COPERNICUS POD SERVICE

GLOBAL MONITORING FOR ENVIRONMENT AND SECURITY

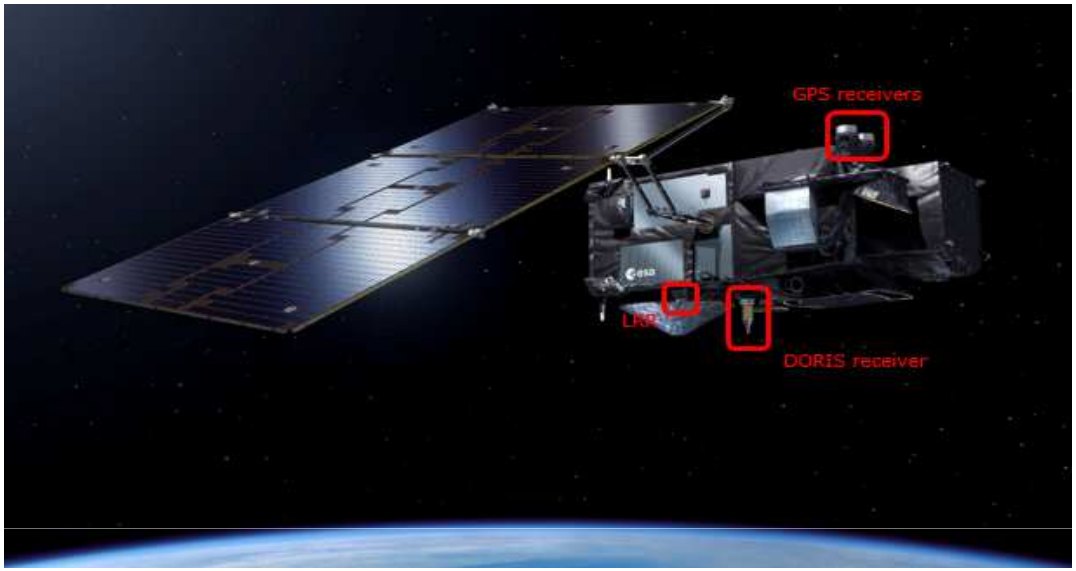
SENTINEL-3 CPOD SERVICE

OSTST-Altimetry 2016, 31 October – 4 November; La Rochelle

Jaime Fernández Sánchez / GMV

SENTINEL-3 – POD

- 814.5 km / 98.65 deg. / 1250 kg
- 2 dual frequency **GPS** receivers
- A **DORIS** receiver
- A Laser Retro-Reflector (**LRR**)



SENTINEL-3 Payloads (Credit: ESA)

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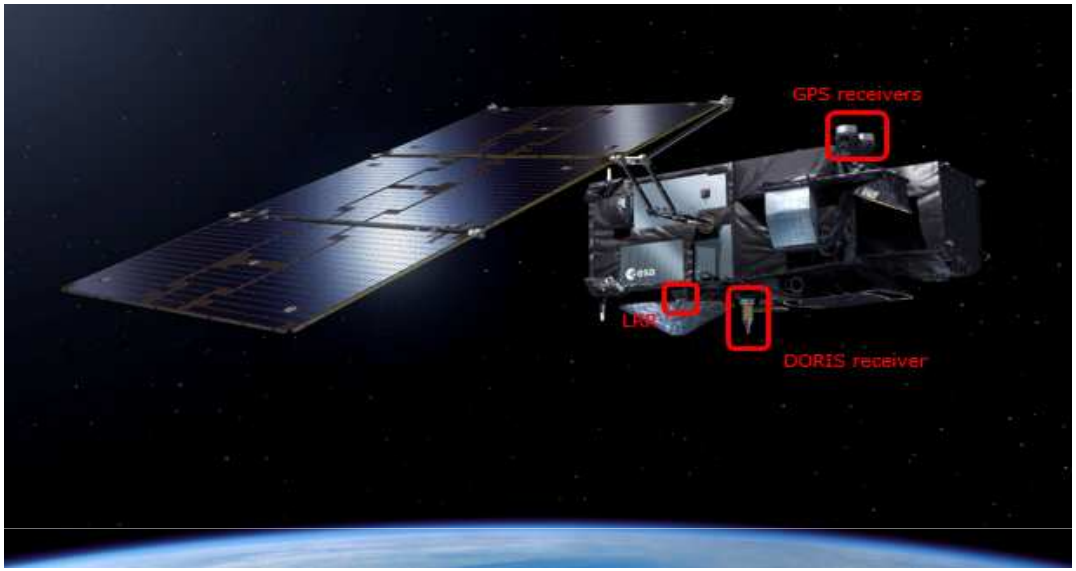

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REQUIREMENTS OF POD PRODUCTS			
Category	**Latency**	**Orbit Accuracy**	**SOLUTIONS**
RT	RT	N/A	DORIS on-board Navigation solution GPS on-board Navigation solution
NRT	30 min	10 cm radial RMS 1-sigma (target of 8 cm)	CPOD (@ Marine and Land PDGS)
STC	1.5 days	4 cm radial RMS 1-sigma (target of 3 cm)	CPOD (@ GMV) CNES
NTC	25 days	3 cm radial RMS 1-sigma (target of 2 cm)	CPOD (@ GMV) CNES

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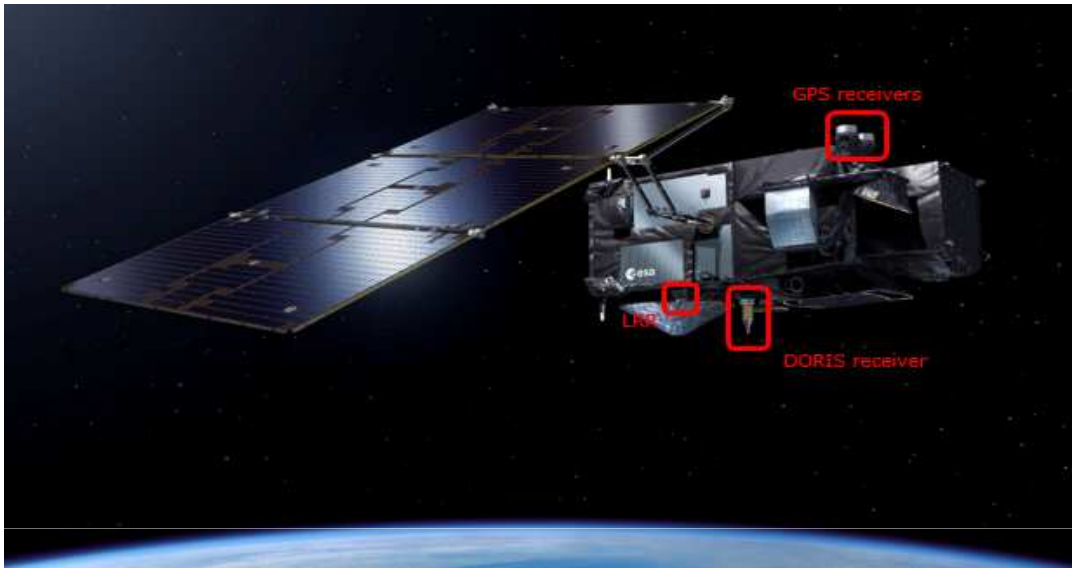

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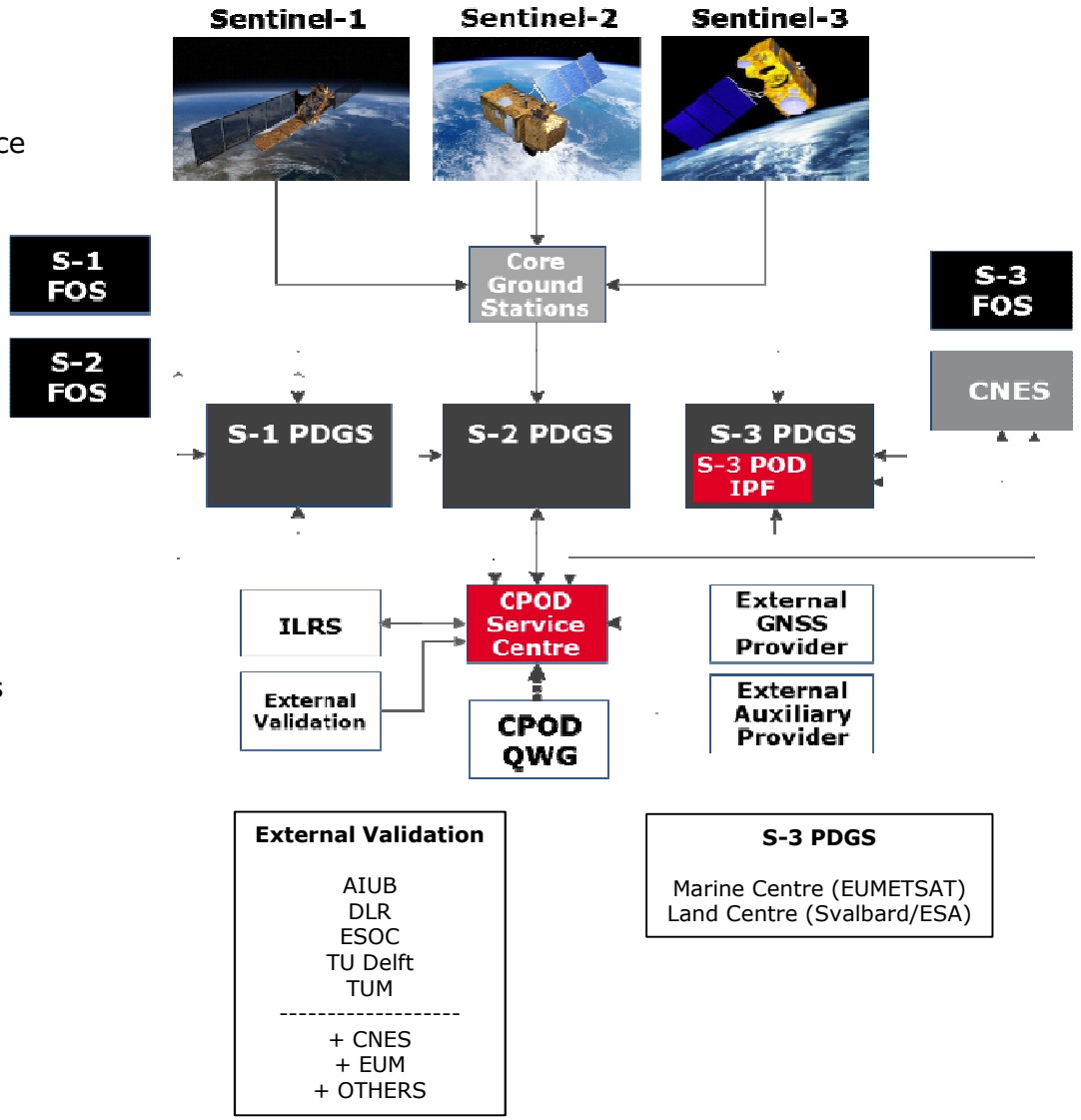
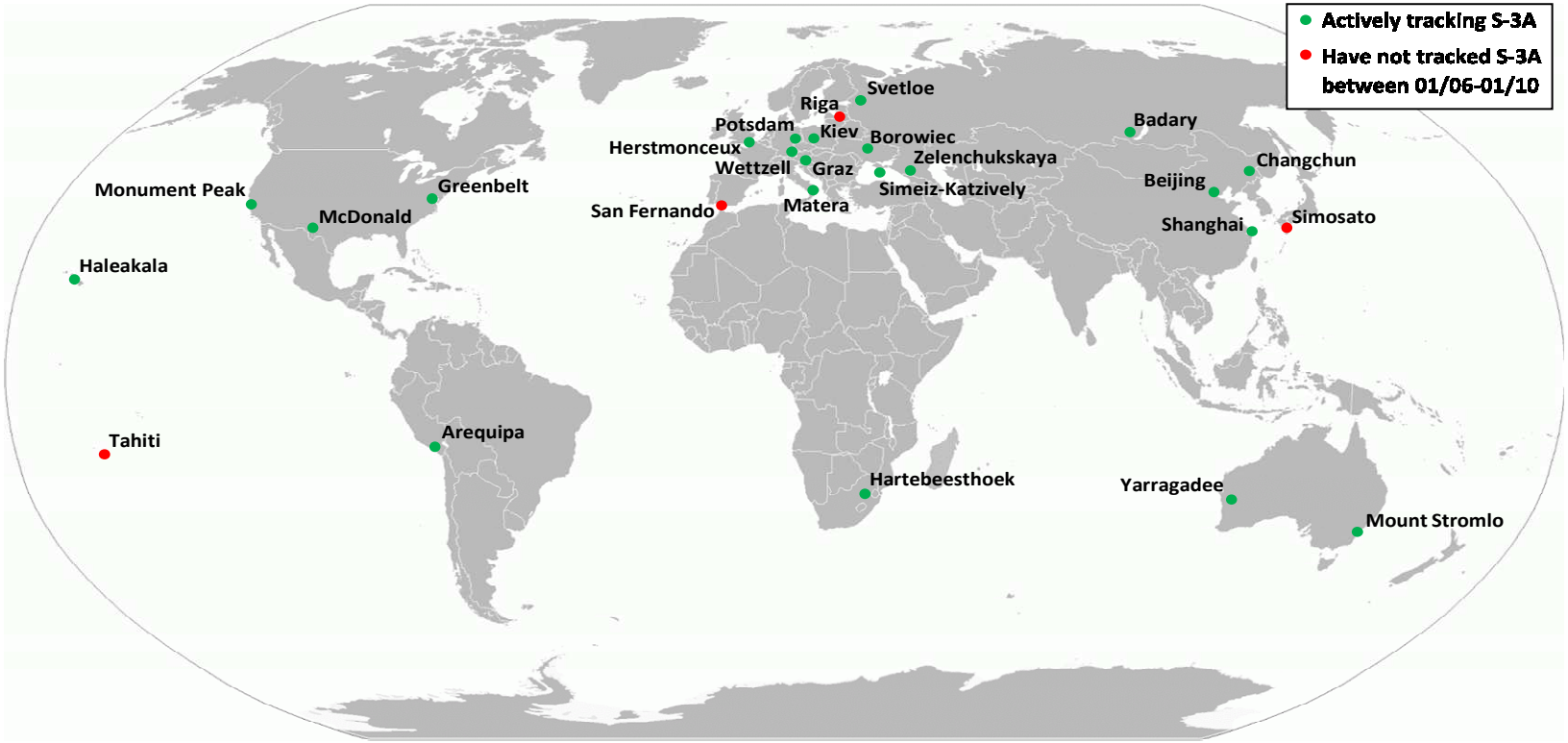
COPERNICUS POD SERVICE (CPOD)

