DESCRIPTION FOR THE GENERAL PUBLIC (IN ENGLISH)

The development of the satellite navigation systems is noticeable until today, as can be seen from the implementation of similar to GPS (Global Positioning System launched in the 90s of the last century) navigation systems, such as the GLONASS (Russia), Galileo (Europe) or Beidou (China), that are based on measurements of pseudoranges to satellites. The increasing popularity of navigational technique of mentioned type causes the need to construct the ground stations that will support the process of determining the position on land, at sea and in the air. The reference stations play also the role of a permanent character, as they continuously register the position changes of the GPS antenna in time. During the re-processing of navigation data, the Zenith Total Delay (ZTD) time series are also estimated. The time series of observations are characterized by the linear trend (or non-linear for stations from tectonically unstable areas), which is identified as the velocity of the station or climate change in case of ZTD data. Apart from the aforementioned trend, the time series also include the seasonal components with different periods as well as outliers and offsets. All the previously mentioned components of time series may be mathematically modelled and therefore are referred to as deterministic part. The stochastic part of data, that remains after the subtracting of modelled values, is called “noise”. An unquestionable advantage of the use of the GNSS observations in comparison to other satellite techniques (e.g. VLBI – Very Long Baseline Interferometry or SLR – Satellite Laser Ranging) is a relatively large number of globally distributed stations, due to a small cost of setting it up and recording the permanent observations.

GPS position time series registered at globally distributed permanent stations beyond the maintenance of kinematic reference frames are used in many geophysical studies such as plate tectonics and vertical land motion (including post-glacial rebound). The ZTD series are used to estimate trends in Integrated Water Vapour which are interpreted as a climate change. In all these cases, trend is estimated from the data together with periodic signals which appear in data as annual oscillation and its harmonics with constant amplitude and phase-lag. However, in reality the annual and semi-annual loading signals arising from atmosphere, oceans or continental hydrosphere, also known as seasonal signals, vary slightly from year to year. With the ever-increasing time span of the GPS observations this variability of the seasonal signals becomes apparent. Omitting this variability in analysis can introduce additional temporal correlation in the data which can lead to an overestimation of the secular motion uncertainty by a factor of around 1.7.

We will start by applying the standard method of weighted least-squares (WLS) estimation to our set of more than 1800 GPS daily position time series with time-spans of over 12 years to remove constant seasonal effects from the observations and demonstrate a significant annual and semi-annual of time-varying curves. At the same time, we will employ WLS to derive the amplitudes of annual and semi-annual curves from ZTD data. This problem was noted earlier by few authors who used various mathematical methods to capture the variable annual and semi-annual signal, but they did not consider in depth what power is being absorbed in the frequency domain from data together with these seasonal changes. To obtain an optimum separation between noise and signal, we propose to use the Adaptive Wiener Filter (AWF) to eliminate the seasonal signal from the GPS position time series and ZTD data as a preprocessing step. Then, noise analysis can be applied to time series without seasonal signals. However, since the amplitude and phase of the seasonal signals are changing over time, we cannot apply the Wiener filter directly to the whole time series. Therefore, we will apply it to overlapping segments of three years. The Wiener filter leaves the noise properties intact which means that after removing the seasonal signal, the data can be processed using standard time series analysis packages.

As soon as the effectiveness of AWF is examined for synthetic and real position and ZTD data, it can be successfully used for any other geodetic time series, where the time-changeability is apparent, as sea-level records or gravity field.