
**IDS Workshop**
*Ponta Delgada, September 2018*

# Improvement of the CNES/CLS IDS Analysis Center solution for the contribution to the next ITRF

Hugues Capdeville, Jean-Michel Lemoine
**CNES/CLS AC (GRG)**

# Outline

- ❑ CNES/CLS (grg) AC status

- ❑ Introduction of Sentinel-3B in the CNES/CLS processing chain
  - Processing strategy
  - OPR and DORIS RMS of fit
  - Independent SLR RMS of fit
  - Orbit comparison

- ❑ Improvement of the CNES/CLS IDS Analysis Center solution
  - Geocenter and scale of single satellite solutions

- ❑ Conclusions and perspectives

# CNES/CLS AC STATUS

## ❑ Status of the routine DORIS data processing

- **We processed DORIS2.2 and RINEX data until August 2018**

- **New serie grgwd41**

ITRF2014 configuration

**List of last additions:**

• Introduction of Jason-3 and Sentinel-3A (RINEX data) in the GRG DORIS processing
• Switch to the ITRF/DPOD2014
• DORIS-only orbits processing and evaluation by SLR processing
• Strategy to mitigate the SAA impact for Jason-2 and Jason-3
  on the orbit (adjusting of frequency Polynomial on SAA station per pass)
  on the positioning (renaming of SAA stations)
• Remove the DORIS scale jump in 2012
  use the new position of the HY-2A CoM given by the Chinese Project
  make our own pre-processing when using Doris2.2 data

•Introduction of Sentinel-3B (RINEX data) in the GRG DORIS processing

- **We provided Sentinel3-A DORIS-only orbits to CPOD QWG since Sep. 2017**

# Introduction of Sentinel-3B in the CNES/CLS processing chain

## ❑ 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** | nominal law like Envisat |
| **Surfaces Forces & Estimated Parameters** | Box-wing model for solar radiation,drag, Albedo and IR<br>Macromodel available at :<br>*ftp://ftp.ids-doris.org/pub/ids/satellites/DORISSatelliteModels.pdf*<br>Radiation pressure scale coefficient :<br>1 coef/day but strongly constrained to: 0.99 for Jason and 1.0 for Sentinel-3<br>OPR empiricals: 2 coeff cos-sin /orbital period in normal direction and 2 coeff cos-sin /orbital period in tangential direction (per arc)<br>Drag coefficients adjusted: 1 coef/4 hours for Sentinel-3 and 1 coef/half day for Jason |
| **Time span processing** | From June to end August 2018<br>3.5-day arcs with a cut-off angle of 12° |

# Introduction of Sentinel-3B in the CNES/CLS processing chain

## ❑ POD Summary

**DORIS RMS of fit and SLR external validation**

**OPR Acceleration Amplitude:**

Along-track and Cross-track / Radiation pressure coefficient

| SATELLITE | DORIS RMS (mm/s) | SLR RMS (cm) | OPR amplitude average ($10^{-9}$ m/s$^2$) | | Solar radiation coefficient |
|---|---|---|---|---|---|
| | | | Along-track | Cross-track | |
| Sentinel-3B | 0.38 | 1.5 | 1.8 | 2.3 | 1.00 |
| Sentinel-3A | 0.37 | 1.4 | 2.3 | 1.9 | 1.00 |

*from June 2016 to August 2018 for Sentinel 3A*
*from June to August 2018 for Sentinel 3B*

