COPERNICUS POD SERVICE
model updates of copernicus sentinel-1,-2,-3 orbits

AGU 2019
9-13 December 2019 San Francisco, CA

Heike Peter (2)
Emilio J. Calero (1)
Javier Berzosa (1)
Jaime Fernández(1)
Marc Fernández(1)
Roberto Pastor (1)
Pierre Féménias (3)

(1) GMV AD., Tres Cantos, Spain
(2) PosiTim UG, Seeheim-Jugenheim, Germany
(3) ESA/ESRIN, Frascati, Italy

ABSTRACT

The European Earth observation satellite missions, Copernicus Sentinel-1, -2, and -3, require consistent orbit time series for highest-level final products. The six satellites of the three missions have been launched beginning with Sentinel-1A in April 2014 and the last launch of Sentinel-3B has been in April last year. Delivering consistent GPS-derived orbit time series for all six satellites with the different mission lengths and also following up model updates and improvements is a challenge to be fulfilled in an operational environment. Recently, several model updates (Peter et al., 2019), including the gravity field model EIGEN.GRGS.RL04.v1, the atmosphere gravity product GFZ AOD1B RL06, plus the use of single-receiver ambiguity resolution have been intensively validated based on orbit comparisons and SLR residuals, when available. Long-term analysis from offline reprocessed orbit solutions based on the updated models support the validation activities necessary for the continuous improvements of the orbital products. The current status of the model updates and the corresponding validation activities are presented for all six satellites focussing on Sentinel-1 SAR (Synthetic Aperture Radar) and Sentinel-3 altimetry missions, because they have the most demanding accuracy requirements.

INTRODUCTION – THE COPERNICUS POD SERVICE

The **Copernicus POD Service (CPOD)**, part of the Copernicus PDGS and located in Tres Cantos (Madrid), is responsible for the generation of precise orbital products and auxiliary data for their use as parts of the processing chains of the PDGS.

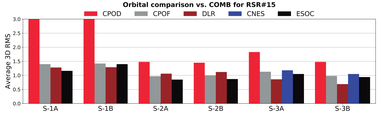
Sentinel-1 Sentinel-2 Sentinel-3

POD CONFIGURATION AND MODELING

Parameter	Element	Value
Software		NAPEOS
Arc length		32 hours
Reference systems	Polar motion and UT1	IERS C04 08
	Pole model	IERS 2010 Conventions
	Precession/Nutation	IERS 2010 Conventions
Surfaces forces and empiricals	Radiation Pressure model	box-wing model with re-radiation
	Earth radiation	albedo and infra-red applied
	Radiation pressure coefficient	1 per arc
	Drag coefficients	11 per day
	1/rev empirical	2 sets per day (along/cross-track, sine/cosine)
GPS measurements	Relativity	IERS 2010
	Sampling	11 sec
	Observations	iono-free of phase and pseudo-range
	Weight	0.8 m (pseudo-range) / 10 mm (carrier-phase)
	Elevation angle cut-off	7 degrees
Geometrical properties	Sentinel-1	GMV-GMESPOD-TN-0025
	Sentinel-2	GMV-GMESPOD-TN-0026
	Sentinel-3	GMV-GMESPOD-TN-0027
GPS ANTEX	Filename	sem08_2025_S1_mod.atx
Other factors		Solid Earth, Ocean, Atmospheric, Earth Pole, Ocean Pole tides + Third bodies (Sun, Moon, Planets DE405)

Scenario	Element	Value
OPERATIONS	Gravity field (static)	EIGEN.GRGS.RL03.v2 (120x120) time-dep (50x50)
	Atmospheric gravity	AGRA (20x20) (Ray-Ponte 2003)
	Atmospheric model	MSISE90 (Hedin, 1991)
NEW MODELS	Gravity field (static)	**EIGEN.GRGS.RL04 (120x120) time-dep (50x50)**
	Atmospheric gravity	**GFZ AOD 1B**
	Atmospheric model	**MSISE00**

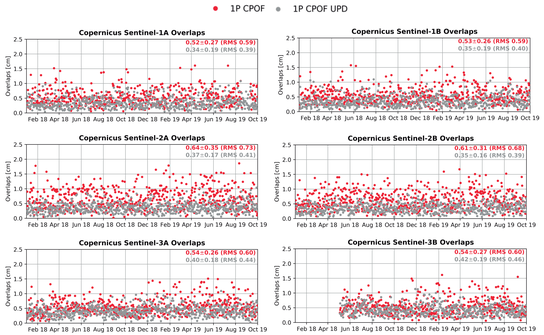
MOTIVATION: QWG RSR#15



Operational CPOD solution is getting obsolete with respect to the current state-of-the-art levels

