An Investigation into the Source of the 59-Day Variations in Jason Sea Level

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Questions to be addressed

Is the TOPEX CoG correction valid?

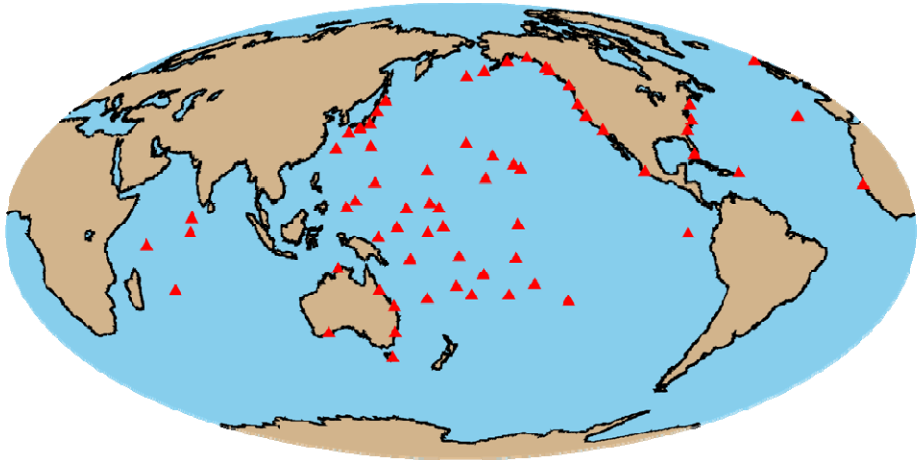
How do J1–TX orbit – range differences depend on sun angle and orbital parameters?

Can an empirical correction based on J1–TX cal phase differences remove the 59-day & semi-annual in the J1 time series?

Tide gauge calibration

Mitchum tide gauge calibration without S2 alias removed

- No IB correction for TX or gauges
- No tide model applied to gauges, GOT4.7 applied to TOPEX

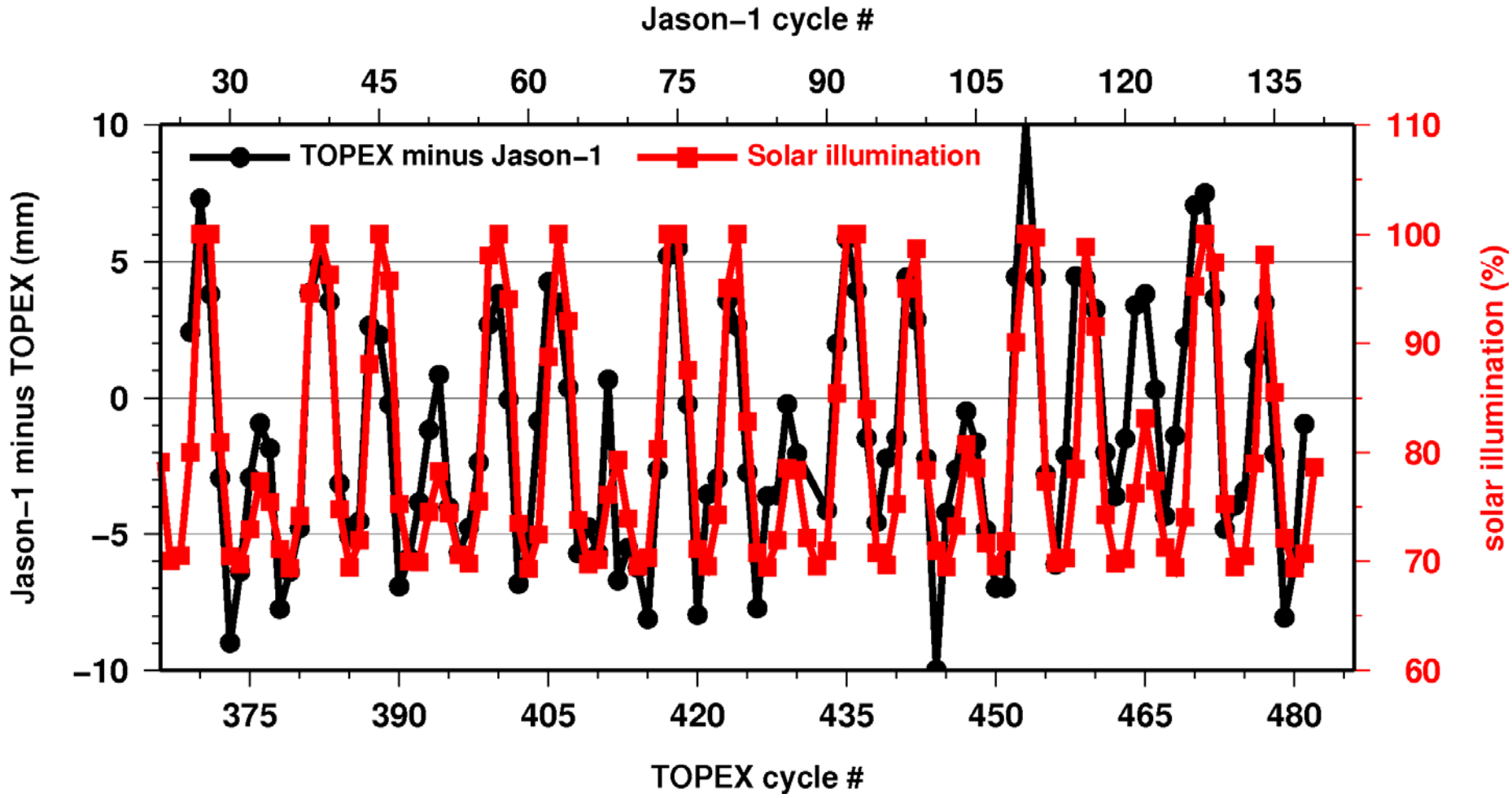


Amplitude (mm) and phase of 58.77 day signal

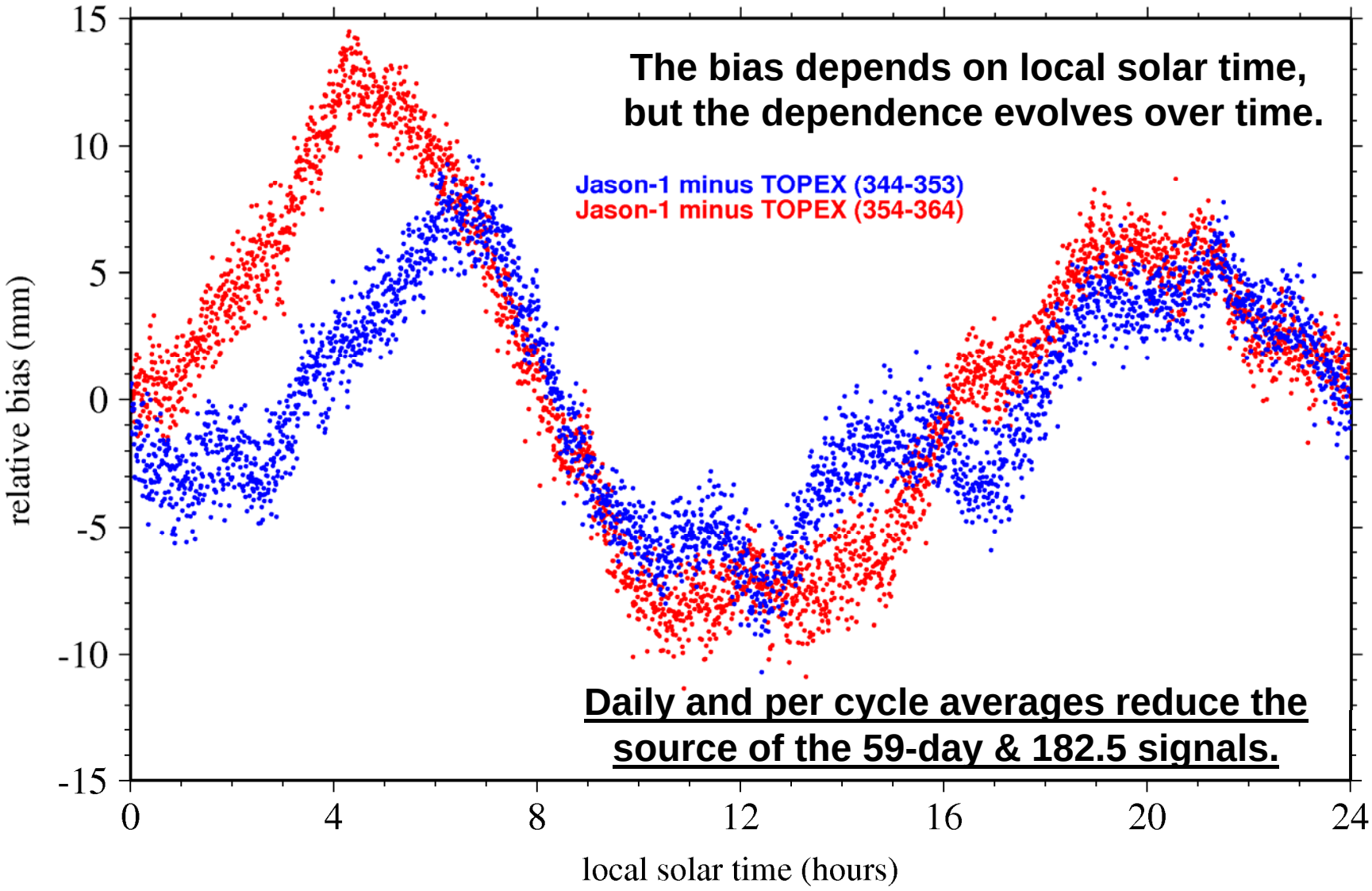
cycles	1 – 364	1 – 235	236 – 364
Weighted gauges	2.4 (205°)	1.6 (200°)	3.2 (197°)
TOPEX@gauges (CoG applied)	2.5 (193°)	2.3 (183°)	2.3 (191°)
TOPEX@gauges (no CoG)	3.2 (196°)	4.8 (197°)	4.4 (192°)
TOPEX (CoG) – gauges	0.5 (103°)	0.8 (142°)	0.9 (17°)
TOPEX (no CoG) – gauges	2.3 (188°)	2.8 (185°)	1.6 (205°)

Bias depends on solar illumination

For per-cycle global means, the J1-TX bias is highly corrected with the amount of time TX/J1 spent in the Sun.



