EUREF 2013 NATIONAL REPORT OF BELGIUM

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1. Contribution to the EPN

1.1 EPN Central Bureau

ROB hosts the EPN Central Bureau (http://www.epncb.oma.be/). In 2012, the site received about 2.1 million hits. The major updates of the EPN Central Bureau since June 2012 consist of the inclusion of the EPN-REPRO1 results in several of the EPN product web pages.

1.2 EPN Tracking Stations

ROB operates four permanent GNSS tracking stations: BRUS/BRUX, DENT, DOUR and WARE; all are streaming real-time data..
BRUX also belongs to the International GNSS Service tracking network and contributes to the IGS M-GEX campaign. BRUX daily and hourly RINEX files are available from ftp://gnss.oma.be/gnss/data/rinex/. A real time RTCMv3 stream is available from www.euref-ip.be on mountpoint BRUX0 and a binary SBF stream is available from www.euref-ip.be on mountpoint BRUX1. The latter stream is also used in the IGS-MGEX campaign.
More details on BRUX can be found at
http://www.epncb.oma.be/_trackingnetwork/siteinfo4onestation.php?station=BRUX_13101M010
In 2013, the full ROB network will be upgraded with SEPT POLARX4 receivers (tracking GPS/GLONASS/Galileo on L1/L2/L5) and TRM59800.00/NONE antenna.

1.3 Data Centers and Broadcaster

ROB maintains an historical EPN data center, providing access to all historical EPN data especially targeting reprocessing activities (ftp://epncb.oma.be/ftp/obs/).

Real-time data of the ROB stations is available on an EPN NTRIP caster operated by ROB. Besides providing the ROB streams, the streams of other EPN stations are relayed. This way, ROB guarantees load sharing with the main EPN broadcaster at Bundesamt für Kartographie und Geodäsie (BKG), Germany and overall communication traffic reduction. At present about 159 EUREF streams are relayed, from 16 different casters. Users can apply for an account by filling in the web form on http://www.gnss.be/data.php#NTRIPaccess. In 2013 the ROB will start offering a secure access to the real-time streams over https.

1.4 Data Analysis

The ROB EPN Local Analysis Center is processing an EPN sub-network located around the Benelux (see http://epncb.oma.be/_dataproducts/analysiscentres/subnetwork.php?lac=ROB).

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2. Services and Products Based on the EPN

2.1 Ionospheric products and Space Weather impacts

The European near real-time ionospheric products generated by the ROB and based on the real-time GNSS data from the EPN are maintained on http://gnss.be/ web pages. Moreover, these models are now freely available through the ftp server (ftp://gnss.oma.be) in real-time in the official data format called IONEX. These IONEX files are used by the external community for research, publications (see Sotomayor-Beltran et al. 2013) and ionospheric monitoring products (http://dias.space.noa.gr/ and http://gpsweather.meteo.be/).

Additionally, the EPN-based ionospheric products presented above and the International Reference Ionosphere (IRI) climatological model are used to estimate the critical frequency at F2 ionospheric layer (foF2) in a near real-time approach. The estimated foF2 shows a good agreement with direct measurements provided by ionosonde instruments. The comparison with five available ionosondes over Europe for January 2012 is 0.9 ± 0.4 MHz for the entire period (see Figure 1).

