Recent activities of the IDS Associate Analysis Center at DGFI-TUM

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Major updates in SLR and DORIS data processing for altimetry satellites at DGFI-TUM in 2019-2020

– Macromodel and other satellite-specific information for TOPEX/Poseidon were implemented in DOGS-OC

– Macromodels and other satellite-specific information for Jason-1/-2/-3 were updated in DOGS-OC

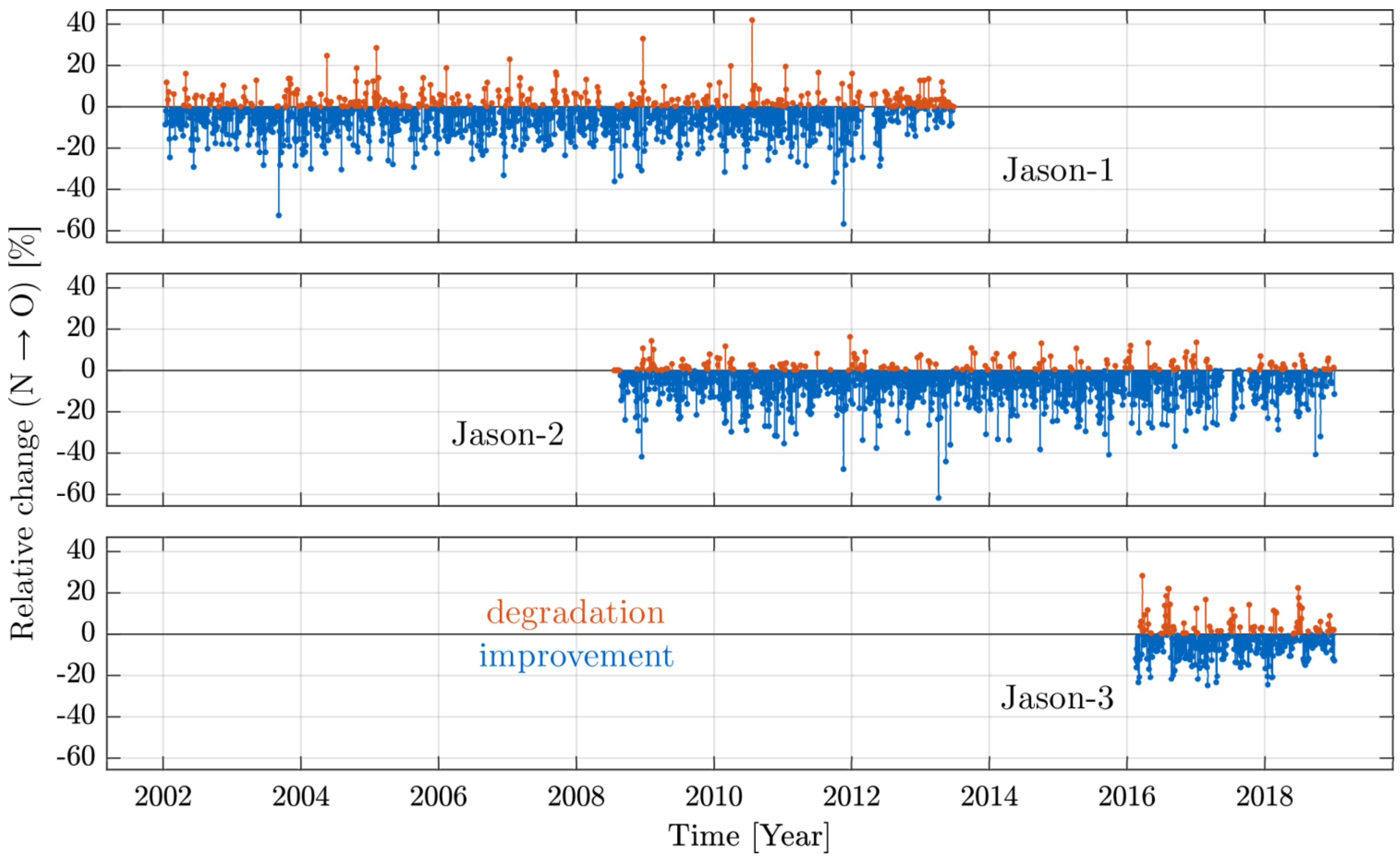
– A detailed study on the use of **observation-based attitude for Jason-1/-2/-3** on their orbits, geodetic and altimetric results was performed (**Bloßfeld et al., 2020**)

– **SLR-only orbits** of TOPEX/Poseidon and Jason-1/-2/-3 were computed for the complete mission periods