- **Payload Data Ground Segment** (**PDGS**):
  - Processing the scientific data
  - Provider of GPS and attitude data to the CPOD Service
  - User of the orbits and platform files from the CPOD Service
- **Sentinels Flight Operations Segment (FOS):**
  - Orbits, manoeuvre and satellite mass evolution
  - ESOC for S1 and S2; EUMETSAT for S3
- **Centre National d'Études Spatiales (CNES):**
  - S-3 orbital and attitude products, DORIS data
- **ILRS - SLR data provider:**
  - International Laser Ranging Service –ILRS- centres
- **External Validation:**
  - AIUB, DLR, ESOC, TU Delft, TUM
  - provision of independent orbital products
- **External GNSS data Provider (EGP):**
  - VERIPOS; provider of high accurate GPS orbits and clocks products
  - MagicGNSS: in-house back-up GPS provider
- **External Auxiliary providers:**
  - Atmospheric gravity models, EOPS and leap seconds, etc.
- **CPOD Quality Working Group (CPOD QWG):**
  - Monitoring the quality of CPOD products
  - Definition of enhancements (algorithms, standards, etc.)



COPERNICUS POD SERVICE – ILRS

ILRS Stations allowed to track Sentinel-3



- ILRS applies **power restrictions** constraints to avoid damage on **OLCI**.
- Only SLR stations able to limit the power of the laser are allowed to track Sentinel-3

SENTINELS POD QUALITY CONTROL

- POD Quality Control is achieve by comparing operational products against **external solutions** computed offline.

- This is done by CPOD routinely by
  - Daily **cross-comparison** between CPOD, CNES and ESOC solutions, and analysis of **SLR residuals**.
  - Quarterly:
    - **Cross-comparison** between AIUB, CNES, CNES, DLR, ESOC, TU Delft, and TUM.
    - Generation of a **combined solution** and compare each external solution against the combined solution
    - Analysis of **SLR residuals**

- Additionally for Sentinel-3 it is possible to assess the quality of the orbital products by means of "**Sea Surface Height Estimation**"

POD PROCESSING SCHEMES

- Six different orbital solutions

- Four different POD SW:
  - BERNESE: AIUB (TUM)
  - GHOST: DLR, TUDF
  - NAPEOS: CPOD, ESOC
  - ZOOM: CNES

- Three solutions are more dynamic: CNES, CPOD, ESOC
- One solution is more kinematic: AIUB (TUM)
- Two solutions are in between: DLR, TUDF

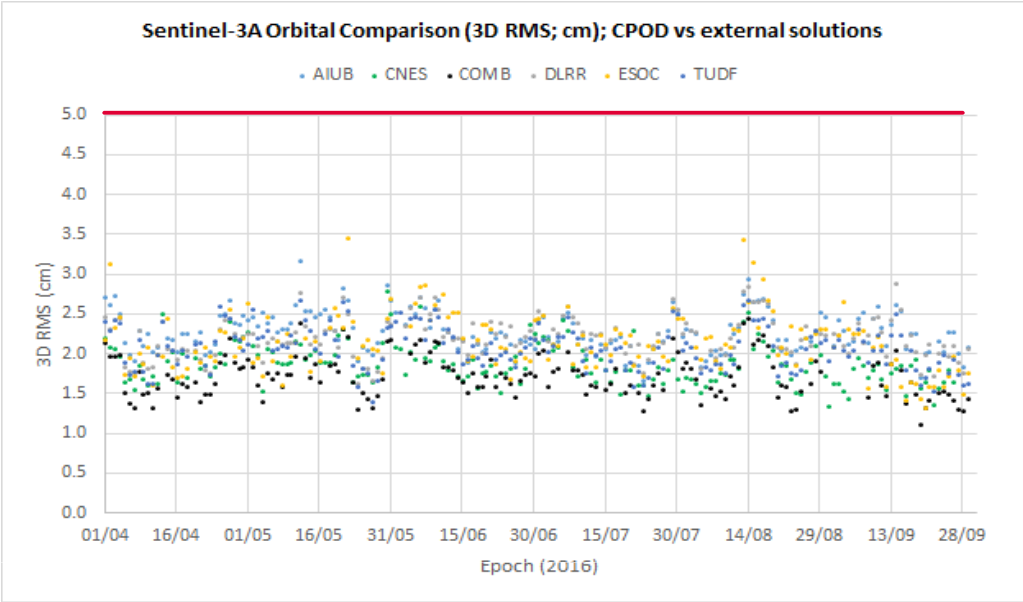
- Different parametrizations are equivalent but with differences in parameters fixed / estimated, and number of empirical accelerations estimated

POD QC – COMBINED SOLUTION

- The combined solution is done using the same approach used in the IGS community for the GPS orbit combinations:
  1. Generate an orbit which is a unweighted average of the different solutions
  2. Compare each solution against the averaged solution to derive weights (The closer to the average solution, the better)
  3. Generate a combined solution using the weights computed above

- This approach is clearly not good enough, as it does not use an external source for the computation of weights, but it is a good starting point
- Possibly in the future the weights could be derived from the SLR residuals.

CROSS-COMPARISONS – 3D RMS



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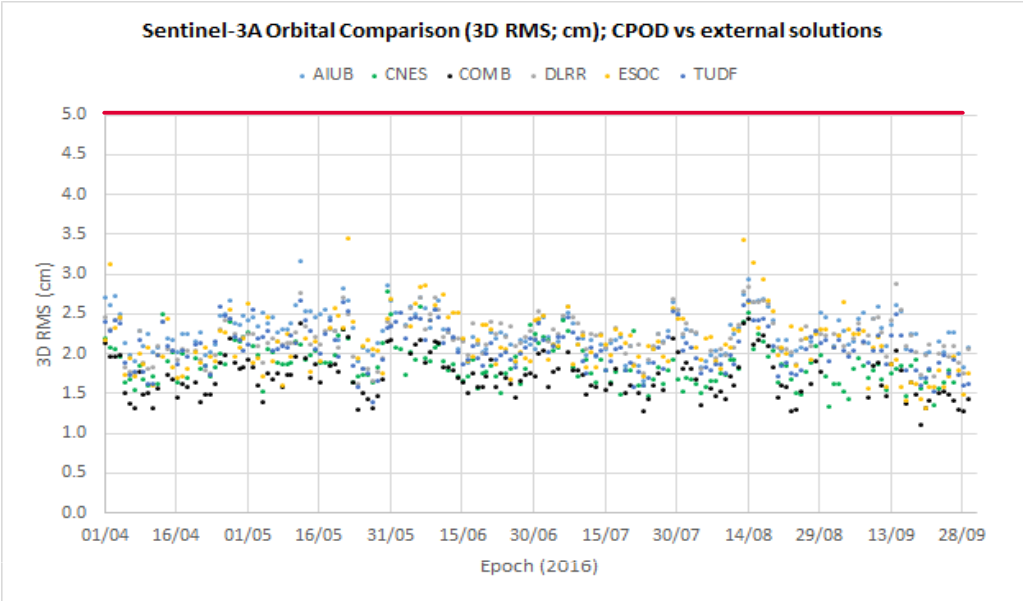

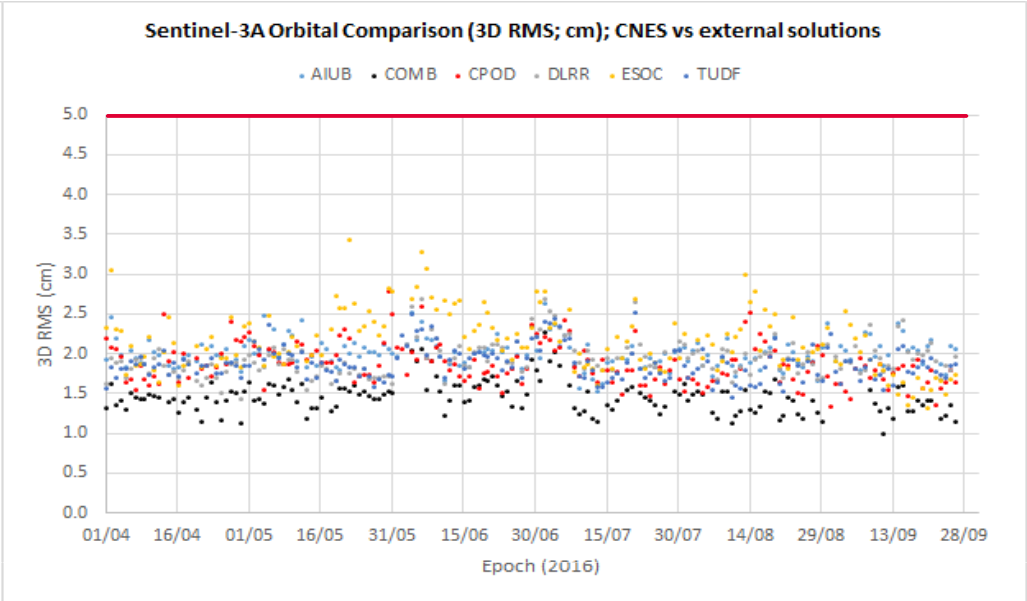

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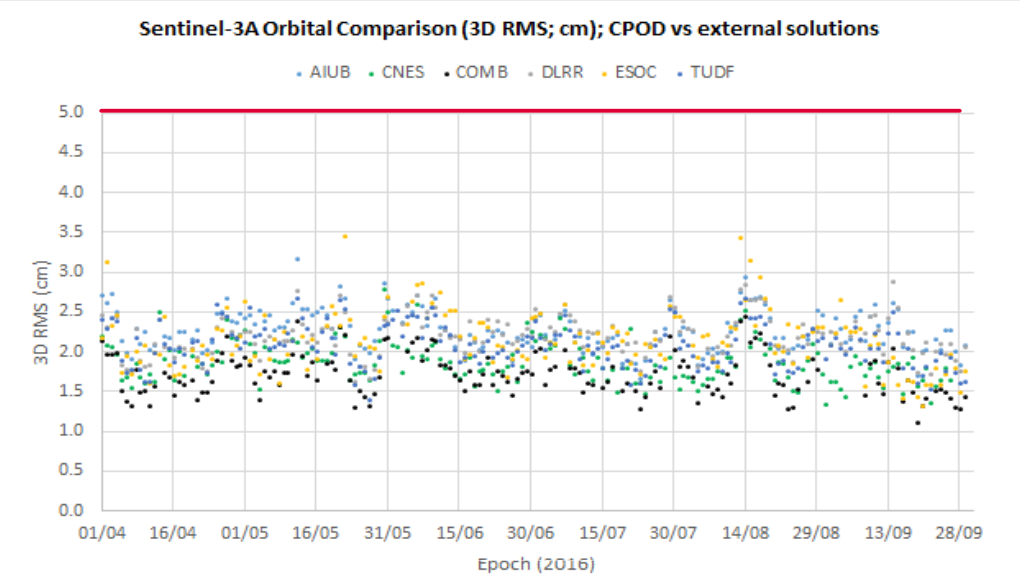

