# Near-Seasonal Periods in GNSS Station Coordinate Time Series

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## Introduction

The Center of Orbit Determination in Europe (CODE), one of the global analysis centers of the International GNSS Service (IGS, GNSS stands for Global Navigation Satellite System), provides daily solutions for the orbits of all active GNSS satellites in a rigorous combined analysis of GPS and GLONASS observations. The daily solutions include about 200 stations from the IGS tracking network. Many of them represent the IGS realization of the terrestrial reference frame.

A reliable realization of the reference frame is the basis for the orbit determination. Obviously the reference frame also benefits from any improvement of the analysis models (e.g. Concerning the satellite orbits).

## Spectral Analysis of Station Coordinate Time Series

Daily solutions between 2003 and 2006 have been homogeneously reprocessed using the standard processing schema of CODE [Hugentobler et al., 2007]. The relative (not absolute) GNSS antenna PCV model was used. Coordinates and linear velocities for 230 tracking stations were computed from the resulting 1408 daily solutions. Approximately 120 ITRF2005 reference sites are involved. The time series of the residuals may be analyzed for geophysical or other effects by means of spectral analysis. The amplitude spectra of individual stations were accumulated to amplify signals that are common for all stations. The result is shown in Figure 1.

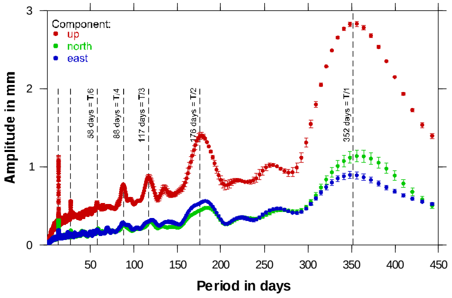

**Figure 1:** Mean accumulated amplitude spectra (with the formal error of the mean value) of the Up, East, and North residuals of the station coordiante time series. The spectral lines of 352/k, with k=1,2,3,4,6 are highlighted by dashed vertical lines.

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The dominant period, estimated with 351.7±2.8 days, is close to the draconitic GPS year (revolution period of the sun w.r.t. the GPS orbital planes, 352.43 days). In [Ray, 2006] similar periods were reported from the analysis of IGS time series.This period cannot be interpreted in the geophysical sense. It has been introduced by the GPS itself (either due to station-related problems like multipath - as suggested in [Ray, 2006] - or due to inadequate analysis models).

## Regional Correlations in the Time Series

By accumulating the time series of stations located in the same region (continent), common signals are amplified, whereas signals that are individual for each station are reduced. Figure 2 shows the accumulated residuals for the Up component of the time series for all stations in Europe, North America, South America, and Australia. The figure confirms that there is a regional correlation between the stations. It is very unlikely that all stations in one region are affected by the same station related problem (e.g., the uncertainty of the antenna calibration values, multipath or other environmental effects). We, therefore, conclude that this variation in the time series was introduced either by a modelling deficiency in the data analysis or as a pure geometrical effect due to the inhomogeneous distribution of the IGS (reference) sites.

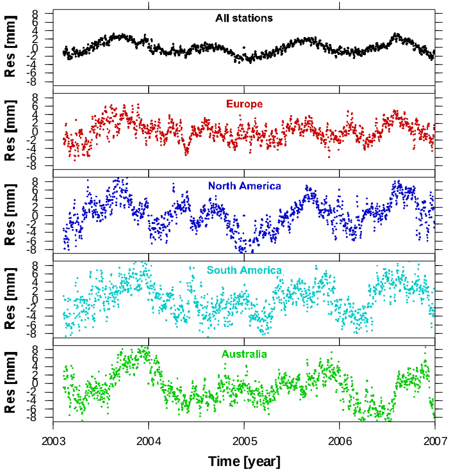

**Figure 2:** Mean residuals of the Up component for all stations (top) and for stations located in four regions (Europe, North America, South America, and Australia).