– **DORIS-only orbits** of TOPEX/Poseidon and Jason-1/-2 were derived as well

– **Combined SLR+DORIS orbit** for Jason-2 was computed and is currently under investigation

Relative change of the arc-wise SLR observation fit of Jason-1/-2/-3 from nominal (yaw steering model) to observation-based (quaternions of the main body and solar array rotation angles) attitude realization



Percentage of the number of arcs showing improvements in arc-wise RMS, when using observation-based attitude realization instead of nominal one:

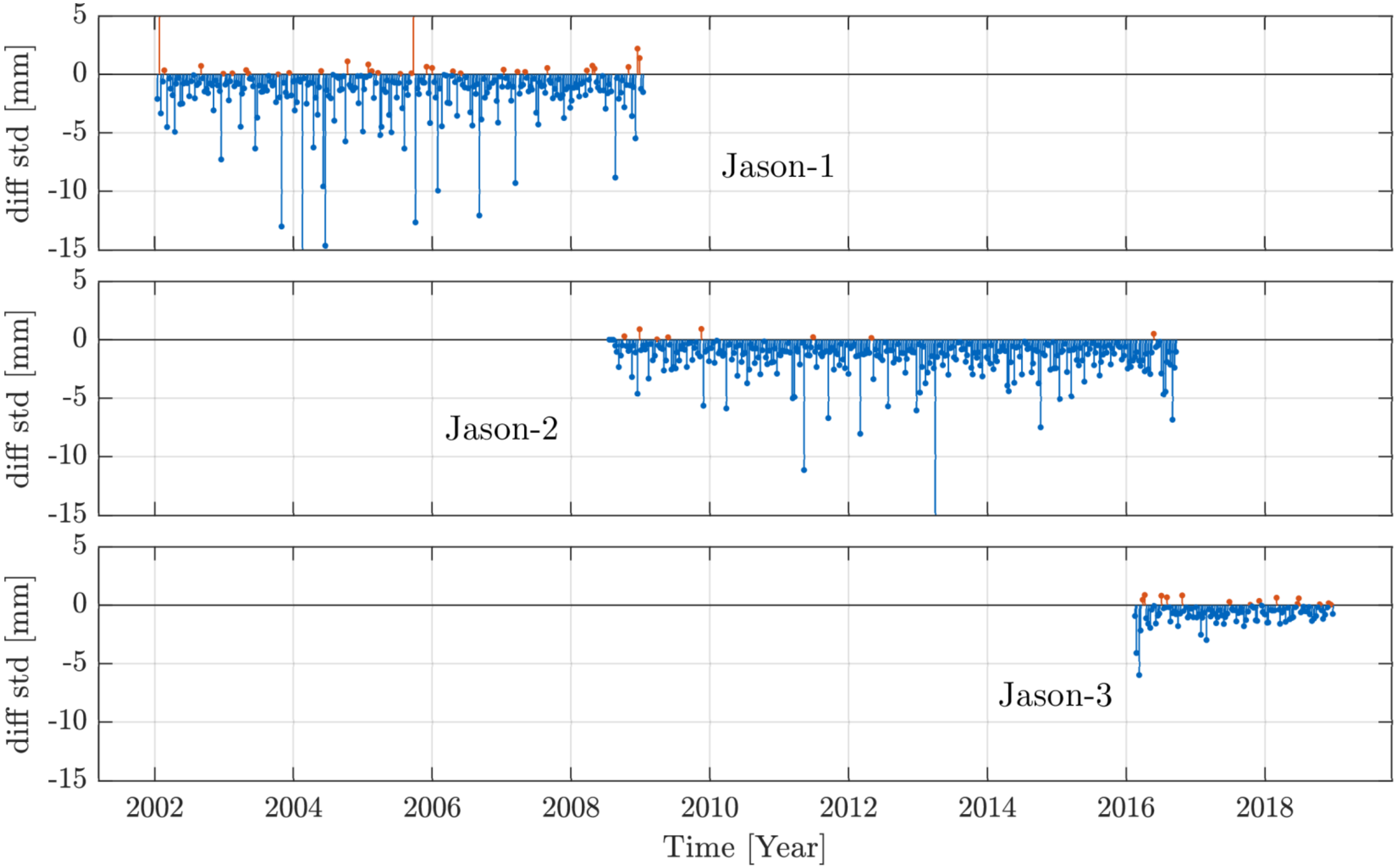
- 74% for Jason-1
- 84% for Jason-2
- 75% for Jason-3

Averaged SLR RMS fits (cm):

