

# Sentinel-6 MF orbit determination at the Copernicus POD Service

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# Copernicus POD Service



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

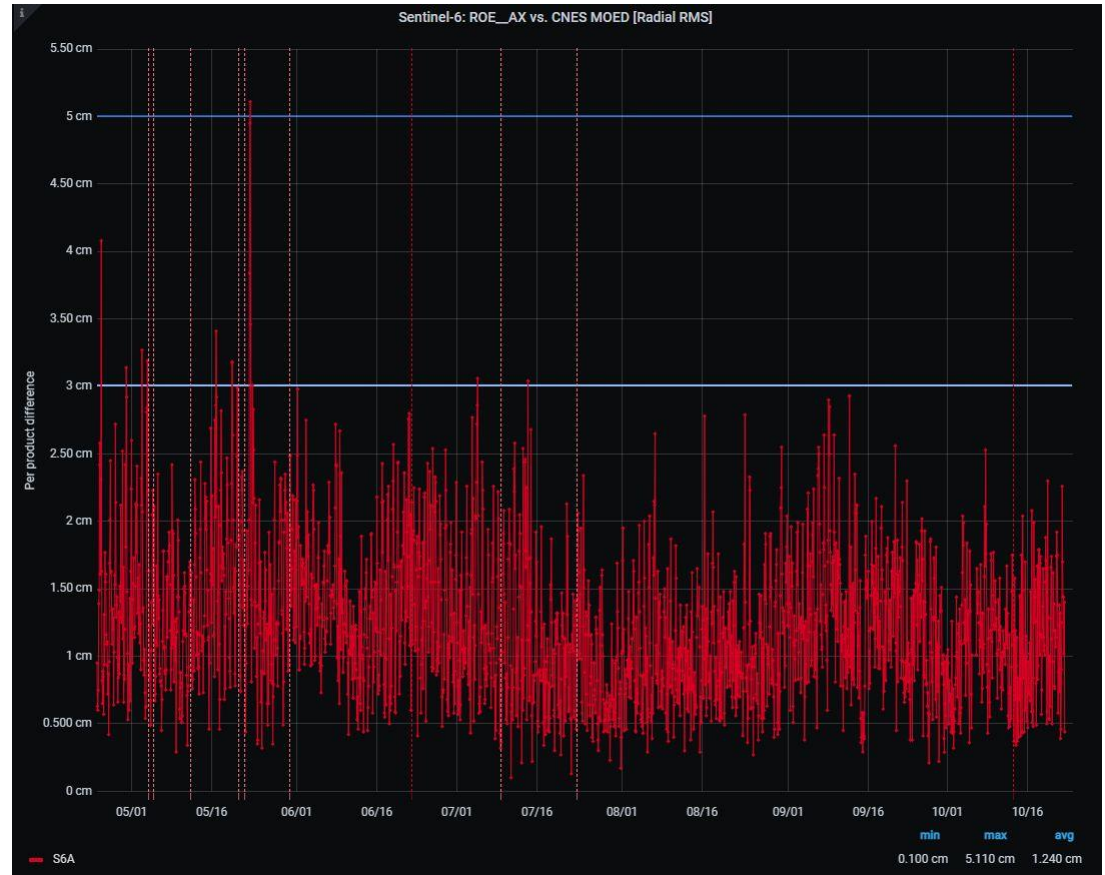
## Copernicus POD Service

- 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

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

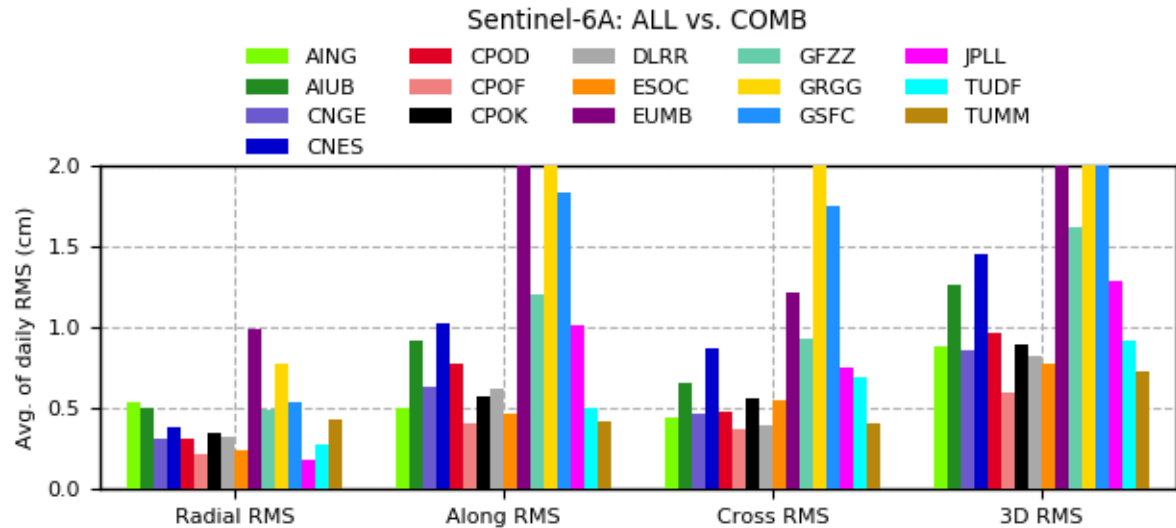
# Sentinel-6 MF POD

- Operational S6 MF orbit solution  
⇒ NRT solution with 10 min latency and radial RMS of 5 cm (target 3 cm)
- GPS only solution
- GPS orbits and clocks from magicGNSS
- Comparison to CNES MOED shows consistency below 3 cm in radial RMS
- Dashed vertical lines indicate manoeuvres or L0 data gaps



# Offline S6MF processing at CPOD Service

- Contribution to Regular Service Reviews (four per year) with an NTC-like solution (CPOD/CPOF)
- Galileo-only solution, ambiguity-fixed
- CODE Rapid orbit and clock (30 s) and bias products
