IDS AWG Meeting Program, 24 March 2025

IPGP-IGN/JPL AC status AWG IDS meeting 2025: the IGN-22 solution and our ongoing studies

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Special thanks to Guilhem Moreaux for his thorough evaluation of our IGN22 solution.

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Outline

- 2024 processing update
  - Weighting method
  - Tropospheric a priori model
  - High solar activities
  - IGN22
- IGN22 4-years solutions for ITRF2020-u2024
- Future developments

2024 processing update

Main evolution from IGN16 submission for ITRF2020-u2023 to ITR2020-u2024 :

- **Weighting method**
  - Before : a flawed approach based on the sin(e) of the on-board satellite antenna
  - Now : a station-specific weighting method using a model that can incorporate up to seven parameters.

$$\sigma = \frac{a_1}{\sin(e)^2} + \frac{a_2}{\sin(e)} + \frac{a_3}{\sqrt{\sin(e)}} + a_4 e^3 + a_5 e^2 + a_6 e + a_7$$

For each station, the optimal model is selected using the Bayesian Information Criterion (BIC) and fitted with three-year residuals from 2021 to 2023. [Nahmani et al, 2024] - IDS 30YPRA

2024 processing update

Main evolution from IGN16 submission for ITRF2020-u2023 to ITR2020-u2024 :

- **Weighting method: results**
  - The primary improvement is in our pole coordinate estimation.
  - A new study is underway to verify that our improvements remain valid once the tropospheric correction bug is fixed (details to follow).
- IGN16 to IGN20 use parameter estimated with **an incorrect ZHD a priori values.**
- IGN21 : Weighting parameters were estimated as before, but incorrect ZHD a priori values have been corrected.
- IGN22: All parameters have been re-estimated, yielding results that are closely aligned with the previous solution. The S6A conrad macromodel has been implemented and used.

Processing

Main evolution from IGN16 submission for ITRF2020-u2023 to ITR2020-u2024 :

- Tropospheric a priori model: incorrect ZHD a priori values
    - Before IGN21: A bug was detected in our process.
    - We used the VMF1 model for the mapping function, but our a priori values were based on a very basic constant model.
- From IGN21: The true VMF1 model is now applied for both a priori values and the mapping function

Greatly improve our station positions !

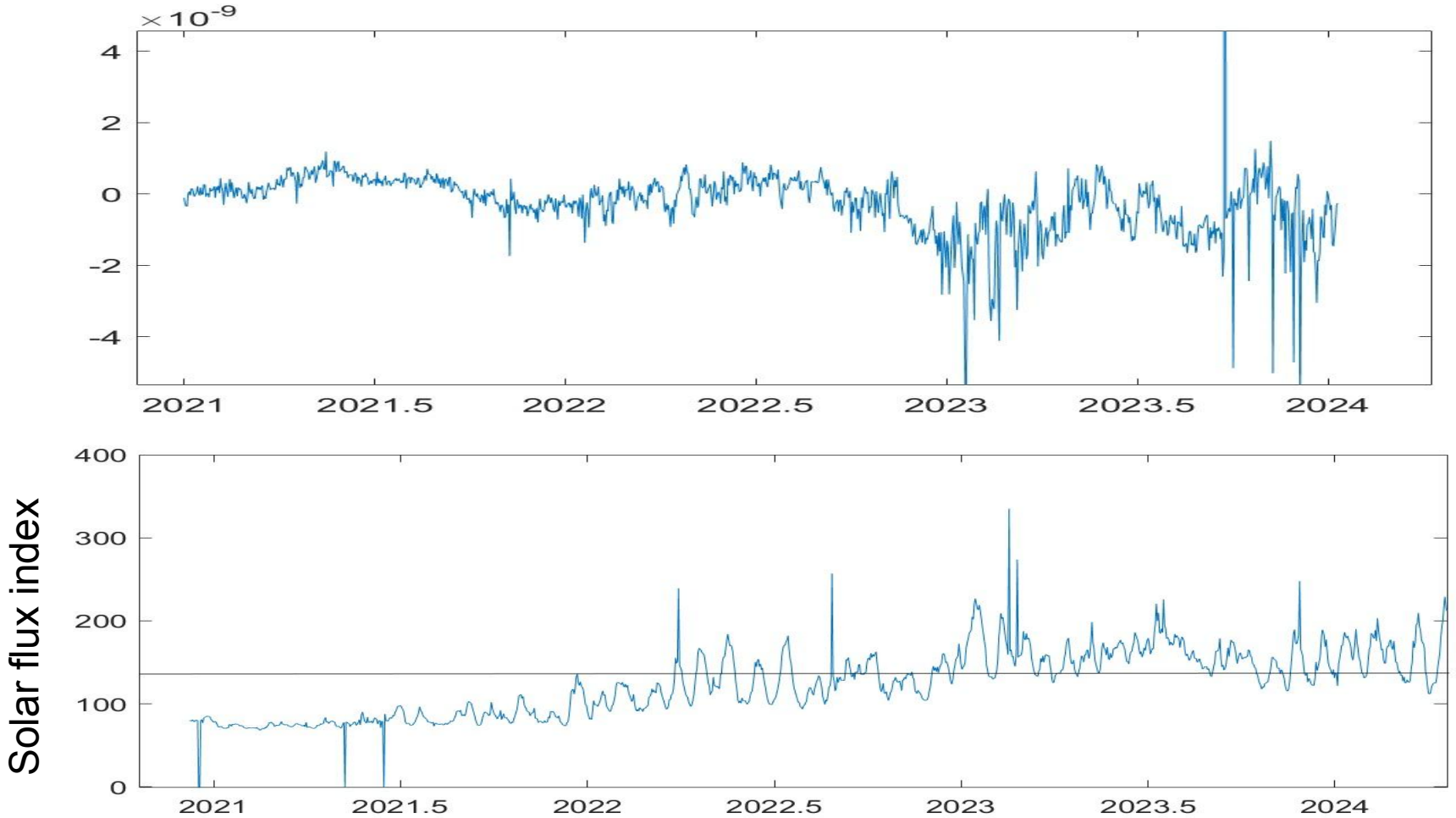
Processing

Main evolution from IGN16 submission for ITRF2020-u2023 to ITR2020-u2024 :