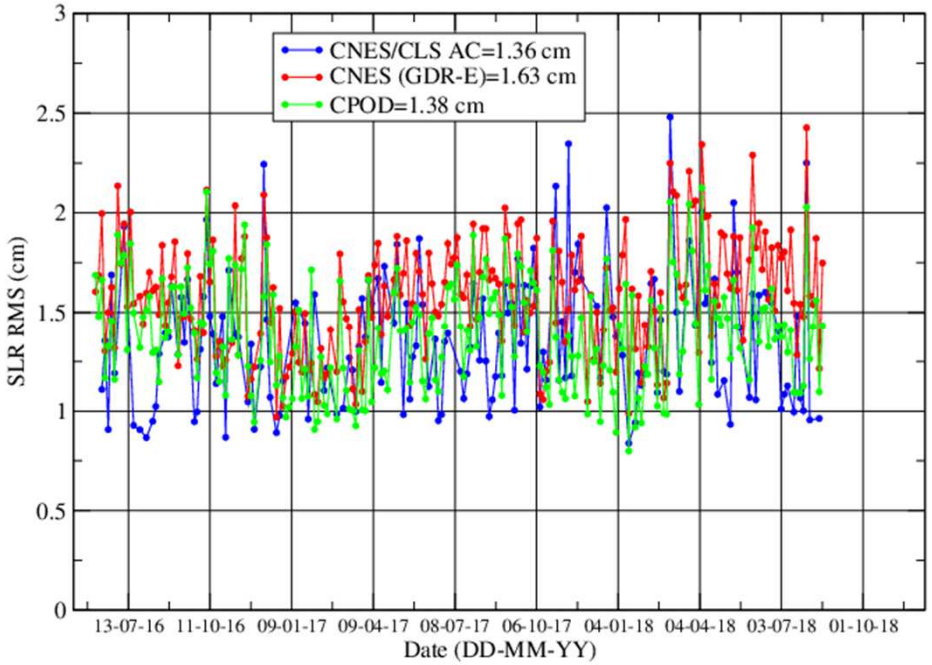
- *Solar radiation coefficient adjusted overall processing period*
- *For the two directions, Along-track and Cross-track, the mean amplitudes are lower than 4x$10^{-9}$ m/s$^2$, reflecting a satisfying level in the modeling of the satellite macromodels and the attitude law.*

# Introduction of Sentinel-3B in the CNES/CLS processing chain

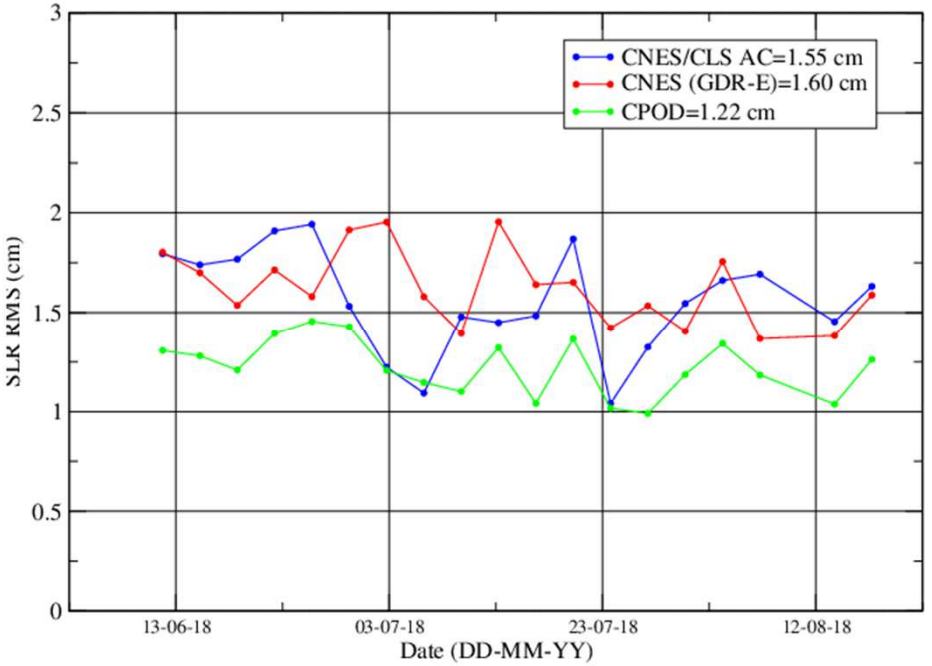
## ❑ Comparison to CNES (GDR-E) / Copernicus (CPOD) orbits

