IDS AWG MEETING

Precision Orbit Determination Splinter

JASON POD STATUS

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October 15th, 2013

Greenbelt (MD), USA

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Contents

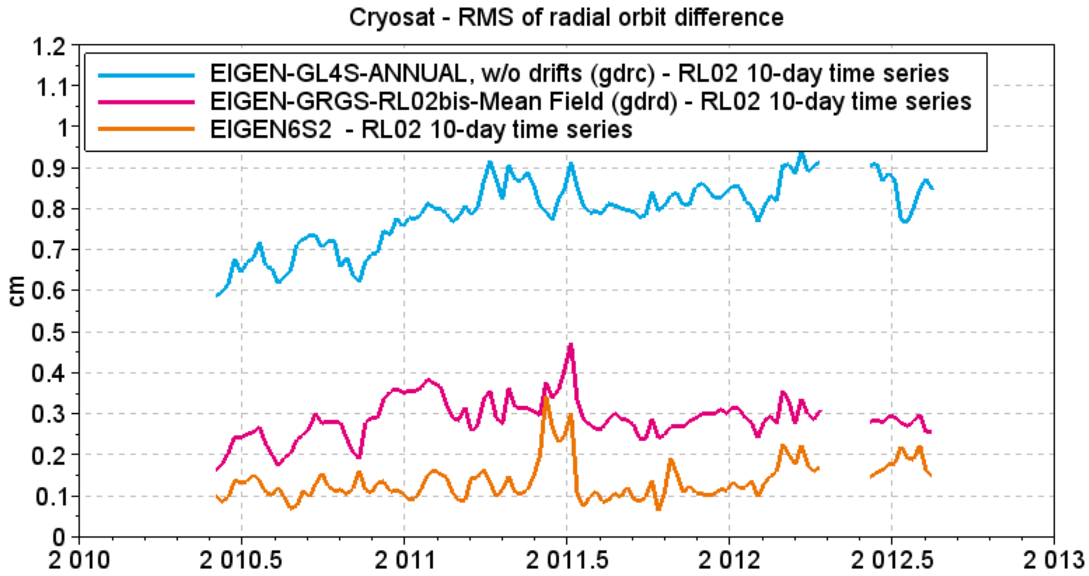
- Outstanding issues from OSTST
- Improved semi-empirical SRP models
- First SARAL POD results

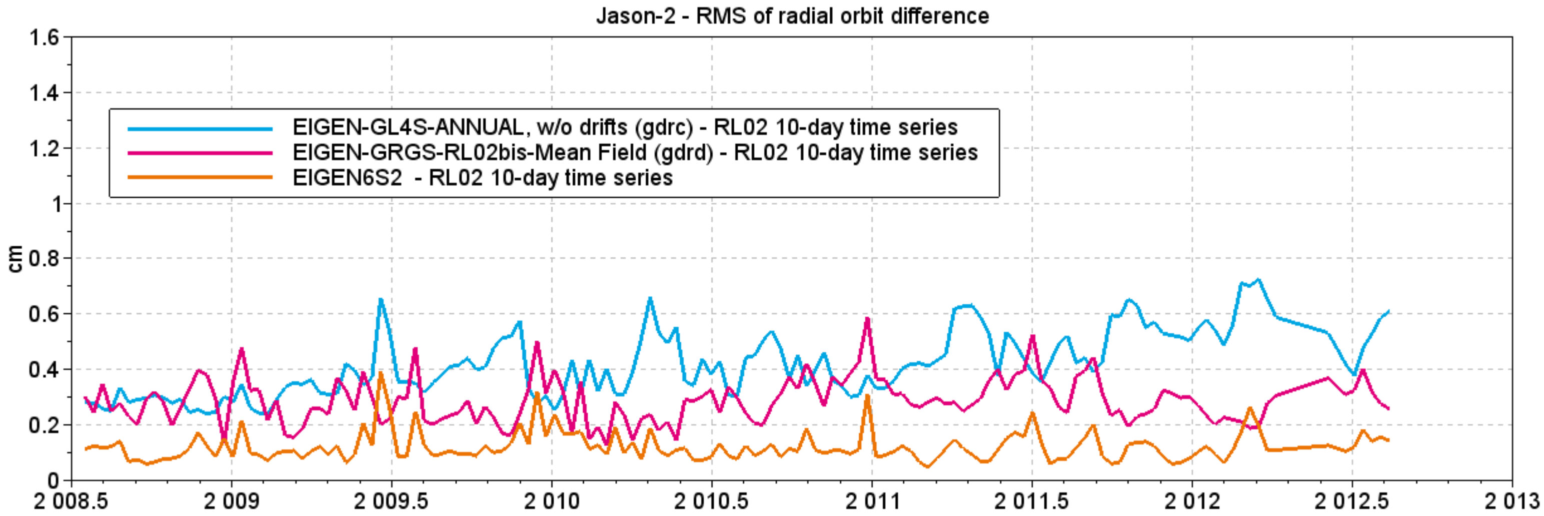
Contents

- Outstanding issues from OSTST

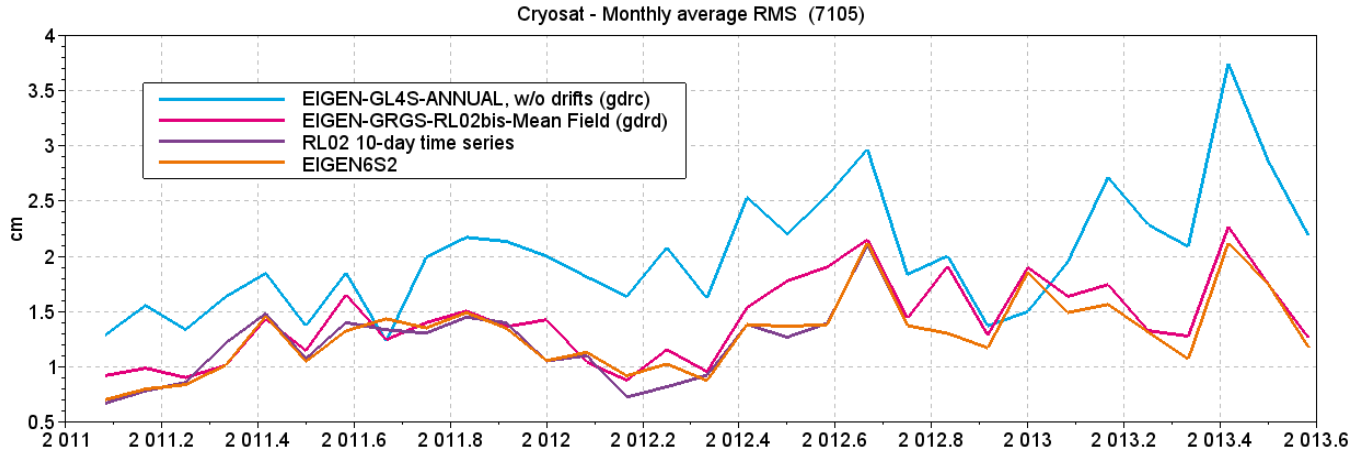
EIGEN6S2(A): closer to the time series

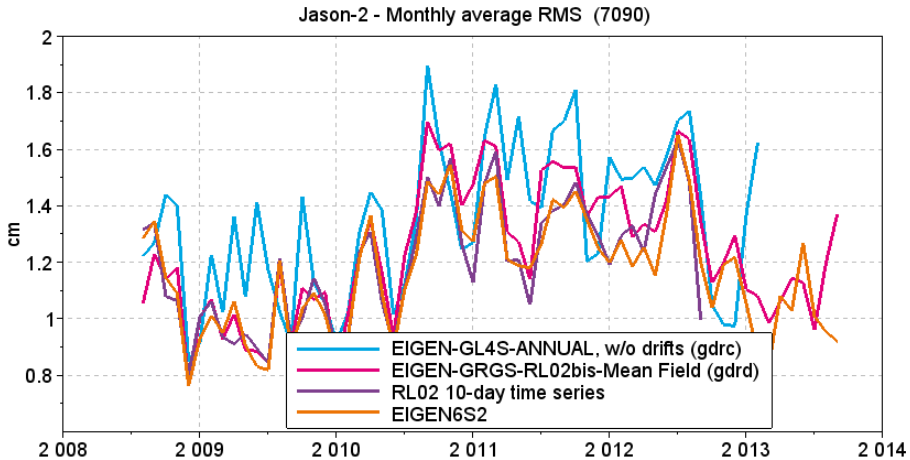
Other satellites in the backup slides …





EIGEN6S2(A): improved SLR fits





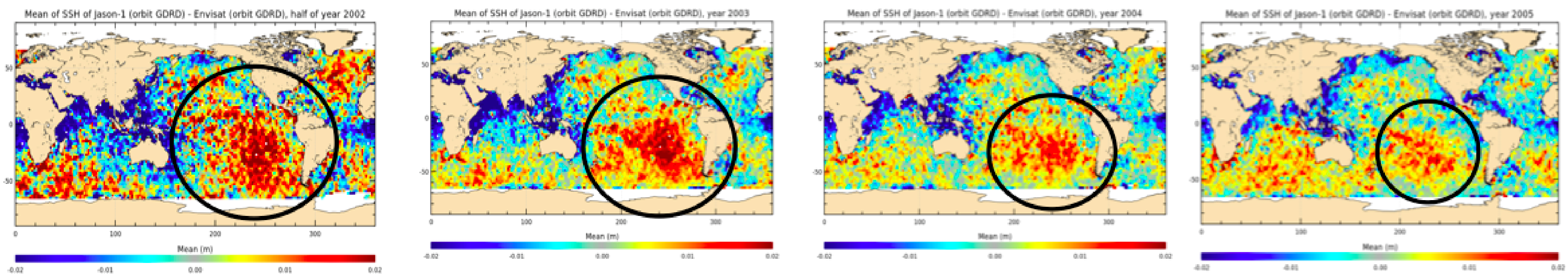
Other satellites and stations in the backup slides …

