G11A-04 - IDS first improvements for the next ITRF2020

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Part 1 – DORIS Scale

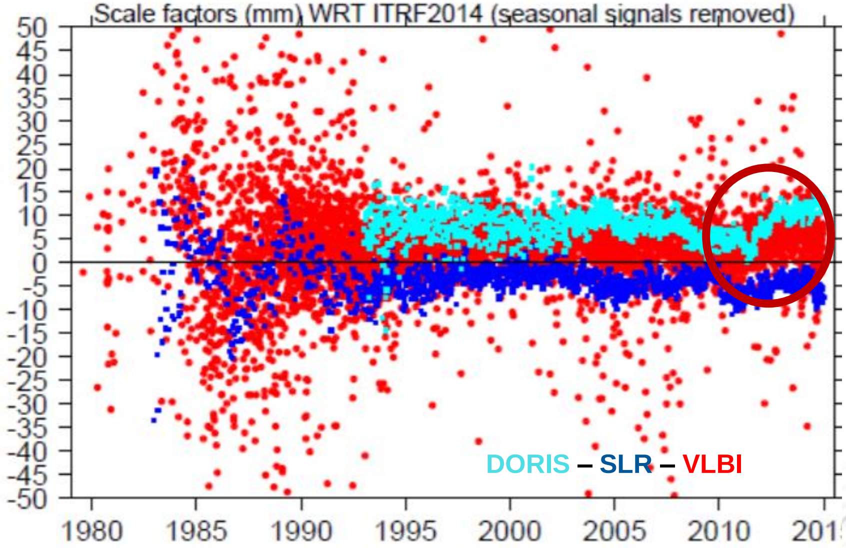
http://ids-doris.org

Scale Increase

The IDS contribution to the ITRF2014 shows a scale increase early 2012.

From VLBI to	Scale at 2010.0 [ppb]	Scale Rate [ppb/yr]
SLR	-1.37 ± 0.10	-0.02 ± 0.02
DORIS	0.48 ± 0.11	-0.03 ± 0.02
SLR with Range Biases	-0.47 ± 0.02	-0.02 ± 0.02

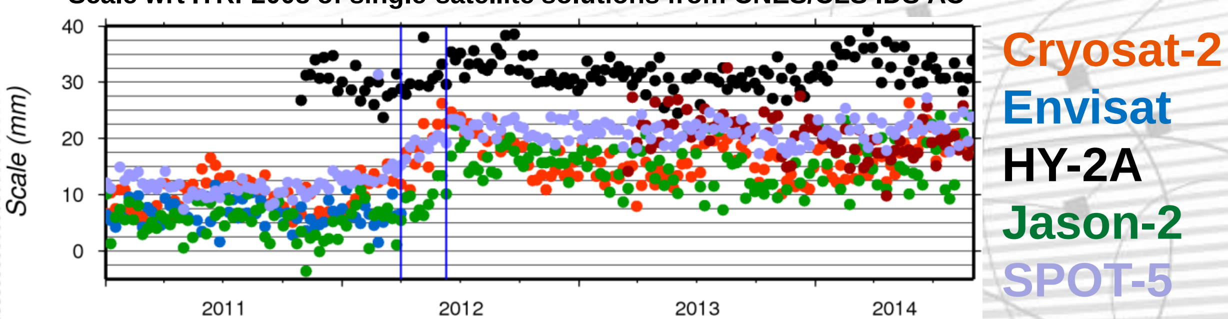
Source: Altamimi et al., IDS Workshop, La Rochelle, 2016.



Consequence of

- Single satellite mission scale increases.
- Adding of the HY-2A mission with a higher scale.

