

# Sentinel-6 Michael Freilich Multi-GNSS POD at ESOC

---

## Navigation Support Office, ESA/ESOC

Wenner Enderle, Rene Zandbergen, Erik Schoenemann,  
Francesco Gini, Florian Reckeweg, Volker Mayer, Michiel Otten

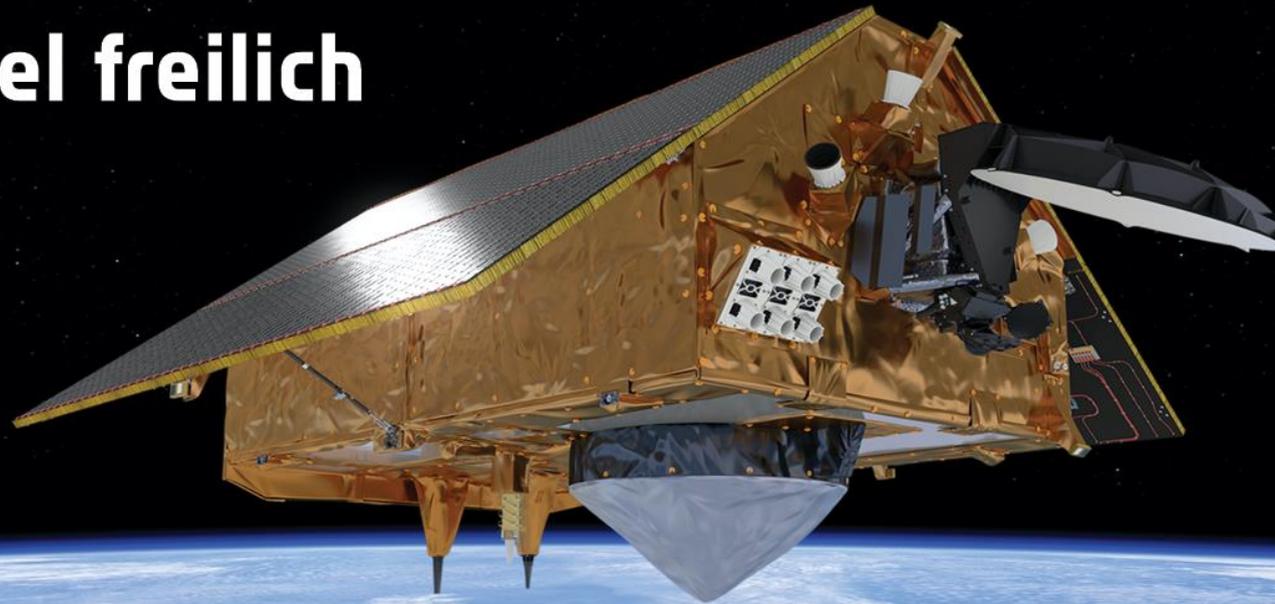


European Union



# sentinel-6 michael freilich

**CHARTING SEA LEVEL  
FOR COPERNICUS**

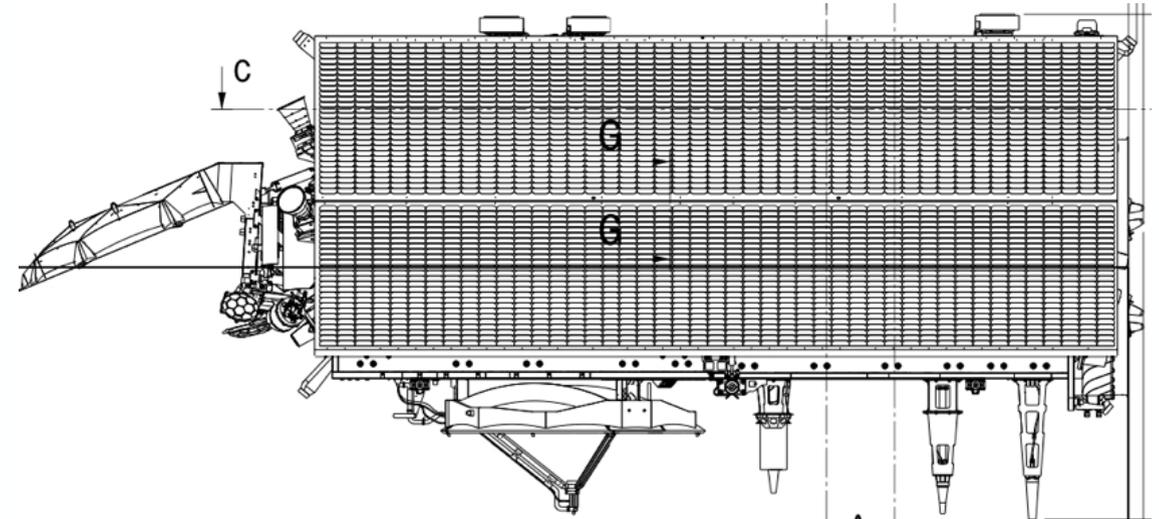


**Partnership between agencies, to study the sea level rise.  
Sentinel-6 carries the first flying high-precision inter-operable dual-constellation GNSS receiver**



## The observations

- 3 POD solutions running daily in parallel:
  - Multi-GNSS-based solution (Galileo + GPS)
  - Galileo-only-based solution
  - GPS-only-based solution