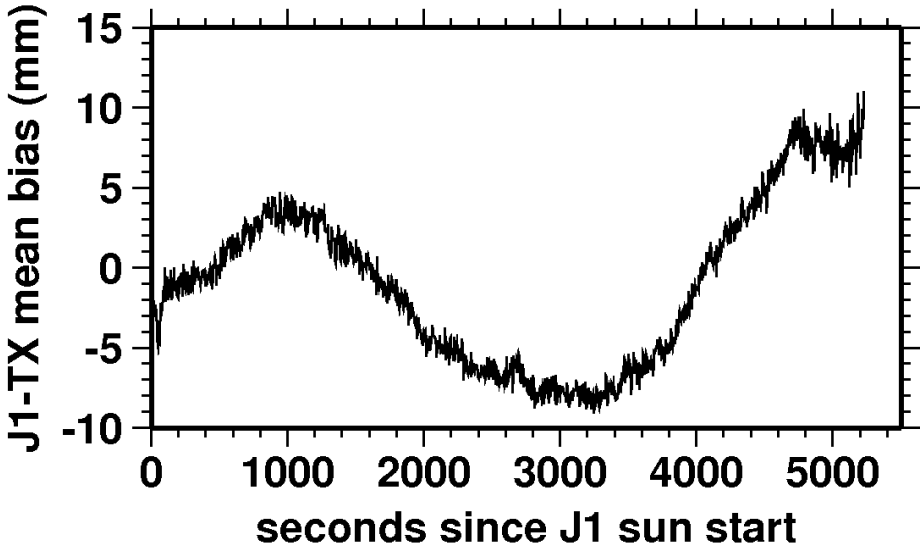
J1–TX bias versus solar time



Bias behavior in/out of eclipse

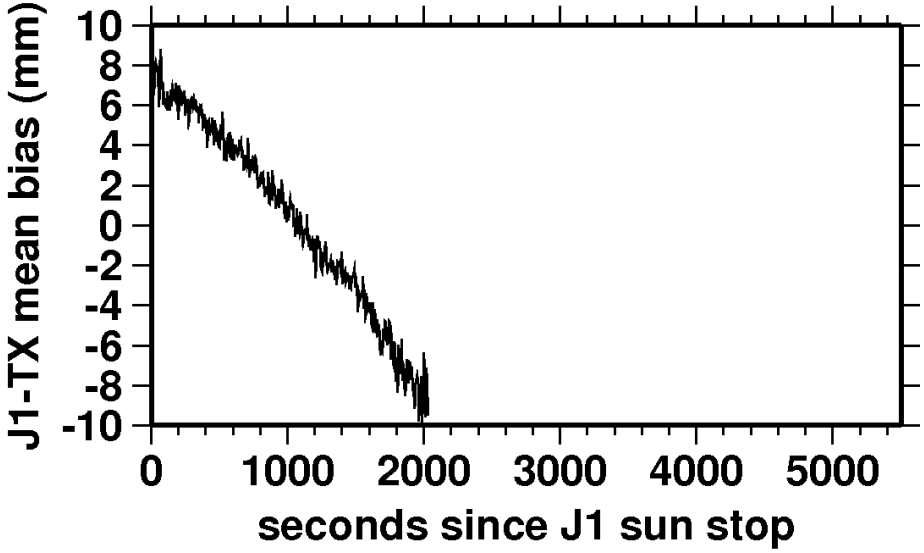
Mean bias after J1–TX leaves eclipse

Not simply a problem at S2 frequency



Mean bias after J1–TX enters eclipse

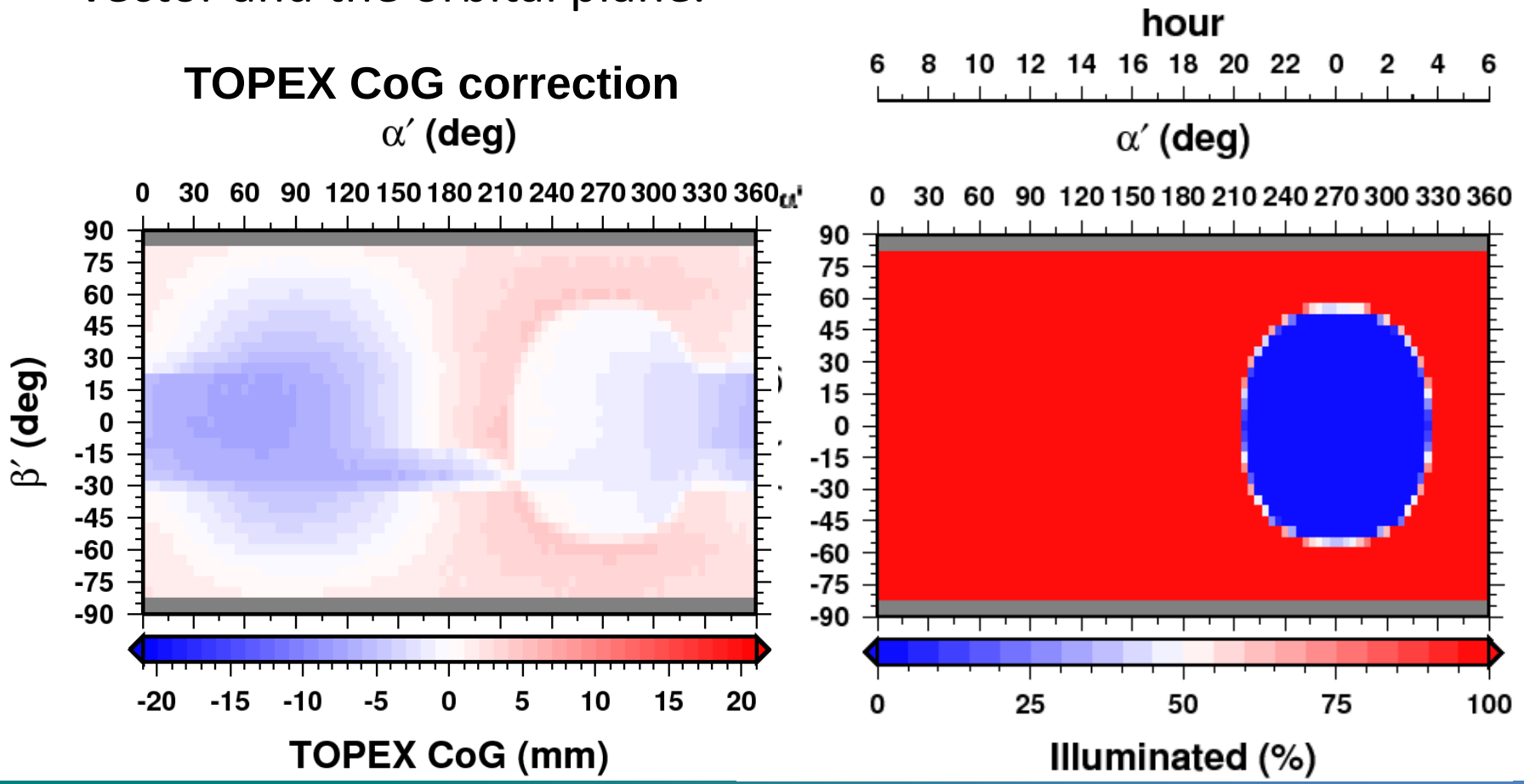
The 18 mm linear drift in range implies a thermal effect in one of the instruments



TOPEX Center of Gravity correction

α', orbit angle, i.e. the angular separation of the spacecraft from the orbital 6 a.m. position.

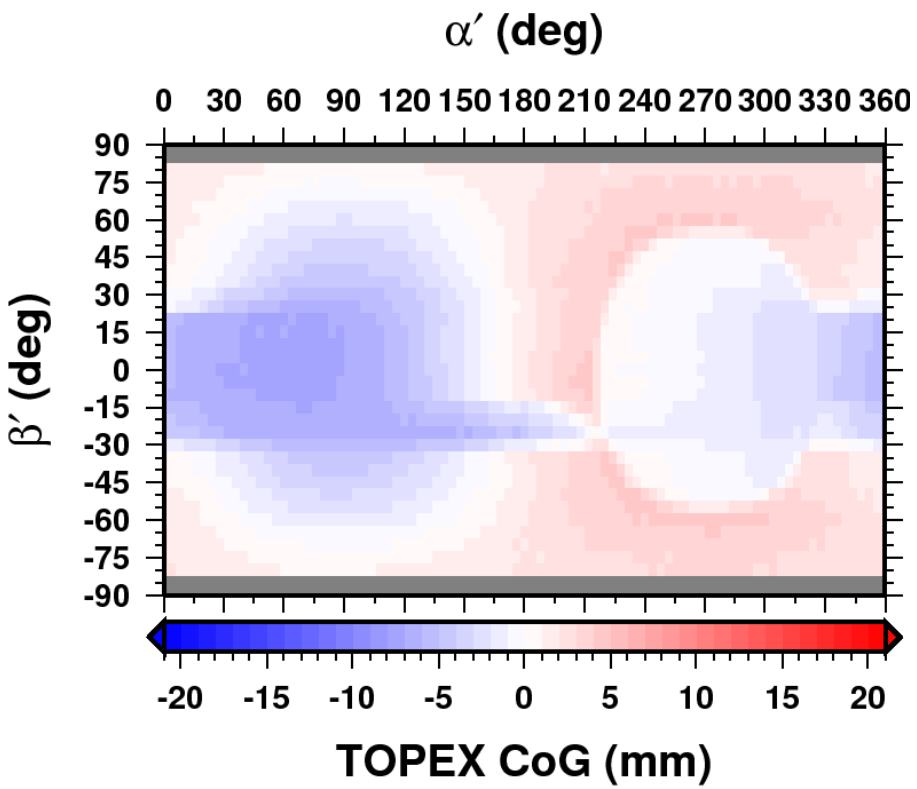
β', solar aspect angle, i.e. the angle between the Earth/Sun position vector and the orbital plane.