- High solar activities
  - After discussions with G. Moreaux and H. Capdeville, we decided that for the IGN20–IGN21 solutions, a drag coefficient (Cd) will be estimated per hour for all low satellites (one every 8 hours for JA3 & S6A), rather than one per 8 hours for all satellites.
  - For the IGN22 solution, we established a threshold to switch between one Cd per hour and one Cd per 8 hours: if the F10.7 index is above 120, we use one Cd per hour for low satellites. [F10.7 cm Radio Emissions]

This approach has improved the stability of all our parameters (TRF, stations).

Solar activity - S3B along-track per rev. emp. acc. amplitude vs F10.7 index



IGN22

Resume of the main change for IGN22 :

- Weighting and Tropospheric Corrections:
  - Weight and tropospheric issues have been resolved;
  - weights are re-estimated using data from 2021 to 2023.

- Drag Coefficient (Cd) Estimation:
  - Cd estimation now varies with solar activity,
  - switching between 1 per hour and 1 per 8 hours.
- Solar Scale Fix:
  The solar scale is now fixed for all satellites (previously not fixed for JA3 and S6A).
  Values reprocessed over 2021–2024 are:
  - Jason3 : 0.95 ; Saral : 0.94 ; S3A : 1.03 ; S3B : 1.02 ; S6A : 1.00 ; CS2 : 1.03

IGN22

Resume of the main change for IGN22 :

- New Gravity Field Data Update (CNES_GRGS.RL05MF):

The solution now uses the CNES/GRGS GRACE+SLR RL05 monthly gravity field time series from April 2002 to August 2024—an update from the previous April 2002 to October 2022 range.

- The S6A conrad macromodel has been implemented and used.

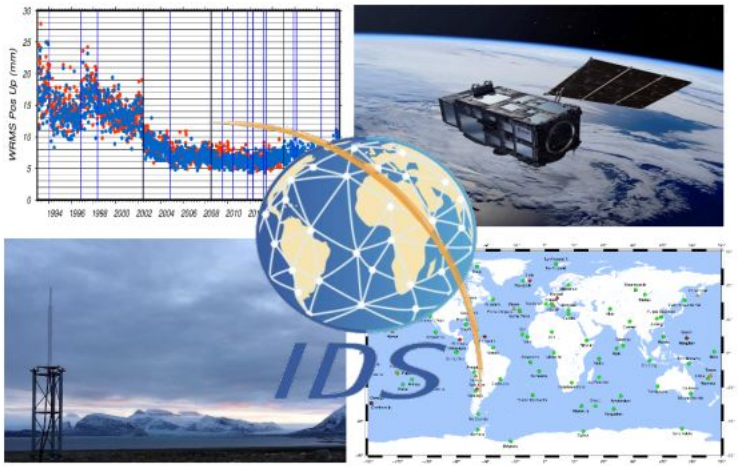
IGN22

AC Parameter Configuration :

- **Satellite Coordinates:** 6 coordinates (position & velocity) per day.
- **Drag Coefficient (Cd):** 1 Cd per hour or per 8 hours, depending on the satellite and the F10.7 index.
- **Solar Scale:** Fixed Solar Scale value.
- **Empirical Accelerations:** Empirical accelerations per revolution (both cross-track and along-track).
- **Clock Rate Parameter:** 1 clock rate parameter per station and satellite per pass.
- **Zenith Wet Delay (ZWD):** 1 ZWD parameter per station and satellite per pass.
- **Trop. Gradient Parameters:** 1 north and 1 east gradient per station and satellite per arc.
- **Station Coordinates:** 3 coordinates per station per week.
- **Additional Parameter for S6A:** 1 scale factor parameter specifically for S6A.

