Status of the CNES Precise Orbit Ephemerides for Sentinel-3A

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Background

The Sentinel-3A spacecraft was launched by the European Space Agency on February 16, 2016, to extend the continuous record of accurate sea surface height measurements performed on the polar Sun-synchronous orbit, begun in 1991 by the ERS mission and continued in 2002 by the Envisat mission. Sentinel-3A, like CryoSat-2 (ESA), HY-2A (CNSA), or Saral/AltiKa (CNES/ISRO) is complementary to the other Jason operational satellites, with a higher altitude and a lower inclination. All of these missions contribute to the altimeter constellation while enhancing the globale coverage, for which the CNES Precision Orbit Determination (POD) group delivers precise and homogeneous orbit solutions. In this poster, the overall accuracy of the Sentinel-3A GDR-E orbit solution is evaluated through inter comparisons with external analysis centers, using different models, combinations of tracking data or parameterization techniques. We also give an overview of the performance of all available tracking systems operating on Sentinel-3A, and address some issues concerning the prospects for improvement in refining the location of the phase center of the DORIS and GPS antennas.

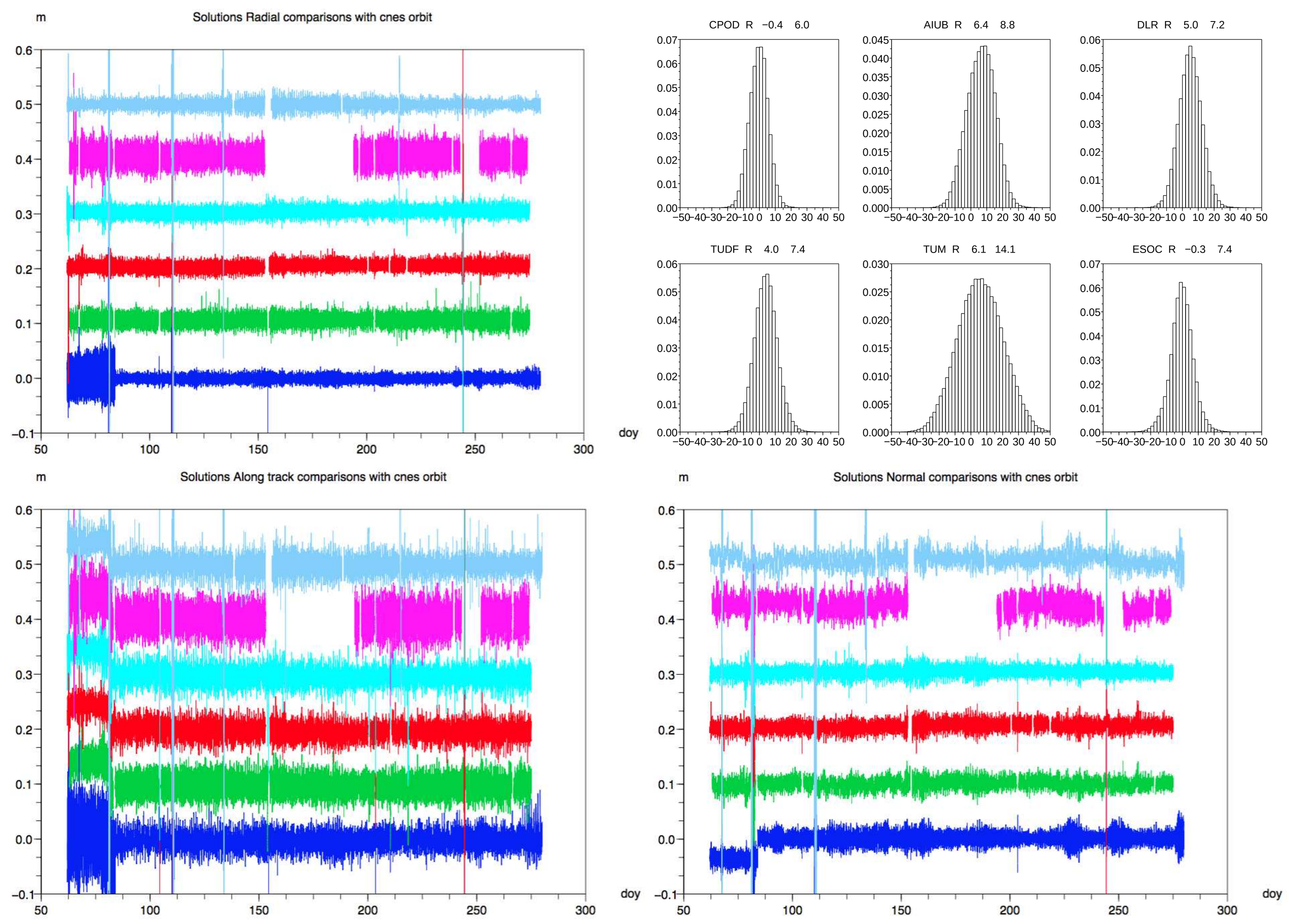
Inter Comparisons with External Analysis Centers