Satellite	Nominal	Observation-based	Improvement
Jason-1	2.15	2.02	5.9%
Jason-2	2.19	2.01	8.3%
Jason-3	2.18	2.08	4.5%

(Bloßfeld et al., 2020)

Improvements in single-satellite crossover differences of Jason-1/-2/-3 when using observation-based attitude modeling instead of nominal one



A few mm reduction
of the standard deviation
of crossover differences

(Bloßfeld et al., 2020)

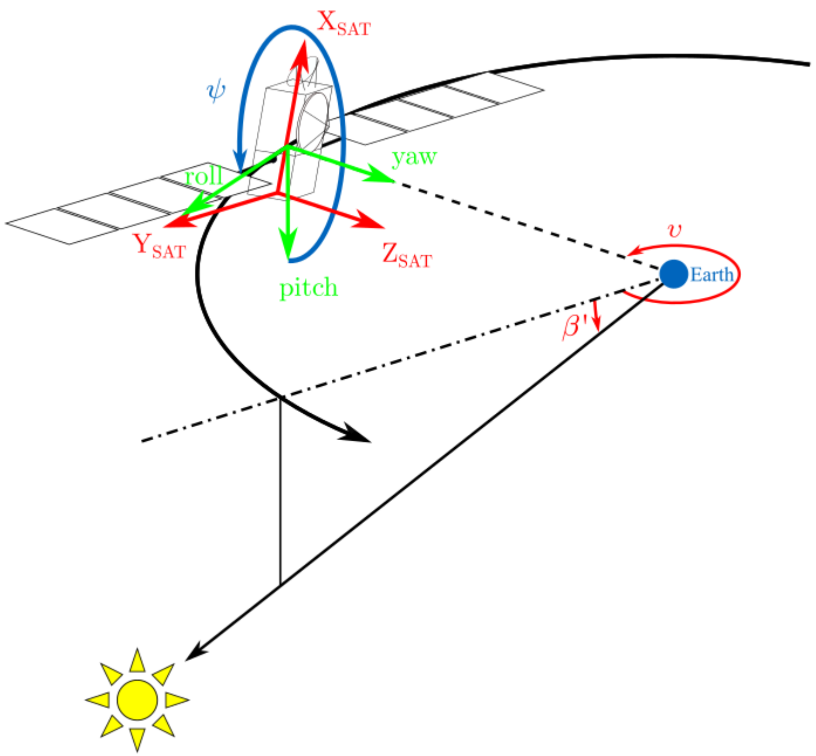
TOPEX/Poseidon attitude implementation

Nominal yaw steering model

1) Spacecraft attitude (Perrygo, 1987; Casotto et al., 1994):

Yaw regime	Occurrence	Description
Sinusoidal	$\lvert\beta'\rvert > 15°$	Yaw sinusoidal law
Fixed	$\lvert\beta'\rvert < 15°$	Yaw = 0° if $\beta' > 0°$ Yaw = 180° if $\beta' < 0°$
Ramp-up	$\lvert\beta'\rvert \geqslant 15°$	Yaw fixed to sinusoidal
Ramp-down	$\lvert\beta'\rvert \leqslant 15°$	Yaw sinusoidal to fixed
Yaw flip	$\lvert\beta'\rvert \approx 0°$	Yaw = 0° if $\beta' > 0°$ Yaw = 180° if $\beta' < 0°$

$$yaw_{nominal} = \psi_{nominal} = \begin{cases} 90° - (90° - \beta')\sin\nu & \text{, if } \beta' > 15° \\ -90° + (90° + \beta')\sin\nu & \text{, if } \beta' < -15° \end{cases}$$



2) Solar array pitch angle modelling:

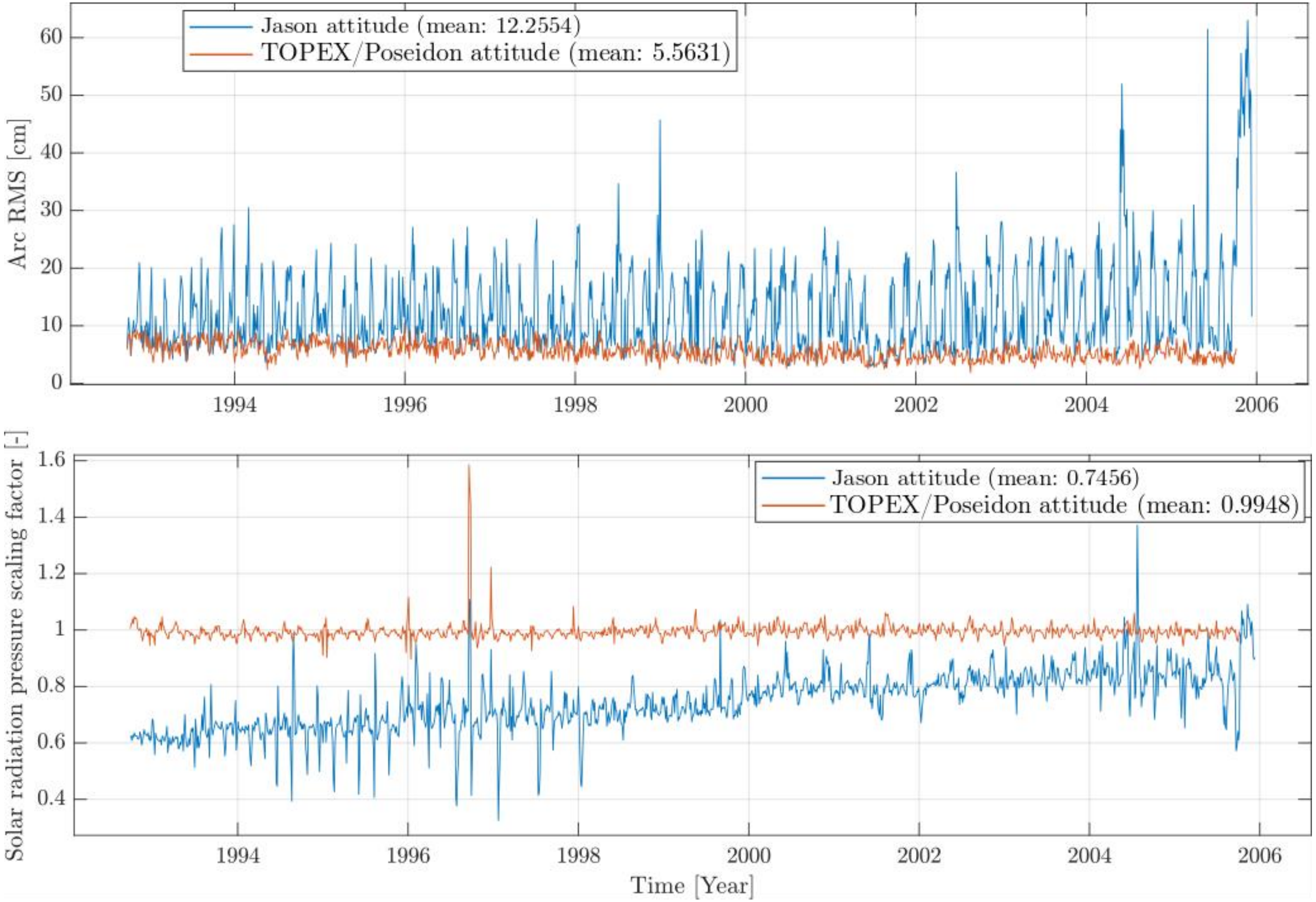
Pitch angle	Occurrence	Description
$\gamma = 90° + \nu$	$0° < \beta' < 15°$	Fixed yaw (flying forward)
$\gamma = 90° - \nu$	$-15° < \beta' < 0°$	Fixed yaw (flying backward)
$\gamma = \arctan\left(\frac{\sin(\nu+90°)\cos\beta'}{\cos(\nu+90°)\cos\beta'\cos\psi - \sin\beta'\sin\psi}\right)$	$15° \leqslant \lvert\beta'\rvert$	Sinusoidal yaw + transition regimes