IGN22 4-years solutions for ITRF2020-u2024

Evaluation of the IGN 22 series by the IDS Combination Center



IGN22 4-years solutions for ITRF2020-u2024

WRMS of Station Position Residuals

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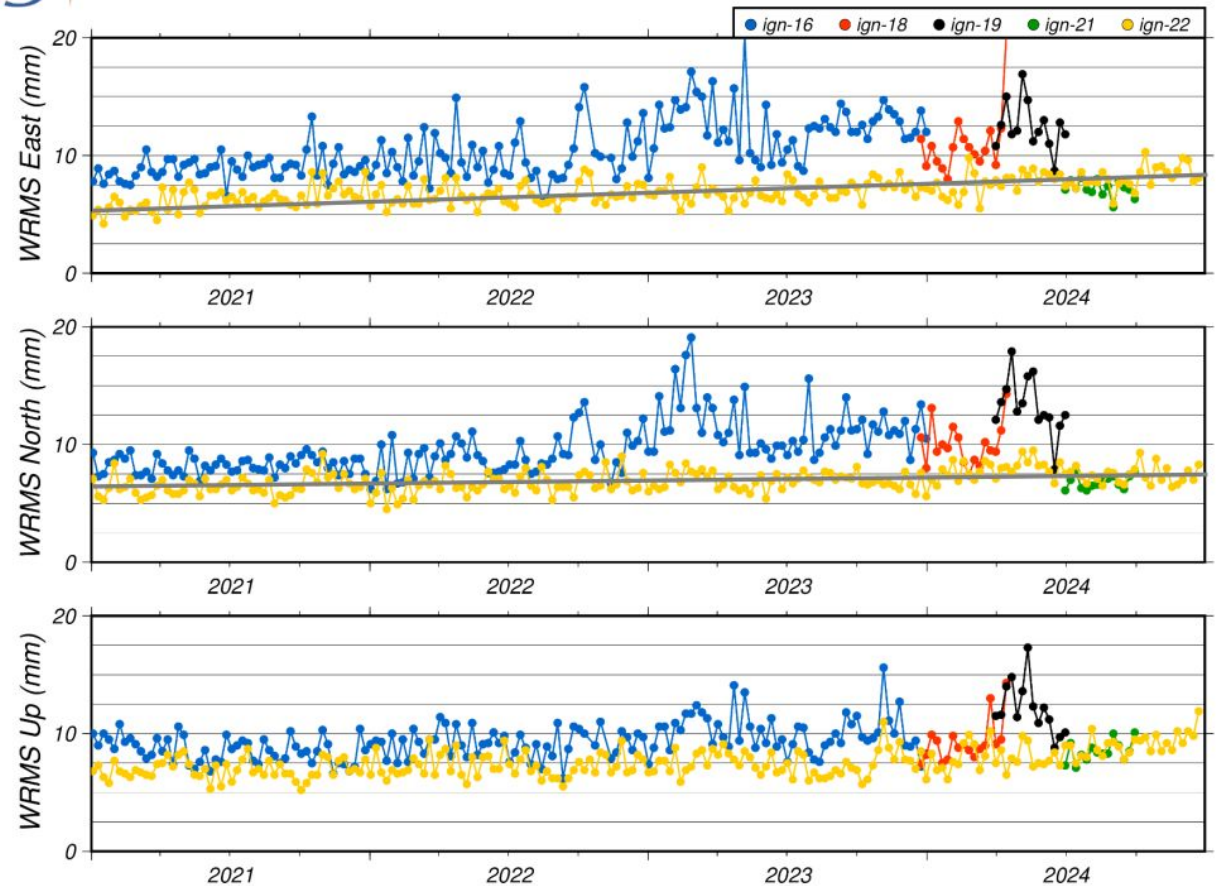
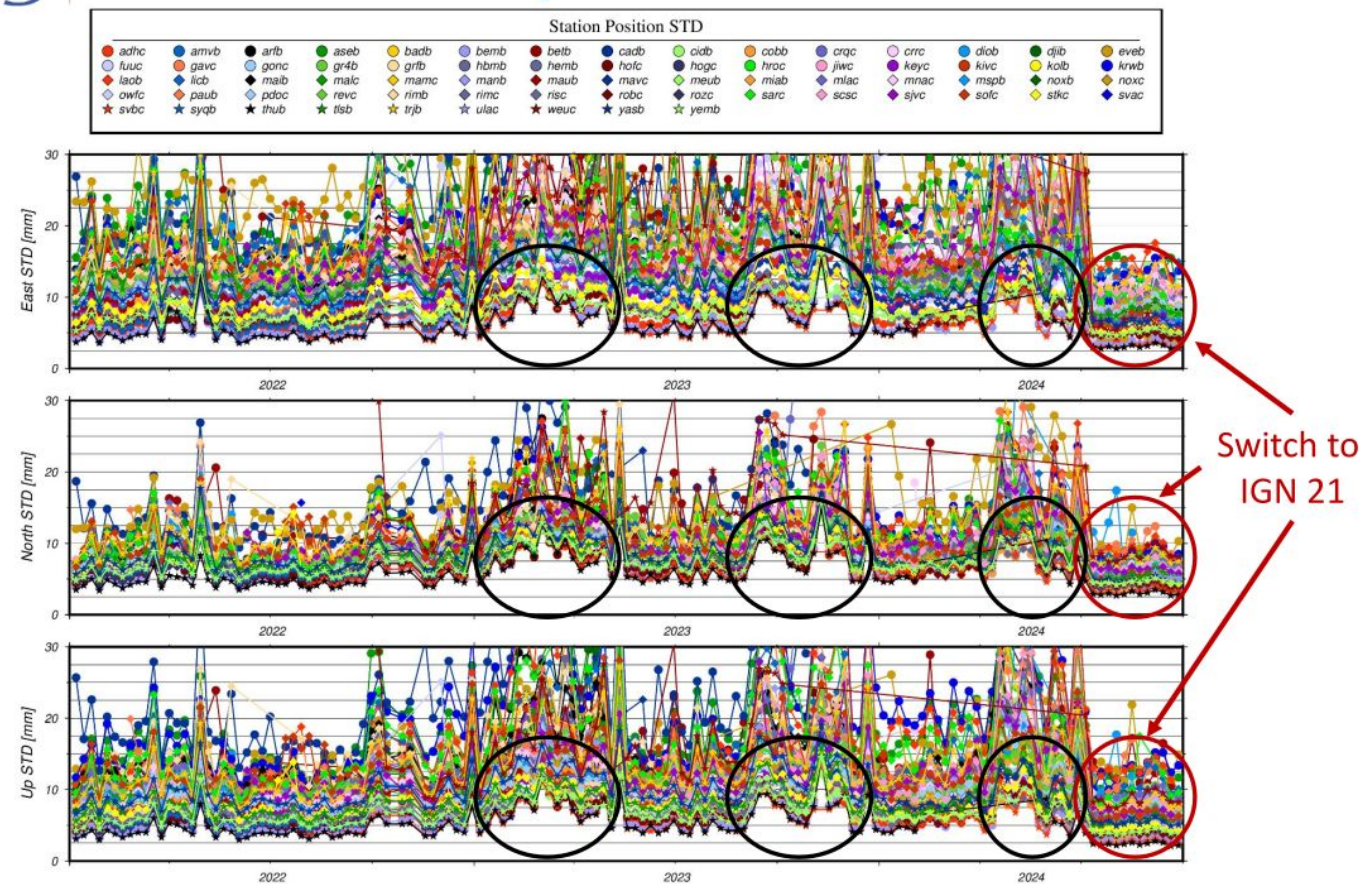
Formal Errors

