Copernicus POD Service: Sentinel-3 and Sentinel-6 orbit determination based on DORIS observations

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Copernicus POD Service

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- Consortium led by **GMV**, Tres Cantos, Spain
- **magicGNSS**, external GPS orbit and clock provider (NRT, STC), backup **DLR Reticle**
- **PosiTim**, QWG management, quality control, improvements, scientific outreach …
- **DLR, TUM, AIUB, TUD, GFZ** quality control, QWG members

Copernicus Sentinel-1   Copernicus Sentinel-2   Copernicus Sentinel-3   Copernicus Sentinel-6 Michael Freilich

- Sentinel satellites are equipped with various Earth observation instruments
- Mission requirements demand high levels of orbital accuracy (**GPS**, DORIS+SLR only S-3 + S-6 (+**GAL**)) → **Copernicus POD Service**

=> More information and details on OSTST poster "Copernicus POD Service: Overview and status" by Fernández et al.

S3 and S6 NTC products from CPOD Service

- NTC solutions: most accurate orbit solutions for the satellites
- S-3A & S-3B: official CPOD product
- S-6 MF: offline processing for quality validation

- **CPOD**: operational processing setup
- **CPOF**: test solution (e.g., new gravity field model)
- **CPOK**: kinematic orbit solution

- GPS-only (S-3) or Galileo-only (S-6), ambiguity-fixed orbit solutions
- No DORIS observations are used

- Other QWG solutions have DORIS included (**CNES** (GNSS+DORIS), **GSFC** (DORIS+SLR)) or provide DORIS-only solutions (**GRGS**)

RSR #23 comparisons – full year 2021

Sentinel-3A: ALL vs. COMB

Sentinel-3B: ALL vs. COMB

Sentinel-6A: ALL vs. COMB
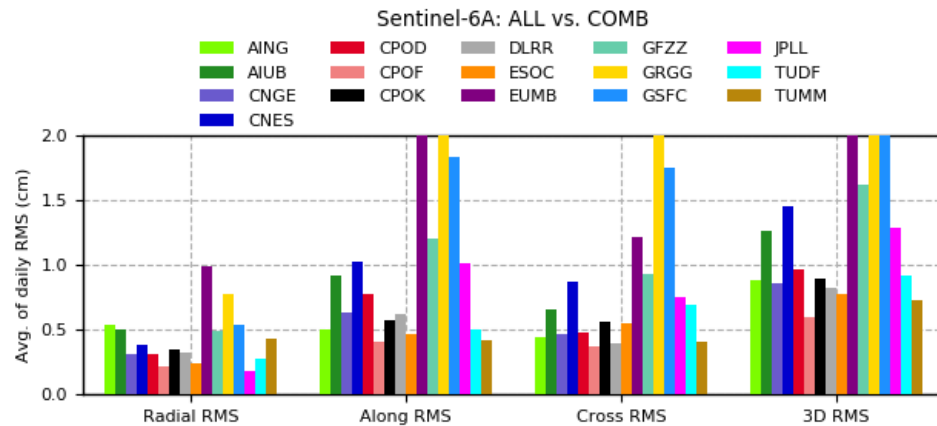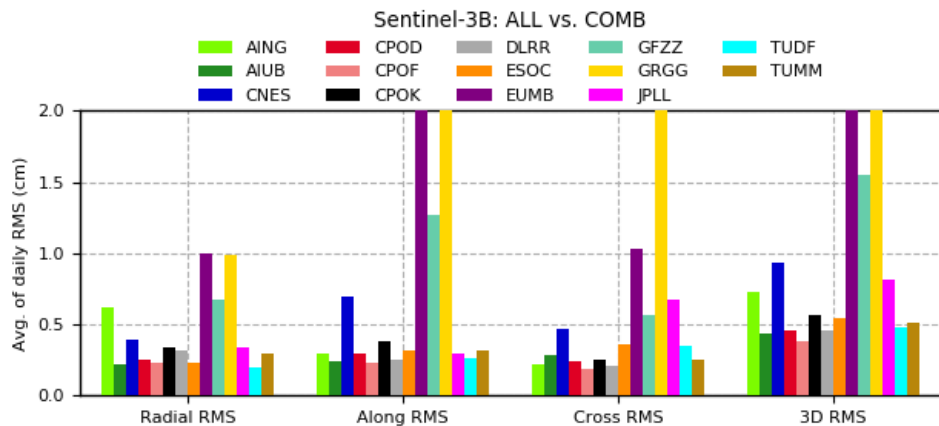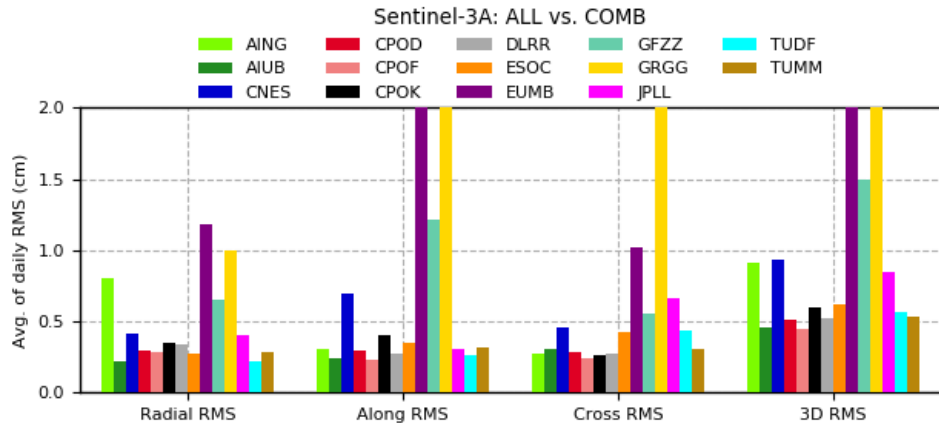
DORIS processing @ CPOD Service