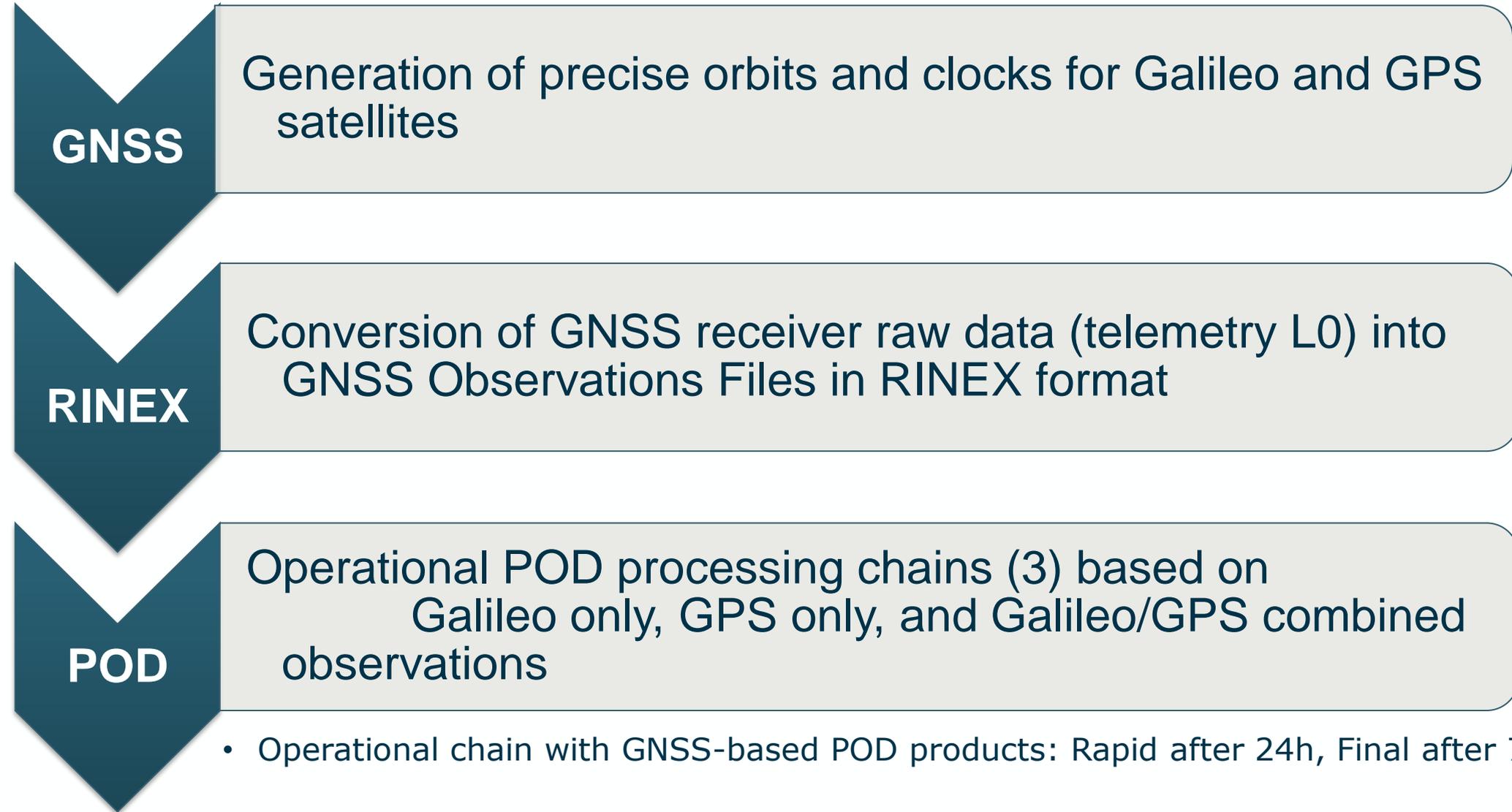
from ESA/ESTEC Sentinel-6 POD Context

## The processing

- Dynamic Precise Orbit Determination approach accounting for:
  - Gravitational forces
  - Aerodynamic and Radiation pressure effects on the satellite

**Sentinel-6 satellite accurate models** of the geometry (surface material, calibrated GNSS antenna phase center, ...) and of the non-gravitational forces were derived and implemented.

**Laser Ranging (SLR)** observations are available for validation purposes.



- Operational chain with GNSS-based POD products: Rapid after 24h, Final after 7 days