- 32 h arc length
- 30 s sampling
- Estimated parameters:
  - state vector
  - CR & CD fixed to 1.0
  - 8 CPR parameter sets  
along- + cross-track: const, sin, cos
- **CPOD: EIGEN-GRGS-RL04**
- **CPOF: COST-G FSM 2109**
- Original macro-model used



More information on RSR results:

<https://sentinel.esa.int/web/sentinel/technical-guides/sentinel-3-altimetry/pod/documentation>

# Offline S6MF processing at CPOD Service

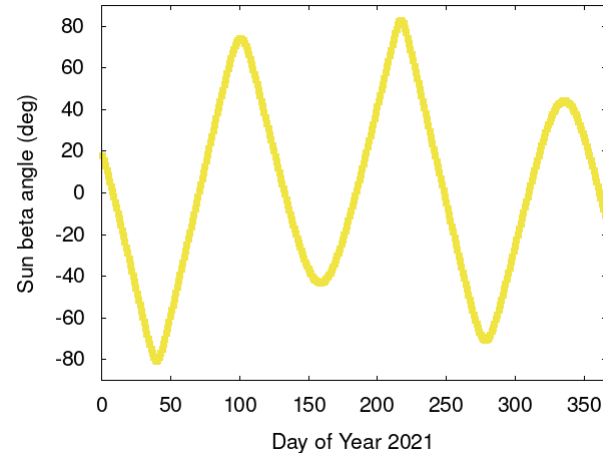
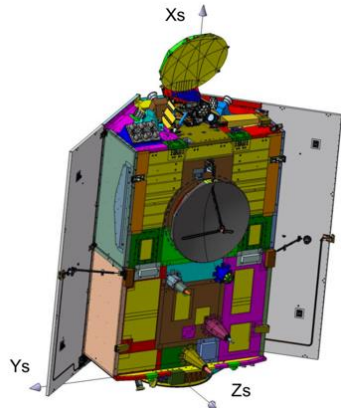
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- Additional studies and tests are performed offline to improve S6MF POD results
  - Improvement of the macro model
  - PODRIX: GPS and/or Galileo: some insights
  - TRIG POD results
  
  - **Improvement of the macro model**
  - Estimation of CR (and CD)
  - No empirical CPR parameters estimated
- => CR estimation gives a hint how good the satellite macro model is

