USING REAL-TIME GNSS DATA FOR ATMOSPHERIC MONITORING

Royal Observatory of Belgium

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Solar-Terrestrial Centre of Excellence

PPP-RTK & Open Standards Symposium, 12-13 March 2012, Frankfurt, Germany

Introduction

In the framework of its monitoring of the atmosphere, the Royal Observatory of Belgium (ROB) maintains a local data centre providing 5-min RINEX files built from Real-Time (RT) GNSS observations from the EPN, IGS and national networks (Figure 1). These RT GNSS observations are streamed in the RTCM SP (Standard Precision) format and collected at the ROB using the BKG NTRIP Client (BNC).

However, the RTCM SP does not comply with the full precision of the RINEX format: carrier-phase observations are truncated to 3 decimals (instead of 4). In addition, the type of observables streamed in RTCM does not necessary match those contained in the corresponding (standard) hourly RINEX files (P1 is replaced by C1, see Figure 1).

This poster investigates the impact of the RTCM (SP) limitations (w.r.t. full precision RINEX format) on the atmospheric products and services developed at the ROB in the framework of its routine space weather monitoring and weather forecasting activities.

(*) Users can register to access the ROB regional NTRIP broadcaster at : http://www.gnss.be/data.php#NTRIPaccess [Söhne et al. 2010]

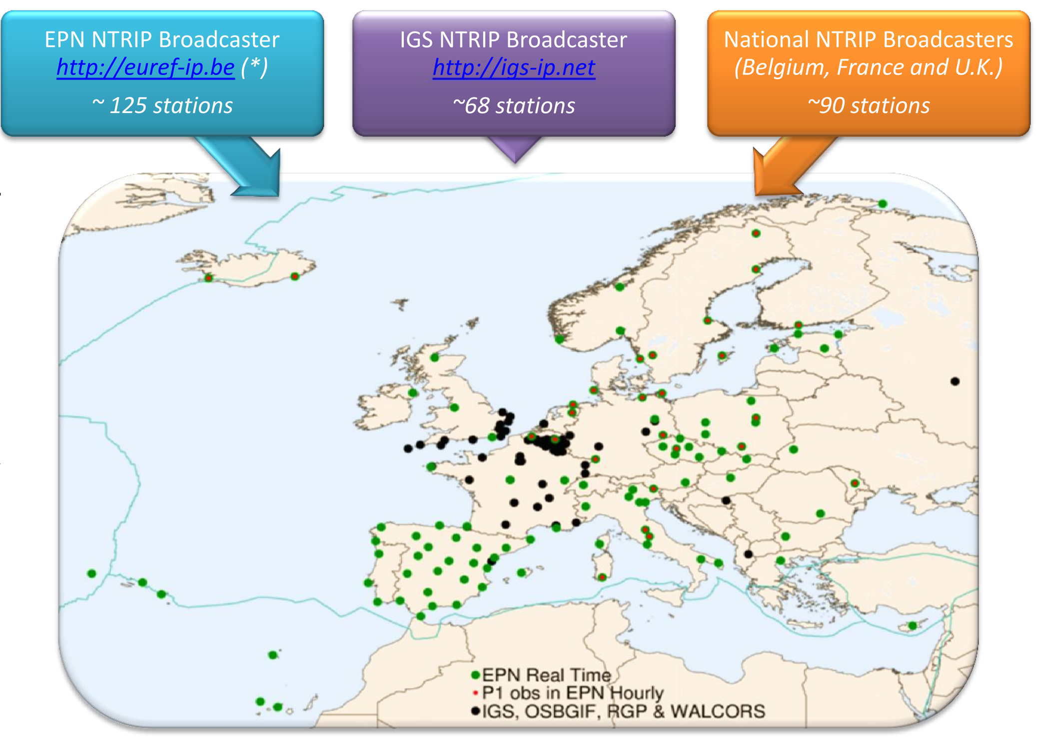

Figure 1: Sources of real-time GNSS observations collected by the ROB for atmospheric monitoring (in total 248 GNSS stations)

Ionospheric Monitoring & Space Weather

Routine Products and Services

Since the 25th of October 2011, the ROB routinely estimates in Near-Real Time (NRT) ionospheric models over Europe **based on RT GPS observations** of the EPN [Bergeot et al., 2011] (map of the stations used in Figure 1).

The models are ionospheric Vertical Total Electron Content (VTEC) maps generated every 15 minutes on a 0.5° x 0.5° grid. The maps are now available on the web-site gnss.be (Figure 2), with a latency of 7-15 minutes with respect to the last GPS measurement available.

