Copernicus POD Service

Copernicus S-3 POD Performance of operational products

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7th Sentinel-3 Validation Team Meeting, ESRIN, Italy
18-20 October 2022

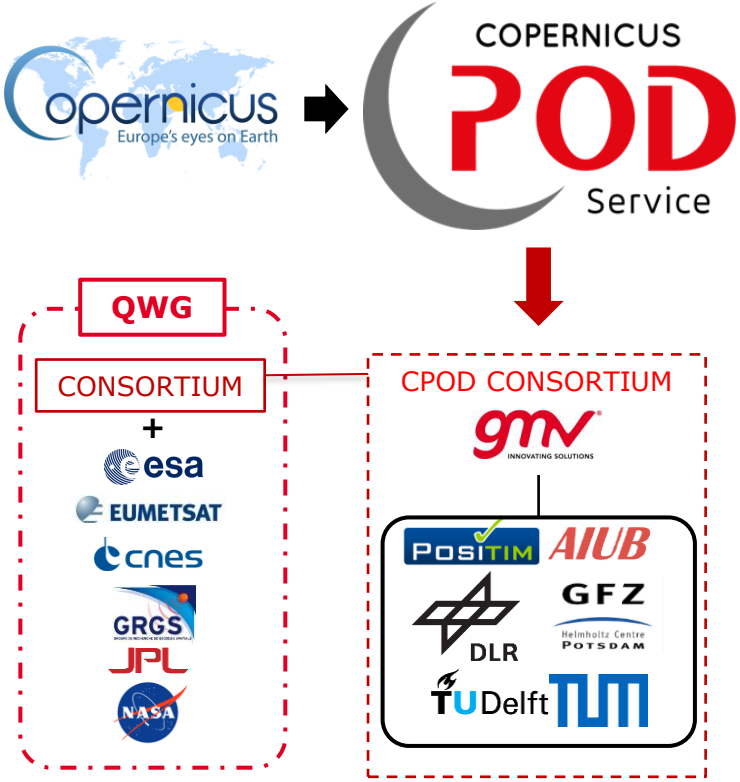
Agenda

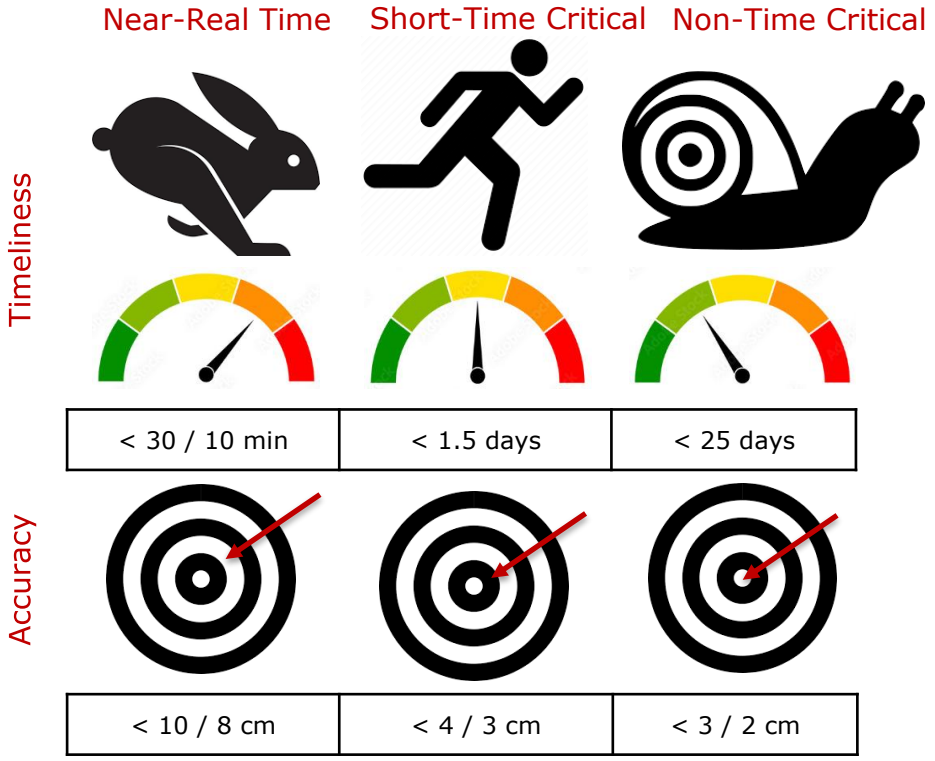
1. **Introduction to Copernicus POD Service**
2. **Performance of operational products**
3. **Next steps**

INTRODUCTION

INTRODUCTION TO CPOD SERVICE

PRODUCTS AND REQUIREMENTS





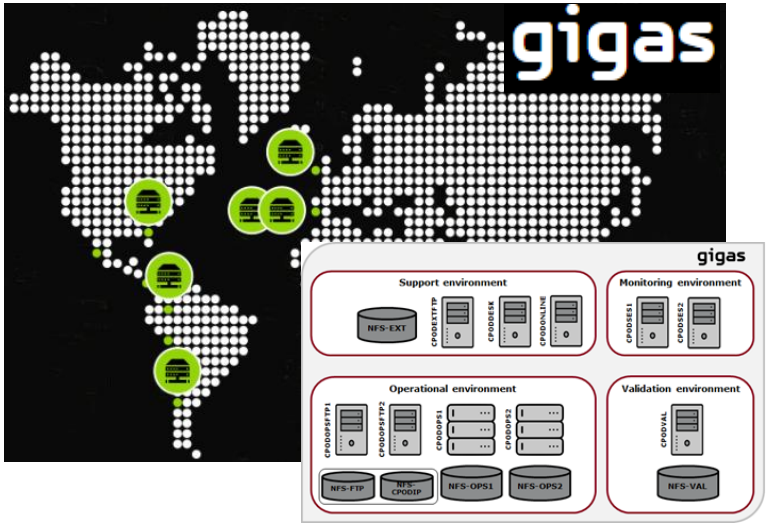
INTRODUCTION TO CPOD SERVICE

PRODUCTS AND REQUIREMENTS

		Orbits	Platform / Attitude	GNSS Observations
PDGS	Marine, Land	NRT (10 min) STC (36 h) NTC (25 d)	NRT (10 min) STC (36 h) NTC (25 d)	Hourly Daily
	ILRS	CPF		
COAH		NRT (10 min) STC (36 h) NTC (25 d)	QUAT Daily	Daily