Context

- Sentinel-3A ephemerides are computed independently by CNES, CPOD, AIUB, DLR, TUDF, TUM, and ESOC.
- The compared solutions use different combinations of tracking techniques and different parameterizations:
  - CPOD and ESOC produce GPS-based, dynamic solutions,
  - CNES orbits are reduced-dynamic solutions, based on GPS+DORIS tracking (without GPS phase maps),
  - TUDF, TUM, DLR and AIUB produce GPS-derived, close to cinematic solutions.

Radial, along-track and cross-track differences w.r.t. CNES orbits

- In each of the plots below, the different solutions are compared to CNES orbits and successively offset by +10 cm.
- The following colors are used to identify the external analysis center: CPOD (blue), AIUB (green), DLR (red), TUDF (light blue), TUM (magenta), and ESOC (gray blue).

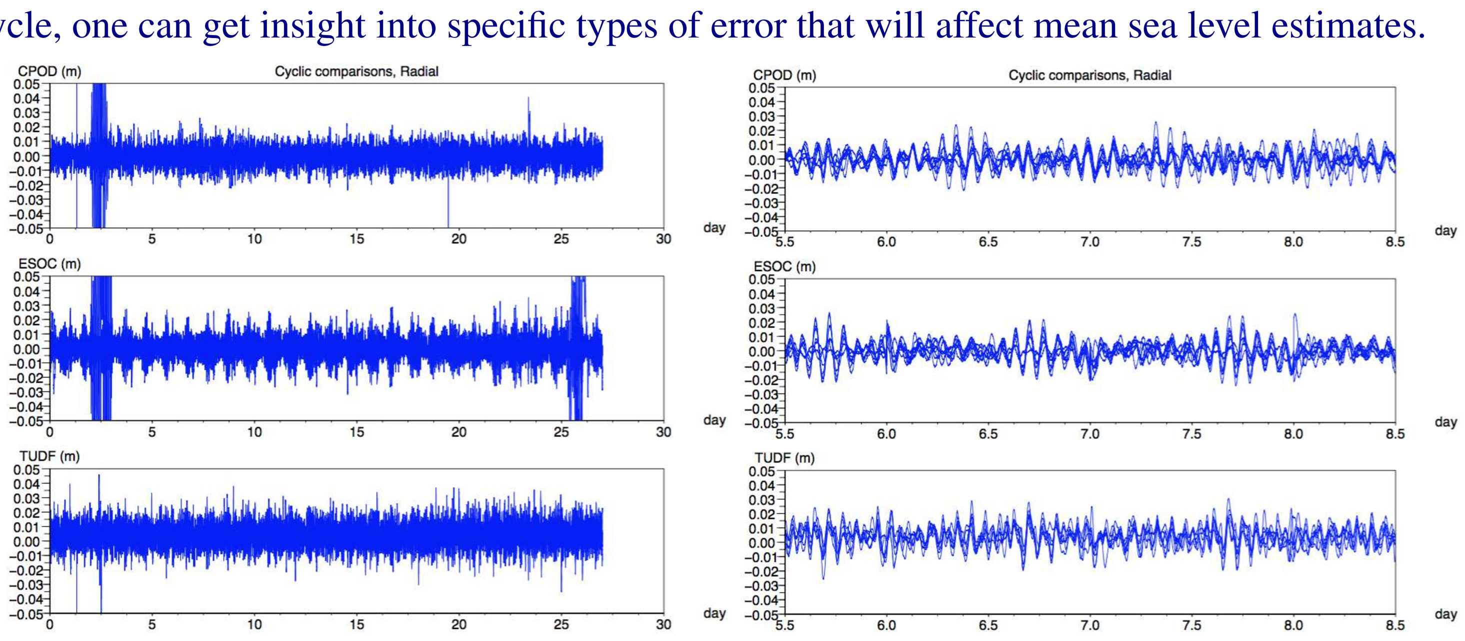


