TeroPoint
online processing service for accurate positioning at national level

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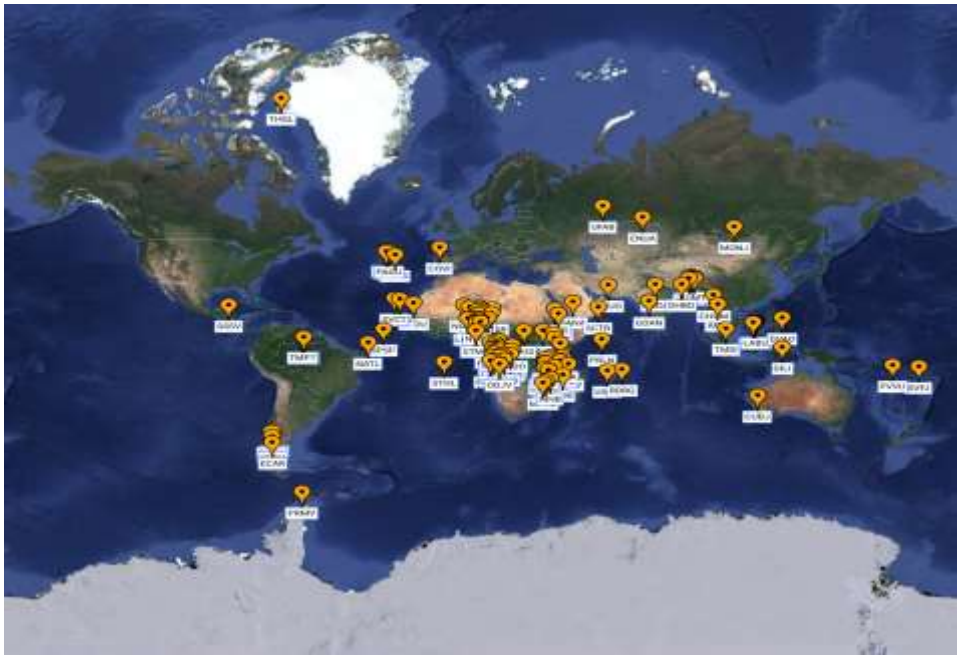
SEGAL (Space & Earth Geodetic Analysis Lab)

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

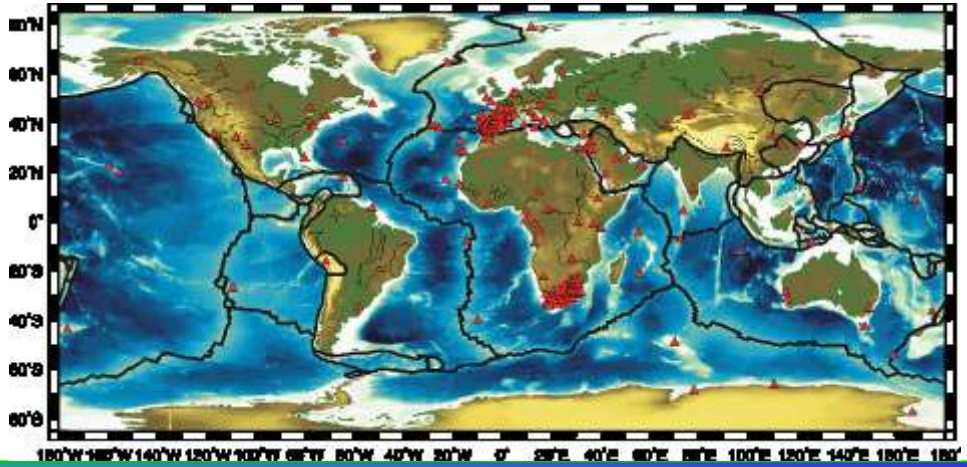
focused on Research of Rigorous Positioning using Space Geodetic Techniques