EIGEN6S2(A): improved SSH consistency (Jason/Envisat)

Ollivier et al. OSTST 2013

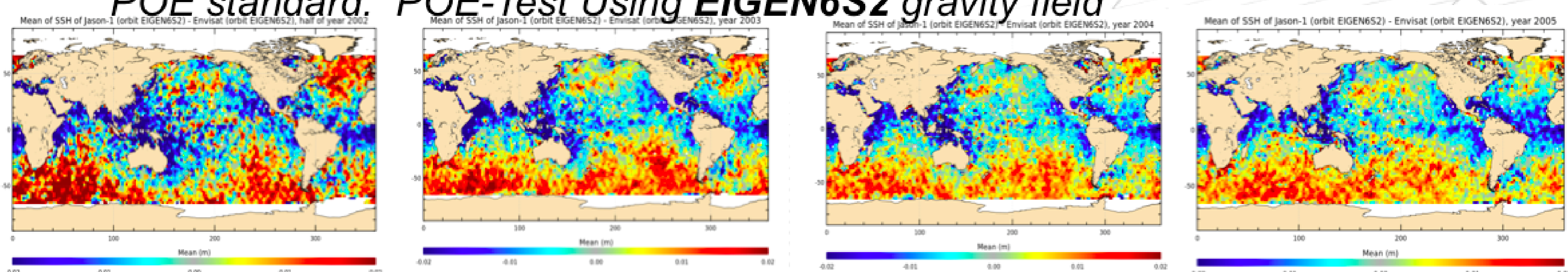
Interannual signal East/West patches remaining on EN-J1 mean difference per year at crossovers efficiently removed!

*POE standard: POE-D Using **EIGEN-GRGS_RL02bis_MEAN** gravity field*



2002 2003 2004 2005

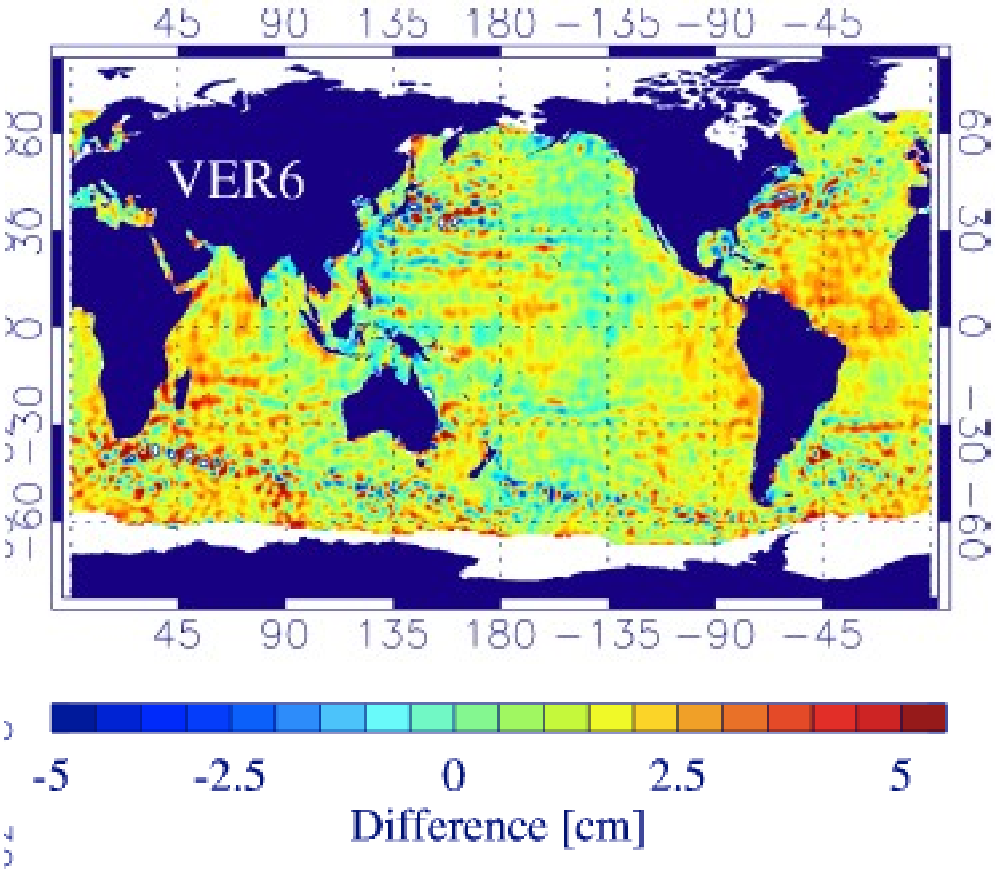
*POE standard: POE-Test Using **EIGEN6S2** gravity field*



-2cm 2cm

Remaining signals now dominating between those missions are most probably due to a mix of other sources (wet tropospheric correction, SSB solutions...)

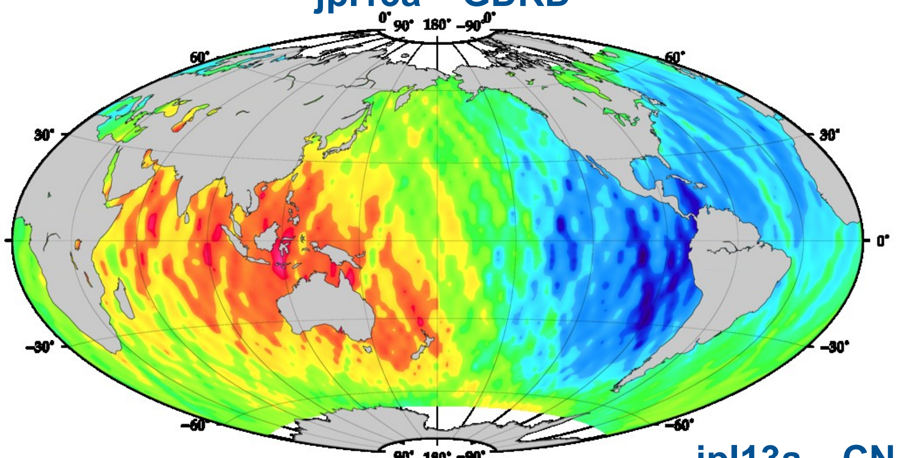
EIGEN6S2(A): improved SSH consistency (Topex/ERS)



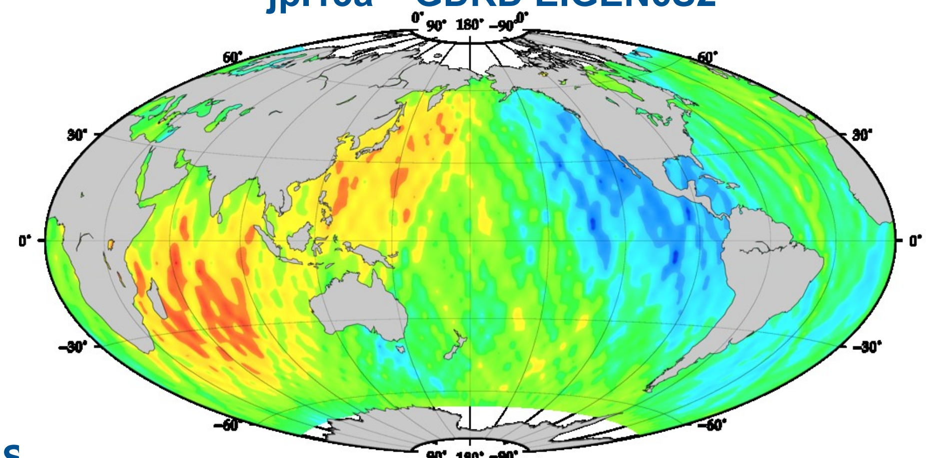
Rudenko et al.
OSTST 2013

EIGEN6S2(A): residual drifts in radial orbit differences to JPL and CNES RED. DYN. orbits, and to GSFC 1204 orbits

