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On the use of fully populated matrices in GPS least-squares adjustment

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The mathematical model for GNSS positioning is well described. However, the stochastic model is said to remain improvable. Indeed, heteroscedastic is mainly assumed, i.e. the variance of the observations is having an elevation dependency, typically based on 1/sin elevation models, on SNR or CN0 based values as well as elevation-based exponential models. However, correlations between satellites observations remain ignored. Over the last years, covariance functions that try to model GNSS correlations have been proposed and tested, such as the empirical exponential model or double integration of turbulence based functions.

In this contribution, we will present a way to take atmospheric correlations into account based on the turbulence theory, which is a simplification of the Schön and Brunner model (2008). As a result, fully populated covariance matrices based on physically plausible results can be easily computed and integrated in least-squares adjustment. Moreover, the use of the flexible Matern covariance family allow put both to model other kind of correlations (stronger or lower) by adapting the smoothness and the correlation length factor of the covariance function. Thus the influence of fully populated matrices versus diagonal matrices on the parameter domain can be tested. By means of simulations where the covariance matrices are exactly known, it is shown that the rms-improvement of the parameters to estimate by taking correlations into account is mainly limited to submm domain, particularly for double-differenced data. The dependency of the estimates differences with the sample length and the correlation structure will be investigated. Finally, we will show that the fully populated matrices can be approximated by an equivalent diagonal kernel that facilitates taking correlations into account.