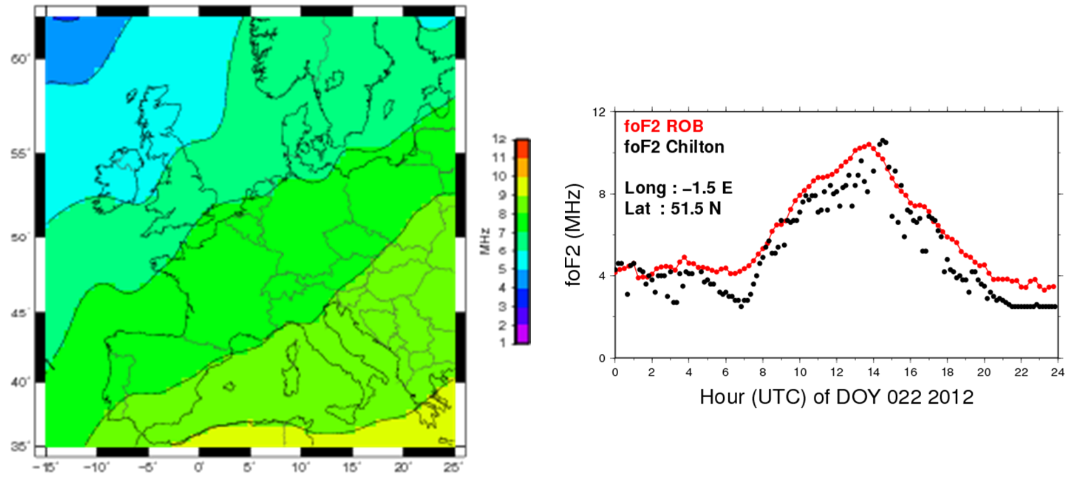

Figure 1: Estimation of foF2 ionospheric parameter in a near real-time approach. Left: Maps of the foF2 over Europe estimated in near-real time for the 1st January 2012 at 10:15 UTC. Right: comparison of the foF2 estimated in near-real time with the ionosonde data from Chilton (UK) for the 22rd January of 2012.

These results comfort us in the strategy used to derive ionospheric parameters which are not directly accessible from GNSS data only. However, in the future, the use of direct ionosonde measurements will be necessary to constrain our models and to improve their accuracy.
Finally, a new research area using the signal-to-noise ratio (S/N) from EPN GNSS data is now open. Indeed, a first study showed a clear correlation between the decrease of the S/N within the EPN (up to 15dB on GLONASS and GPS frequencies) during the 24th September 2011 solar radio burst event. This new application of the EPN data will be useful in the future to monitor the impact of non ionospheric Space Weather on GNSS data quality.

2.2 E-GVAP Analysis Centre

The ROB develops and maintains a GNSS analysis centre to participate in the EUMETNET EIG E-GVAP program. This service provides the European Meteorological Agencies with Europe-wide near real-time Zenith Tropospheric Delays (ZTD) estimated from GPS observations to enhance Numerical Weather Prediction (NWP). In 2012, this service was upgraded to run on a new IT infrastructure. The resulting new/enhanced E-GVAP service provides hourly-updated ZTD estimates from about 350 European GNSS stations (i.e. ~55% increase, see Figure 2) while keeping the processing time below 15 minutes. After an extensive comparisons/validations phase (w.r.t. post-processed ZTD solution from the EPN and IGS and w.r.t. output from NWP models) the new service was adopted in June 2012 as the official ROB solution within E-GVAP and the old service was discontinued. The ROB also continued to prepare a sub-hourly service to provide E-GVAP with 15-min updated tropospheric delays. This service will be used by Meteorological Agencies to enhance high-resolution rapid-update NWP and nowcasting applications. This new prototype service is based on the processing of real-time GNSS observations from the EPN and from national network densifications (e.g. WALCORS and RGP) and includes now 180 stations.

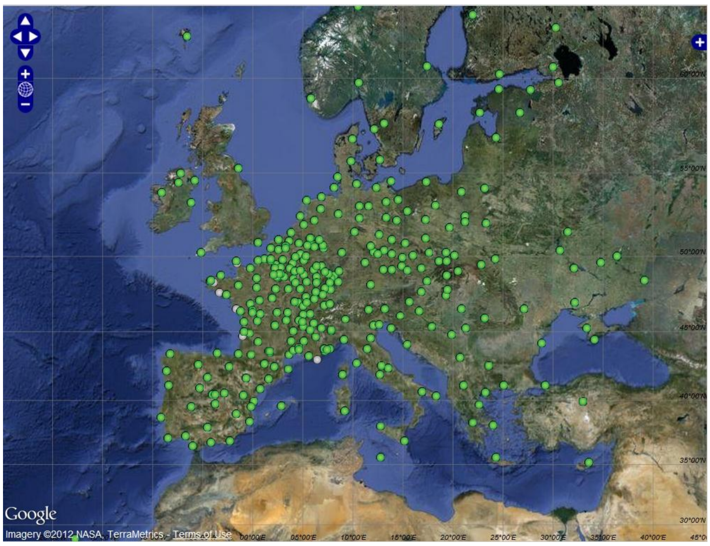

Figure 2: GNSS network processed in near real-time in the framework of E-GVAP (Status: 6 February 2012) (some stations are located outside the region represented by the map)

Finally, the ROB upgraded its web tool to monitor the European wet tropospheric delay estimated from GNSS data in order to benefit from the new E-GVAP services running at the ROB. This interactive web product provides movies and wet delay values over Europe (Figure 3).

