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The Combined Effect of Periodic Signals and Noise on the Dilution of Precision of GNSS Station Velocity Uncertainties

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Station velocity uncertainties determined from a series of Global Navigation Satellite System (GNSS) position estimates depend on both the deterministic and stochastic models applied to the time series. While the deterministic model generally includes parameters for a linear and several periodic terms the stochastic model is a representation of the noise character of the time series in form of a power-law process. For both of these models the optimal model may vary from one time series to another while the models also depend, to some degree, on each other. In the past various power-law processes have been shown to fit the time series and the sources for the apparent temporally-correlated noise were attributed to, for example, mismodelling of satellites orbits, antenna phase centre variations, troposphere, Earth Orientation Parameters, mass loading effects and monument instabilities. Blewitt and Lavallée (2002) demonstrated how improperly modelled seasonal signals affected the estimates of station velocity uncertainties. However, in their study they assumed that the time series followed a white noise process with no consideration of additional temporally-correlated noise. Bos et al. (2010) empirically showed for a small number of stations that the noise character was much more important for the reliable estimation of station velocity uncertainties than the seasonal signals. In this presentation we pick up from Blewitt and Lavallée (2002) and Bos et al. (2010), and have derived formulas for the computation of the General Dilution of Precision (GDP) under presence of periodic signals and temporally-correlated noise in the time series. We show, based on simulated and real time series from globally distributed IGS (International GNSS Service) stations processed by the Jet Propulsion Laboratory (JPL), that periodic signals dominate the effect on the velocity uncertainties at short time scales while for those beyond four years, the type of noise becomes much more important. In other words, for time series long enough, the assumed periodic signals do not affect the velocity uncertainties as much as the assumed noise model. We calculated the GDP to be the ratio between two errors of velocity: without and with inclusion of seasonal terms of periods equal to one year and its overtones till 3rd. To all these cases power-law processes of white, flicker and random-walk noise were added separately. Few oscillations in GDP can be noticed for integer years, which arise from periodic terms added. Their amplitudes in GDP increase along with the increasing spectral index. Strong peaks of oscillations in GDP are indicated for short time scales, especially for random-walk processes. This means that badly monumented stations are affected the most. Local minima and maxima in GDP are also enlarged as the noise approaches random walk. We noticed that the semi-annual signal increased the local GDP minimum for white noise. This suggests that adding power-law noise to a deterministic model with annual term or adding a semi-annual term to white noise causes an increased velocity uncertainty even at the points, where determined velocity is not biased.