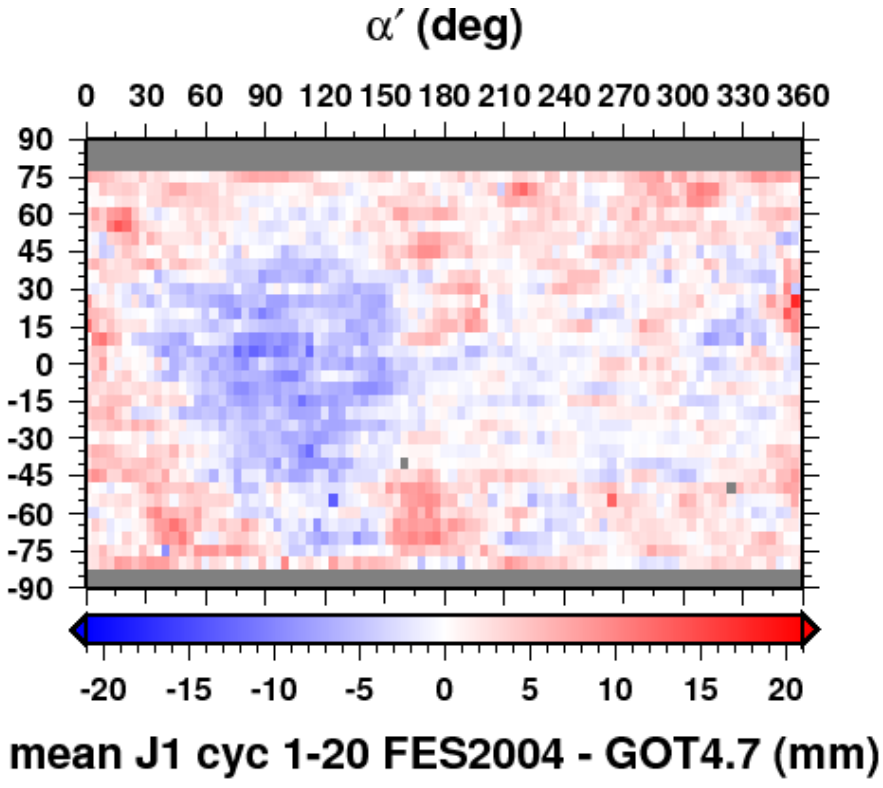
Tide models and TX CoG correction

The differences between FES2004 and GOT4.7 is of similar to the TOPEX center of gravity correction.

TOPEX CoG correction
Cycles 344 – 364

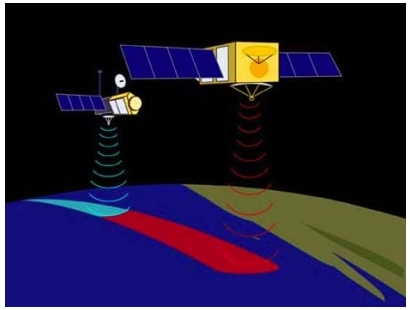


Difference in FES2004 & GOT4.7
Jason-1 cycles 1–20

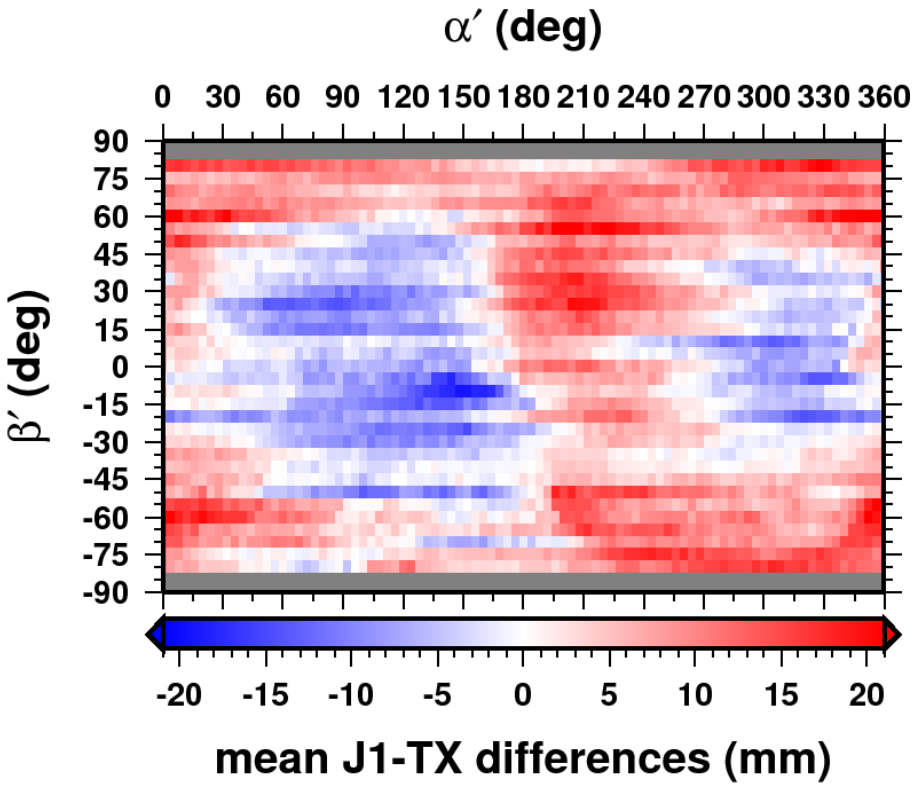


J1–TX calibration phase differences

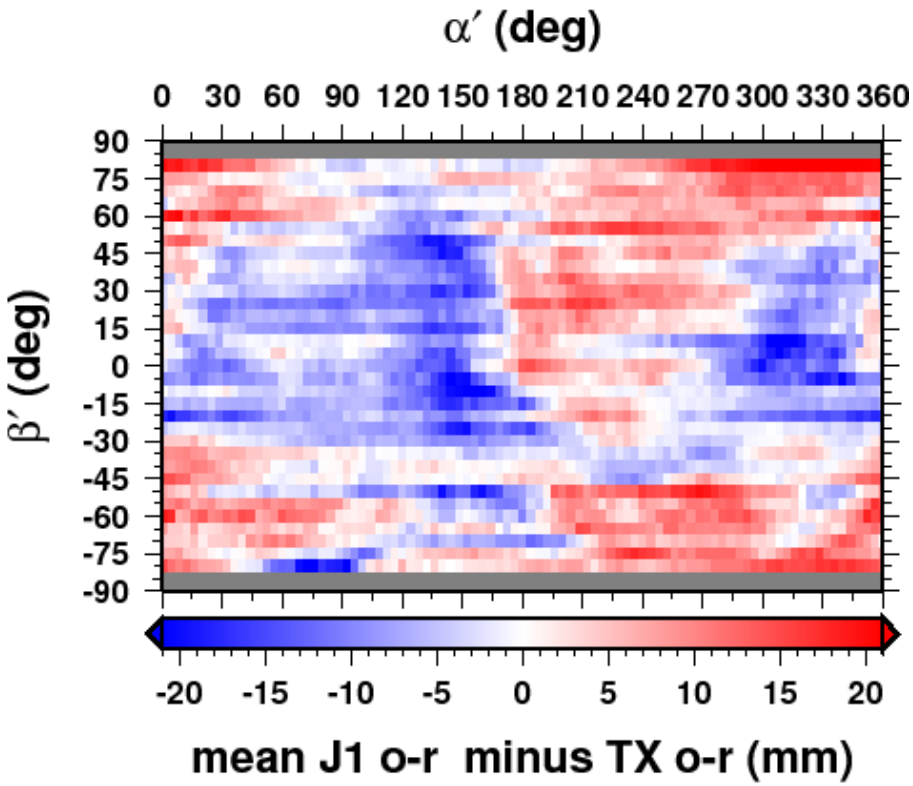
8 727 638 calibration phase differences binned 4° in α' and 5° in β'