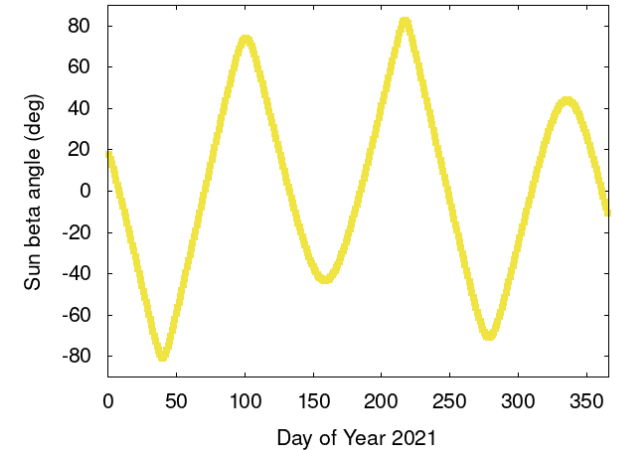
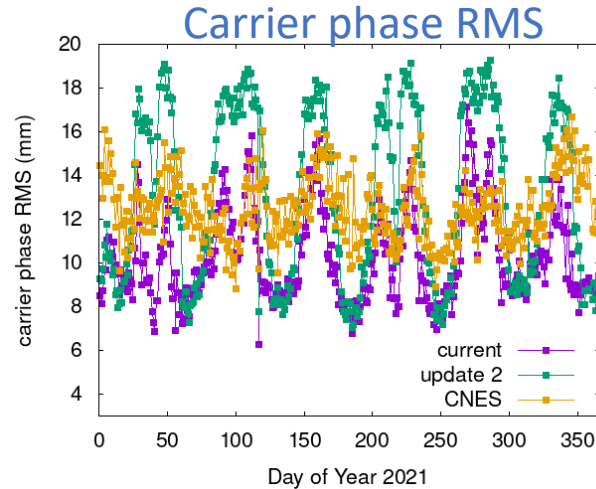
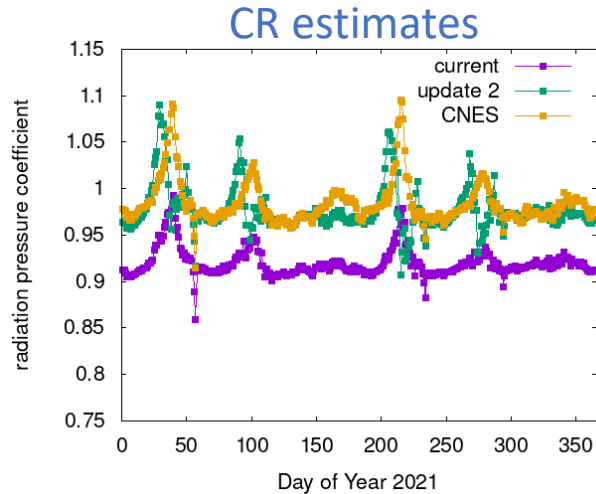
# Sentinel-6A – satellite macro model



- Current satellite macro model in use:
  - 10 panels (Cullen et al.), some small modifications
- Updated model:
  - 12 panels (S6A POD context version 2.0 document), some small modifications
- CNES model:
  - 6 panels (presented at 11th Copernicus POD QWG meeting)



