Developments and assessments of new tropospheric real time products at GOP

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Introduction

G-Nut/Tefnut application was developed at the Geodetic Observatory Pecny (GOP) for the real-time tropospheric estimates based on Precise Point Positioning (PPP) and using precise orbit and clock products from the IGS. A demonstration campaign was started in February 2013 for the assessment of Zenith Total Delay (ZTD) in support of nowcasting and severe weather events monitoring. The campaign consists of selected 18 worldwide and 18 European stations.
G-Nut/Tefnut is being steadily enhanced with current focus on improving a) balance of timeliness vs. accuracy for estimated tropospheric parameters (e.g. implementing a backward smoothing algorithm), b) integration of all GNSS constellations (GPS, GLONASS ready; Galileo, BeiDou: in progress) c) estimation of advanced tropospheric products, e.g. monitoring the atmospheric asymmetry (see poster **Pottiaux et al.** in the same session).

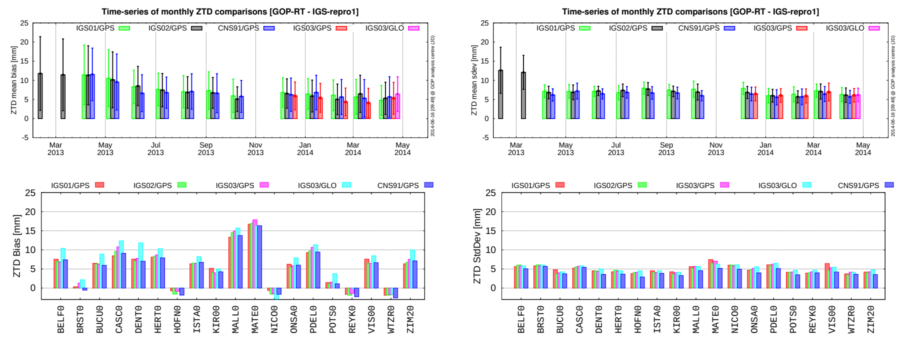
Processing strategy

In demonstration campaign, G-Nut/Tefnut software utilizes PPP approach and real-time Kalman filter. Station coordinates are estimated along with the tropospheric parameters, however, tightly constrained for keeping a stable position. Convergence periods are identified and filtered out using formal ZTD errors.

strategy	real-time PPP
ambiguity	float
GNSS	GPS, GPS+GLONASS
sampling rate	10 s
elevatin cut-off	3 deg
mapping function	ZHD - GMF dry ZWD - GMF wet GRD - Chen and Herring
adjustment	square root Kalman
ORB+CLK	IGS01, IGS02, IGS03, CLK91
troposphere	ZHD - Saastamoinen ZWD - estimated GRD (North, East) - estimated
ionosphere	eliminated by ionosphere free LC

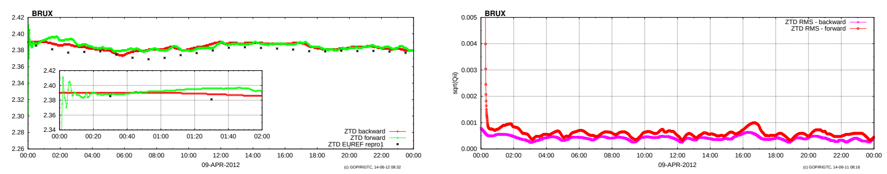
Evaluation of ZTD results

Figures below summarizes ZTD comparison statistics from the period of Feb 2013 - Apr 2014. Top figures show monthly mean biases and standard deviations (and their uncertainties) over all sites compared to IGS final product. It shows the evolution of resulting ZTDs including comparisons of solutions based on different products (IGS combined vs. CNES individual) and GNSS solutions (GPS vs. GPS+GLONASS). Bottom figures show biases and standard deviations for all involved stations compared to EUREF final tropospheric products.



Backward smoothing

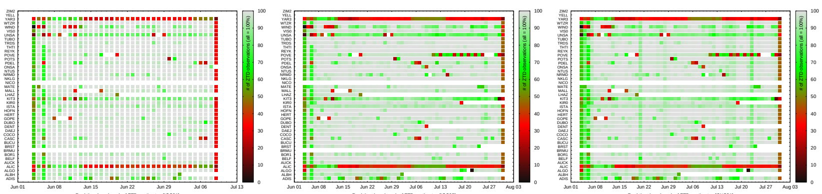
Backward smoothing is a post-processing algorithm based on saved results of the Kalman filter. Parameters estimated with the backward smoothing have almost the same precision during the entire processing interval. Two figures on the right hand side show a) ZTD time-series from a daily solution with a zoom over a convergence period; smoothed results are more stable and eliminates weak results during the convergence, b) progress in ZTD formal errors from forward and backsmooth estimates.



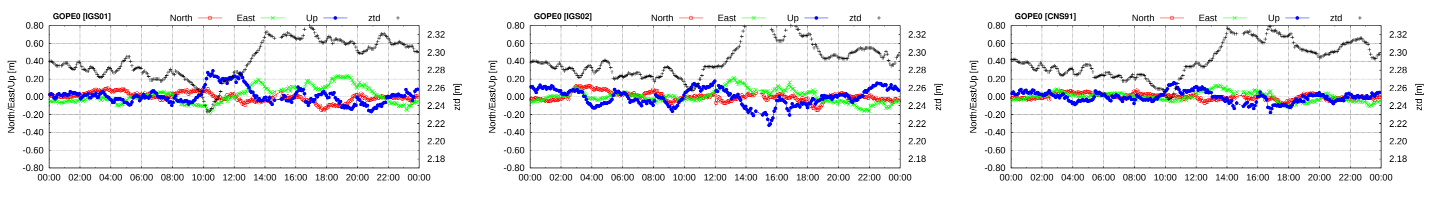
Used real-time orbit and clock products

Table below shows global real-time products exploited in the demonstration campaign since the beginning. Recently, we have added also IGS03 product (not shown) in support of GPS+GLONASS solutions.

Mount point	Update rate	Source /agency	Remarks
IGS01	5 s orbits, 5 s clocks	IGS /ESOC	epoch-wise combination
IGS02	60 s orbits, 10 s clocks	IGS /BKG	Kalman filter combination
CLK91	5 s orbits, 5 s clocks	AC /CNES	individual AC product



Station by station real-time ZTD availabilities over a month (from left to right): IGS01, IGS02 and CNS91 products.



Example kinematic positioning and tropospheric estimates for GOPE station using different real-time products (from left to right): IGS01, IGS02 and CNS91 products.

Conclusion

The poster shows the assessment of the real-time ZTDs from the demonstration campaign (Feb 2013 - Apr 2014) processed with the G-Nut/Tefnut software and IGS (and CNES) real-time orbit and clock products.
Resulted real-time ZTDs can be characterized by the standard deviation of 6-9 mm when compared to the EUREF and IGS final products. Site-specific biases of up to 15 mm (from a monthly statistics) are still present, however, these are stable to be effectively reduced before ZTD use in meteorological applications. High availability of the product is satisfactory too, generally at the level above 92%. The results thus demonstrated an initial readiness for new meteorological applications.

References

Dousa J, Vaclavovic P (2014) Real-time zenith tropospheric delays in support of numerical weather prediction applications. Advances in Space Research (2014), Vol 53, No 9, pp 1347-1358, doi:10.1016/j.asr.2014.02.021

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