Such models based on GPS data estimate the VTEC at a level of 2-5 TECu (1 TECu = 10^{16} e$^-$.m^2) of precision and accuracy.

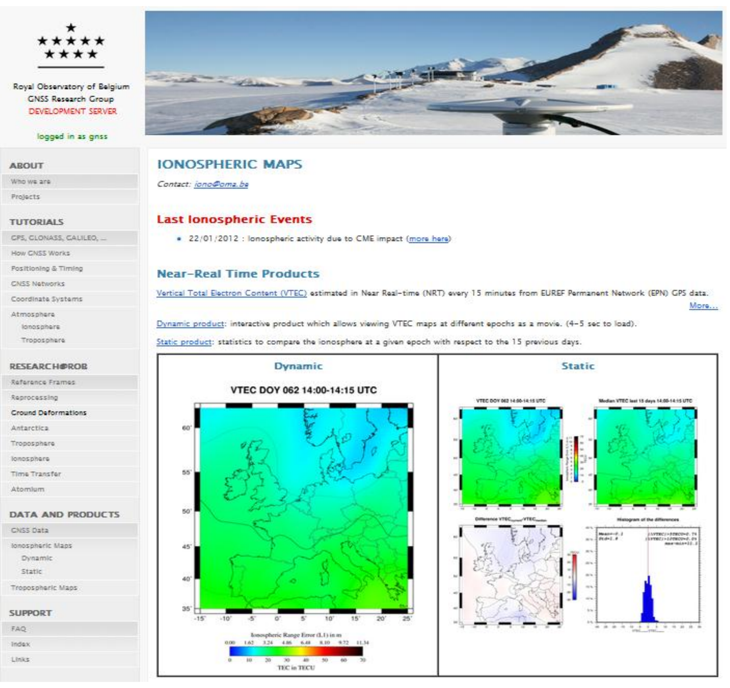

Figure 2: Screenshot of the web portal providing ionospheric maps over Europe (source: http://www.gnss.be/Atmospheric_Maps/ionospheric_maps.php)

NTRIP vs. Hourly RINEX for Ionospheric Modelling

To test the impact of the RTCM limitations (C1 only, and 1 digits less for the L1 and L2 phases), we compared on Figure 3 the VTEC maps based on high-rate RT RINEX data with VTEC maps based on hourly RINEX data. This test is done for one month from the 15/01/2012 to the 15/02/2012.

