GNSS analyses at the National Geographic Institute of Spain. Impact of including GALILEO observables in the processing

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1. Introduction

National Geographic Institute of Spain (IGNE) is **Analysis Center of EUREF** since 2001, carrying out weekly and daily processes of a subnetwork of GNSS permanent stations covering mainly the Western Europe part (Spain, Portugal, France, Italy, Great Britain, Ireland...).

This processing is focused on contributing to **the definition, realization and maintenance of the European Geodetic Reference System**. For this purpose to achieve the highest accuracy is essential.

The latest advances in GNSS, especially the **addition of Galileo** to the Global GNSS constellations and the upgrade of some receivers to multi-constellation devices, have made possible to include Galileo observations to the data processing.

The **determination of the impact** of including Galileo observables in the solution is necessary before adding them in the operational processing. In this poster the estimation of this impact is shown.

2. Motivation and purpose

The main objective of this project is **to study, quantify and analyse the impact of the addition of Galileo** in the IGNE EUREF solution.

The same EUREF subnetwork has been processed in **two campaigns** with the same data, network configuration and processing strategy. The only difference is the use of GPS+GLONASS+**Galileo** observables or only GPS + GLONASS.

Three cases of study have been compared:

- The weekly **repeatability** of the coordinates.
- The **final coordinates**. Stacking the diary solutions to obtain unique coordinates for the period considered.
- The influence of using individual or generic antenna **calibrations**.

3. Resources and Methods

Software	Bernese 5.2
Parameters estimated	Station coordinates (ITRF14 minimum constraint condition nnt. Solution is aligned to a set of EPN stations) and troposphere.
Processing strategy	Standard double difference processing for regional networks and static dual-frecuency stations.
GNSS Data	RINEX 3.0 of 89 EPN stations
Period processed	5 weeks (GPS week from 2034 to 2038)
Orbits and Earth Rotation Parametes	Precise MGEX CODE orbits and ERPs.
Ocean Loading Tidal Model	FES2004.
A priori troposferic model	Vienna Mapping Function Coefficients.

4. Results

4.1. EUREF regional network processings and differences between coordinates.

Two daily processings of the EUREF subnetwork were done: The first one only with GPS+GLONASS observables and baselines defined by using a maximum observation criterion. In the second one GPS+GLONASS+Galileo observables were taken into account and baselines were forced to be the same than in the previous processing. Daily coordinates for both campaigns were obtained. The daily normal equations were stacked to obtain the final coordinates of each station. These coordinates were compared. The absolute value of the differences in each component (North, East & Up) are shown in Figure 2.

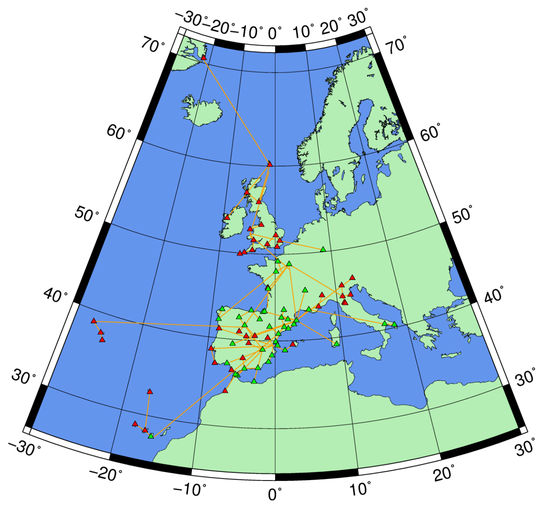

***Figure 1**. Network configuration: a subnetwork of 89 EPN stations. Baselines in yellow; Stations with GALILEO in green; Stations without GALILEO in red.*

