OSTST Meeting, POD Splinter
Ponta Delgada, September 2018

Precise Orbit Determination status on Jason-2&3 and Sentinel-3A&B by CNES/CLS IDS Analysis Center

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Outline

- ❑ POD results
  - • Processing strategy
  - • OPR and DORIS RMS of fit
  - • Independent SLR RMS of fit
- ❑ Orbit comparison
  - • Independent SLR RMS of fit
  - • Comparison to GPS-only orbits and external orbits
- ❑ Introduction of Sentinel solutions in the multi-satellite solution
- ❑Conclusions and perspectives

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ Processing strategy

(we took the IERS conventions and the IDS recommendations)

Software	GINS/DYNAMO
DORIS data	RINEX 3.0 phase measurement converted to DOPPLER
Station Coordinates	ITRF2014 (DPOD2014)
Gravity Field	EIGEN-GRGS.RL03-v2.MEAN-FIELD with mean slope extrapolation
DORIS Troposphere	VMF1 + one gradient per station in North & East directions
Attitude Model	for Jasons: nominal law likeTopex for Sentinel-3s: 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
Time span processing	From June 2016 to August 2018 3.5-day arcs with a cut-off angle of 12°

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ POD Summary

Introduction of Sentinel-3B in the GRG processing chain

DORIS RMS of fit and SLR external validation

OPR Acceleration Amplitude:

Along-track and Cross-track / Radiation pressure coefficient

***Mean of 115 weeks** (from June 2016 to August 2018) and 10 weeks for S3B*

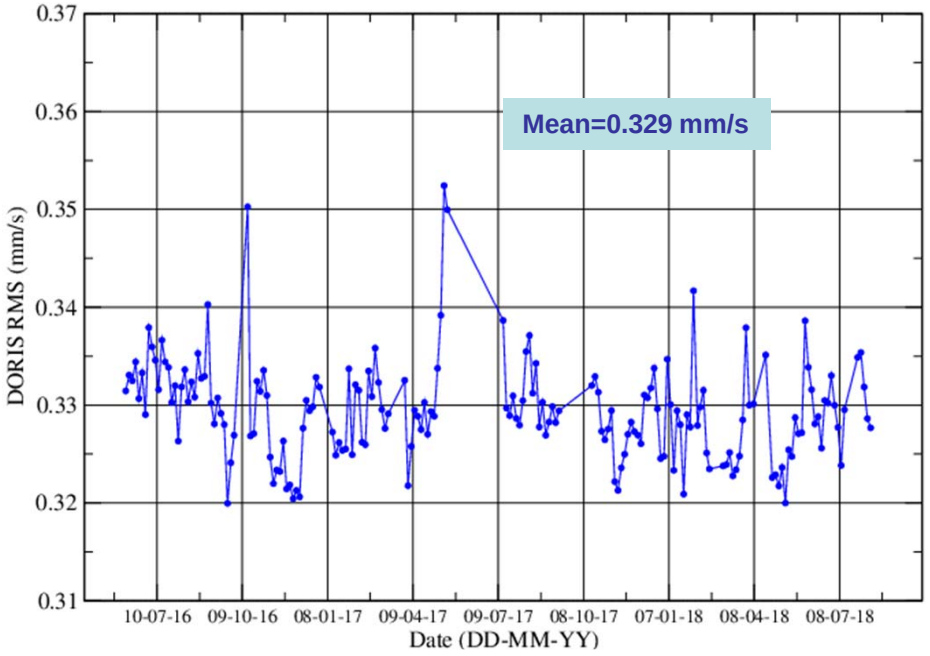
SATELLITE	DORIS RMS (mm/s)	SLR RMS (cm)	OPR amplitude average (10^{-9} m/s^2)		Solar radiation coefficient
			Along-track	Cross-track	
Jason-2	0.329	1.8	2.4	2.2	0.97
Jason-3	0.352	1.9	1.3	2.5	0.99
Sentinel-3A	0.362	1.4	2.3	1.9	1.00
Sentinel-3B	0.381	1.5	1.8	2.3	1.00

▪*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.*

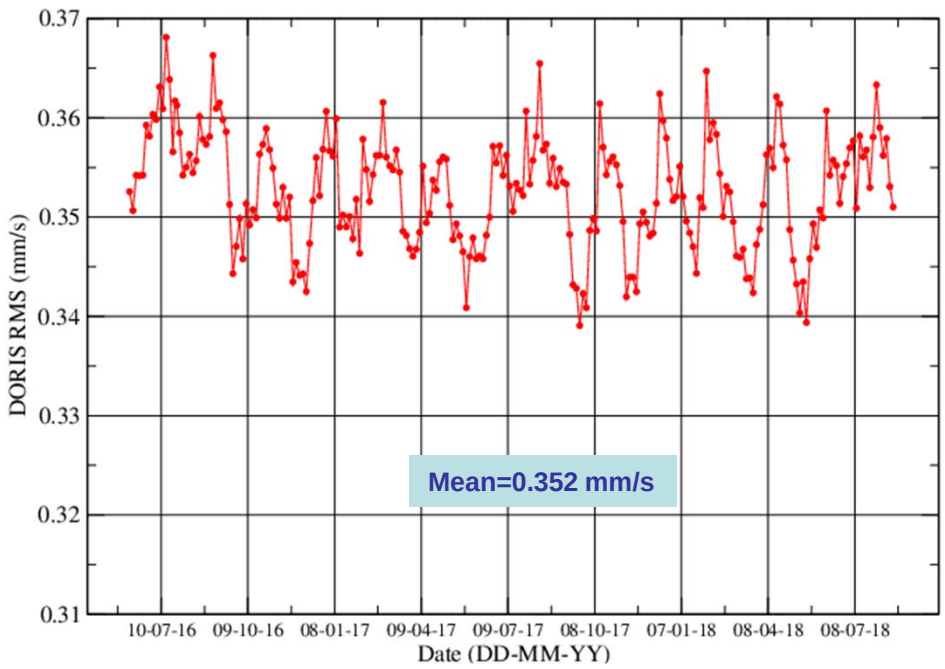
Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ DORIS RMS of fit

Jason-2



Jason-3



- *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 60 days periodic signal for both satellites.*

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

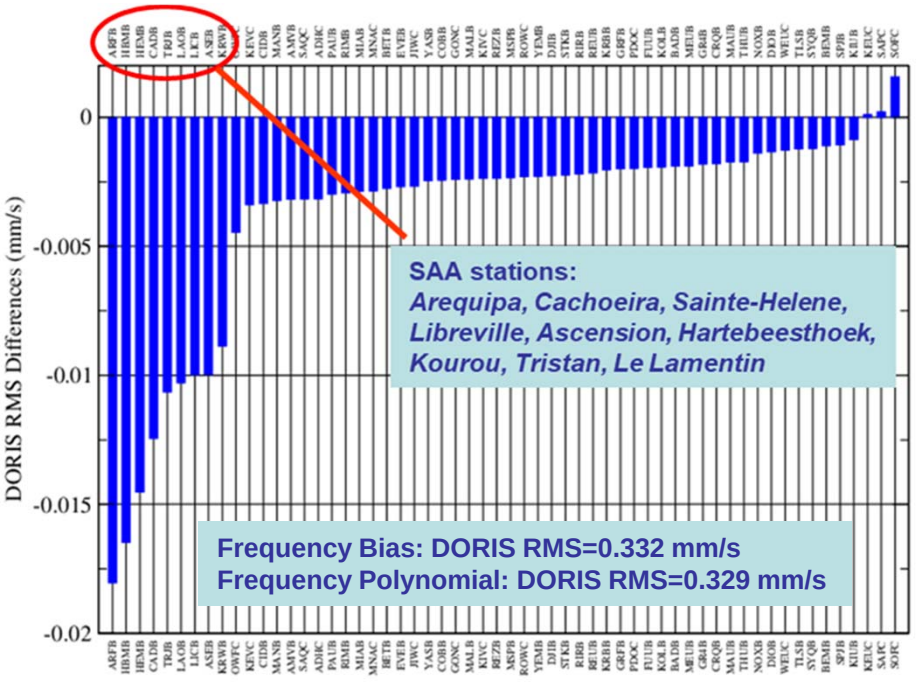
❑ Strategy to mitigate the SAA effect on Jason satellites

