Geophysical Research Abstracts
Vol. 14, EGU2012-6887-1, 2012
EGU General Assembly 2012

Global Spatial Filtering (GSF) of GNSS Coordinates to Capture Small Transient Signals

G. Blewitt, C. Kreemer, J. Goldfarb, H.-P. Plag, and W. C. Hammond
Nevada Bureau of Mines and Geology, University of Nevada, Reno, United States (gblewitt@unr.edu)

GNSS station coordinate time series have spatially-correlated variations that are the sum of geophysical signals plus non-local errors. For geophysical applications such as strain modeling, co-seismic displacements, transient detection, the signal can be over a limited spatial scale, in which case, the signal can be enhanced by filtering out the non-local errors of a much larger scale. Indeed, there are examples of geophysical transients in GNSS time series that may have gone undetected without some form of spatial filtering.

Global spatial filtering (GSF) was introduced by Rius et al. [1995], who applied the method globally to geocentric radial coordinate time series. Unlike the regional common-mode error (CME) correction method of Wdowinski et al. [1997], which is broadly used with some modifications today, Rius et al. [1995] applied corrections to coordinates using a different similarity transformation at each station i, computed from the residuals of all stations j with distance $r_{ij} < s$ to that station, where s is the spatial scale of the filter.

The advantage of GSF is that it is seamless, whereas CME requires an ad hoc separation of the global network into distinct regions, each with its own set of corrections. Moreover, with GSF it becomes possible to systematically investigate the effect of varying the scale of the filter. Rather than enforce Rius' condition $r_{ij} < s$, we allow all stations in the global reference frame to contribute with weights as a continuous function of dimensionless variable (r_{ij}/s), thus avoiding spatial discontinuities in the pattern of corrections. We have designed a weighting function $w_{ij}(s) = (s/r_{ij})e^{-(r_{ij}/s+s/r_{ij})}$, which has elegant properties for GSF.

Marquez-Azua and DeMets [2003] applied a similar technique over a large region, noting that it could be applied to a global scale network, provided the stations were sufficiently close. In our case, solutions during 2011 contain > 7000 stations with ambiguity resolution applied globally. Nearest neighbor distances have a mean of 140 km, are mostly < 31 km, with 90% being < 280 km. About 1% exceed 2000 km for which filtering is less effective.

The first example presented here uses a network of 3355 stations from a 40-day test period in 2008, where no residual station motion model was assumed. Our next step is to develop a generalization of the GSF from a purely spatial filter to a spatio-temporal filter, as a function of both spatial scale s and time period τ. In this model, residuals to an empirical station motion model fit over a tapered time window characterized by τ are used to derive the GSF.

Our conclusion from the first example is that GSF can be implemented seamlessly, giving $> 50\%$ reduction in coordinate variance as the spatial scale s is reduced. In the absence of a real signal, the best results are obtained in the range $s = 90$ to 900 km. At 3000 km the GSF performs equally as well as a common global translation filter. At 30 km the solutions slightly degrade, presumably as there are fewer nearby sites contributing to the filter solution. A demonstration using data from perhaps the smallest earthquake ever detected by GPS (the 26 April 2008 M_w 5.0 Mogul Earthquake) shows that GSF can reduce non-earthquake related artefacts in the time series.