INTRODUCTION TO CPOD SERVICE

PHYSICAL ARCHITECTURE



10 Machines

80 CPU Cores

120 GB RAM MEMORY

1.2 TB Hard disk memory

10 TB Archive Space

4 Missions (S1, S2, S3, S6)

7 Satellites (S-X A/B)

4 Timeliness (PRE, NRT, STC, NTC)

100,000 Orbital products/year

INTRODUCTION TO CPOD SERVICE

QUALITY WORKING GROUP – COMBINED SOLUTION

AIUB | CNES | CPOD | ESOC | DLR | GFZ | TUM | TU Delft | EUMETSAT | CLS | JPL | GSFC

1st Step: Unweighted Mean

$$\mathbf{SV}_{comb\_0}(t^*) = \frac{\sum_j \mathbf{SV}_j(t^*)}{\sum_j 1}$$

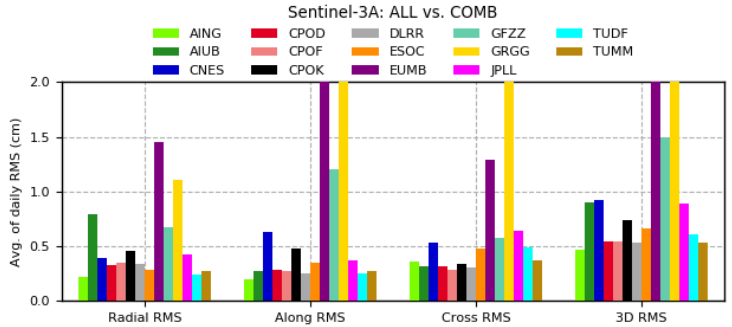
2nd Step: Daily weights as median of distances

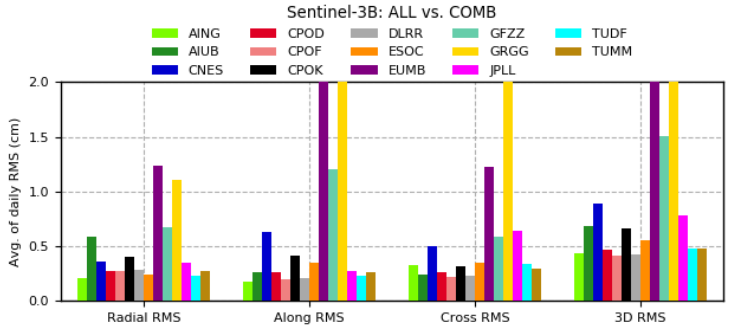
$$w_j = median \left| \boldsymbol{SV}_{comb\_0}(t^*) - \boldsymbol{r}_j(t^*) \right|$$

2nd Step: Weighted Mean

$$\mathbf{SV}_{comb}(t^*) = \frac{\sum_j \mathbf{SV}_j(t^*)/w_j}{\sum_j 1/w_j}$$

Q1 2022





INTRODUCTION TO CPOD SERVICE

SENTINEL-3 POD MODELLING

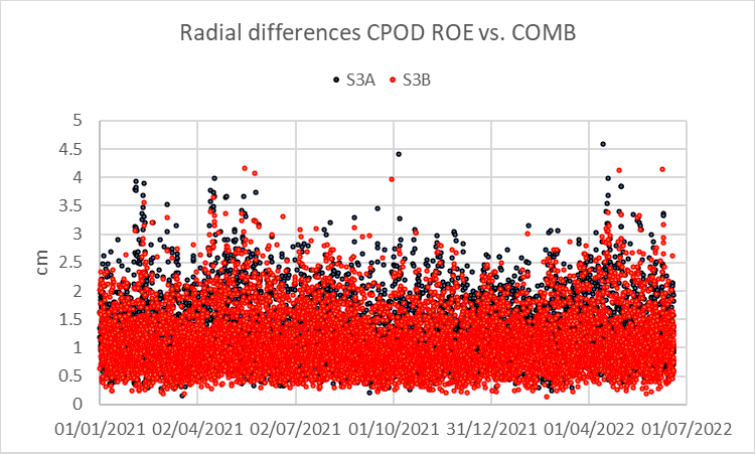
Model	Value
EOPs	IERS rapid / finals
Reference System	IERS standards
Gravity field	Current: EIGEN.GRGS.RL04 TVG Future: COSTG
Solid tides	IERS 2010
Ocean tides	FES 2014
Atmospheric gravity	GFZ AOD L1B RL06
Earth / Ocean pole tides	IERS 2010
Radiation pressure model	Box-wing
Earth radiation	Albedo and infra-red applied
Atmospheric density model	msise00