## GNSS Observations quality

Linear Combination	Galileo	GPS
Ionospheric free combination of code -and carrier phase observations (P3-L3) (cm)	28	56
Melbourne-Wübbena combination of code - and carrier phase observations (cm)	8	18

## GNSS statistics from POD processing

GNSS statistics	MGNSS	Galileo	GPS
# observations	~50 000	~22 500	~27 500
Residual Code RMS (m)	0.49	<b>0.34</b>	0.56
Residual Phase RMS (mm)	6.94	<b>3.47</b>	4.79

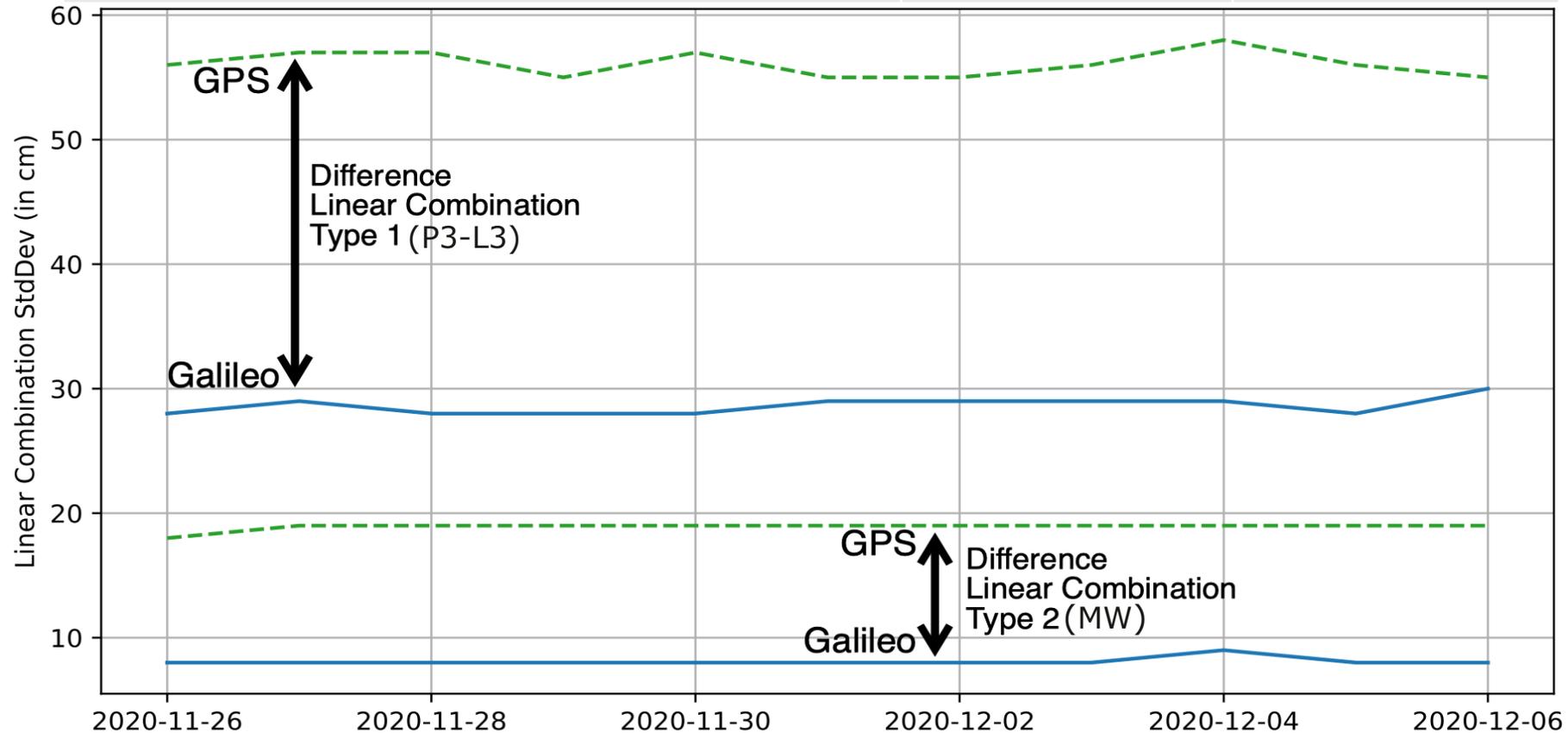
average of the daily values  
MGNSS residuals: combined GPS and Galileo res.

