The Project NNSAT
Precise Height Supervision of Tide Gauges with GPS
by

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Introduction

In the past, precise height supervision of tide gauges was only based on precise levelling and burdened with the restrictions of this method of measurement: no global supervision, continental/ regional supervision on the basis of repeated national levelling networks every 20-50 years, local supervision from tide gauges control points. The use of GPS can fulfil all these tasks and is in use since years. Therefore the Geodetic Institute of the University of Technology , Dresden and the Federal Institute of Hydrology (BfG), Koblenz, have started investigations about an economic replacement of precise levelling by GPS-based techniques in the daily work considering all aspects of supervision. The project is funded by the Board of Trustees of Costal Engineering and the German Ministry of Research (BMBF) and realized in close cooperation with the State Survey Agency of Lower Saxony (LGN), Hannover and the Federal Agency for Cartography and Geodesy (BKG), Frankfurt. In this paper only the concept of the project and the state of the art concerning the accuracy of the GPS-height component is discussed.

Concept of NNSAT

Idea: Use of the permanent GPS-infrastructure in Europe like the EUREF-permanent network, the GREF-permanent network of BKG in Germany (mean distance S between the stations = 200 km), the permanent SAPOS of LGN with S= 50 km and SAPOS-WSV along the main rivers with S = 20km (under development). In addition water vapor measurements with radiometers should be carried out over a longer time period on selected stations.
Main topics of investigation concerning GPS-height accuracy are: influence of station dependant quality control, influence of the density of the permanent network using SAPOS and SAPOS-WSV, influence of the grade of ambiguity resolution using the Bernese GPS Software Version 4.2 (Rothacher, Mervart, 1996) and WaSoft (Wanninger 2000), integration of water vapor measurements with radiometers into the GPS evaluation process.

Design of the NNSAT-Permanent network (see figure 1): *Wallenhorst/Osnabrück*, national height reference point of Germany as „stable point“, coastal tide gauges like *Norderney*, *Emden* and *Wilhelmshaven*, connection to EUREF-permanent and IGS to IERS over the GREF-permanent network, permanent water vapor radiometers at *Osnabrück/Wallenhorst*, *Norderney* (one year) as part of a European network with *Onsala, Brussels* (in preparation), *Wettzell* and *Zurich.*

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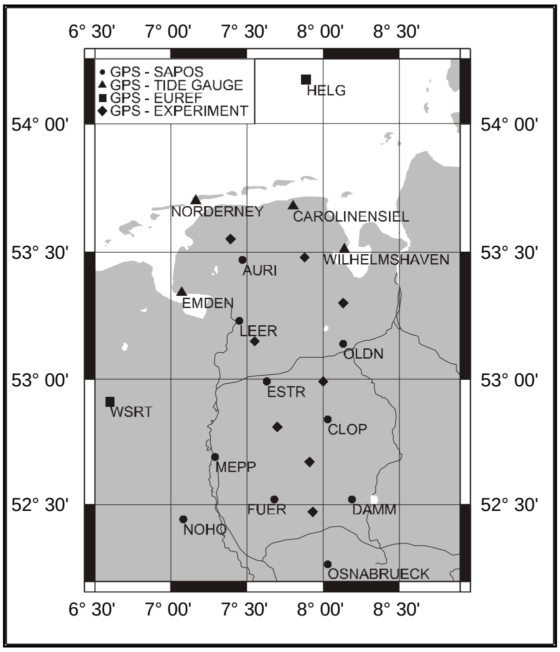

Figure 1: Picture of the NNSAT-Permanent network

First results:

Station validations were carried out for every station of NNSAT-permanent network using the Dresden validation software (Wild, Wanninger 1999). The stations showed a different quality, especially Norderney was strongly disturbed by multipath effects and has meanwhile been moved to another place on the island.
The NNSAT-permanent network is realized with Trimble 4000 SSI/4700 receivers, each antenna (Trimble Microcentered and Trimble Chokering) had been individually calibrated. The main distance is about 40 kilometres.
The additional densification SAPOS-WSV with distances of 20 kilometres along the river Ems is still missing. Therefore an experiment NNSAT 99 with ten additional stations between Osnabrück-Wallenhorst and the coast took place during eleven

days in fall 1999:
- mean distance 25 kilometres, elevation mask 5°, 24 tropospheric parameters/day, Niell-mapping function, elevation dependent weighting.

The dense network allowed the fixing of more ambiguities (Bernese Software Sigma - L5/L3 - algorithm, WaSoft) - up to 97%. The repeatability of GPS-heights is on the 3-4mm level. Using Wa Soft the repeatability of the height component is about 20% better in the dense network than in the SAPOS-net. Using Bernese Software this effect was not significant.

The introduction of water vapor measurements

Was done in a first step with a small European network around the stations Wettzell and Zurich (Kruse 2000) using the existing WVR II - Radiometer measurements (CAPTEC 1999), the existing inversion coefficients for Wettzell and Zurich and the data of about one month. The water vapor radiometer zenith wet delay estimate and the deterministic GPS-model estimate did not fit together very well that time. The disagreement could not be removed by the introduction of only one offset per day. Therefore it had been no surprise that the introduction of these values did not improve the GPS-height component. Meanwhile radiosonde measurements of 15 European stations were used for the determination of inversion coefficients for the PTX-algorithm, see Elgered (1993). It was found, that the major coefficients vary with time and latitude (Somieski 2000).

Outlook

All results presented in this first step are only trends due to the small time frame. The project NNSAT will include measurements of more than one year (NNSAT-permanent network as well as WVR measurements) and allow the determination of results on a more reliable basis.

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