IGN 16-22 wrt DPOD2020 v3.1

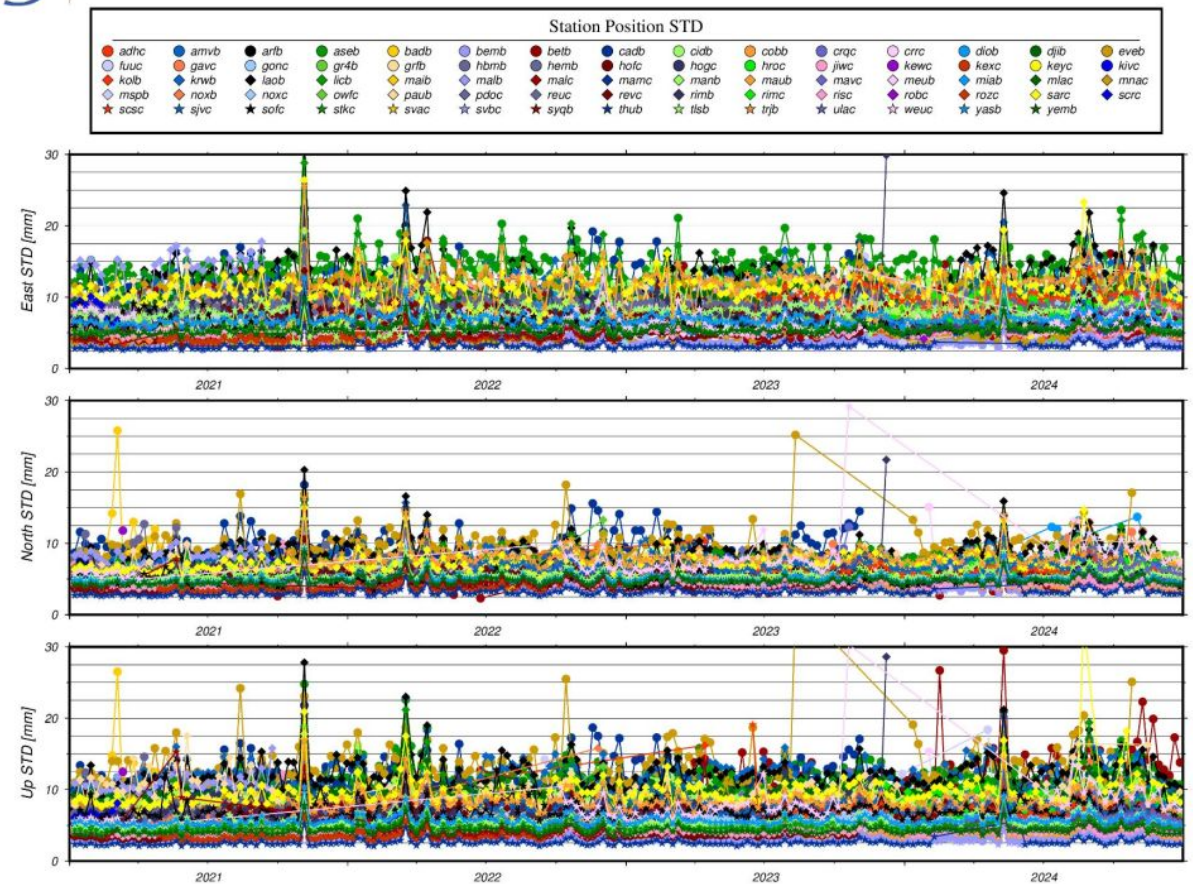
WRMS of Station Position Residuals



IGN 16-21 - Station Position Formal errors Up to 2024.75

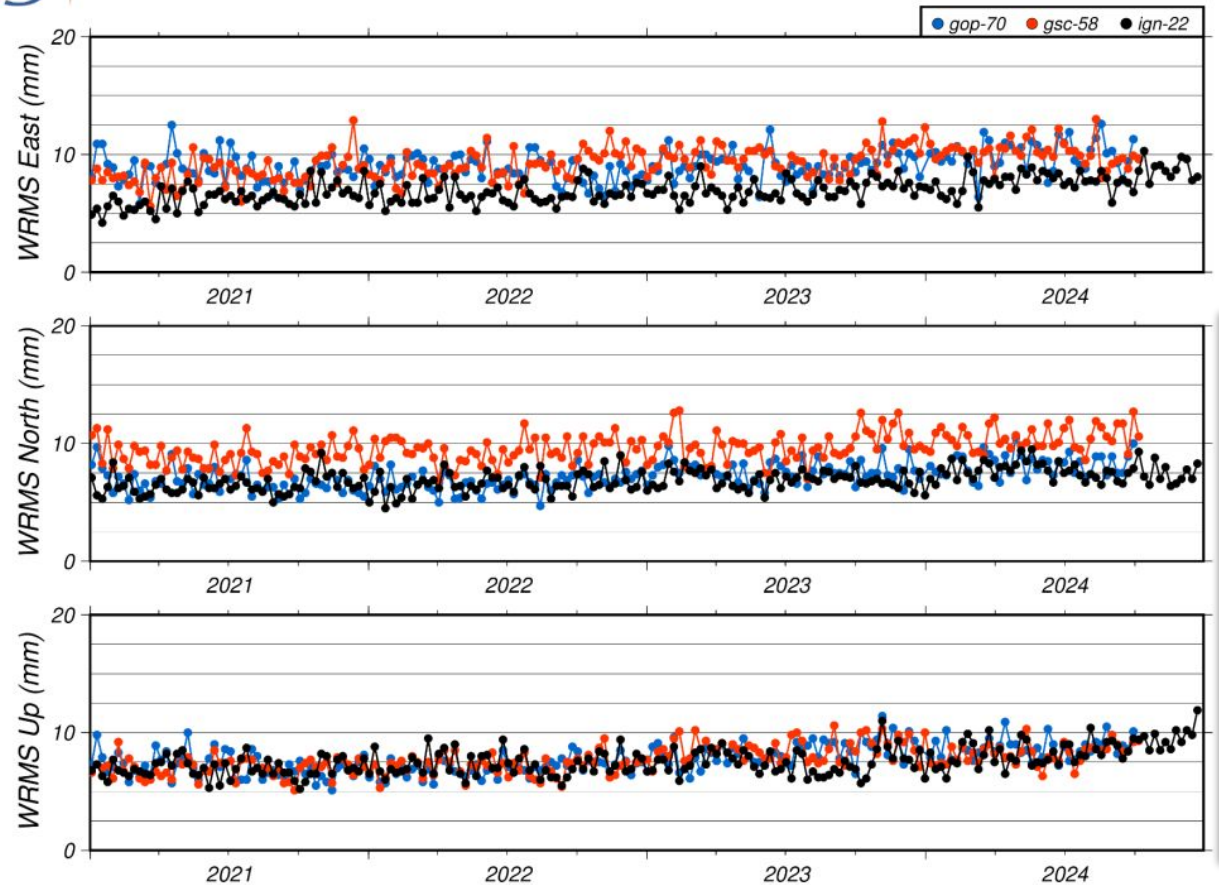


IGN 22 - Station Position Formal errors



IGN 22 / GOP 70 / GSC 58 wrt DPOD2020 v3.1

WRMS of Station Position Residuals