Scale wrt ITRF2008 of single-satellite solutions from CNES/CLS IDS AC

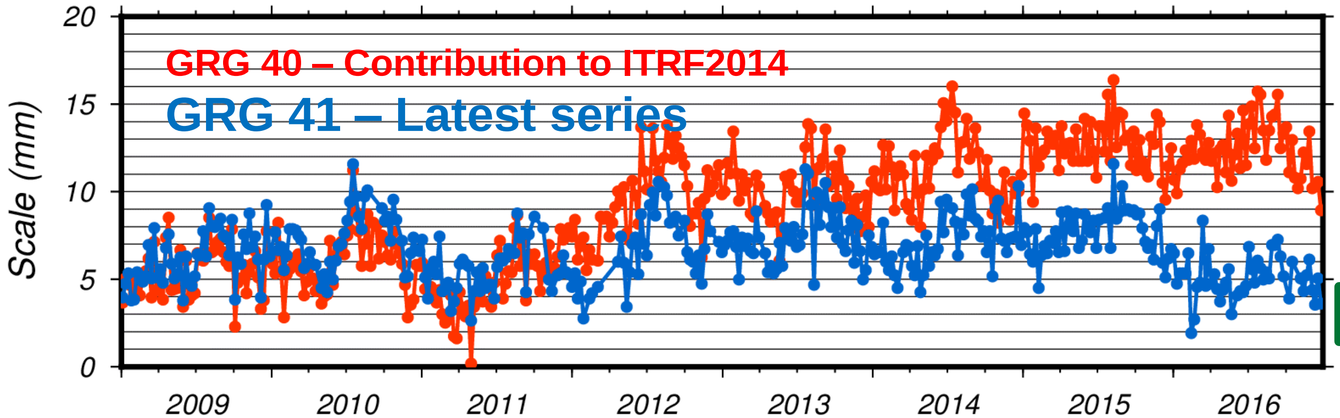


Scale Increase

The IDS identified the reasons for these patterns:

- Wrong CoM-CoP vector for HY-2A.
- Dependency on the validity standards from the data provider.

As demonstrated by the latest GRG multi-satellite solution, **we can now achieve a stable scale from 1993.0 to 2018.0.**



Time Period	Scale Rate [ppb/yr]
1993.0-2012.0	-0.058
2009.0-2018.0	-0.010
1993.0-2018.0	-0.046

Part 2 – South Atlantic Anomaly Mitigation Strategy

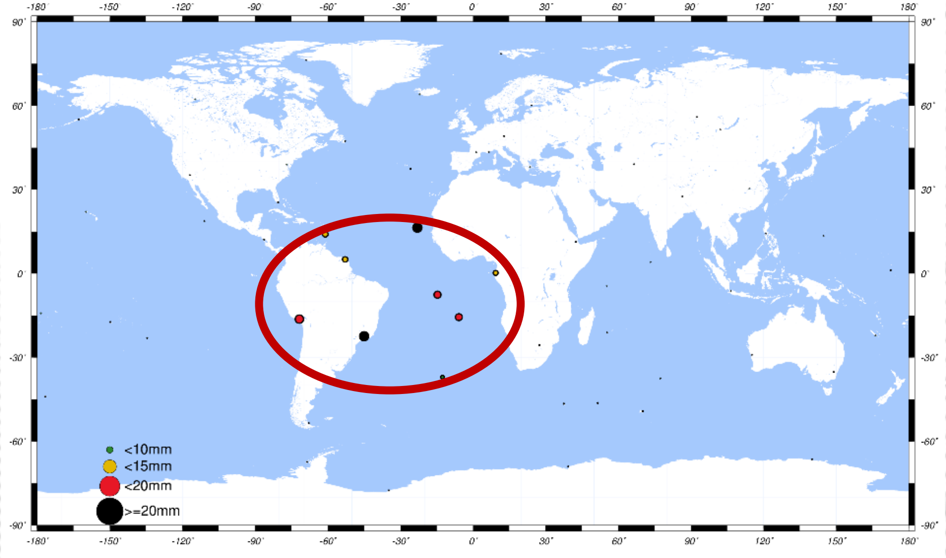
South Altantic Anomaly (SAA)

- The South Atlantic Anomaly (SAA) is an area where the Earth's inner Van Allen radiation belt comes closest to the Earth's surface, dipping down to an altitude of 200 kilometres. This leads to an increased flux of energetic particles in this region and exposes orbiting satellites to higher-than-usual levels of radiation.