- Apart from a few interruptions mainly due to maneuvers, the independent orbits compare well with CNES' ones. Yet, some solutions exhibit more noise (TUM) and radial biases (all cinematic solutions solving for constant empirical parameters in the radial direction).

Repeat Cycle Features

Close-up on radial orbit differences on orbital cycle time scales

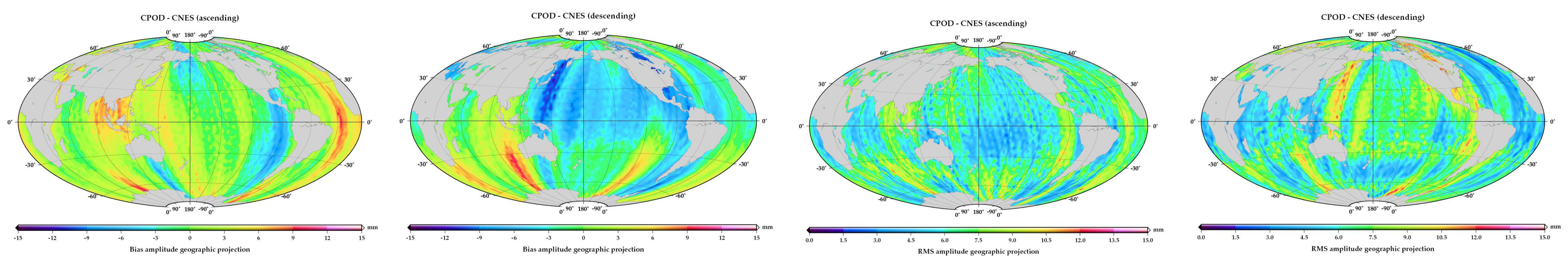
- The orbit of Sentinel-3A was selected to have a repeat cycle of 27 days.
- When sampling the radial orbit differences over each along-track geographic point for each repeat cycle, one can get insight into specific types of error that will affect mean sea level estimates.



- The plots above show such comparisons between CPOD, ESOC, and TUDF solutions with respect to CNES orbits. Radial orbit differences at the 2-cm level seem to repeat well every 27 day. Looking at these differences geographically may help to distinguish between the different possible sources of the observed signatures.

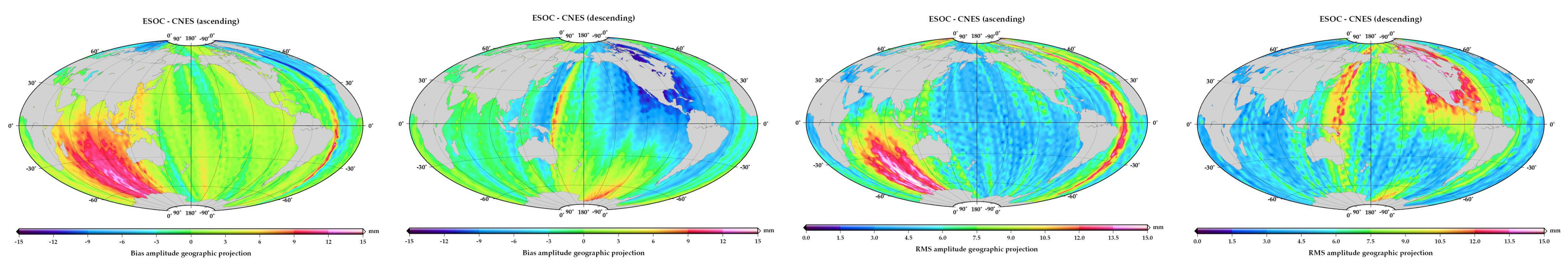
Geographically Correlated Radial Orbit Differences