IGN 22 / GOP 70 / GSC 58 wrt DPOD2020 v3.1

WRMS of Station Position Residuals

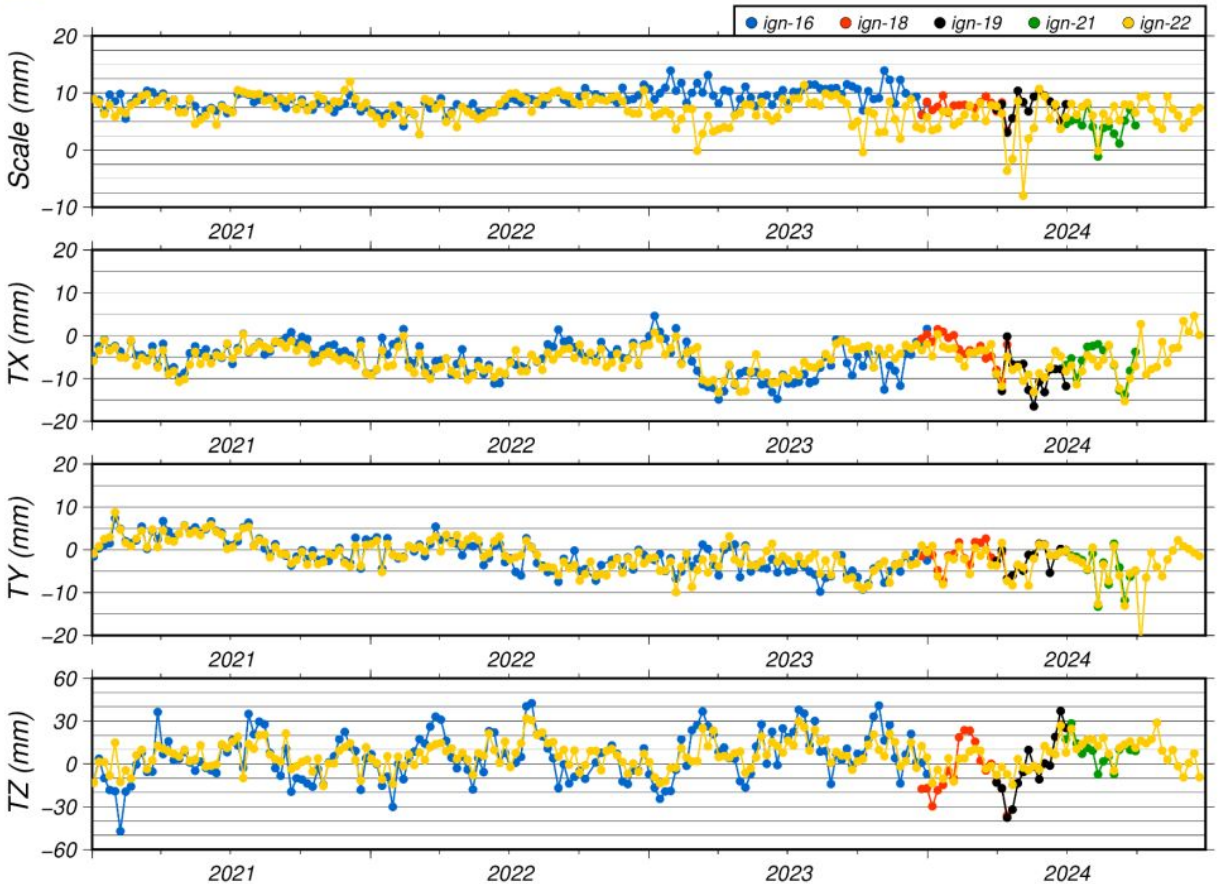
Unit: mm		Mean	STD
North	IGN 22	6.92	0.92
	GOP 70	7.26	1.10
	GSC 58	9.61	1.25
East	IGN 22	6.94	1.09
	GOP 70	9.10	1.26
	GSC 58	9.29	1.32
Up	IGN 22	7.56	1.17
	GOP 70	7.76	1.20
	GSC 58	7.72	1.14

