The GOP analysis center: a global near real-time solution

J. DOUSA[1]

1. Motivation

The activities of the Geodetic Observatory Pecny (GOP) analysis center in the field of the NRT processing has started already in 1999. The operational monitoring of the troposphere has got the highest priority from the beginning. The quality of the NRT orbits and the actual GPS geometry has been the crucial factors in such an analysis. We have used the CODE predicted orbits with its partial relaxation in the year 1999 [e.g. DOUSA 2001a]. Thanks to the IGS's effort in the coordination and thanks to all other responsible contributing agencies, the high quality NRT orbits (ultra-rapid, IGU), has been developed and available two times per day since March 2000 [SPRINGER and HUGENTOBLER, 2001]. The IGU product has been used as 'fixed' in the GOP routine analysis [DOUSA, 2002] for the COST-716 NRT demonstration campaign 2001 [V.D. MAREL et al., 2002]. Although the IGU product proved to be very stable for this purpose, the slight improvements can be still expected. Let assume two reasons:

up to six satellites were missing in the IGU product during 2001, weakening the GPS geometry and

using necesarilly a prediction up to 15 hours the IGU orbits can reach the meters (exceptionally tens of meters) orbit errors for some satellites.

Both limitations can be more or less significant in the high quality troposphere analysis.

2. Introduction

Based on above motivation, the GOP analysis center also processes a NRT global solution for the orbit determination. In future, we would consider worthwhile to contribute into the common orbit determination service rather than to apply any individual orbit relaxation during the NRT analysis. We would thus preffer to share our effort and benefit from the robustness of the combined (IGS) product.

Apart from the other GPS analyses at GOP, the global processing was started at the end of the year 2000. Since October 30, 2001, the analysis has been already running in fully continuous mode. The processing is performed using the Bernese GPS software (BSW) [Hugentobler et al., 2001]. The adapted version 4.2 of the BSW was applied in the beginning, while in the second half of 2001, the new (still preparing) BSW version 5.0 was introduced. Together with the significant changes between these versions, our script system has been completely recreated and efficiently prepared also for the possible update of the Bernese Processing Engine.

3. Processing system for the global solution

Our system of the global NRT analysis is based on the effective method of normal equation (NEQs) stacking. The special experiment [Dousa and Hugentobler, 2002] has proved that optimal strategy consists in six hours data preprocessing with saving the NEQs as the basic subsolutions. These pre-processing steps are analysed in 2-3 clusters combined into the short time-span global subsolution. Afterward, a long-arc orbit determination is applied stacking the sequential set of the NEQs for a 3-day final solution.

Our analysis scheme is sketched in Fig.1. Starting from January 1, 2002, the whole processing cycle and the GOP NRT orbits, has been updated every 3 hours. The global GPS observations from approx. 70 sites over the world are downloaded through the GOP NRT data center [Dousa, 2001b]. The latency of our global product is about 2 hours after the last observation, from which 50 min is the waiting time for GPS data and 60-80 min the total time for the analysis on dual 600MHz Linux PC. The orbits are determined as 3-day arcs, but final product in SP3 format consists of satellites positions of last 24 hours fitted and 24 hours predicted portions. The orbits are checked for the arc-overlap consistencies with the previous two solutions and the orbits of poor agreement are automatically excluded.

4. Global NRT tropospheric parameters

Apart from the orbit determination, the tropospheric parameters are estimated at the end of our NRT solution. It helps us to check our orbit quality directly through the global application, because the GOP orbits are already kept fixed in this solution. The analysis consists in the combination of two last 6-hour special NEQs, where we estimate one tropospheric parameter per hour and the station. From February 2002, our NRT tropospheric results are regularly uploaded to the IGS pilot combination in GeoFortschungs-Zentrum (GFZ), Potsdam. The simple preliminary comparison of our results with the combined IGS NRT product, presented in Table 1, shows a very good agreement.