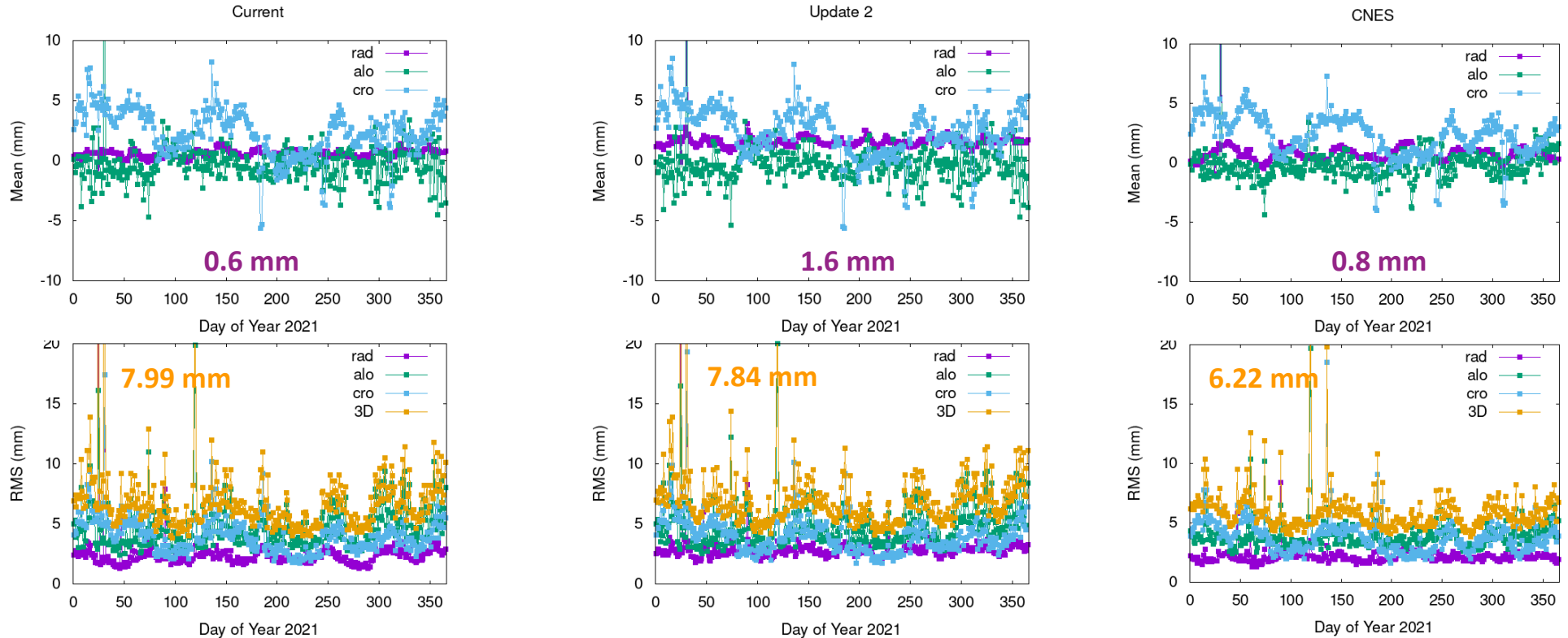
# CR (and CD) estimation – further tests



- CR estimates are closer to 1.0 for **Update 2** and **CNES**
- Carrier phase RMS shows least variations for **CNES** model
- **Mean of CR (days 113-194):**
  - **Current:** CR = 1.0 (operational setting)
  - **Update 2:** CR = 0.97
  - **CNES:** CR = 0.98

=> new orbit solutions are generated with 6 CPR sets added, CR fixed to values listed above, CD = 1.0 fixed

# Comparisons to combined RSR#23 orbit



- Orbit comparisons (very large outliers removed) to combined RSR#23 orbit give preference to the solutions using the CNES macro model.



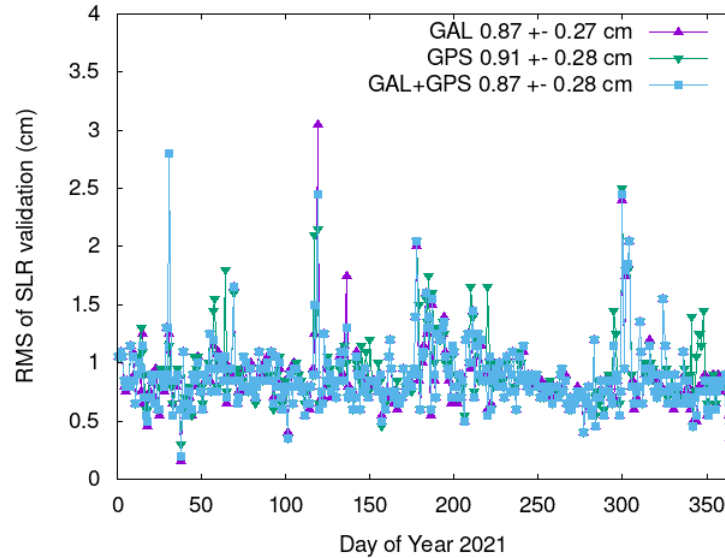
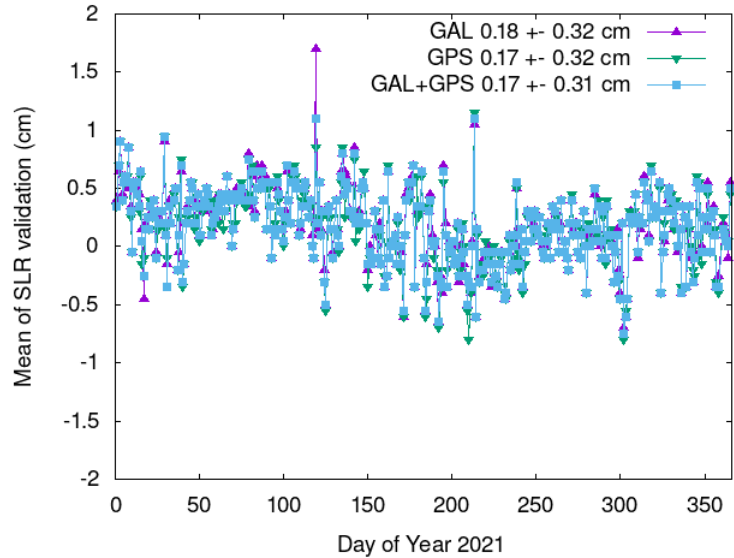
# SLR validation (one-way)