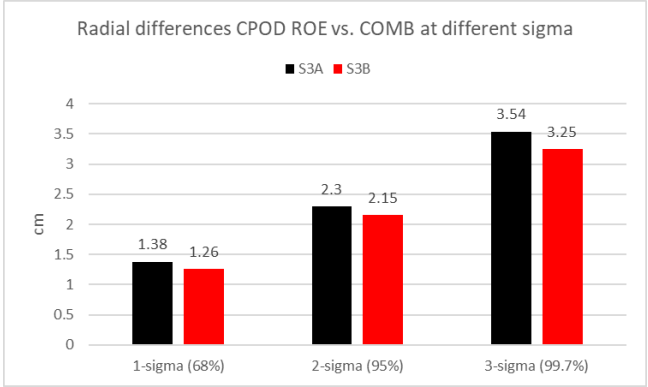
	NRT	STC	NTC
Arc length	24 h	5+24+3 h (32h)	
Drag coefficient	10 (estimated)	1 (estimated)	
Solar pressure coeff.	1 (estimated)	1 (fixed)	
1/rev empiricals (estimated)	2 sets per arc in: along sin+cos cross sin+cos	16 sets per arc in: along cnt+sin+cos cross cnt+sin+cos	
GNSS sampling	30 sec	10 sec	
GNSS products	*magicGNSS*	*magicGNSS*	CODE Finals
Receiver ambiguities	Float *Future: Fixed*	Float *Future: Fixed*	Fixed
Manoeuvres	Calibrated		