5. GOP orbit performance

Only a few satellites are usually missing in our orbit product, see Fig. 2 (left). Mostly it is the lower number than by the IGU product. We were, of course, interested if these additional satellites in our product achieve the sufficient quality. The right plot in Fig. 2 confirms the high quality for the last compared 30 days, where generally 2-3 additional satellites are available in GOP, but missing in IGS products. During 5 month period (Nov 1, 2001 - Mar 2, 2002), the performance of GOP orbits was variant, but it shows the

[1] Jan Dousa, Research Institute of Geodesy, Topography and Cartography,250 66 Zdiby 98, Czech Republic, e-mail: dousa@fsv.cvut.cz

significant improvements especially from the start of 2001, and later on from the beginning of March, 2002, Fig. 3. The reasons were due to the additional implementations in our solution: careful network reconfiguration, optimization of the site monitoring method, setting up an alternative internet connection eliminating significant data gaps and others.

Checking the differences between GOP and IGS rapid orbits during the last 30 compared days resulted in the mean RMS of 10-15cm for the fitted portions and for the 6-hour predicted portion about 20-25cm, see Fig. 3. The comparison performed between GOP and IGU products for the last 3 months (starting on January 1, 2002) is characterized by the values only slightly higher: 13-17cm for the fitted and 20-32cm for 6-hour predicted portions.

The direct use of our orbits for the global tropospheric monitoring gives the mean standard deviation of 3.9mm and mean bias of 2.5mm for the ZTDs based on 350 pairs per site in average (Table 1).

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Table 1. ZTD comparison (GOP, IGS ultra-rapid combined).

Site	Bias [mm]	Sdev [mm]	# pairs
ALGO	+4.4	34	542
AUCK	+1.8	50	183
BRUS	+2.1	21	420
CHUR	+1.5	26	572
COCO	+4.3	59	183
CRO1	+2.9	71	245
DRAO	+3.5	29	559
FAIR	+2.6	40	452
GOLD	+2.3	21	430
GUAM	+2.9	46	162
HARB	+0.3	24	392
HOFN	+6.0	35	580
HRAO	+1.7	43	217
IISC	-26	53	184
KERG	+2.0	57	309
KIRU	-5	24	367

Site	Bias [mm]	Sdev [mm]	# pairs
KOUR	+1.6	66	190
LAE1	+2.8	55	286
MALI	+1.6	65	288
MAS1	+2.5	42	241
MATE	+2.2	35	488
MBAR	+2.6	45	231
MCM4	+2.7	30	447
MKEA	+1.9	47	212
MSKU	+1.8	43	356
NKLG	+0.8	49	294
NLIB	+7.9	72	213
NRC1	+1.4	23	185
ONSA	+2.1	21	358
PERT	+5.5	37	372
POTS	+2.7	25	599
PRDS	+2.2	21	368

Site	Bias [mm]	Sdev [mm]	# pairs
REYK	+2.1	25	526
RIOG	-28	62	227
SANT	+4.4	68	245
SCH2	-15	21	373
STJO	+0.6	33	405
THTI	+0.8	67	155
TIDB	+4.7	39	393
TOW2	-14	30	170
USUD	+3.1	45	196
VILL	+0.4	23	417
WHIT	+0.3	20	393
WTZR	+3.2	26	592
YAR2	-15	26	393
YELL	+3.7	26	555
ZWEN	+2.4	30	528

