CNES/CLS IGS Analysis Center: recent developments

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Abstract IGS Workshop -128
P2: 002

Introduction

Since 2015, the CNES/CLS IGS Analysis Center has been producing orbit and clock products for the GPS, GLONASS and Galileo constellations (GRG products). As part of the developments of the CNES/CLS IGS Analysis Center products, we improved in 2023-2024our software to include the processing of the BeiDou systems (BDS-3) signals.
In this contribution we present our products, the various recent evolutions for final products and for the Multi GNSS Pilot Project products with a focus on the coming participation to the PCO evaluation campaign and our product's evaluation with SLR data.

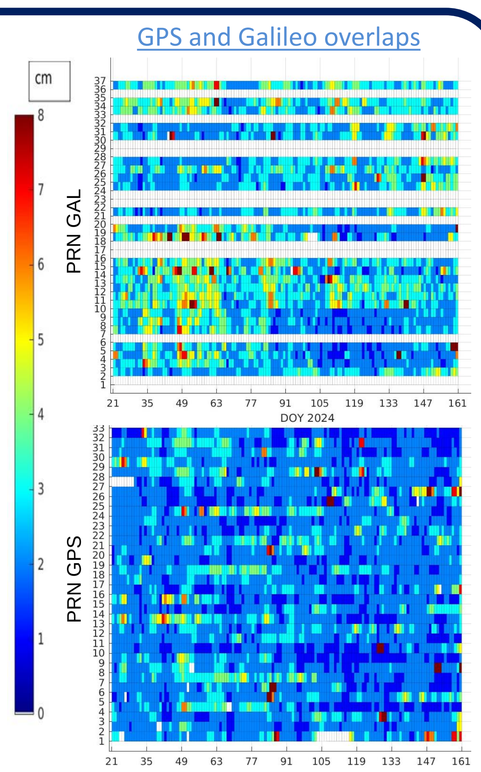
Products overview

Our AC has been a contributor to the IGS since 2007, and we regularly make improvements and enhancements to our products. We are involved in IGS products such as: final products, rapid & ultra-rapid products (see poster P2:003), MGEX products (see BeiDou frame), PPP AR WG (J. Geng et al).

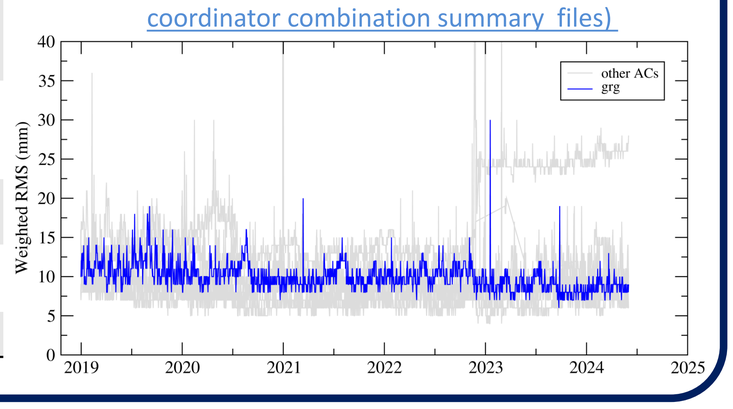
Recent improvements :

2023.11 Start of routine delivery of BeiDou ephemeris as new MGEX products
2022.12 Start of routine delivery of Rapid and Ultra-Rapid products
2022.11 Switch to IGS20/ANTEX20 (GPS week 2238)
2021.05 Start of routine delivery of GNSS satellite OSB biases
2021.01 Start of routine delivery of GNSS ATT files
2020.10 Delivery of GRG06 Solutions for REPRO3 Campaign

Constellations	GPS, GLONASS, GALILEO, BEIDOU
Clock rate	30s
Ambiguity fixing	GPS (Loyer et al (2012)), GALILEO (Katsigianni et al (2018)), BEIDOU (MEO)
Observables	GPS, GALILEO, BEIDOU (OSB)
Specific Biases	
Station position	Estimated (SINEX)
Earth rotation parameter	Estimated (SINEX)
Sat. Attitude	Delivred (OBX)