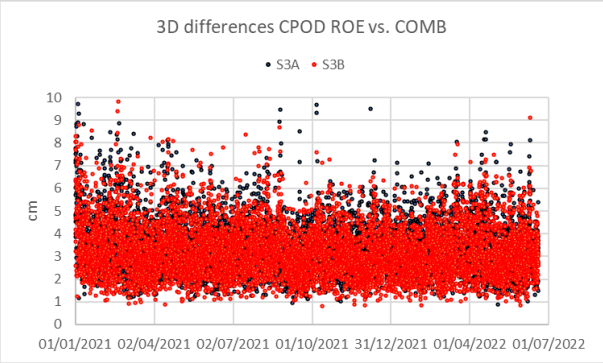
PERFORMANCE

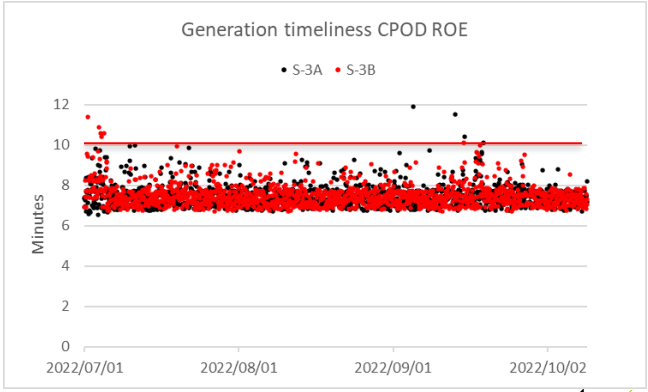
PERFORMANCE

RESTITUTED ORBIT EPEHEMRIS (NRT) – POD



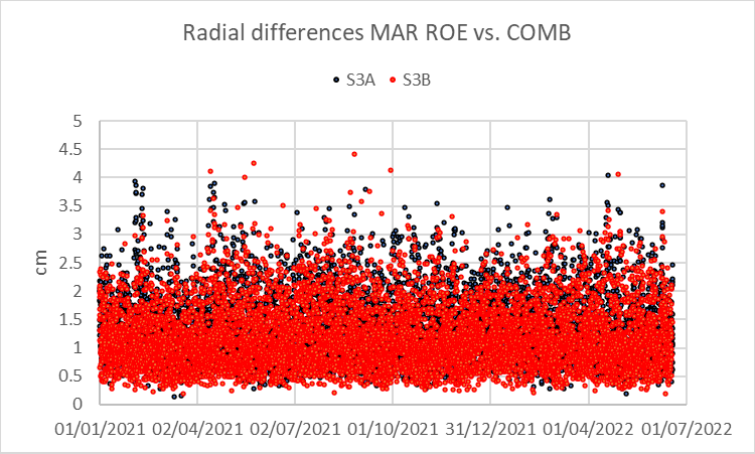


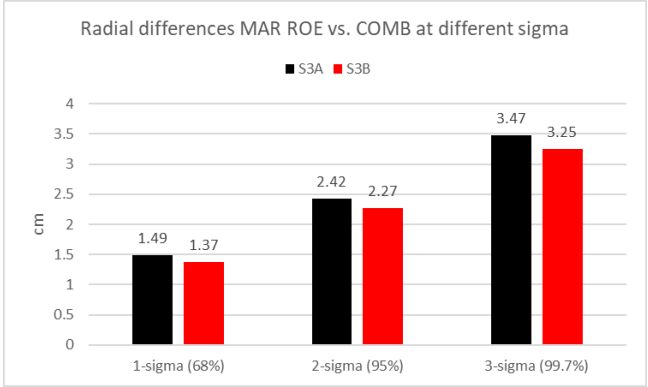


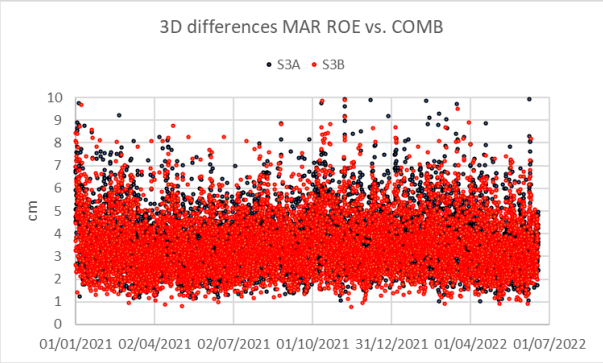


PERFORMANCE

RESTITUTED ORBIT EPEHEMRIS (NRT) – MAR

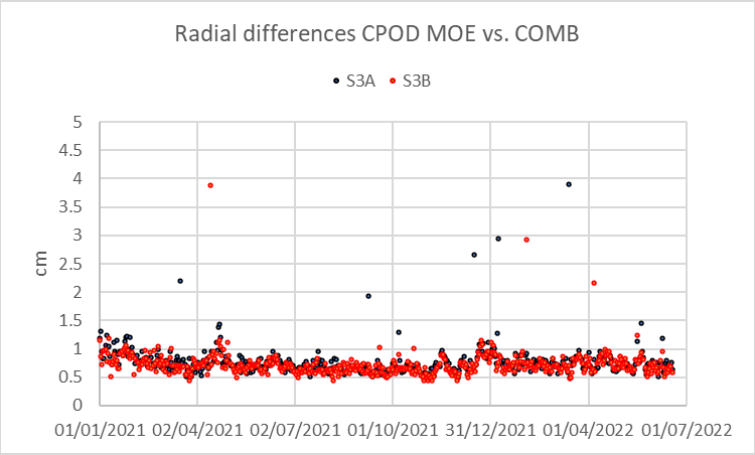


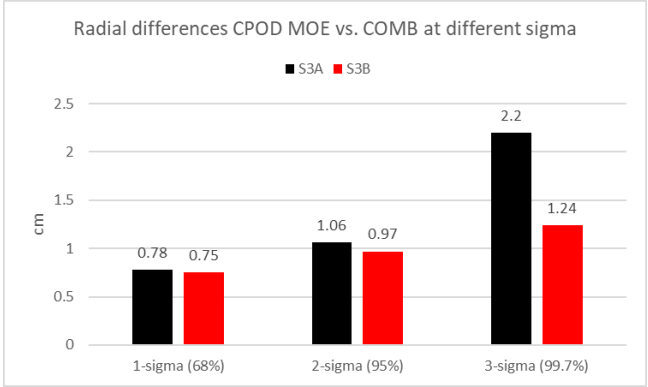


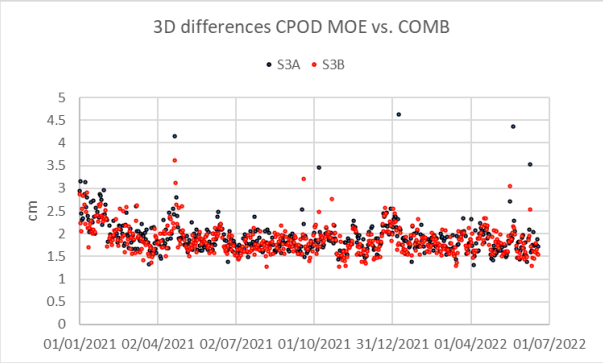


PERFORMANCE

CPOD MEDIUM ORBIT EPEHEMRIS (MOE)



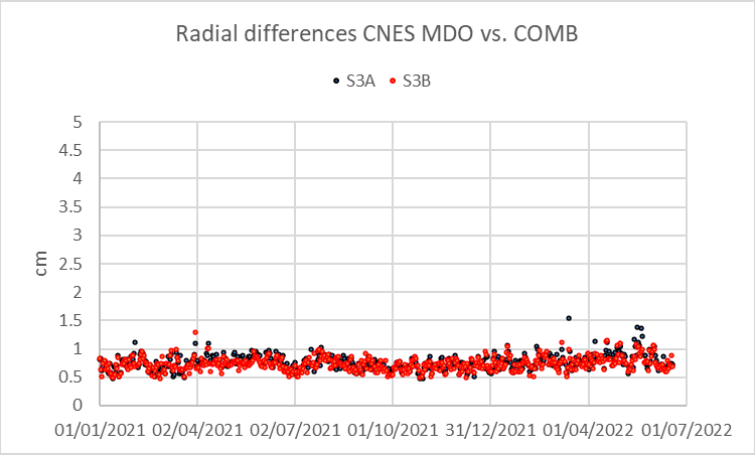


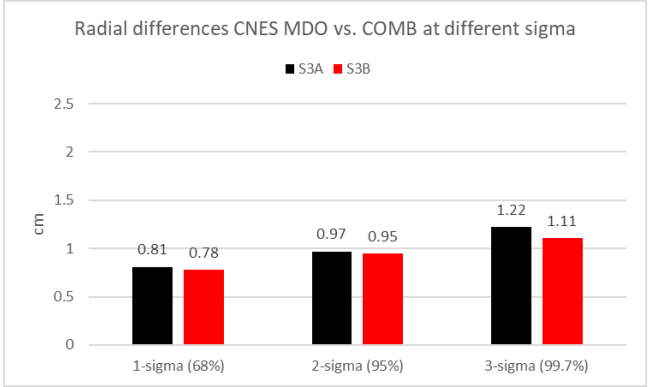


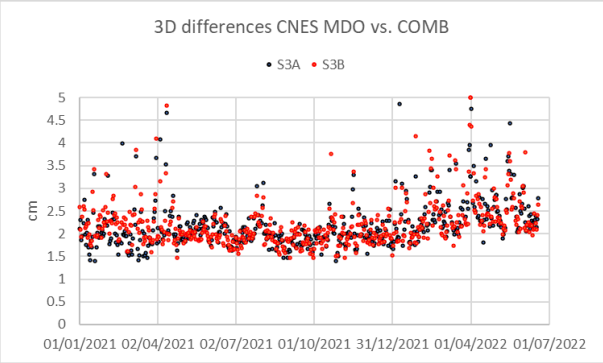
- 3-sigma impacted by outliers!