CPOD w.r.t. CNES orbits



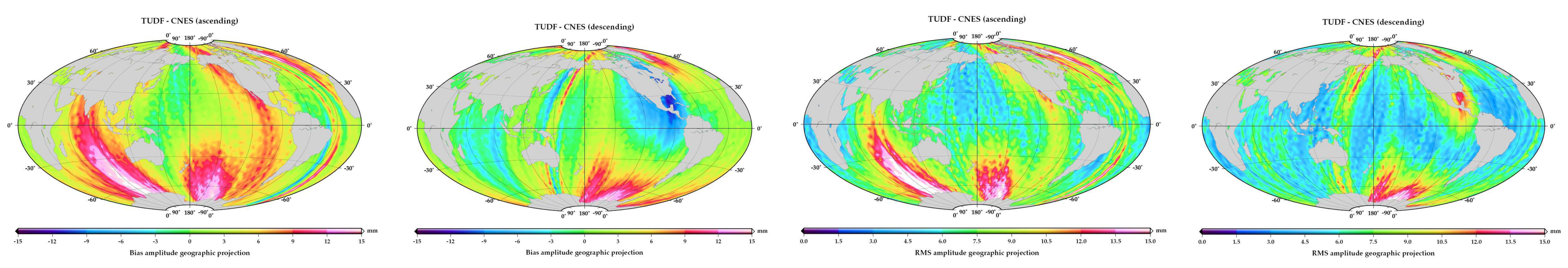
Bias (asc.) Bias (desc.) RMS (asc.) RMS (desc.)

ESOC w.r.t. CNES orbits



Bias (asc.) Bias (desc.) RMS (asc.) RMS (desc.)

TUDF w.r.t. CNES orbits



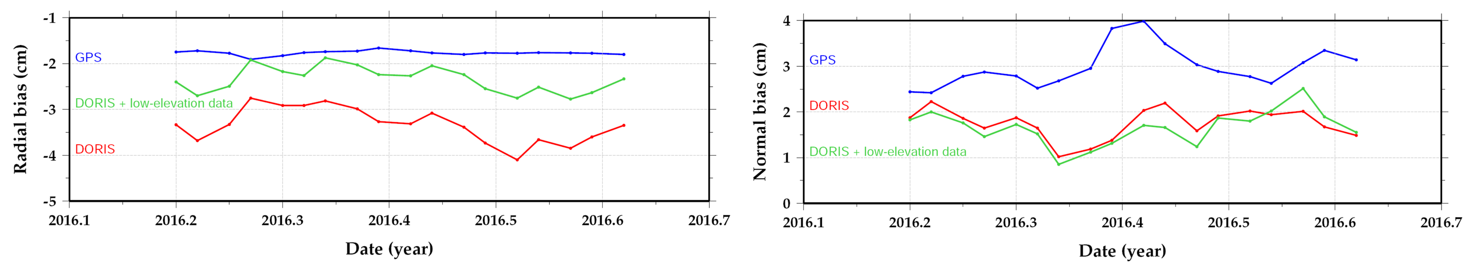
Bias (asc.) Bias (desc.) RMS (asc.) RMS (desc.)

- The noise level seen in the RMS maps is well below 1 cm between CPOD and CNES orbits.
- Focusing on biases, mainly East/West (TVG modeling differences? Sectorial signatures are visible) and North/South (Orbit centering differences?) patterns appear in the comparisons. Yet, relatively high biases can also be seen at high latitudes when comparing TUDF and CNES orbits.