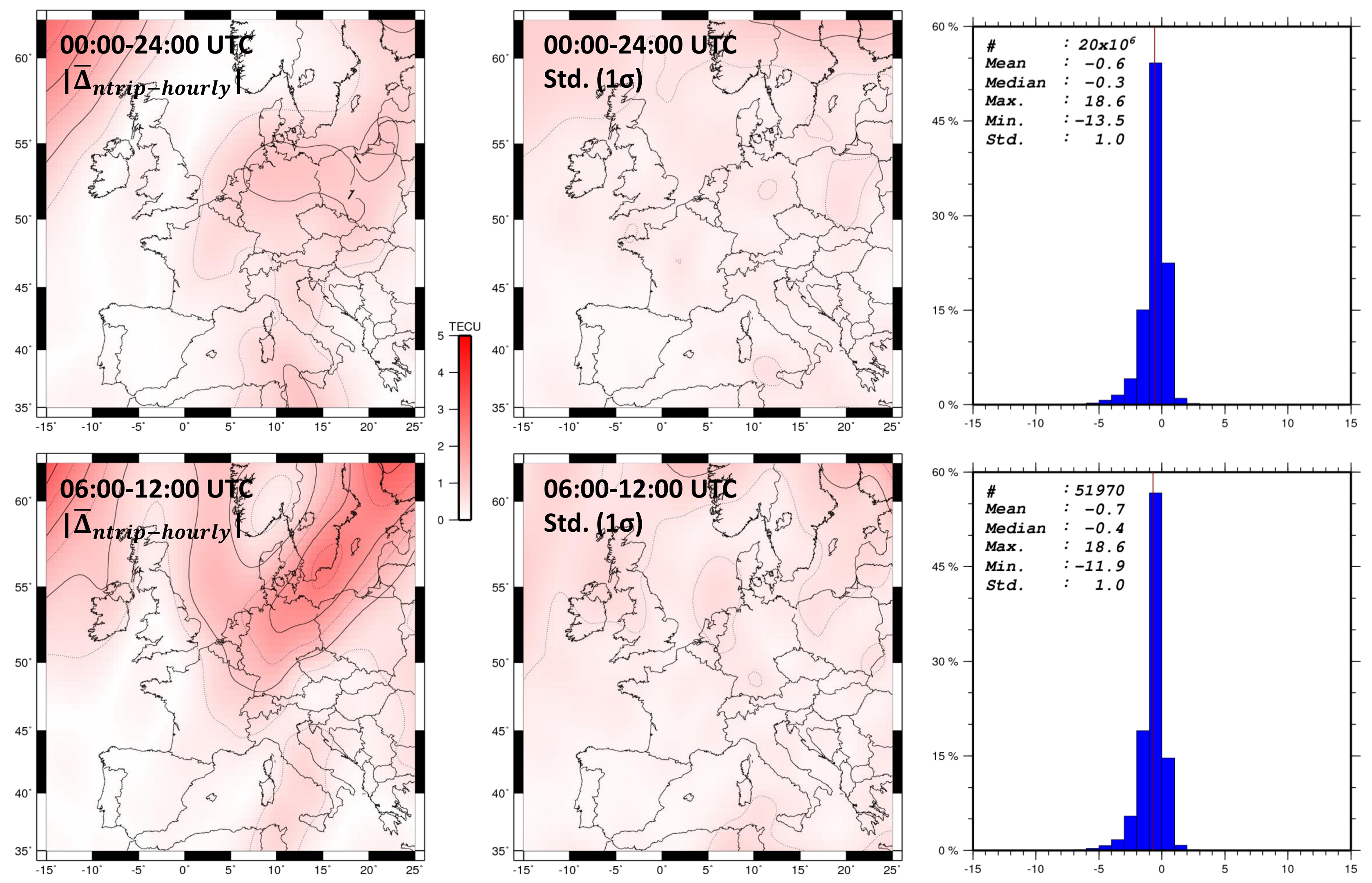

Figure 3: Differences (pixel by pixel) between the VTEC maps estimated with RT and hourly RINEX from the 15/01/2012 to the 15/02/2012.Top from 00:00 to 24:00 UTC, bottom from 06:00 to 12:00 UTC. Left : Absolute mean value; Middle : Standard deviation; Right : Histogram of the differences.

Conclusions, Improvements & Prospects

1. We detected systematic and coherent differences over 31 days in 2012 in the Northern part of the maps (3±1 TECu) which is close to the precision and accuracy of our product.
2. This can be due to the limitation of the current SP RTCM format (C1 only and precision on the phase observables).
3. Moreover an increase of the number of observations particularly in the North would improve the ionospheric modelling where the data coverage is less dense than in mid-latitude regions.

Tropospheric Monitoring & Weather Forecast

Routine Products and Services

The ROB is one of the 13 analysis centre participating in the EUMETNET program E-GVAP II. Since 2004, the ROB provides the meteorologists every hour with 15-min sampled GPS-based Zenith Tropospheric Delays (ZTD) estimated from **hourly RINEX files.** The processing strategy used for that purpose is described in [Pottiaux 2008 and Pottiaux 2010].

Based on this E-GVAP service, the ROB recently developed tools which use a krigging method to map the tropospheric delay over Europe. Maps and animations based on these tools will be soon available on a web portal (Figure 4). These maps are currently updated hourly with a latency of 30-35 minutes with respect to the last GPS measurement.

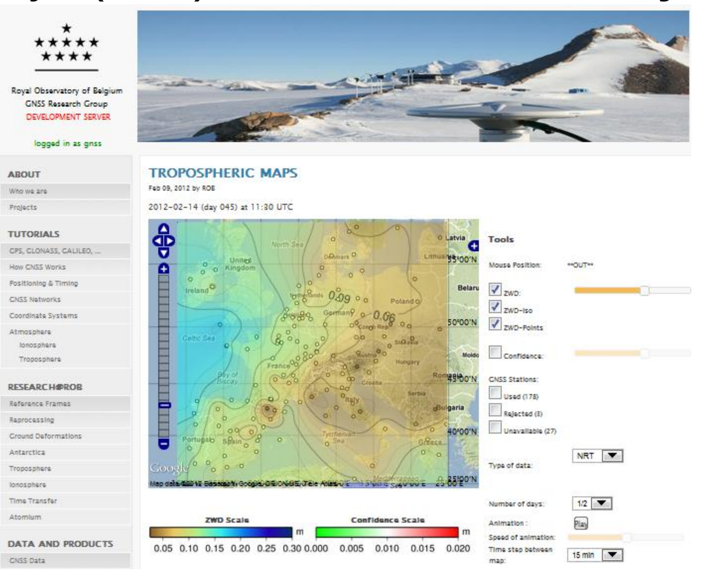

Figure 4: Screenshot of the web portal providing maps of the tropospheric delay over Europe

NTRIP vs. Hourly RINEX for Tropospheric Modelling

However, to further support meteorology (e.g. rapid-update weather forecasting & nowcasting), the ROB needs (1) to reduce the latency of its solutions (from 30 min to 10 min) and (2) to provide its solutions more often (sub-hourly processing), (3) both while keeping the level of quality achieved in its standard hourly analysis (i.e. the precision requirement for meteorology: 3-10 mm of ZTD).

