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Investigation on the coloured noise in GPS-derived position with time-varying seasonal signals

Marta Gruszczynska (1), Anna Klos (1), Machiel Simon Bos (2), and Janusz Bogusz (1)

(1) Military University of Technology, Warsaw, Poland (mgruszczynska@wat.edu.pl), (2) University of Beira Interior, Instituto D. Luis, R. Marqueˆs d'A´vila e Boloma, Portugal

The seasonal signals in the GPS-derived time series arise from real geophysical signals related to tidal (residual) or non-tidal (loadings from atmosphere, ocean and continental hydrosphere, thermo elastic strain, etc.) effects and numerical artefacts including aliasing from mismodelling in short periods or repeatability of the GPS satellite constellation with respect to the Sun (draconitics). Singular Spectrum Analysis (SSA) is a method for investigation of nonlinear dynamics, suitable to either stationary or non-stationary data series without prior knowledge about their character. The aim of SSA is to mathematically decompose the original time series into a sum of slowly varying trend, seasonal oscillations and noise. In this presentation we will explore the ability of SSA to subtract the time-varying seasonal signals in GPS-derived North-East-Up topocentric components and show properties of coloured noise from residua. For this purpose we used data from globally distributed IGS (International GNSS Service) permanent stations processed by the JPL (Jet Propulsion Laboratory) in a PPP (Precise Point Positioning) mode. After introducing a threshold of 13 years, 264 stations left with a maximum length reaching 23 years. The data was initially pre-processed for outliers, offsets and gaps. The SSA was applied to pre-processed series to estimate the time-varying seasonal signals. We adopted a 3-years window as the optimal dimension of its size determined with the Akaike's Information Criteria (AIC) values. A Fisher-Snedecor test corrected for the presence of temporal correlation was used to determine the statistical significance of reconstructed components. This procedure showed that first four components describing annual and semi-annual signals, are significant at a 99.7% confidence level, which corresponds to 3-sigma criterion. We compared the non-parametric SSA approach with a commonly chosen parametric Least-Squares Estimation that assumes constant amplitudes and phases over time. We noticed a maximum difference in seasonal oscillation of 3.5 mm and a maximum change in velocity of 0.15 mm/year for Up component (YELL, Yellowknife, Canada), when SSA and LSE are compared. The annual signal has the greatest influence on data variability in time series, while the semi-annual signal in Up component has much smaller contribution in the total variance of data. For some stations more than 35% of the total variance is explained by annual signal. According to the Power Spectral Densities (PSD) we proved that SSA has the ability to properly subtract the seasonals changing in time with almost no influence on power-law character of stochastic part. Then, the modified Maximum Likelihood Estimation (MLE) in Hector software was applied to SSA-filtered time series. We noticed a significant improvement in spectral indices and power-law amplitudes in comparison to classically determined ones with LSE, which will be the main subject of this presentation.