Progress and Status of the EPN Special Project "Troposphere Parameter Estimation"

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Abstract

After two years of routine processing within the EUREF Permanent Network Special Project "Troposphere Parameter Estimation" a second status report is given. First results of the inclusion of a "rapid" EUREF troposphere solution into the IGS combination of Zenith Total Delay values are shown. Results of a test computation using the EUREF weekly combined coordinate solution instead of the specific coordinate solution of the individual Local Analysis Centers are presented.

Introduction

In June 2001 the EUREF Permanent Network (EPN) Special Project "Troposphere Parameter Estimation" started its practical work [Söhne, Weber 2002]. The number of contributing Local Analysis Centers (LACs) has been growing continuously and since GPS week 1143 all LACs of the EPN have been delivering their troposphere solutions routinely (table 1).

The homogenisation of the parameter settings went on during the past months. The last LACs changed to the "Dry Niell" mapping function. Only the Italian Space Agency (ASI) is still solving for a two hours troposphere sampling rate instead of one hour using an Elevation Cutoff of 15 degree instead of 10 degree. All but two LACs (DEO, IGN) have been fixing the coordinates to ITRF2000 (or IGS00) within their weekly solution. Using this solution for the final computation of the daily troposphere files is still not homogeneous. The coordinates written in the header of these files are varying for some mm even to cm for at least 5 out of the 16 LACs (table 2).

Tab. 1: Progress of the Special Project "Troposphere Parameter Estimation" since June 2001

GPS week	Event
1108	Contribution of BKG
1109	Contribution of UPA
1110	Contribution of ASI and COE
1110	First combination at BKG
1111	Contribution of IGN and LPT
1112	Contribution of OLG
1113	Contribution of WUT
1114	Contribution of NKG
1115	Contribution of GOP
1116	First combination at GFZ
1120	Contribution of BEK
1126	Contribution of IGE
1130	New EUREF processing options: 10 degree elevation cutoff angle Elevation-dependent weighting Use of the „Dry Niell"-mapping function 1 hour troposphere solution Use of the IGS final orbits Additional new options for troposphere: Fixing (constraining) solutions to ITRF 97 coordinates Re-substitution of weekly SNX solution
1130	Contribution of DEO and ROB
1143	Switch to new reference frame ITRF 2000
1143	Contribution of SGO
1185	Contribution of SUT
1203	Contribution of EPN troposphere solution to IGS combination of tropospheric estimates

Tab. 2: Options and parameter actually (GPS week 1210) used by the LACs

LAC	Sampling [hours]	Elevation Cutoff [deg]	Troposphere Model	Software	Fixing coordinates	Re-Substitution of SNX	No. of sites analyzed
ASI	2	15	Dry Niell	MicroCosm	Yes (WTZR)	No (except WTZR; others mm to cm variation)	~ 23
BEK	1	10	Dry Niell	Bernese	Yes (7 sites)	Yes	~ 38
BKG	1	10	Dry Niell	Bernese	Yes (7 sites)	Yes	~ 45
COE	1	10	Wet Niell	Bernese	Yes (all sites)	Yes	~ 37
DEO	1	10	Dry Niell	Gipsy	No	No (some mm variation and discrepancy)	~ 25
GOP	1	10	Dry Niell	Bernese	Yes (5 sites)	Yes	~ 35
IGE	1	10	Dry Niell	Bernese	Yes (YEBE)	Yes	~ 21
IGN	1	10	Dry Niell	Bernese	No	No (some cm variation and discrepancy)	~ 23
LPT	1	10	Dry Niell	Bernese	Yes (5 sites)	Yes	~ 19
NKG	1	10	Dry Niell	Bernese	Yes (8 sites)	Yes	~ 36
OLG	1	10	Dry Niell	Bernese	Yes (BUCU)	Yes	~ 39
ROB	1	10	Dry Niell	Bernese	Yes (2 sites)	Yes	~ 27
SGO	1	10	Dry Niell	Bernese	Yes (PENC)	No (few mm variation)	~ 17

SUT	1	10	Dry Niell	Bernese	Yes (ZIMM)	Yes	~ 26
UPA	1	10	Dry Niell	Bernese	Yes (MATE)	(Yes) (except some mm discrepancy for reference site)	~ 16
WUT	1	10	Dry Niell	Bernese	Yes (3 sites)	Yes	~ 32

