TeroPoint

online processing service for accurate positioning at national level

Rui Fernandes \textsuperscript{1,2}

Machiel Bos \textsuperscript{1,2}

Yoaz Bar-Sever \textsuperscript{3}

\textsuperscript{1} SEGAL (IDL, UBI), Covilhã, Portugal

\textsuperscript{2} TeroMovigo, Covilhã, Portugal

\textsuperscript{3} JPL (NASA), Pasadena, U.S.A.
SEGAL (Space & Earth Geodetic Analysis Lab)

It is a scientific partnership between: University of Beira Interior (UBI) and Geophysical Instituto D. Luís (IDL)

focused on Research of Rigorous Positioning using Space Geodetic Techniques
**SEGAL**

Network of stations installed (~50), and co-managed by SEGAL in collaboration with local partners from >25 countries.

Two dedicated servers managing the data and the daily processing (which is done using a pool of 30 computers) for a network of more than 800 sites.
TeroMovigo is a Portuguese spin-off of the University of Beira Interior (UBI) that was founded in 2017 by researchers of SEGAL (Space & Earth Geodetic Analysis Laboratory) an R&D laboratory focused on Geomatics and GeoIT, hosted by the Faculty of Engineering.
**TeroMovigo Services**

**GNSS**
- Installation of GNSS CORS networks;
- Dedicated and flexible solutions to transmit and manage GNSS data for post-processing and RTK;
- Definition and update of Geocentric reference frames based on Space Geodetic tools;
- Estimation of accurate coordinates with respect to global and/or national reference frames;

**Gravity**
- Gravity campaigns
- Geoid computation
- Installation of tide gauges

**GEO-IT**
- Automatic (TeroPoint) and dedicated estimation of coordinates with respect to global and national referential.
- Management of GNSS networks (TeroNet) using web-services.
- Integrated software/hardware solutions to access remote devices.
- Automatization of procedures to estimate geo-products (e.g., water vapor, position time-series).

**Geomatics**
- Topometric monitoring of structures.
- GIS Consulting.
- Production, validation and consulting of cartographic projects.
- Acquisition and processing of geo-data using UAV systems.

**Training & Formation**
- GNSS data acquisition and processing;
- Operation of GNSS networks
- Gravimetric data acquisition and Geoid Computations
- Geomatics operations
- M.Sc. in GeoIT and GIS (in collaboration with UBI).
TeroMovigo

*Products - TeroNet*

**Objectives**
- Management of CORS GNSS networks;
- Enable easy and controlled access to stations data;
- Simple network management;

**Main Features**
- Web service compatible with all platforms;
- Integrated system independent of GNSS receiver brand/model;
- Support for different types of communications;
- Security – restricted access to data files and metadata;
- Station monitoring;
- Ntrip Caster for RTK corrections

![Station status screen](image)
JPL (Jet Propulsion Laboratory)

JPL has thousands of researchers focused on robotic exploration of the solar system, including Earth science and space-based astronomy missions.

It is the main contributor for the global IGS (International GNSS Service) network with more than one hundred stations globally distributed.

JPL is also the developer of GipsyX – one of the most recognized scientific software package for RTK and post-processing of GNSS observations.

GipsyX is the software engine behind JPL's free RINEX processing service:

http://apps.gdgps.net
Online Services

Several online services:
- JPL (http://apps.gdgps.net)
- ...

Advantages:
- They permit to compute very accurate position solutions using academic software without very specialized training (they are not user-friendly);
- There is no need for baseline computations – each position can be computed independently;
- No need to use expensive commercial software packages.

Limitations:
- They provide the position in the latest International Terrestrial Reference Frame, currently ITRF2014, at the epoch of observation.
- The estimated height is ellipsoidal.
Limitations of global online services

They cannot be directly used to compute the positions with respect to the national datum of any country:

• Epoch of Observation is different of Epoch of Reference;
• Reference ITRF is also normally different: ITRF89, ITRF94, ITRF2000, ITRF2008 - instead of ITRF2014;
• Vertical Heights of the countries are orthometric/normal, not ellipsoidal.
**TeroPoint** – https://www.teopoint.com

**What it is?**

- **TeroPoint** is an online service that provides directly coordinates from GNSS observations into the **Official Datum** (Horizontal and Vertical).
When no mobile network is available or CORS are too far away to do RTK
TeroPoint workflow

Logged Raw GNSS Observations

Upload RINEX file to TeroPoint web service
Logged Raw GNSS Observations

Upload RINEX file to TeroPoint web service

Online GNSS positioning using JPL in ITRF2014 (automatic on background)
Logged Raw GNSS Observations