Estimation of the beacon frequency Polynomial on SAA station per pass

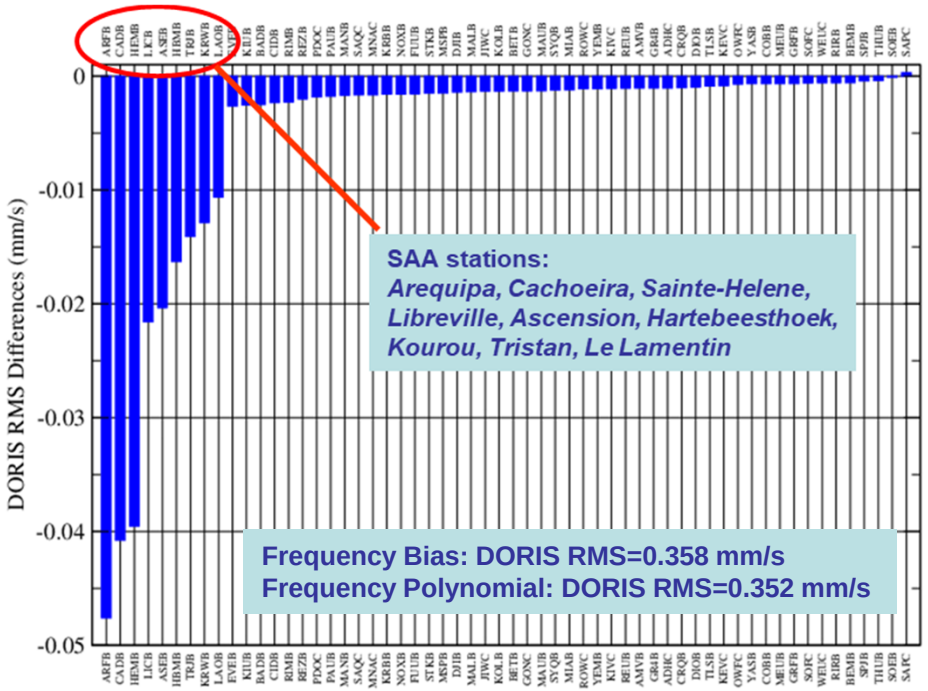
Classical processing: one Frequency Bias adjusted per pass.

With strategy: Frequency Polynomial (degree 4) adjusted per pass.

Jason-2



Jason-3

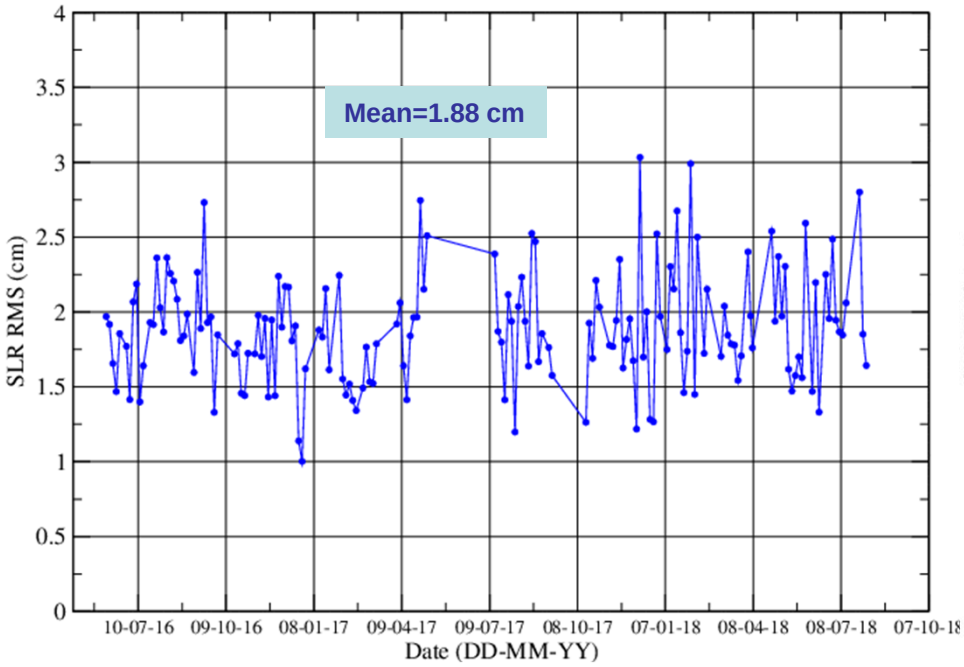


- *The DORIS residuals are lower when we apply the strategy of polynomial adjusting frequency per pass for SAA stations.*
- *The impact is significant for SAA stations and the number of measurements is higher.*

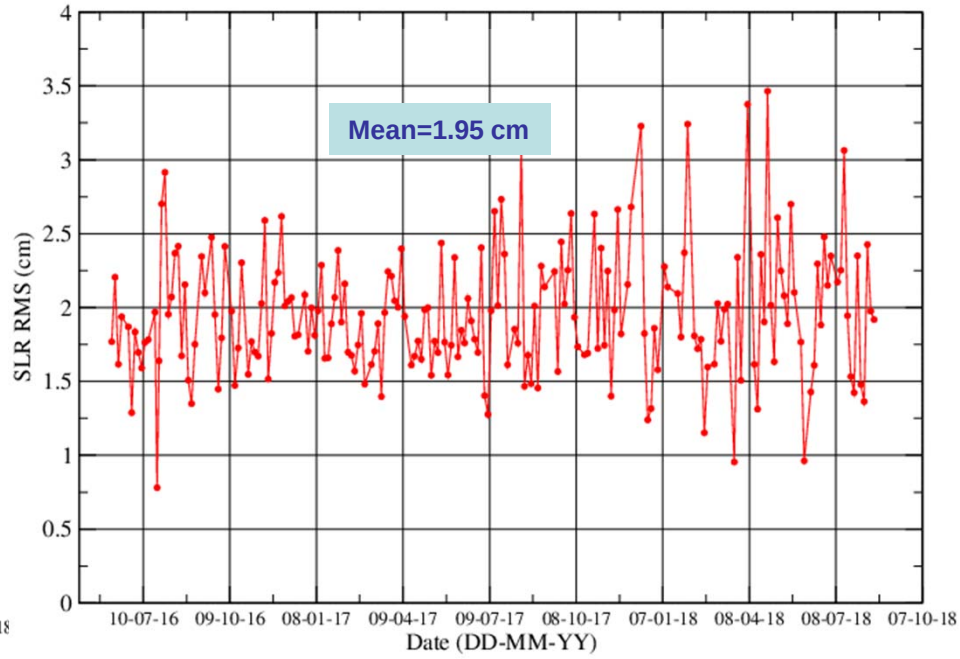
Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ Independent SLR RMS of fit