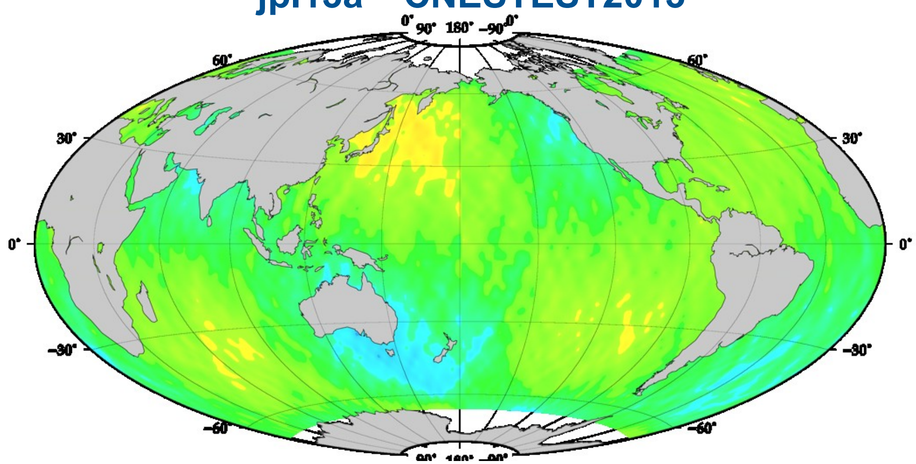
jpl13a – GDRD

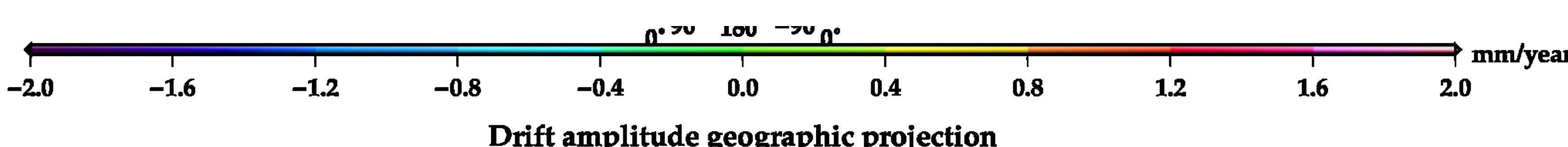


jpl13a – GDRD EIGEN6S2



jpl13a – CNES

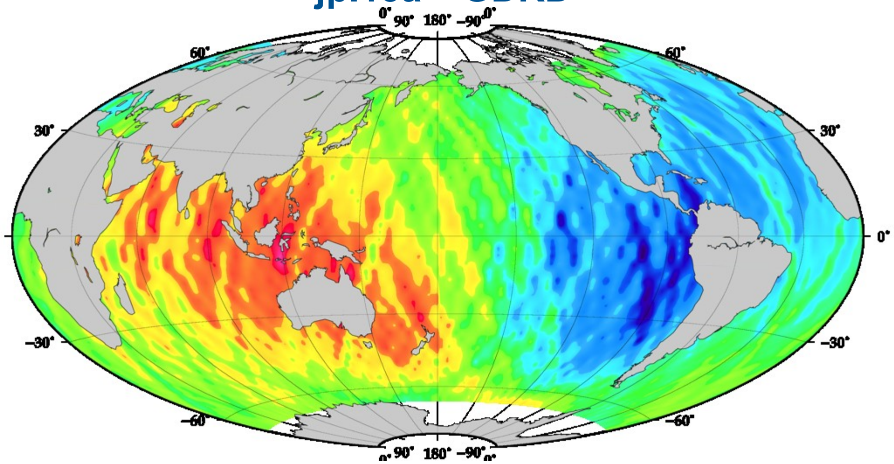




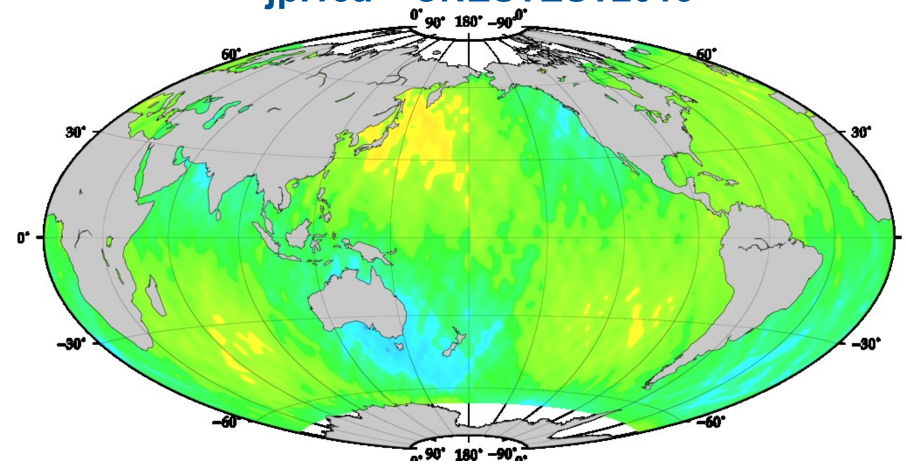
-2 mm/y

EIGEN6S2(A): residual drifts in radial orbit differences to JPL and CNES RED. DYN. orbits, and to GSFC 1204 orbits

