Precise Orbit Determination of DORIS satellites by CNES/CLS IDS Analysis Center in the frame of the next ITRF

Hugues Capdeville (1) and Jean-Michel Lemoine (2).

(1) CLS, Collecte Localisation Satellites, 11 rue Hermès, 31520 Ramonville Saint Agne, France
(2) CNES Centre National d'Etudes Spatiales, 18 av Edouard Belin, 31400 Toulouse, France

First-Author: hcapdeville@groupcls.com
CNES-CLS IDS Analysis Center

Abstract EGU2019-5785
X3.34

Introduction

We are currently preparing the processing configuration for our IDS contribution to the next ITRF realization. We will adopt the last standards and models recommended by IERS and IDS. We now use body and solar array quaternions for Jason-2 and Jason-3 satellites.
A Precise Orbit Determination (POD) status for DORIS satellites by taking into account all these improvements is presented. We give statistical results such as one per revolution empirical acceleration amplitudes and orbit residuals. We also give some comparisons to the CNES precise orbit used for altimetry and to GPS-only orbits contributing to the Copernicus POD Quality Working Group of Sentinel. Some external validations of our orbits are done, such as with independent SLR measurements processing as well as through the use of altimeter crossovers..

POD Processing overview

Software	GINS/DYNAMO
DORIS data	RINEX 3.0 phase measurement converted to DOPPLER
Terrestrial Reference Frame	ITRF2014 (DPOD2014)
Gravity Field	EIGEN-GRGS.RL04-MEAN-FIELD with mean slope extrapolation C21/S21 coherent with the new linear mean pole model Ocean tides: FES2014
Displacement of reference Point	Pole tide: solid earth pole tides and ocean pole tides (Desai, 2002), new linear mean pole model
Attitude Model	for Jason: quaternions for BUS and solar panels and/or nominal law likeTopex for Sentinel-3: nominal law like Envisat
Surfaces Forces & Estimated Parameters	Box-wing model for solar radiation,drag, Albedo and IR Macromodel available at : *ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf* Radiation pressure scale coefficient : 1 coef/day but strongly constrained to: 0.99 for Jason and 1.0 for Sentinel-3 OPR empiricals: 2 coeff cos-sin /orbital period in normal direction and 2 coeff cos-sin /orbital period in tangential direction (per arc) Drag coefficients adjusted: 1 coef/4 hour for Sentinel-3 and 1 coef/half day for Jason
SAA compensation	Estimation of the beacon frequency Polynomial on SAA station per pass (for Jason-2 and Jason-3)
Time span processing	From July 2017 to January 2019 3.5-day arcs with a cut-off angle of 12°

❑ **Standards and models:**
We take the IERS conventions and the IDS recommendations.

To be updated:
- **HF EOP model**
- **Ocean loading**
- **…**

❑ **Re-processing for the next ITRF2020:**
- **Implementation and testing new models**
- **Processing DORIS data from 1992 to end 2020**
- **Starting reprocessing end 2019**

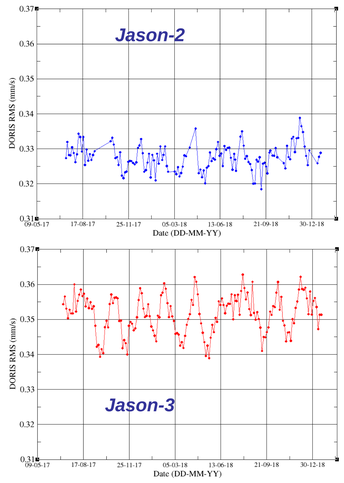
POD results

❑ **DORIS RMS of fit and SLR external validation**
OPR Acceleration Amplitude: Along-track and Cross-track
Radiation pressure coefficient
Mean of 81 weeks *(from July 2017 to January 2019) and 32 weeks for Sentinel-3B*

SATELLITE	DORIS RMS (mm/s)	SLR RMS (cm)	OPR amplitude average (10^{-9} m/s^2)		Solar radiation coefficient
			Along-track	Cross-track	
Jason-2	0.328	1.9	3.2	2.8	0.97
Jason-3	0.352	2.0	0.9	2.3	0.99
Sentinel-3A	0.361	1.4	2.5	1.6	1.00
Sentinel-3B	0.378	1.45	1.5	1.9	1.00