Jason-2



Jason-3

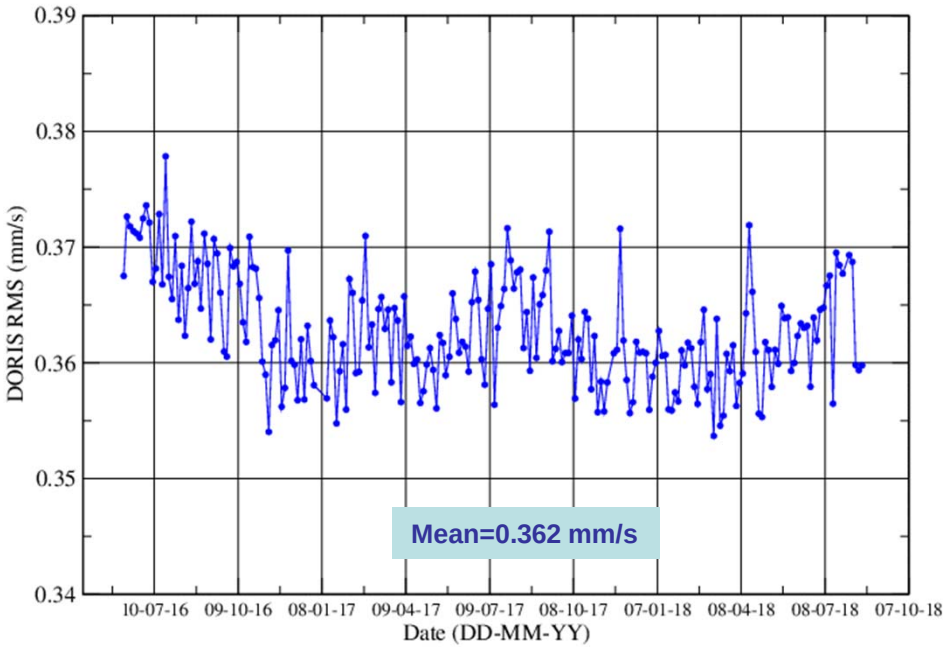


- *The SLR RMS residuals on Jason-2 and Jason-3 orbits are at a good level.*

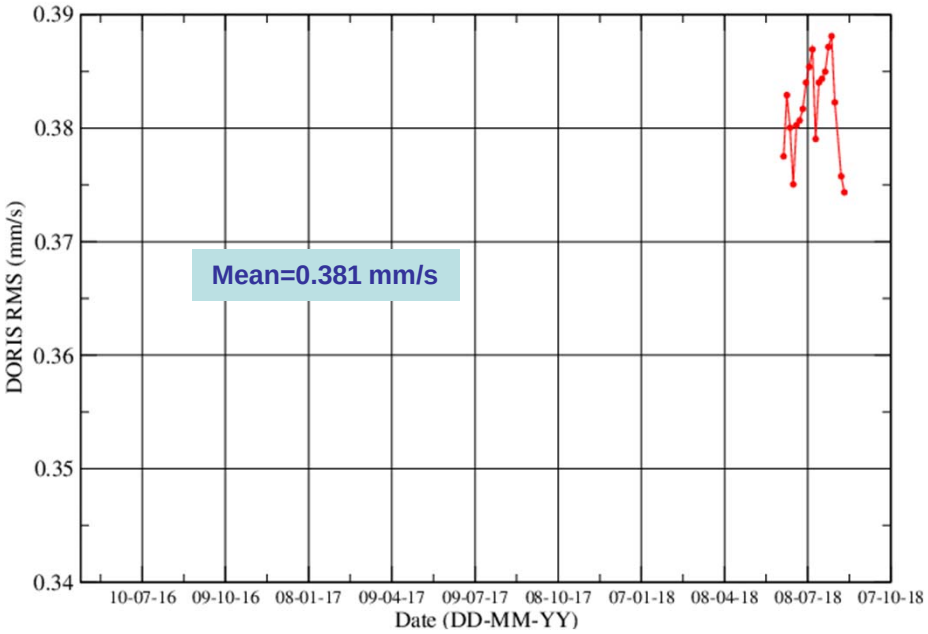
Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ DORIS RMS of fit

Sentinel-3A



Sentinel-3B

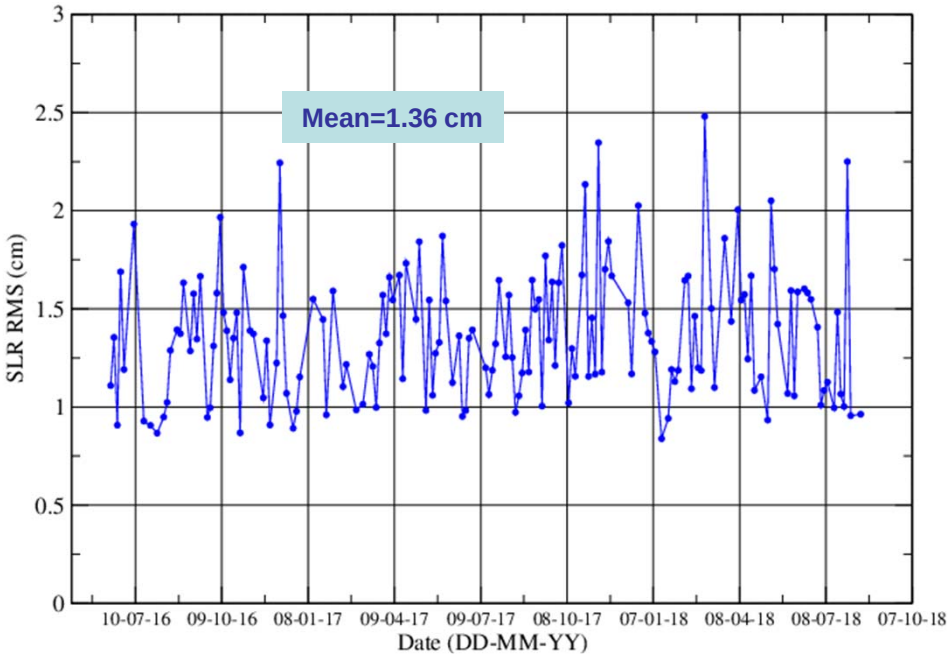


- *The level of DORIS RMS residuals is slightly higher for Sentinel-3B.*

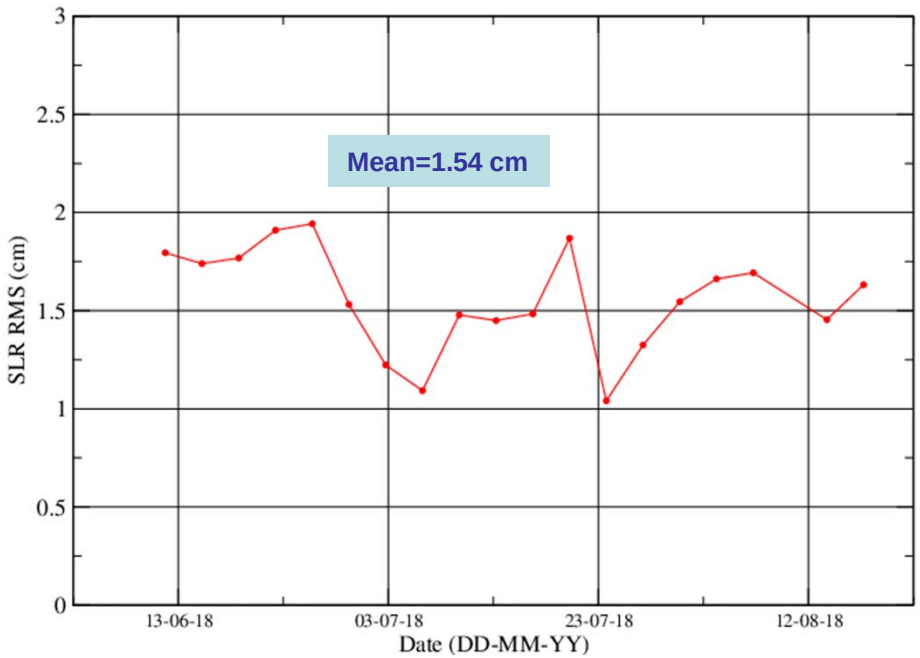
Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ Independent SLR RMS of fit

