COPERNICUS POD SERVICE

EGU 2020

ORBIT VALIDATION: INVESTIGATIONS ON SYSTEMATIC GEOGRAPHICAL DIFFERENCES

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ABSTRACT

The Copernicus POD (Precise Orbit Determination) Service delivers, as part of the PDGS of the Copernicus Sentinel-1, -2, and -3 missions, orbital products and auxiliary data files for their use in the corresponding PDGS processing chains. The precise orbit results from the three missions are validated based on orbit comparisons to independent orbit solutions from members of the Copernicus POD Quality Working Group (QWG). In the case of Sentinel-3 a validation based on satellite laser ranging (SLR) measurements is also possible. The orbit comparisons are done based on orbit time series. Typically, only daily RMS metrics are derived, and its time-series mean and standard deviation are provided. Another possibility is to analyse the dependence of orbit differences with geographical differences; this is already done for the altimeter satellites to guarantee long-term stability of the orbit solutions. Geographical orbit differences may reveal systematics due to, e.g., different background models or different geocenter motion models used in the orbit determination process. The geographical orbit differences of all six satellites and from all POD QWG contributions are analysed and checked for model- or satellite-specific systematics to improve the orbit quality and long-term stability. Additionally, it is proposed to analyse the orbit differences (with respect to other orbital solutions, either reduced-dynamic or kinematic) with Fourier transformation, in order to derive amplitude vs. frequency plots. This could provide light into the sub-daily differences. The Fourier analysis of the sub-daily differences will be assessed for all the six satellites.

1. COPERNICUS POD SERVICE

Consortium led by **GMV** (Tres Cantos, Spain)

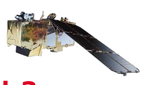
- PosiTim: QWG management, quality control, improvements, scientific outreach.
- Veripos: external GPS orbit and clock provider.
- DLR, TUM, AIUB, TUD: QWG members, quality control.

The **CPOD Service** provides very accurate orbit solutions for the Sentinel missions.

Mission	Category	Orbit Accuracy (RMS)
S-1	PRE	1 m (2D)
	NRT	10 cm (2D)
	NTC	**5 cm (3D)**
S-2	PRE	3 m (2D)
	NRT	1 m (3D)
S-3	NRT	10 cm radial (target of 8 cm)
	STC	4 cm radial (target of 3 cm)
	NTC	**3 cm radial (target of 2 cm)**

Sentinel-1

Sentinel-2



Sentinel-3

2. POD SET-UP

Elements	CPOF (NAPEOS)	DLR (GHOST)	TUDG (GIPSY)	AIUB (BERNESE)
Polar motion & UT1	IERS C04 14	igs96p02.erp	JPL final	CODE final
Gravity field (static)	EIGEN.GRGS.RL04 TVG (120x120)	GOCO03S (100x100)	EIGEN-GRGS.RL04-MEAN-FIELD (150x150)	GOCO05s (120x120)
Gravity field (time varying)	Drift/annual/semi-annual piece wise linear terms up to degree/order 90	N/A	N/A	N/A
Atm. gravity	AOD1B RL06 (100x100)	N/A	AOD1B RL06	None
Radiation Pressure	Box-wing model (with re-radiation)	Box-wing model	Box-wing model	None
Earth radiation	Albedo and Infra-red applied	N/A	Albedo and Infra-red applied	None
Atm. density	msise00	NRLMSISE-00	DTM2000	None
Rad. pressure coeff.	1 per arc	1 per arc	Fixed	None
Drag coeff.	10 per day	1 per arc	1 per arc	None
Empirical	1/rev 2 sets per day in along & cross track (sin/cos)	N/A	1/rev 2 sets in along & cross track (sin/cos) and 10 min constant cross-track & radial	Piecewise constant in R, S, W every 6 min

3. METHODOLOGY

- The orbit validation is performed by comparing different orbit solutions against one common reference orbit.
- In this case, a **combined solution** is computed and accepted as reference orbit. To compute this combined solution, use is made of the orbit solutions computed by the QWG members.

COMBINED SOLUTION

Weighted average of all contributions.
Weights computed based on relative deviations between solutions.

Step: 60 s

- **Coverage:** 2019/10/22 – 2020/01/25 (18 GPS weeks).
- **Geographical analysis:**
  For each solution, the comparisons are projected onto an equirectangular map projection of 4 degrees step grid (~450 km). The average for each cell is then calculated and displayed in color scale.
- **Spectral analysis:**
  For each solution, the Fast Fourier Transform (FFT) of the comparisons temporal series are computed and displayed as a function of the period (inverse of the frequency, 1/f).

