Absolute Calibration of TOPEX/Poseidon, Jason-1&2 Altimeters in Corsica

Latest results

P. Bonnefond[1], P. Exertier[1], O. Laurain[1], T. Guinle[2] , P. Féménias[3]

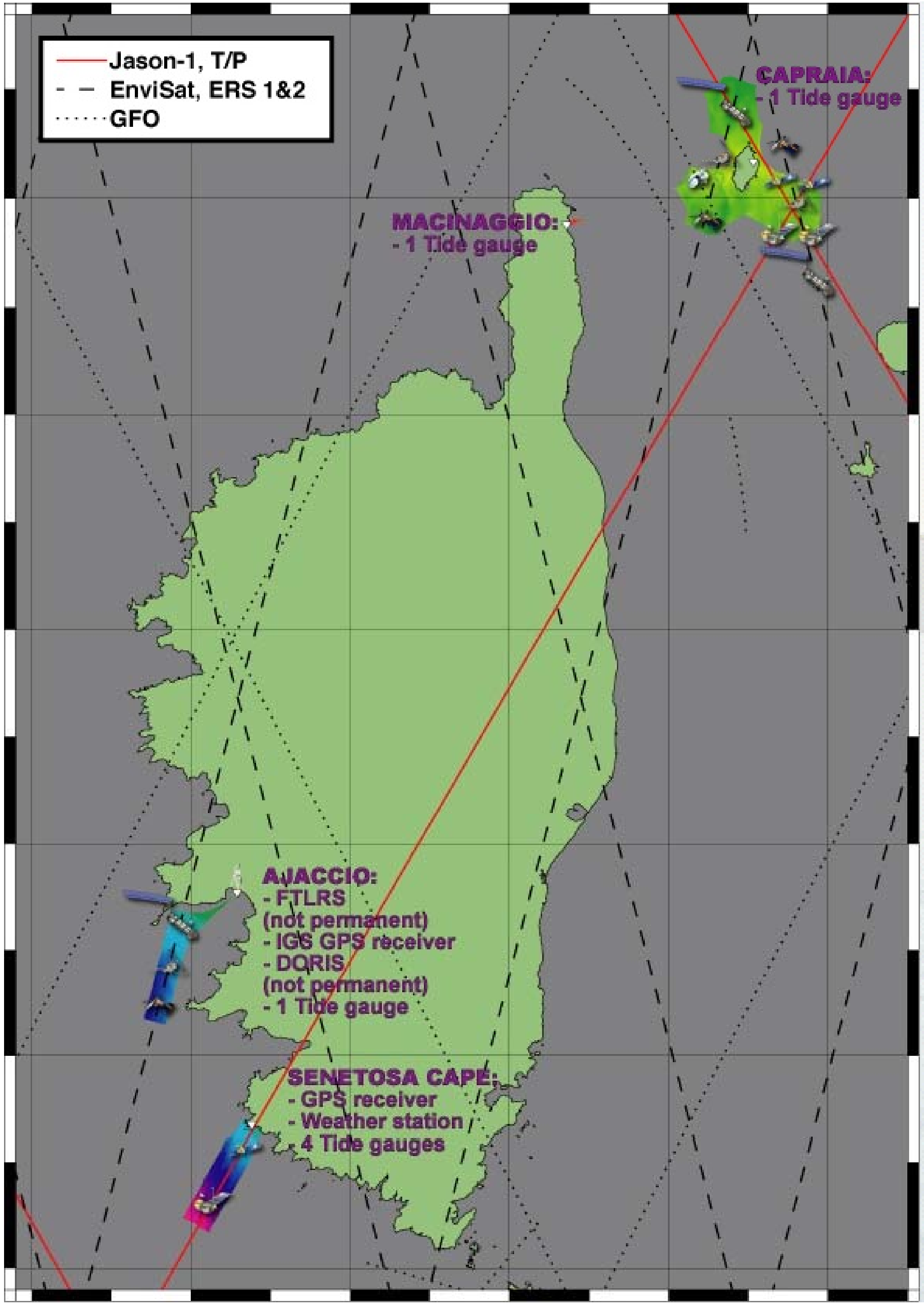
[1]OCA/Geoazur, Grasse, France

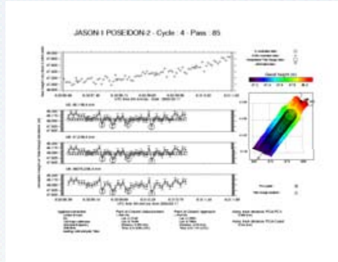
[3]CNES, Toulouse, France

[3]ESA/ESRIN, Frascati, Italy

OSTST Meeting

San Diego, 19-21 October 2011



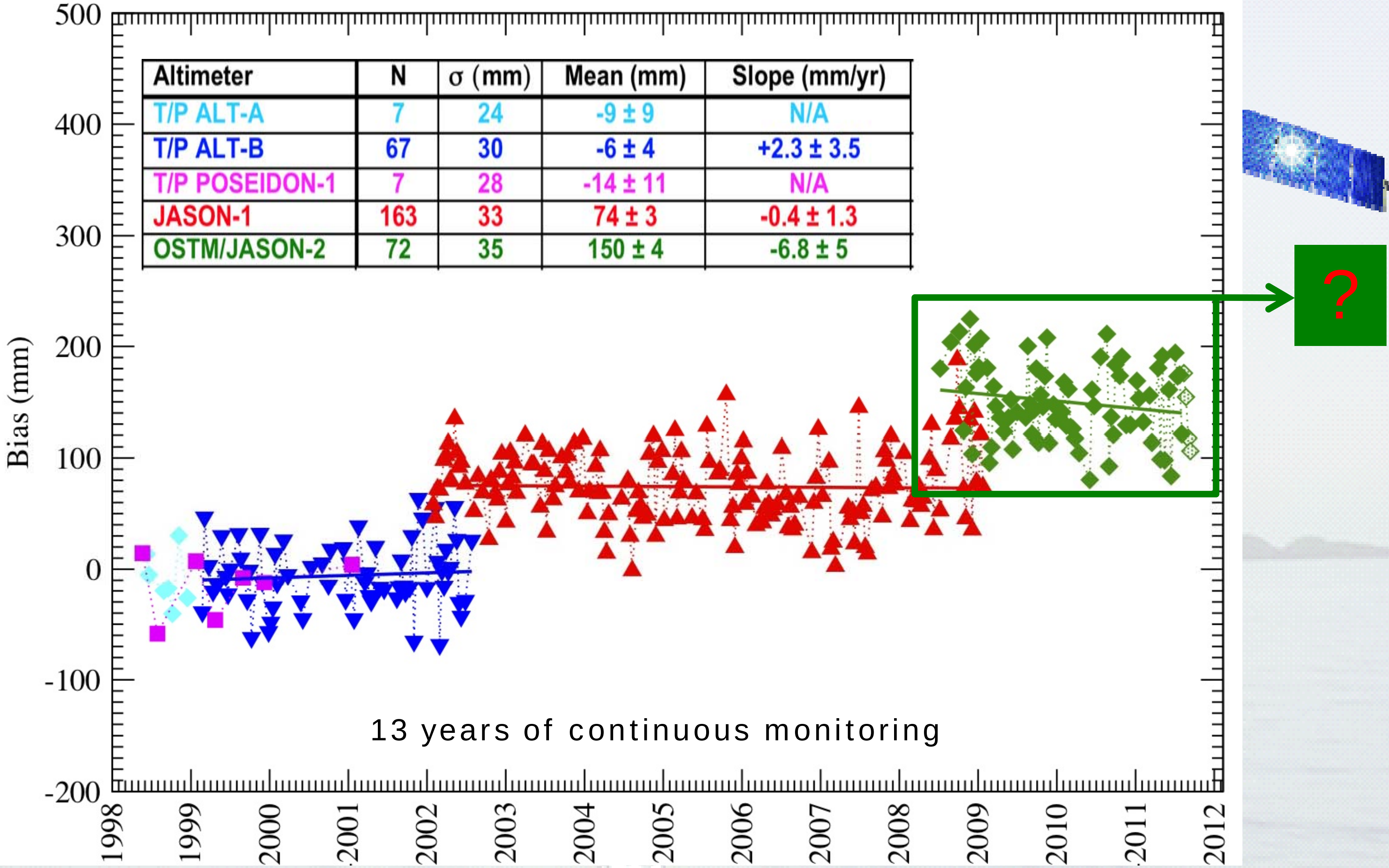


Corsica Calibration Site

- **OCA/CNES calibration site established in 1998**
- Supports continuous monitoring of Jason-1&2 (and formerly T/P)
- **Employs distributed configuration**
  - Fiducial point near **Ajaccio** equipped with a **tide gauge** and **GPS/FTLRS/DORIS**.
  - **Senetosa** coastal site (along ground track) equipped with **tide gauges and GPS**.
  - Open-ocean verification points for **GPS buoy deployments**.
- Open-ocean altimeter readings connected to tide gauges via **detailed local geoid model**
  - Derived from intensive GPS buoy and catamaran surveys along ground track.
- **Extension to Ajaccio (2005) and Capraia (2004)**
  - EnviSat, ERS, GFO, Jason-1&2.

