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Non-parametric estimation of seasonal variations in GNSS-derived time series

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The seasonal variations in GNSS station's position may arise from geophysical excitations, thermal changes combined together with hydrodynamics or various errors which, when superimposed, cause the seasonal oscillations not exactly of real geodynamical origin, but still have to be included in time series modelling. These variations with different periods included in frequency band from Chandler up to quarter-annual ones will all affect the reliability of permanent station's velocity, which in turn, strictly influences the quality of kinematic reference frames. As shown before by a number of authors, the annual (dominant) sine curve, has the amplitude and phase that both change in time due to the different reasons. In this research we focused on the determination of annual changes in GNSS-derived time series of North, East and Up components. We used here the daily position changes from PPP (Precise Point Positioning) solution obtained by JPL (Jet Propulsion Laboratory) processed in the GIPSY-OASIS software. We analyzed here more than 140 globally distributed IGS stations with the minimum data length of 3 years. The longest time series were even 17 years long (1996-2014). Each of the topocentric time series (North, East and Up) was divided into years (from January to December), then the observations gathered in the same days of year were stacked and the weighted medians obtained for all of them such that each of time series was represented by matrix of size 365xn where n is the data length. In this way we obtained the median annual signal for each of analyzed stations that was then decomposed into different frequency bands using wavelet decomposition with Meyer wavelet. We assumed here 7 levels of decomposition, with annual curve as the last approximation of it. The signal approximations made us to obtain the seasonal peaks that prevail in North, East and Up data for globally distributed stations. The analysis of annual curves, by means of non-parametric estimation of amplitudes and phases, led us to divide the IGS stations into different sub-networks for which the similar signals were noticed. In this way, we obtained 26, 20 and 28 sub-networks, called clusters, for North, East and Up components, respectively. Our results show that the station's location has the impact on annual curve character and can be related to ocean's vicinity or climate changes. Here, the greatest seasonal amplitudes were noticed for Up component what may arise from atmospheric and hydrospheric influences. The vast majority of GNSS time series is characterized by vertical changes from 2 to 4 mm per year. The maximum vertical amplitude was noticed to be at the level of 9 mm with the minimum of it equal to -10 mm, what gives the position change of 19 mm when peak-to-peak changes are considered. The horizontal annual changes were estimated here to be no higher than 5 mm with the median oscillation between 1 and 2 mm. The reason of wavelet decomposition usage is the fact that the majority of determined seasonal curves is far from being a sine wave. The division of IGS stations into a few different clusters led us to obtain the mean seasonal signal for different regions of the world. In this presentation, the authors will focus on the annual curves from different clusters determined with wavelet decomposition, their comparison in terms of amplitudes and phases as well as the possible reasons of their occurrence.