### Independent SLR RMS of fit

**Sentinel-3A**




**Sentinel-3B**



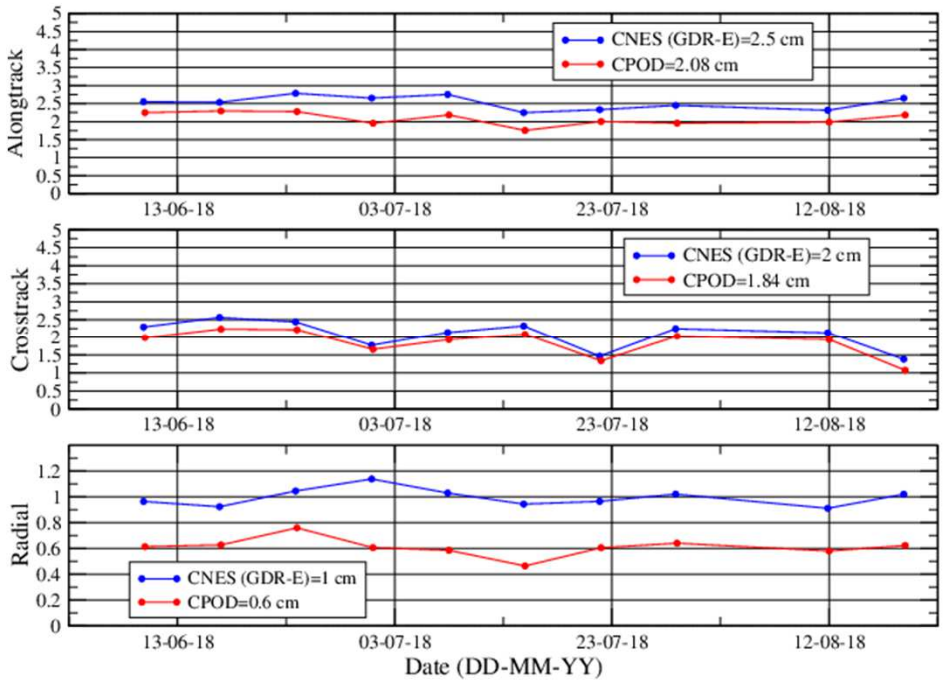

- *The SLR RMS residuals on Sentinel3-A and Sentinel-3B orbits are at a good level.*
- *The level is comparable to the others orbits evaluated, CNES-GDR-E and CPOD.*

# Introduction of Sentinel-3B in the CNES/CLS processing chain

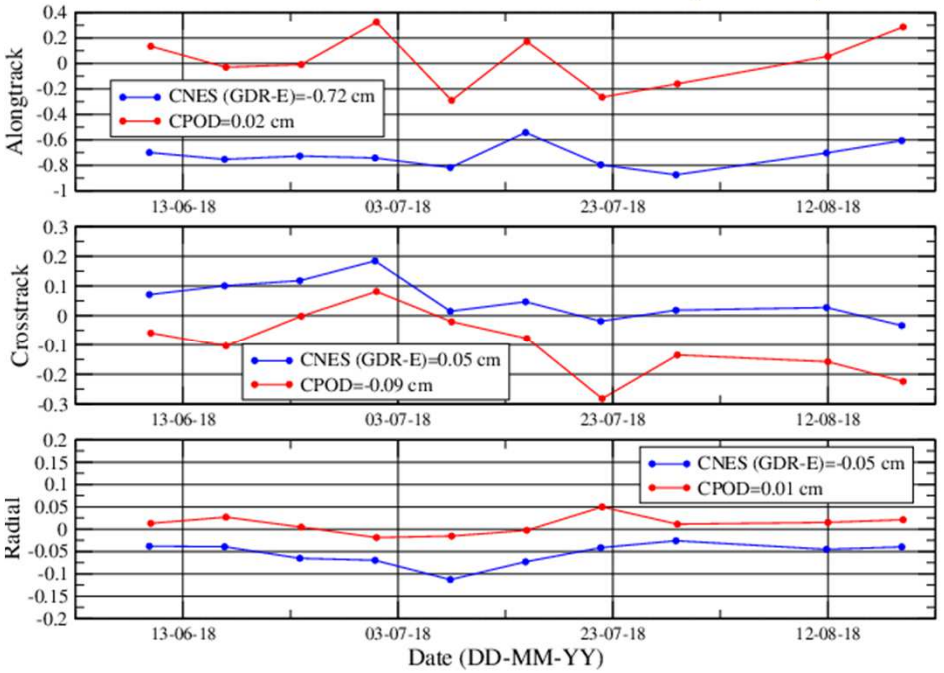
## ❑ Comparison to CNES (GDR) / Copernicus (CPOD) orbits