- High quality of the observations, particularly the Galileo code observations
- Very good GNSS phase residuals
- MGNSS combined phase residuals higher than single constellation residuals

# POD results: GNSS observations quality

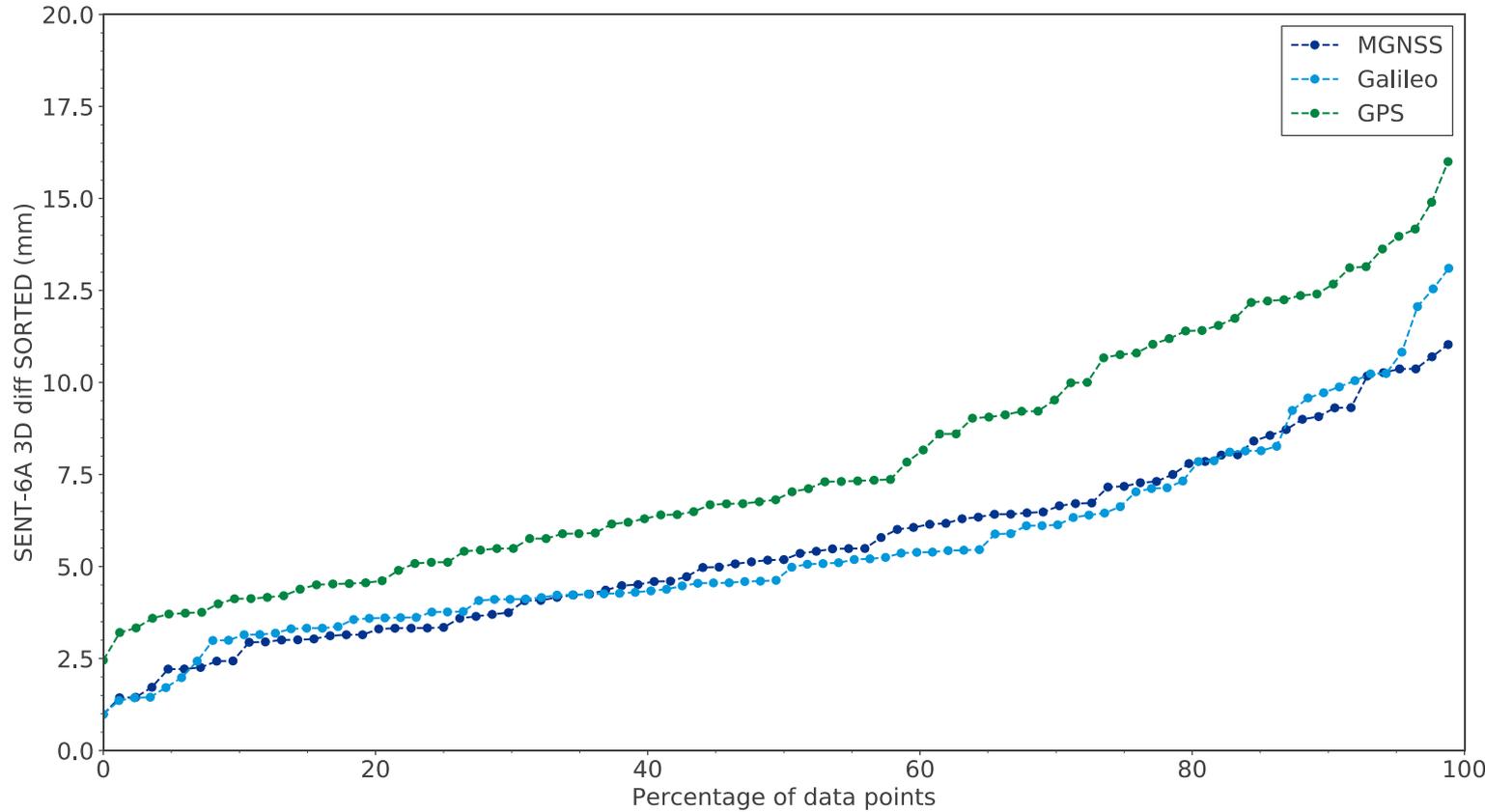
## GNSS Observations quality

Linear Combination	Galileo	GPS
P3-L3 (cm)	28	56
Melbourne-Wübbena (cm)	8	18



# POD results: Internal consistency – Overlaps

Orbital day-boundary overlaps\* 3D RMS, sorted by size (mm)