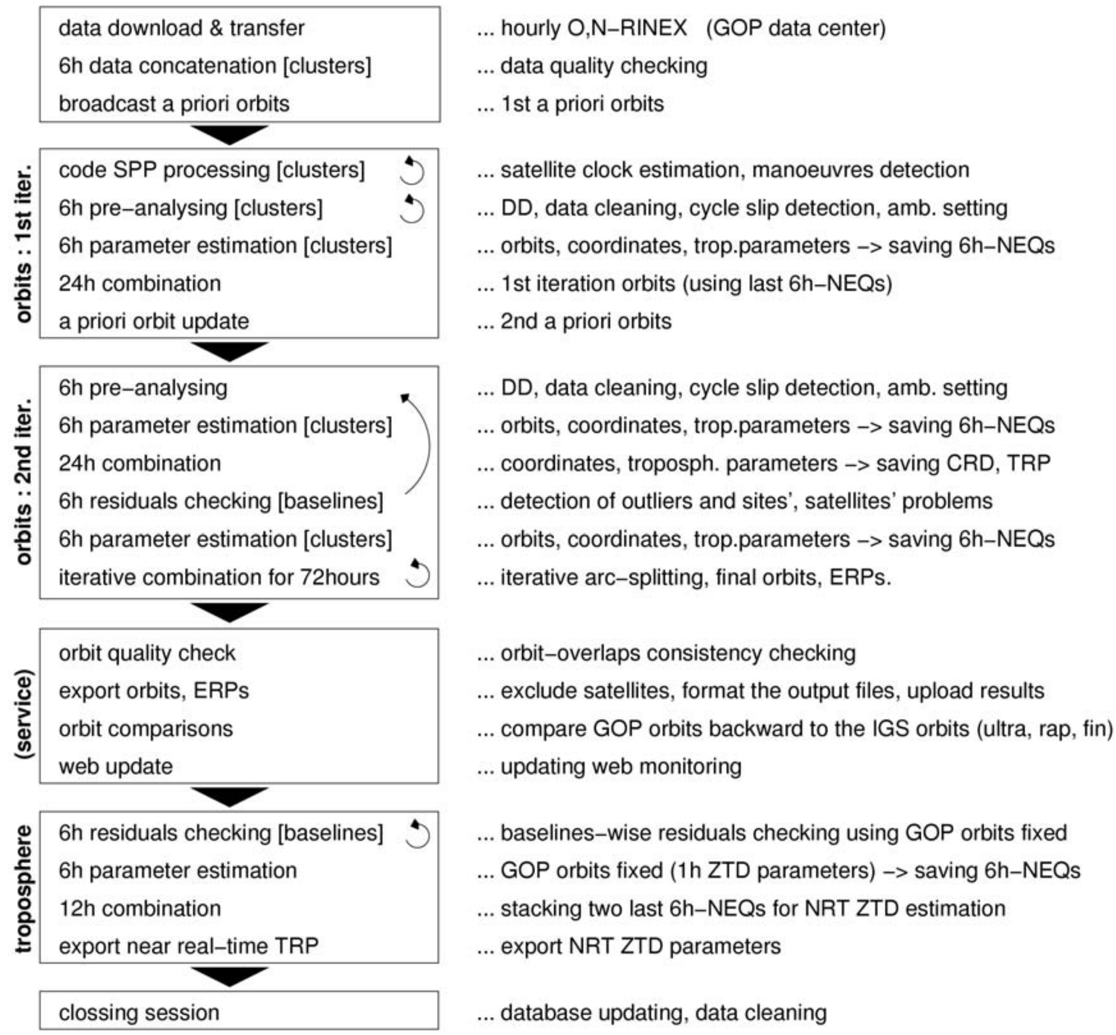
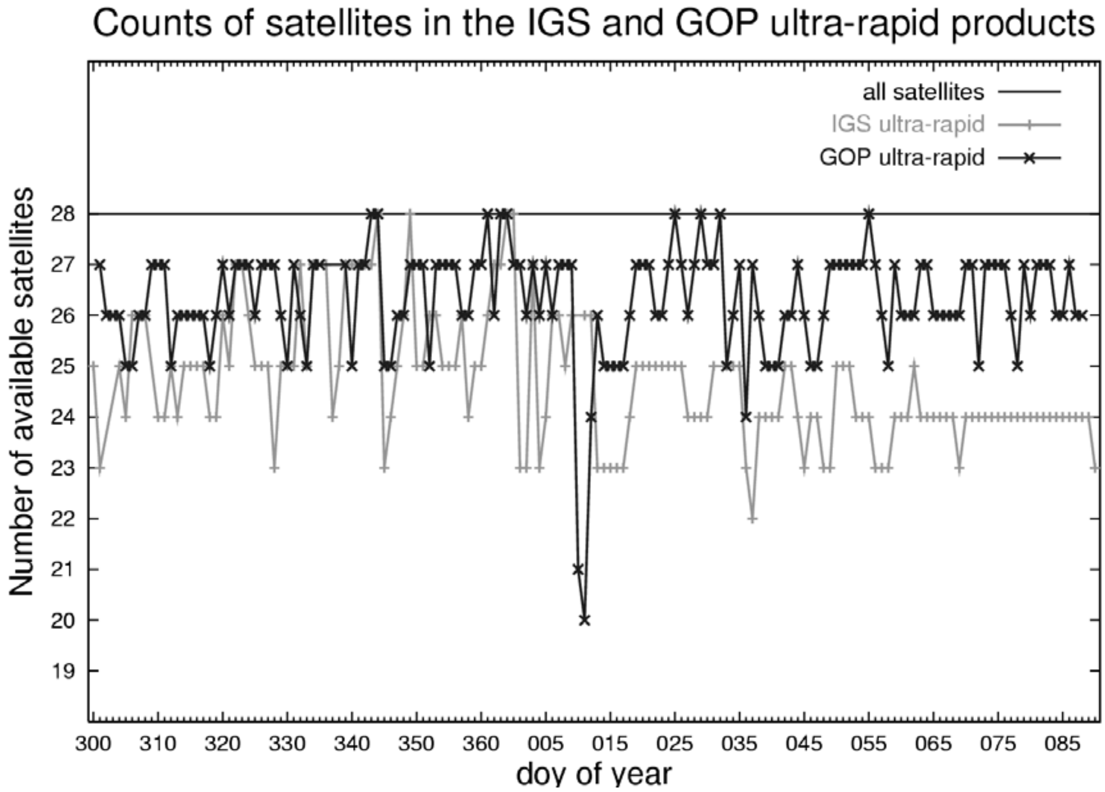