**Sentinel-3B orbit differences**

### 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*

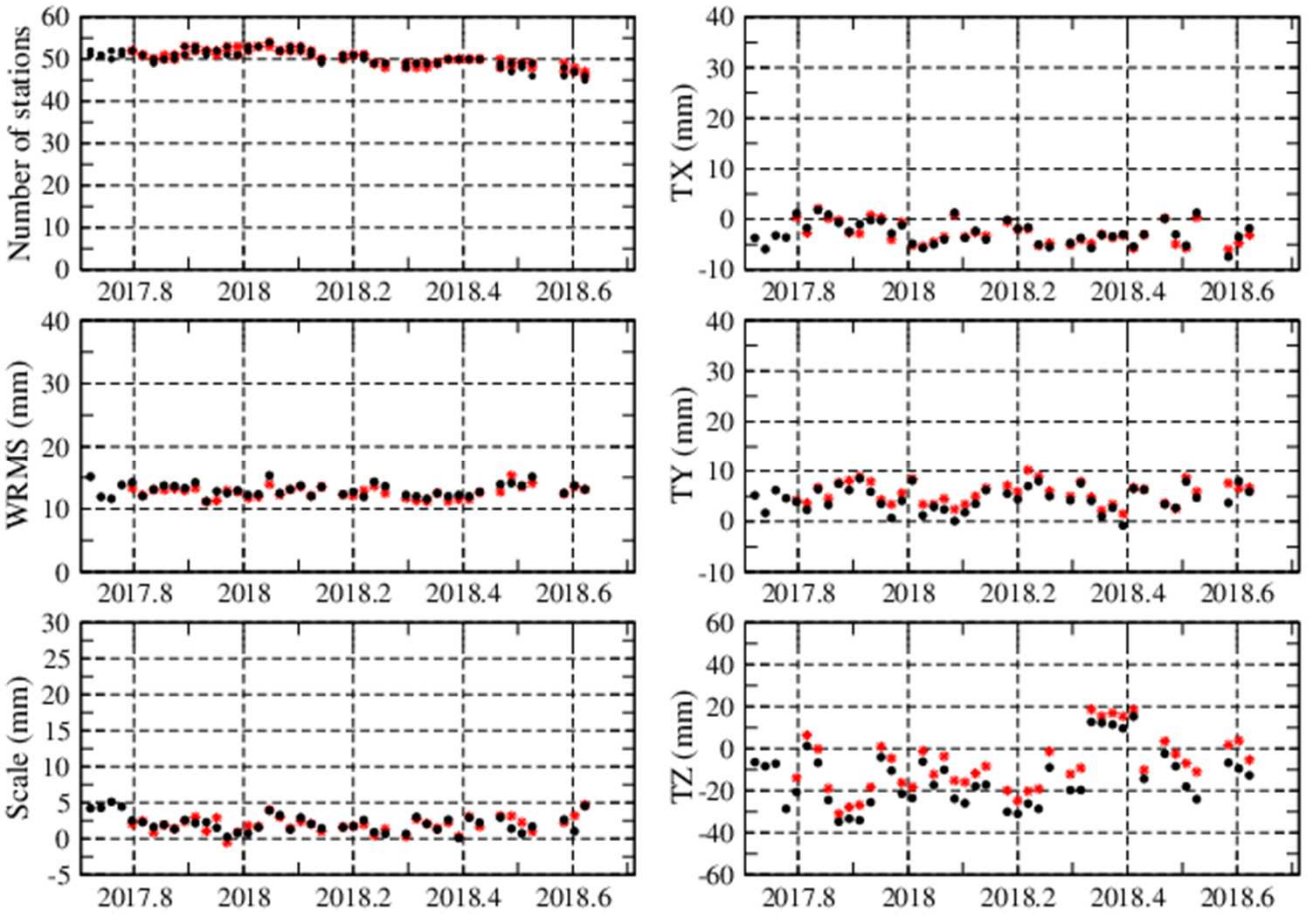
# Introduction of Sentinel-3B in the CNES/CLS processing chain

