GOP NRT tropospheric product for the COST-716 campaign 2001

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1. Introduction

The European action for the exploitation of ground-based GPS for climate and numerical weather prediction applications is organized within the COST project, Action 716 *www.oso.chalmers.se/geo/cost716.html* (COST-716 [ELGERED, 2001]). The project was started in 1999 and one of the main goals of the COST-716 is to demonstrate that it is possible to use the GPS data for the operational meteorology. The COST-716 near real-time (NRT) demonstration campaign has been initiated in February 2001, [MAREL et al., 2002], and the Geodetic observatory Pecny (GOP) has been operating from the beginning as one of the GPS analysis centers. We present here the results of our NRT tropospheric monitoring during this demonstration campaign in 2001. The analysis has been purely based on the use of IGS ultra-rapid orbit product, we thus firstly give an overview of its performance during 2001 as it was monitored by GOP.

2. IGS ultra-rapid orbits (2001)

The IGS ultra-rapid orbits (IGU) have been available since March 2000, [SPRINGER and HUGENTOBLER, 2001]. Since the IGU product is available two times per day, we use the identification IGU_00 and IGU_12 labels for the moorning and the afternoon orbits respectively.

From the beginning, the product suffered especially of the lack of data and a few participating analytic centers. Nevertheless, mostly six centers has already delivered their contributions during the whole year 2001, and thanks to the effort of many operational centers, data centers and the coordination by IGS, the IGU product started to be very stable. This is obvious from Fig. 1, which demonstrates the mean and median RMSs derived independently for each satellite comparing the ultra-rapid and the final IGS orbits. The comparisons are based on daily positional differences over the whole year 2001 separately for fitted and predicted orbit portions. The quality can be characterized as the median RMS 8cm and 18cm (or the mean RMS 10cm and 50cm) for daily fitted and predicted part respectively. The figure shows the results of the afternoon product, but the moorning one looks very similar. From the figure, we clearly see a few satellites mostly cause the problems in 2001: PRN15, 17, 19, 21, 23, (24). These were also very often missing in the product as obvious from Fig.2.

There was only a single missing IGU solution during the year 2001: doy 310 (IGU_12). Using the product in NRT as well as looking at a posteriori comparison time-series, we could identify about 2 - 4 further solutions hardly useable in its predicted parts. These are IGU_12 - doys 059, 064, 079 and 112. Since the problem always dealt with the single IGU combination, we could simply use the extended (predicted) orbit arcs from the previous IGU product in our NRT analysis.

3. The COST-716 near real-time campaign

Since the beginning of 1999, the GOP analysis center has been routinely analysing a part of the EUREF Permanent GPS Network (EPN) for the NRT monitoring of the tropospheric delays. Our solution has been processed using the Bernese GPS software [HUGENTOBLER et al., 2001] and the double-differenced observation approach. From the beginning, various strategies of NRT analyses, especially concerning different orbit handling, were performed, [Dousa, 2001].

High stability of the IGU product in the second half of 2000 allowed us to simplify a procedure by fixing the orbits during analysis for the COST-716 NRT campaign. The procedure of satellite checking is based on the residual monitoring [SPRINGER and HUGENTOBLER, 2001]. In our NRT processing this is performed in two steps: 1) very bad orbits are completely excluded from the processing and 2) in other cases of instability, the PRNs are excluded on every problematic baseline individually (typically by long baselines). The necessity of the first step was rather exceptional during the year 2001, because these satellites were already excluded during the IGS combination.

The procedure of our NRT analysis has been running for every hour by estimating one zenith tropospheric delay parameter (ZTD) per hour and site. The whole procedure is based on the pre-processing hourly batch data followed by the stacking of last 12 hourly normal equations. The coordinates are solved for the last 7 days in step before the final ZTD estimation and then they are already kept fixed. The latency of the COST-716 NRT tropospheric product is required to be less then 1 hour 45 minutes. In our processing the results are usually available in 1 hour, half of which the processing is just a waiting time for the data. The network analysed by GOP for the COST-716 project mostly consists of approx. 40 EPN sites providing GPS data on hourly basis. The central and the eastern part of the Europe is the preffered location, see Fig.4. The GPS sites operated by the UK MetOffice are processed additionally within our contribution to the COST-716.

Apart from the NRT solution, GOP analysis center provided routinely a post-processed GPS solution (PP) in 2001. This is based on the daily processing and the use of IGS rapid orbits. Presented ZTD comparisons between our NRT and PP solutions trepresents the internal GPS quality (Table 1

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and Fig. 3) of two slightly different approaches and applying different fixed orbits.