- **Sentinel-3A & 3B, Sentinel-6 MF**
- DORIS processing is not done on regular basis, only as batch processing.

- 10 sec DORIS phase observables are converted to range-rate observations, GNSS-derived orbit is used as a-priori information.

The key data of the DORIS processing are:
- Three-day arc length (72 hours)
- Estimation of
  - **Sentinel-3: 3/24h sets of CPR along-track and cross-track constant, sine+cosine parameters**
  - **Sentinel-6: 4/24h sets of CPR along-track constant, sine+cosine; cross-track sine +cosine**
  - CR fixed (S3A&B: 0.96; S6MF: 0.98)
  - CD fixed
- Elevation cut-off angle of 10º for DORIS observations, no elevation-dependent weighting
- Tropospheric zenith delays per station pass
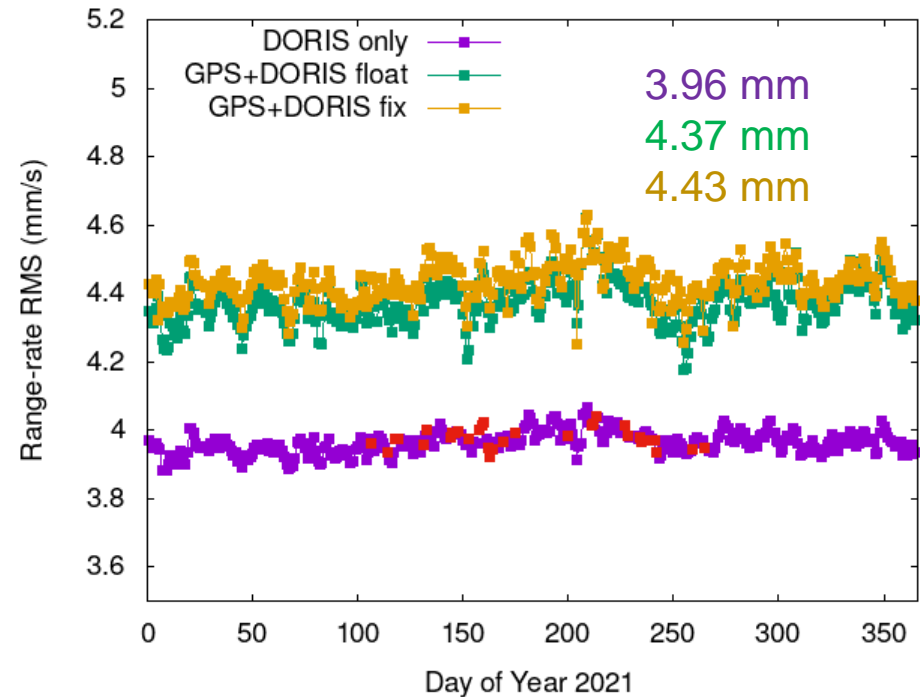- Range-rate bias per station pass