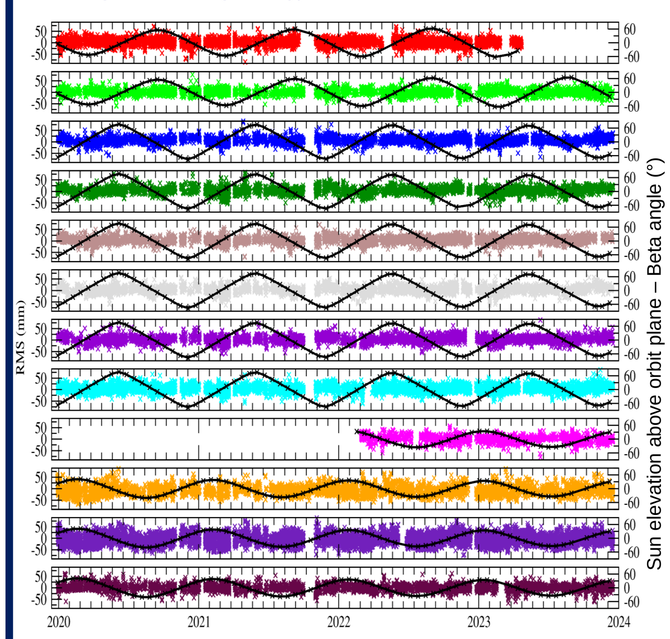
Final orbits WRMS compared to IGS final (from igs-coordinator combination summary files)



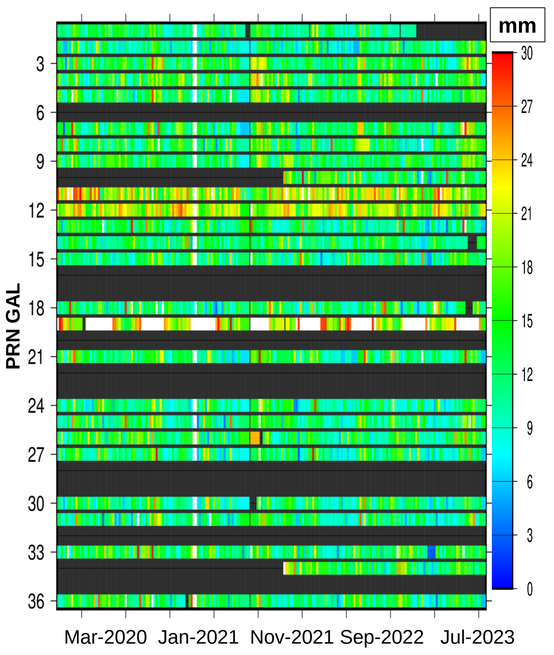
SLR validation

As part of the IGS AC's activities, we use SLR data to review our Galileo orbits quality. The first part of this work involved setting up the processing chain to calculate laser data residuals on a set of fixed orbits (AC or external orbits). The second part involved setting up the analysis and visualization tools.
We therefore carried out processing from GPS week 2086 to week 2294, i.e., 4 years of processing on G20 orbits, i.e., orbits reprocessed as part of the change to ITRF2020. The overall 3D residuals are about 8 to 12 mm.
Station range biases are estimated but we will soon be testing different strategies (RB from ILRS Data Handling File, RB from Saquet et al (2023)).

Constellation	**GALILEO: final, repro, test, other AC, ...**
Arc	**1 week**
MRB	**Estimated**
Input	**Orbits, Macromodel with LRA center of phase, SLR station coordinates (SLRF2020)**



SLR residuals over time per satellite (PRN01 to 12). Black curves correspond to to the sun elevation above the orbit plane