IGN22 4-years solutions for ITRF2020-u2024

Helmert Parameters

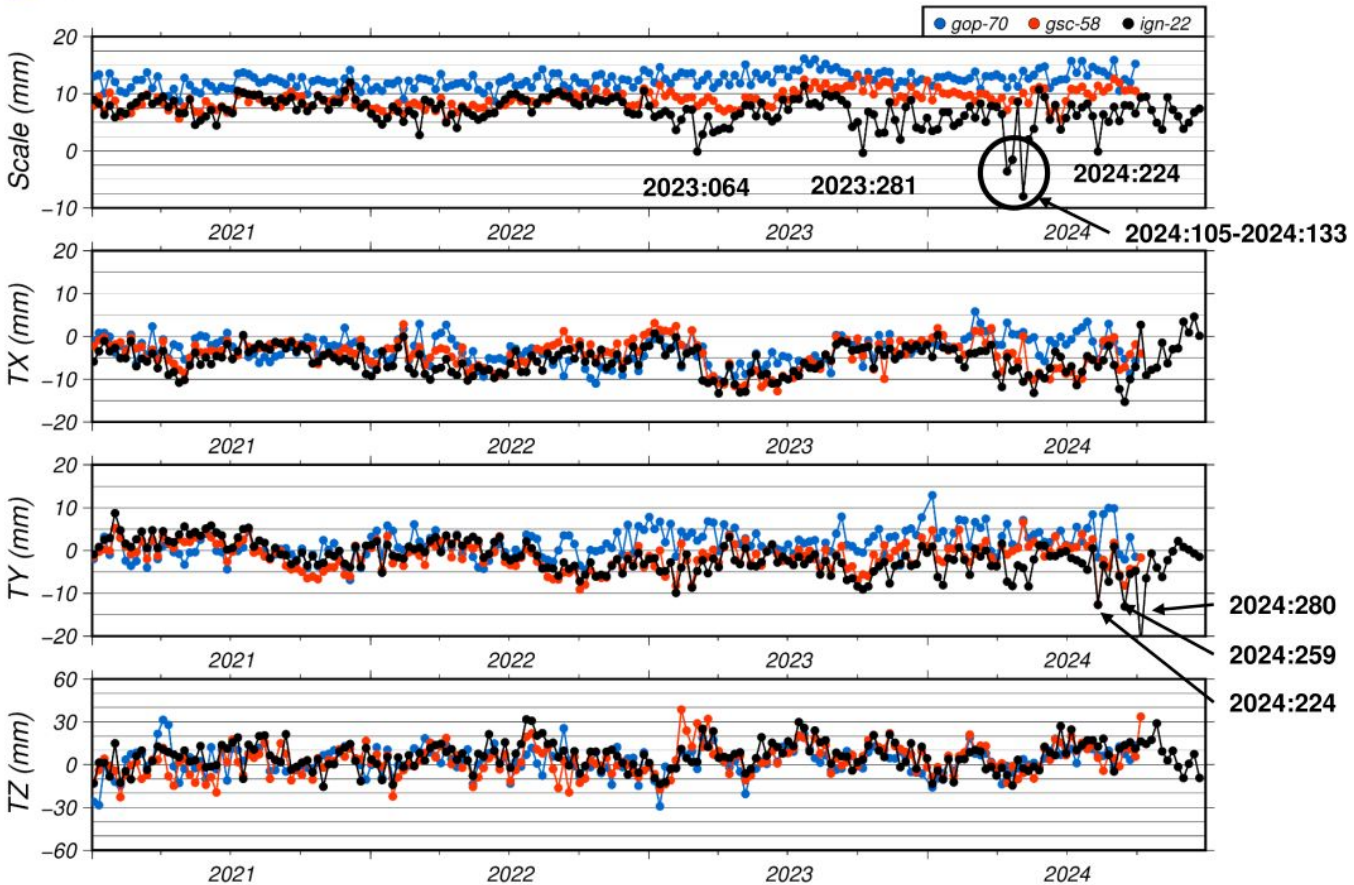
IGN 16-22 wrt DPOD2020 v3.1

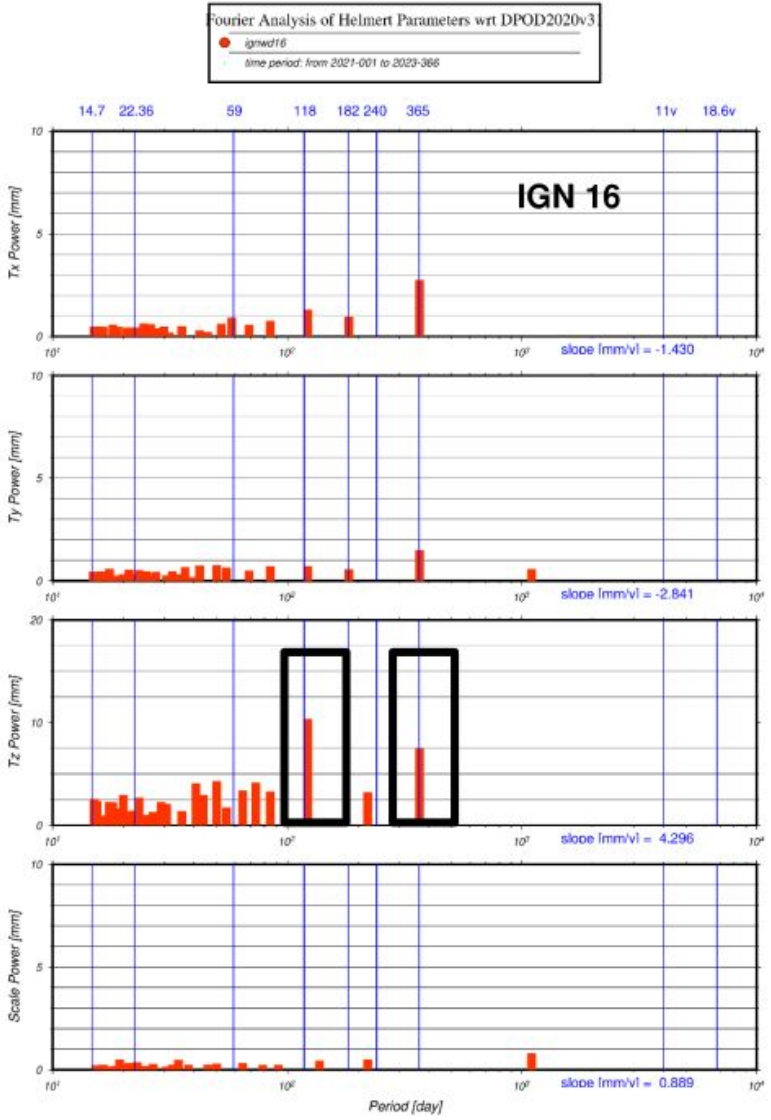
Helmert Parameters

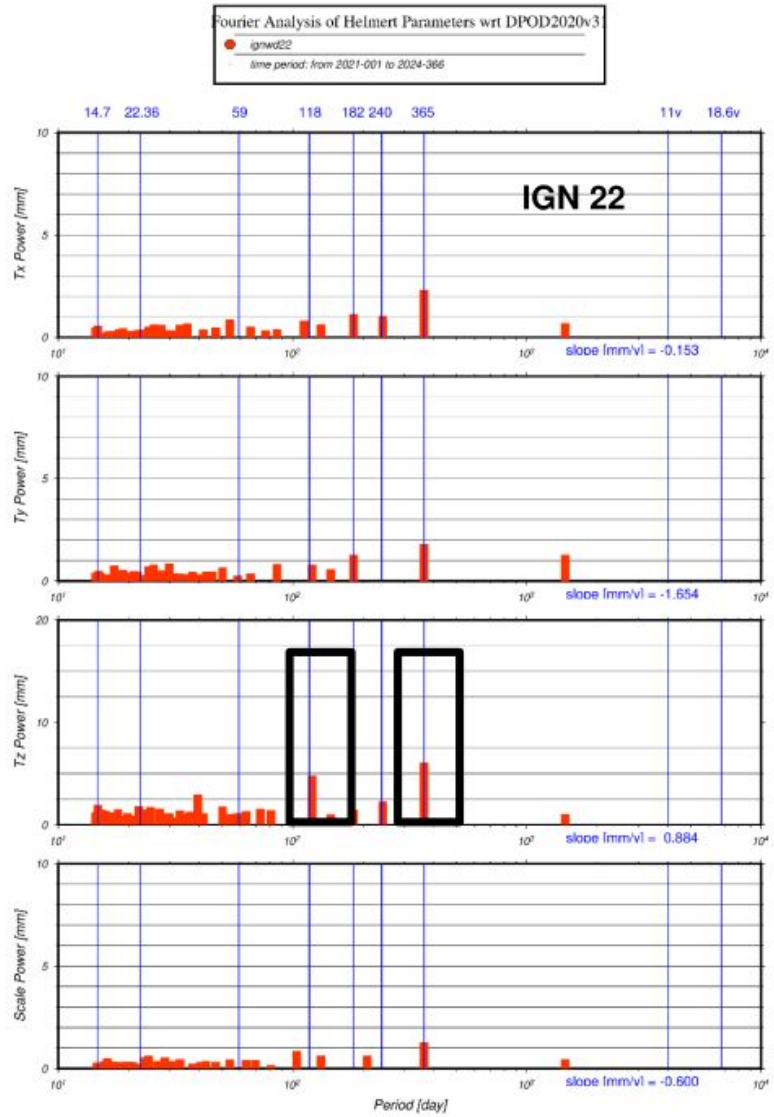


IGN 22 / GOP 70 / GSC 58 wrt DPOD2020 v3.1

Helmert Parameters



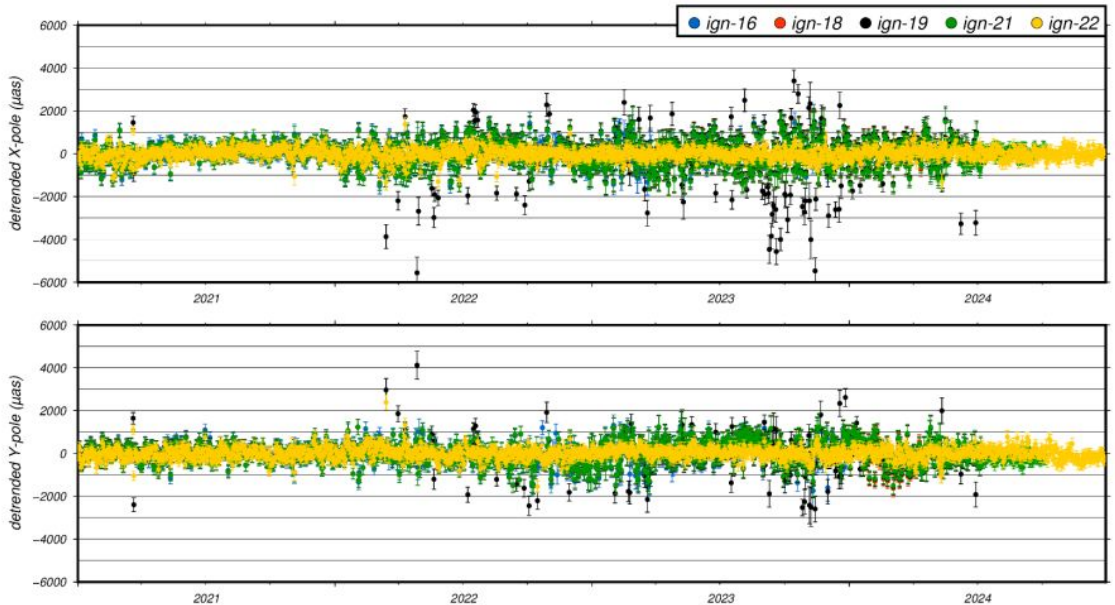

Fourier Analysis of Helmert Parameters wrt DPOD2020v3
igngd16
time period: from 2021-001 to 2023-366
14.7 22.36 59 118 182 240 365 11v 18.6v
IGN 16
Tx Power [mm]
slope [mm/yl = -1.430
Ty Power [mm]
slope [mm/yl = -2.841
Tz Power [mm]
slope [mm/yl = 4.296
Scale Power [mm]
slope [mm/yl = 0.889
Period [day]


