a linear trend for the time series which involves transient deformation due to the slow slip event. Moreover it is difficult to clearly identify the occurrence time, total amount of deformation, and end time of the slow slip event if the time series are contaminated by the errors. We demonstrate that the common-mode errors obtained from the stations that are free from the slow slip events are applicable to the spatial filtering of the time series which are affected by the event. The substituting filtering decreases daily scatters and seasonal variations by about 50%, making the time series smoother and clearer.

Keywords: GPS, coordinates time series, common-mode error, spatial filtering