PERFORMANCE

CNES MEDIUM ORBIT EPEHEMRIS (MDO)

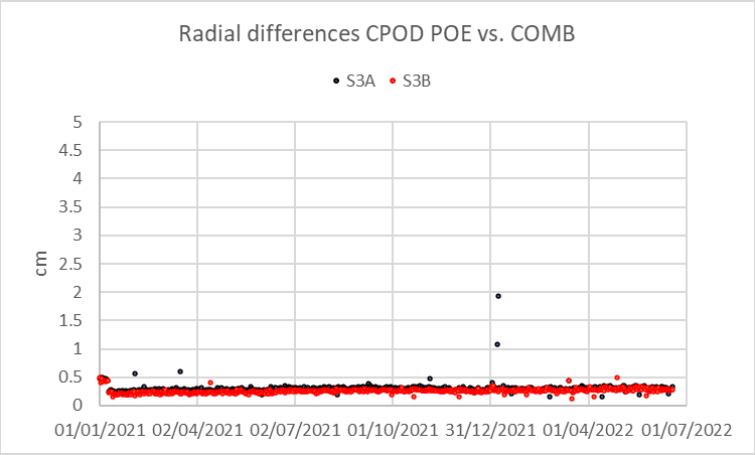


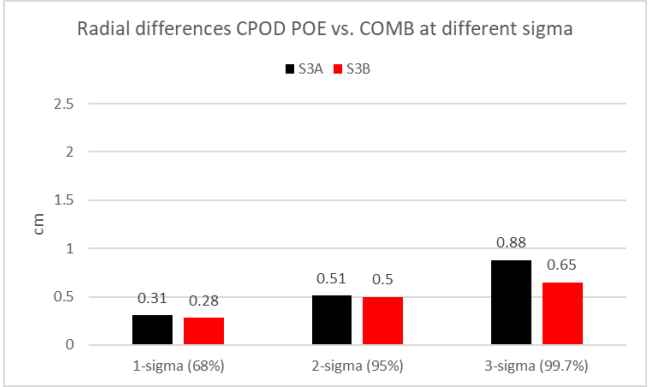


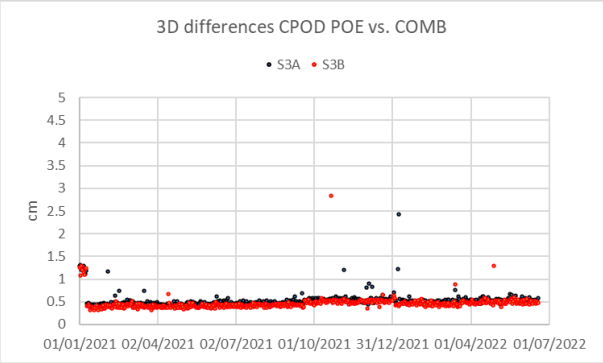


PERFORMANCE

CPOD PRECISE ORBIT EPHEMERIS (POE)



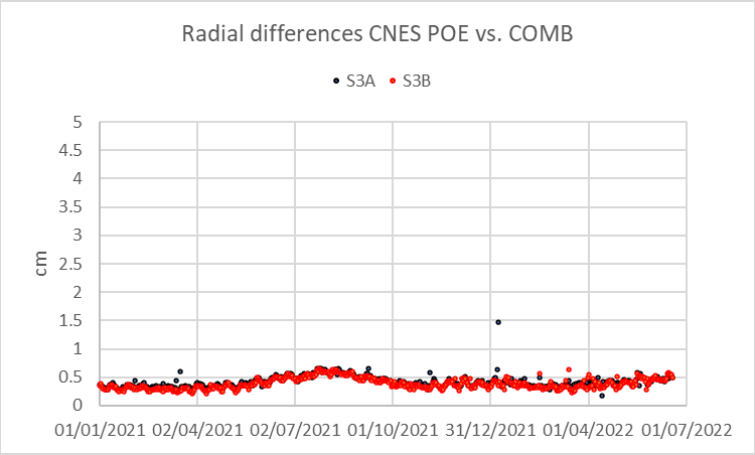


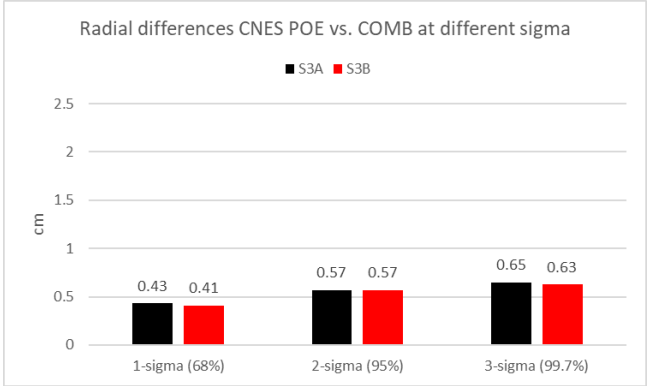


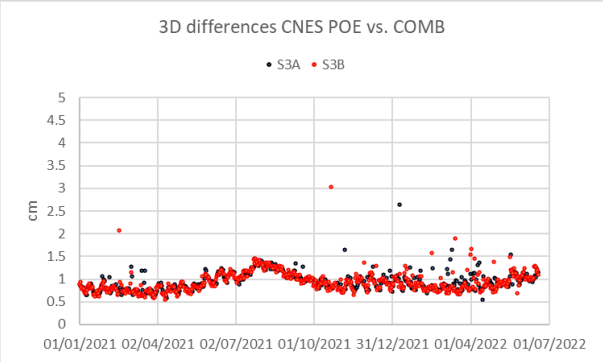
- Change of parametrization in January 2021