Orbit solutions including DORIS

- **DORIS-only** solution, SLR is used for validation

- **GPS** (S-3) or **GAL** (S-6) (30 sec)**+DORIS combined** solution, SLR is used for validation
  a. Ambiguity-float
  b. Ambiguity-fixed

- **Year 2021**
  - Comparison to combined orbits from RSR#23 (full year 2021)
  - SLR validation
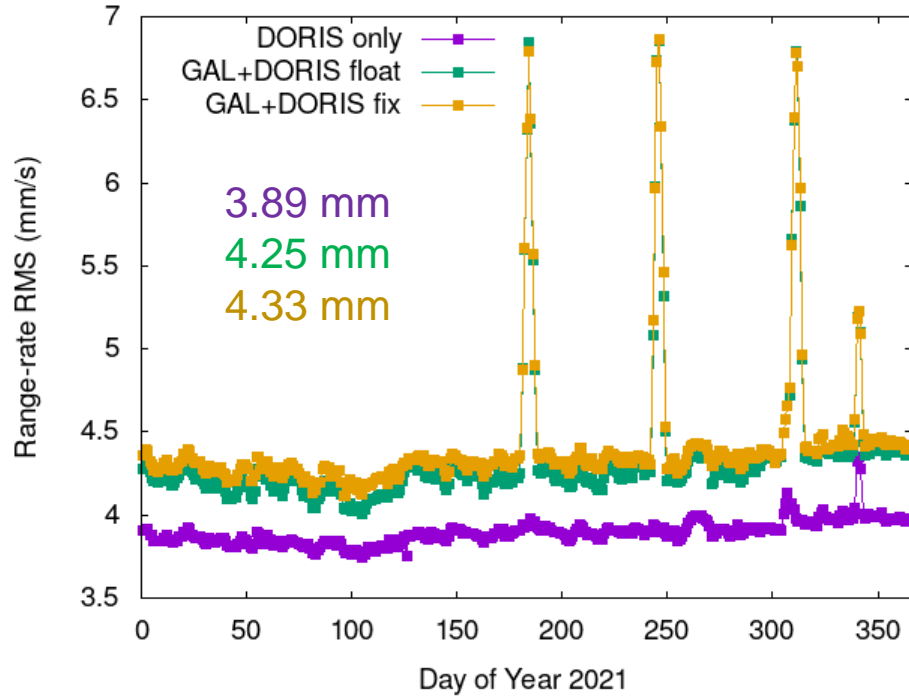
DORIS range-rate RMS