SEGAL



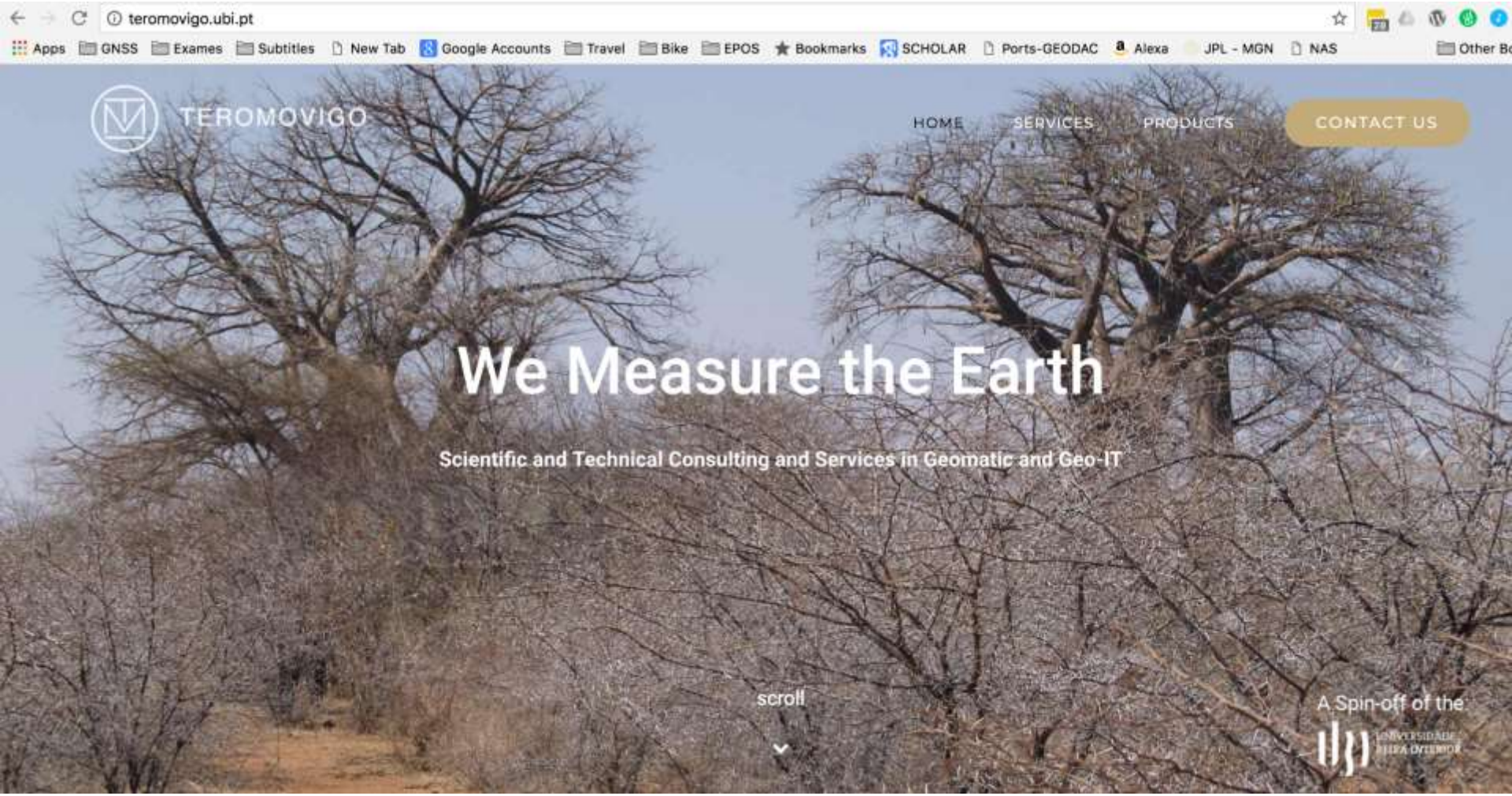
Network of stations installed (~50), and co-managed by SEGAL in collaboration with local partners from >25 countries

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

Earth Innovation



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) a 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

