Overview on available IGS products

Salim Masoumi, Geosciences Australia
Thomas Herring, MIT
IGS Analysis Center Coordinators (ACC)

Australian Government
Geoscience Australia

IGS INTERNATIONAL GNSS SERVICE

Types of products

- Main products produced by the IGS (https://igs.org/products/)
  - GNSS orbits and clocks (operational products GPS and GPS+GLONASS). Multi-GNSS under development
  - Geocentric Coordinates of IGS Tracking Stations
  - Earth Rotation
  - Atmospheric Parameters
- New GNSS products being developed

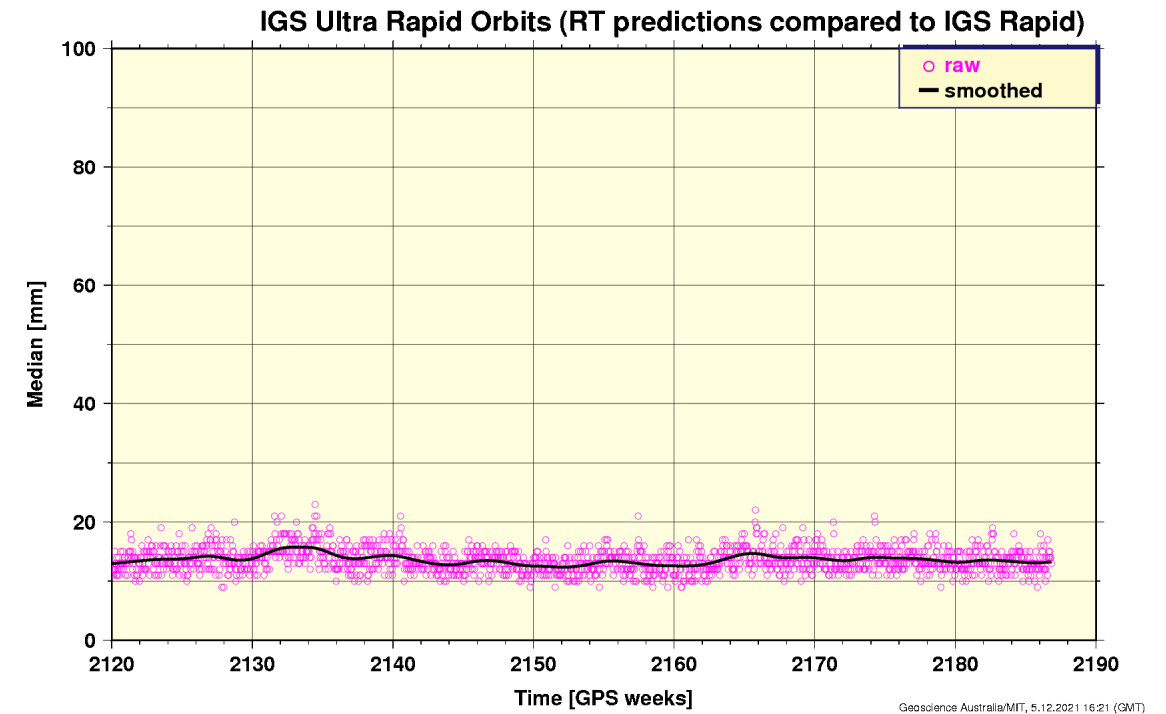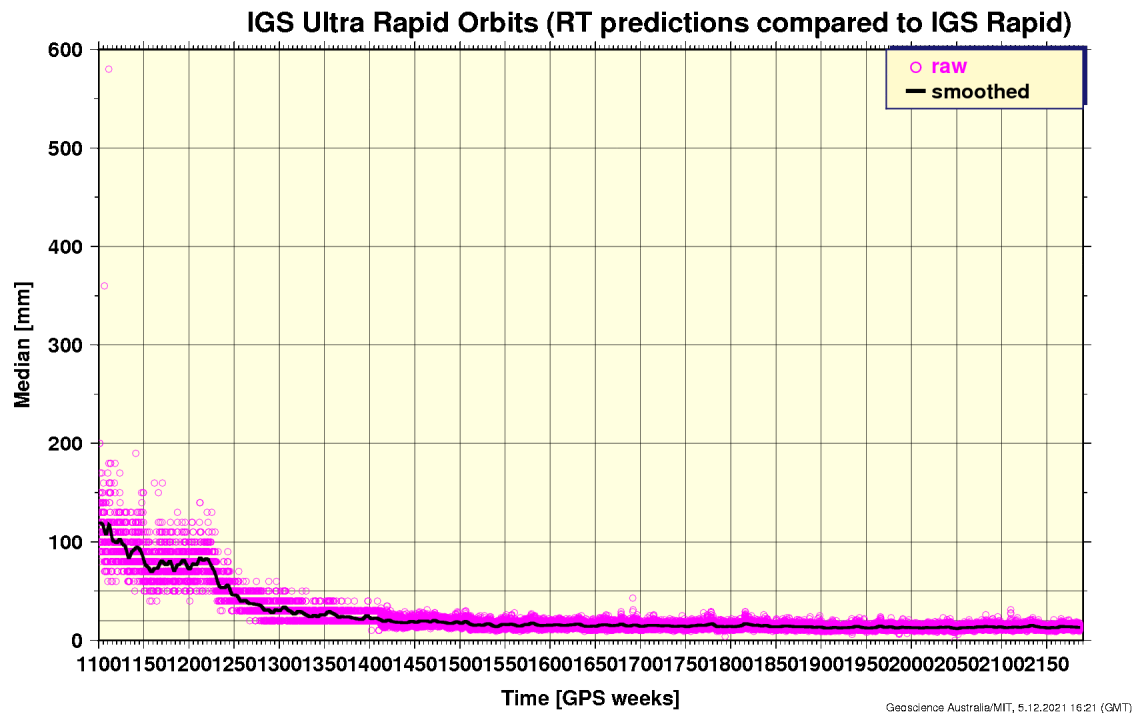(Low-latency, high-rate real-time products discussed elsewhere).