- *For the two directions, Along-track and Cross-track, the mean amplitudes are lower than 4x10^{-9} m/s^2, reflecting a satisfying level in the modeling of the satellite macromodels and the attitude law.*
- *The orbit residuals level of the Jason-3 (0.35 mm/s on average) and Sentinel-3A&B (0.36&0.38 mm/s), are slightly higher than Jason-2 (0.33 mm/s).*
- *The DORIS-only orbits have also been evaluated by an independent SLR measurements processing. SLR residuals on DORIS-only orbits are of a good level.*

❑ **DORIS RMS of fit**

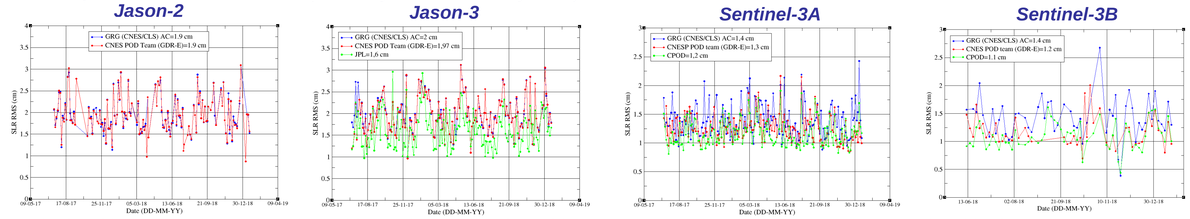


- *For Jason-3, the level of DORIS RMS residuals is slightly higher compared to Jason-2, explained by its higher sensitivity to the SAA.*
- *There is a ~59 days periodic signal for both satellites, even when we use quaternions for attitude satellite.*

REFERENCES
• Lemoine, J.-M., Capdeville, H., 2006. A corrective model for Jason-1 DORIS Doppler data in relation to the South Atlantic Anomaly. J. Geod. 80 (8–11), 507–523. http://dx.doi.org/10.1007/s00190-006-0068-2 (DORIS Special Issue).
• Capdeville, H., Stepanek, P., Hecker, L., Lemoine, J.-M. Update of the corrective model for Jason-1 DORIS data in relation to the South Atlantic Anomaly and a corrective model for SPOT-5. Adv. Space Res. http://dx.doi.org/10.1016/j.asr.2016.02.009
• Lemoine, J.-M., Capdeville, H., Soudarin, L. Precise orbit determination and station position estimation using DORIS RINEX data. Adv. Space Res. http://dx.doi.org/10.1016/j.asr.2016.06.024
• Soudarin, L., Capdeville, H., Lemoine, J.M. Activity of the CNES/CLS analysis center for the IDS contribution to ITRF2014. Adv. Space Res. http://dx.doi.org/10.1016/j.asr.2016.08.006