To reach this goal, the ROB has to process real-time GNSS observations. We investigated the impact of using these RT GNSS observations (instead of hourly RINEX files) in our operational E-GVAP analysis, focusing on the precision of the ZTD estimated. In both computations, the analysis strategy was kept unchanged (E-GVAP analysis) and the same network of 91 EPN stations was used. Figure 5.A-C show the results of a 2-month comparison (Jan-Feb 2012) for all selected stations. First results showed:

- Statistics over all stations: mean bias of 0.4 mm / std. dev. of 5.8 mm / range of -0.1 m → 0.5 m
- An increased sensitivity to the analysis setup (e.g. network geometry, data filtering, ZTD relative constraints…) and to the quality of the orbit product used (e.g. IGS Final orbits w.r.t. IGS ultra-rapid orbits)

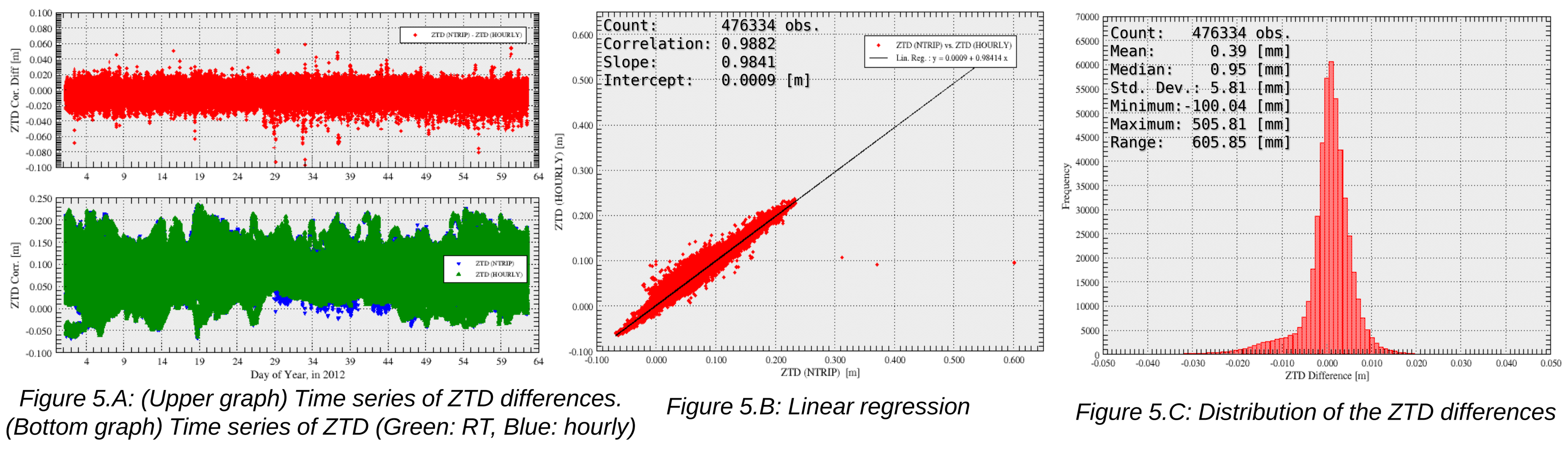

Figure 5.A: (Upper graph) Time series of ZTD differences. (Bottom graph) Time series of ZTD (Green: RT, Blue: hourly)

Figure 5.B: Linear regression

Figure 5.C: Distribution of the ZTD differences

Figure 5: Comparison of the ZTD estimated from real-time versus hourly RINEX file observations for the period Jan-Feb 2012

Conclusions, Improvements & Prospects

1. We observed a degradation of the precision of the estimated ZTD due to a lack of full precision of the carrier-phases transmitted in the RTCM SP format.
2. GNSS meteorology needs the RTCM high-precision format to target the meteorological requirement of 3-10 mm of ZTD precision.
3. We will assess the impact of using the RT GNSS observations on our European tropospheric delay maps.
4. Another important requirement for meteorology is the spatial density of the GNSS observations : we are looking to access more RT GNSS observation streams to improve the spatial density in Europe.

References / Acknowledgements

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These researches and services have been carried out in the framework of the *Solar-Terrestrial Centre of Excellence* (STCE). We are grateful to all partners and real-time data providers below:

International GNSS Service
Formerly the International GPS Service