In addition, for some sites of our network, where radiosonde sites to GPS stations (< 80km) are available (Fig.4), we could compare our ZTD results (transformed into the precipitable water vapor, PWV) with those PWVs integrated from the radiosonde profiles. The total PWV comparison is summarized in Table 2, while monthly comparisons in Fig. 5. The only short examples of the PWV time-series are available in Fig. 6.

4. Conclusion

The results presented in this paper proved that the IGS ultra-rapid orbits have reached the stability sufficient for the operational NRT tropospheric monitoring in 2001.

Summarizing the results, we could find the typical standard deviations of 4-6mm in our GPS ZTD estimates, while about 7mm in ZTD for sites on margin of our network (baselines 2000km). The standard deviation of 1.2-2.1mm is stemming on the preliminary PWV comparisons with an independent technique – radiosonde profiling.

Acknowledgements

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Table 1. GPS ZTD comparisons (NRT - PP)

Site	Bias [mm]	Sdev [mm]	#
ABYW	-0.3	5.4	3996
BEAU	-0.4	5.1	4246
BOGO	-0.1	4.7	3288
BOR1	0	4.4	5171
BUCU	-0.7	5.9	4118
BZRG	-0.9	5.8	3999
CAGL	0.9	7	3050
CAMB	-0.8	5.3	4739
DELF	0.4	4.8	4472
DENT	-0.4	5.1	758
DOUR	-0.8	4.9	4574
DUNK	-1.1	5.3	5112
EIJS	-0.4	4.3	4479
GOPE	-0.8	5.2	4863
HELG	-0.4	5.3	5179
HERS	0.3	5.4	3613
HOFN	-0.6	5.7	3776
HURN	-0.4	5.3	4080
ISTA	-0.8	7	4041
KIRU	0.3	5.2	2079
LERW	-0.4	4.8	5168
MALL	-1.2	7.4	4813
MAR6	0.3	4.7	4958
MATE	-0.9	7	4244
ONSA	1.4	4.5	4985
ORID	-0.9	6.1	4157
OSJE	-0.8	5.1	4978
PENC	-0.1	4.8	4562
PERS	-1.1	5.1	3839
PFAN	-0.4	4	2757
POTS	0.7	4.1	5493
REYK	3.9	7	4982
SBGZ	-0.3	4	3166
TERS	0	4.4	4538
TORI	-0.6	5.8	3742
TUBO	-0.2	4.3	1732
UPAD	-0.4	5.2	4290
VALE	-0.6	7.5	4427
VENE	0	5.1	4529
VIS0	0.4	4.6	5010
WROC	-0.7	4.6	3578
ZWEN	0.6	6.6	3605

Table 2. PWV comparison (GPS – radiosondes).

Site	Bias [mm]	Sdev [mm]	#
BOGO	0.8	1.2	228
BUCU	0.6	1.8	279
CAMB	0.9	1.3	666
DELF	-0.1	2	670
GOPE	0.5	1.6	788
HERS	0.5	1.6	257
ONSA	0.9	1.6	277
PENC	-0.4	1.9	350
POTS	0.1	2.1	847
WROC	0.7	1.6	91

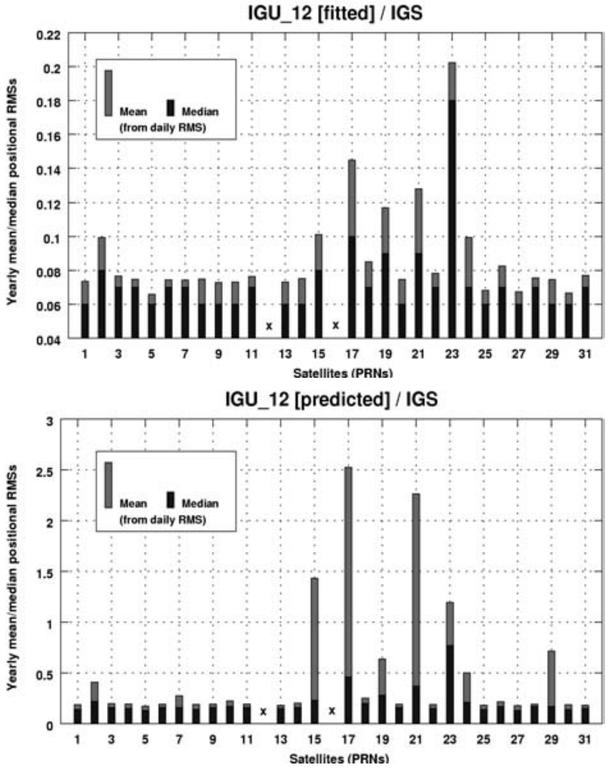

Figure 1. The mean and median RMSs for all satellites based on the IGS ultra-rapid and final orbit comparisons 2001. The left figure represents 24-hour fitted portions and the right plot 24-hour predicted portions (notice the different scales, both in [m]).