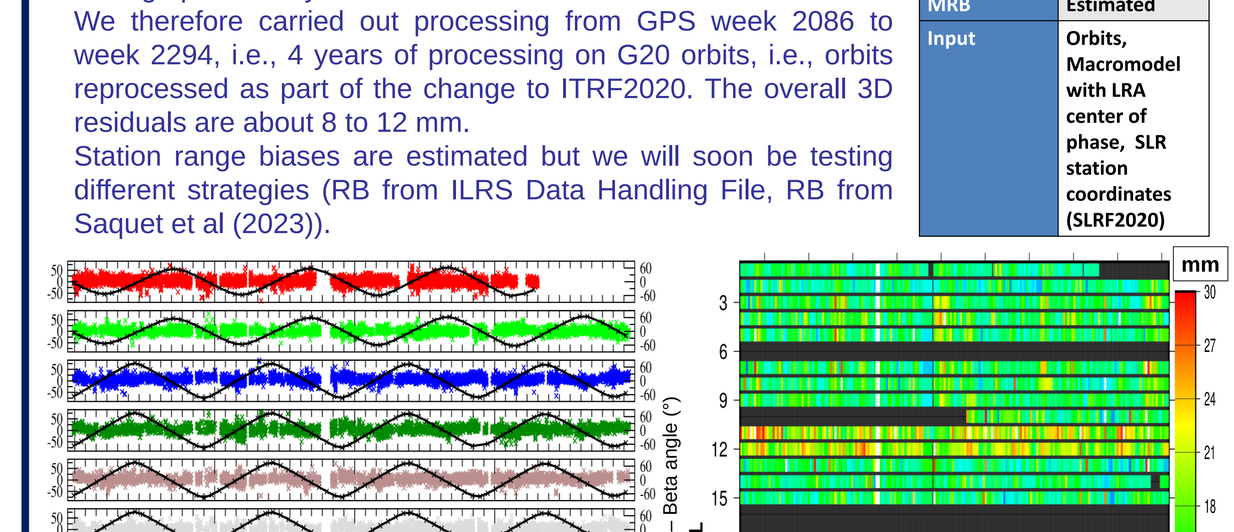


SLR 3D RMS per satellite per day

BeiDou specificities & futur work

Since the end of the year 2023, the CNES/CLS analysis center delivers BeiDou products as a new MGEX products to IGS. To compute the orbits, we use the software GINS combined with DYNAMO (Marty, 2011). We use the igs20 reference frame and the igs20.atx. The ambiguity resolution is done using the undifferenced ionofree linear combination on frequency B1 and B3 (L2/C2 and L6/C6), excepted for IGSO satellites which are left floating. We use a box & wing model (Zhao,2022), an SRP modelling (Li,2018) and we follow the attitude model presented in Yang (2023).
All satellites and constellations are proceeded at the same time. However, BeiDou slightly down-weigthed relatively to GPS/Galileo. There are around 70 stations tracking BeiDou whereas the are 125 stations for GPS & Galileo.

The delivered MGEX products (GRG0MGXFIN) are : SP3, CLK, OBX, OSB.



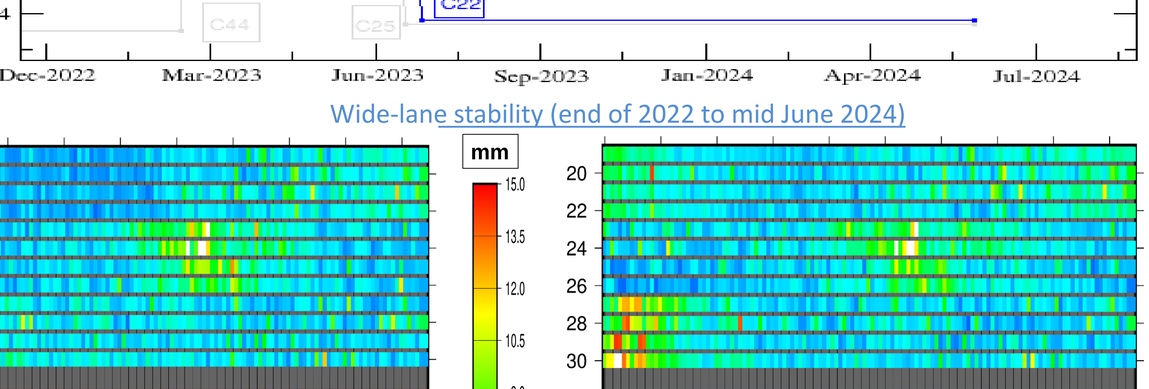
Wide-lane stability (end of 2022 to mid June 2024)

BeiDou overlaps (GPS week 2298 to 2317)

BeiDou orbits comparison vs GFZ (left) and CODE (right)

The map shows an overall low horizontal residuals pointing to Indonesia pattern. It could be an effect coming from the IGSO satellites. An other effect to consider is the impact of the Beidou satellite PCOs provided by the manufacturers. It has been demonstrated in Zajdel (2022) that manufacturer PCOs for B1I/B3I and B1C/B2a showed 0.5 ppb overall inconsistency.
So before incorporating BeiDou constellation into the IGS operational processing, a calibration campaign to adjust satellite antenna phase variations (PVs) and phase center offsets (PCOs) is necessary. It will minimize any possible adverse impact on the IGS terrestrial frame (SINEX) products, as well as on the access to the ITRF by users of the IGS orbit and clock products. The first step (compute PCVs) was completed in June 2024 and the second step (processing of 3 years of data with estimates of BDS-3 PCO's is underway (to be done in 2024).

- CNES/CLS AC participate to the PCO calibration



Sinex comparison between GRG products w or w/o BeiDou satellites. Credit: Paul Rebishung (IGN)

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