Sea level

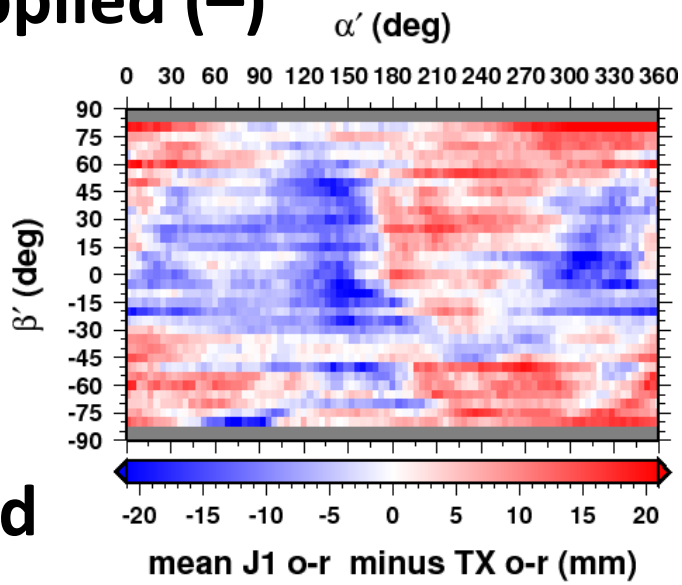


Orbit – range

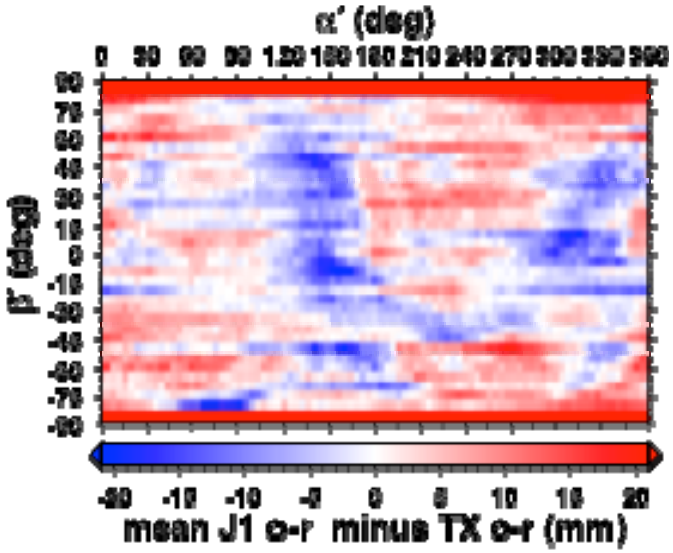


TX CoG applied to orbit–range

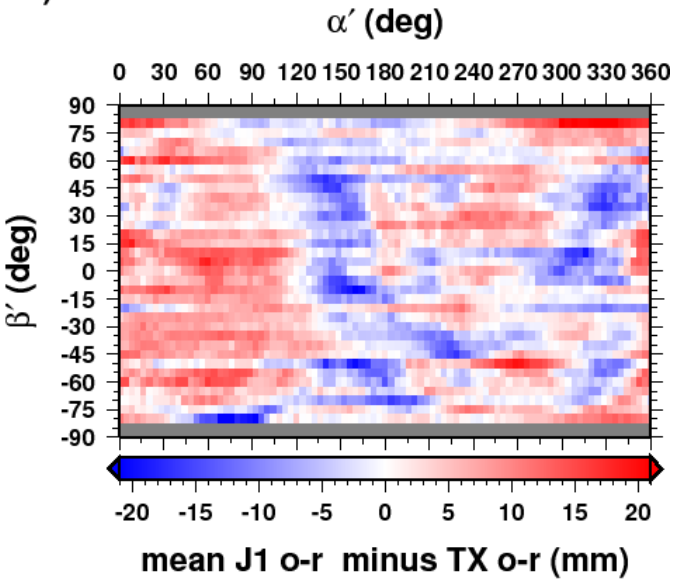
CoG applied (–)



CoG not applied



CoG sign flip (+)