Sentinel-3A



Sentinel-3B



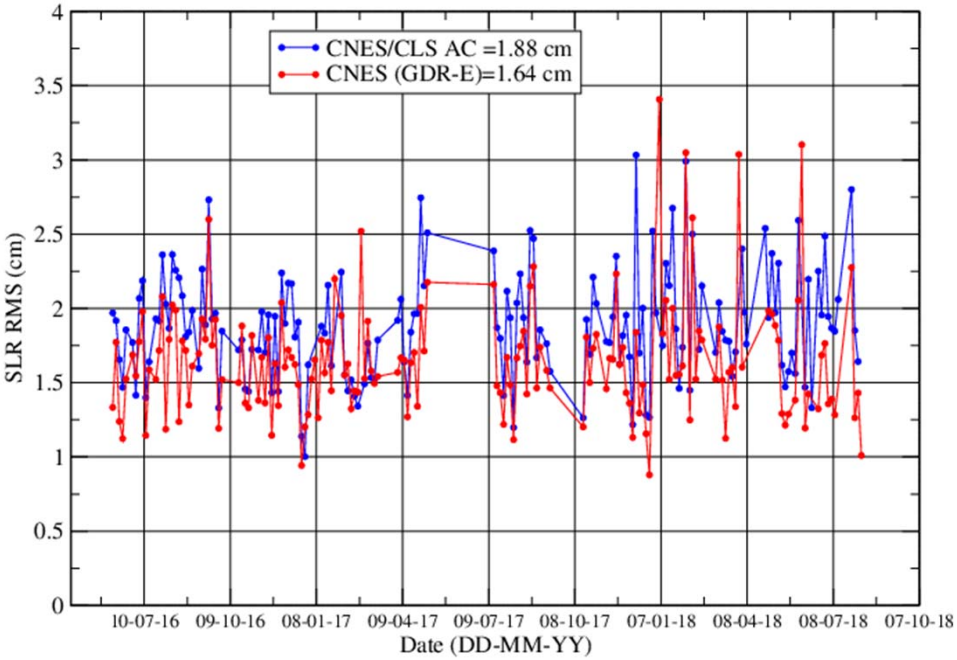
- *The SLR RMS residuals on Sentinel-3A and Sentinel-3B orbits are at a good level.*

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

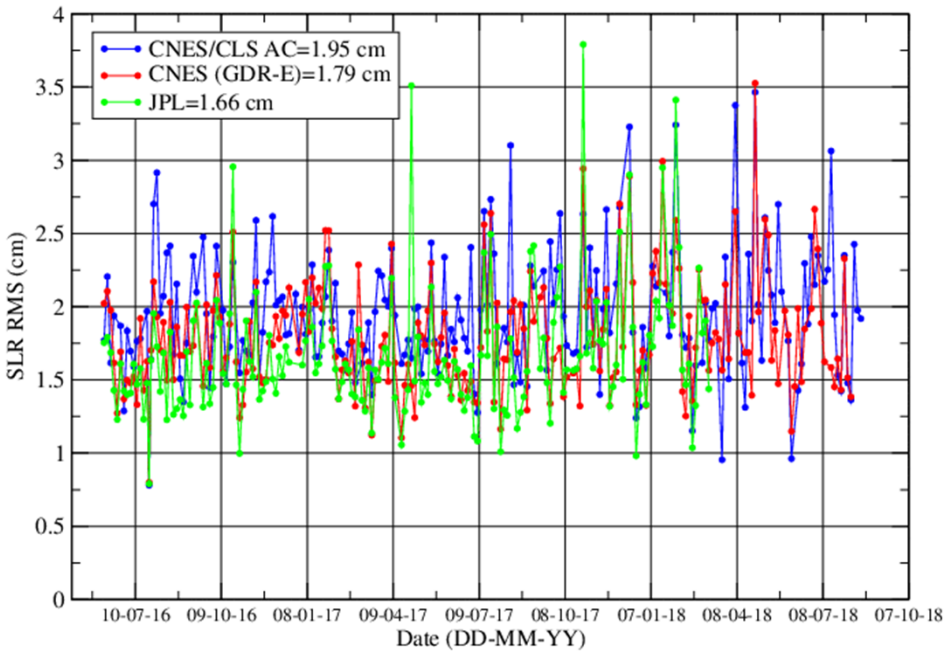
❑ Comparison to CNES (GDR-E) / JPL orbits

Independent SLR RMS of fit

Jason-2



Jason-3



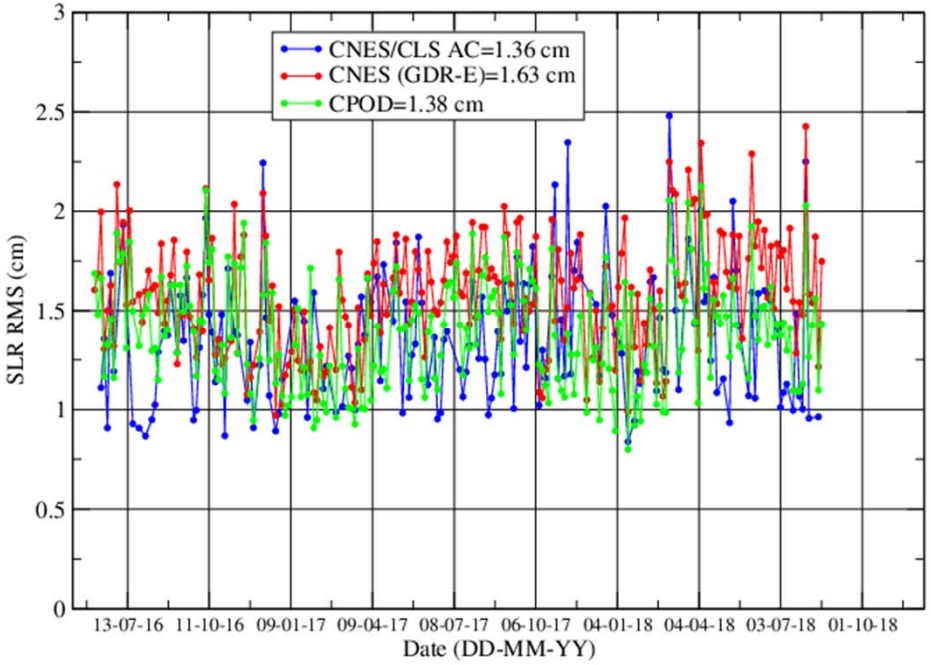
- *The SLR RMS residuals on Jason-2 and Jason-3 orbits are at a good level.*
- *The level is comparable but slightly higher to the others orbits evaluated, CNES-GDR-E and JPL.*

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

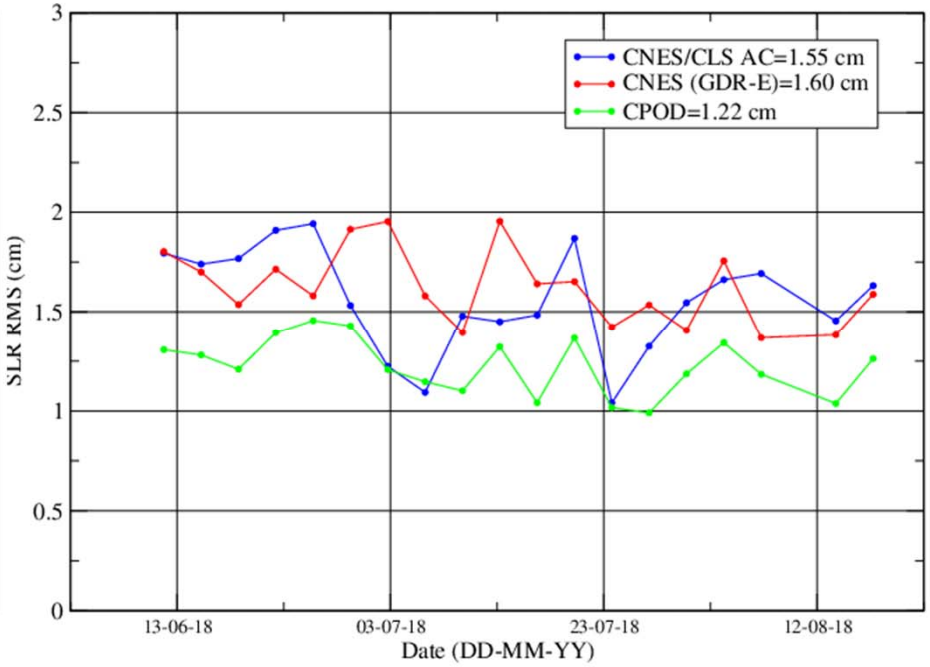
❑ Comparison to CNES (GDR-E) / CPOD orbits