PERFORMANCE

CNES PRECISE ORBIT EPHEMERIS (POE)

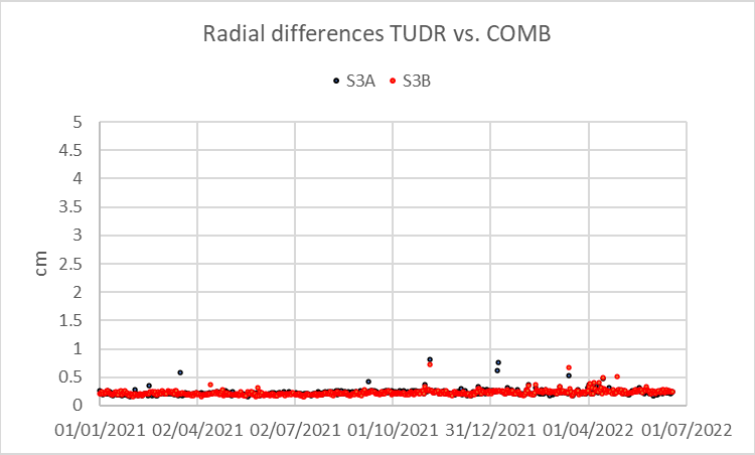


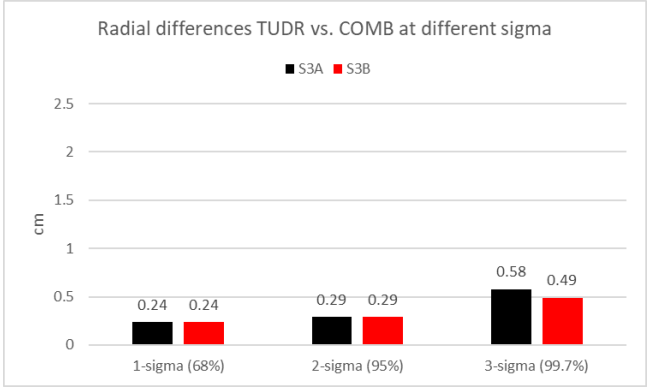


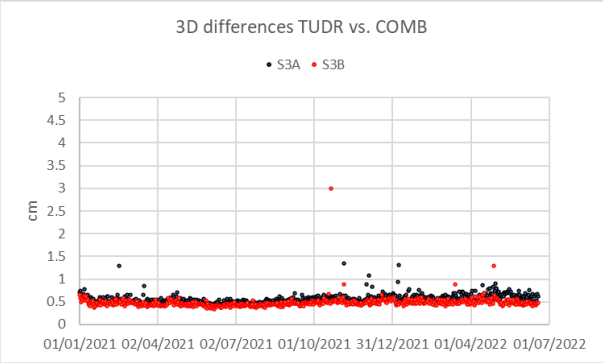


PERFORMANCE

TUD RAPID



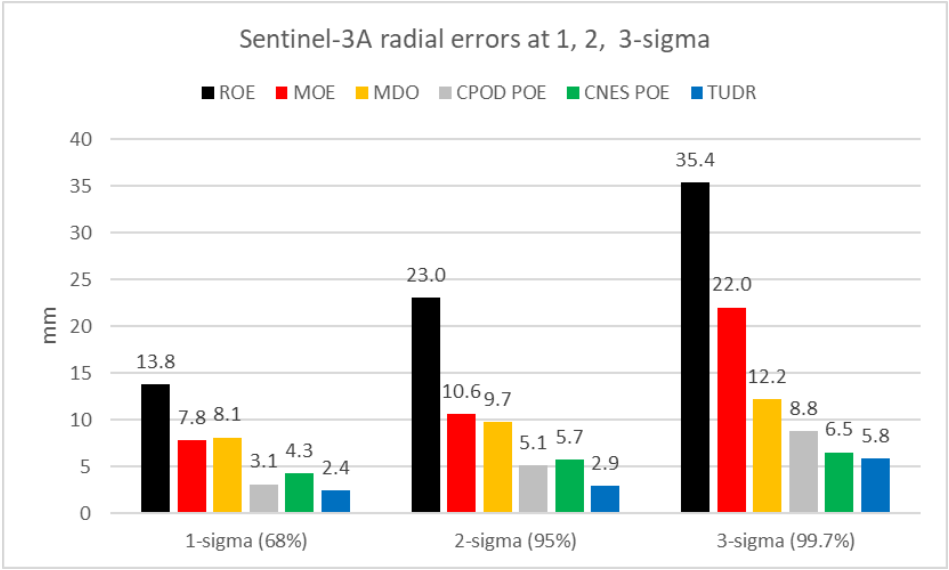


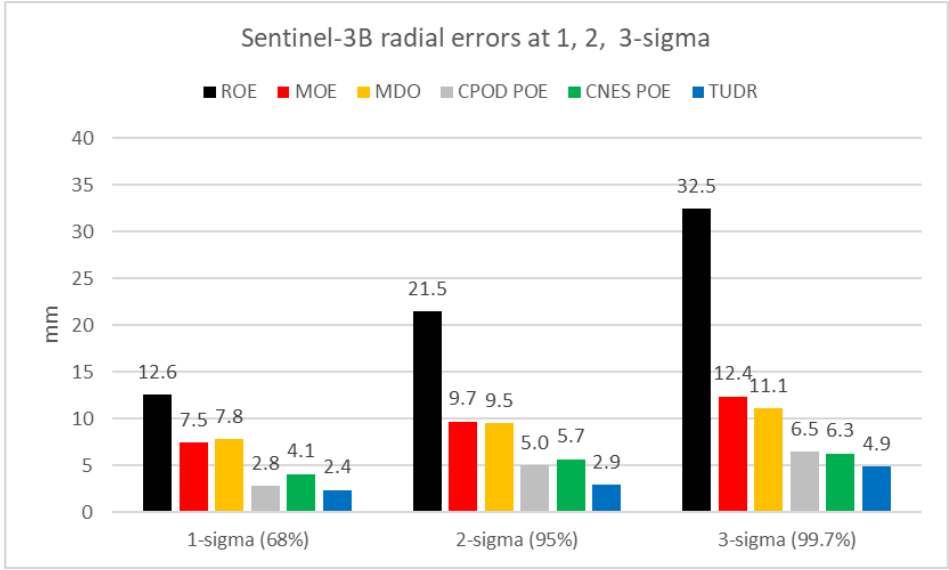


- Generated by TU Delft for QC purposes
- @ 18 – 20h of next day
- Makes use of Integer Ambiguity Resolution

PERFORMANCE

SUMMARY OF RADIAL ERRORS



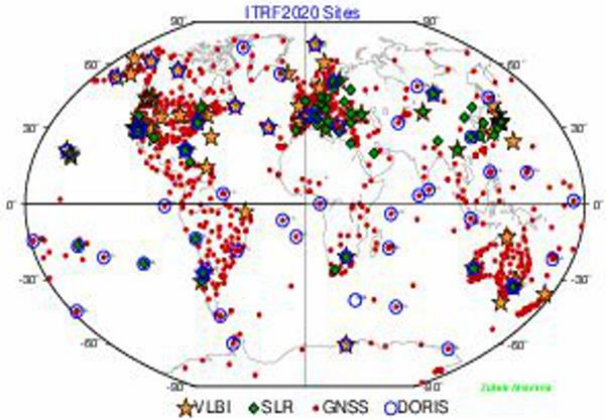


NEXT STEPS

NEXT STEPS

ITRF 20

- WHAT: New realization of the International Terrestrial Reference Frame (ITRF). Impacts:
  - IGS: New mean pole model
  - IGS: New GNSS PCO/PCV (ANTEX); Galileo fixed
  - IGS: New GNSS orbits, clocks and biases; long filenames
  - IGS: New EOPs / ERPs (finals2000A.data)?
  - ILRS: New SLR station´s coordinates
  - IDS: New DORIS station´s coordinates
  - CPOD: New Sentinels PCV map (ANTEX)
  - CPOD/EGP: New GNSS orbits and clocks