Constellation	OL RMS (mm)
Galileo	6.0
GPS	7.8
MGNSS Combined	6.1

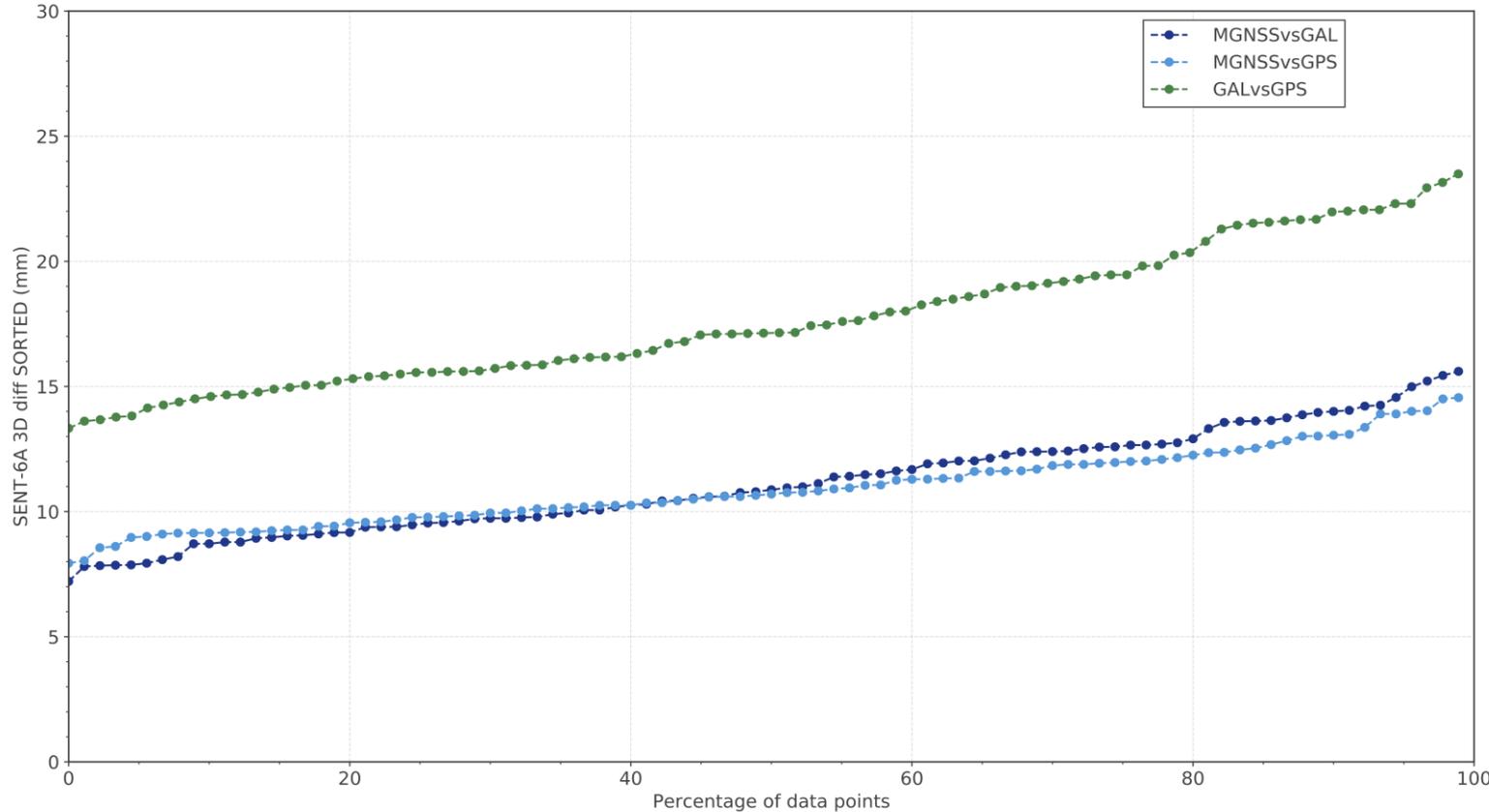
- Average of the daily RMS
- MGNSS = Combined Galileo+GPS

- 90% of the overlaps below 10 mm for Galileo and Combined (MGNSS)
- GPS-only-based solution performing slightly worse (+2/+5mm) than Galileo and Combined
- In some areas, the combined solution outperforms the single constellation solutions