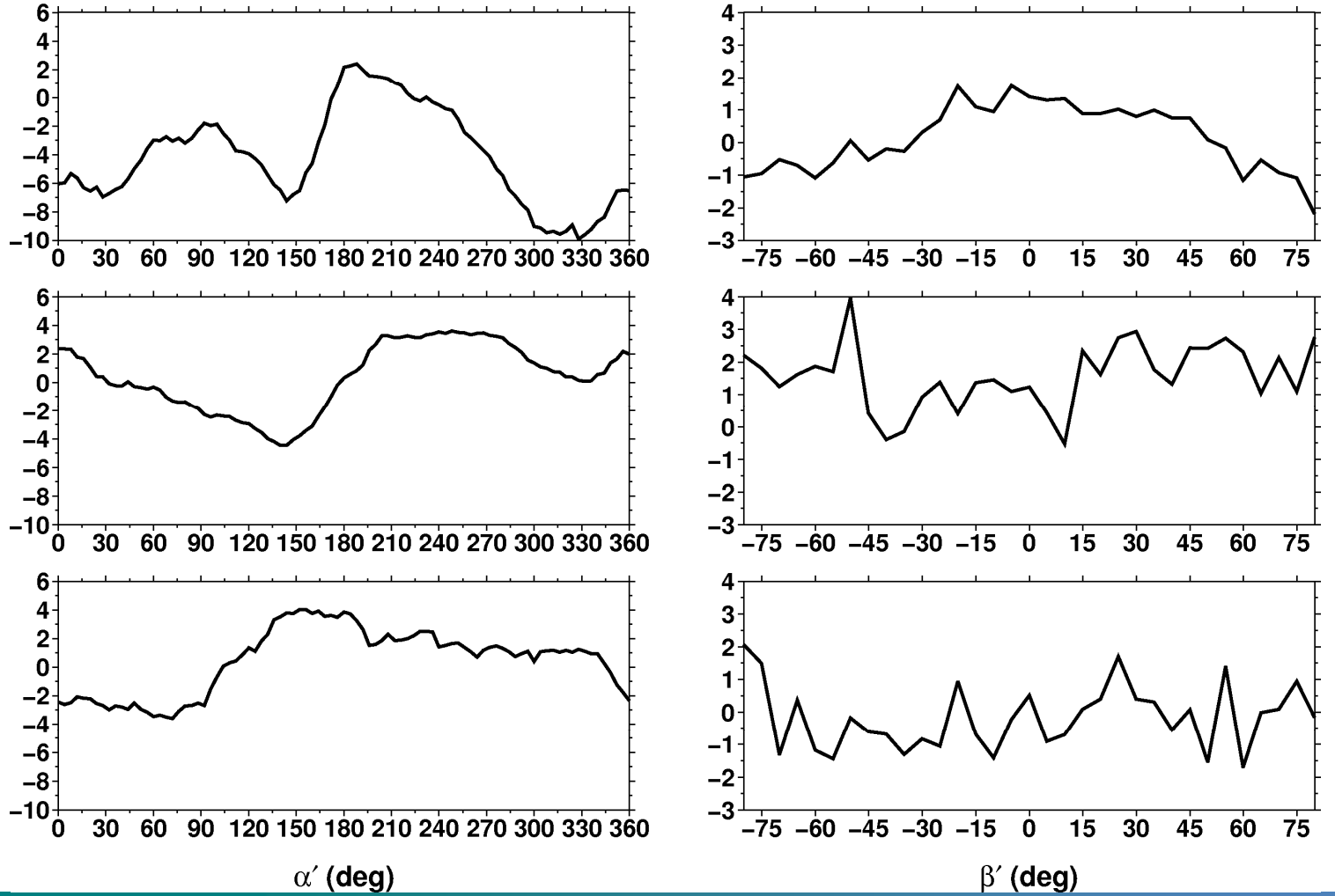


EOFs of the J1–TX cal phase differences

EOFs of J1–TX orbit – range

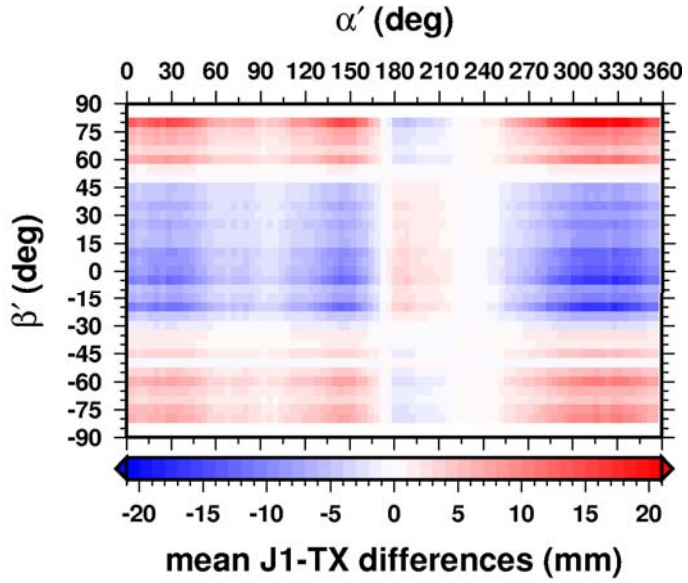
Solar angle basis functions

Beta angle basis functions

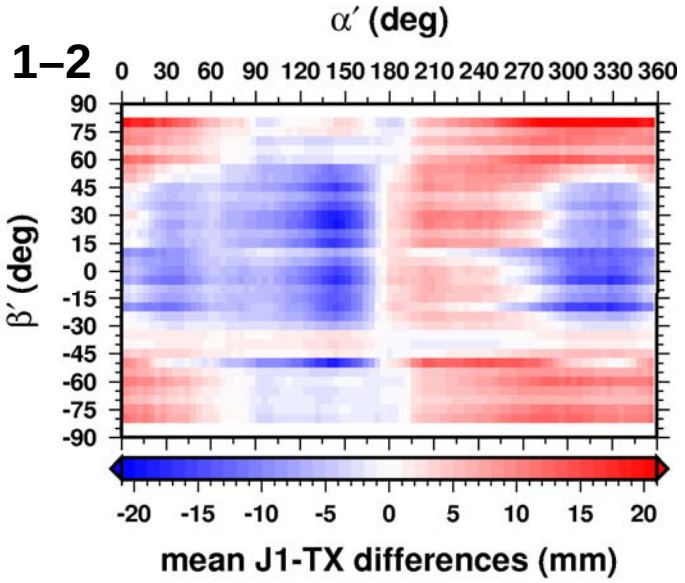


Correction from reconstruction of EOFs

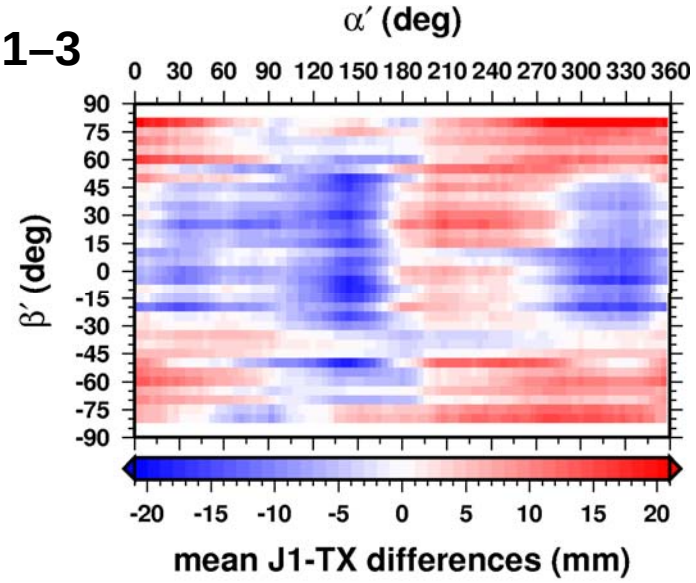
EOF 1



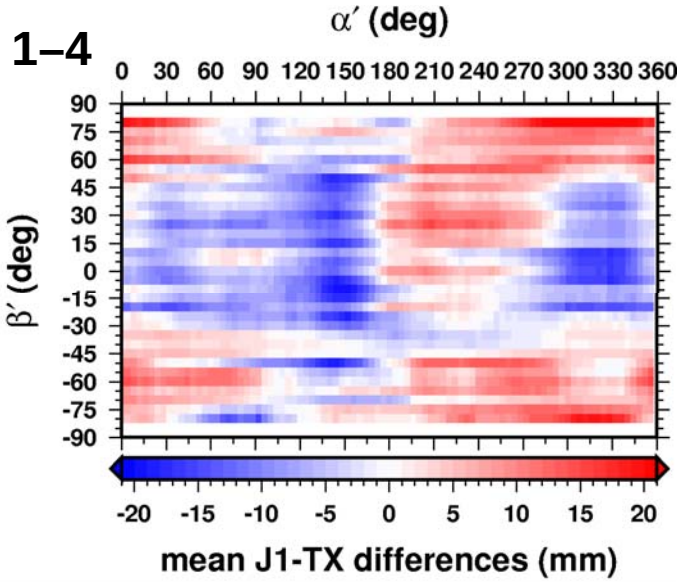
EOFs 1–2



EOFs 1–3

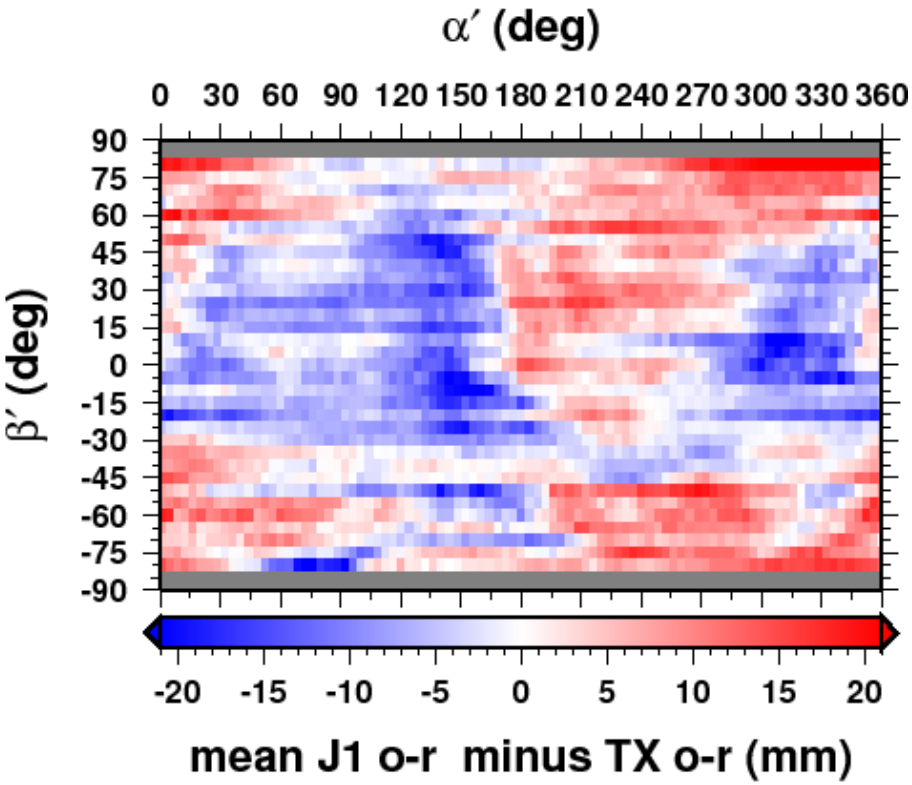


EOFs 1–4

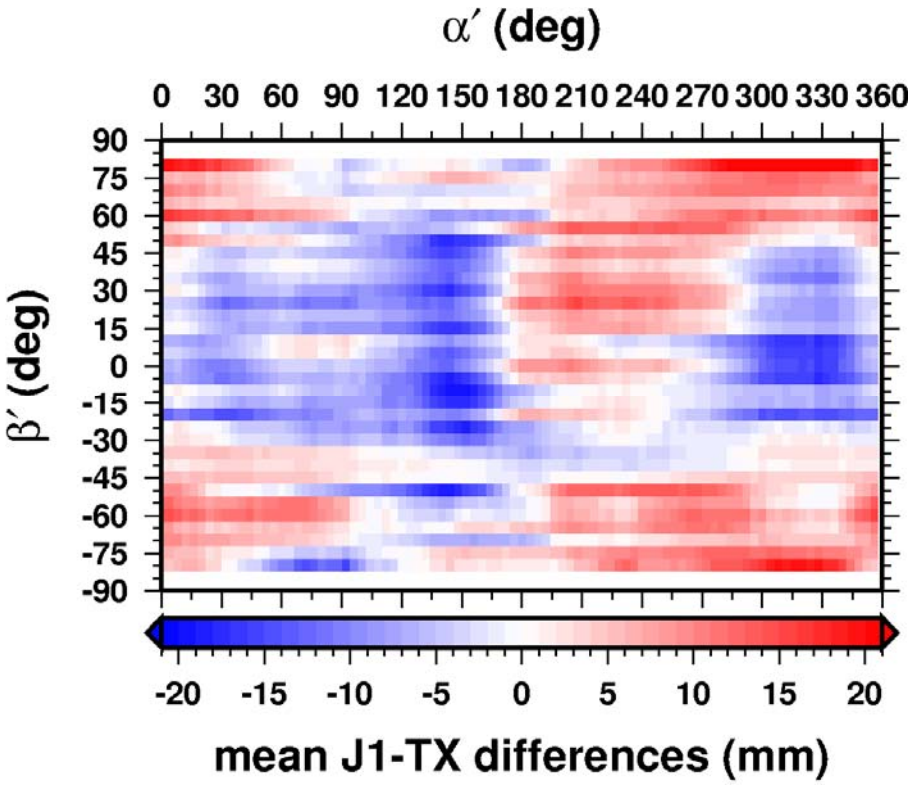


Correction from reconstruction of EOFs

Original differences

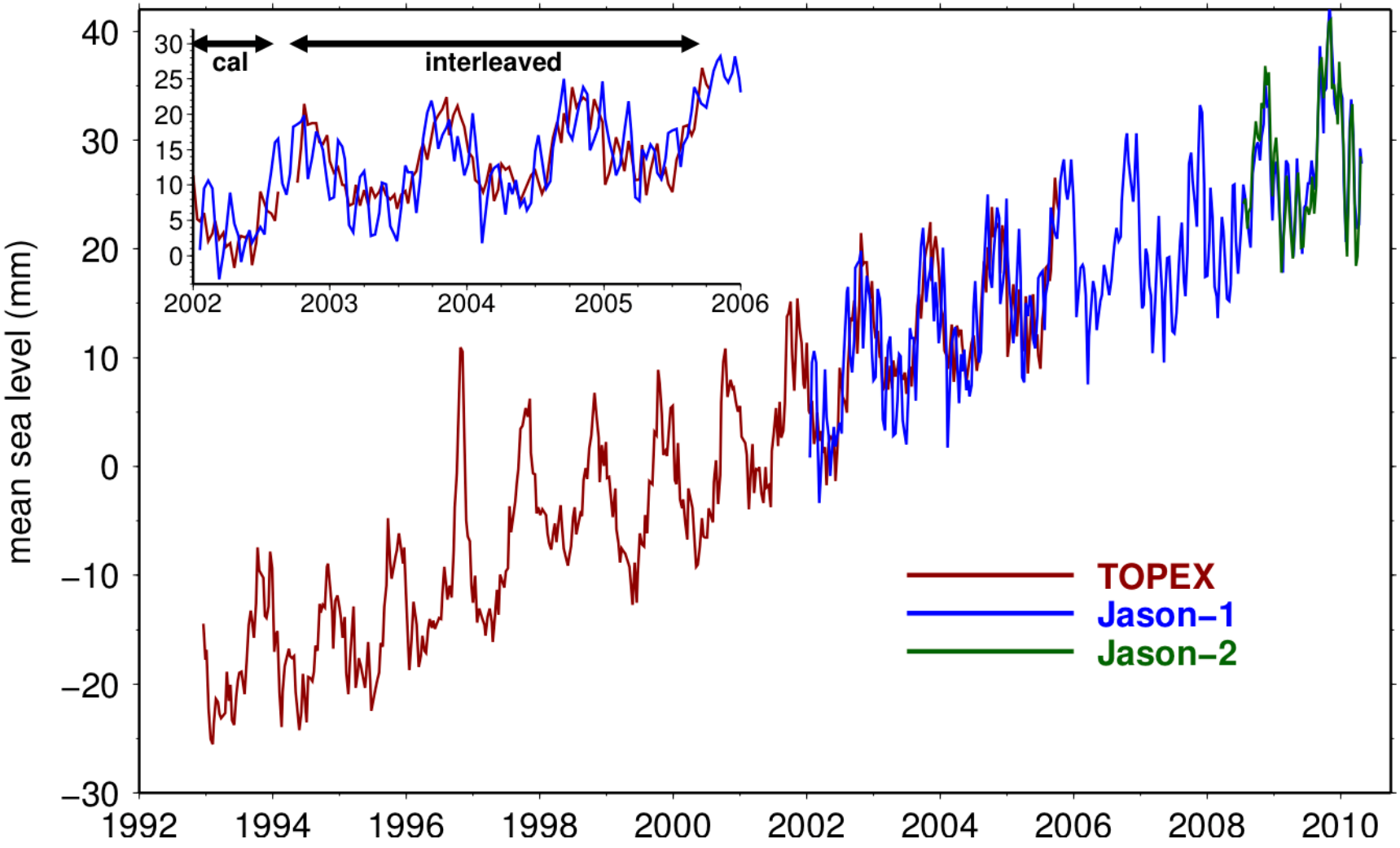


Reconstruction from EOFs 1–4



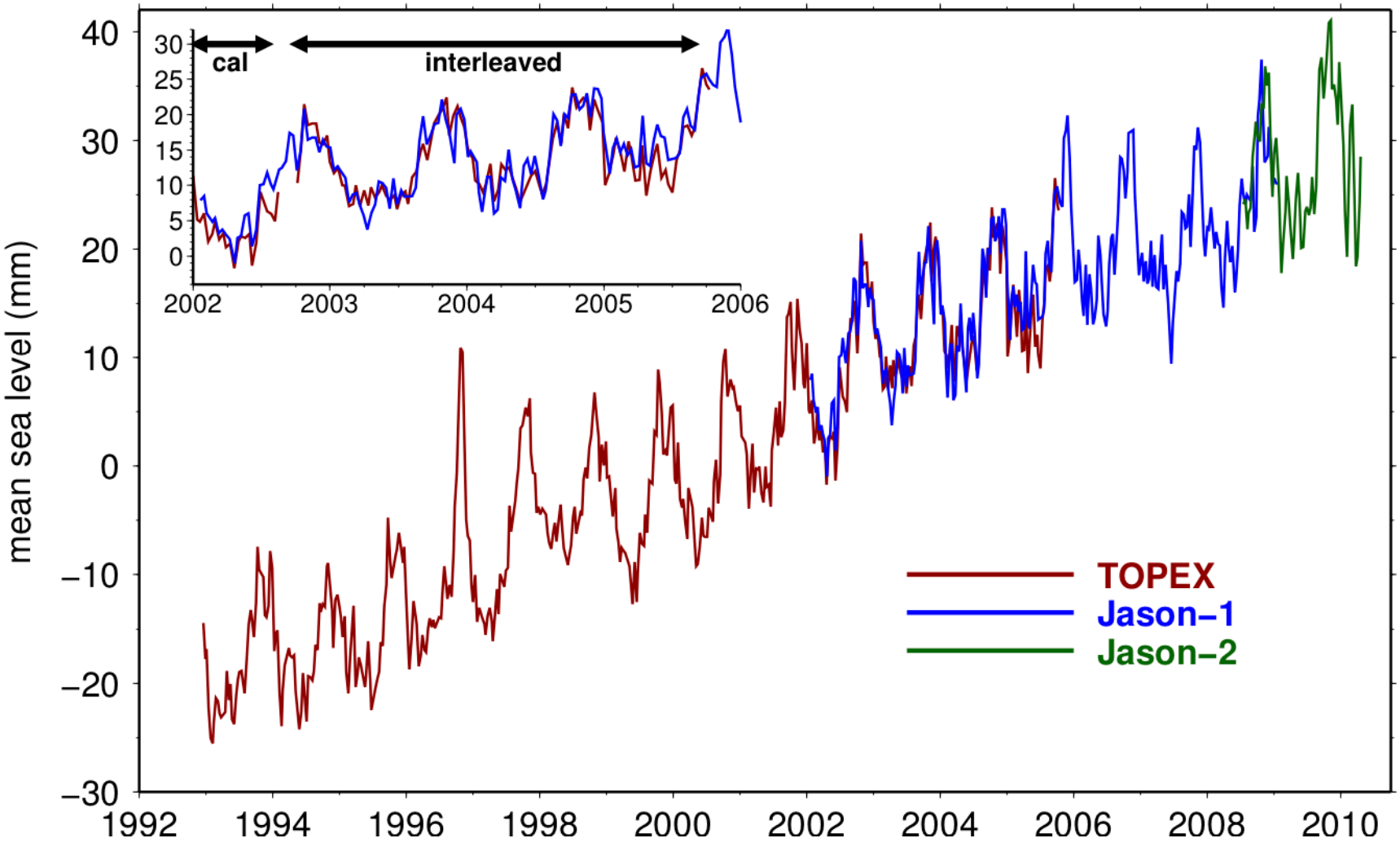
TX/J1/J2 sea level record

Uncorrected



Sea level record with J1 correction

Correction EOF 1–4



Correction applied to J1–TX differences

Statics for J1—TX global mean sea level residuals during each TOPEX phase

	Calibration phase		Interleaved phase	
	St. dev. (mm)	Variance reduction	St. dev. (mm)	Variance reduction
Uncorrected	4.8		4.2	
EOF 1	2.5	73%	2.4	68%
EOFs 1–2	2.2	78%	2.2	73%
EOFs 1–3	2.0	82%	2.1	75%
EOFs 1–4	2.0	83%	2.0	77%

Correction applied to calibration phase

