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Multi-GNSS through Global Collaboration

CNES/CLS IGS Analysis center: recent activities

S. Loyer (1), F. Perosanz (2), L. Versini (1), G. Katsigianni (2), F. Mercier (2), A. Mezerette (1)

(1) CLS, Collecte Localisation Satellites, 8-10 rue Hermès, 31520 Ramonville Saint Agne, France
(2) CNES Centre National d'Etudes Spatiales, 18 av Edouard Belin, 31400 Toulouse, France

contact: sloyer@groupcls.fr

INTRODUCTION

In this poster we present the main changes made in the multi-GNSS processing of the CNES/CLS IGS Analysis Center in 2018 and their impact on the **grg/grm** final products delivered by our Analysis Center.

I. Adoption of elevation cut-off of 8 degrees and a new elevation dependent weighting laws & Change of data sampling to 300 sec (vs 900 sec. before)
II. Adoption of antenna thrust
III. Adoption of Attitude law of ESA release for GALILEO (IOV/FOC)

IV. Undifferenced Ambiguity fixing for Galileo

January 2018 | April 2018 w1997 | June 2018 | August 2018 | October 2018 w2022

I. Consequences of combined use of Elevation dependent Law weighting, lower elevation cut-off and data sampling increase

Over all the changes made during last year in our processing the most important in their consequences is the data selection and the weighting applied to the individual measurements. Our previous processing was showing errors in the stations coordinates estimates characterized by a higher noise in the stations positions residuals relatively to the other Analysis Centers in particular in the up direction. These errors were dominated by an unexplained spectral signature around 3.7 days detected initially in 2013 by Jim Ray and al.[1]. To lower the correlations between stations positions and other parameters (e.g. stations clocks and tropospheric zenithal biases) we decided to lower the elevation cut-off to 8 degrees, and simultaneously we adopted an elevation dependent weighting law for phase measurements. The form of this law, given on the figure 1, was chosen accordingly to fit the observed residuals distribution.

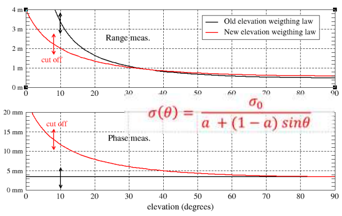


Figure 1: Range and phase elevation dependent laws used for a priori uncertainties of the measurements.

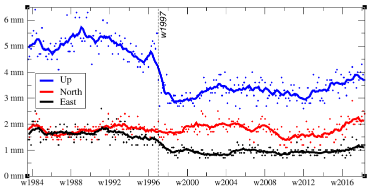


Figure 2: RMS in NEU of GRG minus IGS combined solution (from P. Rebischung, IGS weekly combination reports)

This choice has a significative positive impact on the estimated coordinates of the stations clearly visible on the global RMS (NEU) of our sinex daily solutions relatively to IGS combined solution (see figure 2).

Our investigations have shown that half of the gain in the upward and East directions is due to the new elevation dependent law (associated with the cut-off of 8 degrees), and the other half is due to the increase of the data sampling (from 900 to 300 seconds). Linked to this, the old spectral signature of ~3.7 days has now disappeared (see figure 3). Our solution is now in much better agreement with the other Analysis Centers.

In the North direction it remains some sub-millimeters discrepancies for which the origin is still unknown.

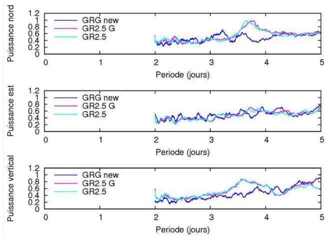
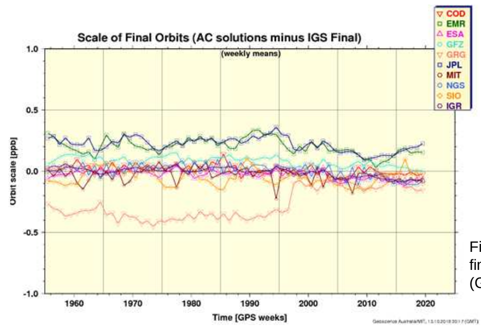


Figure 3: Lomb-scargle normalised periodograms of the NEU residuals of the stations coordinates of various processing strategies vs IGS daily solutions (with special thanks to A. Santamaria – GET/OMP).