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	Mean (mm)	RMS (mm)
Current	2.0	8.9
Update2	1.2	8.8
CNES	1.8	8.7

- 12 selected stations, no range biases or station coordinate corrections estimated
- SLR validation gives no real preference, results are very similar
- ⇒ Satellite macro model has few impact on the orbit accuracy
- ⇒ Decision on which satellite macro model will be used in future is not yet taken.

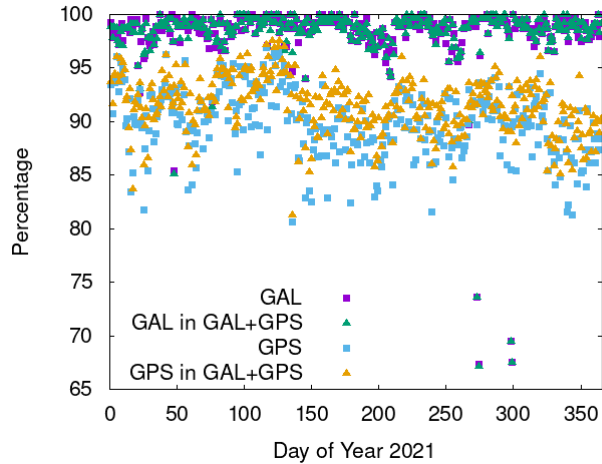
# GPS and/or GAL observations



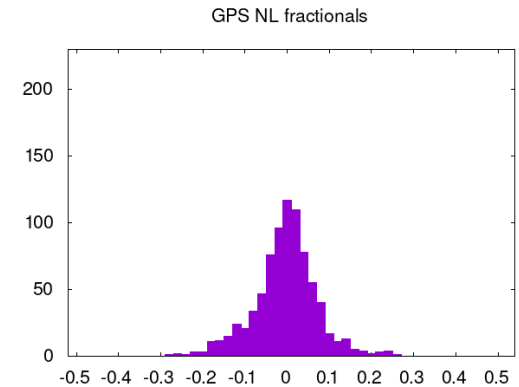
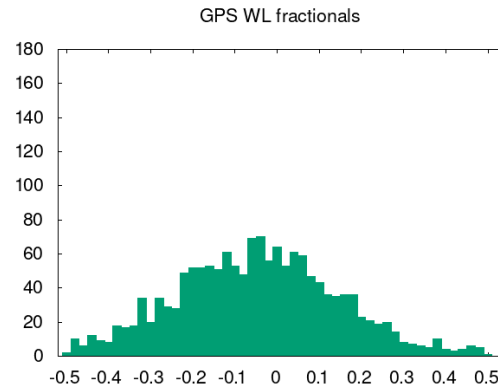
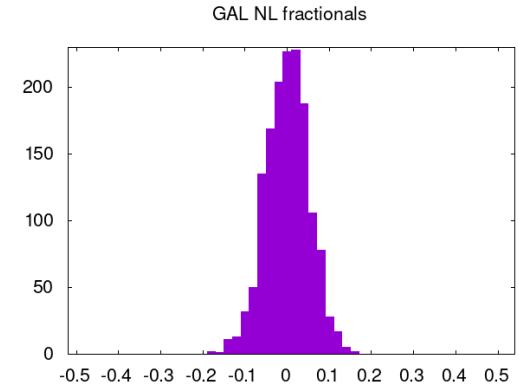
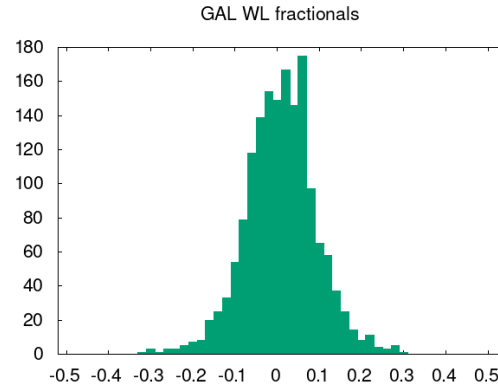
- Observations from 12 well behaving SLR stations are used
- Orbit accuracy is below **one cm** for all three solutions