- The increased radiation perturbs the crystal quartz oscillators that are the heart of the DORIS system, causing short-term and long-term changes in the frequency behavior.

➔ **Positioning of the DORIS stations located in the area of the SAA was drifting away from the true position.**

The error for these contaminated stations can exceed 40 times the standard positioning error of the other stations



3D RMS of station position differences between one solution with Jason-2 & 3 and one without Jason-2 & Jason-3.

DORIS & South Altantic Anomaly

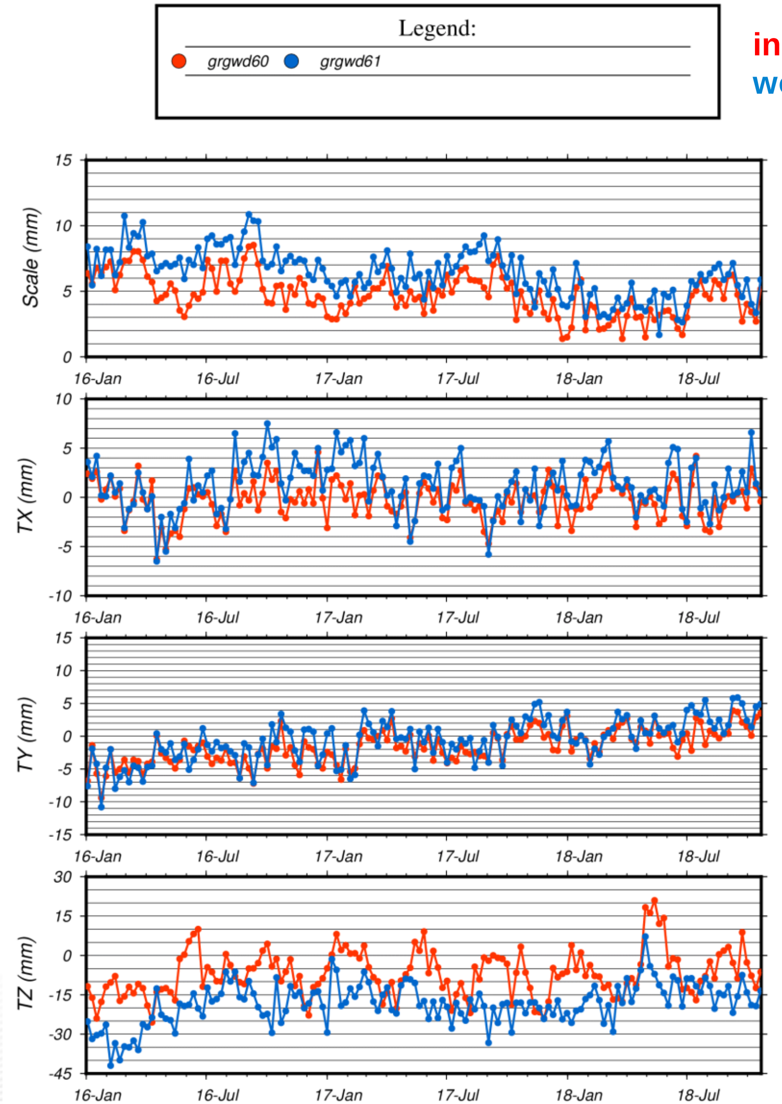
How to solve or account for the DORIS USO frequency shift?