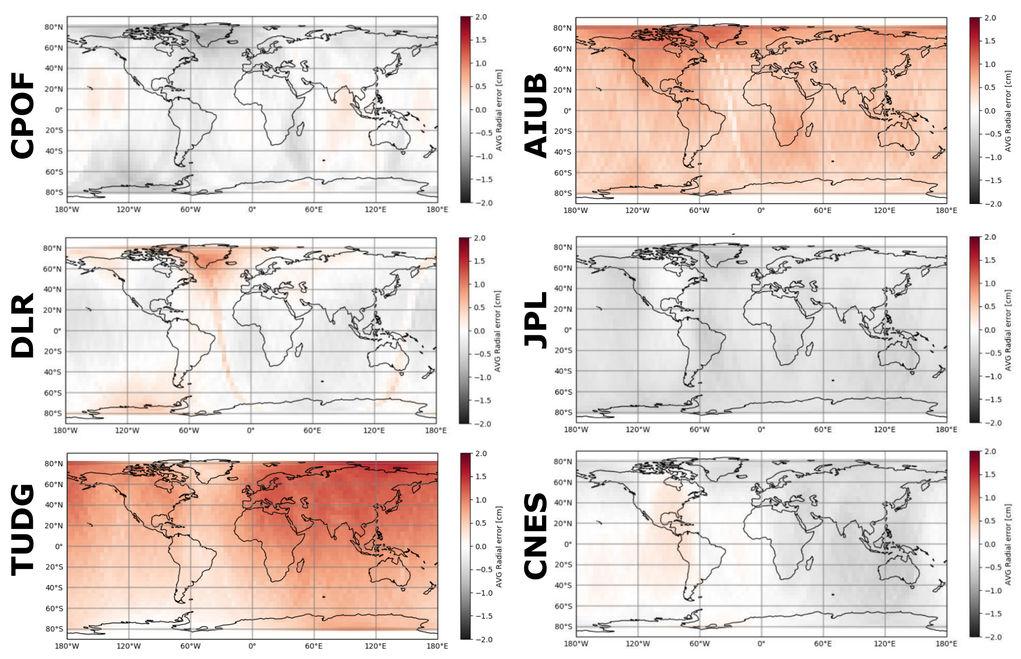
Additional information on the study methodology, the POD set-up and extensive results are available in the Regular Service Review #16. See note at the bottom of the poster for further information.

4. RESULTS

- Results only shown for the A units and particular error components.

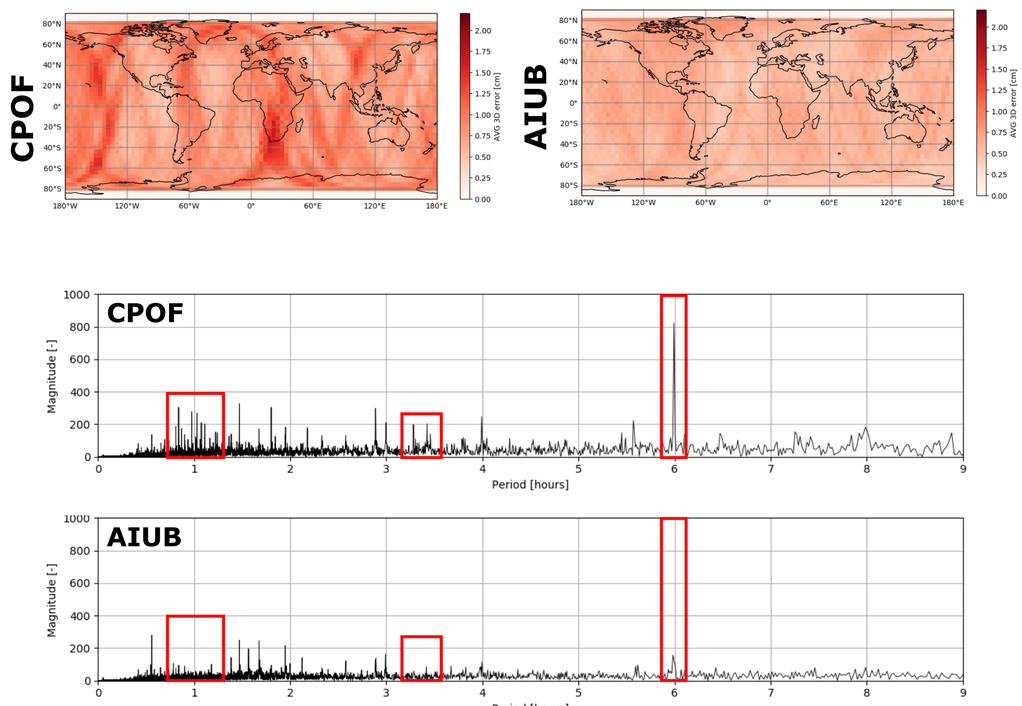
Sentinel-3A

RADIAL ERROR (±2 cm)