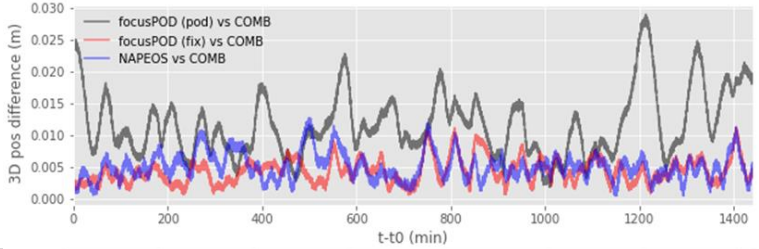
- WHEN: 27/11/2022
- WHY: Periodic realization of ITRF: 94, 96, 97, 2000, 05, 08, **14**, **20**
- IMPACT:
  - Careful orchestration to use ITRF products on NRT / STC / NTC
  - Need of reprocessing?

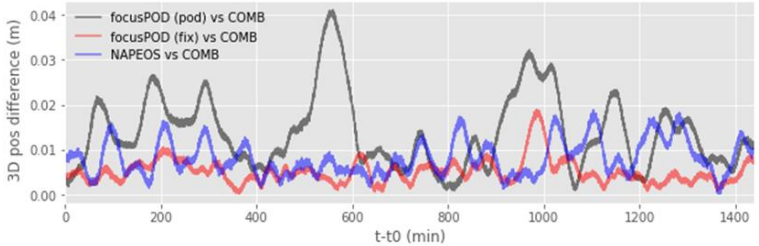
NEXT STEPS

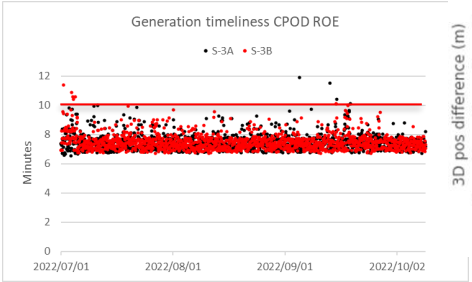
focusPOD

- WHAT: substitution of NAPEOS with ***focusPOD***, a new GMV´s POD SW
  - Written from scratch in C++ / Python
  - Designed as a library
  - Developed to keep same performance (accuracy & timeliness)
- WHEN: 31/12/2022
- WHY:
  - Required by the **CPOD#3 ITT** (no more ESA´s CFIs)
  - To enhance performance (timeliness, accuracy, manoeuvres)
  - Develop service/micro-service architectures
  - Future developments (raw & network processing, etc.)
- IMPACT:
  - Transparent to final users
  - Validation period: Nov+Dec 2022

Satellite	NAPEOS vs COMB (3D RMS)	*focusPOD* vs COMB (3D RMS)
S-3A (GPS)	5.4 mm	4.7 mm
S-6A (GAL)	9.0 mm	5.8 mm







