1. Introduction

The ROB (Royal Observatory of Belgium) is heavily involved in the EPN (EUREF Permanent Network) and is processing GNSS observations from the EPN since February 1996. Nowadays, the errors due to the reference frame definition and the atmosphere still remain the main limiting factors when performing high accuracy GNSS positioning. In that frame, the ROB carries a long-term research program that aims to better understand these error sources, to improve their mitigation in the GNSS data processing and to provide specific products for the scientific community.

2. Ongoing Research based on the EPN and Belgian Densification Networks

2.1 Reference Frame Definition

We used ten years (1997-2006) of weekly reprocessed GPS solutions from the ULR (Université de la Rochelle, France) (Wöppelmann et al. 2007) to investigate the impact of the reference frame definition on the estimated station velocities. These reprocessed solutions contain 205 globally distributed stations. Weekly regional solutions (covering the European region) and global solutions have been respectively stacked to obtain regional and global velocity fields. In both cases, the estimated long-term solutions (station positions and velocities) are tied to the ITRF2005 under minimal constraints using a selected set of reference stations. Several sets of global and regional reference stations were tested to first evaluate the impact of the reference frame definition on the global and regional velocity fields and later on the derived geodynamic interpretations.

Results confirmed that the regional velocity fields show systematic effects with respect to the global velocity field with differences reaching up to 1.3 mm/yr in the horizontal and 2.9 mm/yr in the vertical depending on the geographical extend of network and the set of regional reference stations (see Figure 1).

![Figure 1: Difference between global and regional velocity fields (mm/yr). Left: horizontal differences, Right: vertical differences. Error ellipses are at the 99% confidence level.](image-url)
In addition, the Euler pole rotations of Western Europe differed significantly when considering a global or a regional strategy. After removing the rigid bloc rotation, the residual velocity fields showed differences which can reach up to 0.8 mm/yr in horizontal component.

In Northern Europe, the vertical ground motion is dominated by the Glacial Isostatic Adjustment (GIA). A proper modeling of this effect requires sub-mm/yr precision for the vertical velocities for latitudes below 56°. We demonstrated that a profile of vertical velocities showed significant discrepancies according to the reference frame definition strategy. In the case of regional solutions, the vertical modeling did not predict any subsidence around 52° as predicted by the global solution and previous studies.

In summary, we evidenced the limitation of regional networks to reconstruct absolute velocity fields and conclude that when geodynamics require the highest precisions for the GNSS-based velocities, a global reference frame definition should be applied. More details can be found in Legrand et al (2009).

2.2 Precise Point Positioning

The software ATOMIUM was originally developed by the ROB for GNSS-based time transfer. ATOMIUM inputs GNSS code and carrier phase measurements and uses a least-squares analysis to estimate clock solutions in Precise Point Positioning (PPP), as well as in single differences (also called Common-View). PPP also provides 3D station position and troposphere zenith delays.

We recently started to evaluate the quality of the station positions estimated using Atomium in the PPP mode. For that purpose the IGS orbits and clock files are considered as a priori information while Atomium estimates daily station position, 15-minute tropospheric zenith path delays and epoch-by-epoch station clock synchronisation errors with respect to the IGS time. The preliminary results are proposed in a separate paper: “Precise Point Positioning with Atomium using IGS Orbit and Clock Products: First Results” by Baire et al. (this volume).

2.3 Ionosphere

We started the estimation of TEC (Total Electron Content) maps using our own software and based on the EPN GPS data. We demonstrated that the density of the EPN allows to estimate hourly V (vertical) TEC and its RMS on a 1°/1° grid over Europe. Thanks to their high resolution in time and space, these maps allow to better monitor small structures in the ionosphere than the standard global ionospheric maps. The ROB TEC maps agree with CODE Global Ionospheric Map (GIM) products at 0.1±1 TECU during normal ionospheric activity and 1.2±2.8 TECU during the geomagnetic storm period.

3. Services and products based on the EPN

3.1 EPN Reprocessing at ROB

The Royal Observatory of Belgium has performed two homogeneous reprocessings. The entire EPN (222 stations) has been reprocessed from 1997 until now. The belgian dense network has been reprocessed together with the ROB LAC network from 1996 until now. These solutions contain 134 stations. These two reprocessings have been performed using Bernese and following the identical EPN LAC guidelines. A comparison of both solutions is shown in the paper “Results and Comparisons of a Local and a Regional Reprocessed GNSS Network” by Legrand and Bruyninx.
3.2 E-GVAP Analysis Centre

The ROB participates as an official analysis centre within the EUMETNET GPS Water Vapour Program (E-GVAP) (Pottiaux, 2009a). In that frame, the ROB provides near real-time Zenith Tropospheric Delay (ZTD) estimations of a regional network that covers the whole of Europe (Figure 3). At the present time, this network includes about 168 sites, most of them are EPN and IGS GNSS stations. Moreover, some of these sites are co-located with other instruments such as radiosondes, water vapour radiometers ... This co-location allows the ROB to validate its ZTD estimates by cross-technique comparisons (Pottiaux et al., 2009b)

4. Contribution to the EPN

The ROB contributes to the EPN with:
- 4 permanent tracking stations (all submitting hourly data) : BRUS, DENT, DOUR and WARE ; in addition to BRUS, real-time data streams (RTCM 3.0) are now also available for DENT and WARE.
- An EPN Local Data Center (ftp://epncb.oma.be/gps_rob/data/rinex)
- An EPN Local Analysis Center processing an EPN subnetwork located around the Benelux (see http://epncb.oma.be/_dataproducts/analysiscentres/subnetwork.php?lac=ROB).

In addition, the ROB hosts the EPN Central Bureau (http://www.epncb.oma.be/). For details we refer the interested reader to the paper “EPN Status and Network Management” by Bruyninx et al. (in this volume)

5. RTK networks

In Belgium three RTK-networks are active: the Flepos network covers the Flanders region, GPSBru can be used in Brussels and Walcors is the network for Wallonia. All these networks and the distribution of their RTK-data are run by governmental agencies. Recently the hardware for the reference station of GPSBru was changed and extended with Glonass. The ‘Service Public de Wallonie’, who is responsible for Walcors is planning to do the same by the end of 2009.

6. Official ETRF coordinates in Belgium

The ETRF coordinates used in Belgium have been determined in 2002 and are the result of a nationwide campaign to integrate all RTK reference stations, which were new at that time. The final computations were tied to ITRF2000 at epoch 2002.72 using seven EPN stations, the four Belgian EPN stations BRUS, DENT, DOUR and WARE and three stations from abroad: HERS, KOOT en ZIMM. The results have been transformed to ETRS89 following the guidelines of the memo on specifications for reference frame fixings (Boucher & Altimimi). The comparison of the official coordinates of the four Belgian EPN stations with the most recent release of the EUREF computation (dec.2008) is given in table 1
<table>
<thead>
<tr>
<th>Station</th>
<th>Geocentric difference (mm)</th>
<th>Local difference (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dX</td>
<td>dY</td>
</tr>
<tr>
<td>BRUS</td>
<td>4</td>
<td>-2</td>
</tr>
<tr>
<td>DENT</td>
<td>-7</td>
<td>0</td>
</tr>
<tr>
<td>DOUR</td>
<td>0</td>
<td>-6</td>
</tr>
<tr>
<td>WARE</td>
<td>-3</td>
<td>-2</td>
</tr>
</tbody>
</table>

Table 1: Difference official Belgian coordinates minus EUREF solution both expressed in ETRF2000 ep.2000.0

References