Orbit and Clock products

- Products: GPS (GLONASS only ultra-rapid and final orbit only)

Type		Accuracy	Latency	Updates	Sample Interval
Ultra-Rapid (predicted half)	orbits	~5 cm	real time	at 03, 09, 15, 21 UTC	15 min
	Sat. clocks	~3 ns RMS ~1.5 ns SDev			
Ultra-Rapid (observed half)	orbits	~3 cm	3 – 9 hours	at 03, 09, 15, 21 UTC	15 min
	Sat. clocks	~150 ps RMS ~50 ps SDev			
Rapid	orbits	~2.5 cm	17 – 41 hours	at 17 UTC daily	15 min
	Sat. & Stn. clocks	~75 ps RMS ~25 ps SDev			5 min
Final	orbits	~2.5 cm	12 – 18 days	every Thursday	15 min
	Sat. & Stn. clocks	~75 ps RMS ~20 ps SDev			Sat.: 30s Stn.: 5 min

Product Quality and Reliability

- GPS Ultra-rapids: 4-times per day, latency 3-9 hr, 24-hr prediction

- WRMS of 24-hr prediction <40 mm; median <30 mm.

IGS Ultra Rapid Orbits (RT predictions compared to IGS Rapid)

IGS Ultra Rapid Orbits (RT predictions compared to IGS Rapid)

Ultra-rapid observed compared Rapid orbit

Plots from http://acc.igs.org/

Product Quality and Reliability: GPS Rapid

- GPS Rapid: 17-41 hr latency, once-per-day. 9 centers with Wuhan added late 2020.

Rapid Orbits (AC solutions compared to IGS Rapid)
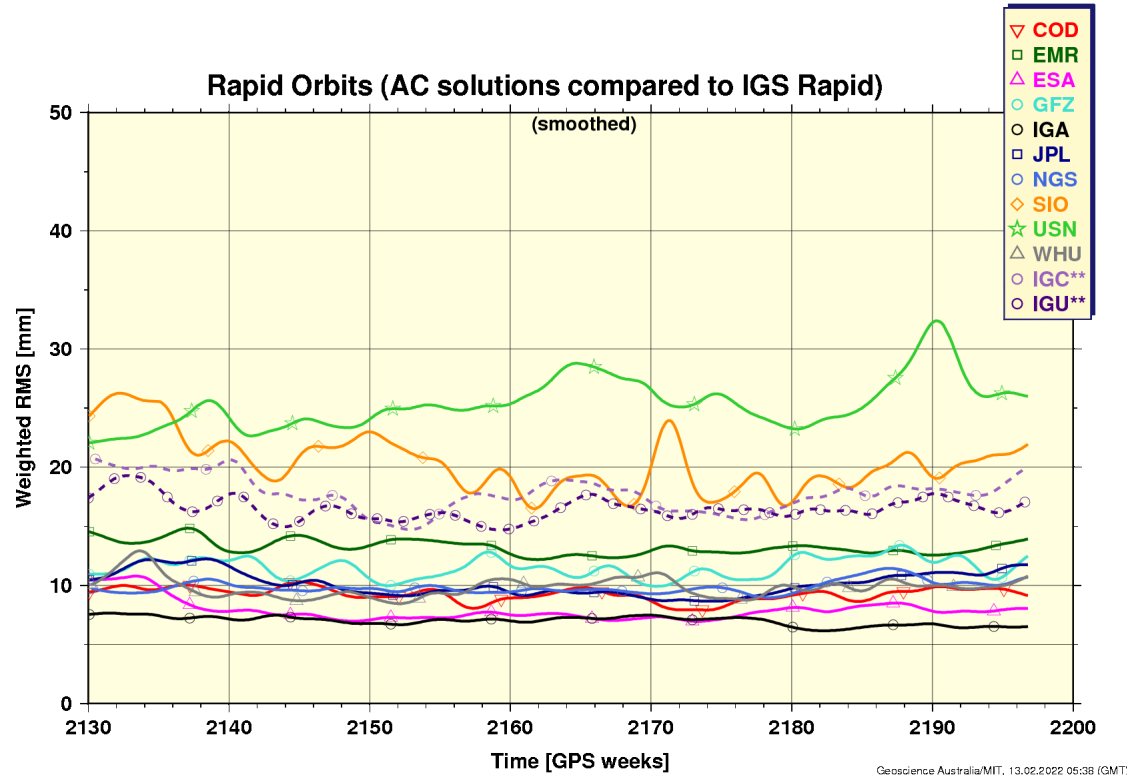
IGA - IGS ultra-rapid adjusted part