Independent SLR RMS of fit

Sentinel-3A



Sentinel-3B



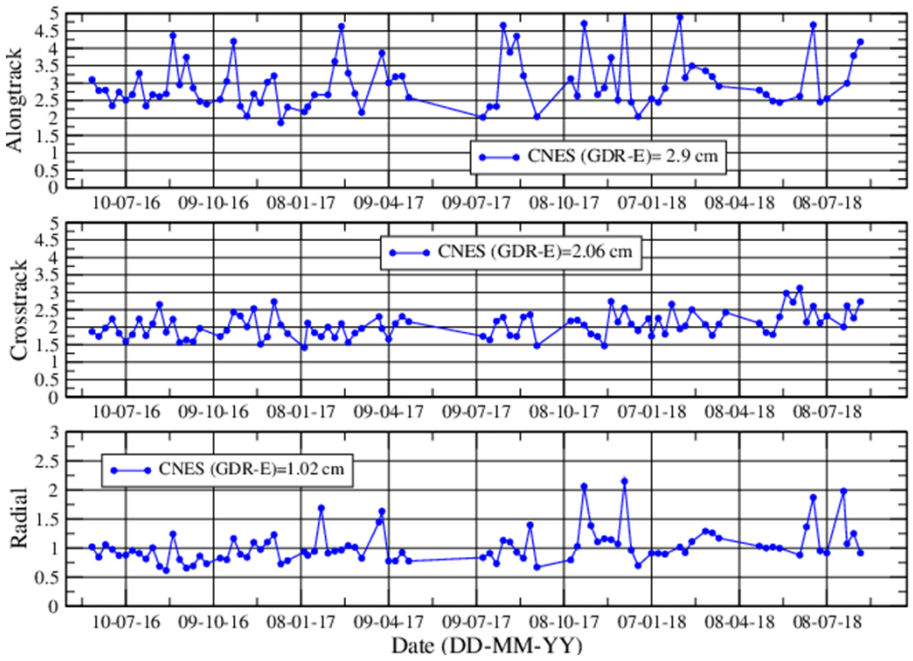
- *The SLR RMS residuals on Sentinel3-A and Sentinel-3B orbits are at a good level.*
- *The level is comparable to the others orbits evaluated, CNES-GDR-E and CPOD.*

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

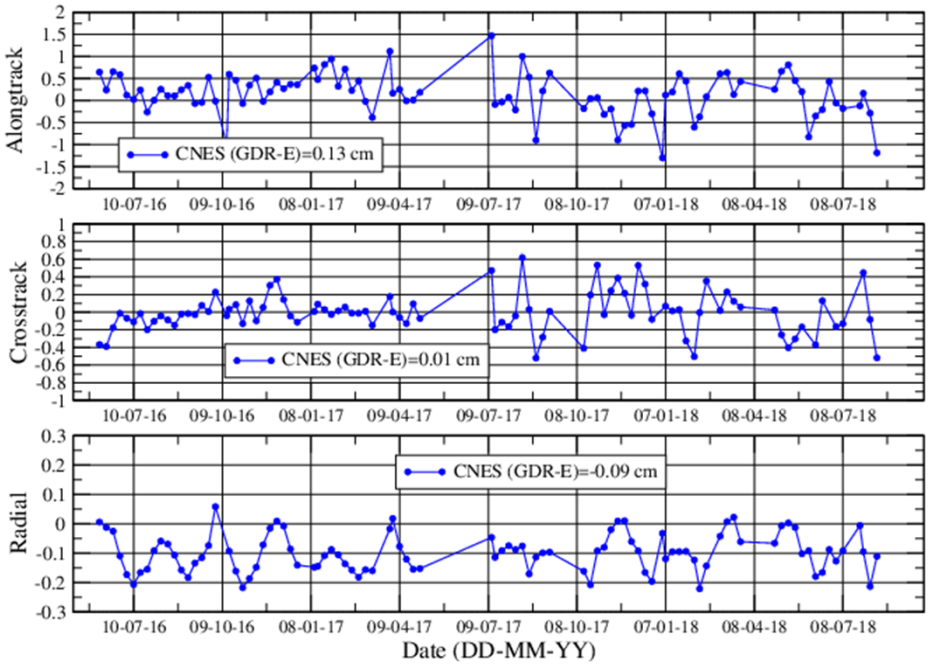
❑ Comparison to CNES (GDR-E) orbits

Jason-2 orbit differences

RMS of orbit differences (in cm)



Mean of orbit differences (in cm)



▪ *There is a good agreement between the orbits calculated with GINS and ZOOM (GDR-E), there is a 60 days periodic signal in the radial component.*

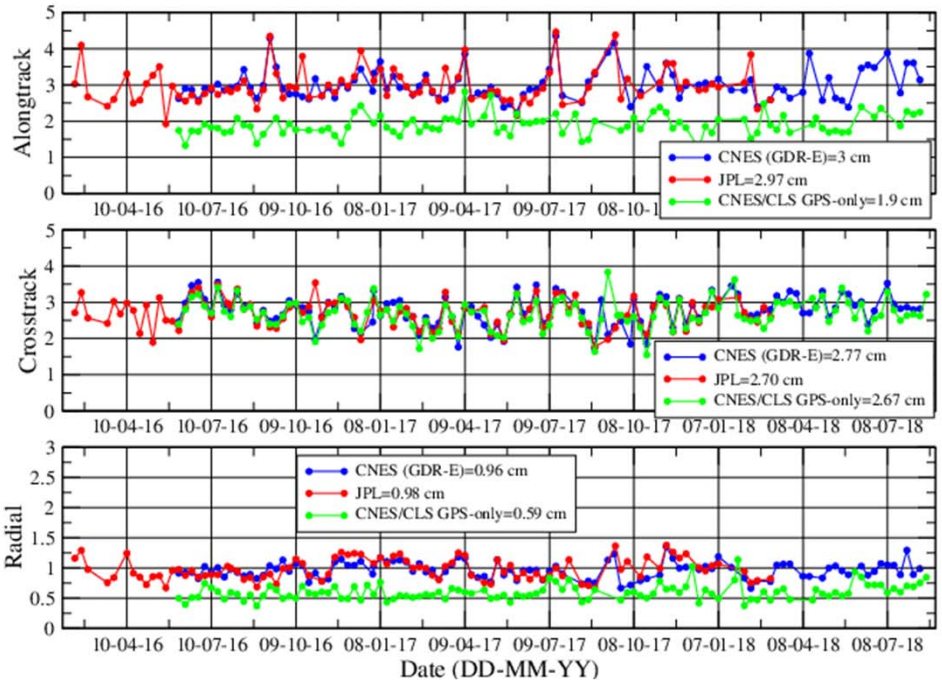
Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ Comparison to CNES (GDR-E) and JPL orbits

