TIME-DEPENDENT CORRELATIONS USING THE GPS – A CONTRIBUTION TO DETERMINE THE UNCERTAINTY OF GPS-MEASUREMENTS

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ABSTRACT

The geodetic use of the Global Positioning System (GPS) relies on the positive correlations among simultaneous observations. These space-dependent correlations justify the relative positioning concept as a powerful tool for co-ordinate determination. The almost identical influence of different error-sources on two or more observation sites is the cause for these stochastic dependencies. It is also well-known, that the error-situation is only slowly changing with time. This leads to time-dependent correlations for short time spans (ten minutes up to some hours). The correlative time-dependent behaviour of GPS-observations and subsequently the GPS determined co-ordinates for longer time spans e.g. years is one aim of present-day research.

First of all the paper presents a synthetic method for the determination of time-dependent correlations. The model of elementary errors constitutes the basis for the method leading to synthetic covariance matrices and correlations among observations at different time epochs. The most important GPS error-sources, respectively their influence on the observations and co-ordinates, have to be modelled. This method may be used especially for planning purpose or if no observed time series are given. An application for GPS-monitoring surveys is presented briefly. The synthetic model is used for an example network in Romania and is valid for baseline lengths up to 50 km. The simulations show interepochal correlation coefficients up to 0.38 for the height component between two deformation epochs.

The second part of the paper deals with the analytic determination of time-dependent correlations using the tools of time-series analysis like outlier elimination and trend separation as well as filtering. The results are presented in the form of autocovariance functions and power-spectra for two exemplary data-sets. Five years of weekly solutions of the BKG (Bundesamt für Kartographie und Geodäsie) are used to investigate possible annual periods in the correlative behaviour. Fourteen days of hourly solutions of the LGN (Landesbetrieb Landesvermessung und Geo-Basisinformation Niedersachsen) reflect the existence of diurnal periods. The described analytic methods may be used, if observed time-series are given, especially if they cover a long time period. The estimated correlation coefficients are higher than 0.5 in both cases. For the LGN data with baseline lengths around 50 km the period of the maximum correlation is 24 hours, that corresponds very well to the assumptions made for the synthetic method. The period may be caused by remaining tropospheric uncertainties. The BKG data with baseline lengths of continental character shows a semi-annual period, that do not

correspond to the periods assumed for the synthetic method. The reason for the contradiction is found in the much longer baselines. Because of this the influence of the ionosphere including annual and semi-annual periods arises in comparison to the synthetic model. In both cases the amount of empirical correlation exceed the synthetically determined. For the LGN data the cause is the dealing with empirical data of two weeks. The influence of error sources with e.g. an annual period are not taken into account. The reason at the BKG data may be given by the different error sources because of the extended baseline lengths in comparison to the synthetic example network.

Finally the consideration of synthetic modelled as well as of empirically determined correlations for determination of uncertainty is outlined. Some easily understandable examples are given. Gains in accuracy up to almost 70 % are simulated.

In the planning phase the time-dependent correlations shall be used to get a realistic idea of the uncertainty. In the post-processing step the knowledge of the time-dependent correlations is important for the same purpose.

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Scientific Interests

- Modelling of Error Sources and Applications of GPS
- Engineering Surveys and Deformation Analysis
- Orbit Determination for GPS-Satellites and Low-Orbiters