IGU - IGS ultra-rapid predicted part
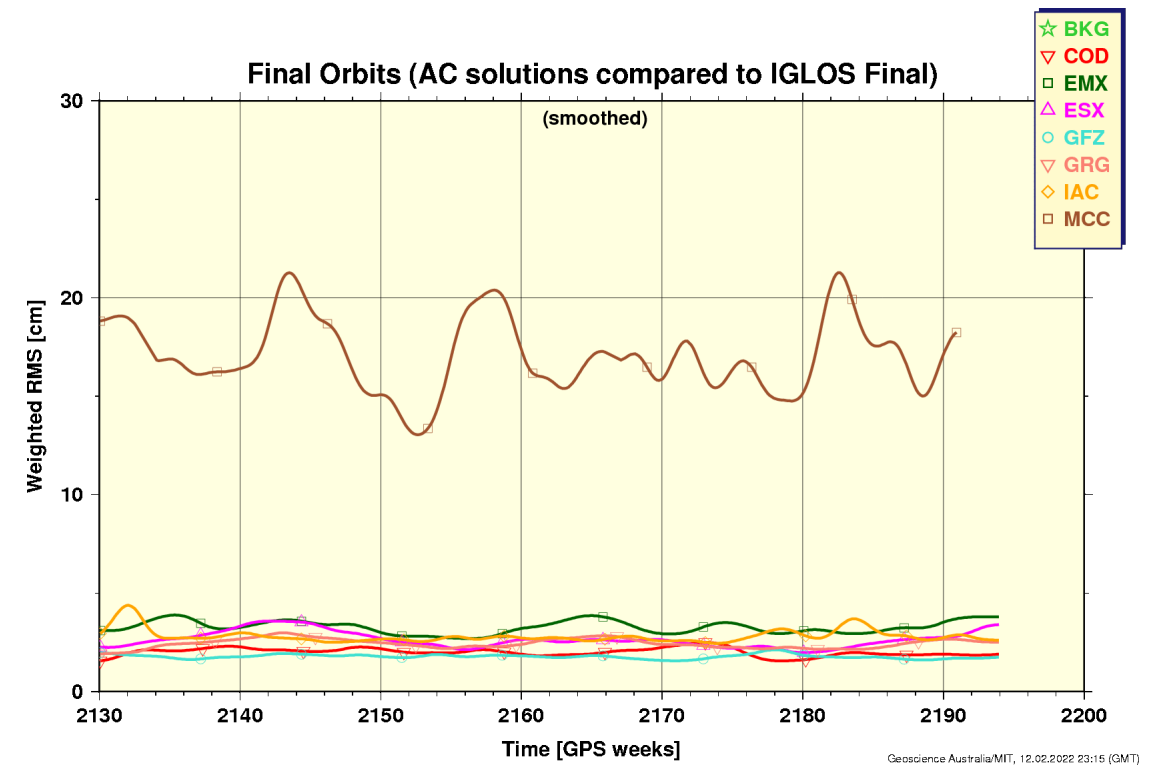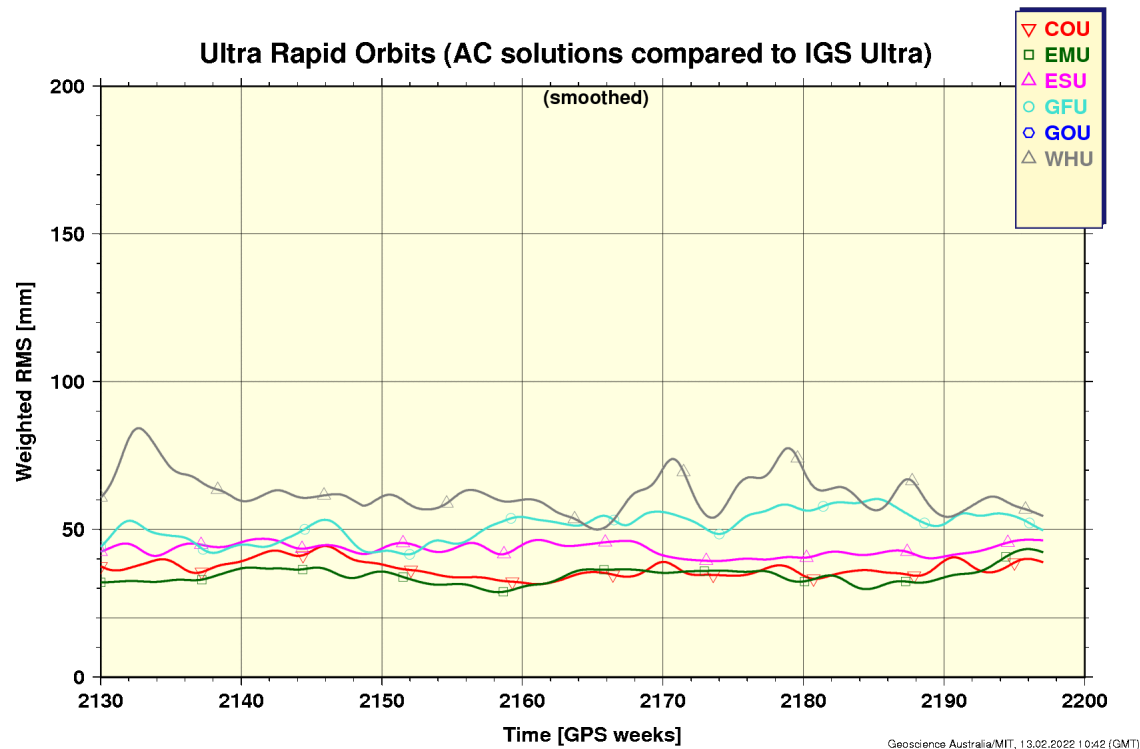
IGU - IGS real-time IGC