- SLR validation of GPS-only, GAL-only, and GPS+GAL is very similar
- Some RMS “peaks” for the GPS-only solution are reduced in the combined GPS+GAL solution

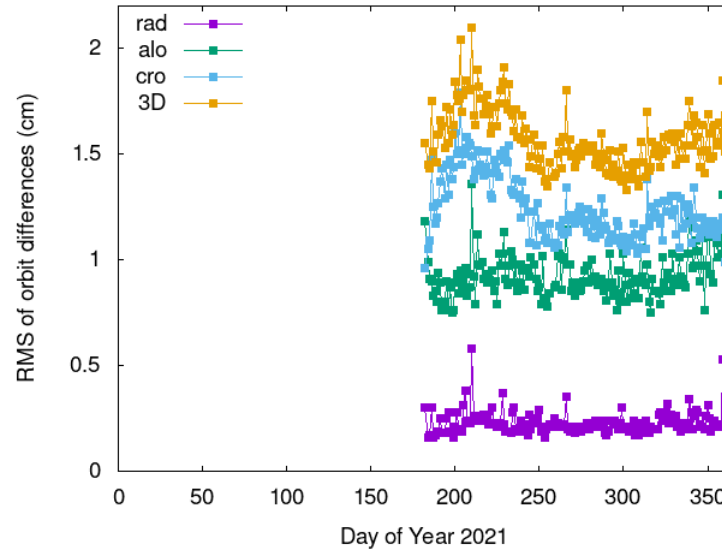
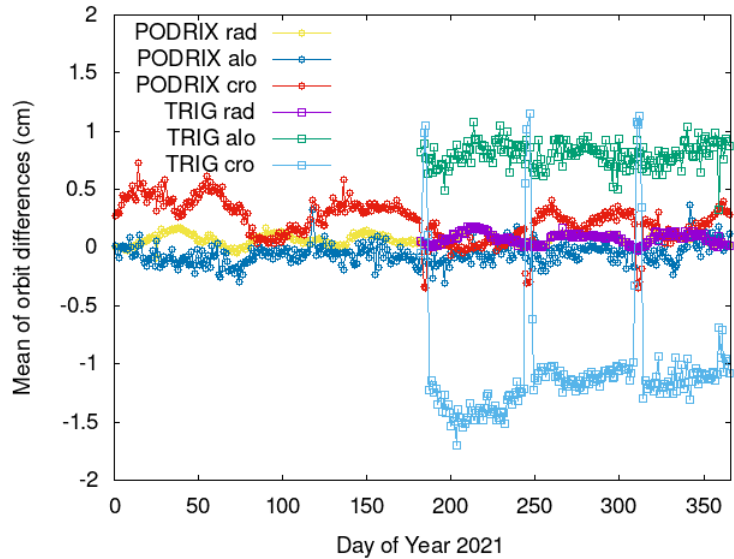
# GPS and/or GAL observations



- Carrier phase ambiguity fixing works much better with Galileo!
- GPS fractionals have a much worse distribution (note: mix of L2P(Y) and L2C => not solved)