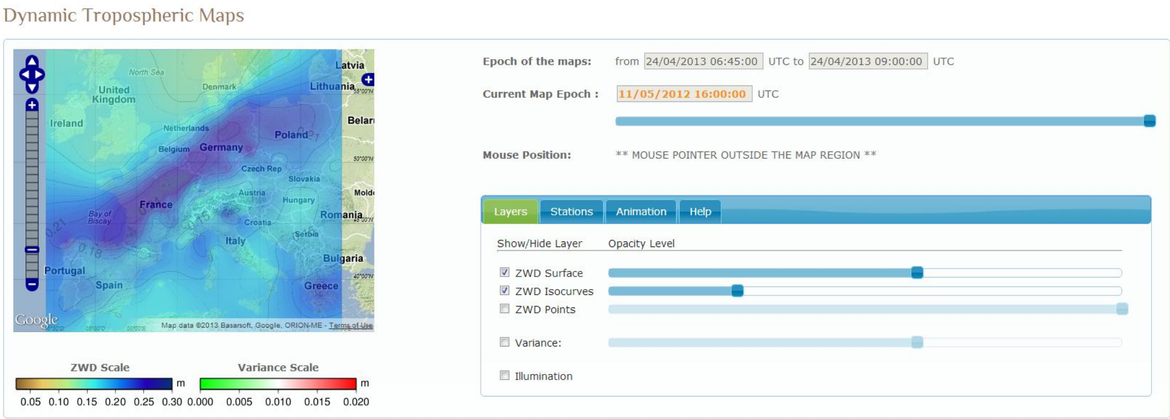

Figure 3: Web-based user interface providing access to the wet tropospheric delay maps and animations. (Status: 11 May 2012)

3. Research Activities

3.1 IAG Working Group 'Integration of Dense Velocity Fields in the ITRF'

ROB is chairing the IAG Working Group "Integration of dense velocities fields in the ITRF". The Working Group is a collaborative effort between the different IAG regional reference frame sub-commissions who are submitting solutions for the GNSS permanent tracking stations installed in their continent to the Working Group with the goal to create a homogenous global velocity field. This was originally done by combining several multi-year position/velocity solutions submitted to the WG by APREF, EUREF, SIRGAS, NAREF and the ULR analysis centers. However, this work demonstrated the limitations of the approach which was affected by geographically correlated biases. Consequently, in 2012, it was decided to start with the combination of weekly position solutions. All contributors agreed with this approach and in addition, the African reference frame sub-commission also started to submit its first solutions. Preliminary weekly combinations which include 8 individual solutions (AFREF, APREF, EUREF, NAREF (NGS, GSB), SIRGAS, IGS, ULR) and contain about two thousand stations (Figure 4).The agreement between the solutions is promising and leads to weekly RMS ranging from 2 to 8 mm. However, this agreement is presently limited by inconsistencies at the GNSS data modeling and metadata level. The work is still in progress and will be continued in 2013. Final results are expected for 2013-2014.

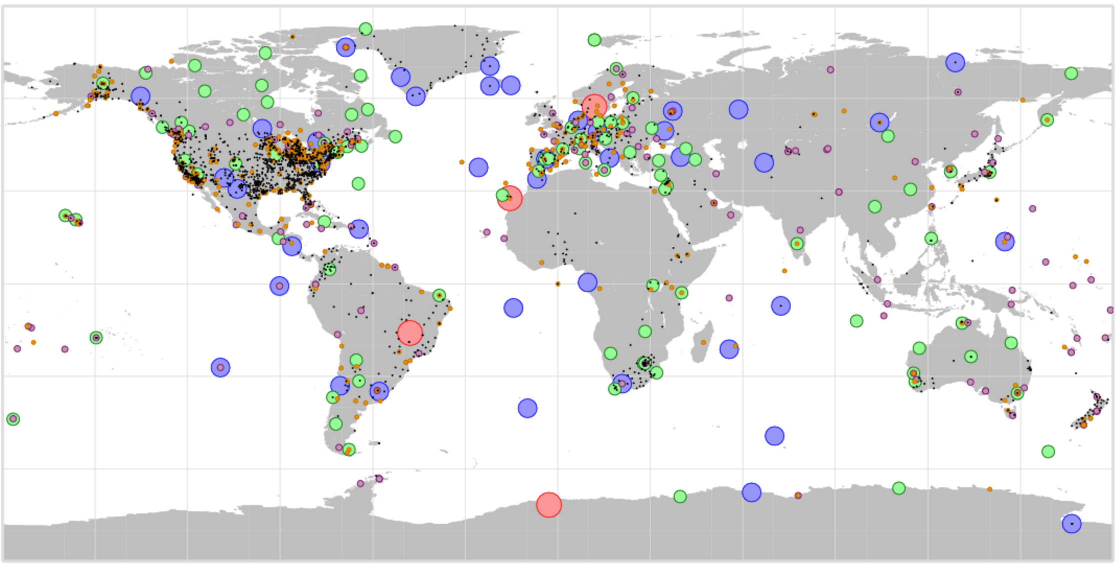

Figure 4: Map of the combined network, stations common to: 6 solutions in red, 5 solutions in blue ,4 solutions in green, 3 solutions in purple, 2 solutions in orange and 1 solution in black.