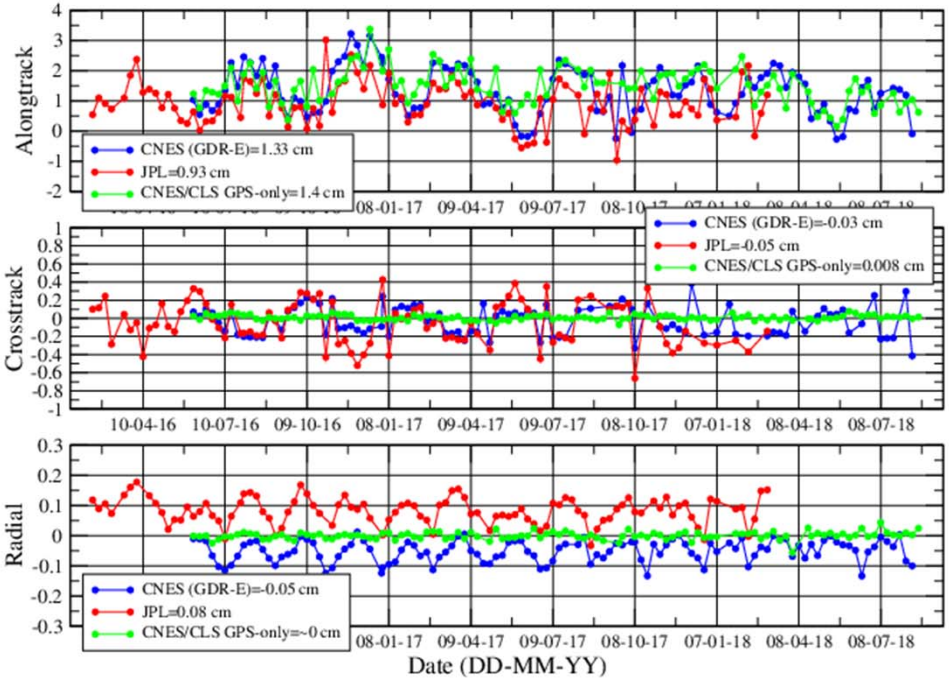
Jason-3 orbit differences

REF = GRG orbit

RMS of orbit differences (in cm)



Mean of orbit differences (in cm)



- *There is a good agreement with the other orbits but there is an along-track bias (>1 cm) which could be explained by the difference in time tagging.*
- *In radial component there is also a bias and a 60 days periodic signal.*

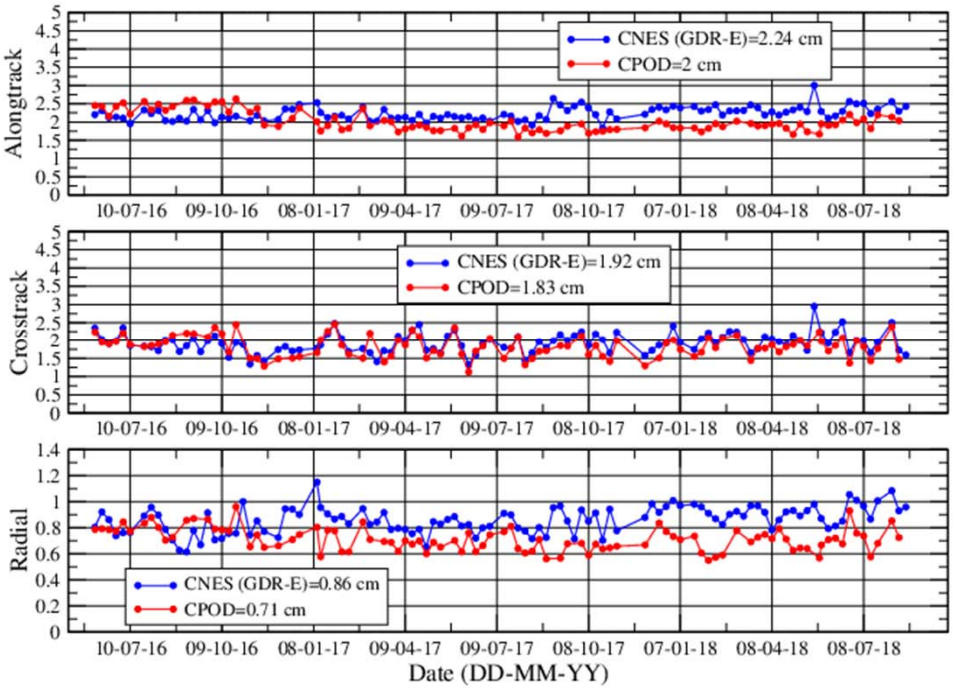
Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ Comparison to CNES (GDR-E) and CPOD orbits

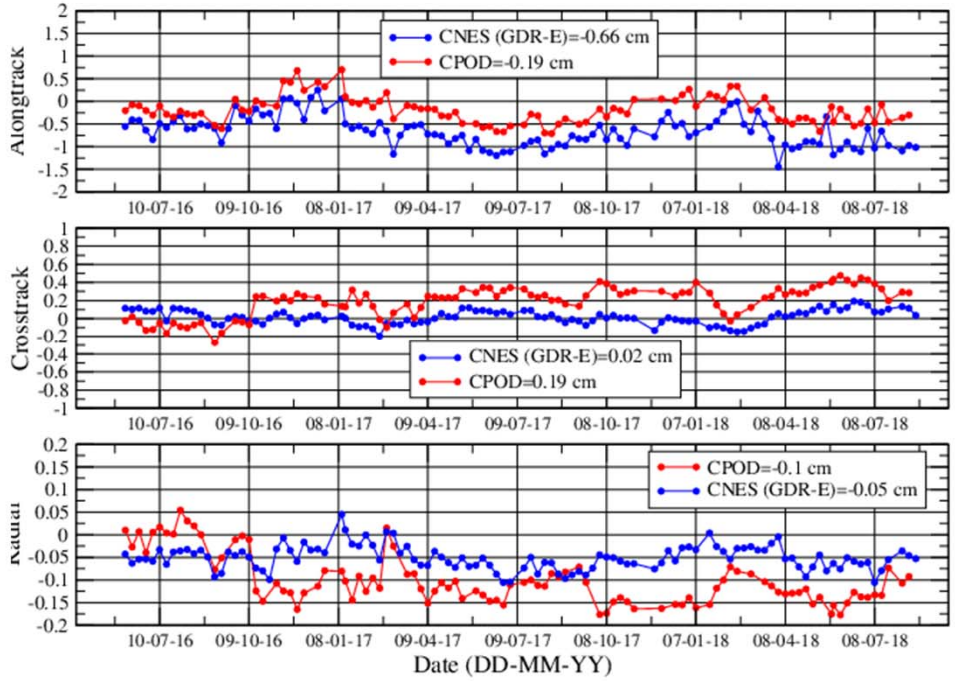
Sentinel-3A orbit differences

REF = GRG orbit

RMS of orbit differences (in cm)



Mean of orbit differences (in cm)



- *For Sentinel-3A, the along-track bias is less important.*
- *In radial component, the bias is higher with CPOD orbit.*