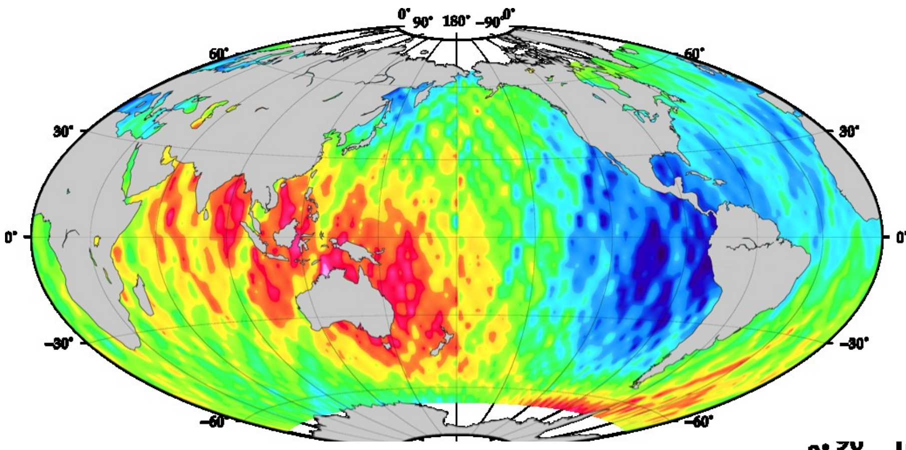
jpl13a – GDRD



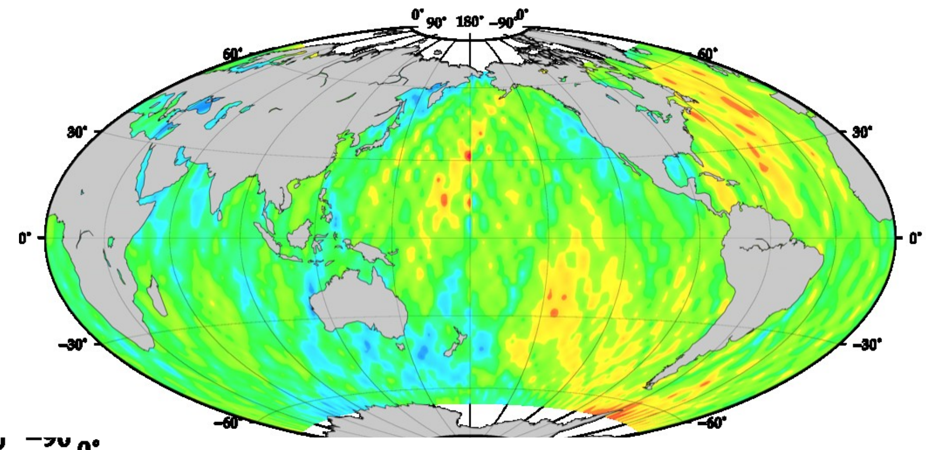
jpl13a – CNESTEST2013

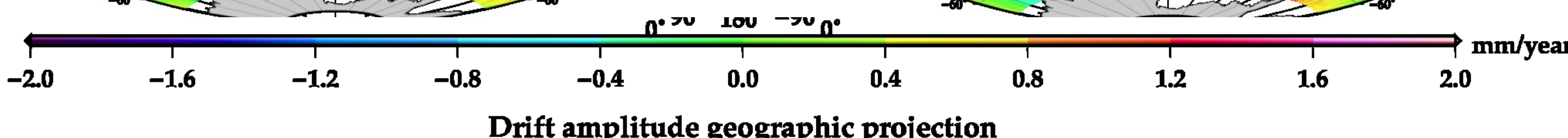


GSFC gsfc_ja2_poe_ld_std1204 – GDRD



GSFC gsfc_ja2_poe_ld_std1204– CNESTEST2013

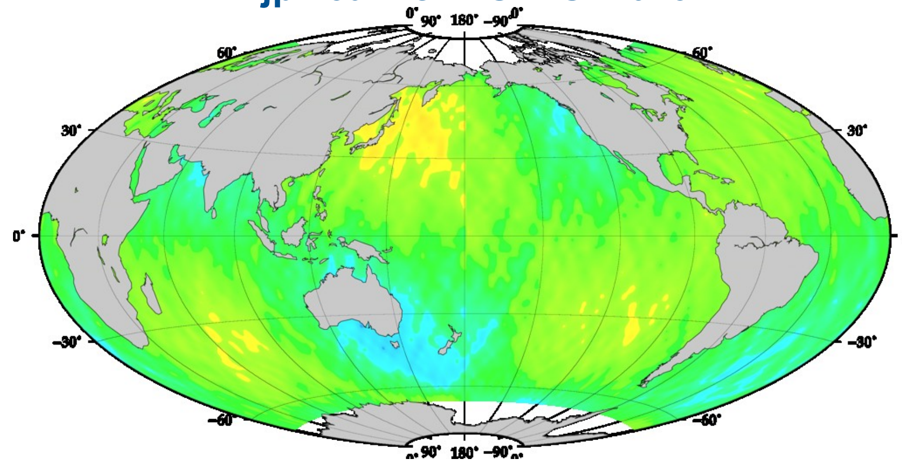




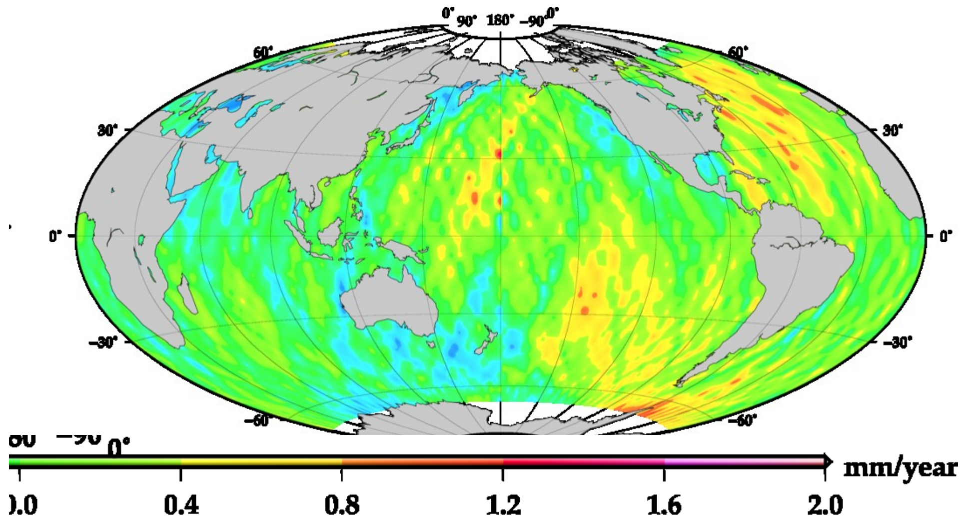
EIGEN6S2(A): residual drifts in radial orbit differences to JPL and CNES RED. DYN. orbits, and to GSFC 1204 orbits

All these 3 sets of orbits use Jason data to accomodate **large scale TVG effects**:
< 1 mm/y (5 years) consistency achieved !

jpl13a – CNESTEST2013



GSFC gsfc_ja2_poe_ld_std1204– CNESTEST2013



Drift amplitude geographic projection

-2 mm/y

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PROSPECTS AND PLANS

- 2014 **reprocessing with ITRF2013** : preliminary solution for next OSTST is the goal !!

- Should we use **"internal" POD data to accommodate large scale TVG** effects ?
  - Test other time-series from GRACE (GRGS RIse03, GFZ, CSR)
  - Need for external CALVAL tests (Sea Level from Argo T/S + GRACE), as SLR and TG are questionable at the 1 mm/yr level over <=5 years

- Review **weighting of DORIS stations over SAA for Jason-1** (impact on Z shift, Ollivier et al.)

- Include an **SLR-based model for annual geocenter motion**, at least for DORIS+SLR station coordinates

- Adopt **calibrated SRP models**
  - Envisat Attitude / Solar Panel information should be made available soon

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Contents

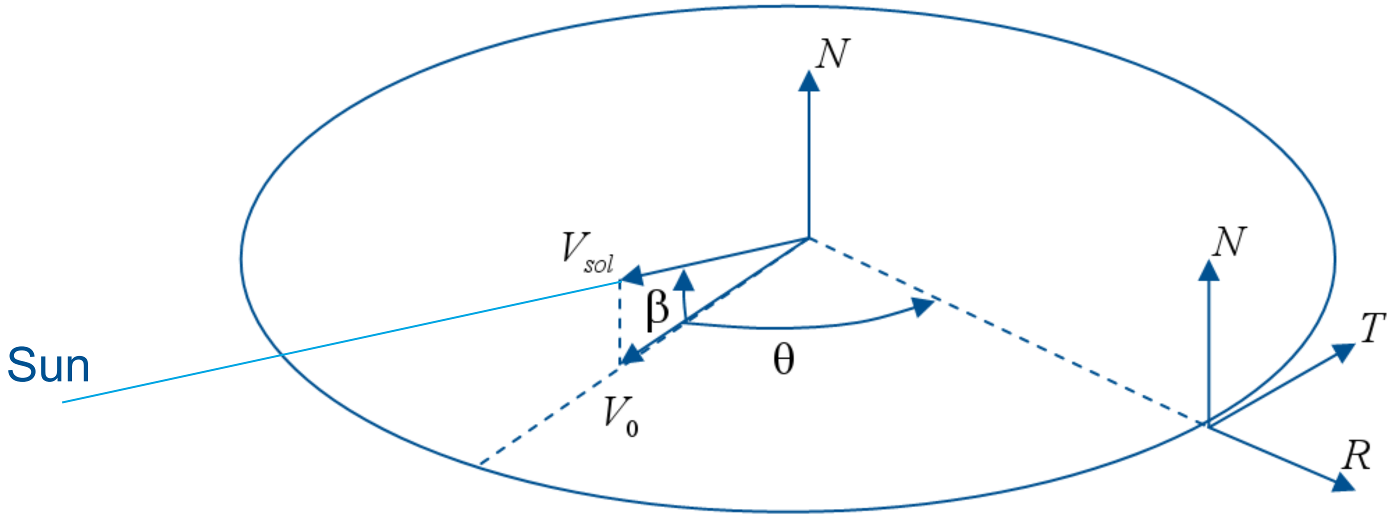
- **Improved semi-empirical SRP models**

  (summary from F. Mercier and L. Cerri, OSTST 2013)

Motivations

- Physical properties and thermal environment of the satellite are not known with sufficient accuracy
- Time series of SRP-related empiricals (1/rev, scale) show clear signatures as function of sun geometry → SRP errors are observable
- Calibration can be performed when the mission time-span is large enough to capture well the SRP variability
  - From few months to few years, depends on the mission
- The example that follows covers Jason-1 and Jason-2 missions

Geometry

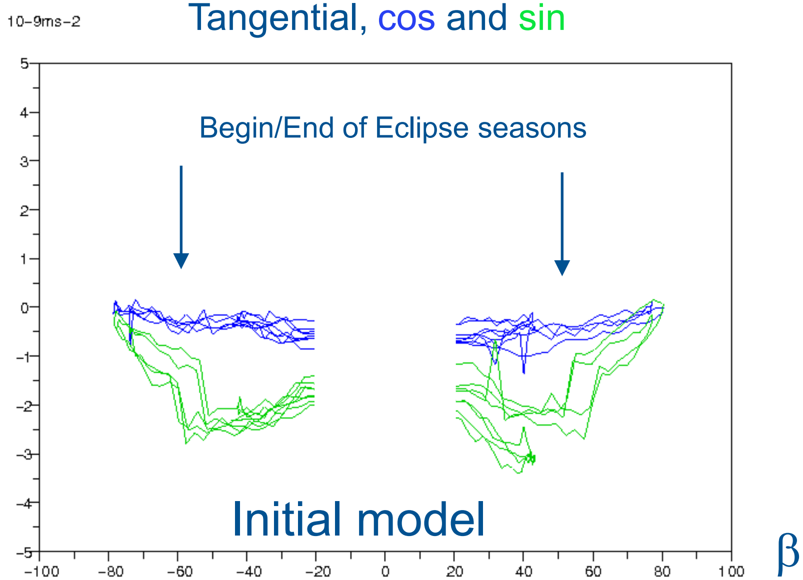


θ : orbital angle (referenced to subsolar direction)