Results

Weekly combined solution

Figures 1 to 4 show some summarized results of the routine troposphere combination at BKG. The weekly mean biases are mainly in the range of ± 2-3 mm except for the LACs DEO and IGN which do not fix the coordinate solution to ITRF. After some modifications within the software the ASI solution fits better to the other solutions. Except for some temporary discrepancies the standard deviations of the weekly mean biases are below 3 mm for all LACs. Within the figures 3 and 4 the distribution of the site-dependent weekly mean biases and standard deviations for every Local Analysis Centre is given. The main peaks in figure 3 should be close to zero (i.e. no biases) which is fulfilled for most of the LACs. For the LACs DEO and IGN the highest number of biases is shifted to –5 with the same explanation of not fixing the coordinate solution to ITRF as described above. The site-specific standard deviations are below 5 mm with the exception of ASI. A possible explanation is that ASI is still solving for the troposphere parameters in two hour intervals which leads to an interpolation to one hour values for the combination.

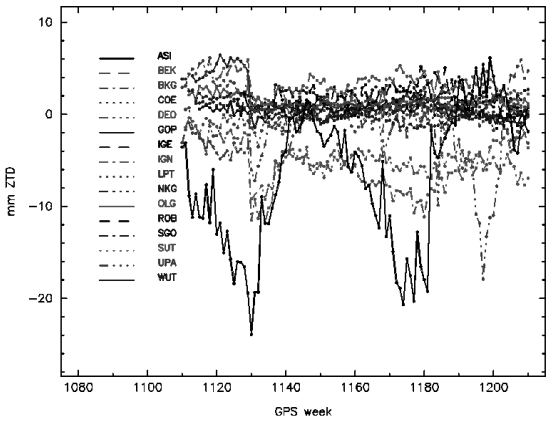

Fig. 1: Weekly mean biases for the Local Analysis Centres compared to the weekly combined solution (GPS weeks 1110-1210)

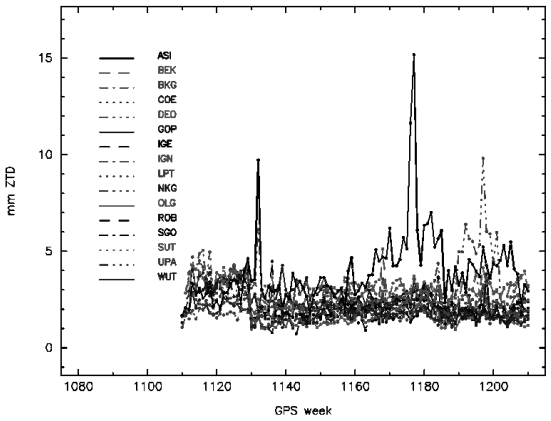

Fig. 2: Standard deviation of the weekly mean biases (GPS weeks 1110-1210)

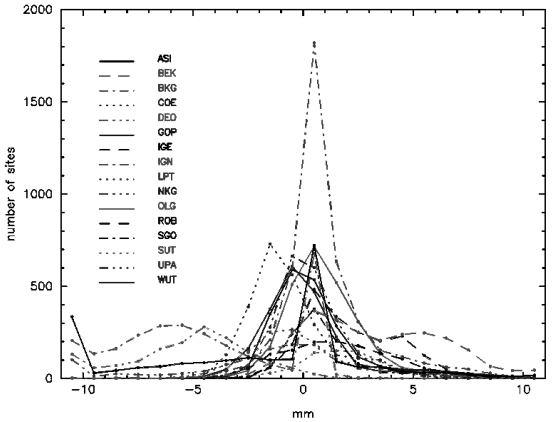

Fig. 3: Histogram of site-specific weekly mean biases for the Local Analysis Centres (GPS weeks 1143-
1210)

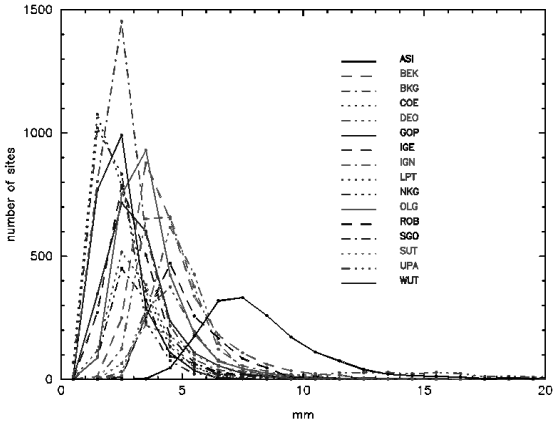

Fig. 4: Histogram of site-specific standard deviations (GPS weeks 1143-1210)