## ❑ 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*

# Improvement of the CNES/CLS IDS Analysis Center solution

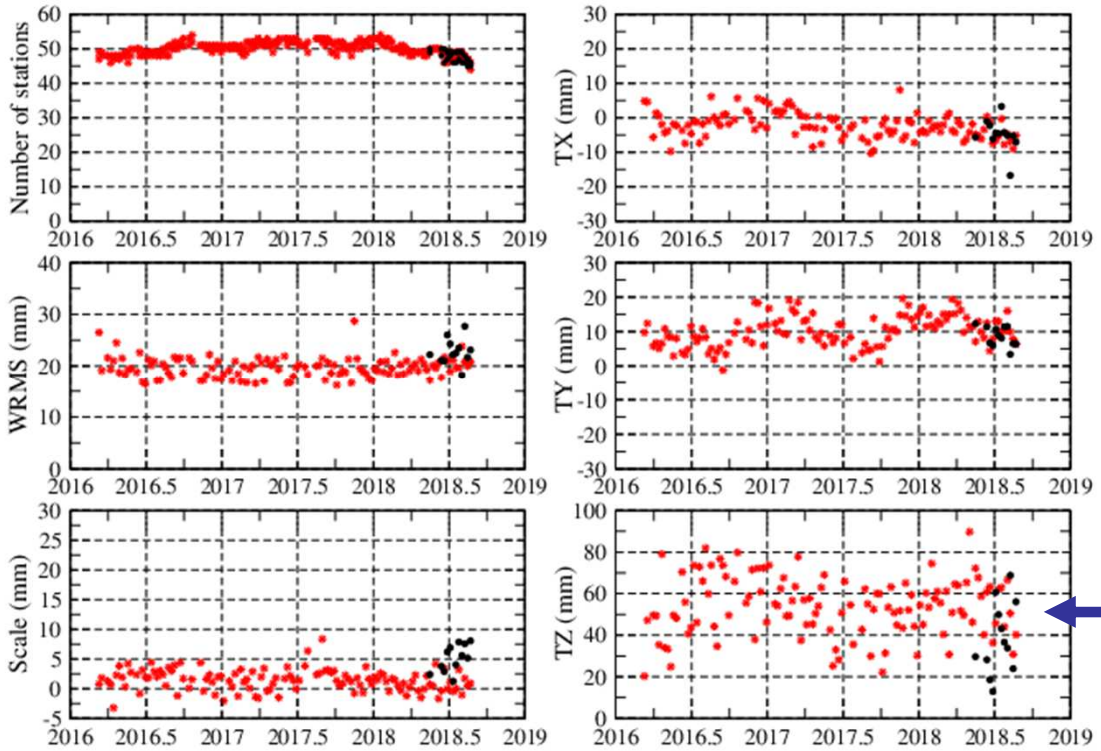
## ❑ Context

The DORIS scale factor and geocenter is the combination of each single DORIS satellite solutions. Previous studies showed that single satellite solutions can have some large scale or geocenter values, such as the HY-2A scale. We have already identified a high value for Tz translation for several satellites.

## ❑ Determination of the single satellite solutions

Comparison of each solution to DPOD2014 (computed by CATREF)

**Scale Factor and Geocenter from single satellite solutions**




**Sentinel-3A&3B Scale and geocenter**

*A high bias in Tz ~ 6 cm*

# Improvement of the CNES/CLS IDS Analysis Center solution

## ❑ Tz bias origin

Could be related to a wrong position in the crosstrack direction for DORIS receiver phase center (CoP) or for Center of gravity (CoG)

## ❑ Estimation of the distance between the satellite CoG and DORIS CoP

- **Cross-track offset for Sentinel-3**

| Component | Original value (m) | Estimated value (m) | Offset (cm) |
|---|---|---|---|
| X (along-track) | +1.570 | +1.570 | no |
| Y (cross-track) | +0.073 | +0.093 | +2 |
| Z (radial) | +0.760 | +0.760 | ~0.1 |