TOPEX/Poseidon attitude implementation

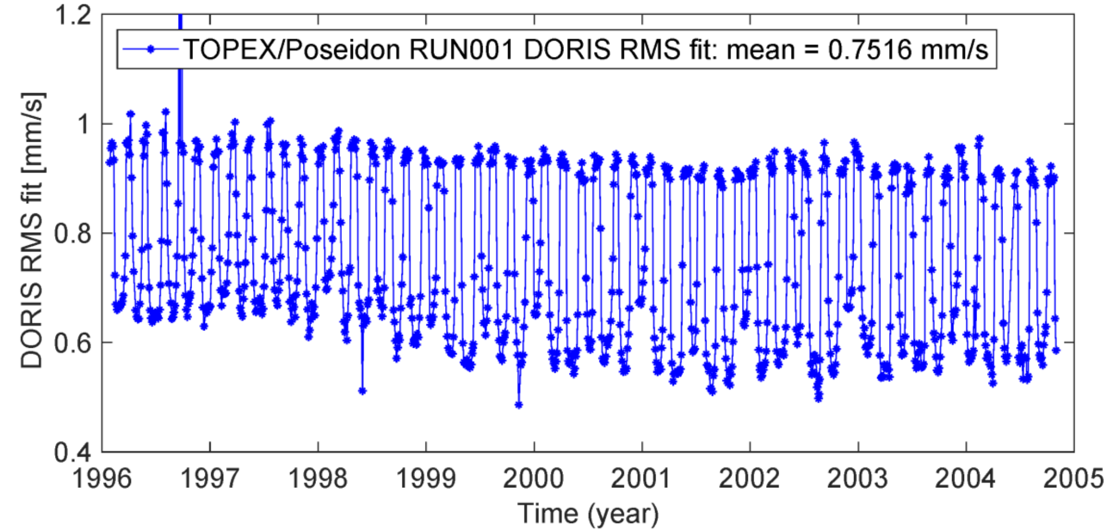
Differences to the Jason attitude:

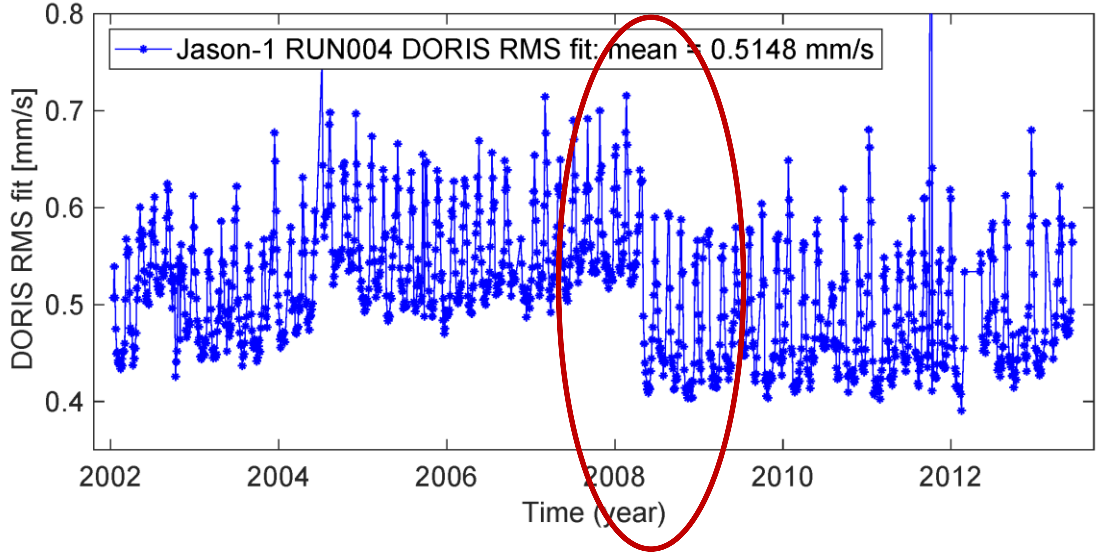
- Bias for the solar array pitch angle
- Exceptions in the yaw steering:
  - Fixed yaw at different yaw angles
  - No transit regimes

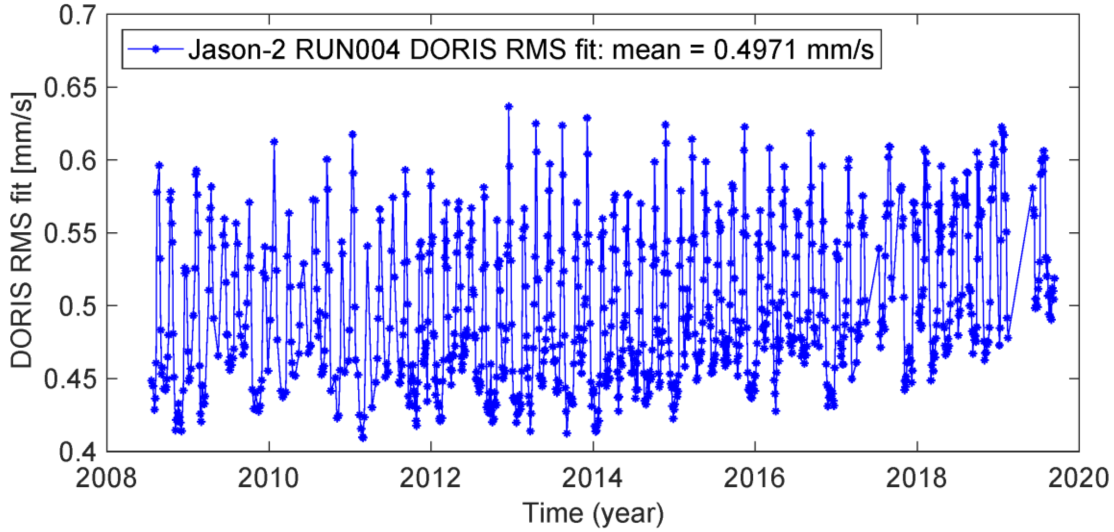
Proper modeling of these differences for TOPEX/Poseidon reduces SLR RMS fits in 2.2 times and provides realistic values of the solar radiation pressure scaling factor (close to 1) instead of 0.75 (without taking these differences into account)