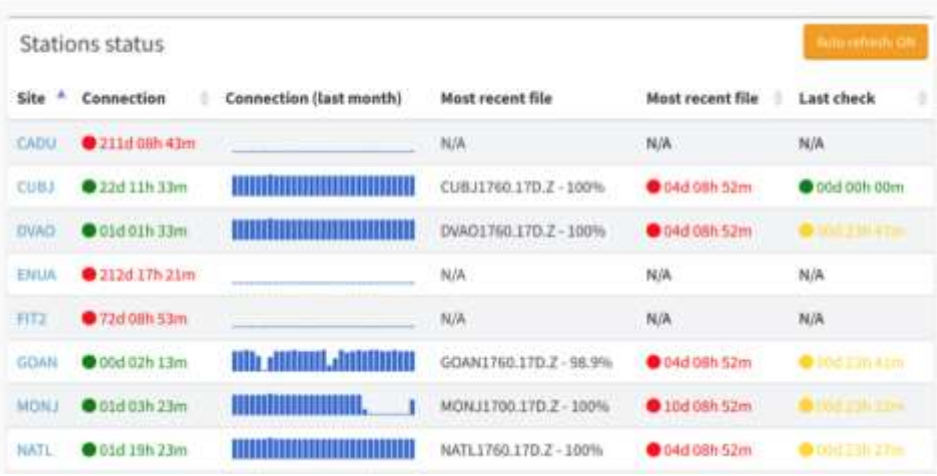
GNSS Network Management

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

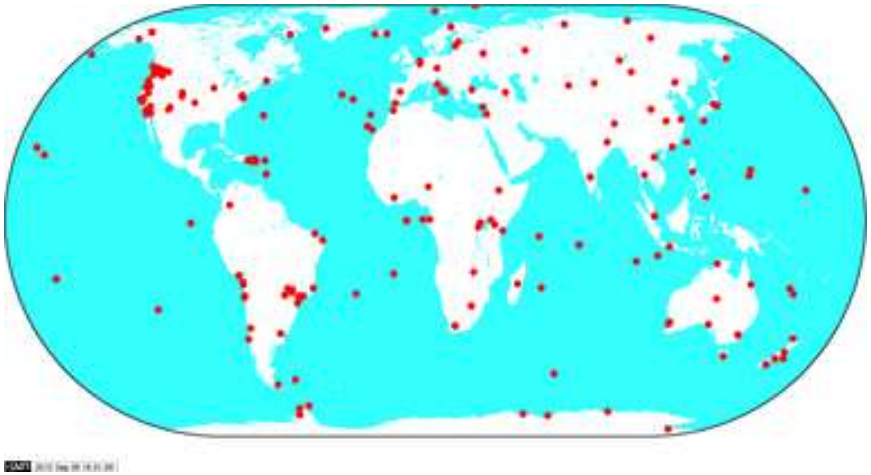


JPL (Jet Propulsion Laboratory)

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.



JPL global GNSS network

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)**
- **NRCAN (https://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php?locale=en)**
- **AUSPOS (https://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/auspos)**
- **…**

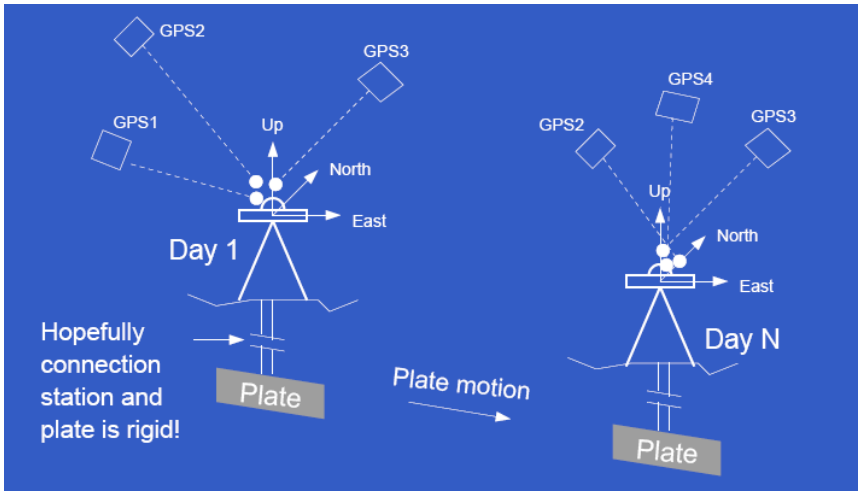
Advantages:

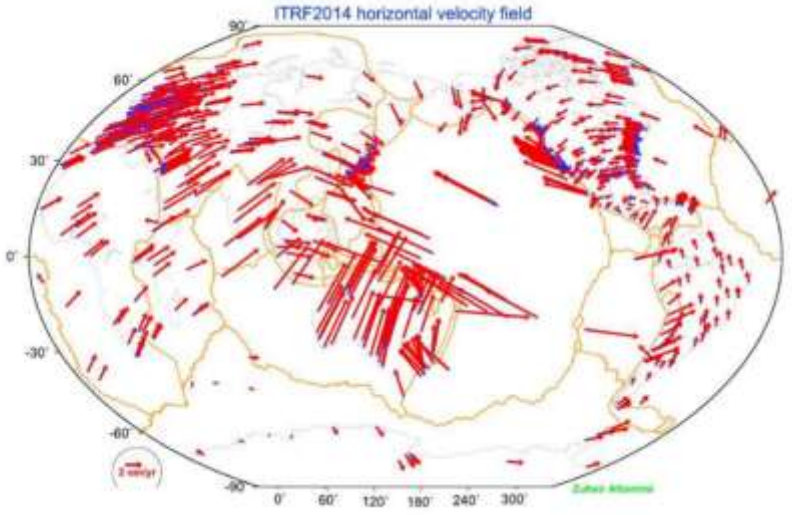
- **They permit to compute very accurate position solutions using academic software without very specialized training (they are not user-friendly);**
- **There is no need for baseline computations – each position can be computed independently;**
- **No need to use expensive commercial software packages.**

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





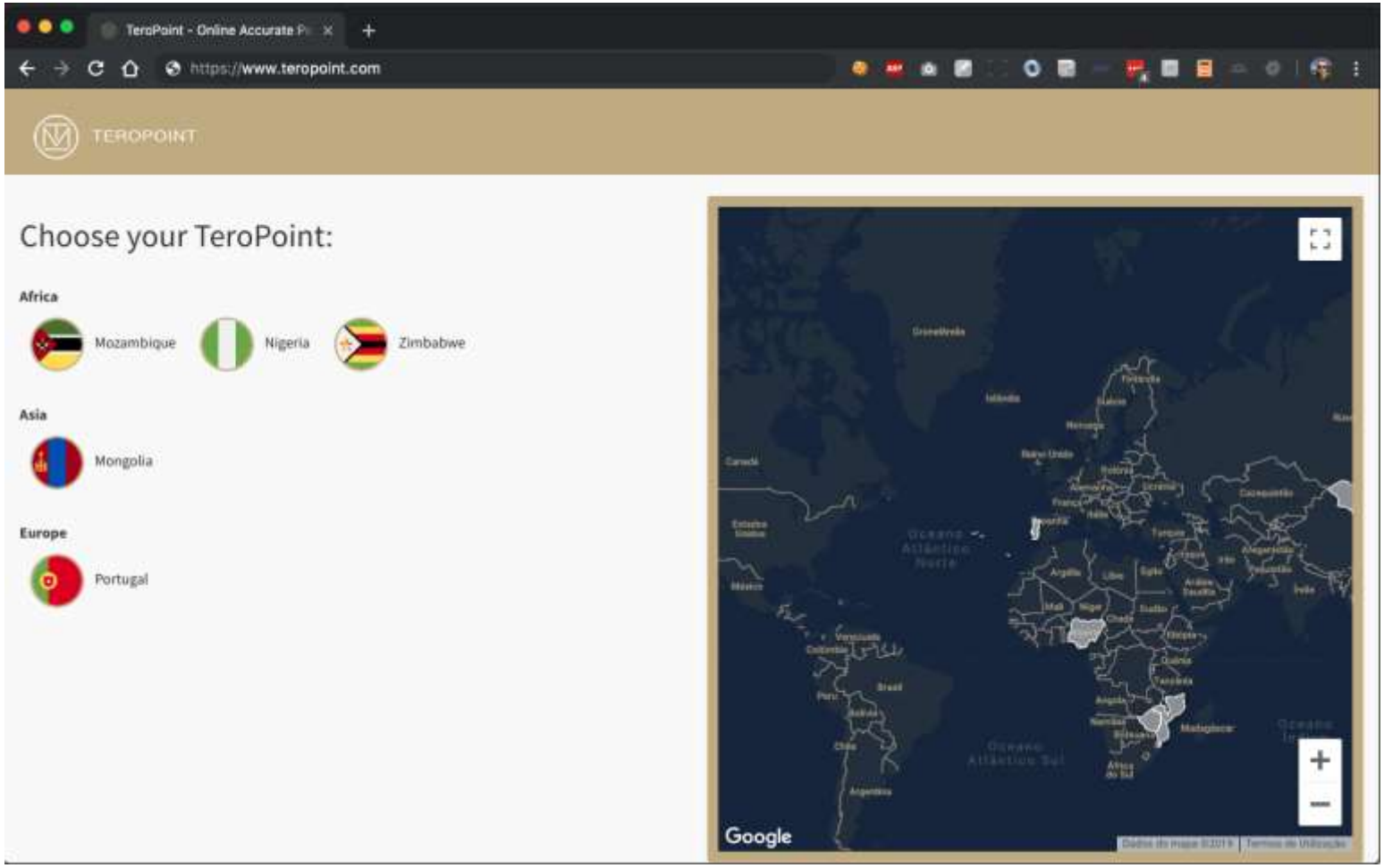
They cannot be directly used to compute the positions with respect to the national datum of any country:

- **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).



TeroPoint workflow

Logged Raw GNSS Observations

Geodetic National Points

Control Points & Base Points for local RTK surveys

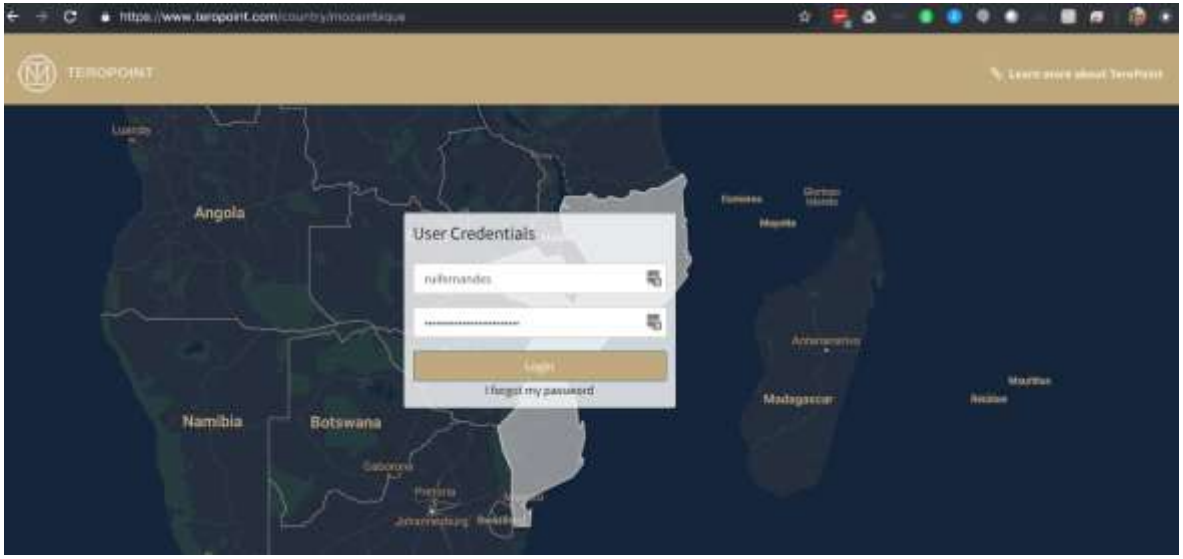
When no mobile network is available or CORS are too far away to do RTK

TeroPoint workflow

Logged Raw GNSS Observations

↓

Upload RINEX file to TeroPoint web service



TeroPoint workflow

Logged Raw GNSS Observations

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Upload RINEX file to TeroPoint web service