Upload RINEX file to TeroPoint web service

Online GNSS positioning using JPL in ITRF2014 (automatic on background)

Retrieve position in ITRF2014 at epoch of observation
**TeroPoint workflow**

1. Logged Raw GNSS Observations

2. Upload RINEX file to TeroPoint web service

3. Online GNSS positioning using JPL in ITRF2014 (automatic on background)

4. Retrieve position in ITRF2014 at epoch of observation

5. Apply corrections for change of ITRF (3D), internal deformations & plate tectonics (horizontal) and geoid undulation (vertical)

Example of the corrections applied due to internal deformation and plate tectonics

Horizontal Grids based on NIGNET – Nigerian GNSS Network
Logged Raw GNSS Observations

Upload RINEX file to TeroPoint web service

Online GNSS positioning using JPL in ITRF2014 (automatic on background)

Retrieve position in ITRF2014 at epoch of observation

Apply corrections for change of ITRF (3D), internal deformations & plate tectonics (horizontal) and geoid undulation (vertical)

Final Position in the National Reference Frame at Reference Epoch
We used data for 3 years (2016-2018) from 15 stations globally distributed (installed by SEGAL for JPL) to analyze the influence of the length of observation on the quality of solutions.

12300 daily solutions were divided in 12h, 8h, 6h, 4h, 3h, 2h, 1h, and 30m (in a total of 1.16M files) that were individually computed and which solutions were compared (difference) with the 24h solution.
**Accuracy of TeroPoint**

**Length of Observation**

Test using a Geodetic Pillar in Portugal.

The Differences between official coordinates (DGT) and solutions from sessions between 1h and 2h are at few centimeter levels, both on horizontal and vertical.

<table>
<thead>
<tr>
<th>Solution</th>
<th>E</th>
<th>N</th>
<th>U</th>
<th>δHorizontal</th>
<th>δVertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>DGT</td>
<td>-26744.54</td>
<td>76852.91</td>
<td>83.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60m</td>
<td>-26744.54</td>
<td>76852.92</td>
<td>83.08</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>60m</td>
<td>-26744.58</td>
<td>76852.95</td>
<td>83.02</td>
<td>0.06</td>
<td>-0.01</td>
</tr>
<tr>
<td>60m</td>
<td>-26744.56</td>
<td>76852.94</td>
<td>83.09</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>75m</td>
<td>-26744.55</td>
<td>76852.93</td>
<td>83.07</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>75m</td>
<td>-26744.55</td>
<td>76852.94</td>
<td>83.09</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>90m</td>
<td>-26744.55</td>
<td>76852.93</td>
<td>83.08</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>120m</td>
<td>-26744.55</td>
<td>76852.94</td>
<td>83.06</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Accurancy of TeroPoint
Type of Orbits – UltraRapid vs Rapid

Ultra-rapid are available in near real-time (~ 3h). Rapid are available 2 days after. If you want the best, wait for the Precise (10 days delay)

This test compares the same data processed with Ultra-Rapid and Rapid. It was done for ten 1h observation files from 4 stations (2 in Nigeria, 2 in Mongolia)

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Vertical</th>
<th>Horizontal</th>
<th>3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>0.001</td>
<td>0.005</td>
<td>0.006</td>
</tr>
<tr>
<td>MAX</td>
<td>0.056</td>
<td>0.039</td>
<td>0.068</td>
</tr>
<tr>
<td>AVG</td>
<td>0.004</td>
<td>0.015</td>
<td>0.019</td>
</tr>
<tr>
<td>RMS</td>
<td>0.020</td>
<td>0.010</td>
<td>0.019</td>
</tr>
</tbody>
</table>

All 10 solutions used

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Vertical</th>
<th>Horizontal</th>
<th>3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>0.001</td>
<td>0.005</td>
<td>0.006</td>
</tr>
<tr>
<td>MAX</td>
<td>0.007</td>
<td>0.018</td>
<td>0.020</td>
</tr>
<tr>
<td>AVG</td>
<td>-0.002</td>
<td>0.012</td>
<td>0.013</td>
</tr>
<tr>
<td>RMS</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
</tbody>
</table>

9 solutions used (one outlier)
Thank You / Cảm ơn

More Info:
- https://www.teropoint.com
- http://teromovigo.ubi.pt
- info@teromovigo.ubi.pt

https://youtu.be/BMQcFcyHPk8