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1 Introduction / site description

At the fundamental site Wettzell actually (June 2004) six different GPS and GPS+GLONASS receiver/antenna pairs have been installed and are observing permanently:

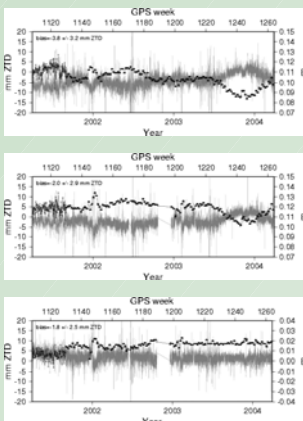
WTZR	AOA SNR-8000ACT	AOAD/M_T NONE
WTZT	Trimble 4000SSI	TRM29659.00 NONE
WTZA	Ashtech Z-XII3T	ASH700936C_M SNOW
WTZZ	JPS Legacy	ASH701073.1 SNOW (GPS+GLONASS)
WTZJ	JPS E_GGD	JPS_REGANT_SD_E NONE (GPS+GLONASS)
WTZL	Leica GRX1200PRO	Leica AX1202

The antennas are mounted on a concrete survey tower, about 7.5 m over ground. Most of the data have been analysed routinely at BKG within the German Reference Network (GREF), the IGLOS project and within a private network "RGAG". Results of local monitoring at the fundamental site were presented by (Rothacher et al., 2004). While the antennas are mounted very close together with small absolute height differences it can be assumed that the atmosphere is acting on all antennas in the same way. Therefore remaining differences in the Zenith Total Delay (ZTD) parameters may represent the noise level, external influences or differences in the various equipment packages. The time series of ellipsoidal height differences can show the influence of equipment changes, reference frame changes or network definition.



2 ZTD and ellipsoidal height parameter from GREF analysis

The data of the stations WTZR, WTZT and WTZA are analysed within the GREF on a daily basis. The final weekly coordinate solution is fixed to the ITRF2000 coordinates of seven reference stations (GRAZ, KOSG, MATE, ONSA, POTS, REYK, WTZR). The daily ZTD parameters are finally estimated with the weekly coordinate solution fixed. The resolution for the ZTD parameter estimation was changed to one parameter per hour in GPS week 1130.

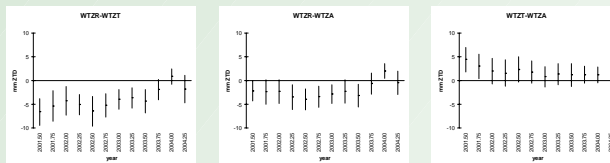


2.1 ZTD and height differences

The three figures on the left show the differences in ZTD and height (black triangles) for WTZR minus WTZT (top), WTZR minus WTZA (middle) and WTZT minus WTZA. The changes in the processing options starting with GPS week 1130 are visible. There seem to be small biases regarding WTZR but they are still on the noise level. Concerning the differences to WTZR an anomaly of approx. 10 mm ZTD and approx. -15 mm in height can be seen between GPS weeks 1230 and 1260. The non-reference stations WTZT and WTZA behave in the same way and their differences are almost stable. The correlation between the two ZTD series is 0.9985, for the series including WTZR the coefficients are 0.9975 and 0.9981. The standard deviations of +/- 2.5 - 3.2 mm are in a good agreement and show the precision of ZTD parameter estimation with GPS.

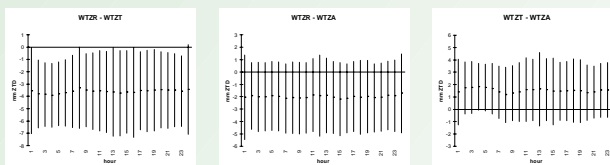
2.2 ZTD seasonal mean differences

The three figures below contain the quarterly mean differences in ZTD between the three stations WTZR, WTZT and WTZA. A small annual signature of 2 mm maximum can be seen in the differences with reference station WTZR. The values at 2004.00 reflect the disturbance between GPS weeks 1230 and 1260.