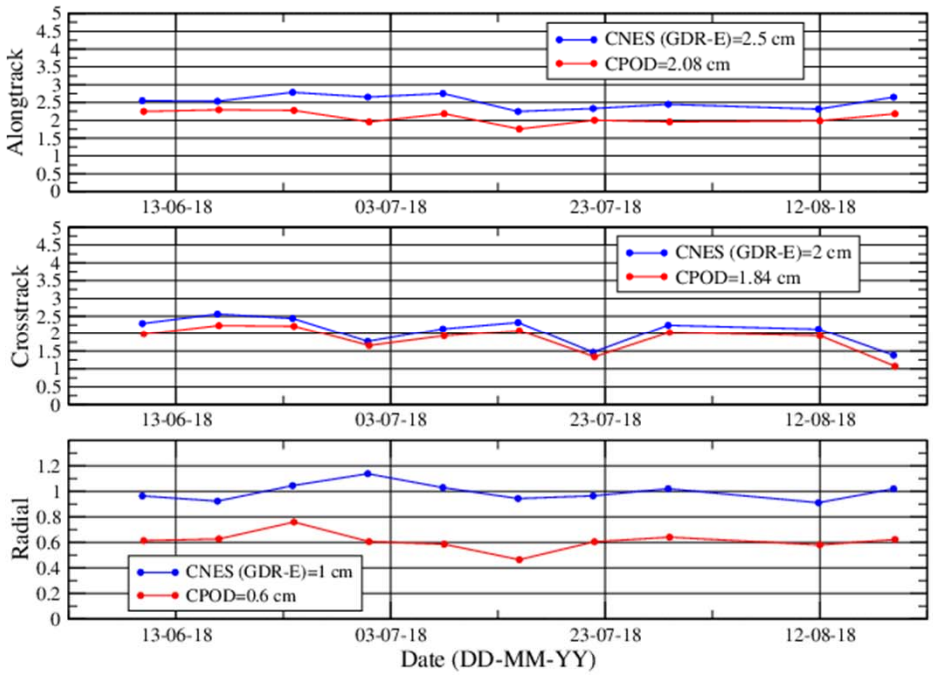
Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ Comparison to CNES (GDR-E) and CPOD orbits

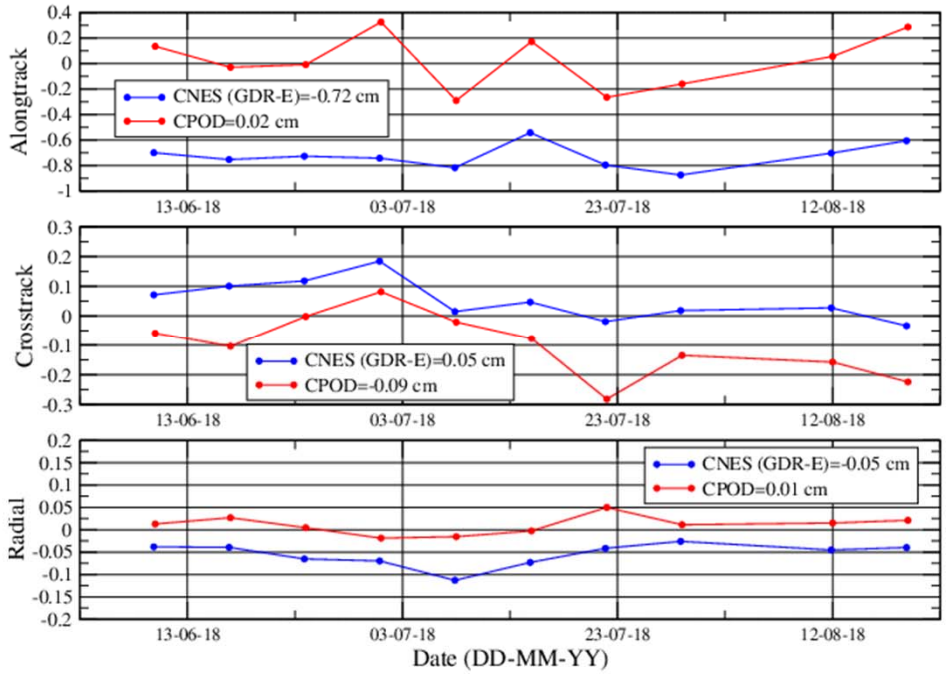
Sentinel-3B orbit differences

REF = GRG orbit

RMS of orbit differences (in cm)



Mean of orbit differences (in cm)



- *The agreement is good but there is an along-track bias (~ -7 mm) vs GDR-E orbit.*
- *The comparison to CPOD orbit gives better results*

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

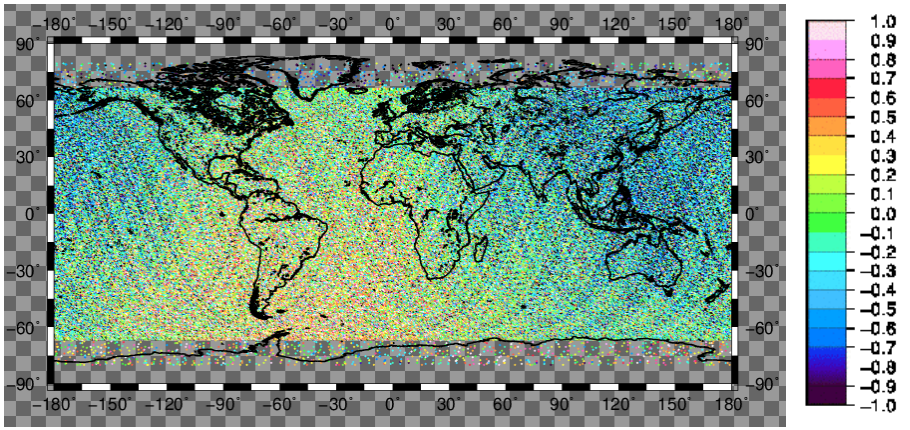
❑ Comparison to CNES (GDR-E) / JPL orbits

Radial geographically correlated errors

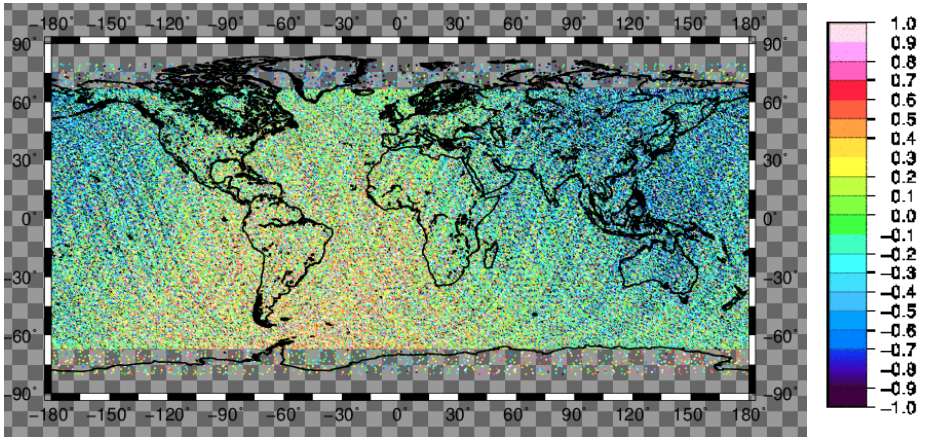
Mean of 115 weeks
(from June 2016 to August 2018)
(2° by 2° grids)

REF = GRG orbit

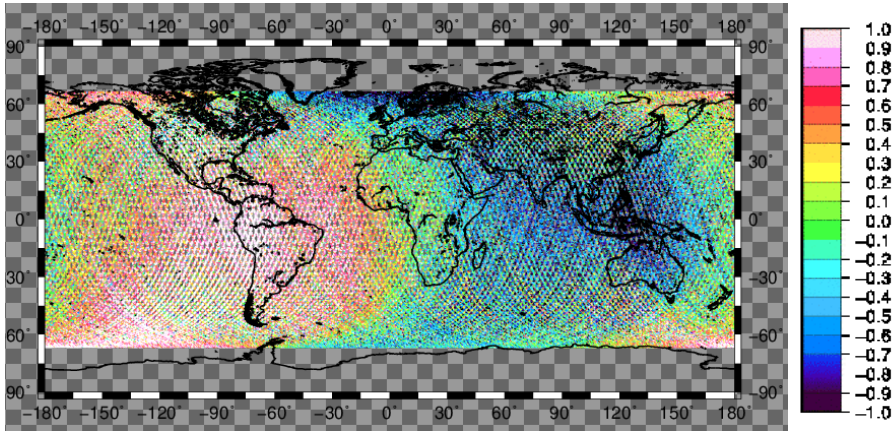
Jason-3
GDR-E – REF (in cm)