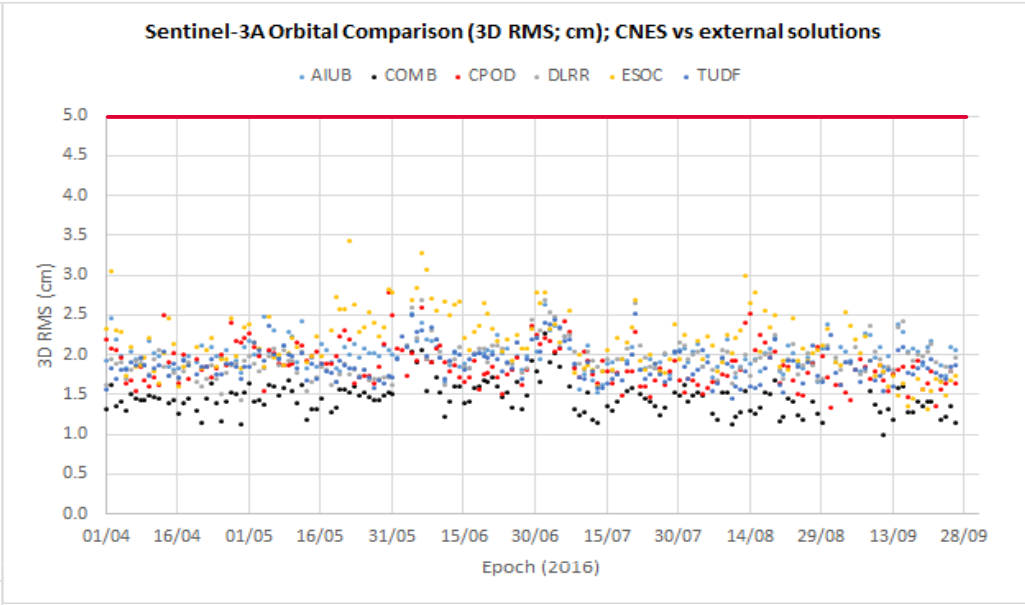

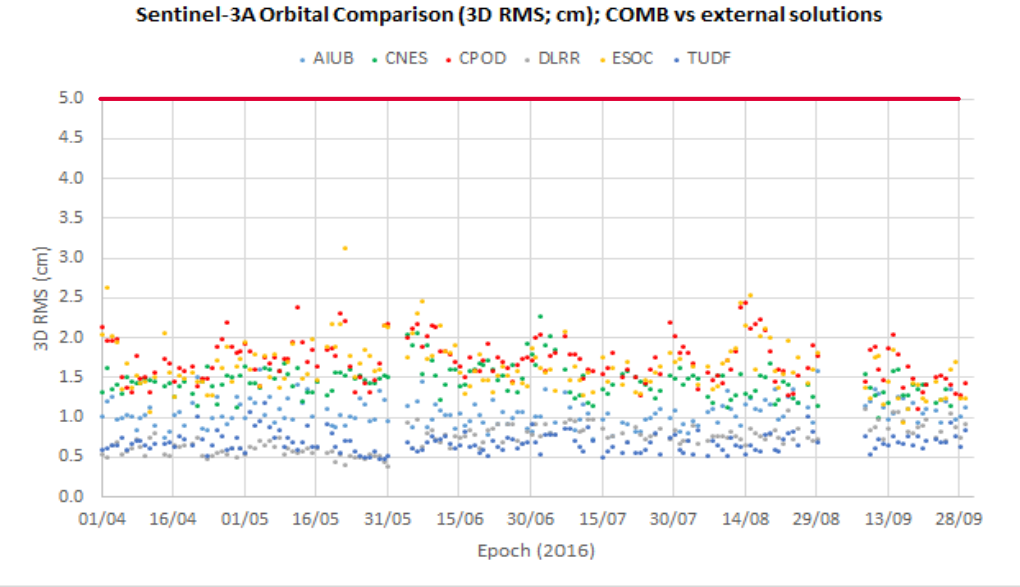

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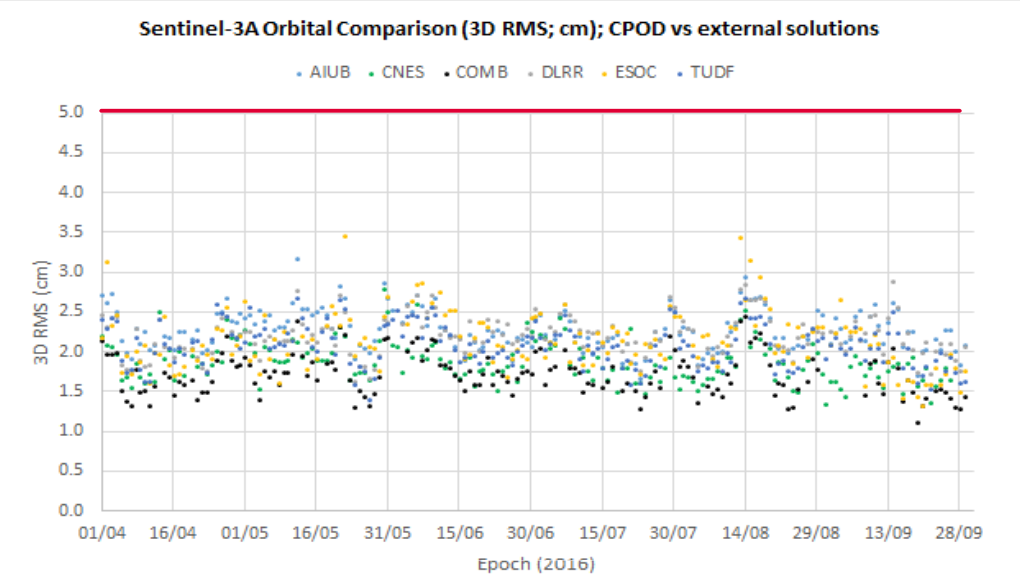
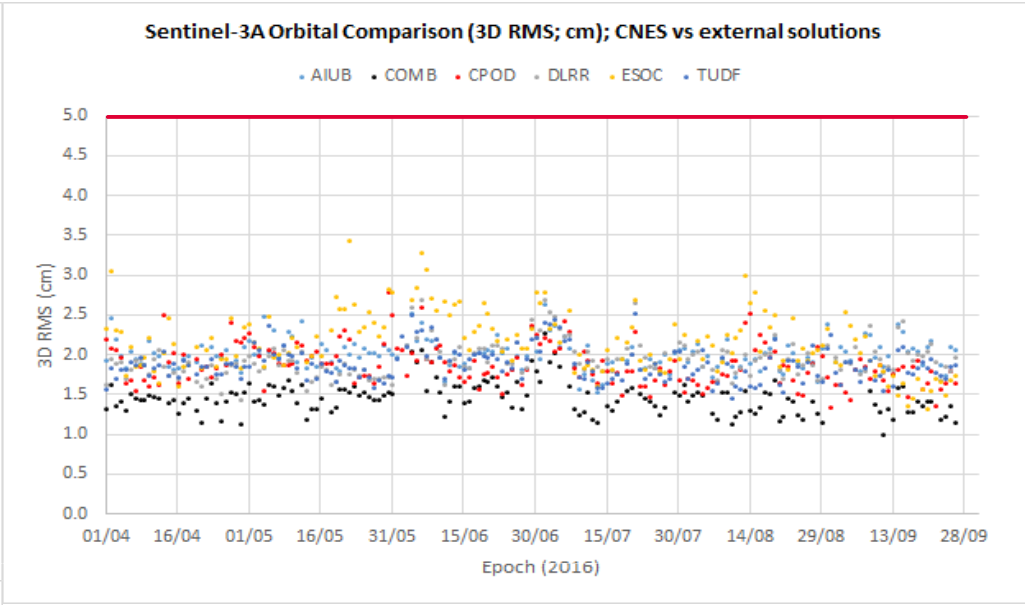
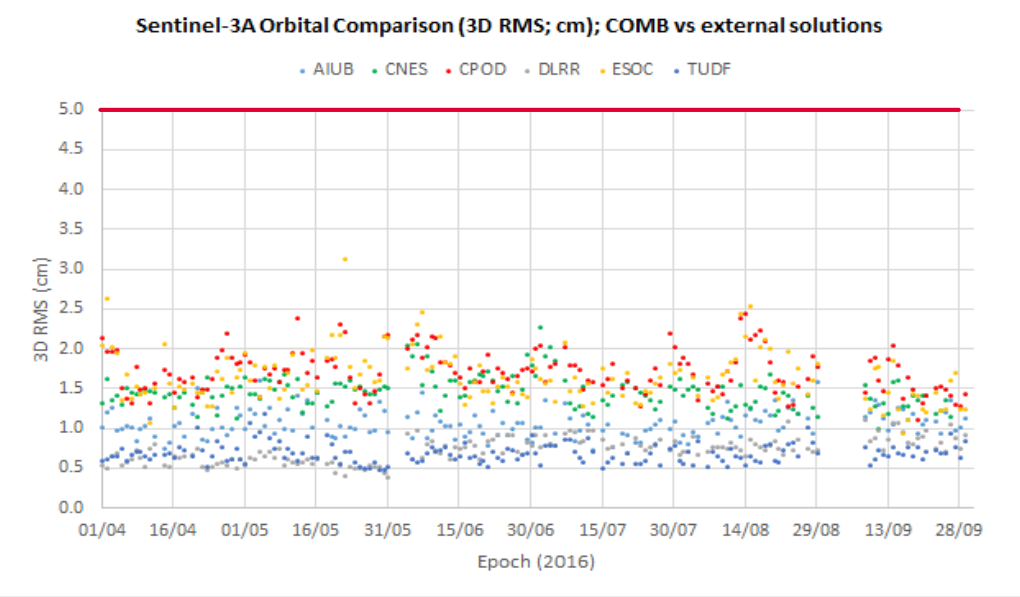
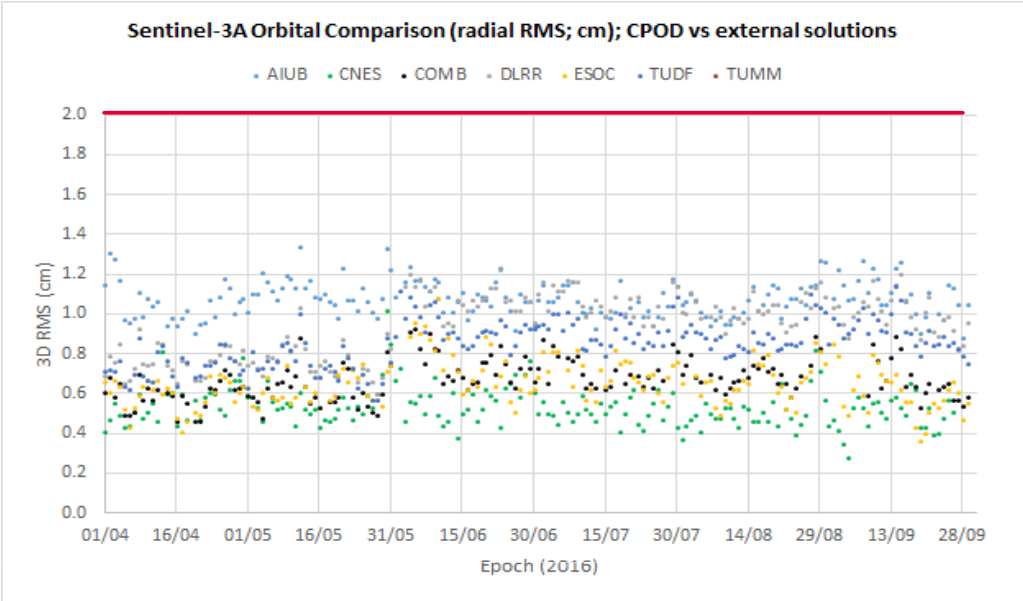






- CPOD solution has differences in 3D RMS with respect to other centres better than 3 cm systematically.
- Same with CNES and obviously with the combined solution.
- COMB solution matches better with AIUB, DLR and TUDF.

CROSS-COMPARISONS – RADIAL RMS



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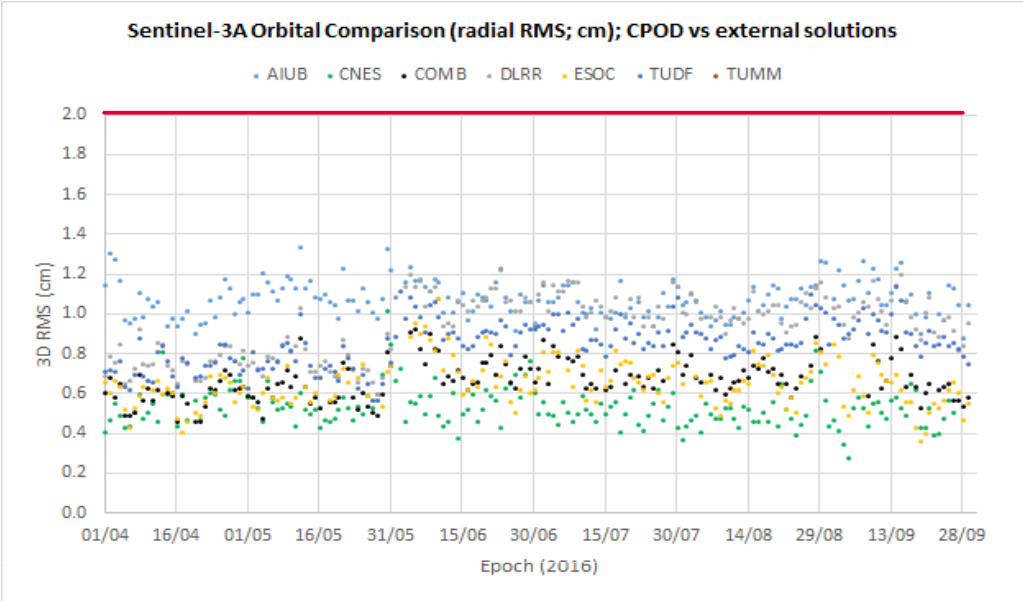