Amplitude of 59-day cycle in J1—TX sea level differences during the calibration phase (Jason cycles 1 – 20)

	Amplitude, 59 days (mm)	Variance reduction	Amplitude, 182.5 days (mm)
Uncorrected	**5.9**		**1.4**
EOF 1	**2.6**	**80%**	**0.1**
EOFs 1–2	**2.2**	**86%**	**0.3**
EOFs 1–3	**2.0**	**89%**	**0.4**
EOFs 1–4	**1.9**	**90%**	**0.6**

Correction applied to interleaved phase

Amplitude of 59-day cycle in J1—TX sea level differences during interleaved phase (Jason cycles 26 – 138)

	Amplitude, 59 days (mm)	Variance reduction	Amplitude, 182.5 days (mm)
Uncorrected	**5.1**		**1.3**
EOF 1	**1.8**	**87%**	**0.1**
EOFs 1–2	**1.3**	**94%**	**0.2**
EOFs 1–3	**1.1**	**95%**	**0.2**
EOFs 1–4	**1.1**	**95%**	**0.3**

Conclusions

Is the TOPEX CoG correction valid?

- Amplitude of 59-day signal is smallest when CoG & GOT4.7 applied
- Tide gauge calibration implies CoG should be applied

How does the J1–TX SSH and orbit – range bias depend on sun angle and orbital parameters?

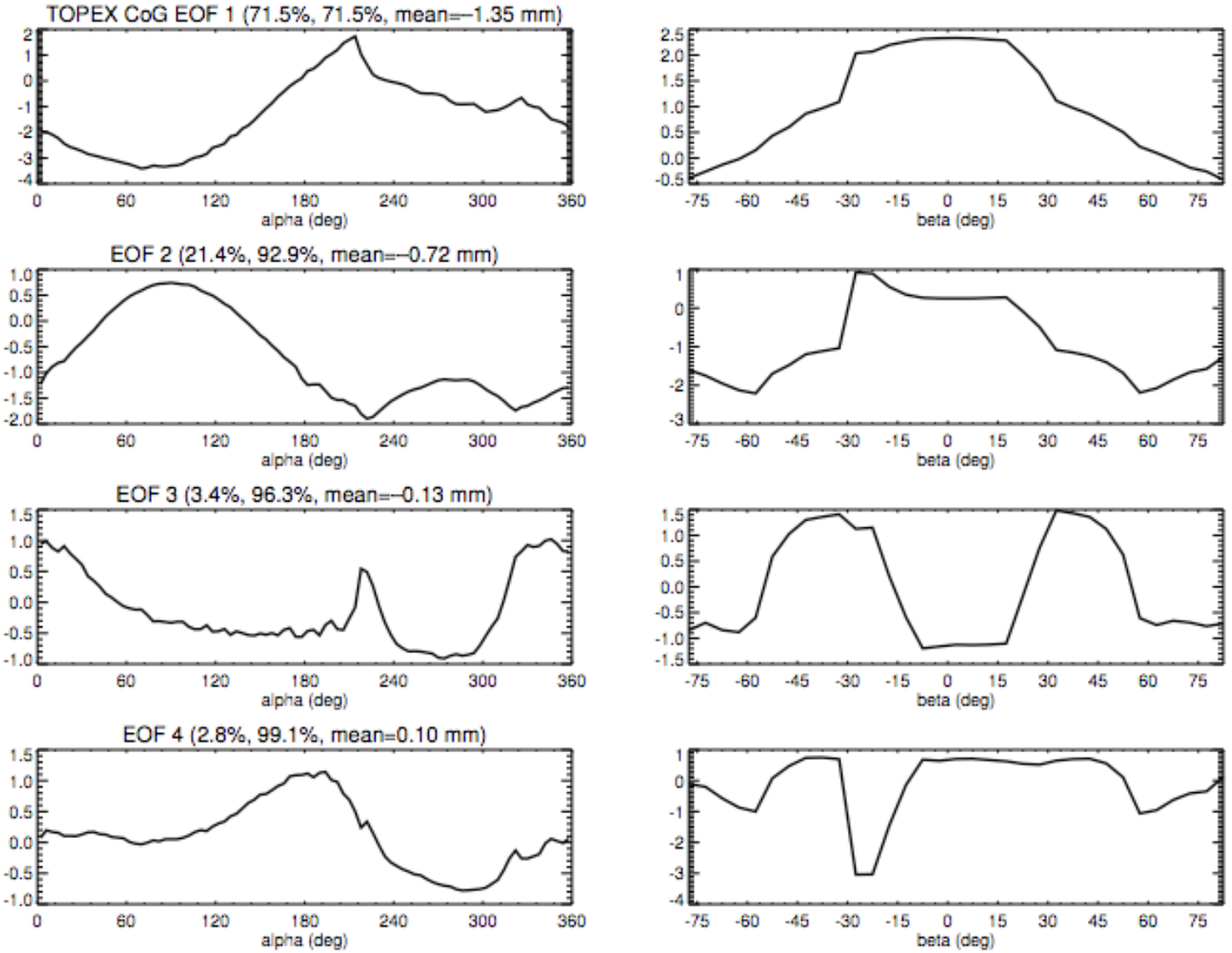
- Coherent patterns with a range of 5 cm

Can an empirical correction based on J1–TX cal phase differences remove the 59-day & semi-annual in the J1 time series?