Jason-2
GDR-E – REF (in cm)



Jason-3
JPL – REF (in cm)



- *There is a good agreement between CNES/CLS and CNES GDR-E orbits*
- *An East/West patches for radial geographical systematic differences with JPL orbits.*

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ Comparison to CNES (GDR-E) / CPOD orbits

Radial geographically correlated errors

Mean of 115 weeks

(from June 2016 to August 2018)

(2° by 2° grids)

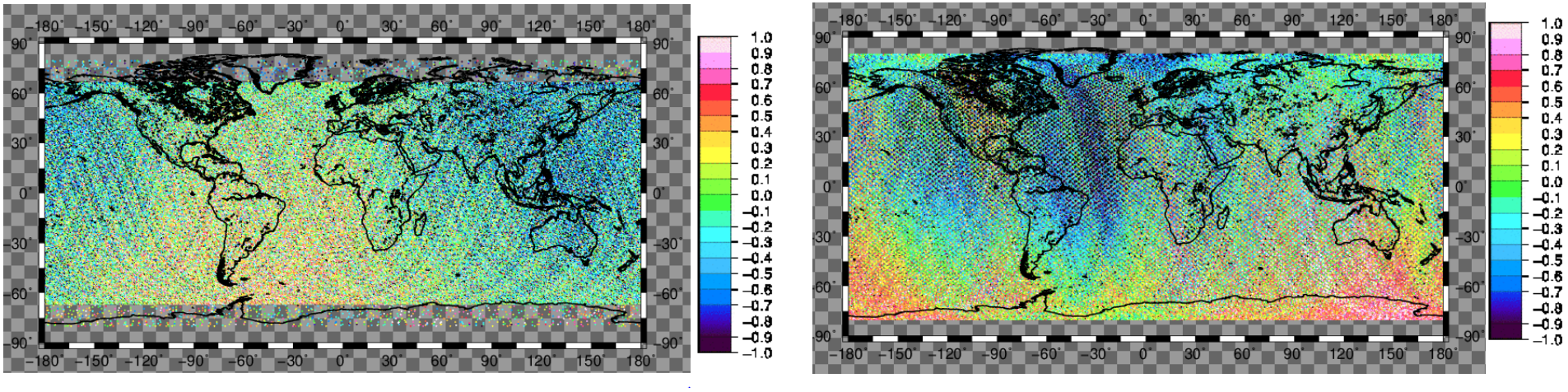
Sentinel-3A

GDR-E – REF (in cm)

REF = GRG orbit

Sentinel-3A

CPOD – REF (in cm)



- *There is a better agreement between CNES/CLS and CNES GDR-E orbits*

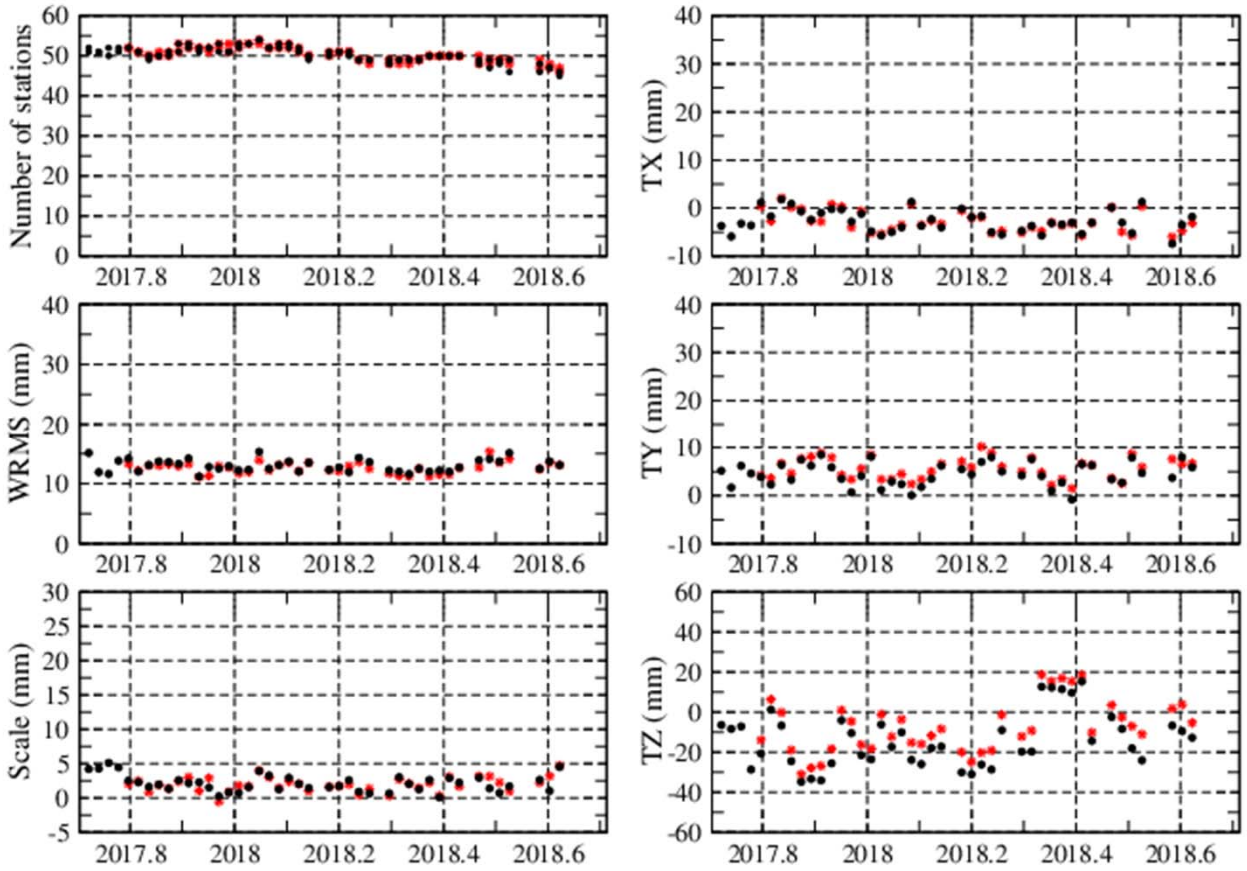
Status of POD for Jason-2&3 and Sentinel-3A&B satellites

❑ Add Sentinel-3 single satellite solutions in the multi-satellite solution

Multi-satellite Solution (weekly) compared to DPOD2014 (from June 2016 to August 2018)

Solution 1: Jason-2 + Cryosat-2 + HY-2A + Saral + Jason-3

Solution 2: Solution 1 + Sentinel-3A + Sentinel-3B



- *The addition of Sentinel-3 solutions has not a big impact on the multi-satellite*

Conclusions and perspectives

Status of POD for Jason-2&3 and Sentinel-3A&B satellites

- *The Sentinel-3B satellite was added in the DORIS processing chain of the CNES/CLS Analysis Center.*
- *The POD results are of good quality but the DORIS RMS for Jason-3 and Sentinel-3 satellites are still higher than the other DORIS satellites. For Jason-3, that could be explained by the SAA effect.*

- *The orbit comparisons give good agreement with CNES GDR-E and CPOD orbits.*

- *The Sentinel solutions were added in the multi-satellite solution which will be provided to IDS combination center*

Future work

- *Using quaternions for the s/c body and solar array for Jason-2 and Jason-3 (in progress)*
- *Comparison to GPS-only and DORIS-GPS orbits*
- *Preparation to the next ITRF:*
  - *Implementation of models recommended by IERS (linear mean pole model FES2014, …)*
  - *Analyze Geocenter and Scale factor from single satellite solutions (in progress)*