## ❑ Impact of the use of the DORIS CoP value estimated

Use new cross-track value DORIS Phase center position: Y=Yi + 2 cm

- **Impact on the obit**

No significantly impact:

The orbit differences are very small in the three components

DORIS RMS of fit very slightly lower

| SATELLITE | Sentinel-3A | Sentinel-3B |
|---|---|---|
| DORIS RMS (mm/s) | 0.36295 / 0.36275 | 0.38181 / 0.38173 |

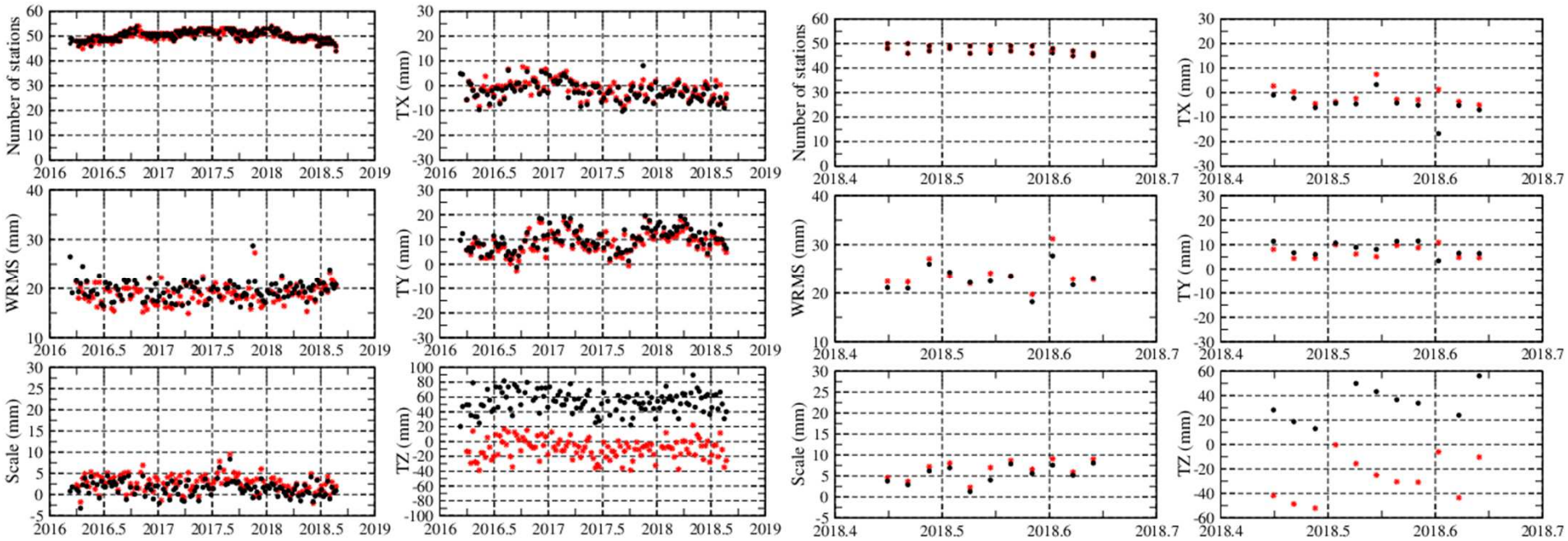
# Improvement of the CNES/CLS IDS Analysis Center solution