GPS final products

- GPS Finals: 12-18 day latency; no constrained stations (no net rotation frame); 2nd order ionosphere, Meteorological models for atmospheric delay modeling. Products for highest quality GPS processing.

- 30 ps clock == 9 mm range

Final Orbits (AC solutions compared to IGS Final)

(smoothed)

Weighted RMS [mm] vs Time [GPS weeks]

Legend: COD, EMR, ESA, GFZ, GRG, JPL, MIT, NGS, SIO, IGR

Geoscience Australia/MIT, 12.02.2022 20:18 (GMT)

Final Clocks (AC solutions compared to IGS Final)

(weekly means)

Clock Std Dev [ps] vs Time [GPS weeks]

Legend: COD, EMR, ESA, GFZ, GRG, JPL, MIT, NGS, SIO, IGR

Geoscience Australia/MIT, 12.02.2022 20:18 (GMT)
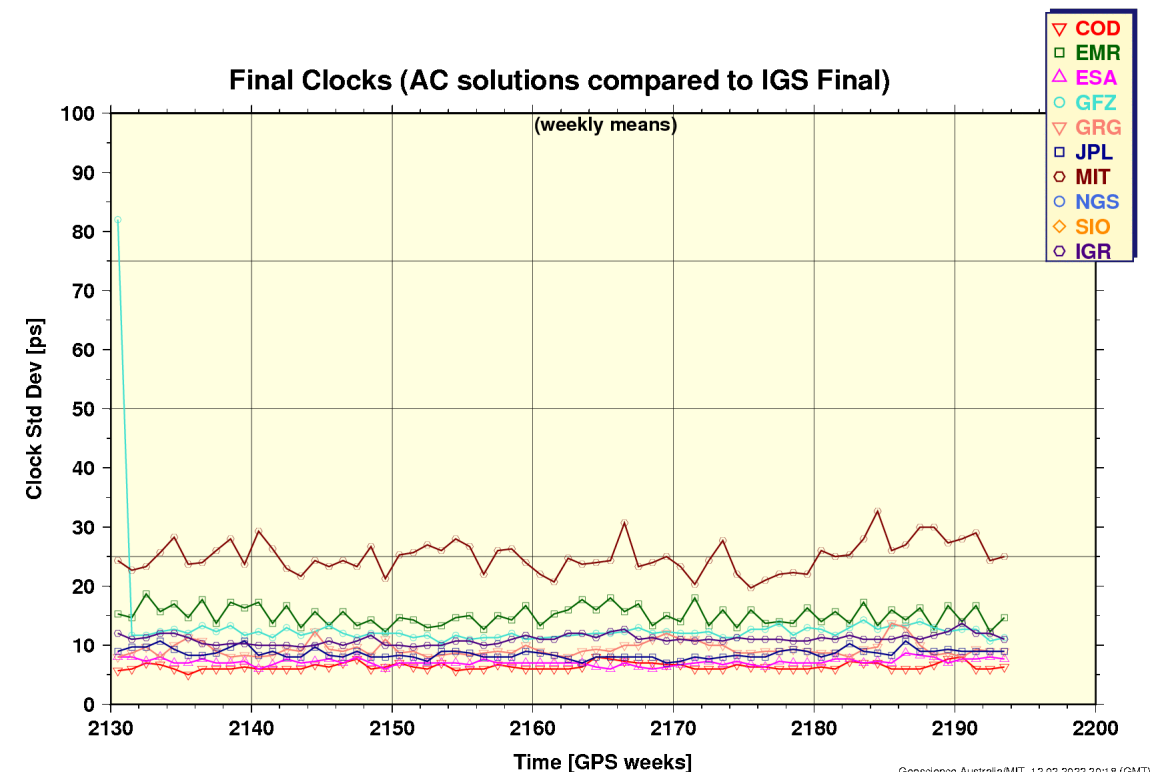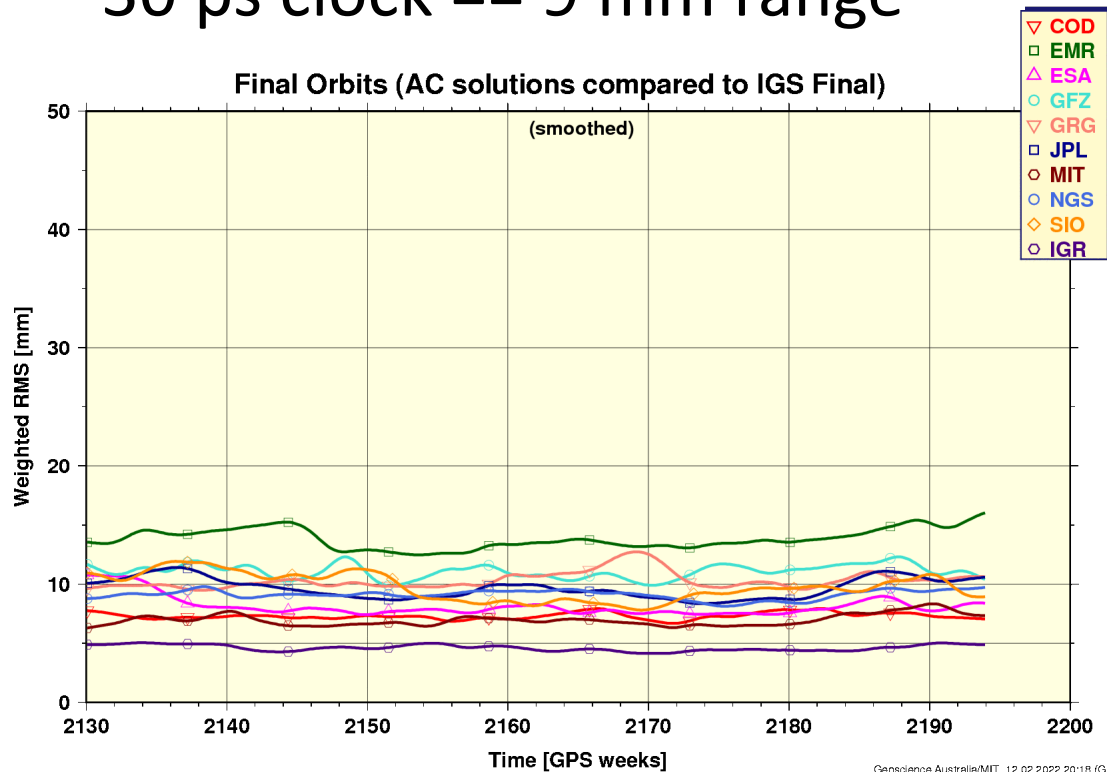
GLONASS Products