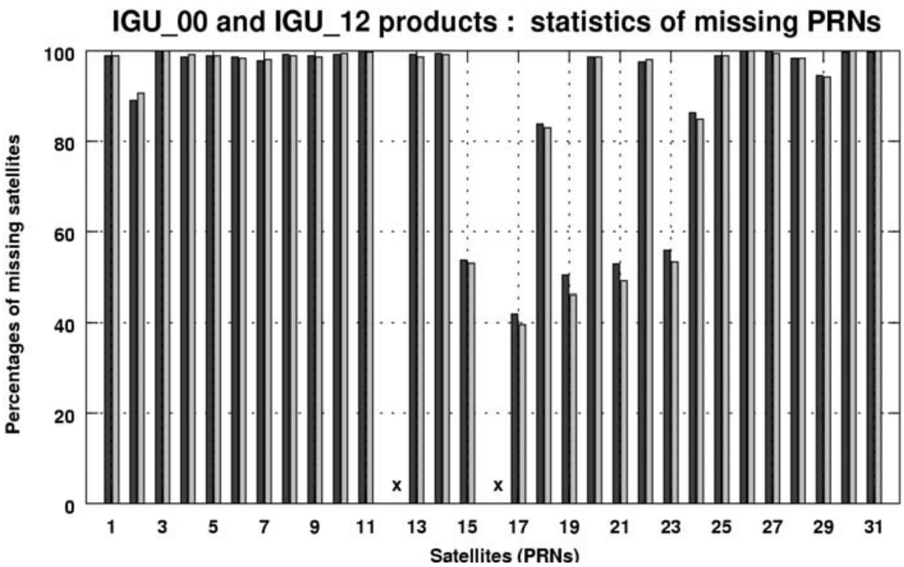

Figure 2. Statistics of the satellites missing in the IGU_00 and IGU_12 products during the year of 2001.

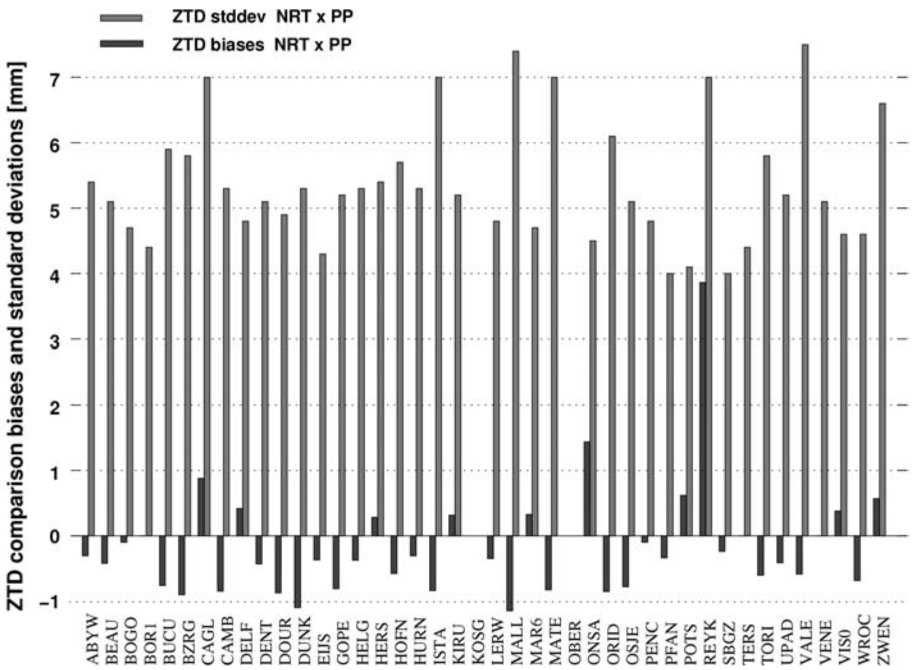

Figure 3. ZTD comparison statistics between the near real-time and the post-processed results (May-Dec, 2001).