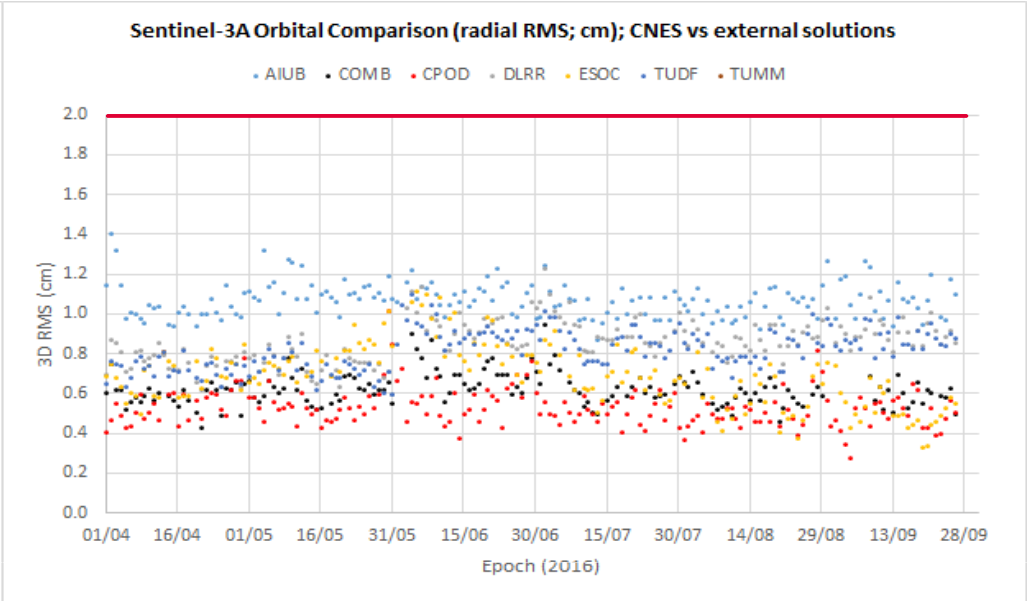

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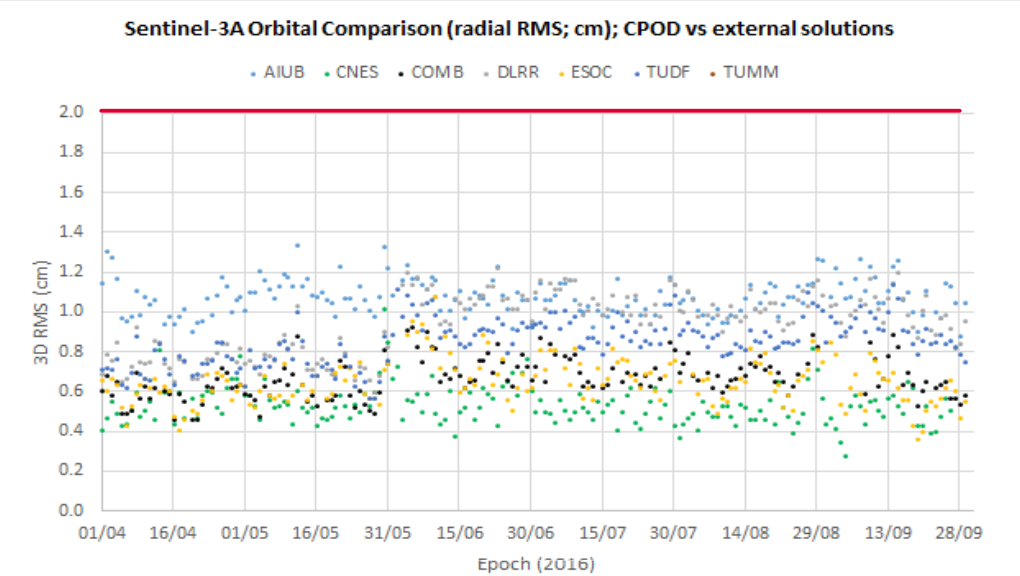

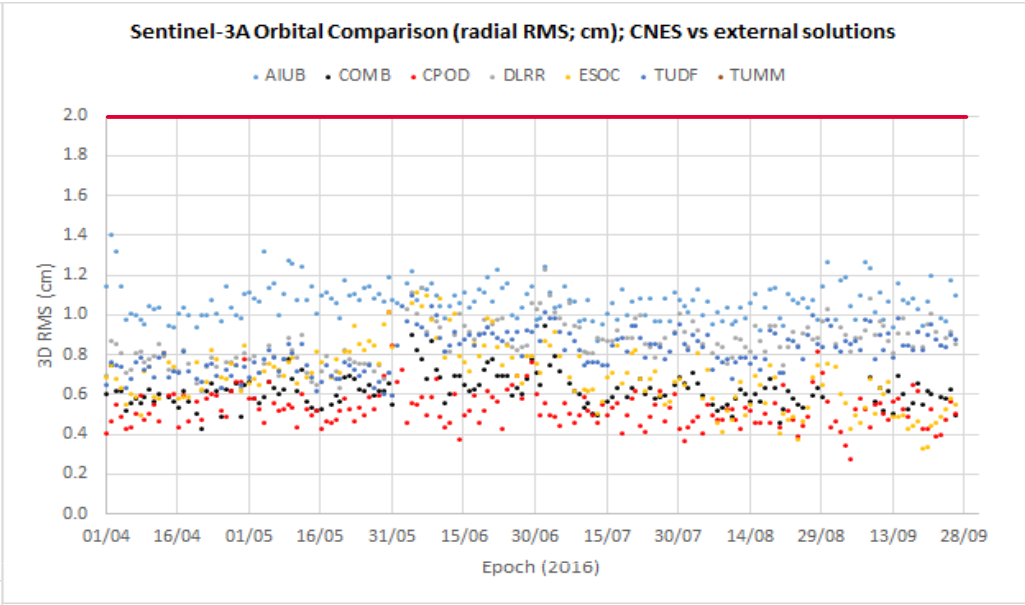

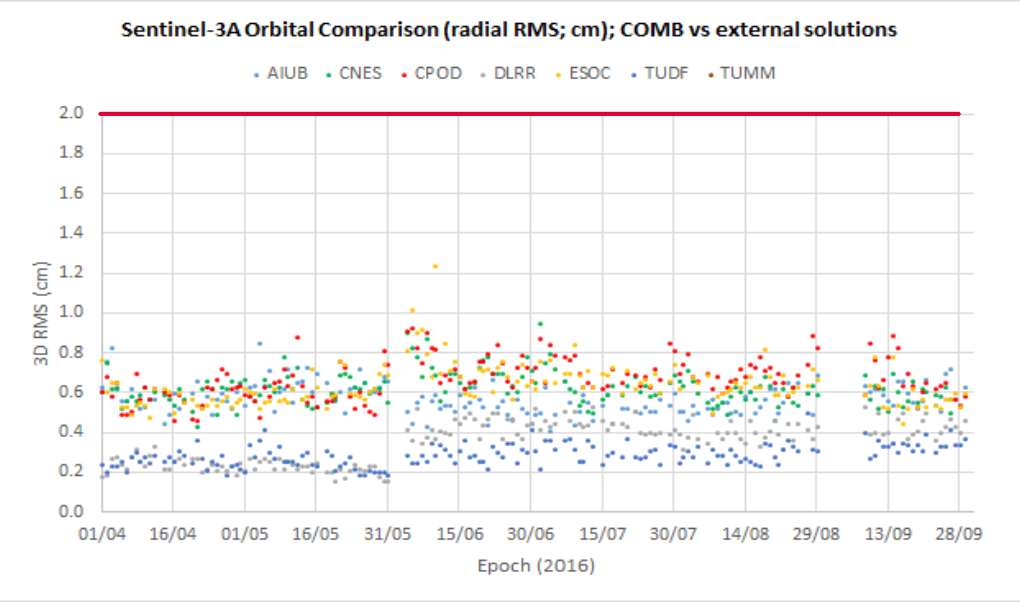

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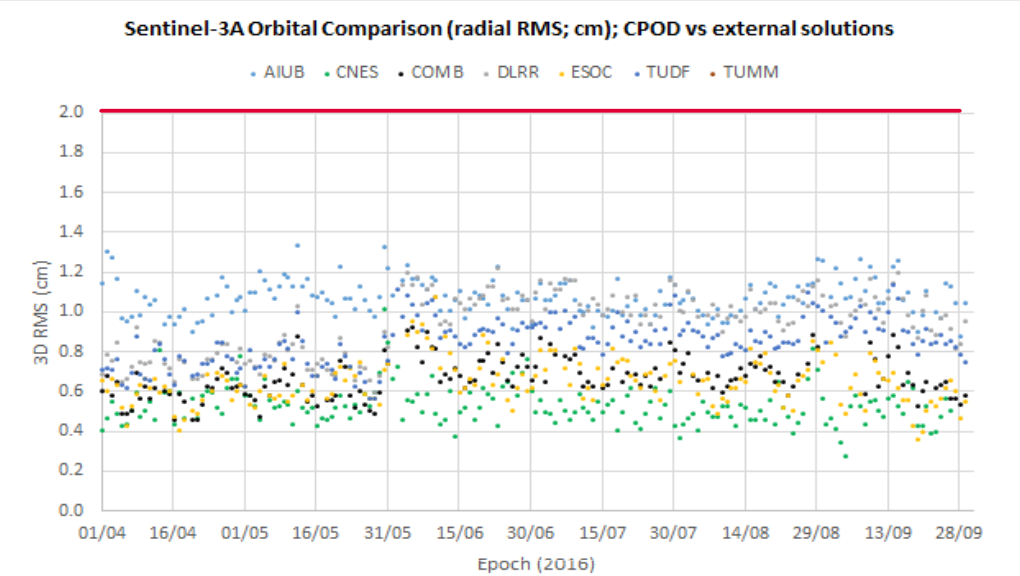