3.2 Receiving Antenna Calibration Models

ROB continued a study of the contribution of GNSS receiver antenna calibration models to the error budget of GPS positioning.

The influence of switching from the epn_05.atx to epn_08.atx antenna calibration model on the position obtained with GPS has been estimated by ROB using all historical EPN data. The resulting position offsets have been applied on REPRO1 results and then used by the EPN reference Frame coordinator to generate an improved set of EPN station positions and velocities.
The position of six GNSS antennas, installed at ROB, has been computed using two different individual calibrations (anechoic chamber calibrations and robot calibrations) in order to investigate the impact of the different calibrations on the position. Differences at the millimeter level for the calibrations induce sub-centimeter level position offsets (see Baire et al., 2012 and 2012b).

The study of different calibration methods (see Aerts et al., 2012) has revealed that the dominant error for chamber and robot calibration is near field multipath. There are still significant inter-method differences, higher than each method's repeatability with the same set-up. It has been shown (see Aerts et al., 2013) that between the calibration set-up and the station set-up, differences are at the same level as the inter-method difference. A sub-millimeter absolute positioning won't be reachable until the multipath issue for the calibration is solved.

3.3 Long-term Stability of GNSS-based ZPD

ROB continued its collaboration with the Royal Meteorological Institute (RMI) of Belgium and the Belgian Institute of Space Aeronomy (BISA) on the inter-comparison of atmospheric water vapour observed by several ground-based (GNSS, sun-photometers), in-situ (radiosondes) and satellite-based (GOME/GOME2/SCHIAMACHY) techniques. The IGS REPRO1 troposphere product has been used to produce GPS-based IWV data. The inter-comparison has been carried out for 28 IGS sites world-wide having a colocation with the other instruments (max. colocation distance of 30 km). In 2012, a new infra-red instrument (AIRS) and a new version of the GOME/GOME-2 products were used. Also external factors (e.g. the cloud cover) impacting the inter-comparisons were carefully studied. Results of this study were finalised and a paper was prepared for publication in a special issue of ACP (Atmospheric Chemistry and Physics) in 2013.

3.4 Geological Study of Belgian GNSS Station Locations

ROB finished a new analysis of the GNSS data of all the permanent GNSS stations installed in Belgium up to Jan. 2012 (about 60 stations), collected station meta-data, tried to correlate erroneous results with station events, and corrected the results for position jumps caused by equipment changes. New improved site positions, velocities and residual position time series were estimated and used to investigate correlations between position changes and geologic and meteorological information, as well as monument type. The results demonstrate no correlation between geological or meteorological information and nonlinear GNSS station positions.

More information on the activities of the GNSS research group of the Royal Observatory of Belgium can be found at http://www.gnss.be/.

4. Update of a part of the national levelling network

In the eastern part of Belgium, close to the Dutch border, there were mining activities between 1930 and 1992. Not surprisingly, the coal extraction caused local land subsidence. So we waited for eight years after the closing of the last mine in 1992, to perform new observations for the leveling network in the area during the year 2000. One might assume that sometime after mining activities have stopped, land movement also stops, but it seems not to be the case.

Last year some surveyors using the leveling benchmarks in the area reported several anomalies, especially when they compared leveling results with heights obtained four to five years ago. In order to determine the degree of the problem and the limits of the influenced zone, we performed static GPS observations on, or in the immediate neighborhood of the benchmarks. Comparing the results with the heights determined in 2000, all values are bigger; meaning that during this twelve year period there has been uplift. The mean difference is 8.2 cm with a maximum of 17.4 cm. The area where uplift took place corresponds almost perfectly with the boundaries of the mining exploitation zone.

These surprising results have been confirmed by a second, independent series of observations: One of the permanent GNSS stations of the Flemish RTK network is situated in this mining area. It has been operational since July 2004. When analyzing the mean weekly results for the height component (ETRF2000) the uplift shows clearly with a mean rate of 8 mm per year.