- Ultra-rapid and final products

Units for finals are centimeters

ITRF Products

- ITRF: From final products

Type		Accuracy	Latency	Updates	Sample Interval
Final positions	horizontal	3 mm	11 – 17 days	every Wednesday	weekly
	vertical	6 mm			
Final velocities	horizontal	2 mm/yr	11 – 17 days	every Wednesday	weekly
	vertical	3 mm/yr			

Product access:
https://igs.org/products-access/#geocentric-coordinates

Earth Rotation

- Generated for all latency products
- Ultra-rapid and rapid: sites constrained; Final SINEX datum constraint

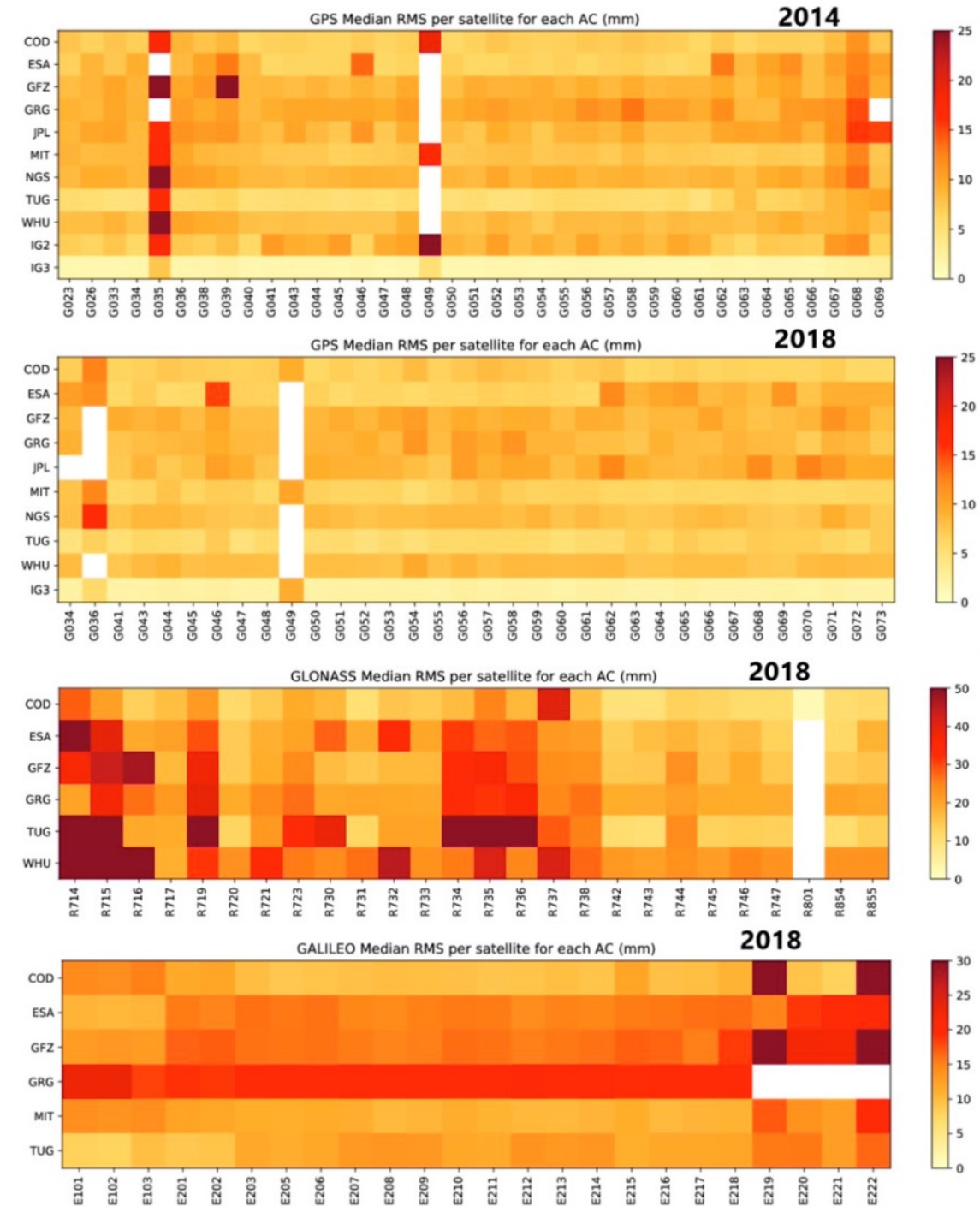| Type		Accuracy	Latency	Updates	Sample Interval
Ultra-Rapid (predicted half)	PM	~200 µas	real time	at 03, 09, 15, 21 UTC	daily integrations at 00, 06 12, 18 UTC
	PM rate	~300 µas/day			
	LOD	~50 µs			