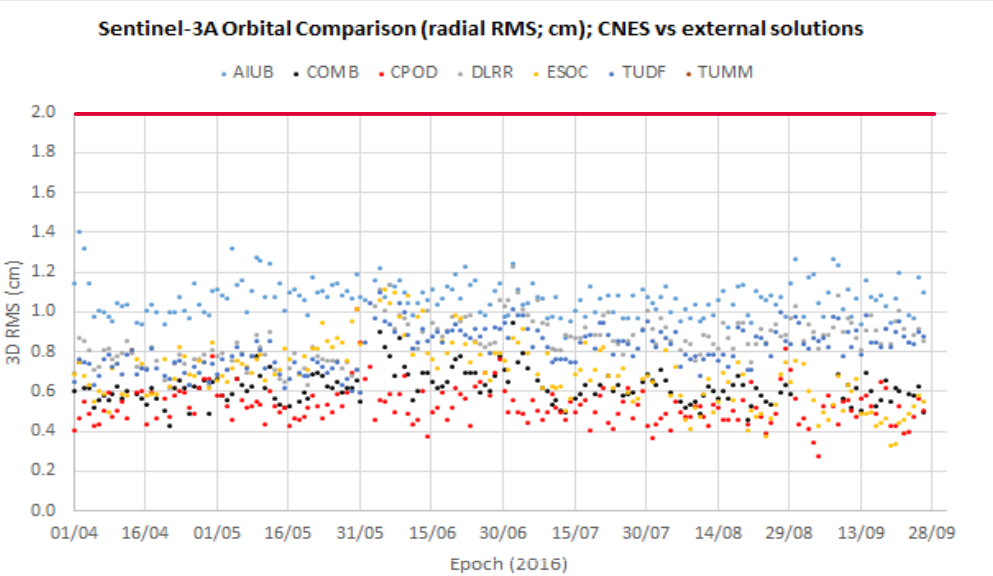

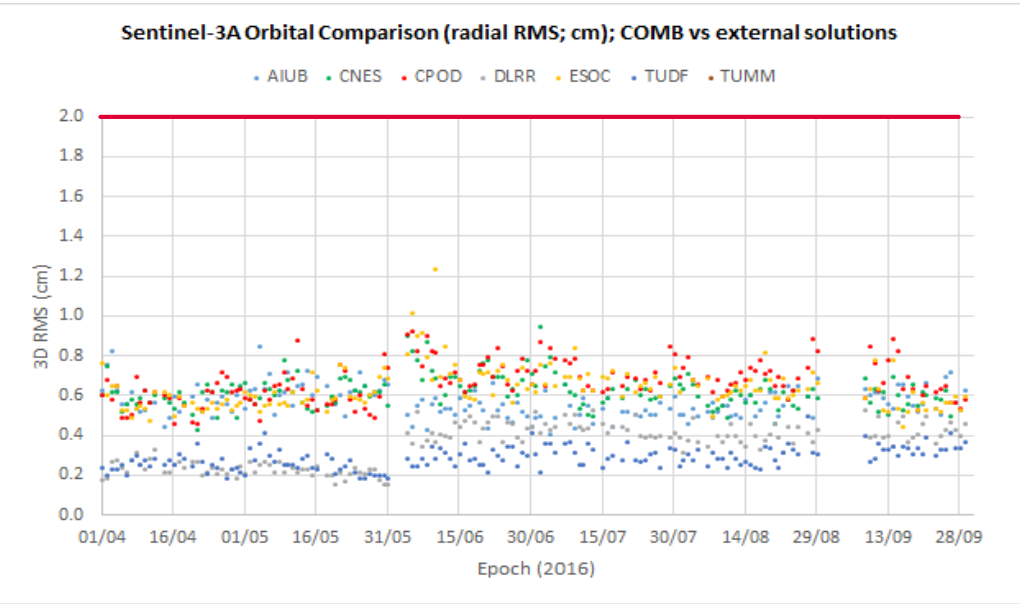

- CPOD solution has differences in radial RMS with respect to other centres better than 1.5 cm systematically.
- Same with CNES and obviously with the combined solution.
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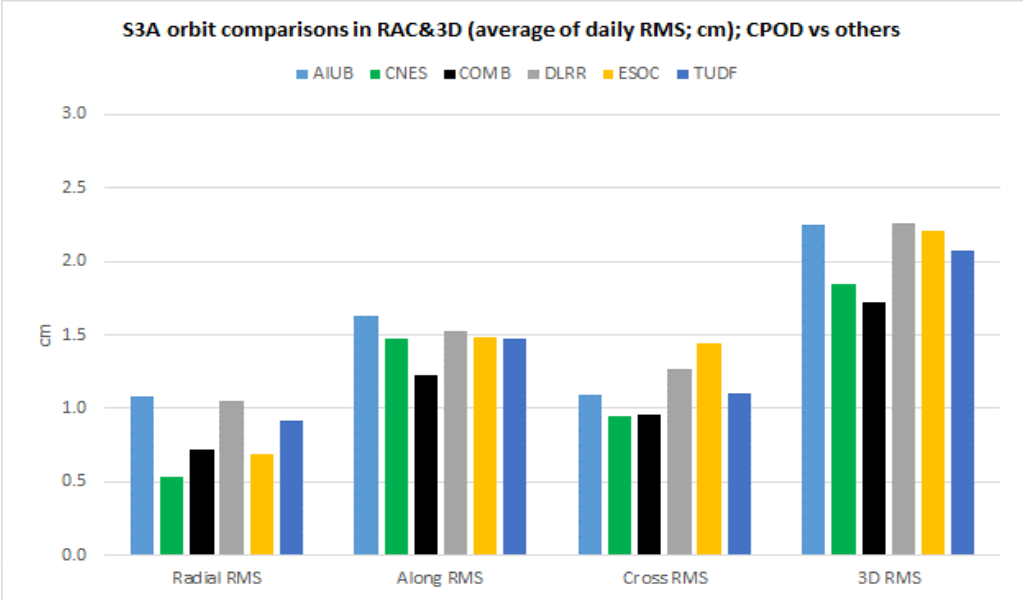
CROSS-COMPARISONS – OVERVIEW



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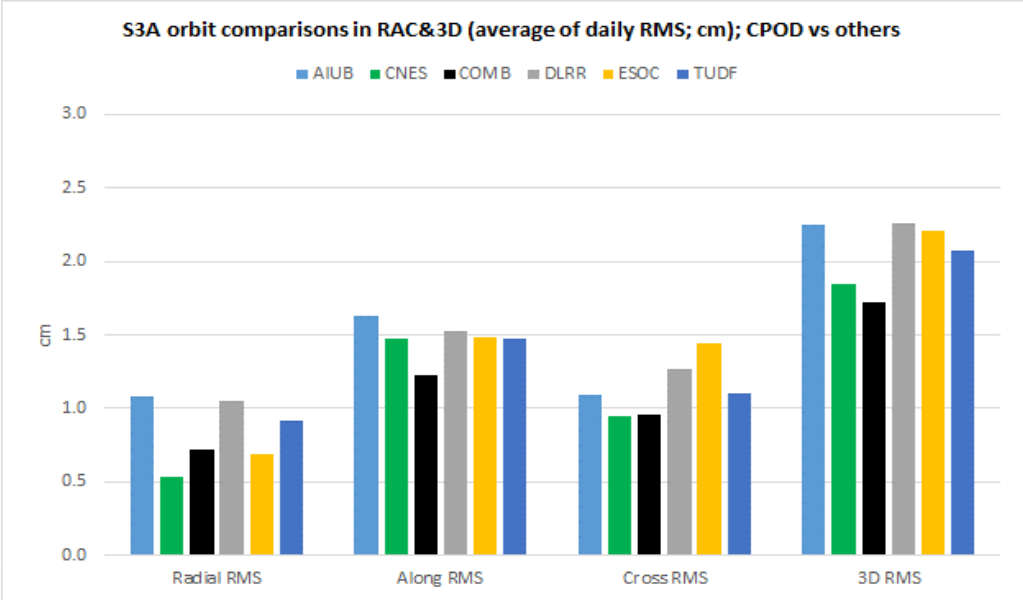

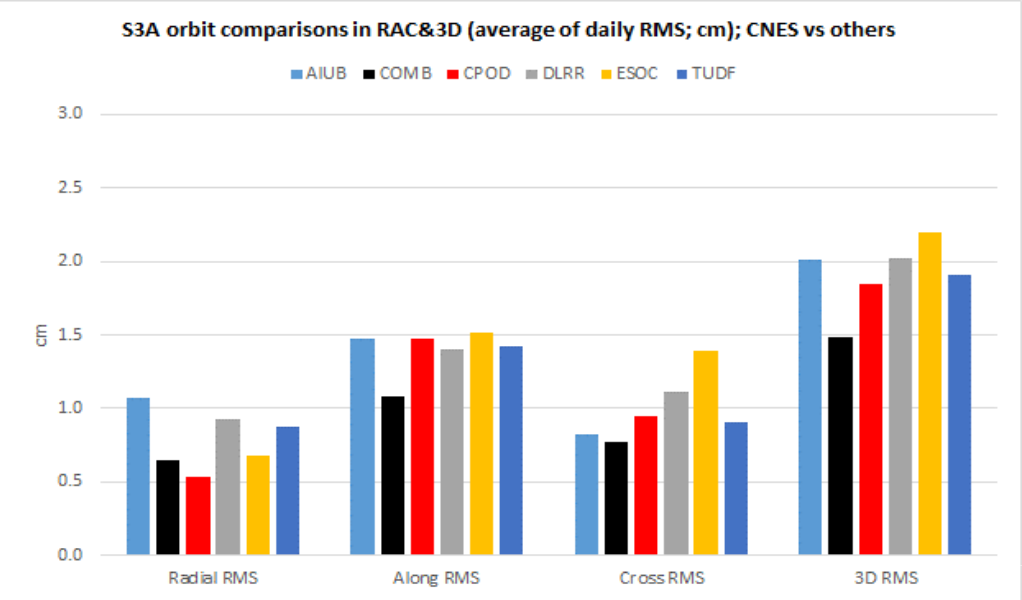

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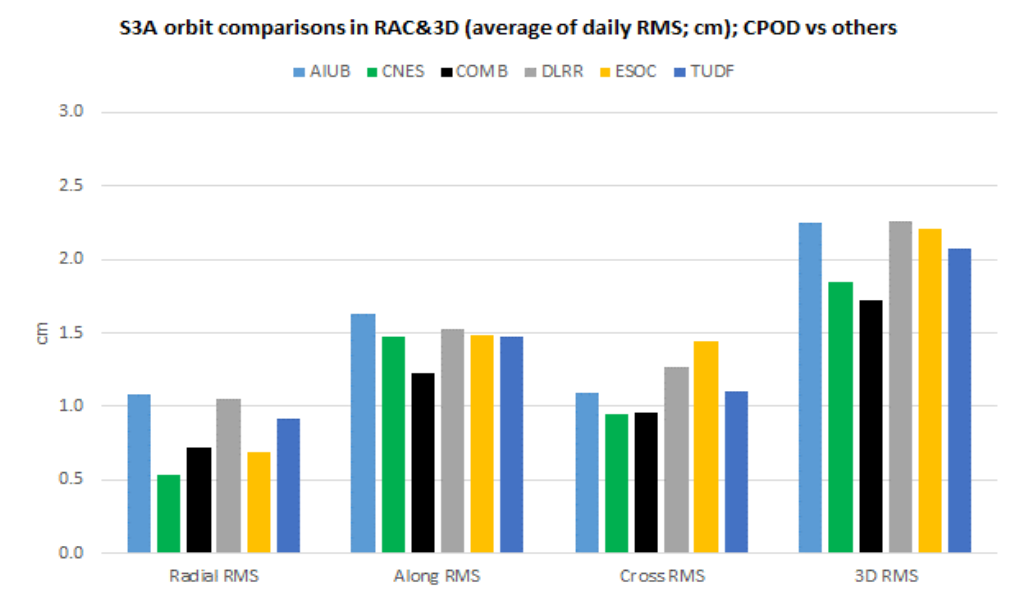

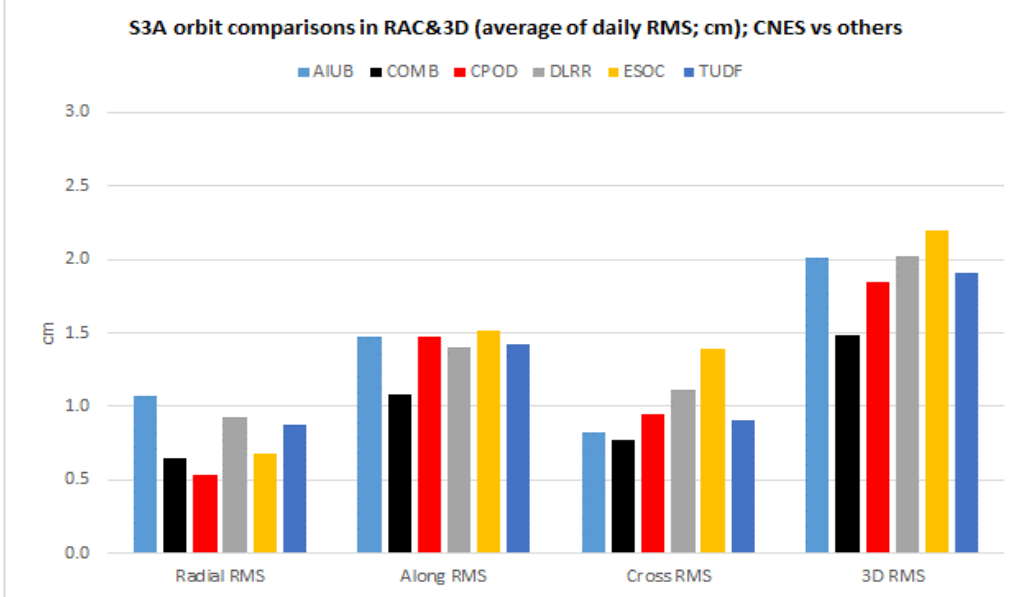

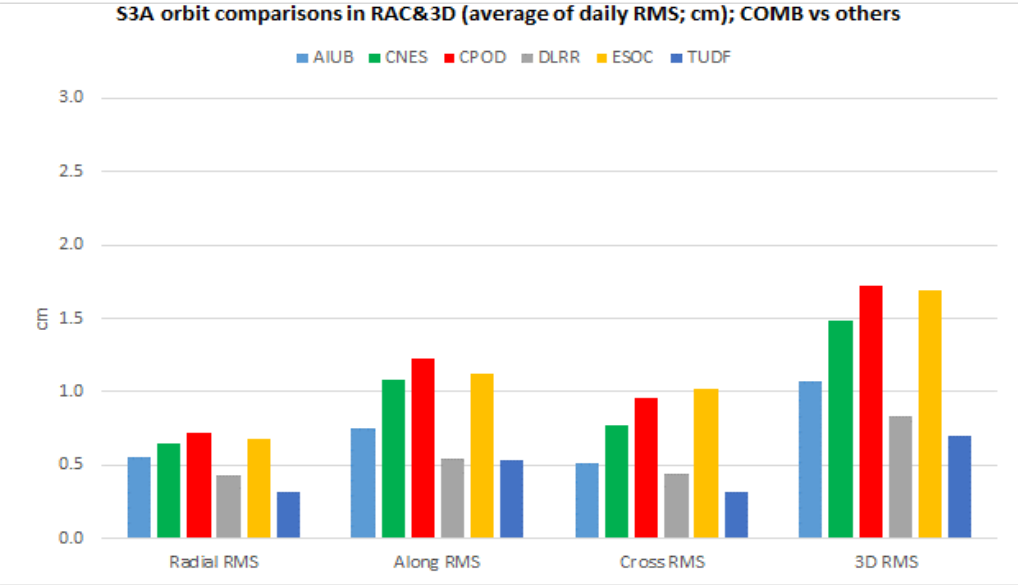

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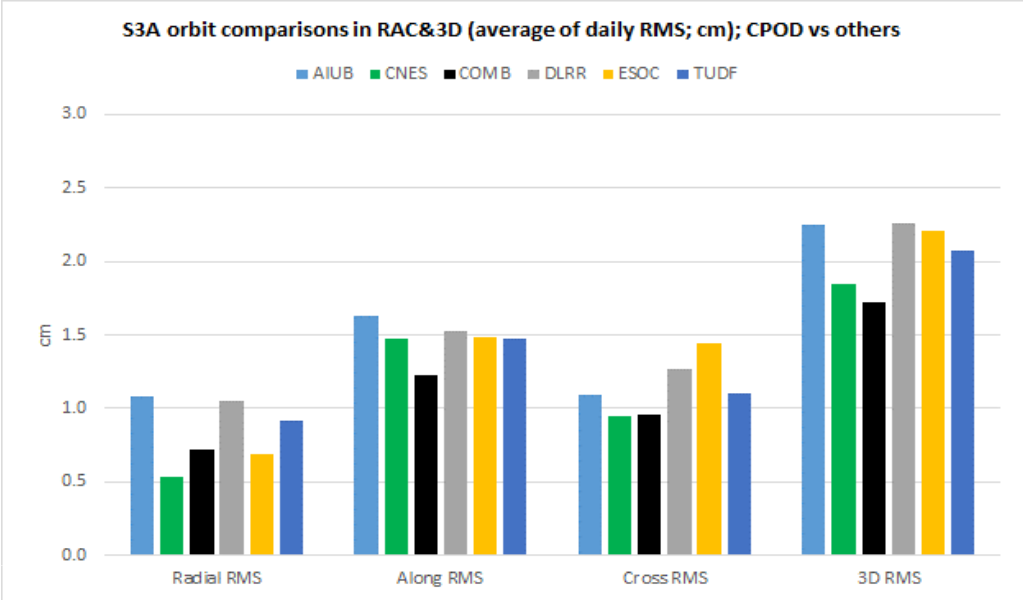