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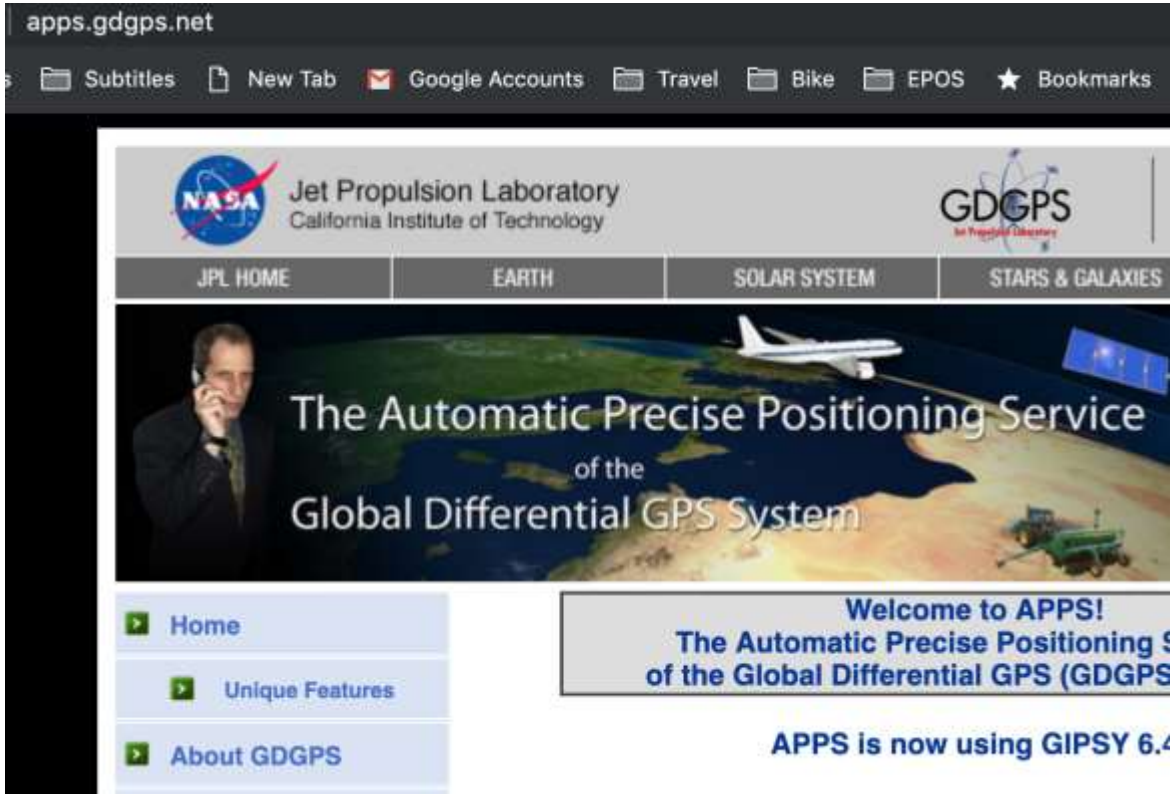
Online GNSS positioning using JPL in ITRF2014 (automatic on background)



TeroPoint workflow

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

2019-04-13.NLKH.sum

```
# APPS Summary file for site  NLKH. Produced from RINEX file NLKH20190410300.19o on Tue Apr 23 05:57:23 UTC 2019
# The reference frame is ITRF14 (with semi-major axis = 6378137 m; flattening factor = 1/298.257222101)
# Output data rate is  300 seconds. Minimum elevation angle is 7.5 degrees.
# Satellite antenna phase center offset and maps taken from IGS Standards igs14_2035.atx.
#
# Receiver antenna phase center offset and maps taken from IGS Standards igs14_2035.atx.
# Receiver antenna phase center offset relative to the antenna reference is 0.0902417 m
# The antenna reference point offset from the monument reference, based on the RINEX file header, is 0 m
#
# Product used to process NLKH20190410300.19o: JPL Final
#
# Static point positioning mode (a single set of site coordinates are estimated):
#
#  Total number of Phase measurements:         121. RMS post-fit Phase residuals:    0.007 m. Number of excluded Phase
measurements:   0
#  Total number of Pseudorange measurements:    121. RMS post-fit PRange residuals:   0.445 m. Number of excluded PRange
measurements:  0
#
# Estimated Cartesian coordinates:     X = -1274263.9337 m     Y =  4102135.8157 m     Z =  4700918.5875 m
# Sigmas of Cartesian coordinates:  SigX =        0.0208 m  SigY =        0.0196 m  SigZ =        0.0233 m
# Estimated Geodetic coordinates (WGS84/GRS80):    Lat =   47.77184048 deg     East_Lon =  107.25658466 deg     Height =
1424.3194 m
# Sigmas of Geodetic coordinates: SigLat =        0.0116 m        SigLon =        0.0204 m    SigHeight =    0.0284 m
```