Ultra-Rapid (observed half)	PM	~50 µas	3 – 9 hours	at 03, 09, 15, 21 UTC	daily integrations at 00, 06, 12, 18 UTC
	PM rate	~250 µas/day			
	LOD	~10 µs			
Rapid	PM	~40 µas	17 – 41 hours	at 17 UTC daily	daily integrations at 12 UTC
	PM rate	~200 µas/day			
	LOD	~10 µs			
Final	PM	~30 µas	11 – 17 days	every Wednesday	daily integrations at 12 UTC
	PM rate	~150 µas/day			
	LOD	~10 µs			

Atmospheric Parameters

- Types and latencies (Rapid TEC used in final orbit products)

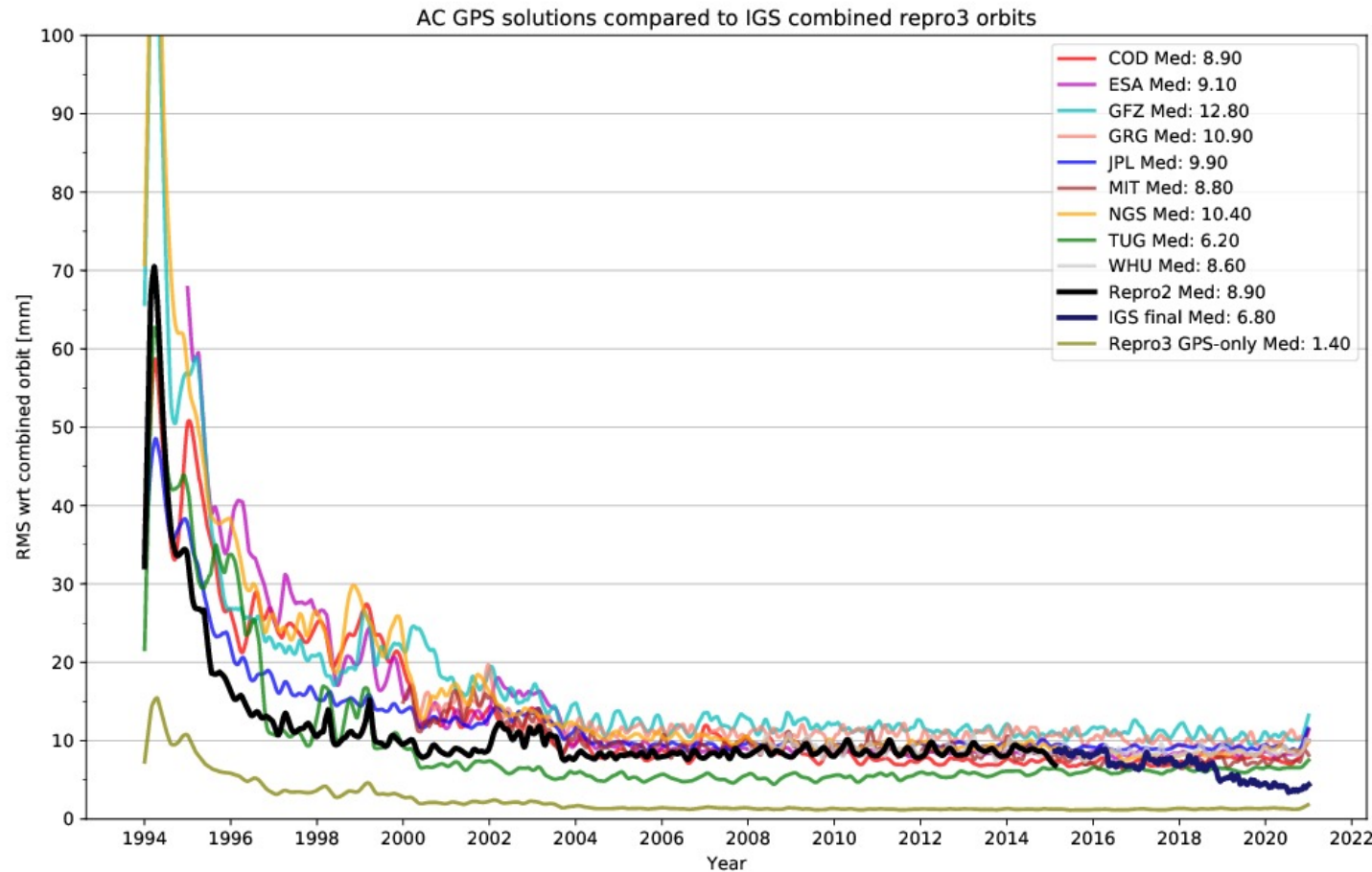| Type	Accuracy	Latency	Updates	Sample Interval
Final tropospheric zenith path delay with N, E gradients	4 mm (ZPD)	< 4 weeks	daily	5 minutes
Final ionospheric TEC grid	2-8 TECU	~11 days	weekly	2 hours; 5 deg (lon) x 2.5 deg (lat)
Rapid ionospheric TEC grid	2-9 TECU	<24 hours	daily	2 hours; 5 deg (lon) x 2.5 deg (lat)