1) Do not include the DORIS missions sensitive to the SAA.
2) Do not include data from stations in the SAA area for missions sensitive to the SAA.
3) Downweight data from stations in the SAA area for missions sensitive to the SAA.
4) <u>Rename the SAA stations in the normal equation while estimating the station positions.</u>
5) <u>Estimation of station clock frequency as linear instead of constant per satellite pass.</u>
6) Develop a data correction model.
7) Obelix strategy: exhibit before launch the DORIS USO to the proton flux.
   But contrary to Obelix, the effect is not for always (Jason-2).

DORIS missions sensitive to the SAA

Mission	SAA Sensitivity	Mitigation Strategy	Comments
SPOT-5	++	Data correction model available	Used for ITRF2014
Jason-1	+++	Data correction model available	Used for ITRF2014
Jason-2	+	TBD – Model expected from Belli	
Jason-3	++	TBD	

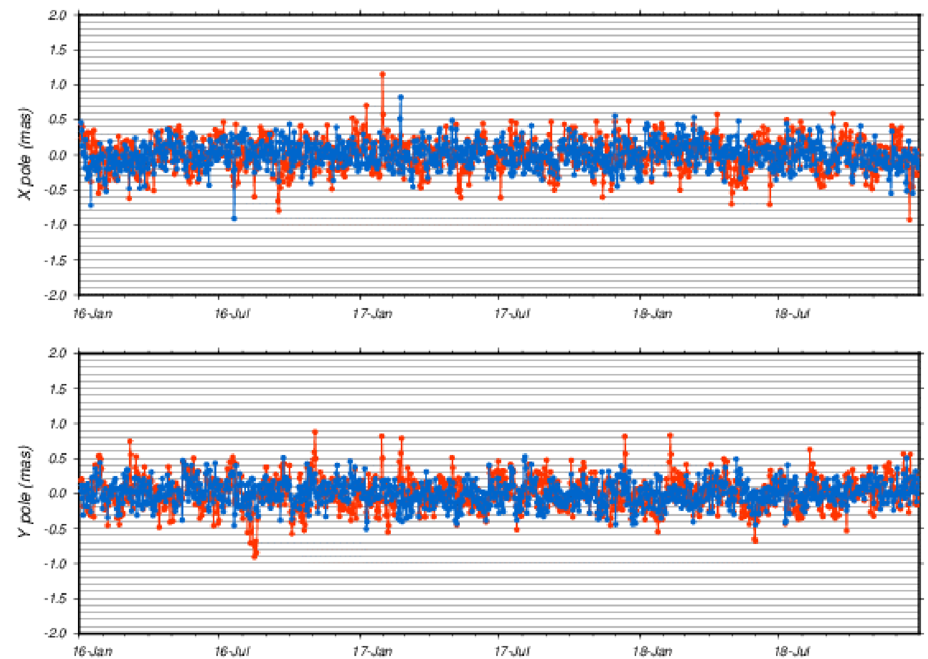
Helmert Parameters & EOPs



includes Jason-2&3 with SAA strategy applied

wo Jason-2&3

Time period: 2016.0-2019.0

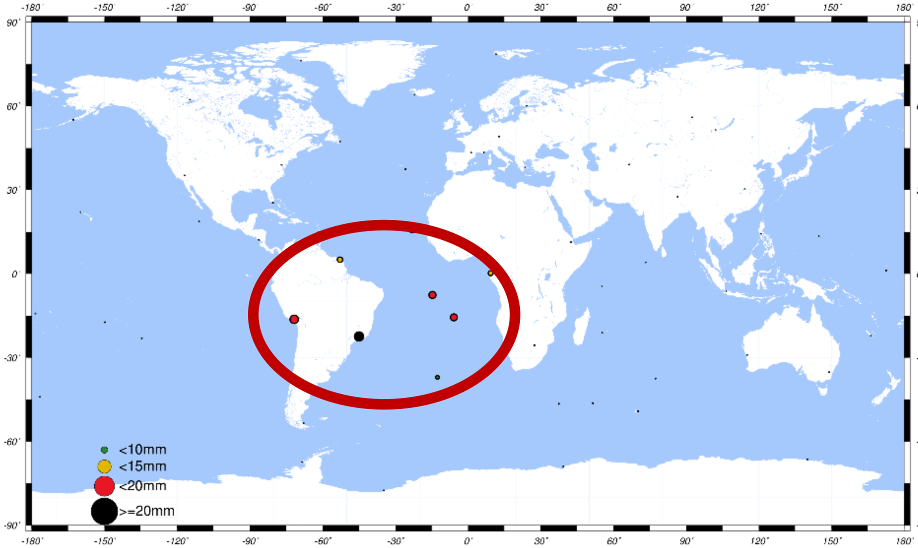


Including Jason-2 & 3 with SAA strategy applied

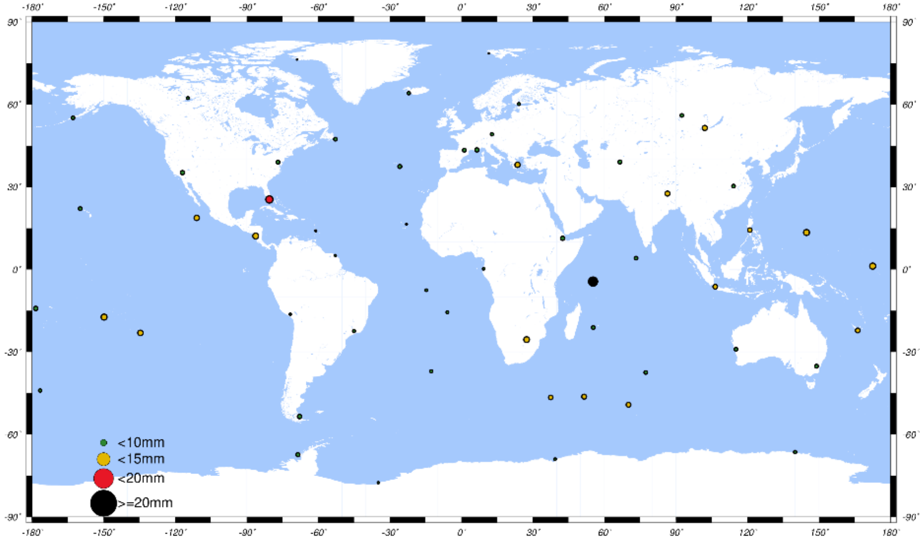
- **Reduces the mean Tz offset.**
- **Increases the stability of almost all the parameters by reducing the stds.**
- **Slightly degrades the X- and Y- EOPs stds.**

RMS of weekly station position differences

Impact of adding Jason-2/3 wo any SAA mitigation strategy



Impact of adding Jason-2/3 with SAA mitigation strategy



Time period: 2016.0-2019.0

Using the mitigation strategy mostly vanishes the SAA impact.