β : solar angle

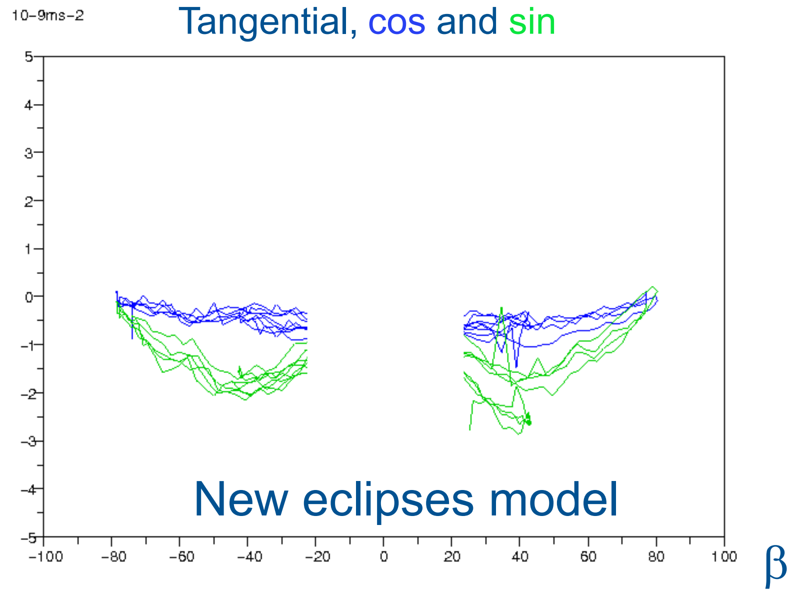
Empirical forces signatures, yaw steering cases

Tangential, cos and sin



Jason-2 example, Along track (daily estimate of 1/rev)

Tangential, cos and sin



Correction of
atmospheric absorption/refraction effects

Phase reference : subsolar point

acceleration order of magnitude 2 10-9 ms^{-2} equivalent to 0.2 m^2 (total absorption)

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Current ‘box and wings’ Jason model

Applied since GDR-C standards (with 0.97 scale coefficient for Jason-1)

Axis	m2	Normal direction			Ks	Kd	Ka
X	1.65	1.0			0.09	0.28	0.21
-X	1.65	-1.0			0.43	0.21	0.01
Y	3.00		1.0		1.19	-0.01	-0.01
-Y	3.00		-1.0		1.20	-0.00	-0.00
Z	3.10			1.0	0.24	0.40	0.33
-Z	3.10			-1.0	0.32	0.37	0.27
+SA	9.80	1.0			0.34	0.01	0.65
-SA	9.80	-1.0			0.00	0.30	0.70

Remarks : +SA towards the sun (solar array)

adjusted on a precise model
(Ks+Kd+Ka not constrained on central part to have correct surfaces)

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Different attitude descriptions

Ideal Yaw-steering attitude : Z satellite towards earth,
Y satellite orthogonal to sun direction (same as GPS)

Topex/Jason theoretical attitude : similar to the above yaw case, with limitations on rates (important effect for small β values)

True attitude : close to the theoretical attitude
but : obtained by daily adjusted expressions
corresponding accelerations are not well represented by 1/rev empiricals

→ Verify acceleration differences for these three models
is it possible to use 1/rev, 2/rev .. in θ terms to mitigate ?

Remark : $|\beta|<15°$ fixed-yaw attitude , other definitions for the model
(this case is not detailed in the following slides)

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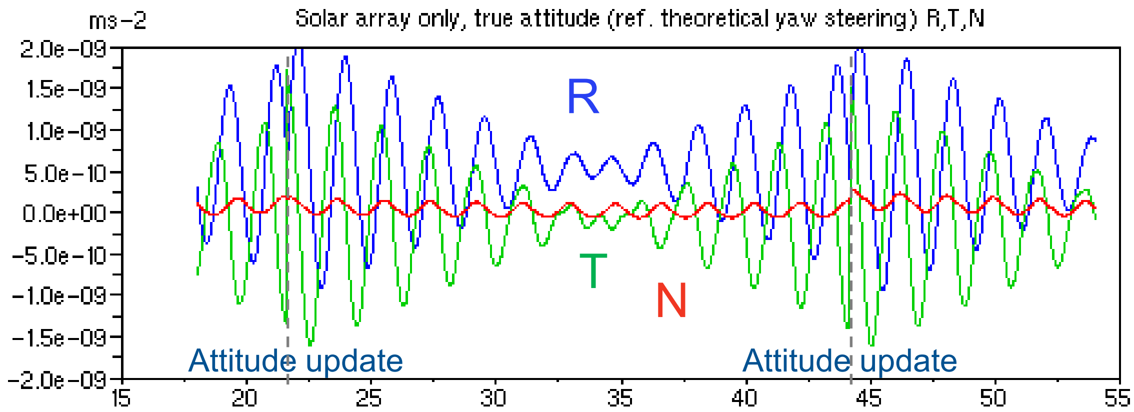
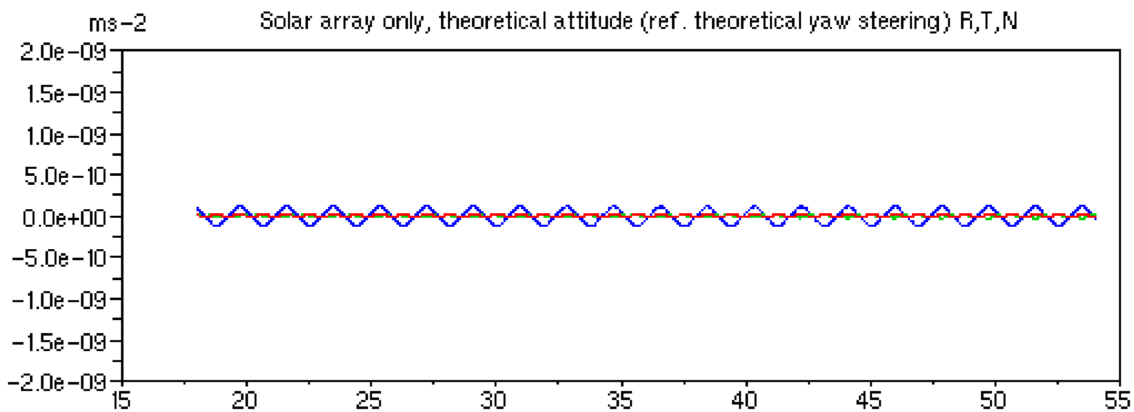
Example : accelerations, β ~80 °, solar array contribution

Impact of attitude law on solar array SRP acceleration



True attitude – Ideal Yaw

hours



Jason theoretical attitude – Ideal Yaw

hours

R and T accelerations of 2.0 10^{-9} ms^{-2} at frequencies close to orbital frequency

for complete attitude case, not correctly cancelled by θ 1/rev terms

these T and R accelerations are due to transverse effects on the solar array

(solar array is ~parallel to orbital plane for high β values)

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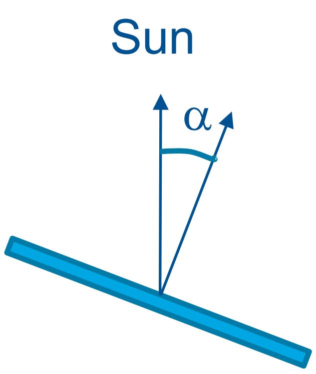
Models choice : solar array

A precise model is needed for the solar array accelerations

Standard plate model with Ks,Kd,Ka and exact pointing

must be used with the correct orientation (true attitude law)
optical coefficients must be updated for transverse behavior
(deviations with respect to the sun direction may reach 10 degrees)
tuned model represents also thermal radiation effects (diffuse emission)
must be representative up to 10 degrees mispointing



How to update in a simple way ?
Transverse diffuse and specular effects are not separable (α remains small)

simultaneous update of specular part and absorbed part
total force is unchanged : 2*Ks+Ka = 0

Models choice : central part

The central part may be empirically modeled (or corrected)

- attitude misrepresentation effects are much smaller than for the solar array
- a precise model is not possible (antennas, various shapes, shadows, thermal behavior)

Construction of a model in the sun-pointed frame (referred to as ***Rg***)

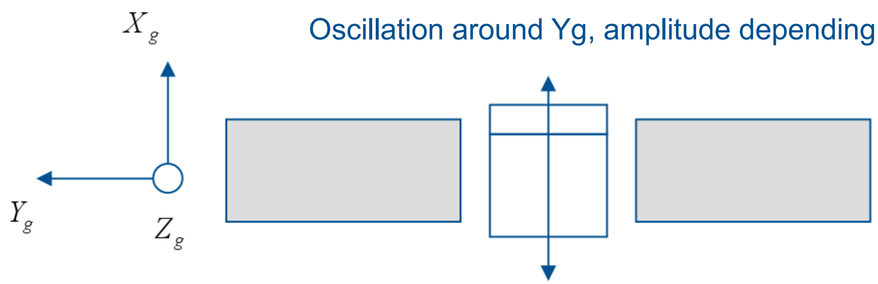
- represents all radiation effects on the central part including thermal radiation effects
- represents the difference between theoretical yaw attitude and true attitude