TeroPoint workflow

Logged Raw GNSS Observations

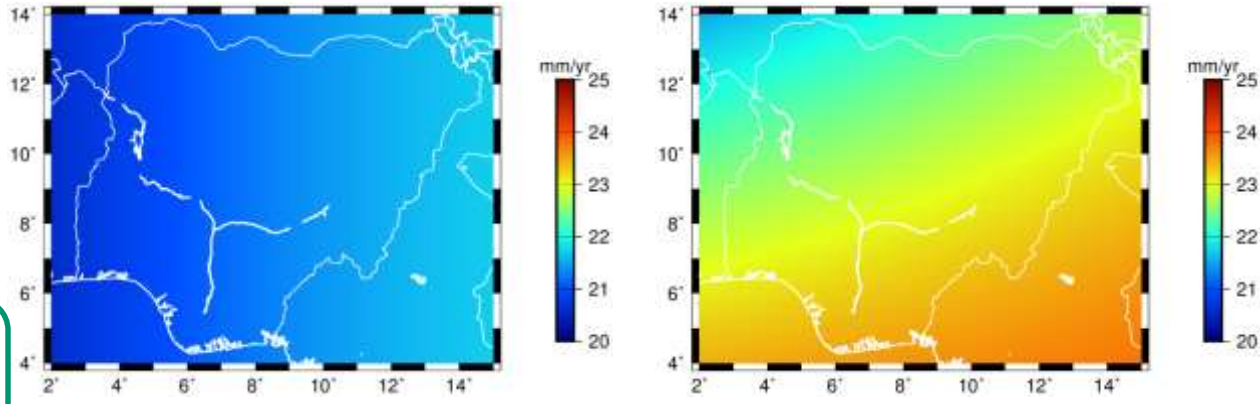
Upload RINEX file to TeroPoint web service

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)

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



Horizontal Grids based on NIGNET – Nigerian GNSS Network

TeroPoint workflow

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

TEROMOVIGO

In cooperation with: Território, Jet Propulsion Laboratory

2. Outcome of Estimation

Cartesian Coordinates

X:	4831615.015 m	+- 0.002 m
Y:	-636863.728 m	+- 0.002 m
Z:	4101935.508 m	+- 0.002 m

UTM Coordinates

E:	626760.600	m
N:	4459560.800	m
Zone:	29N	

Ellipsoidal Coordinates

Latitude:	40.27692947
Longitude:	-7.50896999

Projected Coordinates in National Reference Frame (PT-TM06/ETRS89)