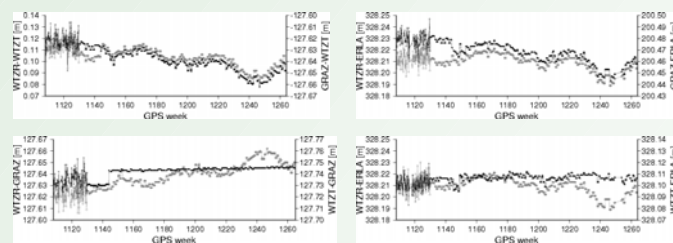
2.3 ZTD sub-daily mean differences

For the three figures below the mean differences in ZTD between the three stations WTZR, WTZT and WTZA were calculated separately for every hour (GPS week 1130-1263). The mean values are nearly constant on a sub-day level for all three combinations. The differences between the two non-reference stations WTZT and WTZA show the smallest noise level. The highest standard deviations are at noon and at midnight.



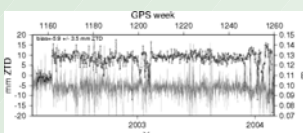
2.4 Cross-comparison with other stations

Comparisons of the height difference time series of reference station WTZR and non-reference station WTZT with two other stations, reference station GRAZ and non-reference station ERLA (approx. 145 km distance to Wettzell), are given in the four figures on the right. They left y-axis is corresponding to the grey cycles. The differences between the two reference stations and ERLA (top left) as well as WTZT (top right) show the same anomaly between GPS weeks 1230 and 1260. On the other hand, the height difference between the non-reference stations ERLA and WTZT (bottom right) is as stable as the difference between WTZT and WTZA (see figure above). Therefore the anomaly can not be ascribed to reference station WTZR but seems to be a result of the reference frame fixing.



3 ZTD estimates derived from private network „RGAG“

The permanent station WTZJ – only the GPS data stream is used – has been included in the analysis of a private GNSS network „RGAG“. This network, which also includes some IGS and EUREF stations as reference stations, consists of approx. 55-60 sites and is primarily analysed on a daily basis using IGS Rapid Orbits. Here the results of a post-processing using IGS Final Orbits are presented. A minimum constraint solution using the stations GRAZ, KOSG, ONSA, POTS, WTZR and ZIMM has been processed, the ZTD parameters are estimated every two hours.

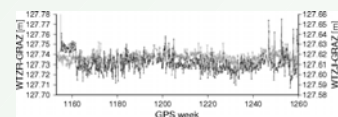


3.1 ZTD and height differences

ZTD and height differences are quite stable. The correlation between the ZTD values of the stations WTZR and WTZJ is high (0.9976). There is a bias of approx. 6 mm between the ZTD estimates of both stations. The visible scattering in the differences during the winter periods is mutually caused by ice and snow covering on the antenna of WTZJ.

3.2 Comparison with other stations

The figure on the right shows the height differences between the two reference stations WTZR and GRAZ (grey cycles) and between the non-reference station WTZJ and GRAZ. It can be seen that the two series match quite well. The anomaly between GPS weeks 1230 and 1260 observed in the GREF analysis is not visible here. Since the reference stations are not fixed in this solution the difference between WTZR and GRAZ is not constant (or linear) over time.



4 Conclusions

Although the GNSS antennas at the Wettzell fundamental site are mounted very close together with (for Zenith Total Delay estimation) negligible height differences small biases between the estimated ZTD parameters have been observed. These biases especially concern the differences to station WTZR.

From the standard deviations of the mean differences between the ZTD time series a realistic value of 2.5 - 3.5 mm for the precision of ZTD parameter estimation with GPS can be derived.

The way of fixing or constraining the network to a reference frame influences the height and ZTD parameter estimation.