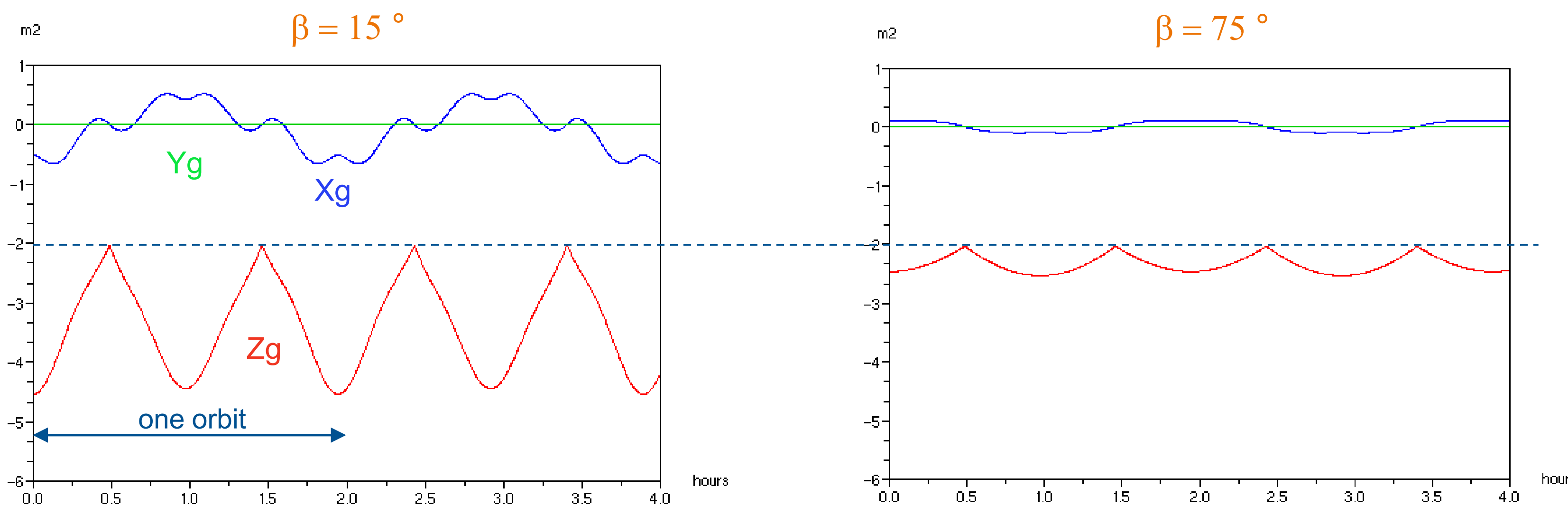
Rg frame : Xg,Yg,Zg reference frame, assuming a perfect yaw attitude
Yg solar array rotation axis in the ideal yaw case
Zg towards the sun

This reference frame is used at IGS for GPS satellite empirical accelerations for SRP modelling

Accelerations in Rg: periodic functions of θ

Oscillation around Yg, amplitude depending on β





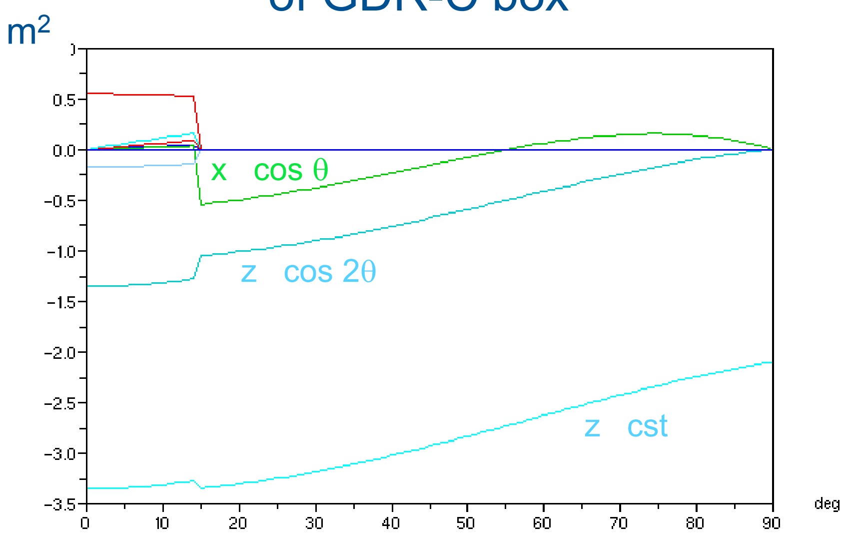
Central body model, yaw attitude

- Yg acceleration is null
- Xg and Zg accelerations periodic, with harmonics amplitudes vary with β
- Zg : bias, cos(θ) (small), cos(2θ) , …

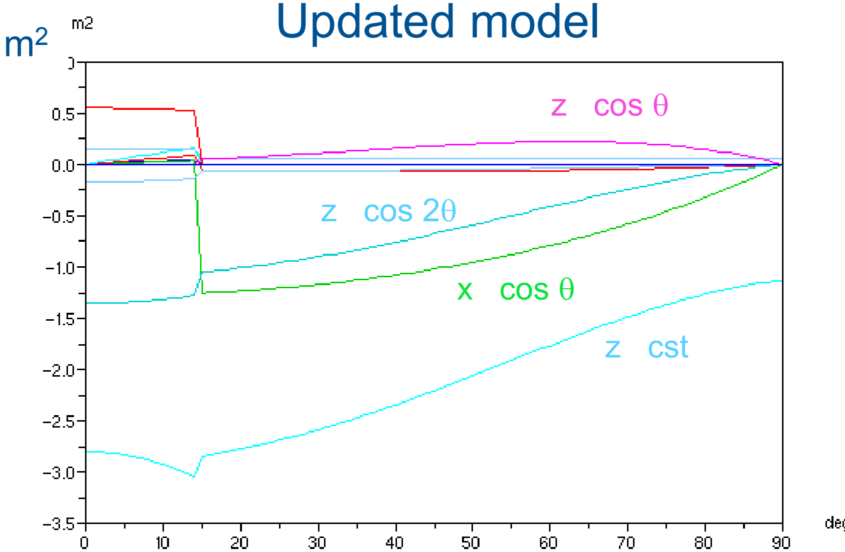
→ harmonic components functions of β

Jason 1 updated model characteristics

Harmonic representation in Rg of GDR-C box



Updated model



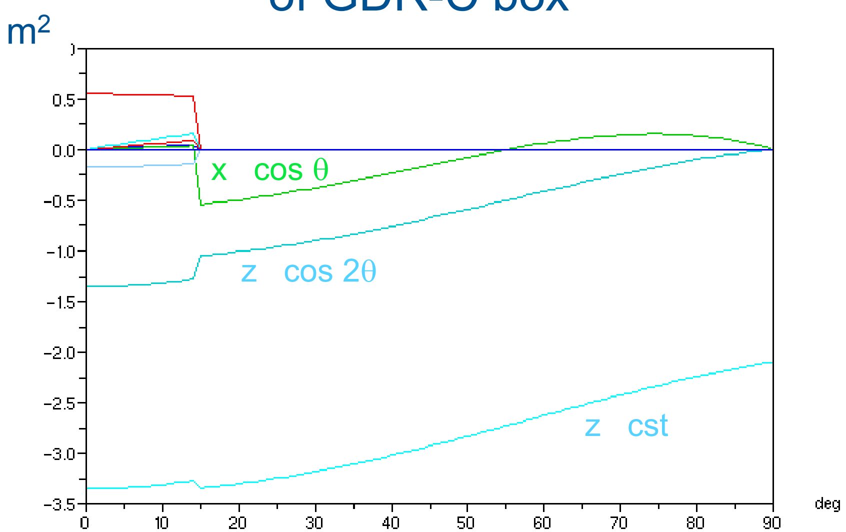
The updated model remains close to the initial one
(z cst, z cos, x cos were adjusted without constraints)

The x and z sin contributions are small (symmetric satellite and sun-orientation)