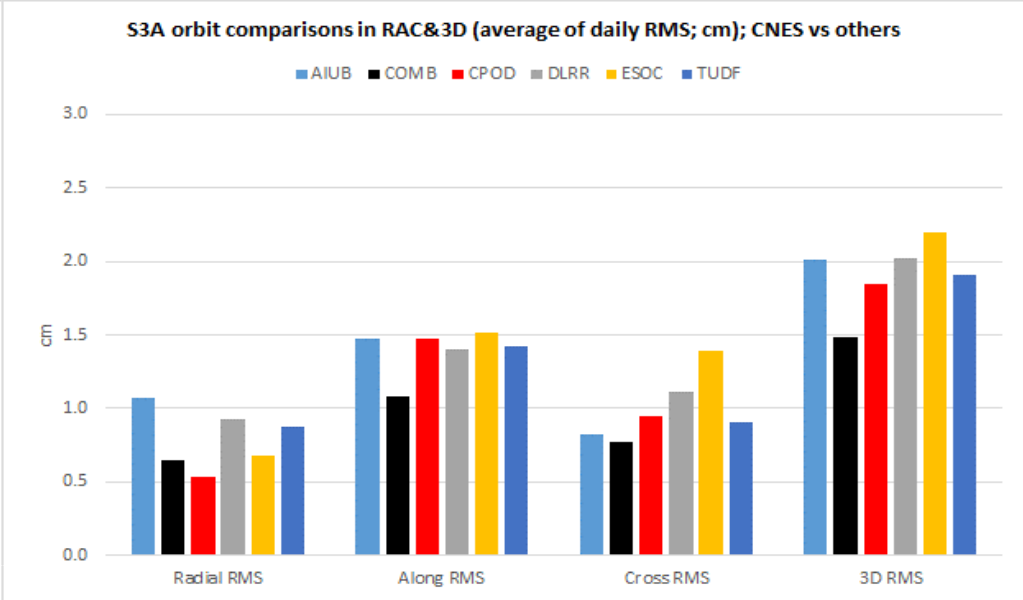

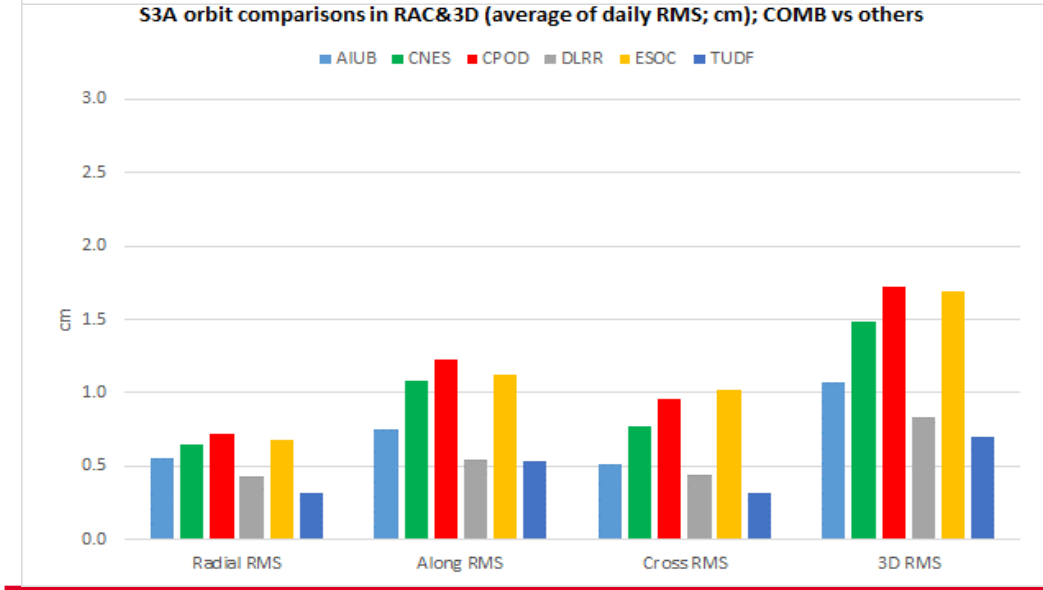

- It looks there are two types of solutions:
  - CPOD, CNES and ESOC (more dynamic)
  - AIUB, DLR and TUDF (reduce dynamic)
  - COMB is closer to AIUB/DLR/TUDF

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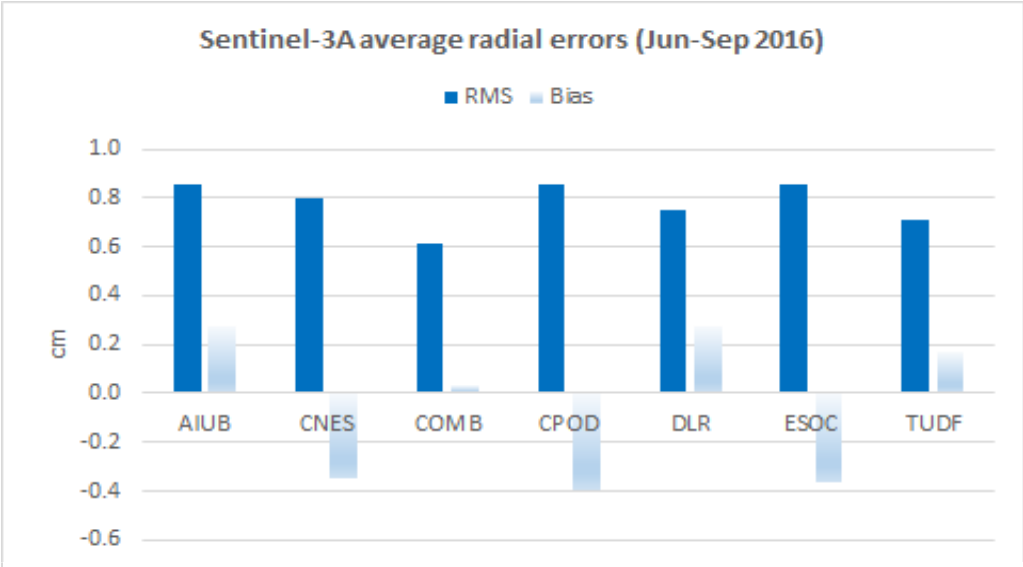

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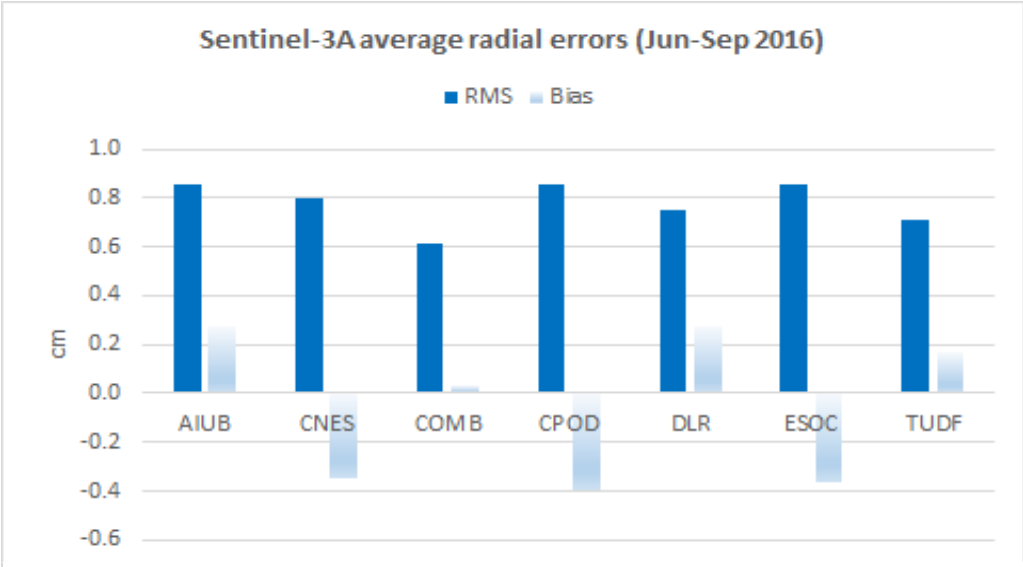

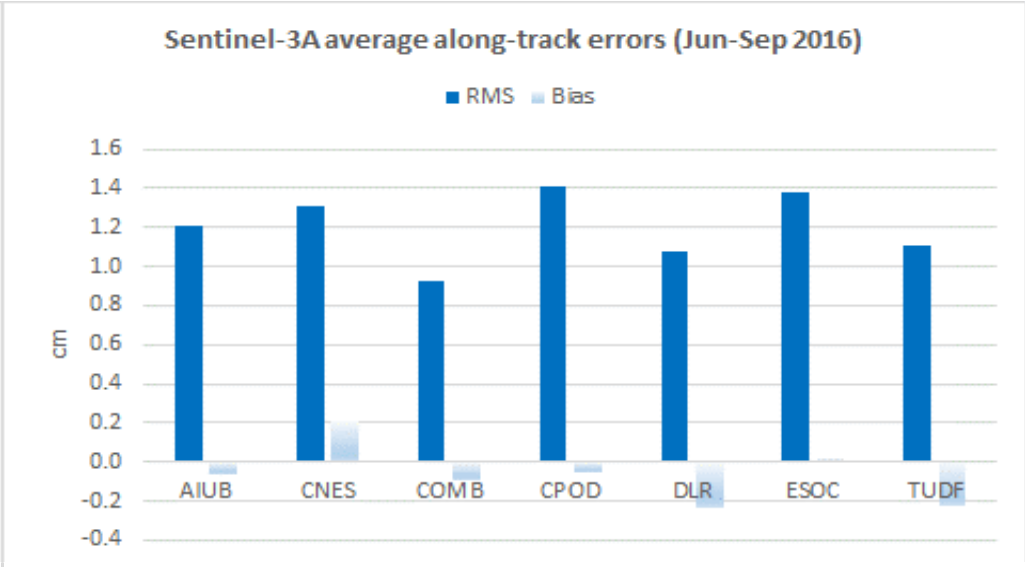

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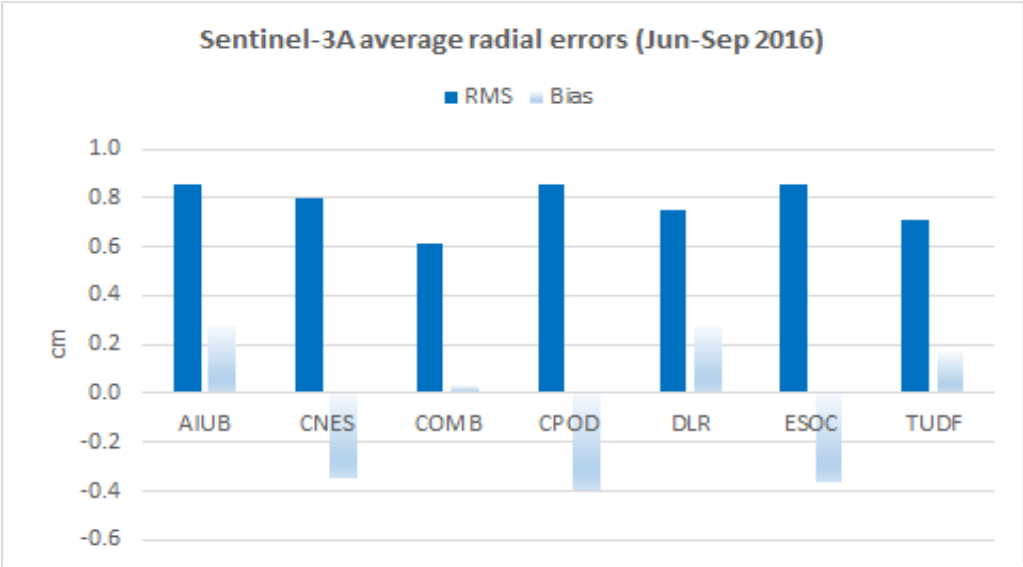