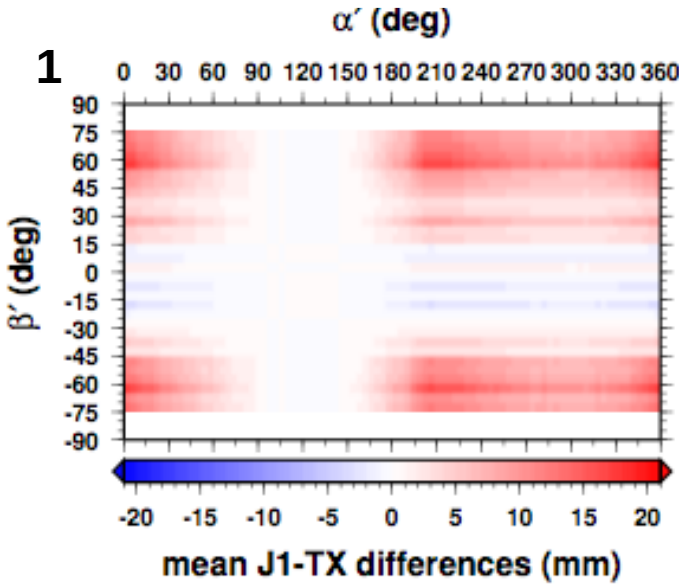
- A correction based on 1 or 2 EOFs reconstructing J1–TX biases during the calibration phase can nearly eliminate the 59-day signal during the entire Jason-1 mission