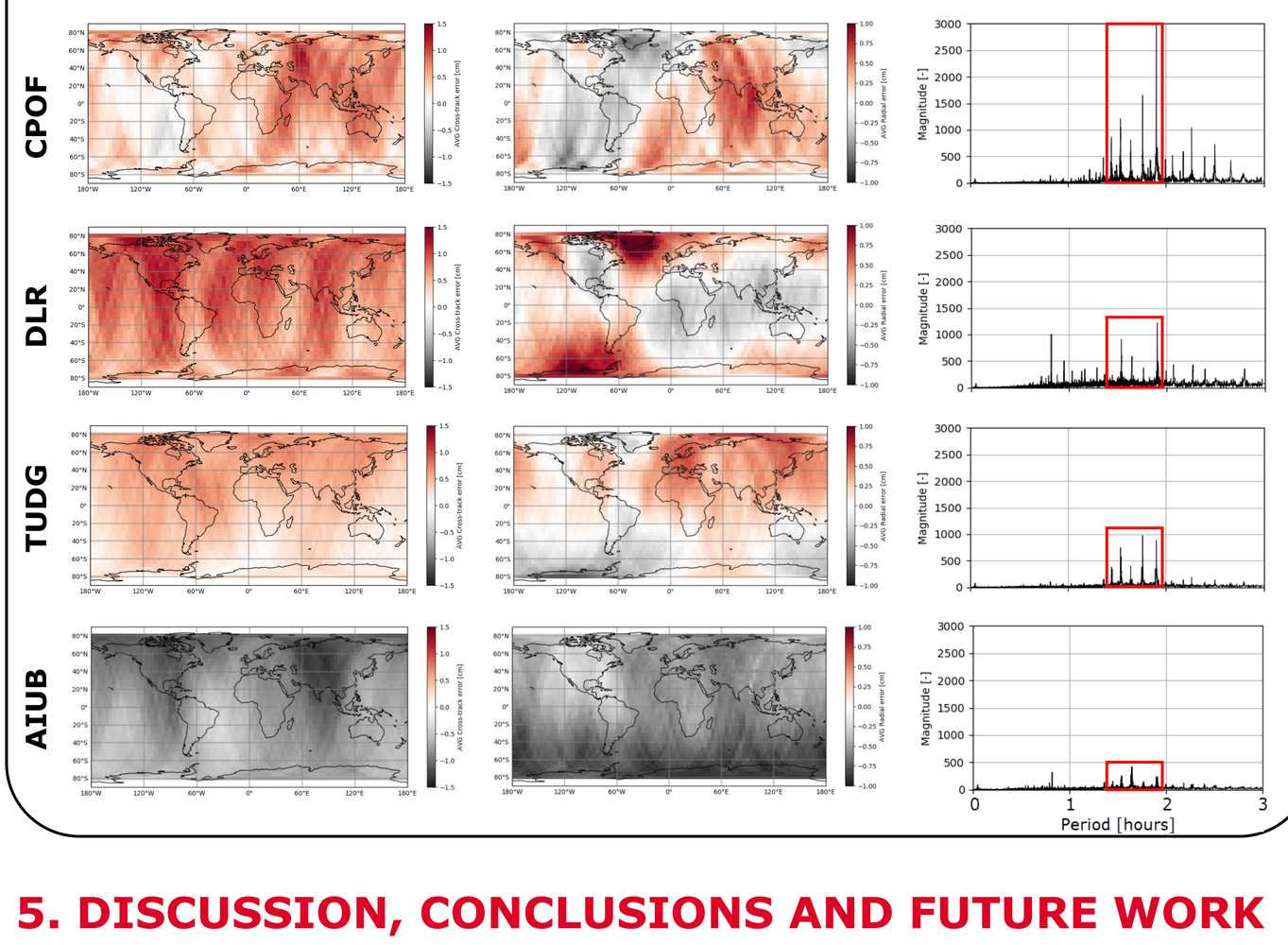


Sentinel-2A

3D ERROR (0 – 2.25 cm)



Sentinel-1A



5. DISCUSSION, CONCLUSIONS AND FUTURE WORK

Sentinel-1A

- The geographical differences depict notorious correlations for all solutions. In the case of the along-track differences:
  - CPOF presents a west-east pattern.
  - TUDG and AIUB present a north-south patter.
  - DLR shows a notably higher error at higher latitudes.
- The presented solutions have unveiled different levels of systematic period errors, being the CPOF solution the one with most systematics and AIUB the least, looking at the along-track results.

Sentinel-2A

- The 3D error spectral result for the CPOF and AIUB solutions present important differences, potentially imputable to the additional modelling used by the former. In particular, the CPOF solution presents relevant signals around 1h, 3.3 and 6 hours.

Sentinel-3A

- For Sentinel-3A, the solutions by CPOF, DLR, TUDG and AIUB are complemented by those of JPL and CNES.
- The results show a great variety of geographical correlation of the orbital radial error.

In general, most of the solutions present periodic signals at combined harmonics of the orbital period and the 24h period, i.e. frequencies of the shape $f = f_{orbit} + i \cdot f_{24h}$.

Systematic errors introduced in the combined orbit could disrupt the results presented for the different solutions and hamper the drawing of conclusions.

Further studies shall be conducted in order to asses potential correlations between the geographical orbital errors and the modelling involved in the POD processing.

ACKNOWLEDGEMENTS

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The presented material is an extract from the "**Copernicus POD Regular Service Review Oct 2019 – Jan 2020"** document to be shortly published on the Sentinel Online website.

https://sentinels.copernicus.eu/web/sentinel/