Figure 1. Analysing scheme of the GOP global NRT solution for the orbit determination and the tropospheric delay monitoring.



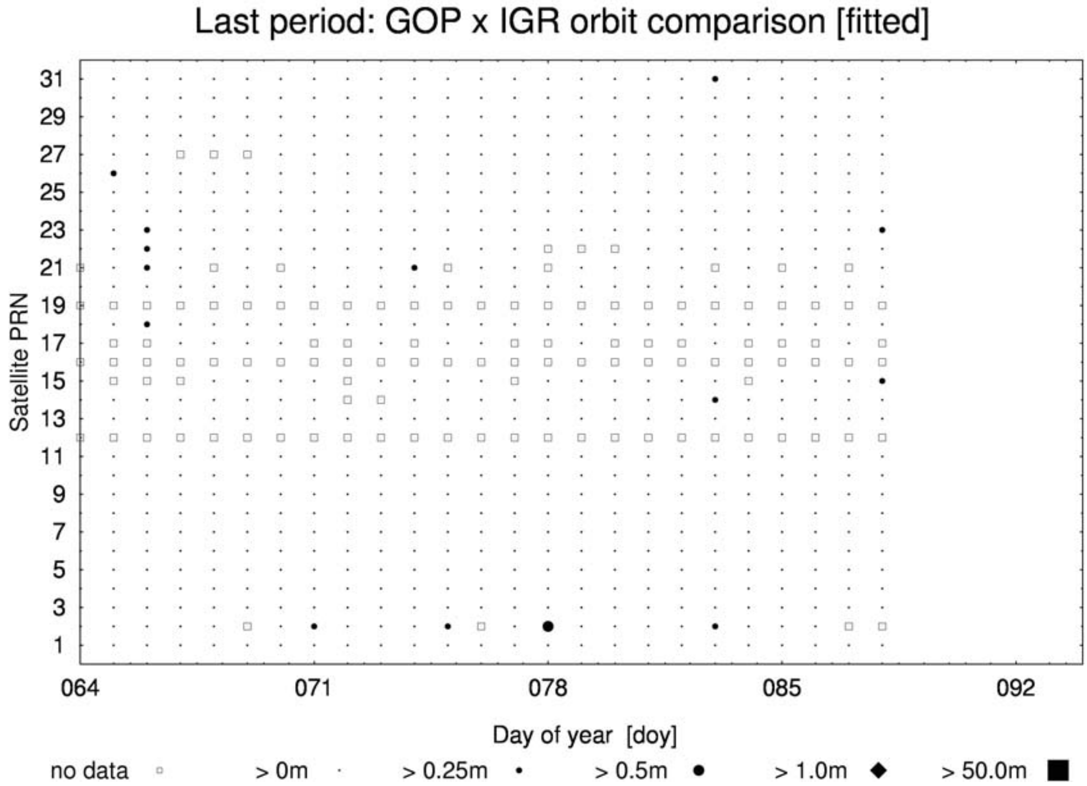


Figure 2. Number of satellites available in IGS ultra-rapid and GOP products (left). The right plot shows the GOP orbits compared to the IGS rapid orbits during the last available 30-day period.