## ❑ Impact of the use of the DORIS CoP value estimated

- Impact on the positioning

Scale Factor and Geocenter

**Sentinel-3A** **Sentinel-3B**




*when we use the CoP estimated*

- *The Tz bias vanishes*
- *Solution is more consistent with the ITRF-DPOD2014*

# Improvement of the CNES/CLS IDS Analysis Center solution

## ❑ Impact of the use of the DORIS CoP value estimated

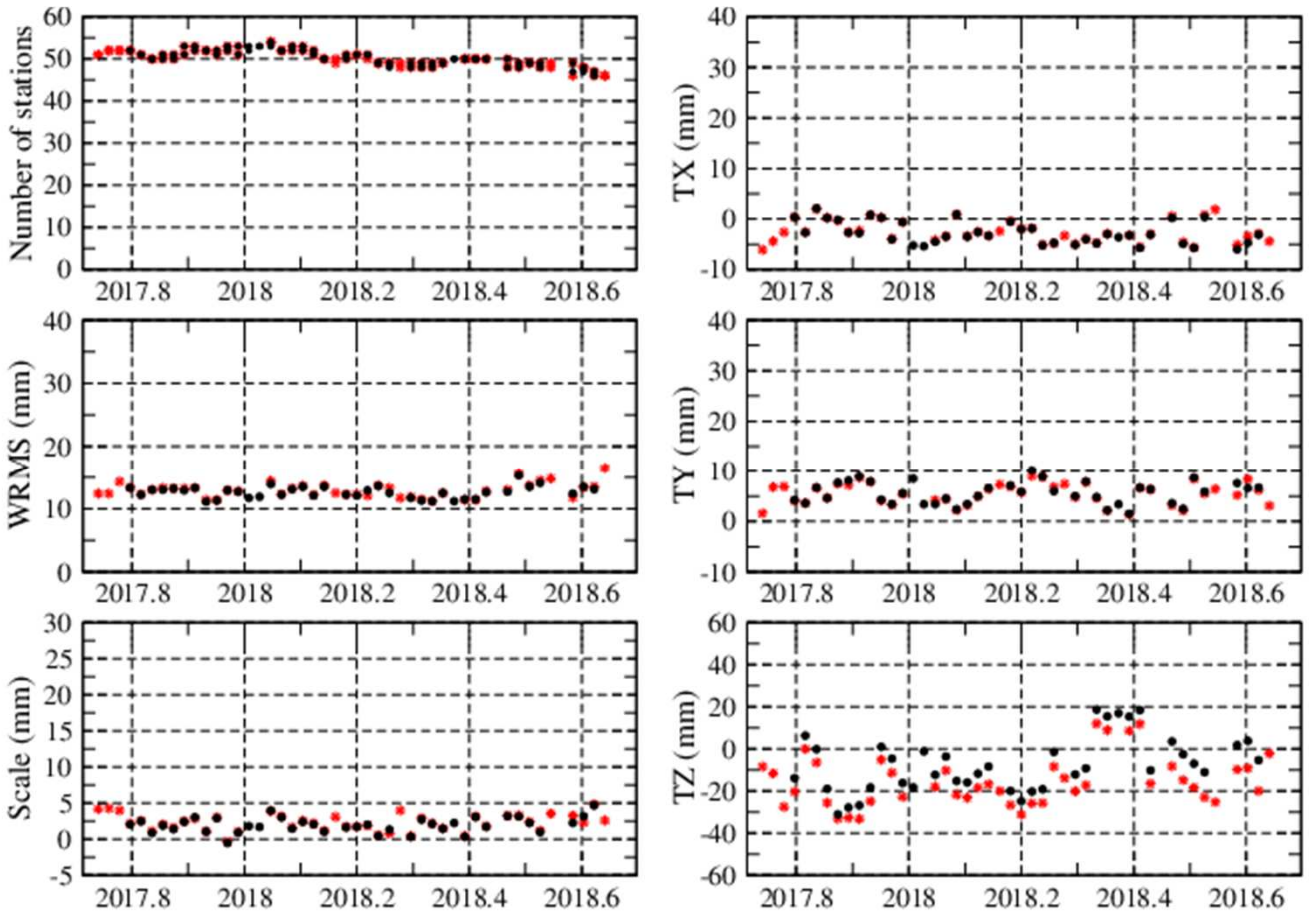
- Impact on the positioning

**Multi-satellite satellite Solution compared to DPOD2014 (computed by CATREF)**

Differences between the solution with original and estimated DORIS CoP

Solution=Jason-2 + Cryosat-2 + HY-2A + Saral + Jason-3 + Sentinel-3A + Sentinel-3B