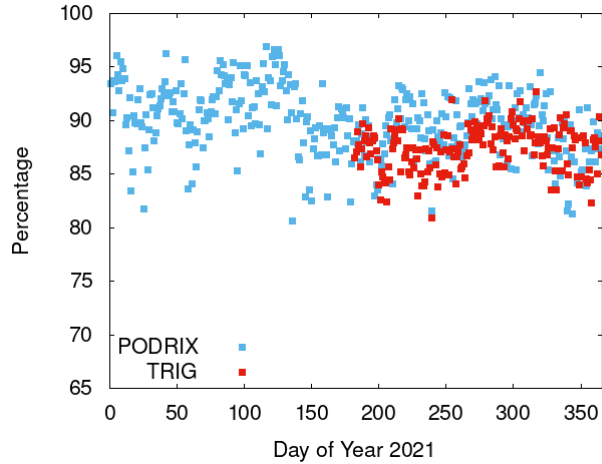
# TRIG POD results



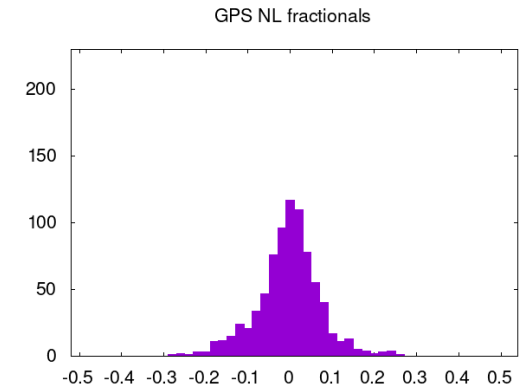
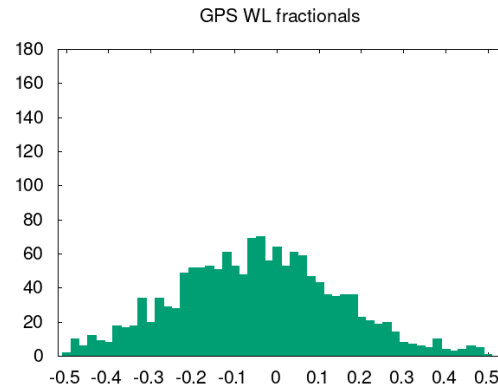
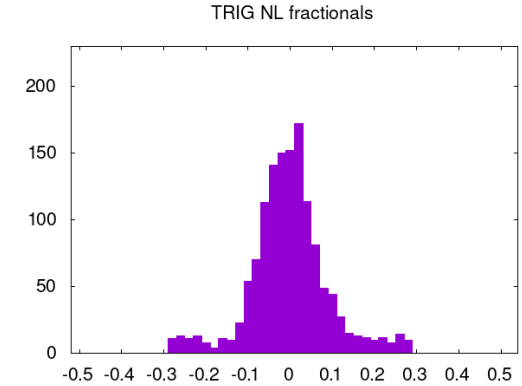
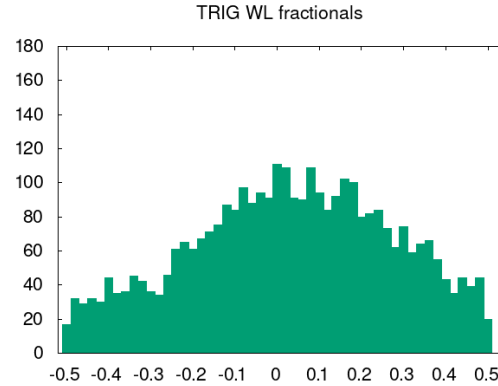
- 1 Jul – 31 Dec 2021
- L1W & L2W
- Same orbit parametrization as for PODRIX processing used
- No TRIG PCVs applied

- Orbit comparison to combined RSR#23 orbit
- Mean offsets of PODRIX-derived orbit solutions added for comparison
- Mean offsets to combined RSR#23 orbit:
  - Radial: + 0.9 mm
  - Along-track: + 8.0 mm
  - Cross-track: - 11.9 mm

# TRIG – ambiguity fixing



- GPS fractionals of TRIG observations are not much better than those of the PODRIX  
=> Cause is not clear



# Conclusions

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- Sentinel-6MF offline processing at CPOD Service is used for testing new models and to improve orbit determination results
- Update of S-6 satellite macro model is foreseen; not yet clear which one will be used.
- GPS ambiguity fixing from both receivers (PODRIX and TRIG) shows some unexpected behaviour, but results are good and do not reflect this.
- TRIG POD results confirm offsets already reported by O. Montenbruck.

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# Thank you for your attention!

**Acknowledgements:**

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