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Impacts of GNSS position offsets on global frame stability

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Positional offsets appear in Global Navigation Satellite System (GNSS) time series for a variety of reasons. Antenna or radome changes are the most common cause for these discontinuities. Many others are from earthquakes, receiver changes, and different anthropogenic modifications at or near the stations. Some jumps appear for unknown or undocumented reasons. Accurate determination of station velocities, and therefore geophysical parameters and terrestrial reference frames, requires that positional offsets be correctly found and compensated. Williams (2003) found that undetected offsets introduce a random walk error component in individual station time series. The topic of detecting positional offsets has received considerable attention in recent years (e.g., Detection of Offsets in GPS Experiment; DOGEx), and most research groups using GNSS have adopted a mix of manual and automated methods for finding them. The removal of a positional offset from a time series is usually handled by estimating the average station position on both sides of the discontinuity. Except for large earthquake events, the velocity is usually assumed constant and continuous across the positional jump. This approach is sufficient in the absence of time-correlated errors. However, GNSS time series contain periodic and power-law (flicker) errors. In this paper, we evaluate the impact to individual station results and the overall stability of the global reference frame from adding increasing numbers of positional discontinuities. We use the International GNSS Service (IGS) weekly SINEX files, and iteratively insert positional offset parameters. Each iteration includes a restacking of the modified SINEX files using the CATREF software from Institut National de l'Information Géographique et Forestière (IGN). Comparisons of successive stacked solutions are used to assess the impacts on the time series of x-pole and y-pole offsets, along with changes in regularized position and secular velocity for stations with more than 2.5 years of data. Our preliminary results indicate that the change in polar motion scatter is logarithmic with increasing numbers of discontinuities. The best-fit natural logarithm to the changes in scatter for x-pole has R^2 = 0.58; the fit for the y-pole series has R^2 = 0.99. From these empirical functions, we find that polar motion scatter increases from zero when the total rate of discontinuities exceeds 0.2 (x-pole) and 1.3 (y-pole) per station, on average (the IGS has 0.65 per station). Thus, the presence of position offsets in GNSS station time series is likely already a contributor to IGS polar motion inaccuracy and global frame instability. Impacts to station position and velocity estimates depend on noise features found in that station's positional time series. For instance, larger changes in velocity occur for stations with shorter and noisier data spans. This is because an added discontinuity parameter for an individual station time series can induce changes in average position on both sides of the break. We will expand on these results, and consider remaining questions about the role of velocity discontinuities and the effects caused by non-core reference frame stations.