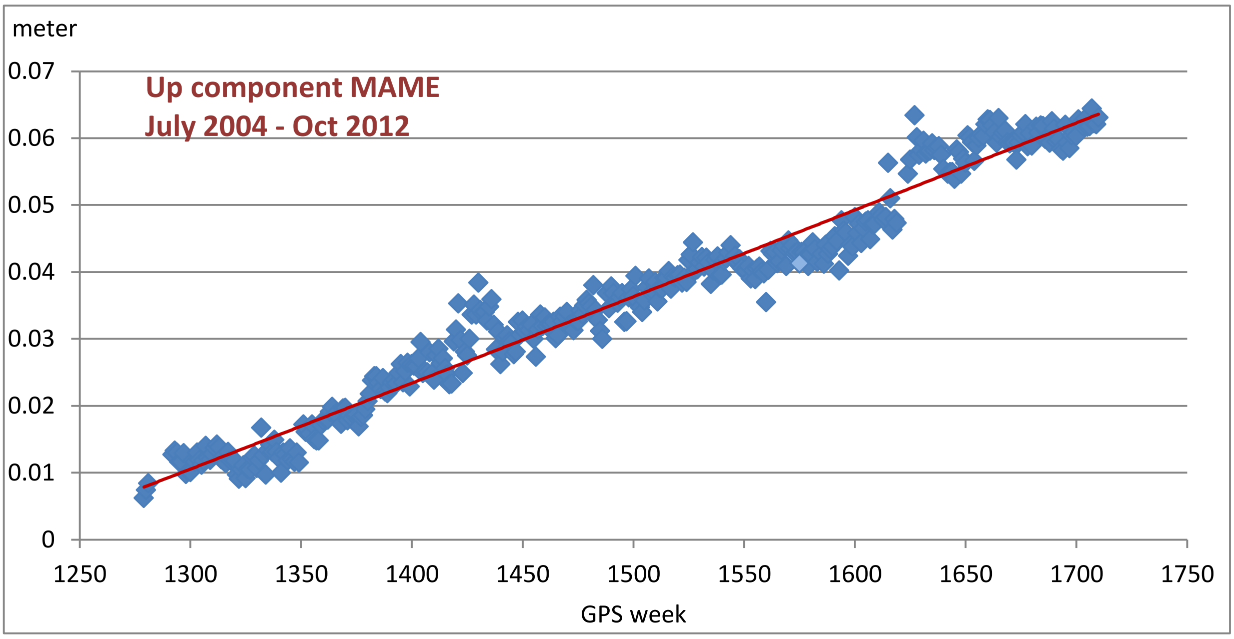

Figure 5: time series (ETRF2000) of the up component of station MAME

It was obvious that all leveling benchmarks within this former mining zone need to be updated. Spirit leveling observations have started in early spring 2013 and the new values will be available before the end of the year. In the near future the weekly results of the permanent station MAME will give us an indication to what degree uplift will continue or not.

5. Some changes in RTK services

In several national reports presented at the EUREF symposia of the past ten years we have described the RTK services which are available in Belgium.

They are based on the three regional networks of permanent stations, all managed by public authorities; Flepos for Flanders, GPSBru for the Brussels region and Walcors for Wallonia.

The most important changes that took place during the past year are:

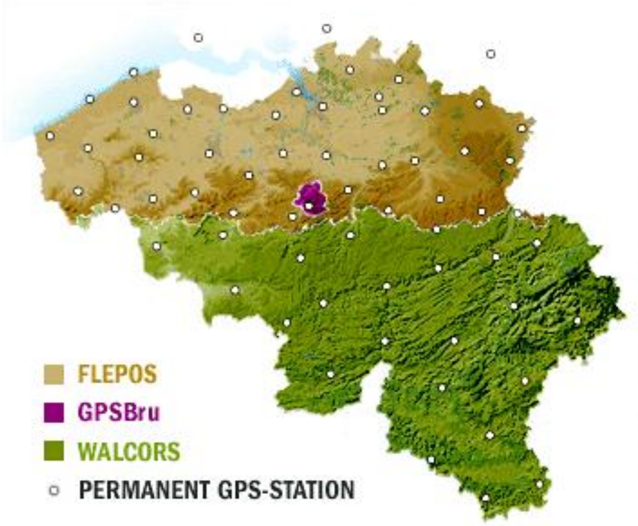

Figure 6 : The Belgian RTK networks

- Until now, as they were considered as a public service to the users, all RTK-data were freely available. However, recently the amount of users in the machine guidance sector grew significantly, and the authority responsible for Walcors was forced to counter some technical limitations. So they granted an exploitation license to two private companies. Since the beginning of 2013 all users in the machine guidance branch have to appeal to one of these commercial services. Surveyors can continue to use Walcors for free.
- The entrance from the North Sea to the port of Antwerp is a 60 km waterway through Dutch territory. To better serve hydrographic navigation on these crowded and economically very important waters, Flepos has added the data of several Dutch permanent stations. The correction signals are also disseminated by radio waves now, while it used to be by mobile phone and Ntrip only.

Acknowledgements

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