Validation of SENTINEL 3A and 3B modeling for precise orbit determination

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1. Abstract

As a part of the engagement within the International DORIS Service (IDS) of the International Association of Geodesy (IAG) GFZ has started with precise orbit determination (POD) of the Sentinel-3 constellation. For this GFZ's orbit determination software EPOS-OC was migrated.

For POD processing of SENTINEL 3A and 3B the new RINEX format of Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) observations has been adopted.

Further a macro model of both satellites and the attitude information have been applied, and maneuver modeling was tested.

Also state of the art models and standards were invented to the POD processing.

The results are presented and characterized in form of orbital fits and orbit comparisons.

2. Transition to RINEX

As the first step for POD of Sentinel-3 the RINEX format for Doppler observations has been adopted in EPOS-OC. The basis for this were CNES routines to read the DORIS RINEX files and to get the data in GINS format, from where these have been transformed into the EPOS-OC internal format.

In order to increase the accuracy of the POD the frequency biases for each DORIS ground station and each processing arc were estimated in a first step and the Doppler observations have been corrected before further processing.

Also the threshold for the screening of the Doppler observations was optimized to efficiently eliminate outliers.

For validation JASON-2 arcs for 2013 have been reprocessed with new RINEX data. The results are compared to the old Doppler data and compiled in terms of orbital fits and in Fig. 1

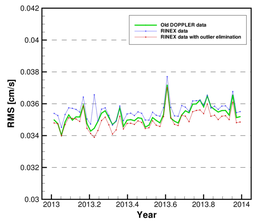

Figure 1: POD of old Doppler vs. new RINEX observations

3. POD for Sentinel 3

Data analyzed:
•Sentinel-3A: Feb. 2018 – Dec. 2018
•Sentinel-3B: Jun. 2018 – Dec. 2018

Arc length: 7 day arcs according to GPS weeks

Models and standards used in POD:
•Earth Gravity Field: EIGEN-6C up to degree/order 90
•Non-tidal atmospheric mass variations: GRACE AOD1B RL06
•Atmospheric density model: CIRA 86
•Albedo model: Knocke, CSR
•Ocean tides: EOT11a
•Station coordinates: DPOD2014-03 by IDS and SLRF2014 by ILRS
•DORIS troposphere model: VMF1
•SLR troposphere model: Mendes-Pavlis

4. Orbital fits

The POD for Sentinel-3 was performed in two steps. In the first step the DORIS observations from RINEX files have been corrected by the original a-priori frequency biases. With this new frequency biases the Doppler observations have been corrected and then be used in the final POD run.

The results of both processing steps are compared and compiled in terms of orbital fits in Fig. 2 and 3. In particular the RMS values of the DORIS observations show significant improvement.

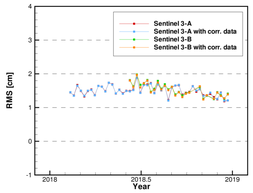

Figure 2: RMS values of SLR observations

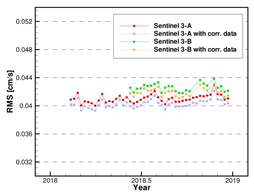

Figure 3: RMS values of DORIS observations

The orbital fits for Sentinel-3 show similar accuracy to the Envisat mission, which has almost the same orbit characteristics and environmental difficulties.

5. Orbit comparison

The orbit comparison has been performed versus the combined solutions from the COPERNICUS Sentinel-3 quality working group. The results of the orbit comparison are compiled in terms of RMS values for each processed day and each axis of the satellite reference frame in Fig. 4 and 6. Further the mean values of the orbit comparisons are also compiled equivalent to the RMS values. The orbit comparisons show a significant offset in along-track by about 4 cm for each satellite. This suggests a bias in the offsets of the DORIS, GNSS and SLR reference points, which needs further investigation.

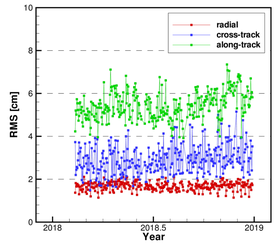

Figure 4: RMS values from Sentinel-3A comparison

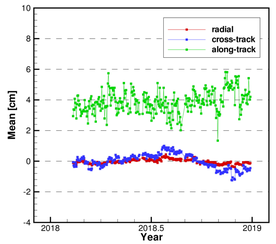

Figure 5: Mean values from Sentinel-3A comparison

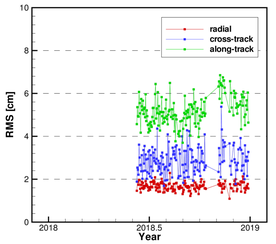

Figure 6: RMS values from Sentinel-3B comparison

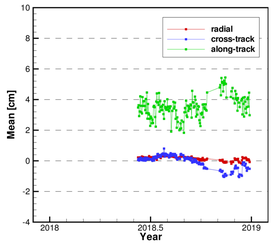

Figure 7: Mean values from Sentinel-3B comparison

6. Maneuver modeling

The modeling of maneuvers has been performed by setting of additional empirical coefficients fixed to the known maneuver boost acceleration. This modeling is in particular very successful for short maneuvers of several seconds.

For validation of the maneuver modeling the DORIS residuals are compared to those from the same arc with no maneuver modeling and compiled in terms of residual distribution in Fig. 8 and 9. While there is a significant jump in the residuals with no maneuver modeling (Fig. 8), the residuals with maneuver modeling (Fig. 9) show an expected smooth distribution.

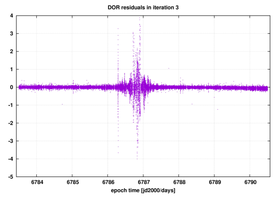

Figure 8: DORIS residual (m) for Senfinel-3A with no maneuver modeling

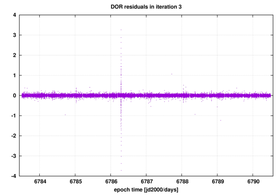

Figure 9: DORIS residual (m) for Senfinel-3A with maneuver modeling

While the current modeling of maneuvers is successful for short maneuvers it still needs some improvements for larger maneuvers up to several minutes of boost. Because the Sentinel-3 satellites also undergo maneuvers with up to 14 minutes of boost, the maneuver modeling is quite difficult and needs further investigation.

7. Conclusion

The orbital fits for Sentinel-3 show similar accuracy as with the Envisat mission.

The offsets in along-track direction from the orbit comparisons indicate a bias in the offsets of the DORIS, GNSS and SLR reference points.

The current modeling of the maneuvers is successful for short maneuvers.