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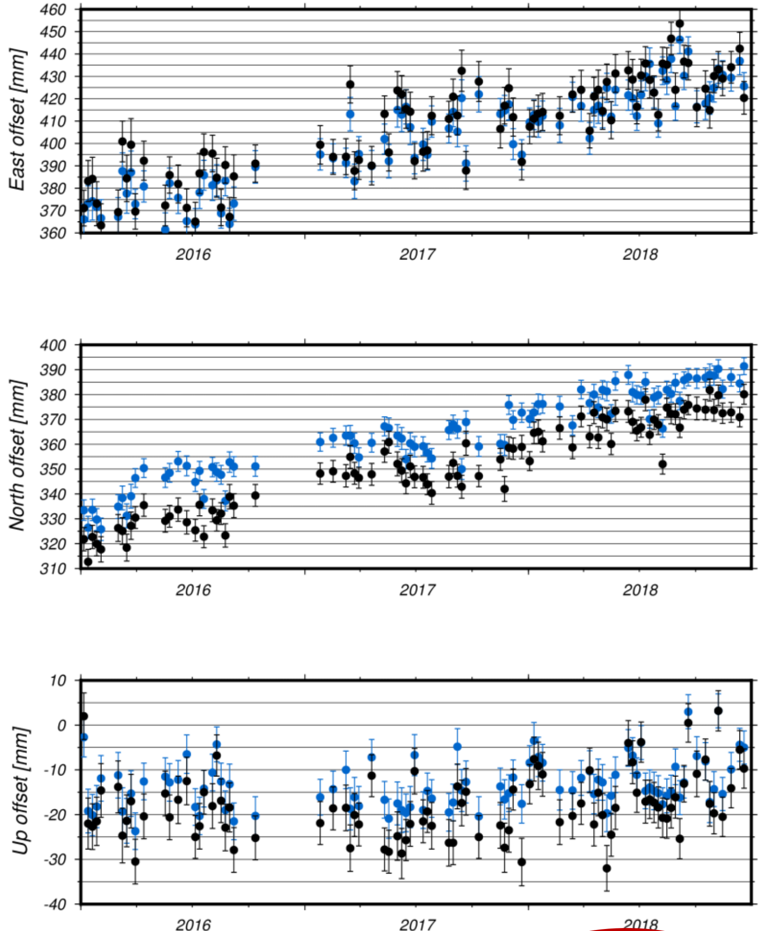
SAA Mitigation Impact - Example: Saint Helena

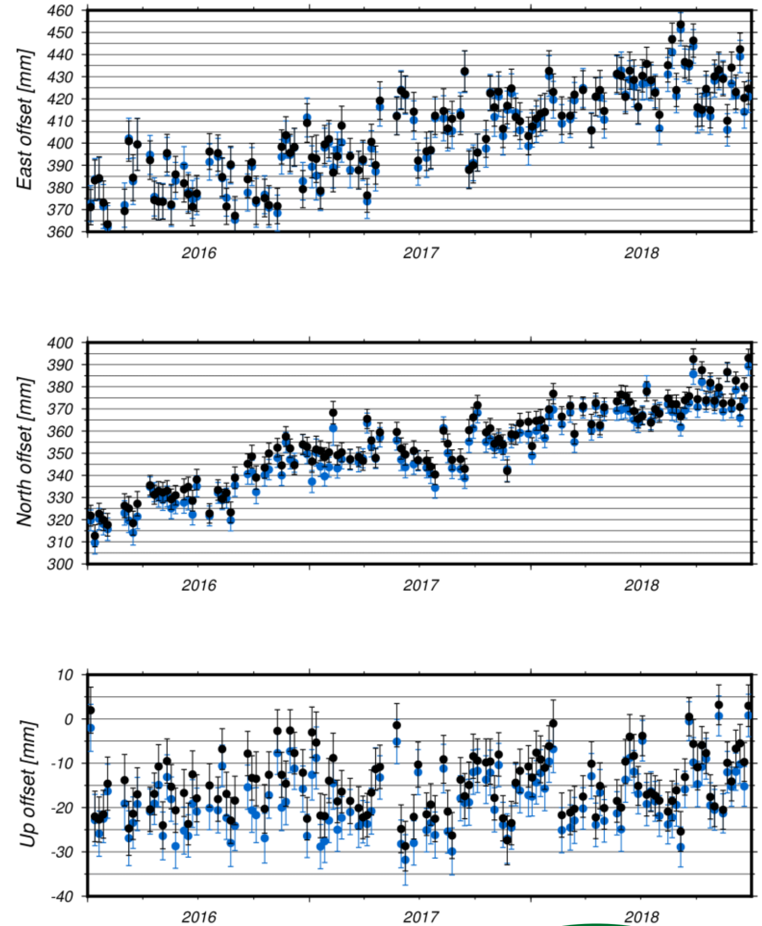
Adding Jason-2 & 3 with no SAA mitigation strategy