Fourier Analysis of Helmert Parameters wrt DPOD2020v3
igngd22
time period: from 2021-001 to 2024-366
14.7 22.36 59 118 182 240 365 11v 18.6v
IGN 22
Tx Power [mm]
slope [mm/yl = -0.153
Ty Power [mm]
slope [mm/yl = -1.654
Tz Power [mm]
slope [mm/yl = 0.884
Scale Power [mm]
slope [mm/yl = -0.600
Period [day]

IGN22 4-years solutions for ITRF2020-u2024

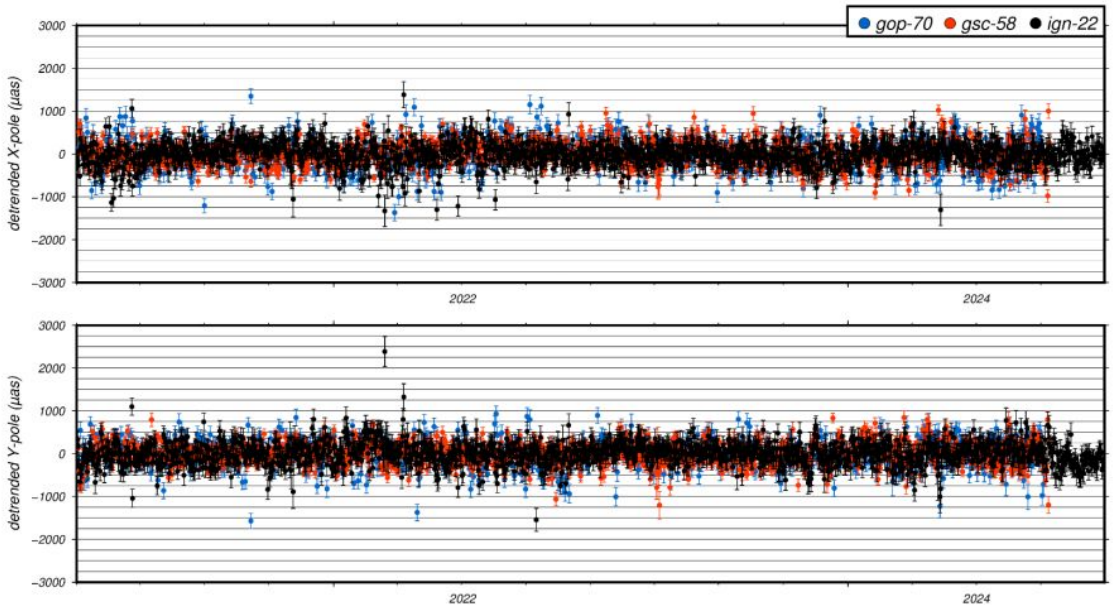
Earth Orientation Parameters

IGN 16-22 – EOP Differences wrt IERS C04



AC	serie	# days	X pole (µas)			Y pole (µas)		
			trend	mean	std	trend	mean	std
ign	16	1014	-41.115	-0.211	506.009	152.100	-5.545	464.105
ign	18	1101	-42.524	-1.461	510.405	126.390	-4.277	464.347
ign	19	1267	-66.422	-35.323	787.140	117.270	-6.303	581.712
ign	21	1271	-27.487	-2.319	495.537	93.040	-1.343	448.766
ign	22	1458	17.703	-3.814	265.679	-8.620	0.258	266.974

IGN 22 / GOP 70 / GSC 58 – EOP
Differences wrt IERS C04



AC	serie	# days	X pole (µas) trend	X pole (µas) mean	X pole (µas) std	Y pole (µas) trend	Y pole (µas) mean	Y pole (µas) std
gop	70	771	86.624	0.517	364.555	-53.070	-3.711	335.461
gsc	58	1385	-9.382	0.885	270.884	-8.810	-0.664	253.925
ign	22	1458	17.703	-3.814	265.679	-8.620	0.258	266.974

IGN 22 IDS CC Evaluation

- IGN 22 shows clear improvements in station position residuals, formal errors of station positions and EOP differences wrt IERS C04 compared to the previous IGN series.
- IGN 22 scale wrt DPOD2020v3.1 looks to be more scattered since third quarter of 2023. Any reason?
- IGN 22 Tx and Ty very similar to GOP 70 and GSC 58 ones wrt DPOD2020v3.1.
- Few dates may be investigated due to anomalous Helmert parameter values (see slide 8).
- Compared to GOP 70 and GSC 58, IGN 22 Tz wrt DPOD2020v3.1 shows a clear annual signal with amplitude of around 6 mm. Furthermore, compared to IGN 16, we observe a decrease of the amplitudes of the annual and 118-day signals.

Future developments

Future developments

- Adapting strategy for high solar activity
- Adding SWOT in our AC products
- Multi-satellite process
  - Tropospheric parameters per station
  - Clock corrections per satellite and clock correction per station
- DORIS + GNSS clock with GipsyX

Meeting

- EGU 2025 - abstract 5635
  - Pollet A, Nahmani S, Bertiger W: DORIS analysis center, status and future development

- IAG scientific assembly 2025
  - Pollet A, Nahmani S, Bertiger W: First assessment of SWOT DORIS data by the IDS IGN-IPGP/JPL Analysis Center

  - Samuel Nahmani, Arnaud Pollet and Willy Bertiger: Assessing the quality of DORIS tropospheric products: Insights from the IDS IGN-IPGP/JPL analysis center for ITRF2020-u2024