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The impact of seasonal signals on spatio-temporal filtering

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Existence of Common Mode Errors (CMEs) in permanent GNSS networks contribute to spatial and temporal correlation in residual time series. Time series from permanently observing GNSS stations of distance less than 2 000 km are similarly influenced by such CME sources as: mismodelling (Earth Orientation Parameters - EOP, satellite orbits or antenna phase center variations) during the process of the reference frame realization, large-scale atmospheric and hydrospheric effects as well as small scale crust deformations. Residuals obtained as a result of detrending and deseasonalising of topocentric GNSS time series arranged epoch-by-epoch form an observation matrix independently for each component (North, East, Up). CME is treated as internal structure of the data. Assuming a uniform temporal function across the network it is possible to filter CME out using PCA (Principal Component Analysis) approach. Some of above described CME sources may be reflected as a wide range of frequencies in GPS residual time series. In order to determine an impact of seasonal signals modeling to existence of spatial correlation in network and consequently the results of CME filtration, we chose two ways of modeling. The first approach was commonly presented by previous authors, who modeled with the Least-Squares Estimation (LSE) only annual and semi-annual oscillations. In the second one the set of residuals was a result of modeling of deterministic part that included fortnightly periods plus up to 9th harmonics of Chandlerian, tropical and draconitic oscillations. Correlation coefficients for residuals in parallel with KMO (Kaiser-Meyer-Olkin) statistic and Bartlett's test of sphericity were determined. For this research we used time series expressed in ITRF2008 provided by JPL (Jet Propulsion Laboratory). GPS processing was made using GIPSY-OASIS software in a PPP (Precise Point Positioning) mode. In order to form GPS station network that meet demands of uniform spatial response to the CME we chose 18 stations located in Central Europe. Created network extends up to 1500 kilometers. The KMO statistic indicate whether a component analysis may be useful for a chosen data set. We obtained KMO statistic value of 0.87 and 0.62 for residuals of Up component after first and second approaches were applied, what means that both residuals share common errors. Bartlett's test of sphericity analysis met a requirement that in both cases there are correlations in residuals. Another important results are the eigenvalues expressed as a percentage of the total variance explained by the first few components in PCA. For North, East and Up component we obtain respectively 68%, 75%, 65% and 47%, 54%, 52% after first and second approaches were applied. The results of CME filtration using PCA approach performed on both residual time series influence directly the uncertainty of the velocity of permanent stations. In our case spatial filtering reduces the uncertainty of velocity from 0.5 to 0.8 mm for horizontal components and from 0.6 to 0.9 mm on average for Up component when annual and semi-annual signals were assumed. Nevertheless, while second approach to the deterministic part modelling was used, deterioration of velocity uncertainty was noticed only for Up component, probably due to much higher autocorrelation in the time series when comparing to horizontal components.