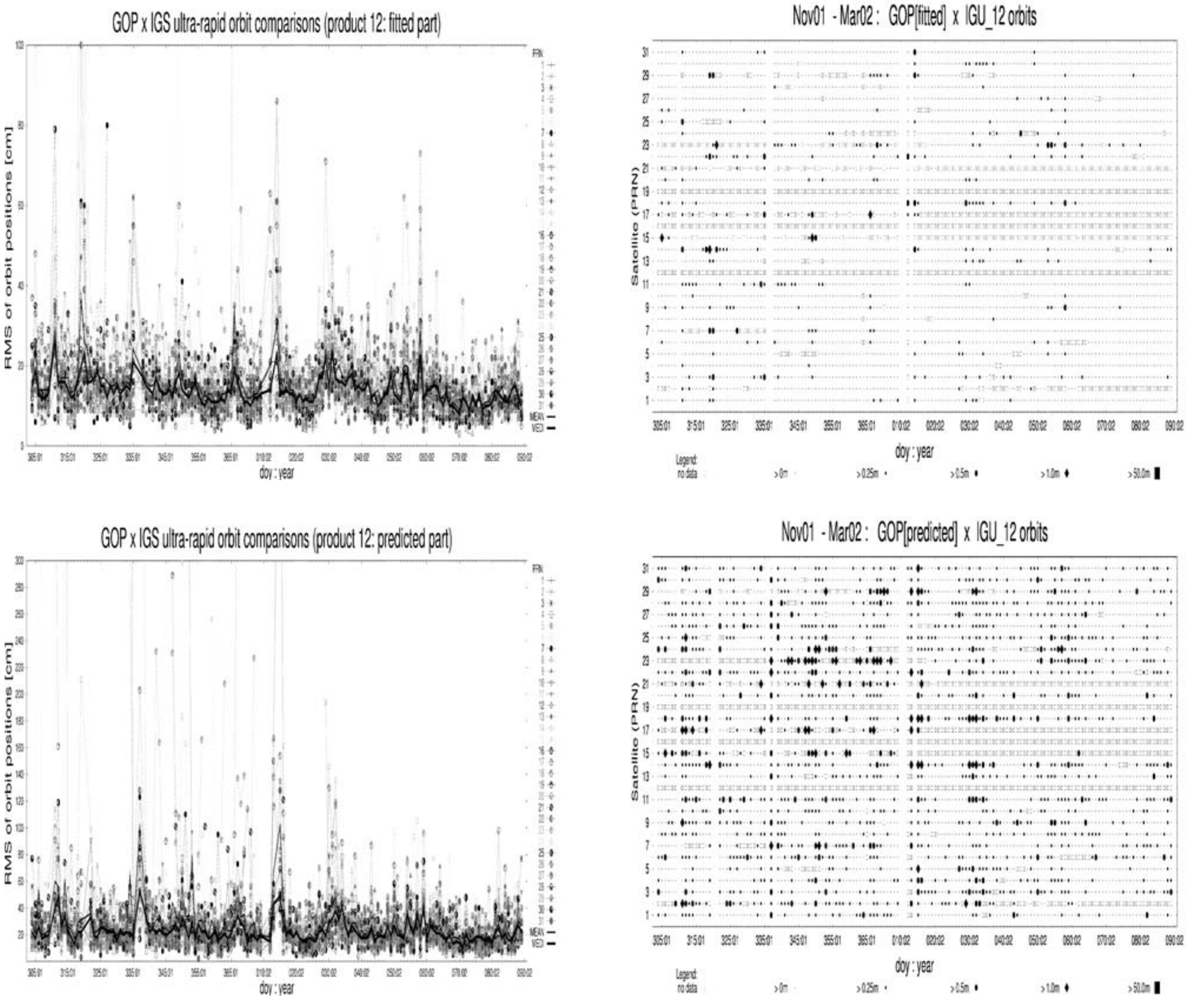


Figure 3. The comparisons between GOP and IGS ultra-rapid NRT orbits for fitted and predicted portions.