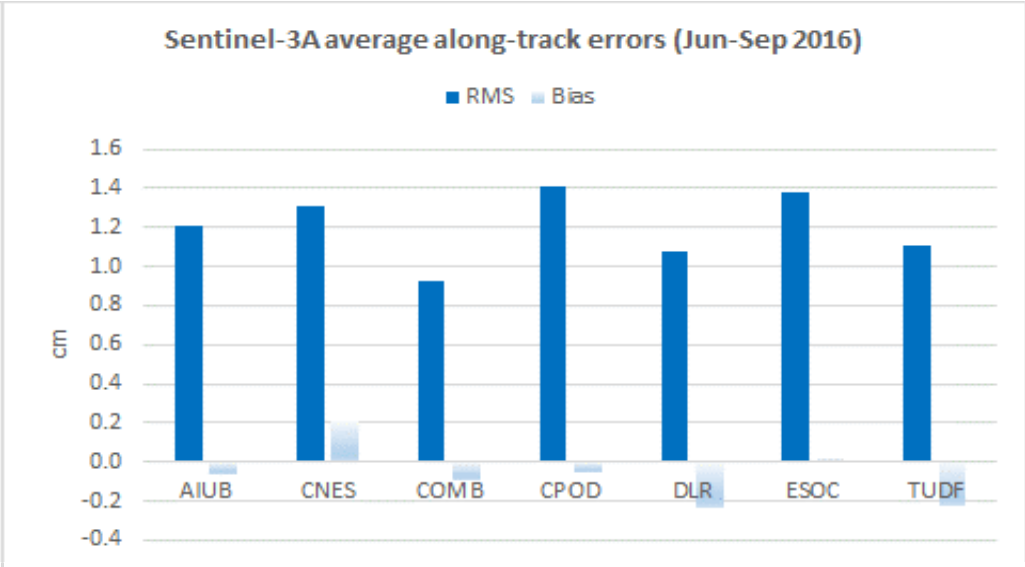

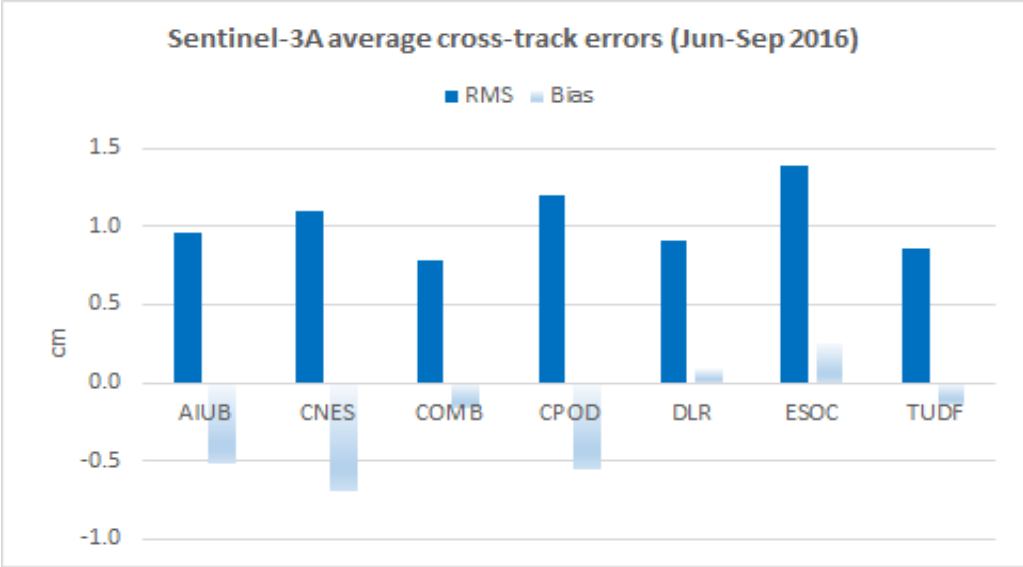

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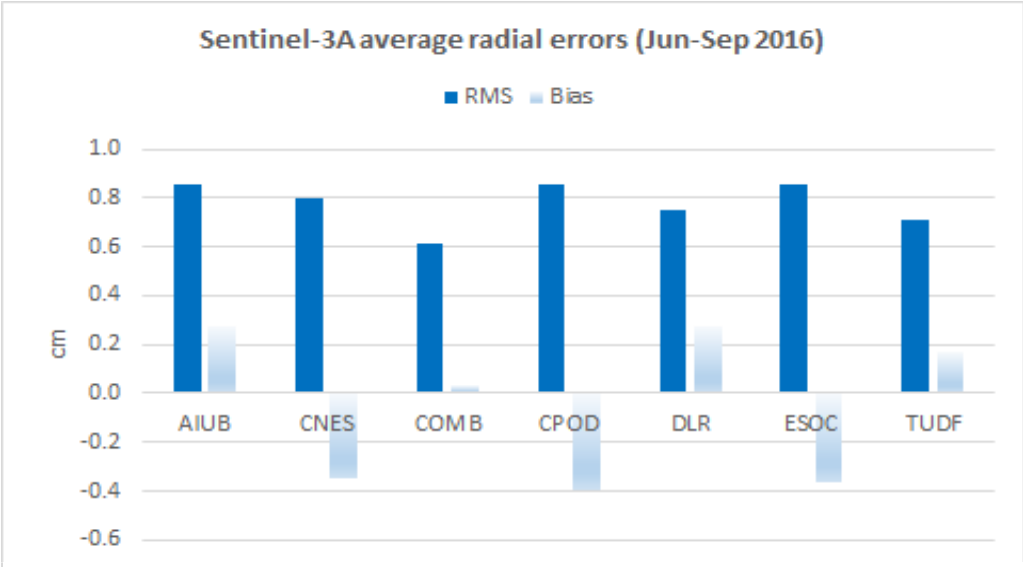
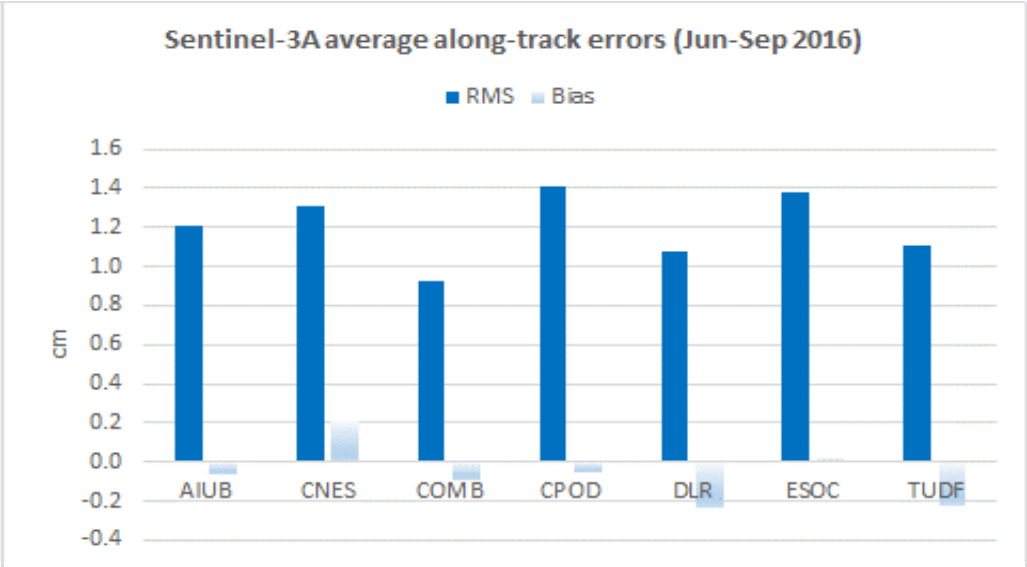
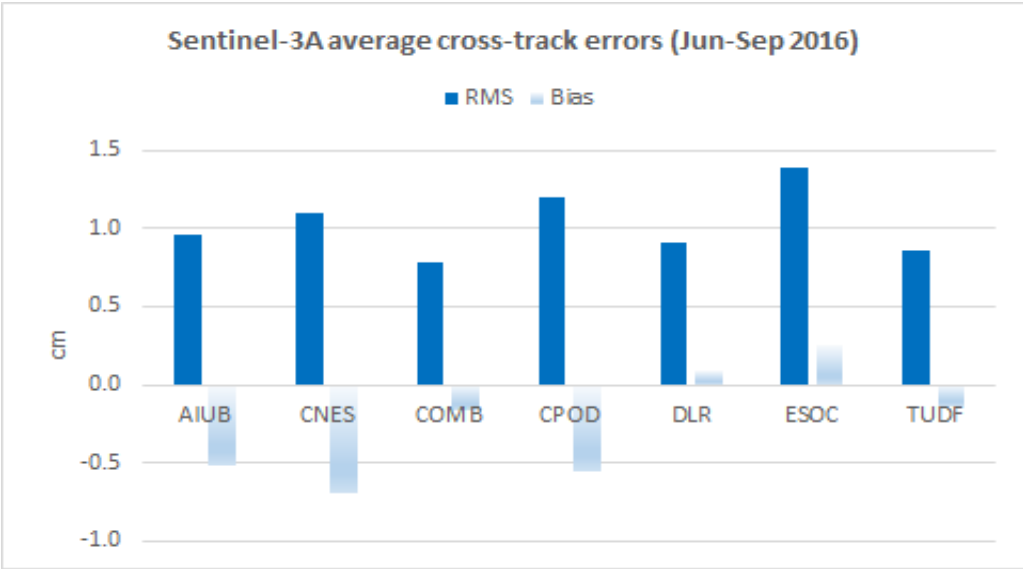
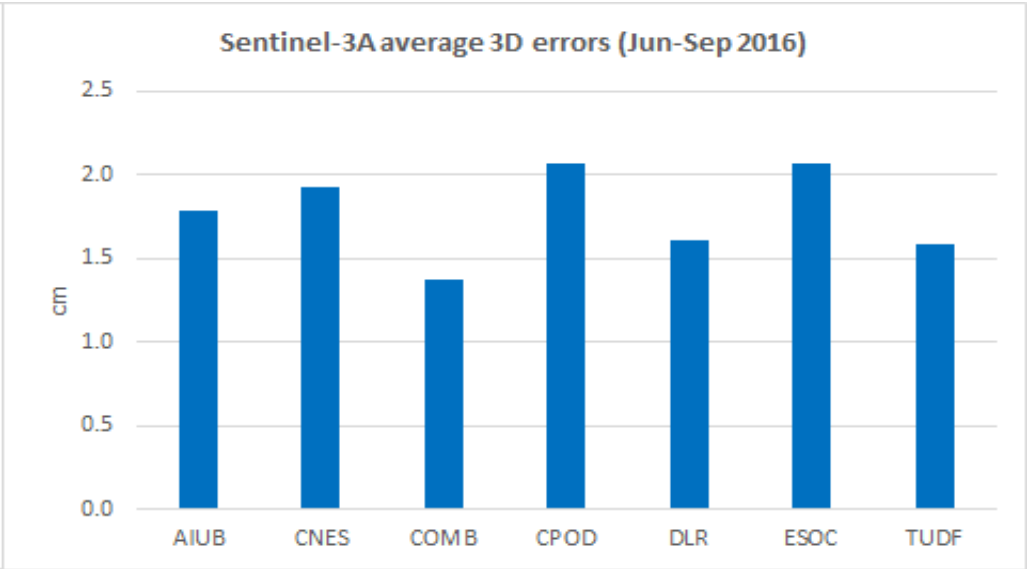
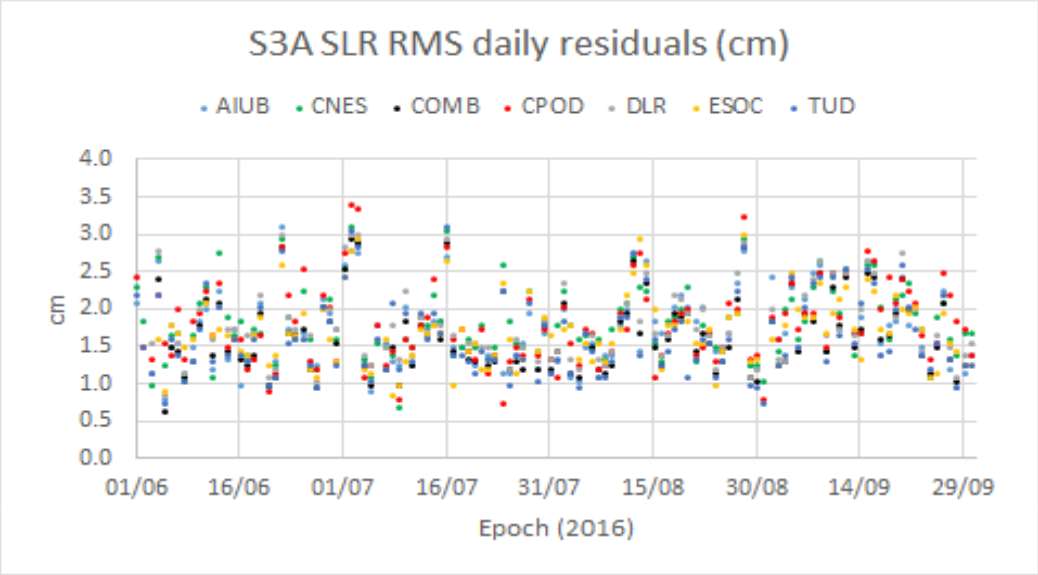