NEW GNSS PRODUCTS

- Repro3: Preliminary orbit comparisons, Indications of quality of new products

- GALILEO and GLONASS orbits comparing at the 10-30 mm level in 2018.

GPS Median RMS per satellite for each AC (mm) — 2014

GPS Median RMS per satellite for each AC (mm) — 2018

GLONASS Median RMS per satellite for each AC (mm) — 2018

GALILEO Median RMS per satellite for each AC (mm) — 2018

Multi-GNSS combination software

IGS Repro3 orbits - GPS

AC GPS solutions compared to IGS combined repro3 orbits

Legend	Median
COD	Med: 8.90
ESA	Med: 9.10
GFZ	Med: 12.80
GRG	Med: 10.90
JPL	Med: 9.90
MIT	Med: 8.80
NGS	Med: 10.40
TUG	Med: 6.20
WHU	Med: 8.60
Repro2	Med: 8.90
IGS final	Med: 6.80
Repro3 GPS-only	Med: 1.40

RMS wrt combined orbit [mm] vs *Year* (1994–2022)

- New orbit combination software developed based on the same robust algorithm of the current software, but allowing for multi-GNSS combinations and based on a satellite-specific weighting approach

- The multi-GNSS combination software used to process the Repro3 orbits 1994-2020

- Clock combinations currently underway by Wuhan University (PPP-AR WG) and full set of orbit/clock products expected to be released early to mid-2022

- Plan to integrate orbit and clock combinations for operational products in 2022

