EUREF Symposium, 06-08 June 2007, London, United Kingdom

Epoch-by-Epoch Coordinate Estimation with GPS – Results and Applications

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1 Introduction

Usually, data of GNSS permanent stations is analysed for various parameters in hourly or daily batches. The original data sampling rate can be reduced (down-sampled) and a higher number of observations can be used for the parameter estimation.

Moving towards real-time, the epoch-by-epoch analysis becomes more and more important. Beside real-time tools which are able to process consecutive observations, existing (post-processing) software is able to solve for coordinate parameters epoch-by-epoch. The Bernese GNSS software v5.0 for example has a kinematic option which is well suited also for high resolution "static" observations.

Since the noise of the residuals of the epoch-by-epoch parameters is higher than for static estimation an additional analysis step is necessary to considerably reduce the noise of the resulting time series. We used the sidereal filtering on the coordinate level which makes use of the repeating orbits constellation of the GPS satellites.

This presentation shows two examples of epoch-by-epoch coordinate solutions concentrating on both on the horizontal and on the up component:

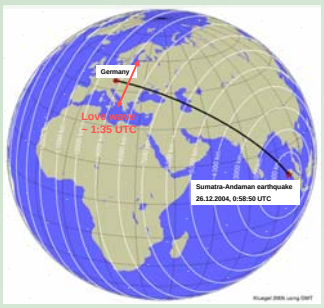
- Analysis of 1 Hz data sampled in Central Europe following the Sumatra-Andaman earthquake of December 2004;
- Analysis of 30 second data sampled at EPN stations during the surge "Britta" in October/November 2006.

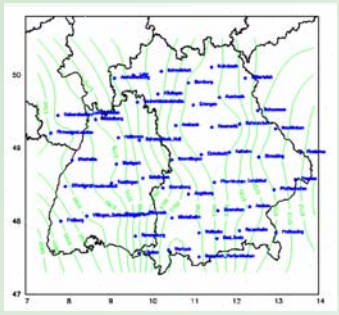
2 Analysis of high-rate (1 Hz) data

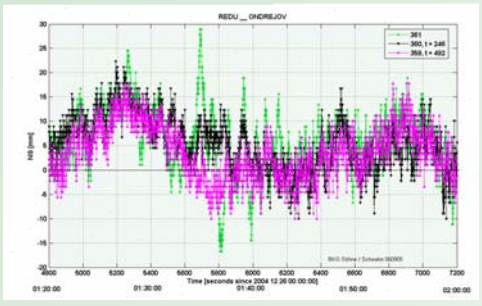
The surface waves induced by the Sumatra-Andaman earthquake (M_W 9.2) of December 26, 2004 (day of year 361) could be analysed by means of GPS even more than 9000 km apart from the epicentre. Since the displacements due Love waves were rectangular to the direction of propagation and the propagation moved from East to West (see figure 2a) the analysis was concentrated to the North-South component of the coordinate time series using a western site as reference station. Figure 2c shows the time series for the Latitude of site GOPE with REDU as reference station. Three consecutive days are plotted showing the low frequent deviations due to e.g. multi-path. Applying the modified sidereal filtering (Larson et al., 2006) on the coordinate level led to a remarkable reduction of the noise level.

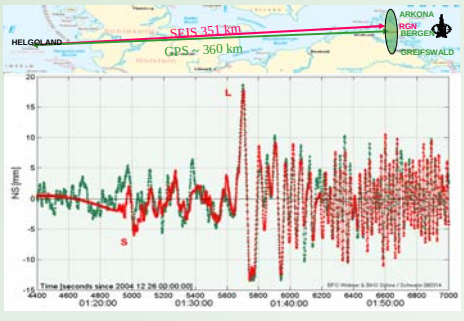
In figure 2d the GPS-derived time series after modified sidereal filtering is compared to a time series derived from seismometer observations. Note that the two seismometer time series are differenced to be comparable to the DGPS time series. Additionally, spatial filtering by stacking three neighboured sites was carried out for GPS. The coincidence between the two series can be seen clearly.

Figure 2b visualizes the propagation of the Love wave by picking up the time of the first peak to the North for each "rover" station. Here, IGN site METZ was used as reference.