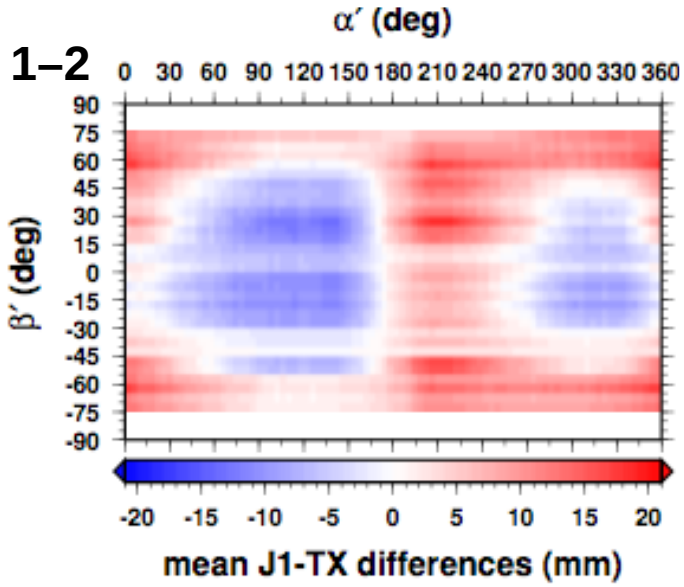
Backup slides

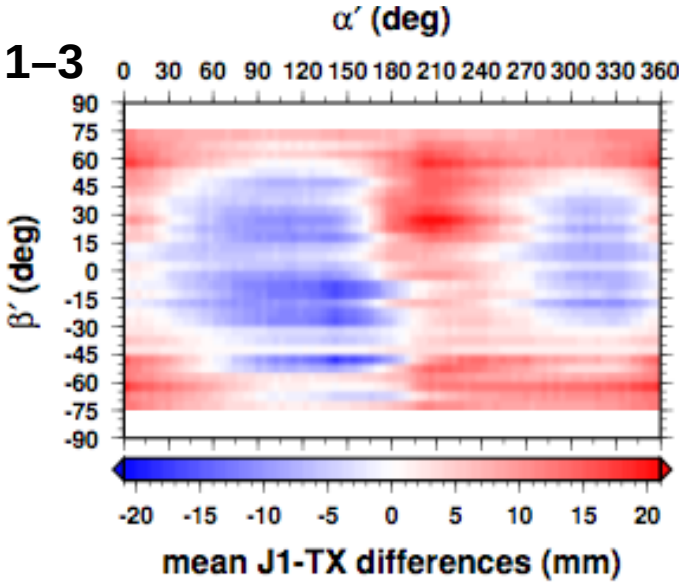
EOFs of the TOPEX CoG correction

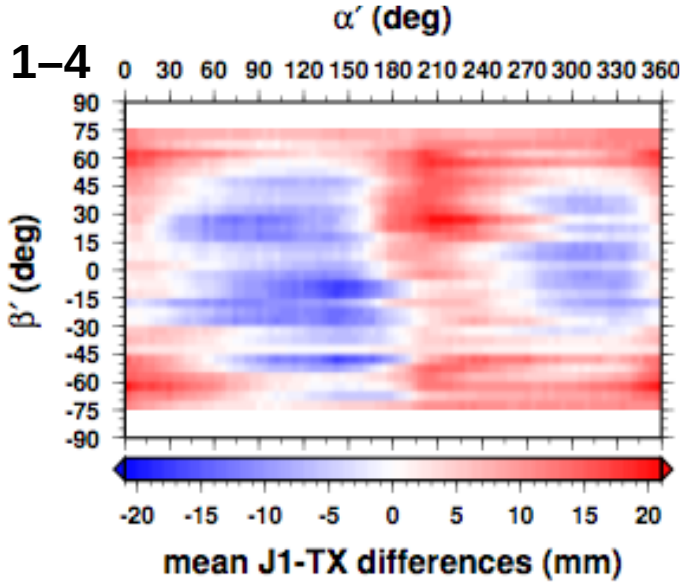


SSH Corrections constructed from EOFs

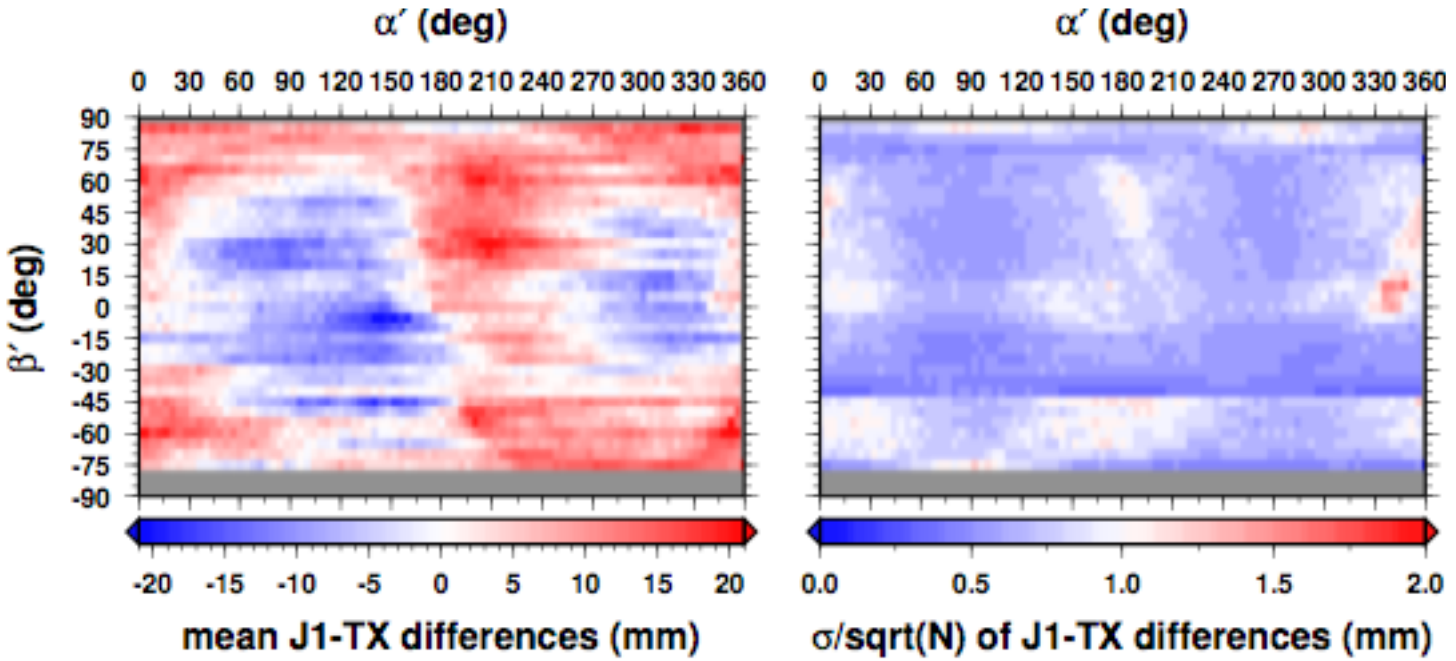




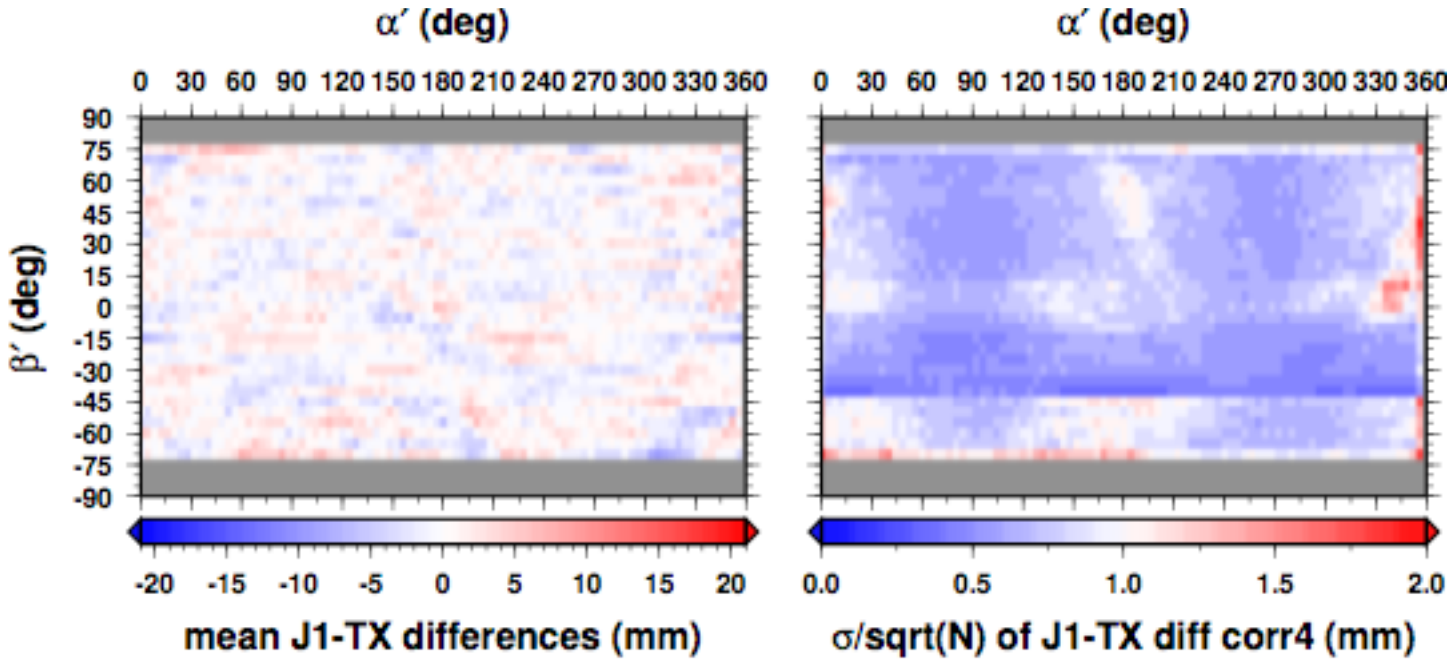




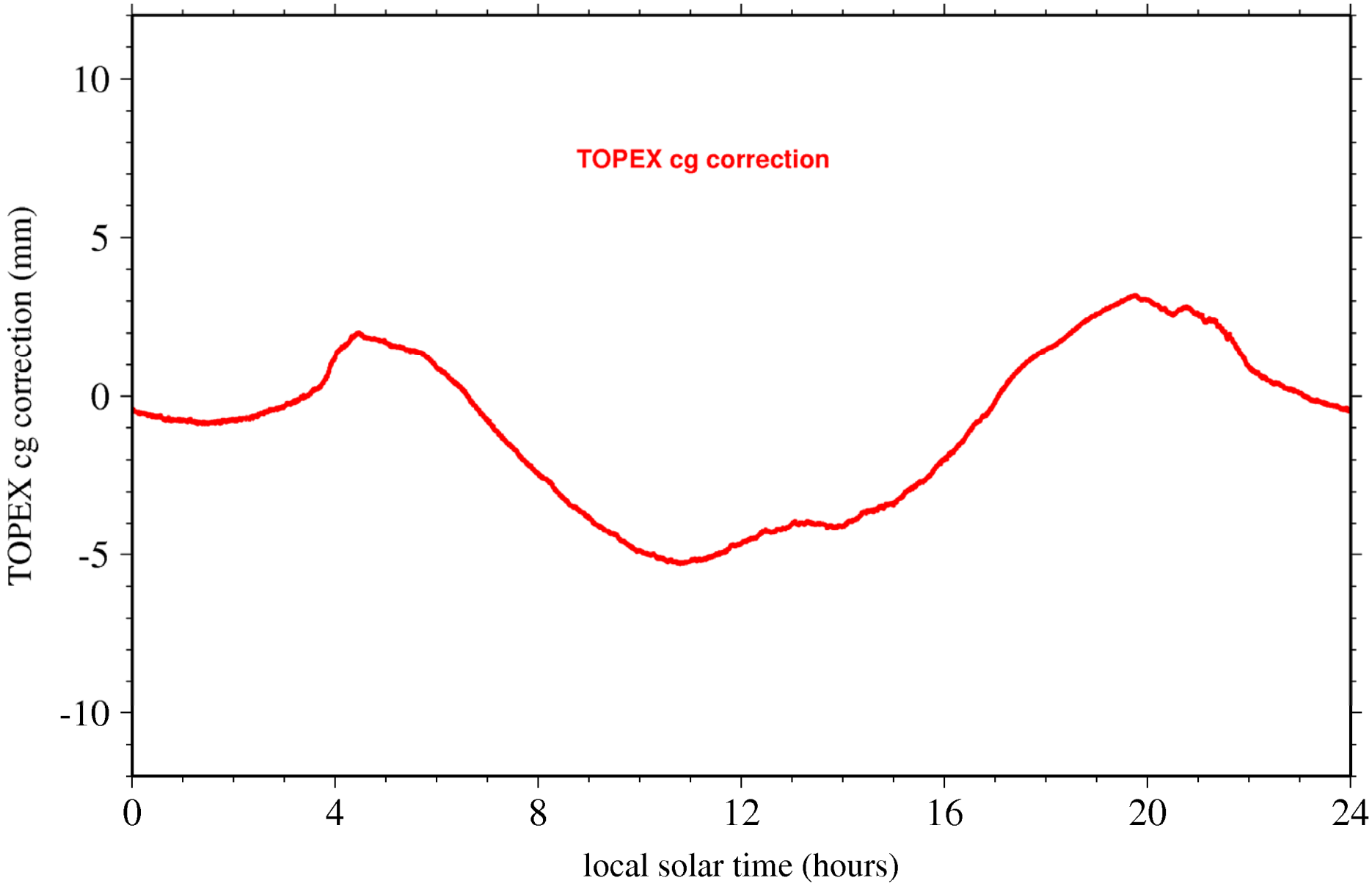
Significance of biases



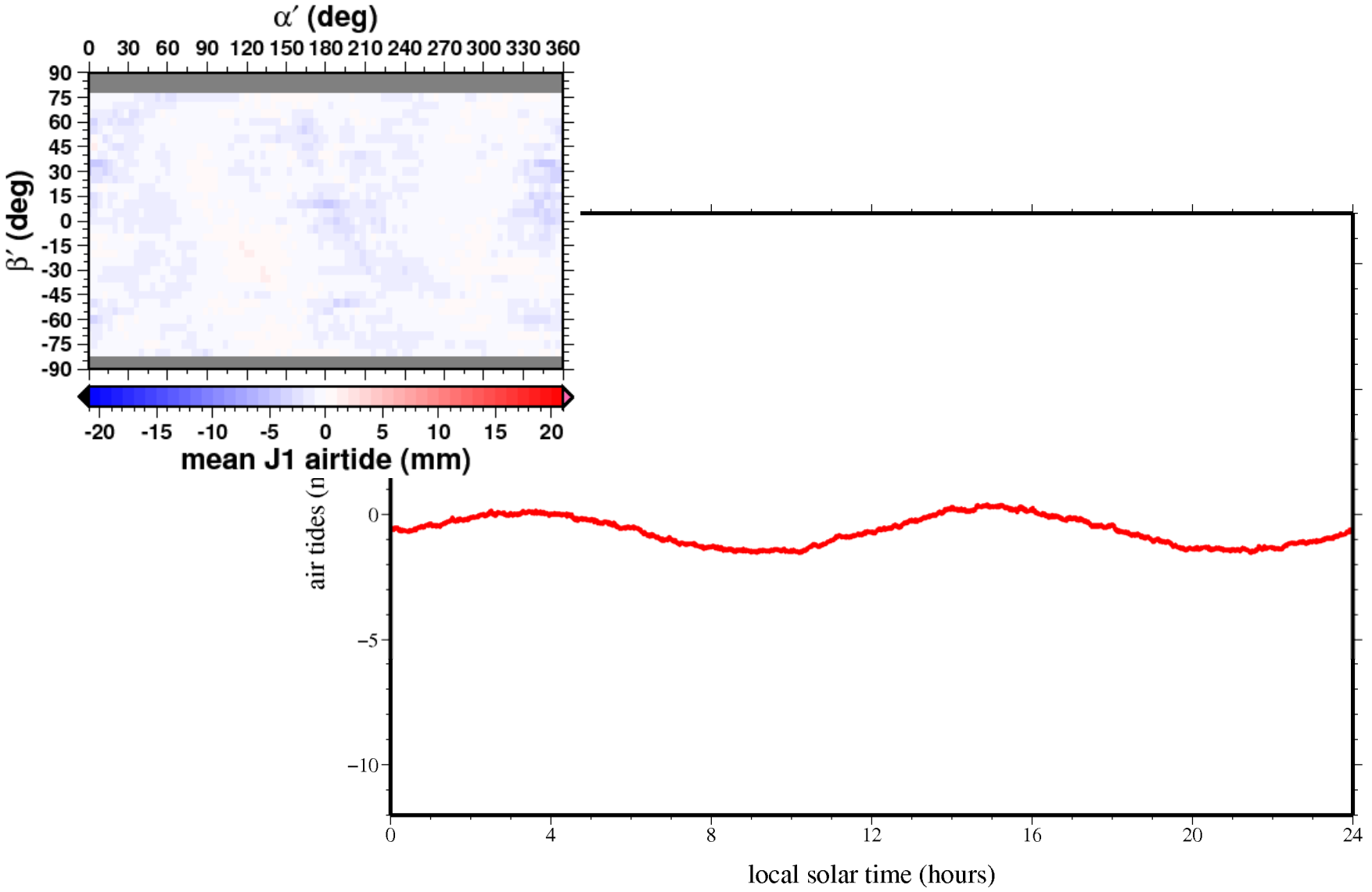
After correction applied



TOPEX CoG


TOPEX cg correction
TOPEX cg correction (mm)
10
5
0
-5
-10
0
4
8
12
16
20
24
local solar time (hours)

Air tides


α′ (deg)
0 30 60 90 120 150 180 210 240 270 300 330 360
β′ (deg)
90 75 60 45 30 15 0 -15 -30 -45 -60 -75 -90
-20 -15 -10 -5 0 5 10 15 20
mean J1 airtide (mm)
air tides (n
0
−5
−10
0 4 8 12 16 20 24
local solar time (hours)