Multi-GNSS combination software

IGS Repro3 orbits - GLONASS
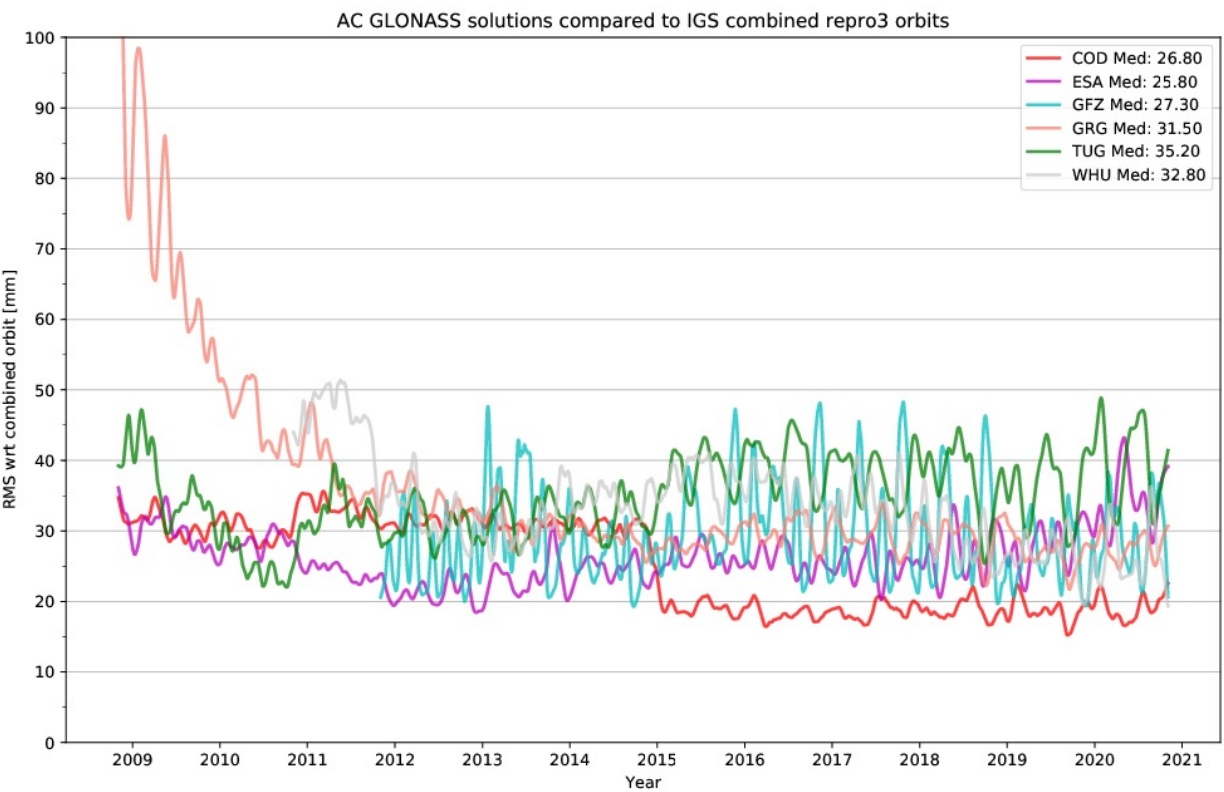
IGS Repro3 orbits - GALILEO
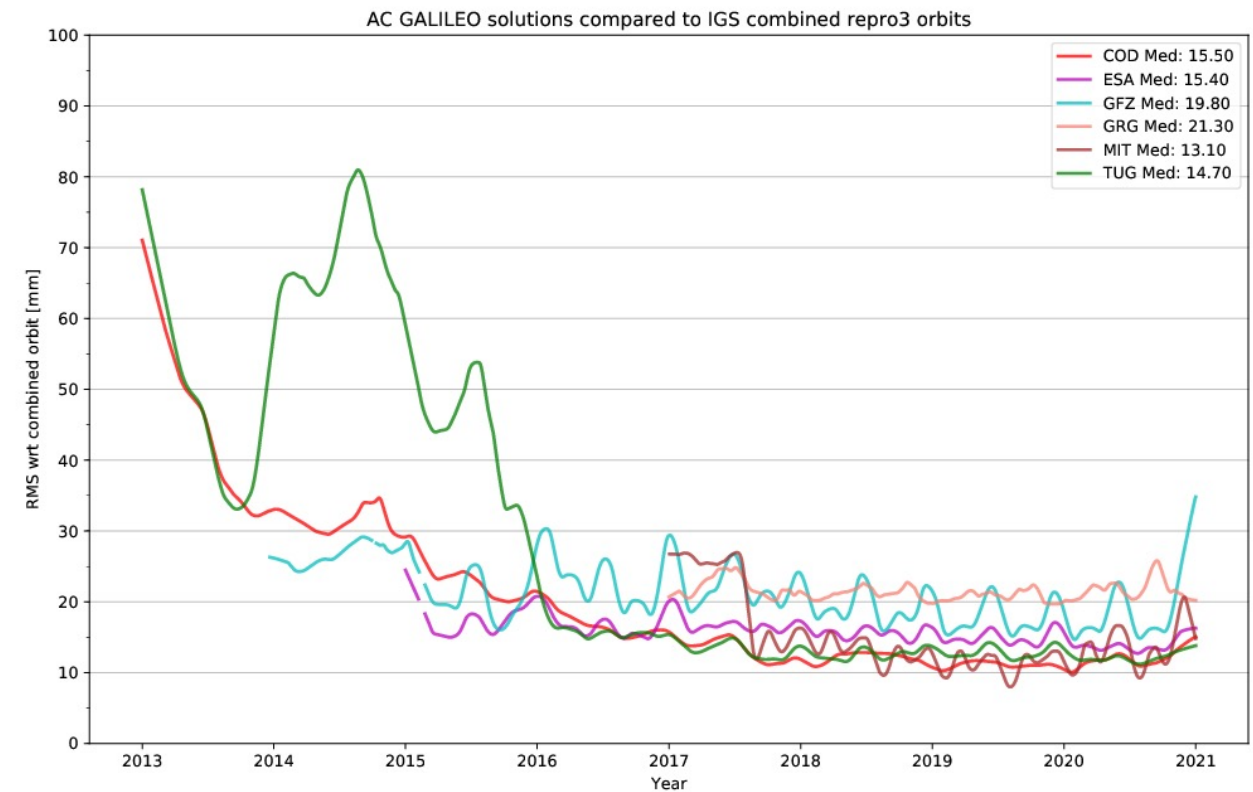
Summary

- Main products produced by the IGS (https://igs.org/products/)
  - GNSS orbits and clocks (operational products GPS and GPS+Glonass). Multi-GNSS under development
  - Geocentric Coordinates of IGS Tracking Stations
  - Earth Rotation
  - Atmospheric Parameters
- New GNSS products being developed: Expected later in 2022.