E:	53081.826	m
N:	67770.170	m

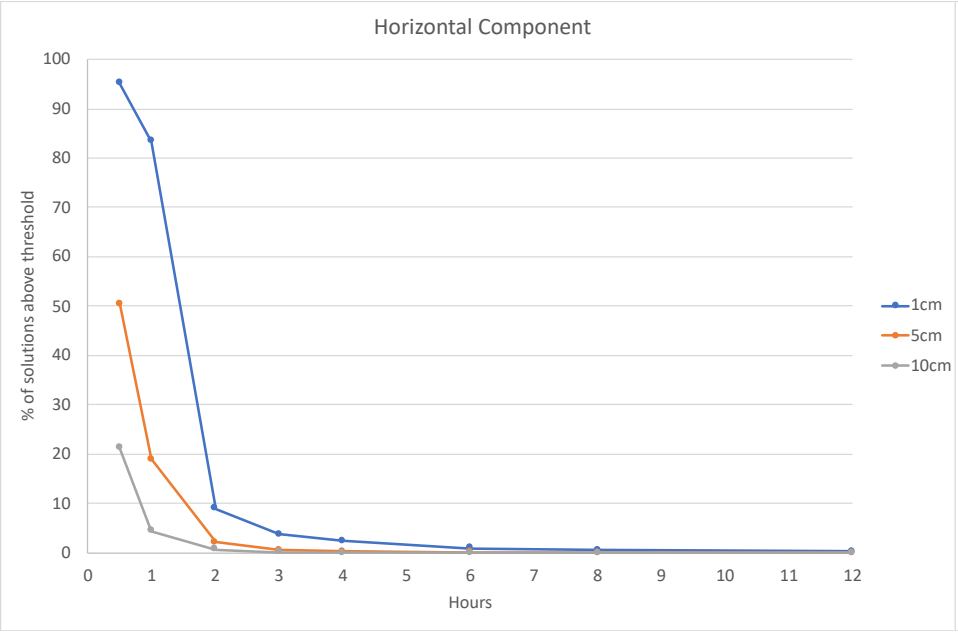
Heights

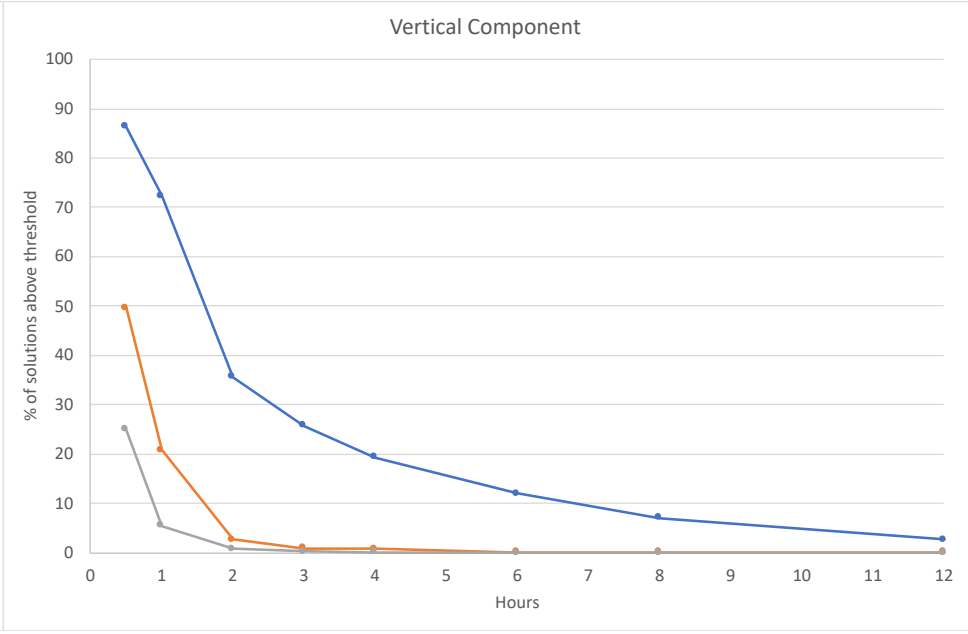
Ellipsoidal Height:	684.181	m
Orthometric Height:	628.081	m
Undulation:	56.101	m
Geoid Model:	GeodPT08	

Accuracy of TeroPoint
Length of Observation

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.

Solution	E	N	U	δHorizontal	δVertical
DGT	**-26744.54**	**76852.91**	**83.03**		
60m	-26744.54	76852.92	83.08	0.01	0.05
60m	-26744.58	76852.95	83.02	0.06	-0.01
60m	-26744.56	76852.94	83.09	0.03	0.06
75m	-26744.55	76852.93	83.07	0.02	0.04
75m	-26744.55	76852.94	83.09	0.03	0.06
90m	-26744.55	76852.93	83.08	0.02	0.05
120m	-26744.55	76852.94	83.06	0.03	0.03

Accuracy 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)**

Statistic	Vertical	Horizontal	3D
MIN	0.001	0.005	0.006
MAX	0.056	0.039	0.068
AVG	0.004	0.015	0.019
RMS	0.020	0.010	0.019

All 10 solutions used

Statistic	Vertical	Horizontal	3D
MIN	0.001	0.005	0.006
MAX	0.007	0.018	0.020
AVG	-0.002	0.012	0.013
RMS	0.005	0.005	0.005

9 solutions used (one outlier)

Thank You / Cảm ơn

More Info:

https://youtu.be/BMQcFcyHPk8

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