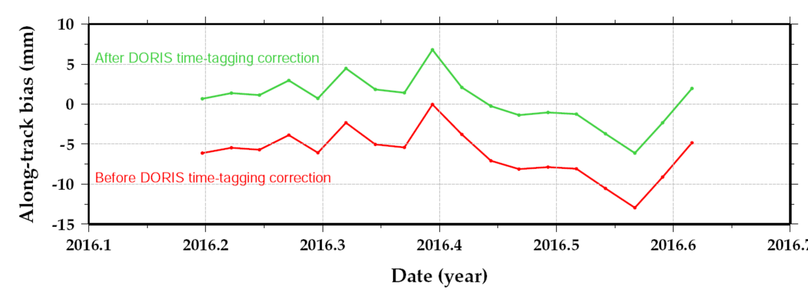
Consistency Between the Three Tracking Systems on Sentinel-3A

DORIS w.r.t. GPS

- Radial and cross-track phase center offset for the DORIS and GPS instruments can be adjusted separately in independent DORIS-only and GPS-based dynamic orbits.



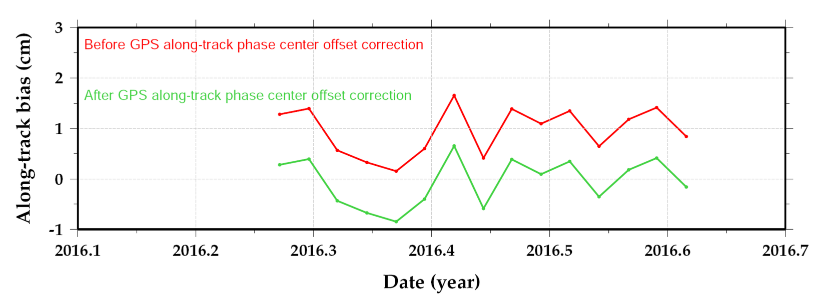
- The DORIS and GPS estimates present a good agreement in the radial direction (~-2 cm), when including low-elevation (below 10 degrees) DORIS measurements.
- The cross-track estimates are less stable and should be looked at carefully given the numerous possible correlations in this specific direction (SRP errors, ...).



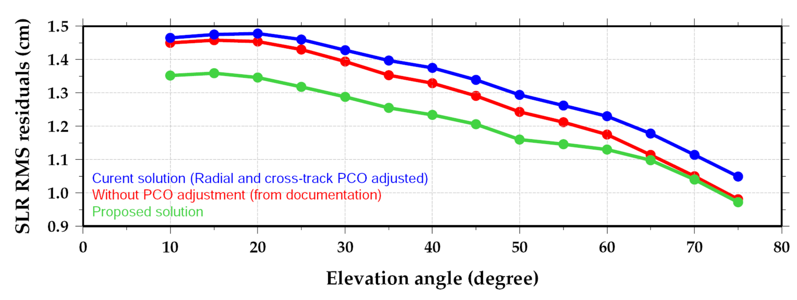
- The along-track GPS offset of ~-7 mm as seen by DORIS measurements can be explained. Indeed, a 24 microseconds offset delay, for the 400 MHz frequency, was pointed out at the production level of the Sentinel-3A DORIS RINEX files. In the ionosphere-free combination, this error thus introduces a ~1 microsecond time-tagging bias in the DORIS measurements.

SLR w.r.t. DORIS and GPS

- Now the consistency of the DORIS and GPS antenna phase centers in the radial and along-track directions has been checked, SLR can be used to independently assess their accuracy. GPS+SLR dynamic solutions were computed to analyze this consistency in the along-track direction.
- As seen by SLR data, a ~1 cm along-track bias can be seen in GPS (or DORIS) orbits.



- In the end, looking at SLR RMS residuals w.r.t. elevation angles show the orbit improvement due to these phase center adjustments in the proposed updated CNES solution.



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