\* Midnight single point orbital difference of consecutive daily arcs

# POD results: Internal consistency – Orbital Comparison

**Orbital Difference btw. Combined, Galileo and GPS solutions, sorted by size (mm)**

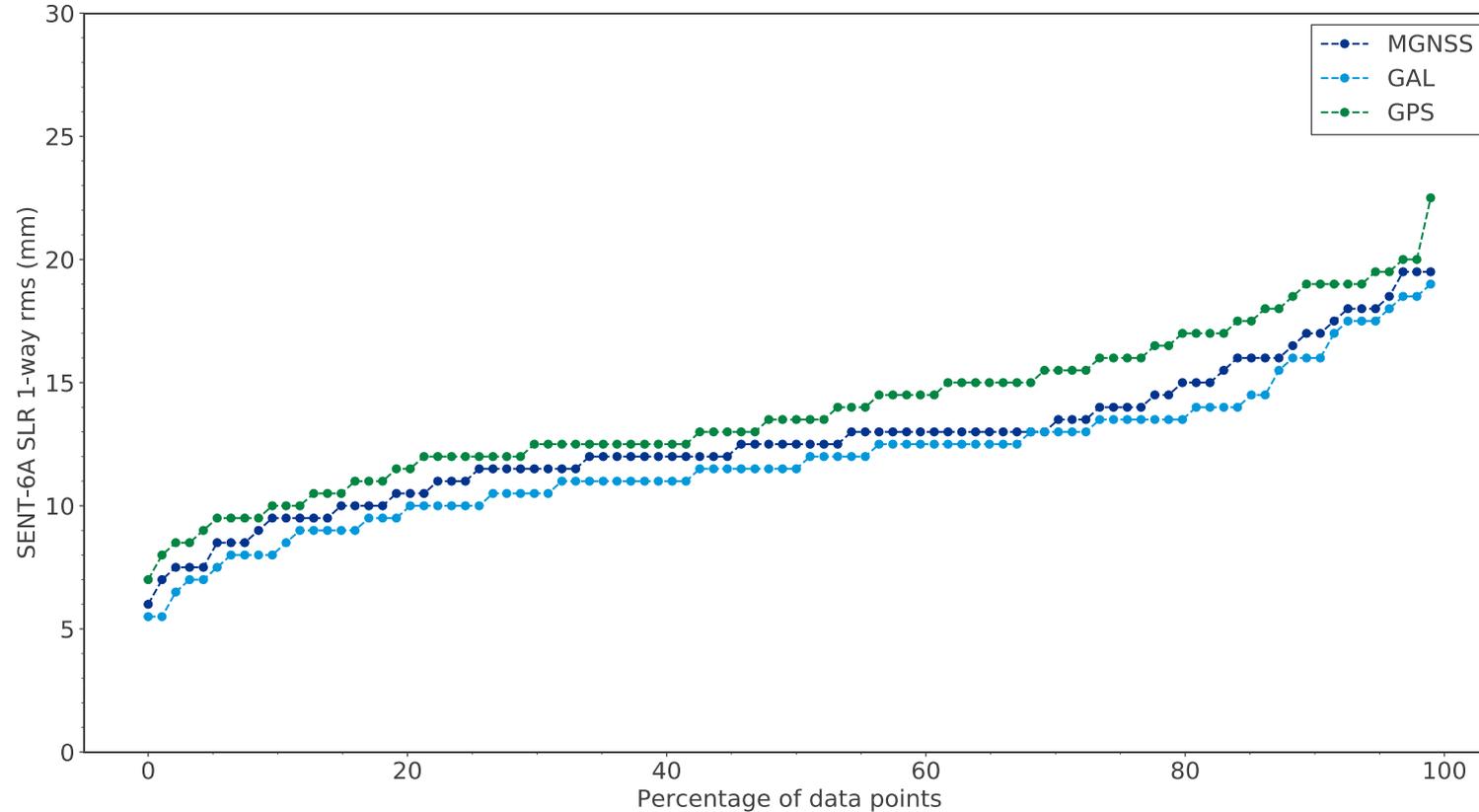


Constellation	3D RMS (mm)
MGNSS Combined VS Galileo	10.9
MGNSS Combined VS GPS	10.9
Galileo VS GPS	17.2

- Average of the daily RMS
- MGNSS = Combined Galileo+GPS

- On average 1 cm difference between the combined solution and the single-constellation solution
- Small inconsistency (~17mm) between the Galileo-only- and GPS-only-based solutions
- ESOC suspects some mismodelling related to the satellite, particularly to the Antenna Phase Centre
- Further investigation is undergoing, to fully exploit the multi-constellation interoperability

SLR 1-way residuals RMS, sorted by size (mm)



Constellation	SLR RMS (mm)
Galileo	11.8
GPS	13.9
MGNSS Combined	12.4

- Average of the daily RMS
- MGNSS = Combined Galileo+GPS

- The SLR residuals are already very good, also compared to the S3A/B SLR (rms~17.2mm)\*
- The Galileo-only-based solution has the lowest RMS, with 85% of data points below 1.5cm
- The GPS-only-based solution shows slightly (1.5-2.5 mm) higher RMS than the other two solutions

\*SENTINEL-3 SLR YEARLY REPORT – 2020, CPOD

- Sentinel-6 carries the first high-precision, Galileo/GPS flying space receiver for Copernicus
- Very high quality of GNSS observations and Precise Orbit Determination performance
- Very good SLR validation, with residuals in the order of 1.2-1.4 cm
- Very good internal consistency among the ESOC orbital solutions (1-2cm) and the day-boundary orbital overlaps (6-8mm)
- Further investigation is on-going for the analysis of joint processing of Galileo and GPS observations in order to fully exploit the interoperable multi-GNSS capabilities.