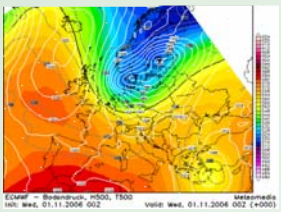


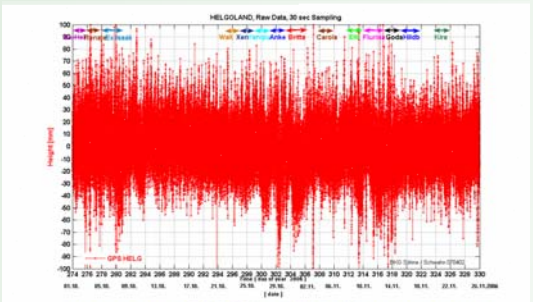


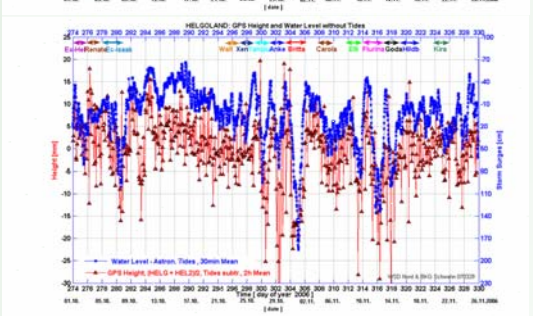
3 Analysis of 30 seconds data

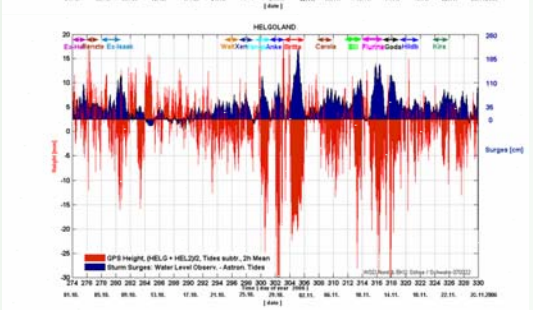
Starting in October 2006 a number of low pressure systems passed over Central Europe and the North Sea. No. 8 of these storms, "Britta" (Oct 30 - Nov 1, see figure 3a) induced a surge at the German Bight (see figure 3b). The GPS data of a number of coastal EPN stations (e.g. BORK, BORJ, HELG, HEL2 and HOE2) was analysed with the original data sampling rate of 30 seconds with a number of continental stations as reference stations.

Figure 3c shows the residuals for the up component of the 30 seconds kinematic solution as an average of the stations HELG and HEL2. The rms of these raw values is about 15 mm. After sidereal filtering with time series of preceding days the residual GPS time series for HELG is shown in figure 3d, together with the storm surge time series (both down-sampled to one hour for visualisation). Note, that the y-axis of the water level was inverted for better comparison. Figure 3e (bottom) demonstrates the principal anti-correlation between the two time series due to the loading effect of the surges.









4 Conclusions

The application of (modified) sidereal filtering is a simple and data-adaptive tool for coordinate time series analysis and can be applied to any kind of epoch-by-epoch analyses.

The subsidence caused by the storm surge as a result of the intense low-pressure system "Britta" reached an amount of up to –15 mm and could be clearly identified within the GPS time series. The loading effect due to water masses caused by heavy storms should be taken into account for high-precision applications. The loading effect monitored by GPS is an expression for the water load in the whole North Sea. If GPS technology can contribute to storm surge prediction is a matter of investigation.

Acknowledgement

We like to thank the "International GNSS Service" (IGS), the "EUREF Permanent Network" (EPN), "Institut Géographique National" (IGN), "Satellitenpositionierungsdienst der deutschen Landesvermessung" (SAPOS) and the colleagues from BKG for providing us with GNSS data as well as "Gewässerkundliches Informationssystem der Wasser- und Schifffahrtsverwaltung des Bundes" (http://www.pegelonline.wsv.de) for providing us with continuous water level data. The astronomical tides were computed using the "WWW Tide and Current Predictor" (http://tbone.biol.sc.edu/tide/tideshow.cgi). Seismological data were provided by "Black Forest Observatory" (BFO).