- Note that the main signature centered on 3.7 days disappear when using new elevation dependent law and new data sampling. The use of Glonass (GRG2.5) or not (GRG.2.5G) has no effects on this signature

II. Antenna thrust

Several studies presented in Paris in 2017 discussed the use of improved and more realistic values for antenna thrust[3, 4]. We adopted, after GPS week 1997, the antennae thrust transmitting power values given in Table 1 to compute the associated radial forces acting on the satellites. As expected, we observe a reduction of the global scale disagreement of our orbit relatively to other Analysis Centers solutions, clearly visible in the scale residuals issued from the IGS combination process (see figure 4)



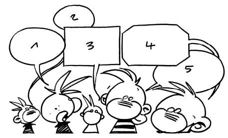
GPS I/II	:	76 W
GPS IIR(AB)	:	85 W
GPS IIR(M)	:	198 W
GPS IIF	:	249 W
GPS IIF (prv62)	:	154 W
GAL IOV	:	130 W
GAL FOC	:	200 W

Table 1: Antenna thrust transmitting power values.

Figure 4: Scale of final orbits (vi IGS final), from IGS analysis coordinator (Geoscience Australia/MIT)

IV. Galileo Ambiguity in MGEX solutions

Starting with GPS week 2022 the Galileo products delivered to MGEX (grm) are computed with undifferenced ambiguities fixed. The processing strategy is similar to the one described by G. Katsigianni and al in 2018 [2]. Some details are also given in the Multi-GNSS poster session **"Improving Galileo Orbit Determination using Zero-difference Ambiguity Fixing in a Multi-GNSS Processing".** The method used here was just adapted to support operational weekly processing constrains.



The improved quality of the orbits can be accessed either by external check (using SLR) or internally by computing orbits differences between successive overlapping orbits; Figure 7 illustrates the gain achieved with the ambiguity fixing: for the month of September 2018 the 3D RMS of the overlaps decrease by a factor of two for all satellites (The method was identically applied to the eccentric satellites E14 & E18).

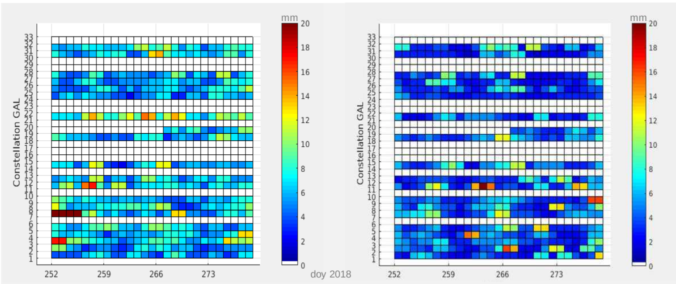
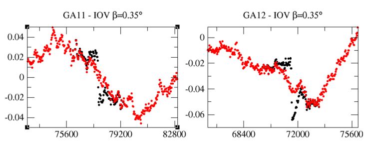


Figure 7: 3D RMS of Galileo orbits overlaps for unfixed (left) and fixed ambiguities (right)

III. Galileo ESA Attitude Law

During Autumn 2017, GSA(ESA) released metadata and gave the description of the attitude models to be used when nominal attitude cannot be followed by the spacecraft, i.e. for low β_angle (elevation of the sun above orbit plane). The two different models followed by IOV & FOC satellites have been implemented in our software Gins.

As the attitude of GNSS satellites have a geometrical effect on the CoM-PCO vector and on the computation of phase wind-up corrections, potential errors in attitude map into the clock estimates; using this property we expect that the clocks estimates behavior to be more regular if these models are correctly reproducing the real-behavior of the satellites. This is checked on the following figures for the two kind of satellites.



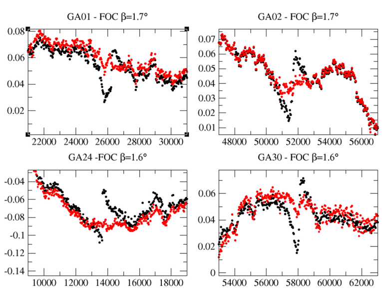


Figure 5 & 6 : Estimated stochastic clocks for the two IOV (top, doy 170/2017) and the four FOC (right, doy 20/2017) satellites under eclipse on and for the two models: nominal (i.e no particular attitude law, in black) and with ESA model (red).

Conclusions

Our solution quality has been significantly improved and several historical problems have been solved:

- Improved stations coordinates thanks to revisiting elevation dependent weighting laws and data sampling.
- Reduced orbit scale thanks to antenna thrusts
- Better attitude law for Galileo
- Galileo orbits internal consistency divided by two thanks to ambiguity fixing

REFERENCES

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