S-3A
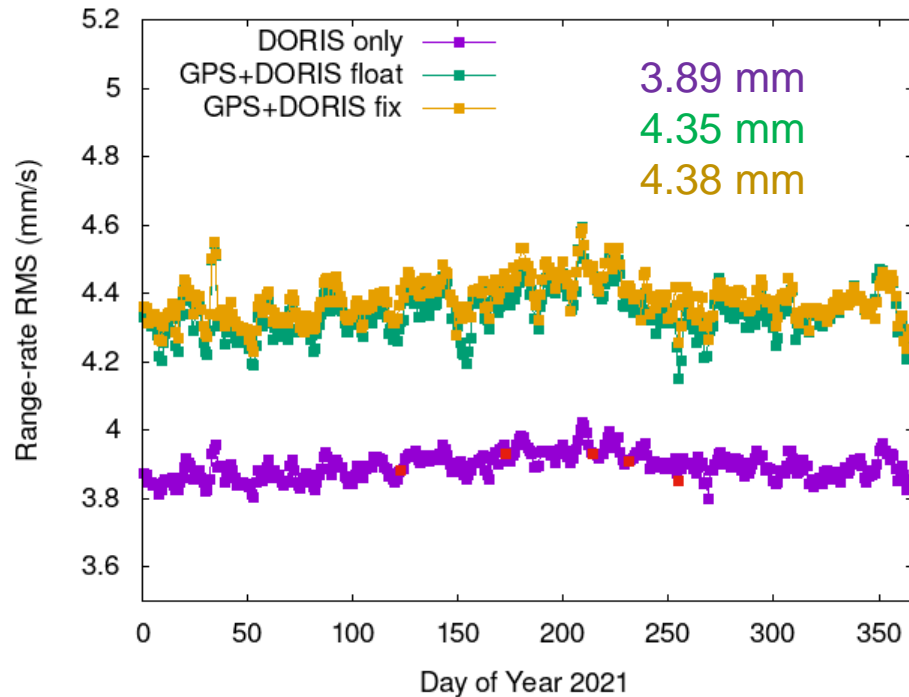
S-3B

- DORIS range-rate RMS (mm/s) slightly larger for S-3B than for S-3A
- On some days there were problems with the iterations (processing stopped too early)
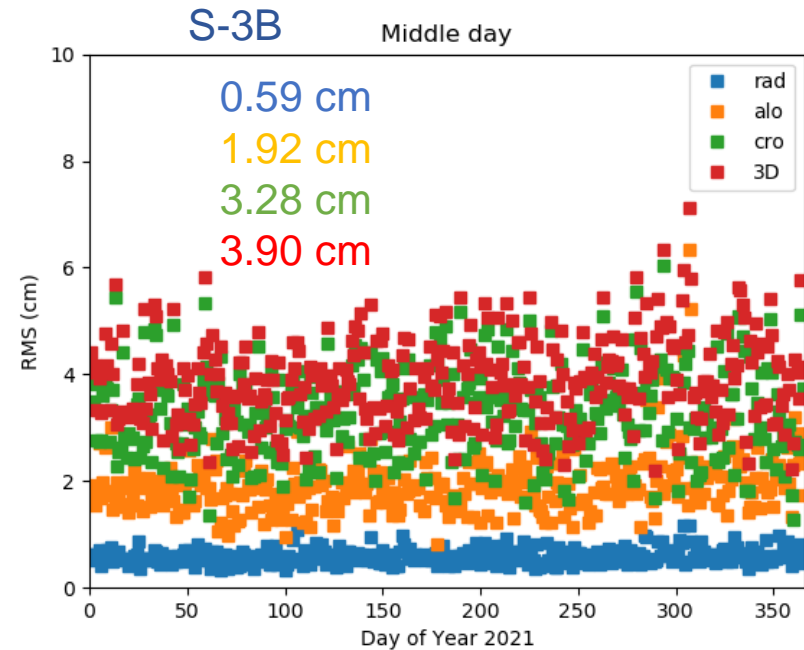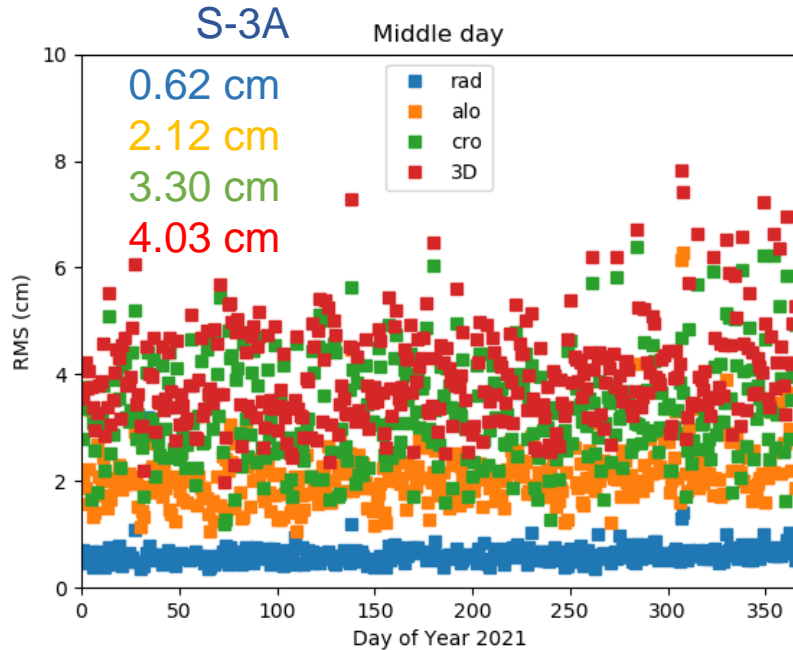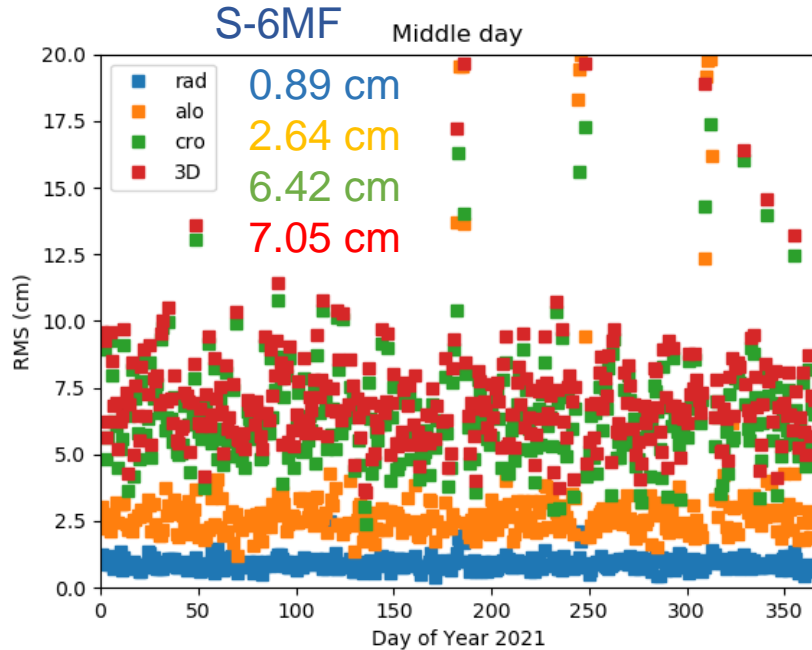
DORIS range-rate RMS

