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Impact of temporal correlation on the probability distribution of GPS carrier phase observations

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In common practice of processing observational data from Global Satellite Navigation Systems (GNSS), e.g. Global Positioning System (GPS), the carrier phase measurements are generally assumed to follow a Gauss-Laplace normal distribution. The distributional properties of GPS observations play an important role in procedures for quality control (e.g. outlier and cycle-slip detection), in ambiguity resolution, as well as in reliability-related assessments of estimation results. Analysing original carrier phase observations or corresponding residuals resulting from GPS data processing, the discrepancies from assumed normal distribution are generally attributed to deficiencies in the functional model describing the disturbing factors, such as multipath effects and atmospheric delays. In addition to these external error sources, temporal correlation of GPS observations − which also remains in observation residuals due to the deficiencies of the stochastic model applied in many GPS software products − may affect the observables' distributional characteristics as well.

This paper presents a detailed analysis of influences of temporal correlation properties on the probabilistic distribution of GPS phase observations. In order to exclude a priori the impacts of external error sources, like multipath effects and atmospheric delays, representative samples of temporally correlated data are simulated by means of so-called autoregressive moving average (ARMA) processes. The model parameters used in the ARMA simulation are taken from published studies and are considered appropriate for characterising the temporal correlation behaviour of GPS observations. In addition to temporally correlated data, Gaussian white noise processes are generated for comparison and for illustration of distributional discrepancies. The statistical inferences are made by analysing the first through fourth sample moments as well as by applying different hypothesis tests for normality. Finally, using independently identified ARMA models, decorrelation procedures are applied to the correlated data to verify the effects of temporal correlation on the probability distribution. The investigation results show that the deviations of the distribution parameters from a normal distribution increase with a rising correlation level. In the presence of strong positive temporal correlations, particularly for small sample sizes, all four sample moments are significantly biased and the hypothesis of normality is rejected for nearly half of the analysed data.