EPN weekly combined solution and IGS combination of tropospheric estimates

In GPS week 1203 the inclusion of the EPN troposphere solution into the IGS combination of Zenith Total Delay (ZTD) values started as it was proposed during the last EUREF workshop in 2002. The IGS combination is based on a two hours sampling rate, therefore the higher sampled EPN solution has to be averaged. There are about 40 IGS sites enclosed in the EPN which are routinely analyzed for coordinate and troposphere parameters by the EPN LACs. At the moment the IGS combination consists of 7 individual solutions of the IGS Analysis Centers (COD, EMR, ESA, GFZ, JPL, NGS, SIO) [Gendt 1997]. The IGS troposphere coordinator, Gerd Gendt of GeoForschungsZentrum Potsdam, has started the extended IGS troposphere combination in GPS week 1203. For about 10 European sites the number of individual solutions could be increased from 2 to 3 or from 3 to 4.
The critical point of the EPN contribution to IGS is the timing. The weekly troposphere combination in IGS should have only a small time delay compared to the IGS final orbits. These final orbits are made available 13-16 days after closing the observations of a GPS week. On the other hand, for computing the individual EPN troposphere solutions the input of the IGS final orbits is mandatory and, therefore, there is a need for an additional time delay for the EPN LACs to complete their solutions. We decided to take the end of the (calendar) week (Friday afternoon) as a good compromise between the needs of EPN analysis and IGS troposphere combination to compute a preliminary EPN troposphere combination. Analyzing 10 weeks (GPS weeks 1190-1199), between 6 (e.g. GPS week 1195) and 12 (e.g. GPS week 1198) EPN LACs met this requirement. The other LACs were asked to consider the chances to accelerate their routine EPN analysis to meet the special requirement.
Figures 5 and 6 show the weekly mean bias and the standard deviation of the IGS troposphere combination. The standard deviation of the EPN contribution agrees with the other solutions on a ± 2.5 mm level. The remaining bias of ~ 2 mm ZTD is probably because of the fact that the EPN solution is a regional instead of a global solution such as the other seven solutions. For the first 14 weeks (GPS weeks 1203-1216) between 10 and 14 EPN LACs have delivered their troposphere solutions within the above mentioned time frame.

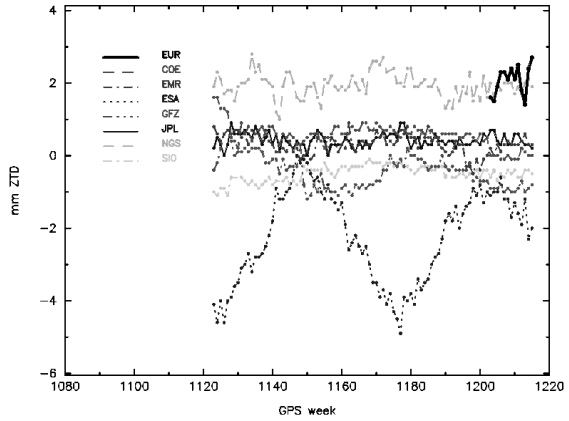

Fig. 5: Weekly mean biases for the Analysis Centers of IGS troposphere combination

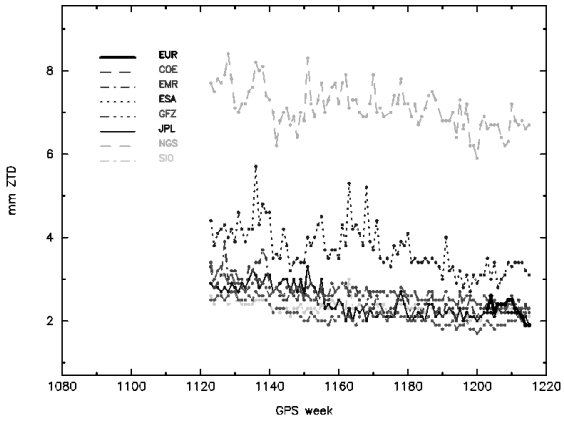

Fig. 6: Standard deviation of weekly mean biases of IGS troposphere combination

Using EPN weekly combined coordinate solution

Within the routine processing of the troposphere parameters every LAC is using its own weekly coordinate solution. Comparing the ellipsoidal coordinates a variation in the height component in the range of some mm up to few cm between the individual LACs can be seen. These height differences may be an explanation for the biases between the individual solutions. To overcome this problem an interim solution is the correction of the ZTD values by the height differences. The correction of the ZTD values for height differences in a manner "EUREF combined solution minus specific LAC solution" roughly follows a simple 3:1 relation between height and troposphere variation.