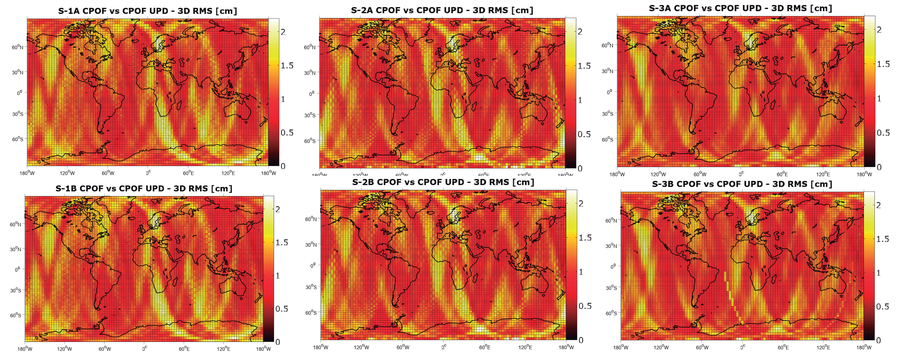
ORBITS OVERLAPS

New models yield better overlaps between orbits



GEOGRAPHICAL DIFFERENCES

Similar geographical 3D RMS differences for each mission account for the net contribution of the updated models



VALIDATION AGAINST BASELINE SOLUTION

New models yield systematic improvements when comparing against the baseline solution (Fernandez et al. 2019)

Comparisons against baseline solution – 3D RMS [cm]

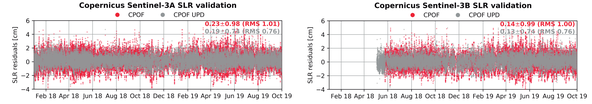
	SEN-1A	SEN-1B	SEN-2A	SEN2B	SEN-3A	SEN-3B
CPOF	1.53 ± 0.20	1.55 ± 0.21	1.34 ± 0.18	1.37 ± 0.17	1.40 ± 0.19	1.30 ± 0.21
CPOF UPD	1.41 ± 0.22	1.44 ± 0.25	1.02 ± 0.11	1.07 ± 0.12	1.09 ± 0.10	0.95 ± 0.09

***Bias per SLR station**

Yarragadee	5.96 mm
Greenbelt	1.56 mm
Haleakala	12.50 mm
Hartebeesthoek	9.14 mm
Graz	11.08 mm
Herstmonceux	3.99 mm
Potsdam	-7.43 mm
Matera	-3.29 mm
Wettzell	-17.03 mm

SENTINEL-3 SLR VALIDATION

New models yield lower dispersion of SLR residuals after removing a bias per SLR station*



CONCLUSIONS

Some effort has been devoted to update and validate different physical models at the Copernicus POD Service:

- The gravity field, atmospheric gravity and atmospheric density models have been updated.
- The assessment of overlaps as well as SLR residuals shows an improvement in accuracy for the new solutions. Similar improved figures are observed when comparing against the baseline solutions.
- The updated models yield consistent geographical differences within the Sentinel missions.

References

GMV-GMESPOD-TN-0025 Sentinel-1 properties for GPS POD: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/ground-segment/pod/documentation
GMV-GMESPOD-TN-0026 Sentinel-2 properties for GPS POD: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/ground-segment/pod/documentation
GMV-GMESPOD-TN-0027 Sentinel-3 properties for GPS POD: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-3/ground-segment/pod/documentation
Fernández J., Peter H., Calero E.J., Berzosa J., Gallardo L.J., Féménias P., 2019. Sentinel-3A – Validation of Orbit Products at the Copernicus POD Service
Hedin, Alan E. "Extension of the MSIS thermosphere model into the middle and lower atmosphere." Journal of Geophysical Research: Space Physics 96, no. A2 (1991): 1159-1172.
Peter H., Calero E. J., Fernández J., Féménias P. "Copernicus POD Service - Model Updates and Validation of Sentinel-3 Orbit Determination" OSTST 2019, Chicago, IL

Acknowledgements

The Copernicus POD Service is financed under ESA contract no. 4000108273/13/I-NB, which is gratefully acknowledged.
The work performed in the frame of this contract is carried out with funding by the European Union. The views expressed herein can in no way be taken to reflect the official opinion of either the European Union or the European Space Agency.
The Copernicus POD Service is grateful to the CPOD QWG members for their support in the validation of the results.
Finally, IGS, and, particularly, CNES/CLS Analysis Center, is greatly appreciated and acknowledged for the provision of the GPS products.