Another confirmation for the regional correlations of the time series is given in Figure 3, where the amplitude (color coded) and the phase (vectors) for the period of the spectral term of 352.43 days is displayed for each station. The X,Y,Z components correspond to a variation of the geocenter.

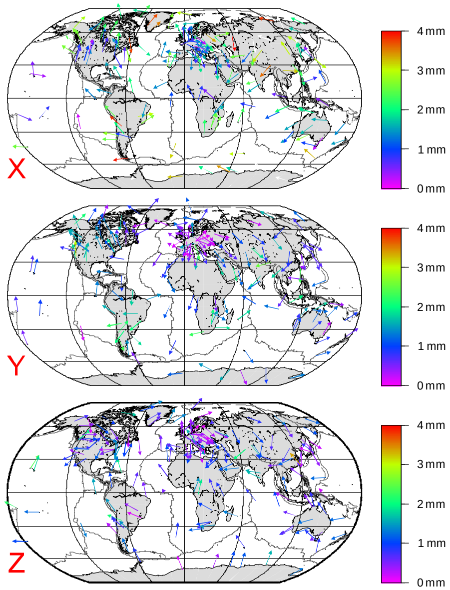

**Figure 3:** Polar representation of amplitude (color coded) and phase (vector) for the spectral line of 352 days in geocentric coordinate system (X,Y,Z components).

## Global Correlations

Figure 4 compares the accumulated residuals in the Up component with the variation of the scale of the global network obtained from Helmert transformations of the individual daily solutions with respect to the long-term solution.

The high correlation between the two time series demonstrates that the variation in the Up component of the stations are globally correlated and may be interpreted as a variation of the scale. The reason for the scale variation may be manifold.

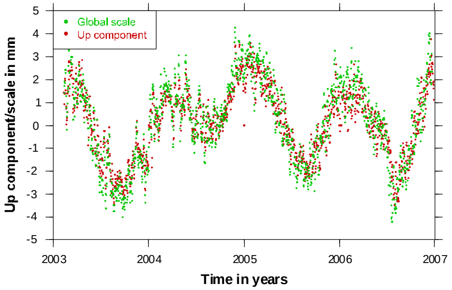

**Figure 4:** Time series of the accumulated residuals of the Up component and the variation of the global scale in time.

## Impact of Orbit Modelling

Three types of time series of solutions were generated using no model (NONE), the ROCK model [Fliegel and Gallini, 1996], and an updated CODE model [Springer, 1999] as a priori radiation pressure model. In each case, the absolute component and an once-per-revolution term of the extended CODE orbit model [Beutler et al., 1994] were estimated. An impact of the introduced radiation pressure model on the obtained time series for the geocenter was found (see Figure 5). No significant differences in the time series of the station coordinates could be detected. The periodic variation displayed in Figure 1, therefore, cannot be explained by radiation pressure modelling.

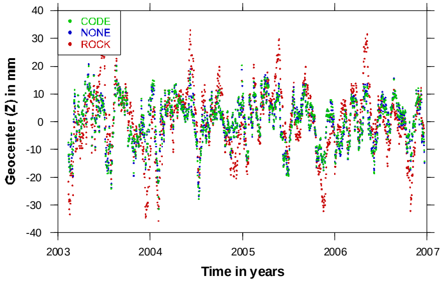

**Figure 5:** Geocenter time series (Z component) obtained using the a priori radiation pressure model: ROCK model [Fliegel and Gallini, 1996], no model (NONE), and the updated CODE model.

## Summary and Conclusions

A spectral analysis of station coordinate time series of 230 IGS tracking sites reveals a dominant period of 352 days, which corresponds to the draconitic GPS year. It has been shown that this signal is regionally correlated in both amplitude and phase. Therefore, we conclude that it is not introduced by station-specific effects (like, e.g., multipath), but it is introduced rather by the analysis model. This conclusion is confirmed by the fact that the variation in the Up component may be transferred to a variation of the scale for the global network. Using different radiation pressure models for the orbit determination has no significant impact on the time series of the station coordinates (but on the variation of the geocenter).

### References

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