In red multi-satellite solution with COP correction for Sentinel satellites



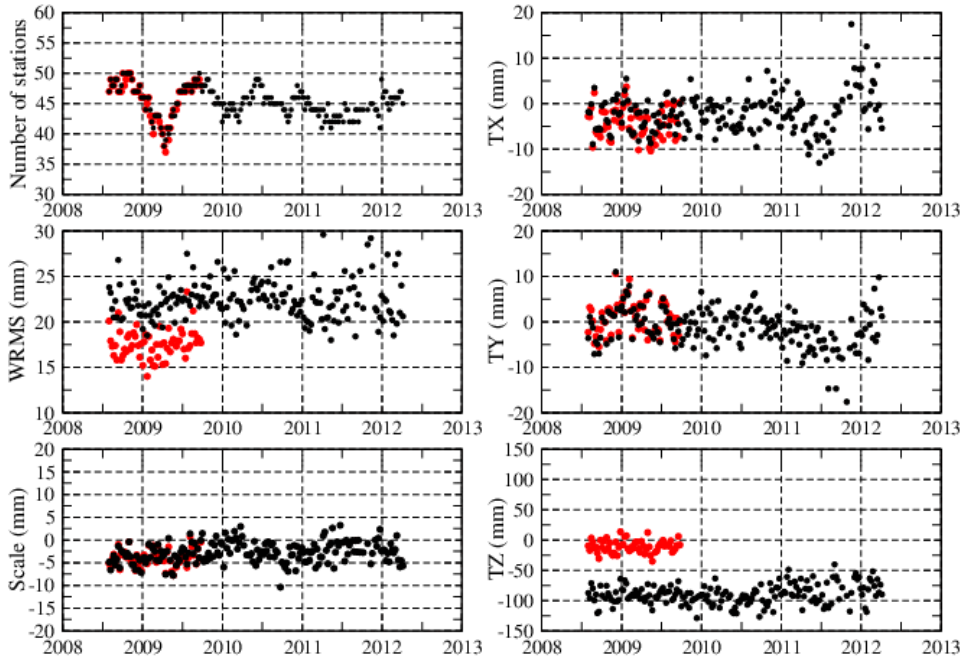
# Improvement of the CNES/CLS IDS Analysis Center solution

## ❑ Estimation of the distance between the satellite CoG and DORIS CoP

- **Cross-track offset for ENVISAT**

| Component | Original value (m) | Estimated value (m) | Offset (cm) |
|---|---|---|---|
| X (cross-track) | -7.052 | -7.077 | -2.5 |
| Y (along-track) | -1.085 | -1.085 | no |
| Z (radial) | -1.725 | -1.725 | ~-0.1 |

## ❑ Impact of the use of the DORIS CoP value estimated




*When we use the CoP estimated*

- *No significantly impact on the orbit*

*The orbit differences are very small in the three components*
*DORIS RMS of fit very slightly lower*

- *The Tz bias vanishes*
- *Solution is more consistent with the ITRF-DPOD2014*

# Conclusions and Perspectives

## ❑ Introduction of Sentinel-3B in the CNES/CLS AC processing chain

The POD results are of good quality but the DORIS RMS are still higher than the other DORIS satellites. The orbit comparisons give good agreement with CNES GDR-E and CPOD orbits.

## ❑ Improvement of the CNES/CLS IDS Analysis Center solution

- Strategy to mitigate the SAA impact for Jason-2 and Jason-3
  - on the orbit (adjusting of frequency Polynomial on SAA station per pass)
  - on the positioning (renaming of SAA stations)
- Remove the DORIS scale jump in 2012
  - use the new position of the HY-2A CoM given by the Chinese Project
  - make our own pre-processing when using Doris2.2 data
- Analyze Geocenter and Scale factor from single satellite solutions (in progress)

Estimation of the distance between the satellite CoG and DORIS CoP

- done for Sentinel satellites and HY2A

Same analysis to be done for the other DORIS satellites

An IDS working group could analyze the impact of the cutoff angle/ data down-weighting law at low elevation / mapping function of the tropospheric correction on the scale factor and vertical positioning

## ❑ Using quaternions for the s/c body and solar array for Jason-2 and Jason-3

(in progress)

## ❑ Implementation of models recommended by IERS

as linear mean pole model, FES2014, …