No Jason-2/3 **With Jason-2/3**



	days	min	max	mean	std
E diff.	91	-14.200	7.200	-4.173	5.046
N diff.	91	5.700	22.700	12.458	3.462
U diff.	91	-4.700	13.000	4.667	3.122

No Jason-2/3 **With Jason-2/3 and SAA strategy**



	days	min	max	mean	std
E diff.	124	-8.500	7.900	-1.563	2.614
N diff.	124	-9.100	2.600	-3.340	2.250
U diff.	124	-9.600	0.400	-3.608	2.012

Adding Jason-2 & 3 with a SAA mitigation strategy

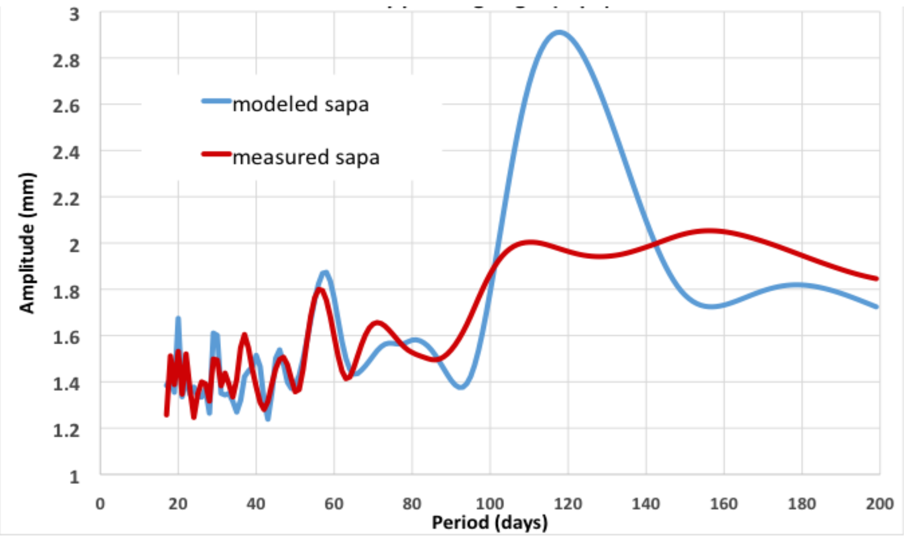
Part 3 – Solar Radiation Pressure Modelling

SRP Modelling

How to reduce draconitic signals in derived geodetic variables, especially the 117-day draconitic signal for the Jason satellites ?

1) Use best available macromodel, or a more detailed model (e.g. "UCL-type" model).
2) **Use quaternions** rather than an attitude model, if they are available for s/c and/or appendage orientation. **Even small changes in attitude, especially of solar array can cause orbit error**.
3) Retune macromodel parameters for different satellites.
4) Adjust C_R **"per arc".** Adjustment of C_R per mitigates residual errors in the non-conservative force modelling, and reduces the amplitude of resultant empirical accelerations.

Spectrum of Jason-2 radial orbit differences:
SLR/DORIS-dynamic orbits vs. GPS Reduced-dynamic orbits



Using JA2-solar array quaternions improves the force model.

The differences between SLR/DORIS dynamic and JPL/GPS Reduce-dynamic orbits are reduced, especially at the 117-day draconitic period.

Conclusions

- **DORIS Scale**
  - According to GRG (and GOP) studies and new series, the scale increase after 2012 is **fully understood** and **corrected**.

  ➔ **DORIS scale may be now fully compatible in terms of mean offset and stability with the SLR and VLBI scales.**

- **South Atlantic Anomaly**
  - The SAA mitigation strategy applied by GRG for Jason-2 and Jason-3 **mostly vanishes** the effect of the SAA on the positioning.
  - SAA effect on SPOT5 and Jason-1 was already minimized by two data correction models used for the ITRF2014.

- **SRP Modelling**
  - Use of Jason-2 solar array quaternions strongly reduces draconitic signal on orbits.