S-6MF

- DORIS range-rate RMS (mm/s) for S-6MF is equivalent to S-3
- Increase of RMS on days with flip manoeuvres is not yet understood (not yet investigated)

Comparisons to combined RSR#23 orbit

- Comparison of DORIS-only solution shows very good radial agreement.
- Overall comparison is not fully satisfying.

Comparisons to combined RSR#23 orbit

- Quality/Accuracy of DORIS-only solution is not sufficient.
- Radial component is acceptable, but overall it is not satisfying.

- Correct application of satellite data has to be checked again.
- Parametrization has to be reviewed.

SLR validation (one-way)

Solution	S-3A		S-3B		S-6A	
	Mean (cm)	STD (cm)	Mean (cm)	STD (cm)	Mean (cm)	STD (cm)
DORIS	0.47	2.21	0.37	2.13	0.26	3.46
DORIS+GNSS float	0.36	1.24	0.32	1.14	0.17	1.55
DORIS+GNSS fix	0.32	1.25	0.30	1.14	0.15	1.45

- 12 selected stations, no range biases or station coordinate corrections estimated
- SLR validation confirms that the orbit solutions based on DORIS can be improved

Conclusions

- DORIS-based orbit determination at the Copernicus POD Service is done as an offline batch processing.

- DORIS processing is still „work in progress" and still in a learning process.

- Sentinel-6MF has recently been included.

- DORIS-only, GNSS (float ambiguities)+DORIS, and GNSS (fixed)+DORIS solutions are determined.

- Orbit parametrization of Sentinel-6MF has to be optimized.

- DORIS-only solutions are not as good as combined GNSS+DORIS solutions.
- Combined GNSS+DORIS solutions can also be improved.

=> Any suggestions and ideas for improvement are very welcome.

Thank you for your attention!