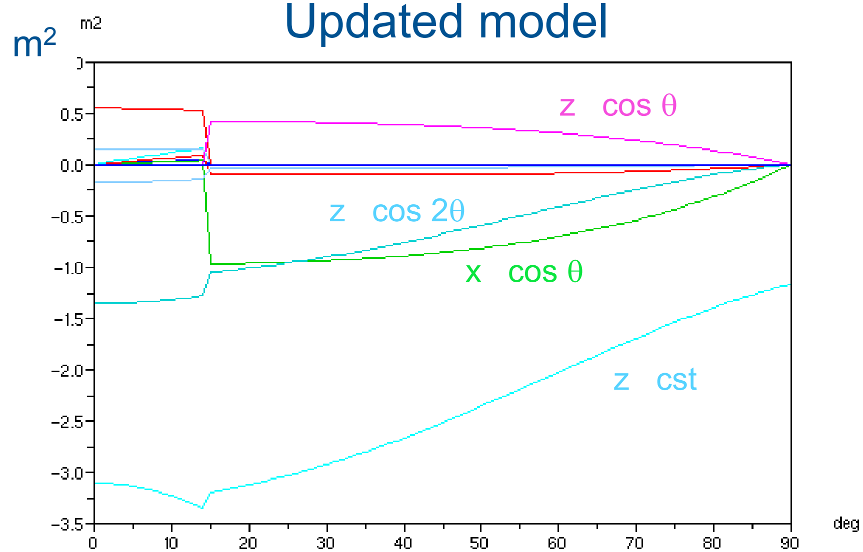
The z cos term reflects a dissymmetry between Earth and anti-Earth faces

Jason 2 updated model characteristics

Harmonic representation in Rg of GDR-C box



Updated model

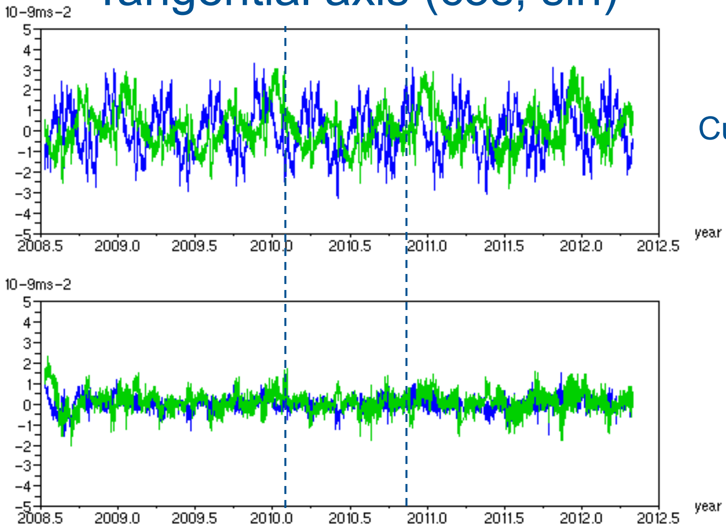


Jason 2 and Jason 1 updated models are very similar

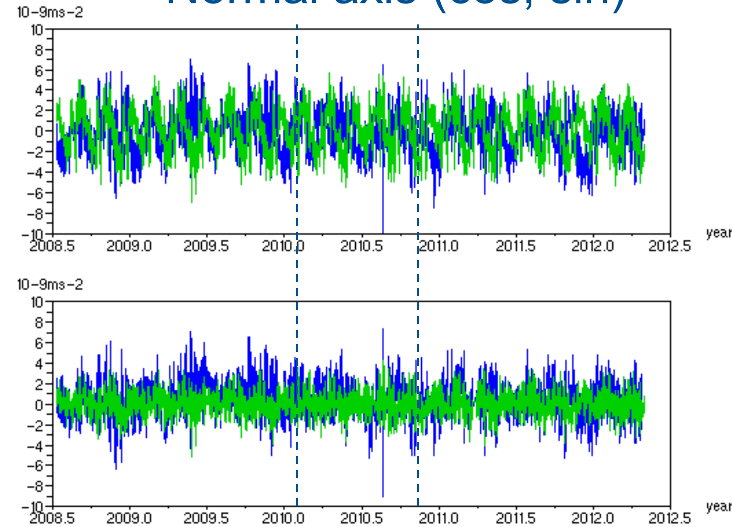
Jason 2 POD performances (1)

Empirical 1/rev terms

Tangential axis (cos, sin)



Normal axis (cos, sin)



Current model

New model

Adjusted period

Adjusted period

- Systematic effects are fully removed
- Model has identical performances outside the adjusted period
- Different behavior at the beginning of life

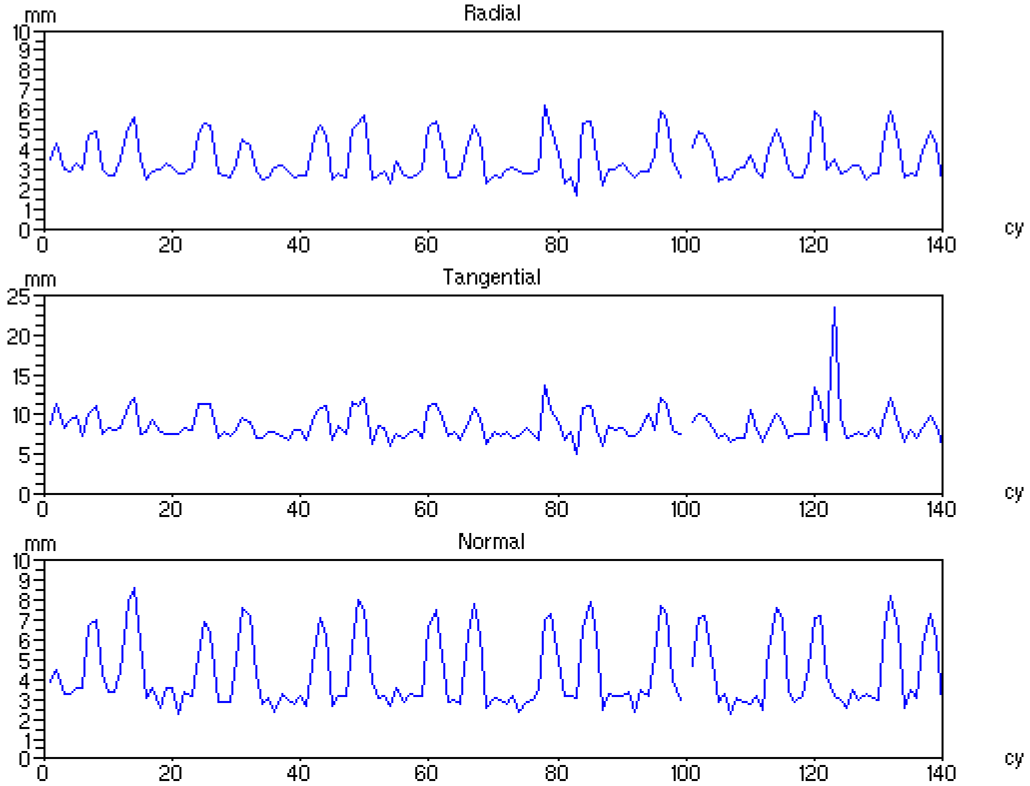
Jason 2 POD performances (2)

rms R,T,N orbit differences, new model and current model

Radial

Tangential

Normal



Radial effect is between 3 and 5 mm, important for high β values

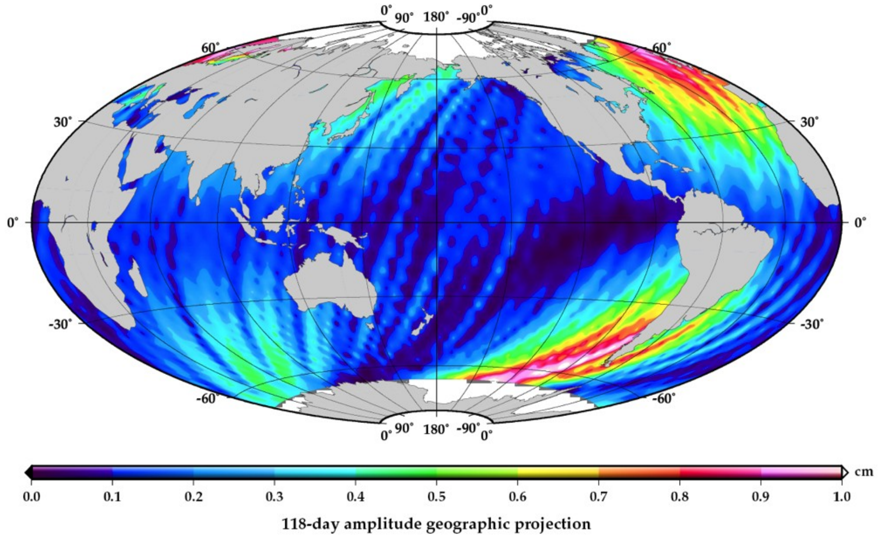
Jason 2 POD performances (4)