SLR EXTERNAL VALIDATION



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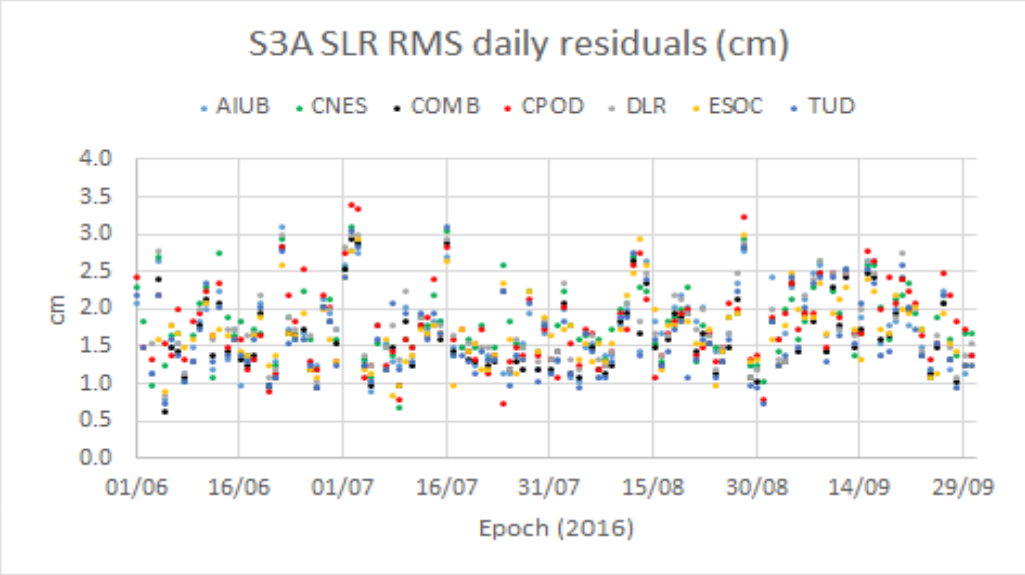

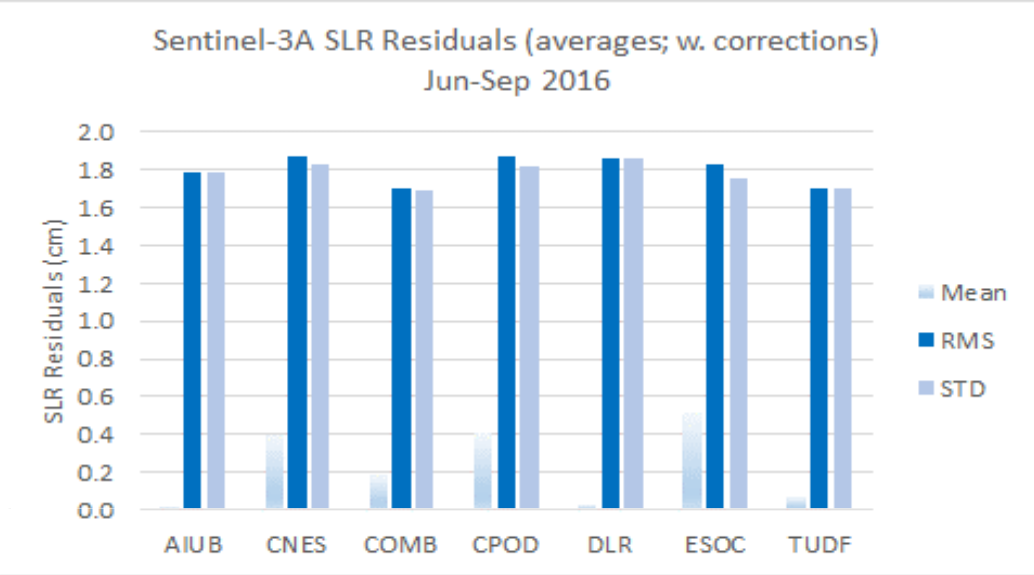

	Mean	RMS	STD
AIUB	0.02	1.79	1.79
CNES	0.40	1.87	1.83
COMB	0.19	1.70	1.69
CPOD	0.41	1.87	1.82
DLR	0.03	1.86	1.86
ESOC	0.51	1.83	1.76
TUDF	0.07	1.70	1.70

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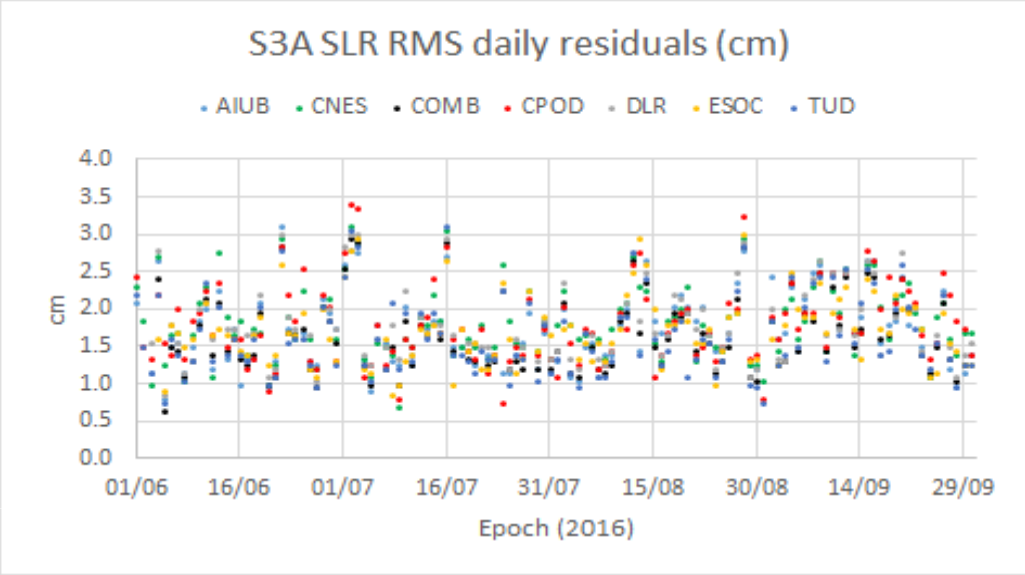
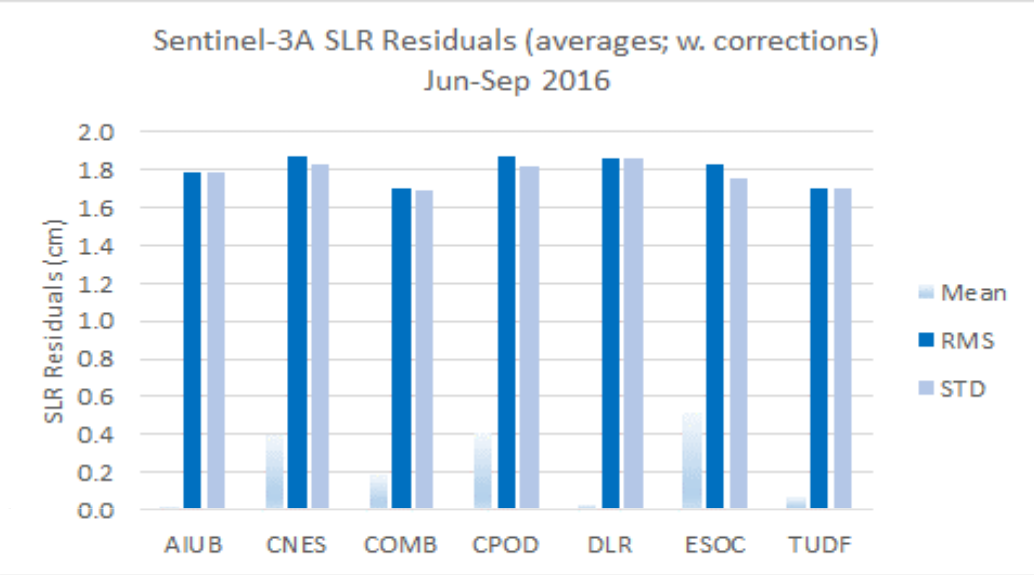




- The better match to SLR is obtained with the combined solution! But this solution has a small bias (~2 mm)
- It is followed by AIUB, DLR and TUDF which has almost no bias at all.
- Finally CNES, CPOD and ESOC, which show biases between 4 and 5 mm.

	Mean	RMS	STD
AIUB	0.02	1.79	1.79
CNES	0.40	1.87	1.83
COMB	0.19	1.70	1.69
CPOD	0.41	1.87	1.82
DLR	0.03	1.86	1.86
ESOC	0.51	1.83	1.76
TUDF	0.07	1.70	1.70

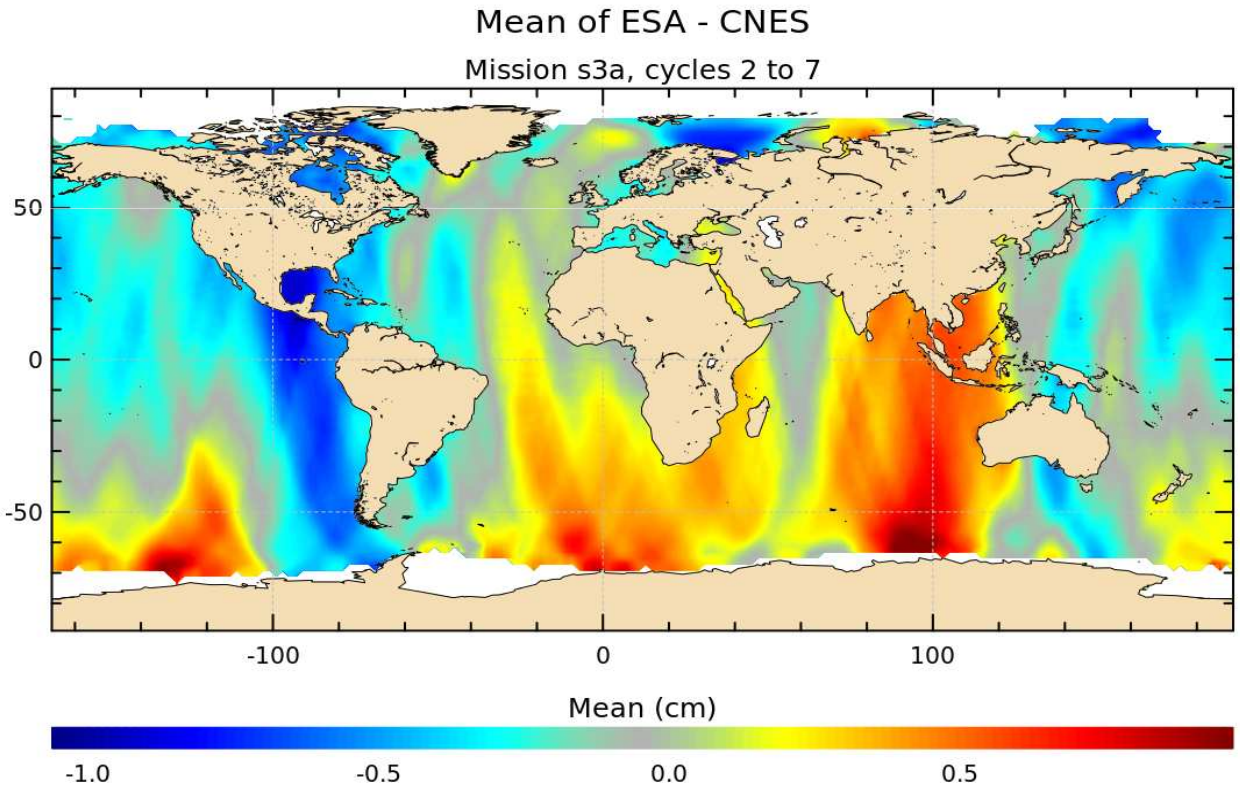
POD QC – POSSIBLE BIASES SOURCES

- Location of Centre of Phase of GNSS antenna
- Location of Centre of Mass
- On-going analysis to identify source of discrepancies between different solutions

SEA SURFACE HEIGHT ESTIMATION

- Reference: Poster "Assessment of Orbit Quality through the SSH calculation Multimission approach focus on Sentinel-3 mission"; A. Ollivier et al.

- CNES and CPOD solution average difference is centimetric



SEA SURFACE HEIGHT ESTIMATION

- CNES and CPOD solutions are rather equivalent, being CNES solution slightly better on the criteria of variance at crossovers (by **2.6 mm**).
- Geographically, a longer time series would be required to identify if this gain is significantly higher on specific areas.
- Comparison to other missions (Jason-2, Altika) highlight a **fair consistency** provided the short period analyzed. Further investigations would be needed to better assess the long term stability and to refine the bias analyses.
- CPOD and CNES orbits have very **similar performances** in terms of Sea Level Anomaly data consistency.

CONCLUSIONS

- The Copernicus POD Service is generating precise orbits for the Sentinel-1, -2 and -3 missions.
- In all the missions the accuracy requirements are routinely fulfilled with enough margins.
- Sentinel-3 allows for independent quality control by SLR and Altimetry processing.
- The SLR residuals indicate that small biases (4-5 mm) exist in the CPOD, CNES and ESOC solutions while it is not present in the AIUB, DLR and TUDF solutions.
- This could be related with the different type of parametrization, as the AIUB, DLR and TUDF solutions are more kinematic than the CPOD, CNES and ESOC solutions, indicating that there is some bias present. Possibly related with the Phase Centre Offset (PCO) / Centre of Gravity
- The Sea Surface Height Estimation shows very good agreement between CPOD and CNES solutions.

COPERNICUS POD QUALITY WORKING GROUP MEETING

- Topic: Sentinel-3 POD Quality Working Group Meeting
- Date: 3rd November 2016
- Location: Espace Encan, La Rochelle, France
- Room: Heron
- Time: 08:30 – 12:30

- People interested to attend this meeting are welcomed