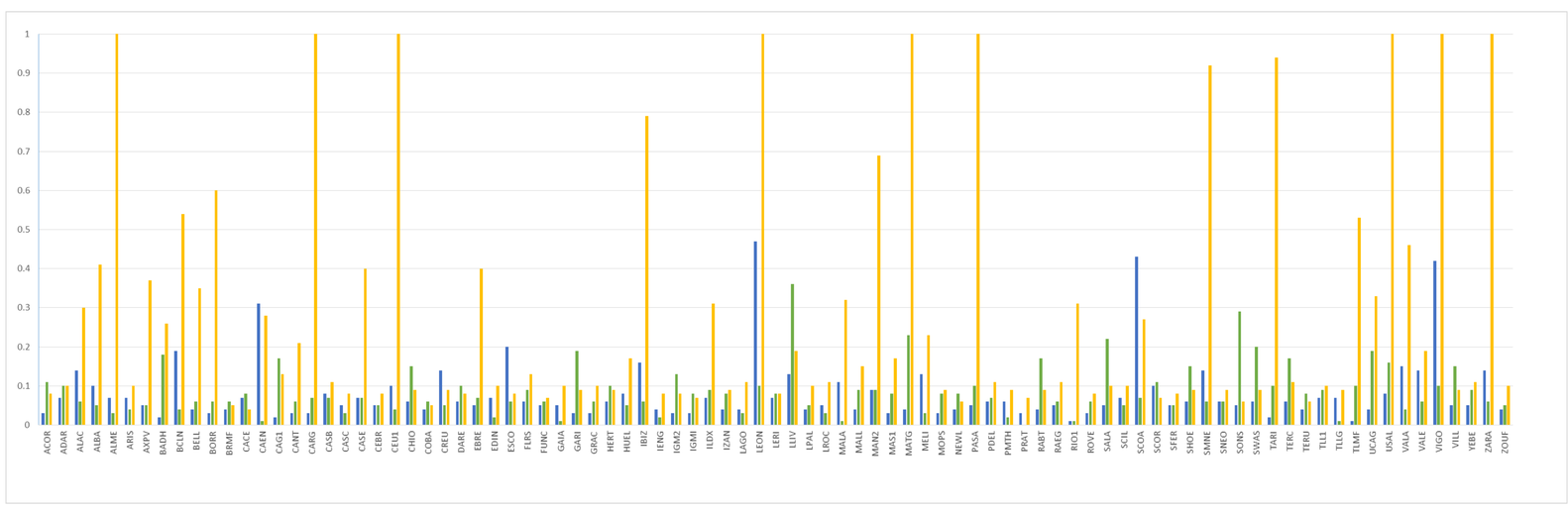

***Figure 2**. Absolute value of the differences in North, East and Up . (mm)*

4.2. Repeatability

The weekly total repeatabilities of both cases (GPS/GLO and GPS/GLO/GAL) were checked. Results are shown in Figure 3.

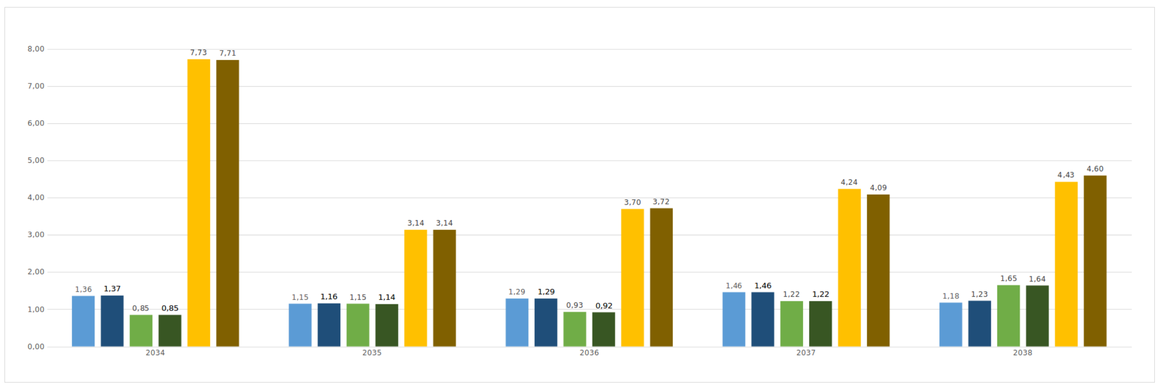

***Figure 3.** Weekly total repeatabilities (mm) in North, East and Up components. GPS+GLO light colours, GPS+GLO+GAL dark colours.*

4.3. Repeatability analysis depending on antenna calibration

An analysis of the mean repeatability depending on the antenna calibration and constellations is shown in figure 4. A total of 89 stations were processed: 3 only GPS observables, 43 GPS + GLONASS (36 of them with generic calibration and 7 with individual) and 43 GPS + GLONASS + Galileo (25 of them were processed with generic calibration, 17 with individual calibration GPS+GLONASS and 1 with individual including Galileo).

Segmentation criteria	Samples	Mean Repeatability		
		N (mm)	E (mm)	U (mm)
G+generic calibration	3	0,04	0,06	0,07
GR	43	0,05	0,06	0,09
GR+generic calibration	36	0,05	0,06	0,09
GR+individual calibration	7	0,06	0,06	0,09
GRE	43	0,11	0,11	0,71
GRE+generic calibration	25	0,12	0,09	0,89
GRE+individual calibration without Galileo	17	0,09	0,13	0,49
GRE+individual calibration with Galileo	1	0,02	0,16	0,26

***Table 1.** Mean repeatability depending on the antenna calibration and observables.*

5. Conclusions and future plans

Conclusions:

- The bigger differences in coordinates were obtained in the stations with Galileo observables as expected, but these differences are not significant.
- The weekly repeatability of the stations is not affected by the inclusion of Galileo in most cases.
- The cases where this inclusion affects to the repeatability are those stations with Galileo and without individual calibration.

Future plans:

- In the light of these results Galileo observables were included into IGE routinary processing as EUREF Analysis Center.
- It is planned to expand this comparison to a longer time period and to study more in detail the influence of Galileo regarding to the calibration used in the processing.

6. References

[1] Bernese GNSS Software. *R. Dach; S. Lutz, P. Walser, P. Fridez*. (2015). Published by Astronomical Institute, University of Bern.

[2] CODE product series for the IGS MGEX project. *L. Prange; D. Arnold; R. Dach; S. Schaer; D. Sidorov; P. Stebler; A. Villiger; A. Jäggi* (2018). Published by Astronomical Institute, University of Bern.