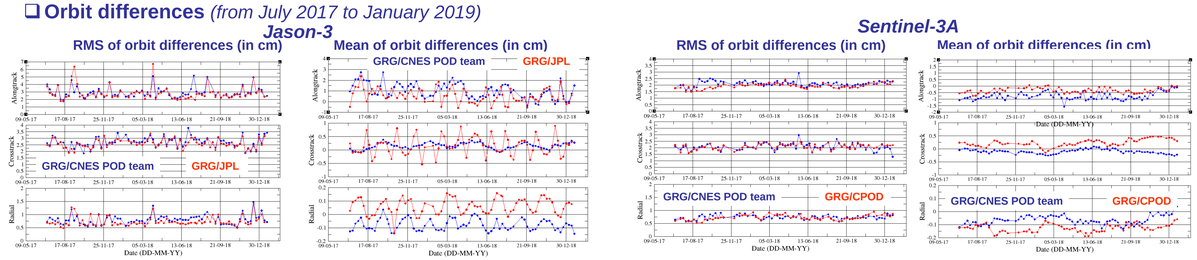
Orbit comparison

❑ **Independent SLR RMS of fit** *(from July 2017 to January 2019)*



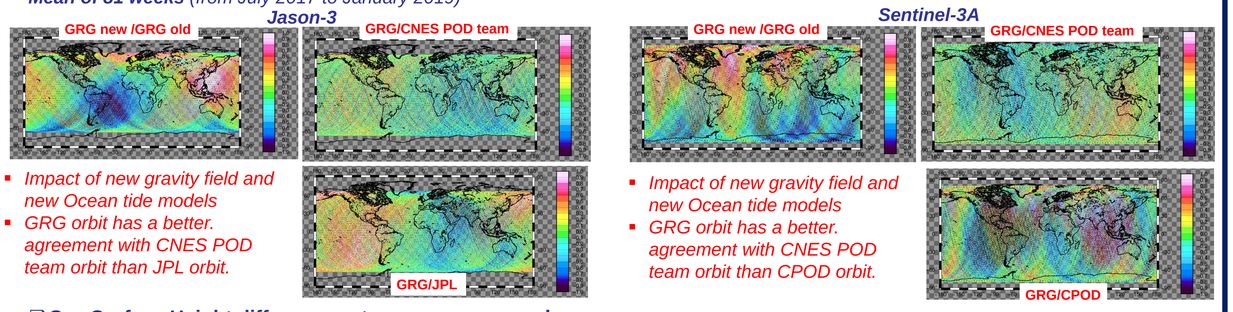
- *The level is comparable to the other orbits evaluated, precise orbit DORIS+GPS of CNES POD team, GPS-only orbit of JPL (for Jason-3) and GPS-only orbit of CPOD (Copernicus POD service) (for Sentinel -3A&B).*

❑ **Orbit differences** *(from July 2017 to January 2019)*



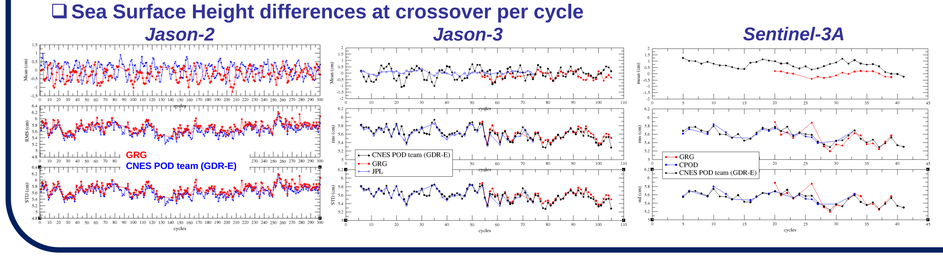
- *For Jason-3, there is a good agreement between our orbits and the others but there is a tangential bias > 1 cm which could be explained by a difference in the time tagging of the DORIS and GPS measurements. This bias is present for all GPS orbit comparisons. There is also a signal at ~59 days in the average of the radial component, still present even when we use measured quaternions BUS + solar panels angles. For Sentinel-3A, the agreement between the orbits is better but there remains a tangential bias certainly correlated to the time tagging of the measurements.*

❑ **Radial Orbit differences (geographically correlated errors, *2° by 2° grids*)**
Mean of 81 weeks *(from July 2017 to January 2019)*



- *Impact of new gravity field and new Ocean tide models*
- *GRG orbit has a better. agreement with CNES POD team orbit than JPL orbit.*
- *Impact of new gravity field and new Ocean tide models*
- *GRG orbit has a better. agreement with CNES POD team orbit than CPOD orbit.*

❑ **Sea Surface Height differences at crossover per cycle**



- *For Jason-2, the STD and RMS of the SSH differences are at the same level for the CNES POD team orbit and GRG orbit. For Jason-3 and Sentinel-3A, the statistical results are also very similar to the external orbits (from CNES POD team, JPL and CPOD)*

Conclusions

The GRG orbits have been evaluated by comparison to external orbits from CNES POD team, JPL team and Copernicus POD service. Some external validations of our orbits were also done, such as with independent SLR measurements processing as well as through the calculation of the SSH differences at crossover per cycle.
For Jason and Sentinel satellites, there is a good agreement between the GRG orbits and other orbits, DORIS+GPS from CNES POD team and GPS-only orbits from JPL and CPOD. For Jason satellites, there is a ~59 days periodic signal visible in DORIS RMS and in the radial differences with other orbits for both satellites, even when we use quaternions. We plan to make a reduced dynamic orbit.
We will continue our preparation for the next ITRF by testing models recommended by IERS and IDS.