NEXT STEPS

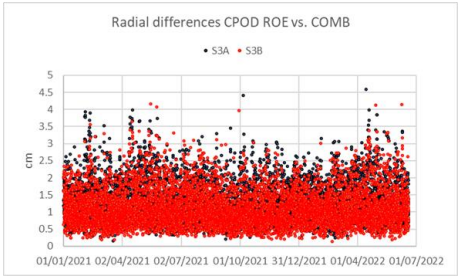
USE OF COST-G

- WHAT: International Combination Service for Time-variable Gravity Fields (COST-G)
  - https://cost-g.org/
  - See next presentation (Copernicus Sentinel-3 POD with COST-G)
- WHEN: First half of 2023 (To be agreed by CPOD QWG)
- WHY: To improve the accuracy and stability of products
- IMPACT:
  - Better accuracy and stability of orbital products
  - To update the geopotential quarterly
  - Dependency with COST-G

NEXT STEPS

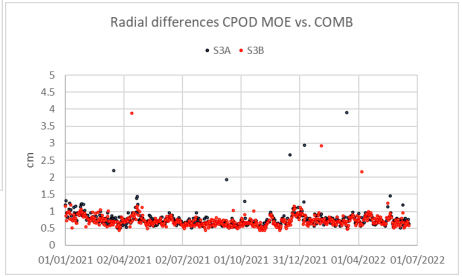
IAR in STC / NRT

- WHAT: Integer Ambiguity Resolution in shorter timeliness
  - Use GNSS biases from EGP on STC/NRT POD
  - Enhance robustness of STC/NRT POD
  - Exhaustive experimentation to confirm expected results
- WHEN: First half of 2023; first in STC, then in NRT
- WHY: To improve the accuracy and stability of products
- IMPACT: Better accuracy and stability of STC / NRT products

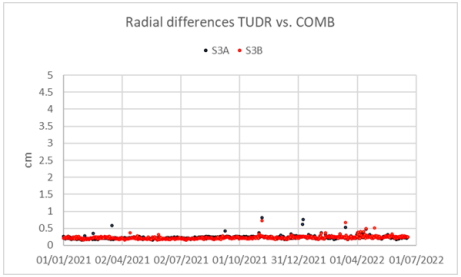


NRT

STC



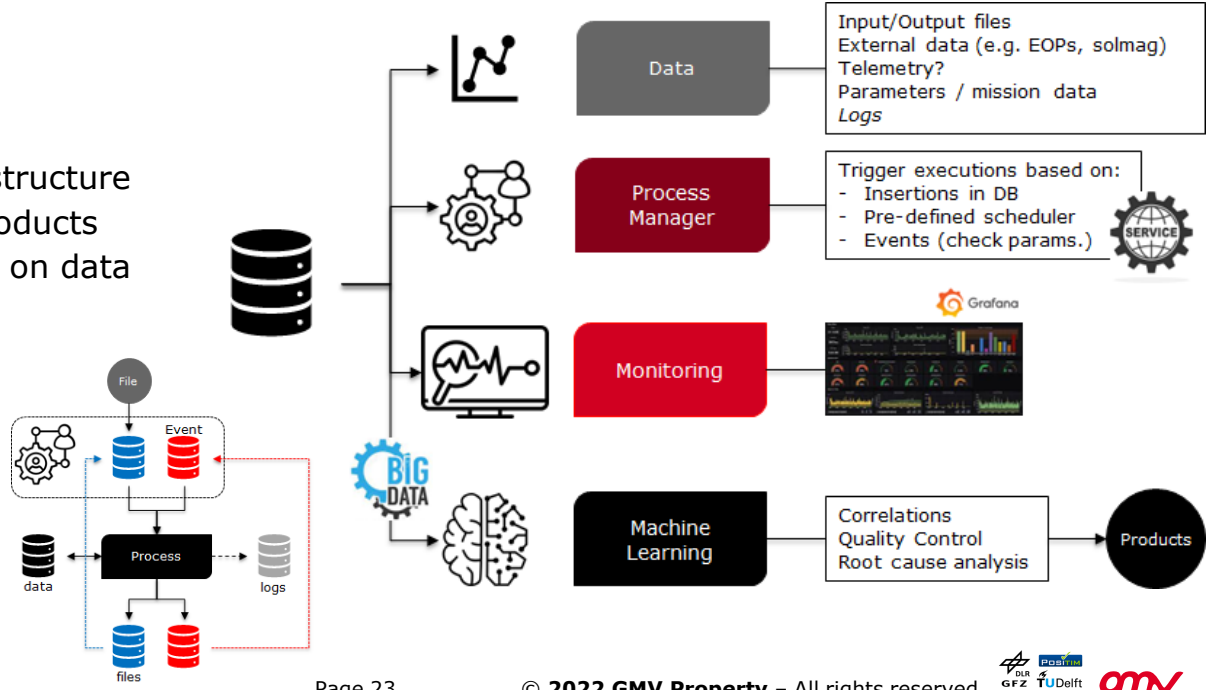
STC IAR



NEXT STEPS

REDESIGN OF CPOD SERVICE

- WHAT:
  - To enhance the use of DBs to archive processing metrics, QC, monitoring.
  - To orchestrate processing using a modern service or micro-service architecture.
- WHEN: 2023
- WHY:
  - To optimize the hardware infrastructure
  - To improve the timeliness of products
  - To develop new products based on data
- IMPACT:
  - Better timeliness of products
  - Better quality control
  - More data to exploit



CONCLUSIONS

CONCLUSIONS

- Mature service: +8 years of continuous operations
- Significant improvement of accuracy and timeliness with respect to original requirements
- Big changes in the following month / year: ITRF20, focusPOD, COST-G, IAR, DBs & Services

Thank you

Copernicus POD Service

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Pierre Féménias (ESA/ESRIN)
Carolina Nogueira Loddo (EUMETSAT)