RMS fits of DORIS measurements for TOPEX/Poseidon, Jason-1/-2

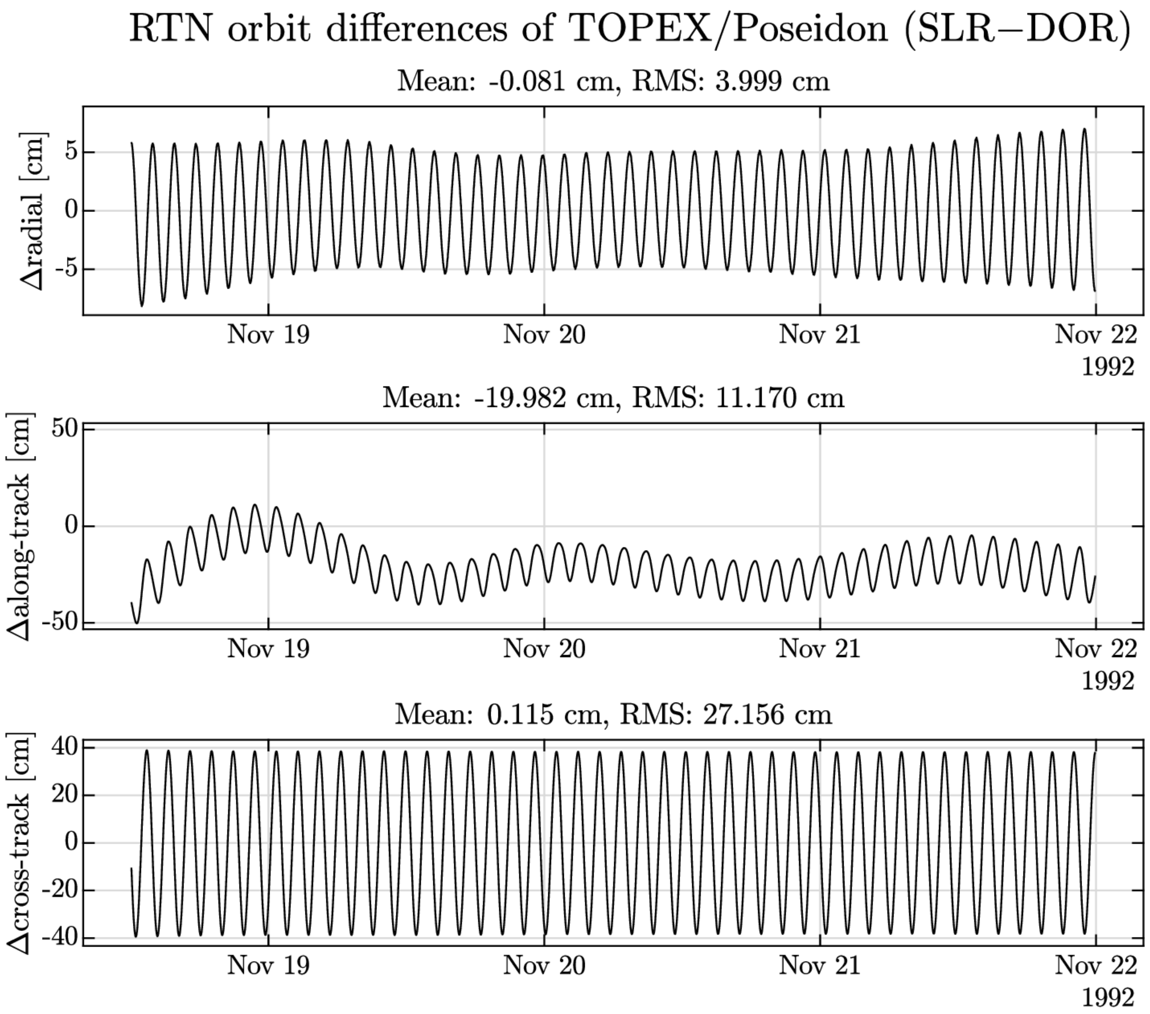


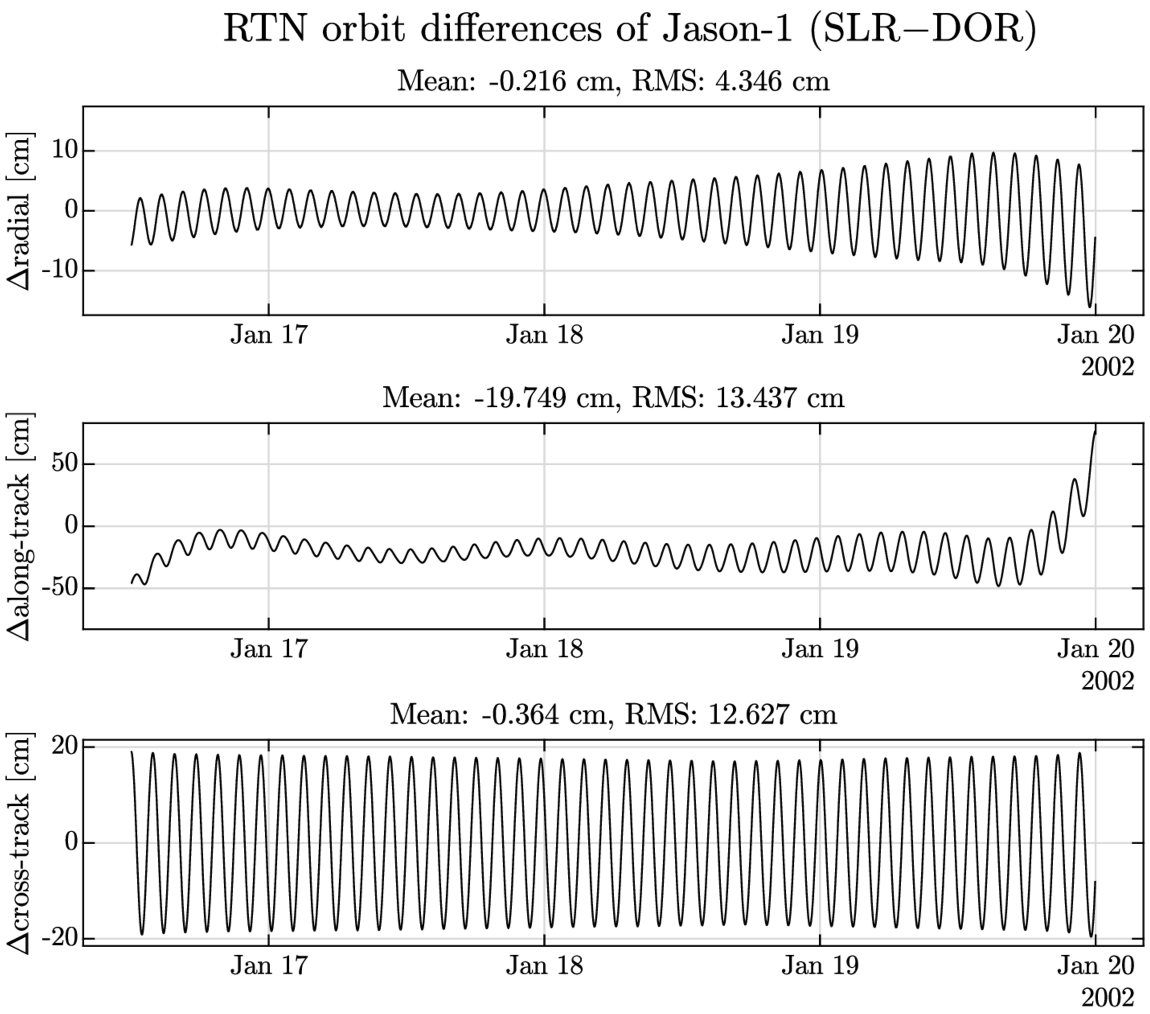




Reduction of the RMS fits of DORIS measurements of Jason-1 in May 2008 has no correlation with any of the following parameters:
the number of used measurements,
changes in the list of estimated parameters,
the estimated values of solar radiation scaling factor,
Earth albedo, IR and atmospheric drag scaling factors,
empirical accelerations, mean fit of DORIS measurements.