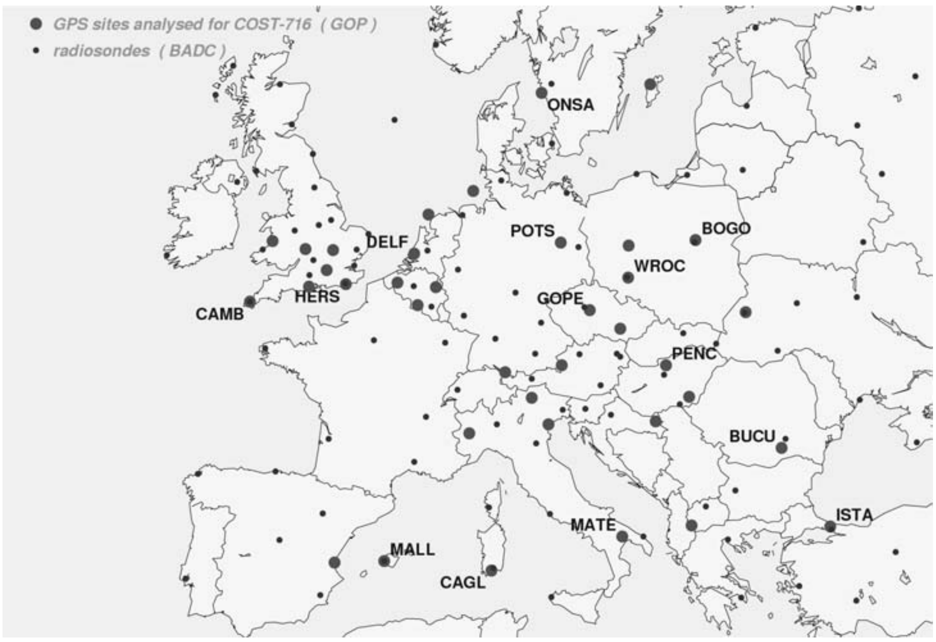

Figure 4. Maps of GPS and radiosonde sites available for the comparison.

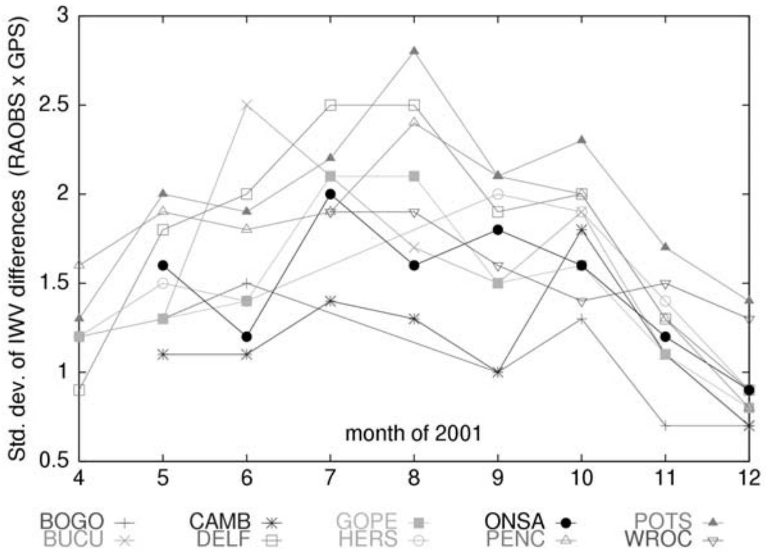

Figure 5. Site std.dev. of integrated water vapor (IWV in [kg/m²] » PWV in [mm]) for the monthly differences: GPS - radiosondes.

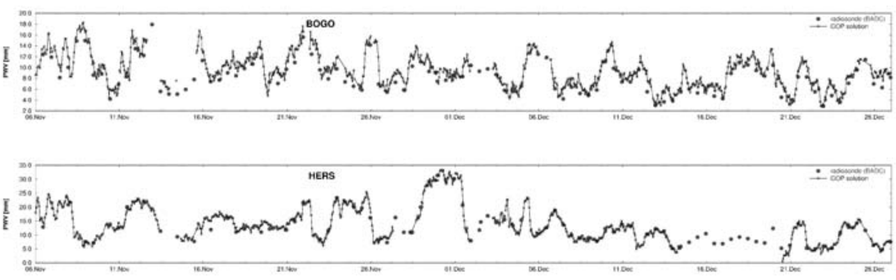

Figure 6. GPS and radiosonde derived precipitable water vapor [mm] time-series for the sites BOGO and HERS