The next step of unification may be the use of an identical set of coordinates, i.e. every LAC uses the EUREF weekly combined solution instead of the specific LAC solution for the final ZTD computation. Within a test campaign the troposphere solutions of GPS weeks 1143-1163 were re-computed. 5 LACs - ASI, BKG, NKG, ROB, WUT - were participating. The lack of the ASI solutions was that they had a lower sampling rate. For the WUT solutions there was still a variation of the coordinates of some mm. Therefore for the first comparisons only the three LACs BKG, NKG and ROB were used.Figure 7 shows the daily mean biases and standard deviations of the combination of BKG, NKG and ROB for the four common sites BRUS, HERS, KLOP and POTS from the routine processing

(left), the height corrected solution and with common set of coordinates (right) (GPS weeks 1154-1156).
It can be seen that the height corrected solutions give higher biases compared to the routine processing but it is the most consistent combination, i.e. the biases have the smallest standard deviations.
The solutions with the EUREF weekly combined coordinates as input give worse results. The biases as well as the standard deviations are bigger than the others solutions. Possible explanations are: the LACs are using quite different networks (~25-30 sites (NKG, ROB) vs. ~45 sites (BKG)). The fixing of the EPN combined coordinate solution – which is a solution fixed to ~12 sites - does not seem to be appropriate for final computation of LAC's individual troposphere solutions. The conclusion is that further investigations are necessary for the use of a common set of coordinates as input for the final computation of the individual troposphere parameter solutions.

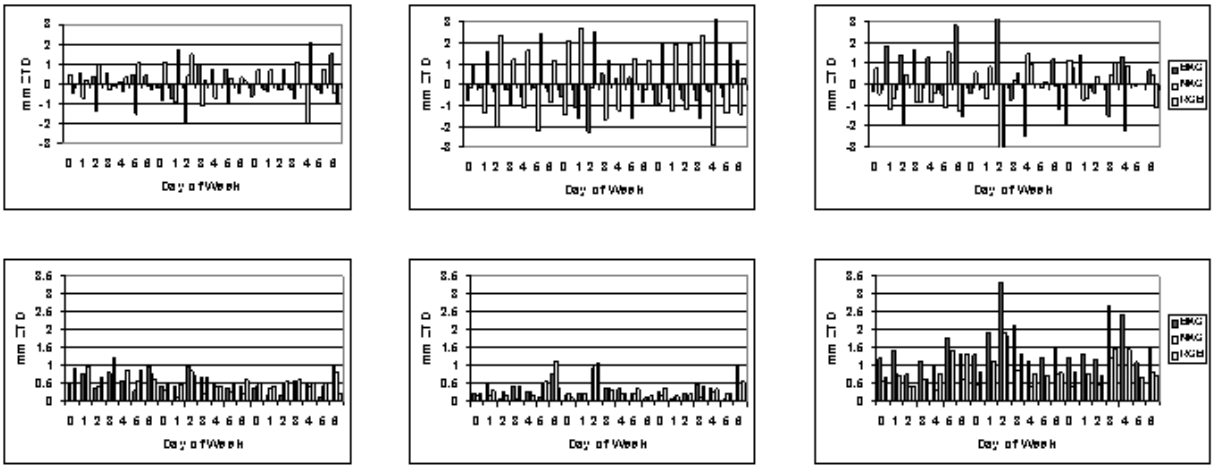

Fig. 7: Biases (top) and standard deviations for different troposphere combinations

Acknowledgement

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References

[Gendt 1997]: Gendt, G. – IGS Combination of Tropospheric Estimates (Status Report), in: Proceedings IGS Analysis Centre Workshop, Pasadena, 1997

[Söhne, Weber 2002]: Söhne, W. and G. Weber – EUREF Permanent Network Special Project – Status Report, Report on the Symposium of the IAG Subcommission for Europe (EUREF), Acores, 05-08 June 2003, (in press)