effect of the radiation model update on radial orbit differences

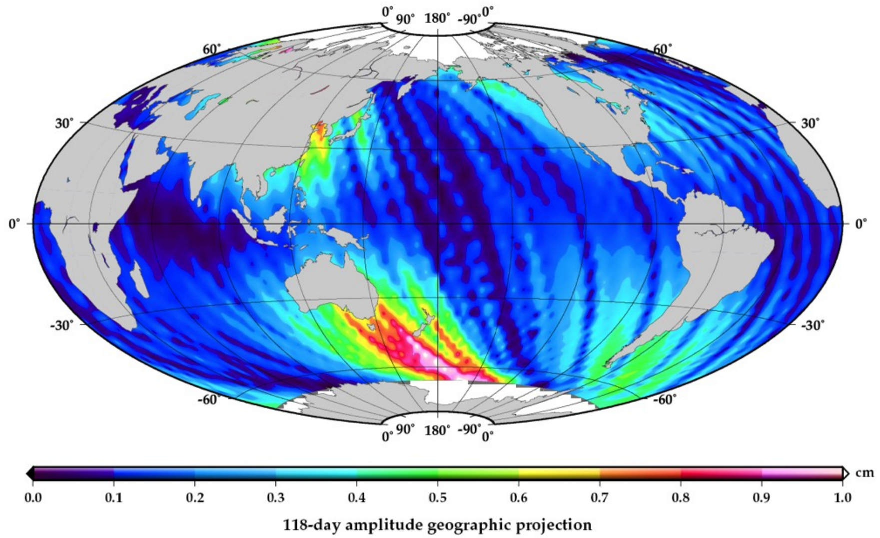
main component is at 120 days

Amplitude of the 120-day signal in the radial orbit differences

Ascending



Descending



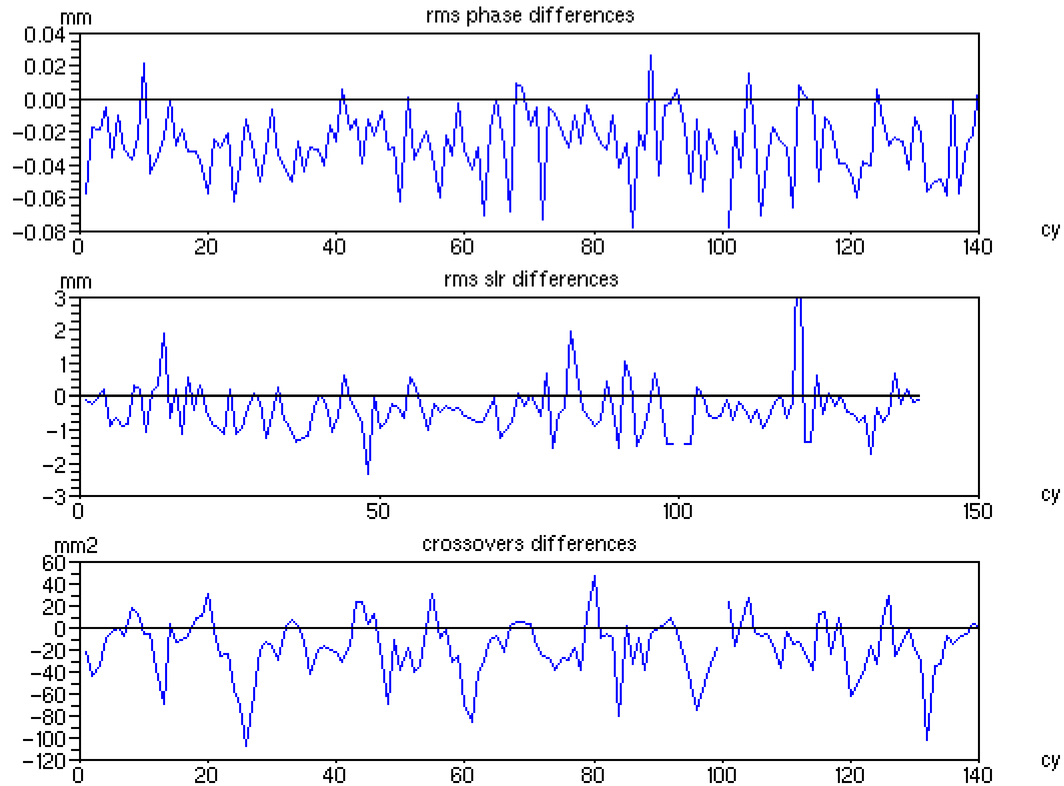
Jason 2 POD performances (3)

Improvements (negative value means improvement)

Phase

SLR

Crossovers



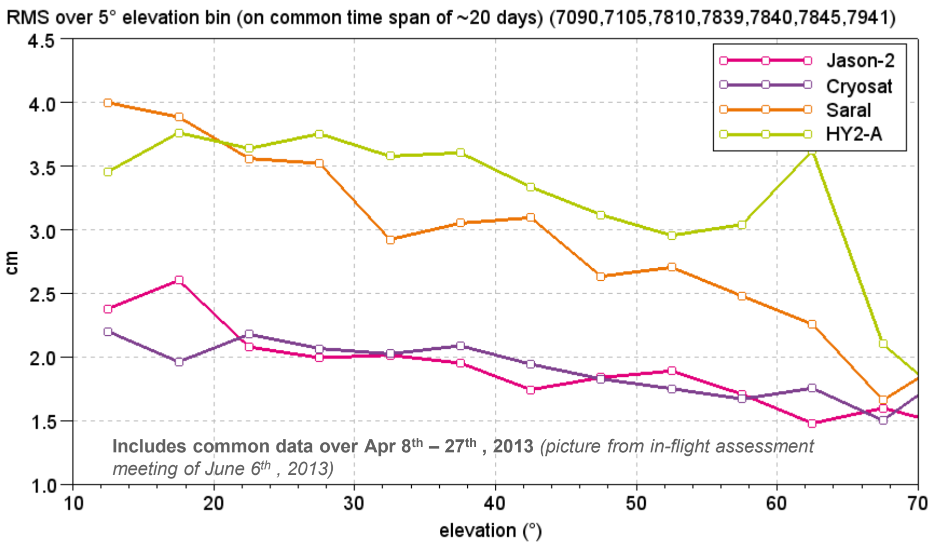
Small but systematic improvements on all metrics

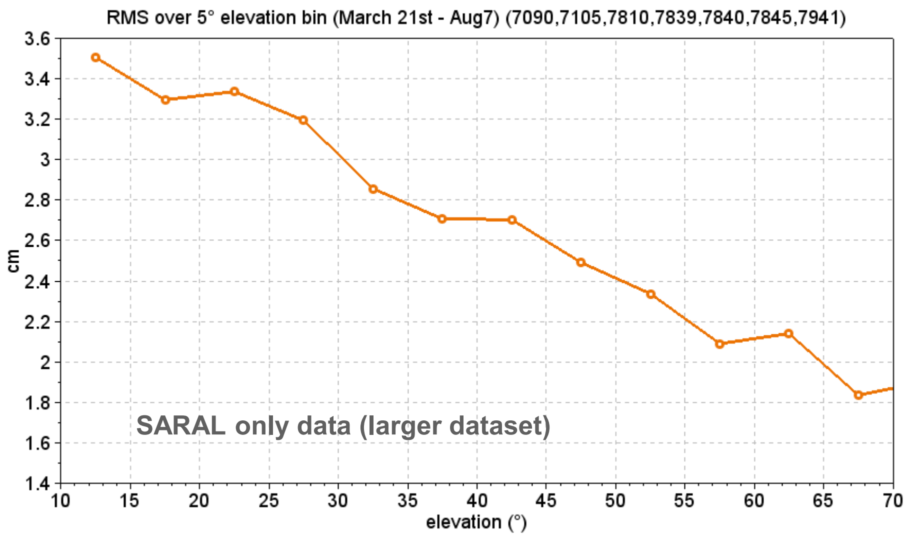
Contents

- First SARAL POD results

SARAL POE: SLR RESIDUALS ON DORIS-ONLY ORBITS

- **Radial accuracy** of DORIS-only orbits **better than 2 cm RMS** (SLR residuals > 70°) – Similar to other DGXX-based missions
- Significant error is observed in the horizontal plane (low elevation residuals)





- Cross-track bias of the orbits of about 5 cm ; effect is common to Doris-only or SLR-only orbits : either a mismodeled cross-track force or CoM correction
- This effect is likely too large for SRP/TRR mismodeling only, given the satellite surface towards the sun
- No impact on the altimeter mission , but relevant for the IDS analysts

SARAL POD conclusions

- The radial accuracy of SARAL precise orbits is comparable to that of other DORIS-based altimeter missions.
- **The current estimate of the radial accuracy is better than 2 cm RMS**, as measured by the core network SLR residuals at high elevations on DORIS only orbits
- The most significant contributor to the geographically correlated error is to the time varying gravity field; its contribution does not exceed 5 mm on average over the time interval covered by this analysis – TBC when GRACE time series become available
- A **significant cross-track error is observed using either DORIS or SLR data**. This could be due to an error along Z in a surface force model or in the center of mass Z-coordinate, or both. Given the amplitude of this error, it is unlikely that the cause is a surface force alone. **No impact expected on altimeter data analysis – relevant issue for IDS**

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