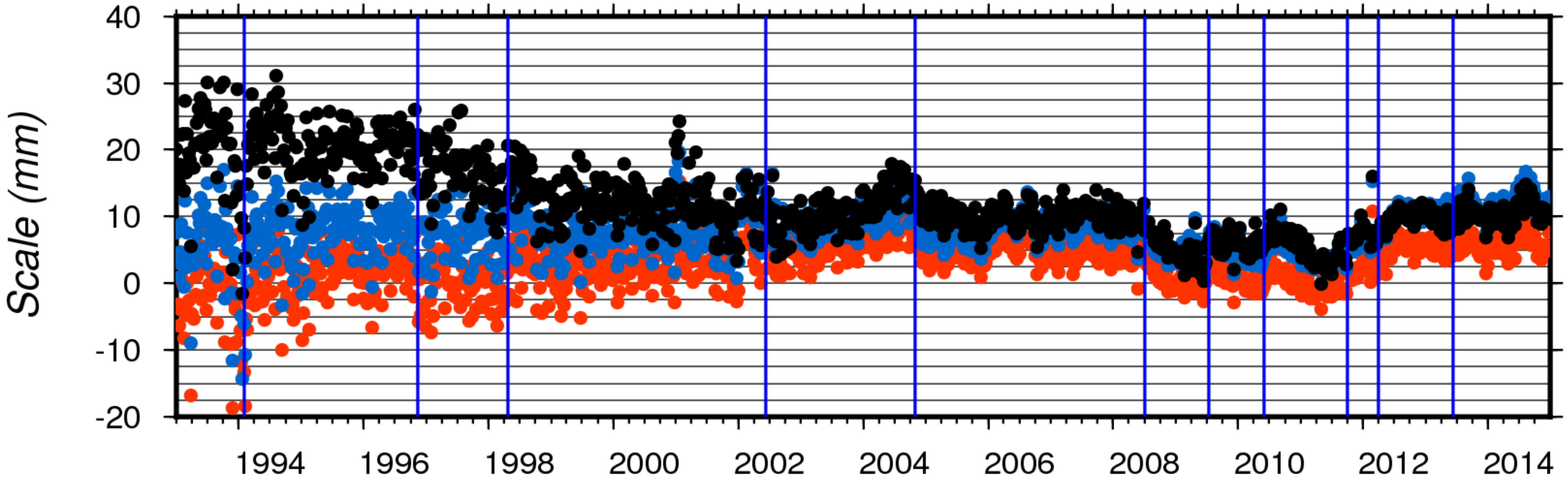
An example of SLR-only and DORIS-only orbit differences for TOPEX/Poseidon and Jason-1





Evaluation of DTRF2014, ITRF2014 and JTRF2014 solutions

DGFI-TUM contributed to the evaluation of the latest ITRS realizations (Rudenko et al., 2018, Rudenko et al., 2019; Angermann et al., 2020; Moreaux et al., 2020)



Scale factors of IDS 09 time series w.r.t. DTRF2014 (red), ITRF2014 (blue), and JTRF2014 (black). The vertical lines correspond to DORIS satellite constellation changes (Moreaux et al., 2020)

Conclusions

- **Macromodels for TOPEX/Poseidon and Jason-1/-2/-3 satellites successfully implemented** in DOGS-OC software

- **Significant improvement** of the orbits when using observation-based orientation information (quaternions of the main body orientation and solar array rotation angles)

- Mean values of DORIS RMS fits:

  0.75 mm/s for TOPEX/Poseidon (SLR RMS fit: 3.33 cm),

  0.52 mm/s for Jason-1 (SLR RMS fit: 2.02 cm) and

  0.50 mm/s for Jason-2 (SLR RMS fit: 2.01 cm).

- A **jump visible in DORIS RMS fits** at around May 2008

- Mean value of RMS **orbit differences is about 4 cm in the radial direction between SLR- and DORIS-only orbits** of TOPEX/Poseidon, Jason-1/-2

- A contribution to **the comparison and evaluation of the recent ITRS realizations** (DTRF2014, ITRF2014, JTRF2014) using SLR and DORIS

Future plans

- Major interest at DGFI-TUM is on a combined orbit determination of altimetry satellites using SLR and DORIS (in house altimetry satellite solution at DGFI-TUM)
- Additional satellites to be implemented (e.g., CryoSat-2, SARAL, Sentinel-3A)
- Implementation of DORIS RINEX data processing
- Further improvement of the troposphere correction modeling
- Refined thermospheric density modeling (e.g., model updates)
- Further improvement of DORIS data processing

References

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