SITE DESCRIPTION

Corsica Absolute Altimeters Calibration



Altimeter	N	σ (mm)	Mean (mm)	Slope (mm/yr)
T/P ALT-A	7	24	-9 ± 9	N/A
T/P ALT-B	67	30	-6 ± 4	+2.3 ± 3.5
T/P POSEIDON-1	7	28	-14 ± 11	N/A
JASON-1	163	33	74 ± 3	-0.4 ± 1.3
OSTM/JASON-2	72	35	150 ± 4	-6.8 ± 5

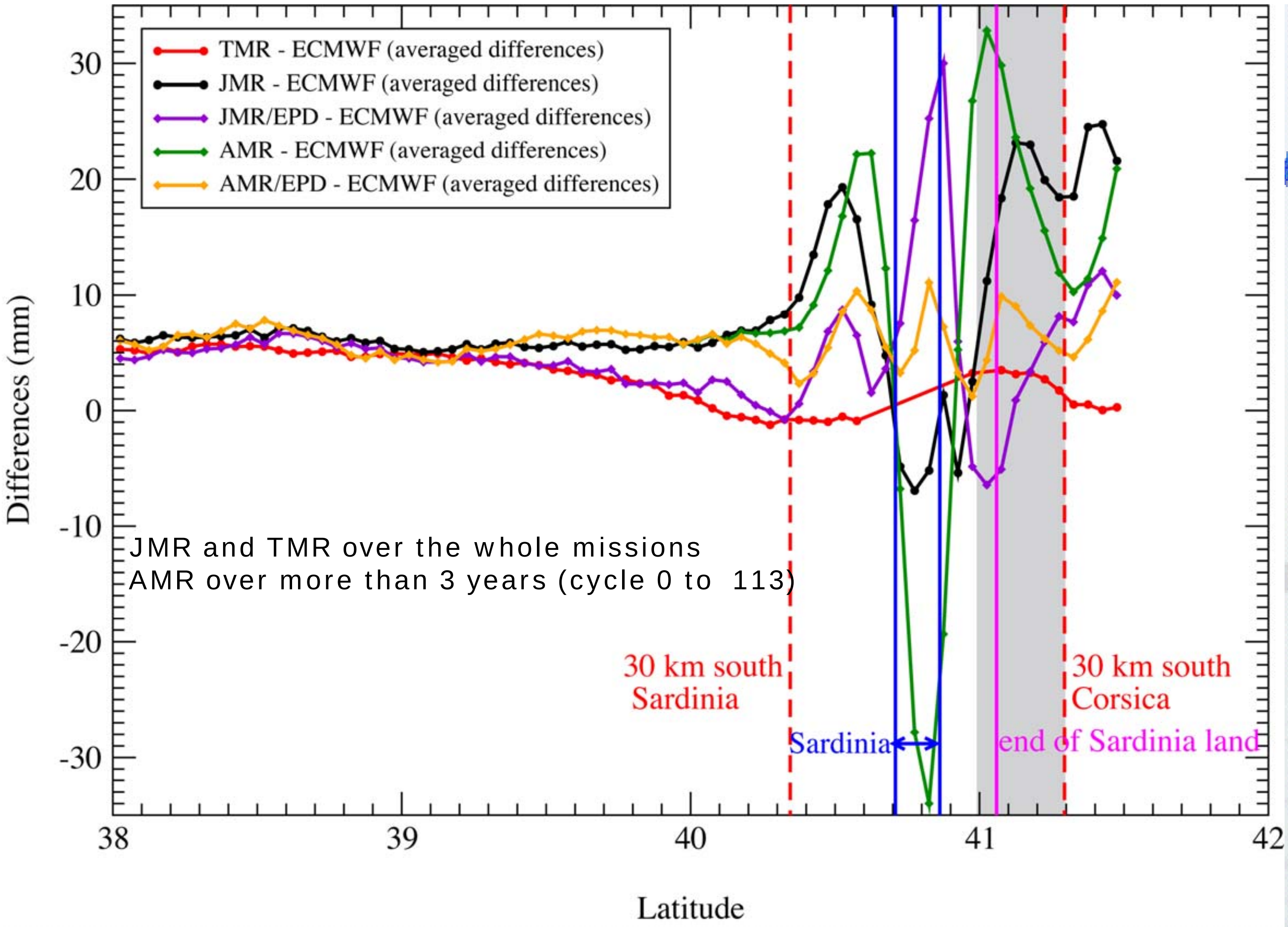
BIASES TIME SERIES

Products used:

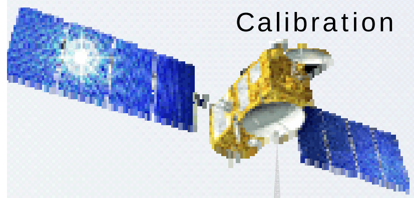
T/P: MGDR + TMR replacement products + std0905 orbits (GSFC)

ALT-B +3 mm add -3 mm add -6 mm => -6 mm

Jason-1: GDR-C (cycle 1 to 259)



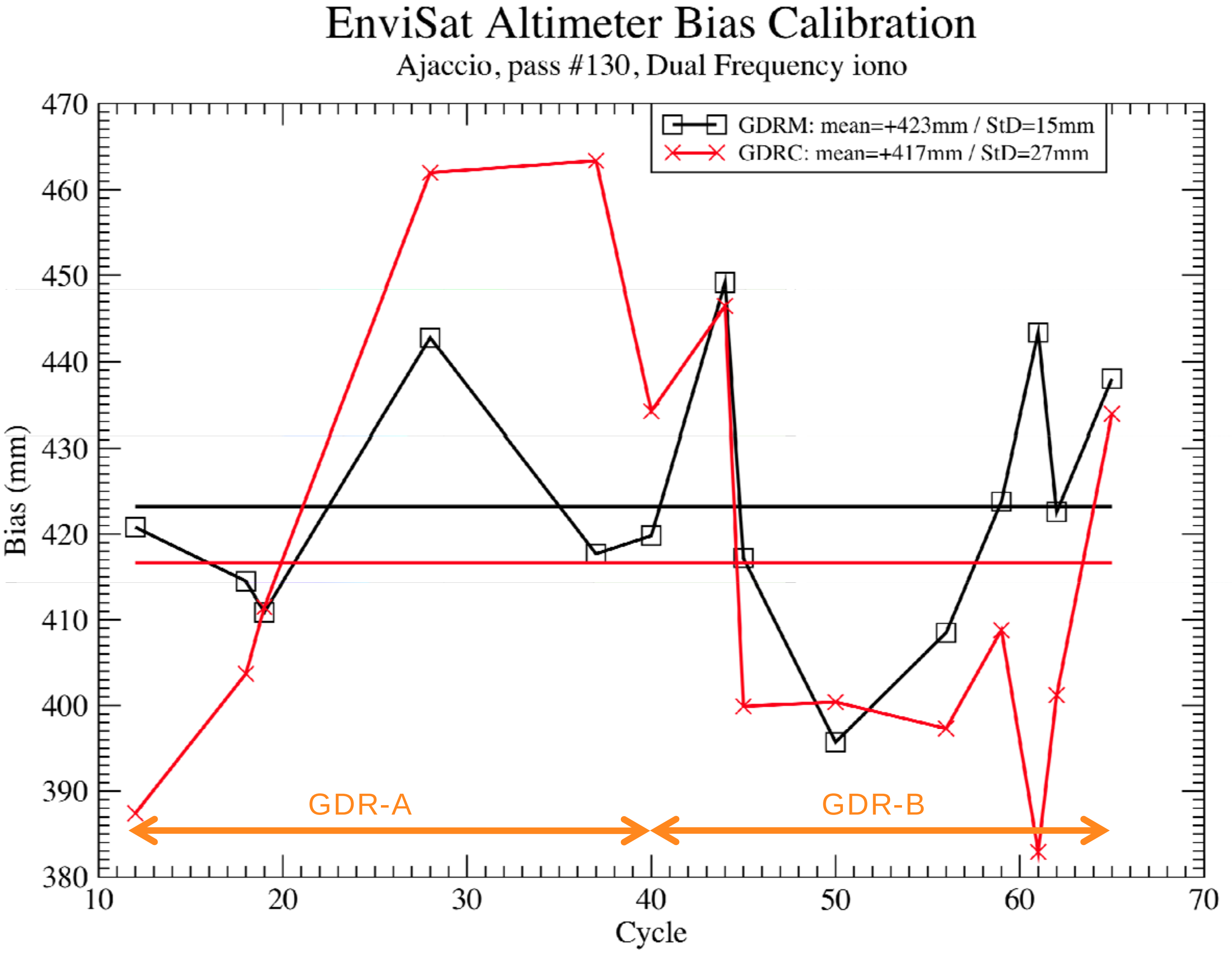
Corsica Absolute Altimeters Calibration



WET TROPOSPHERE

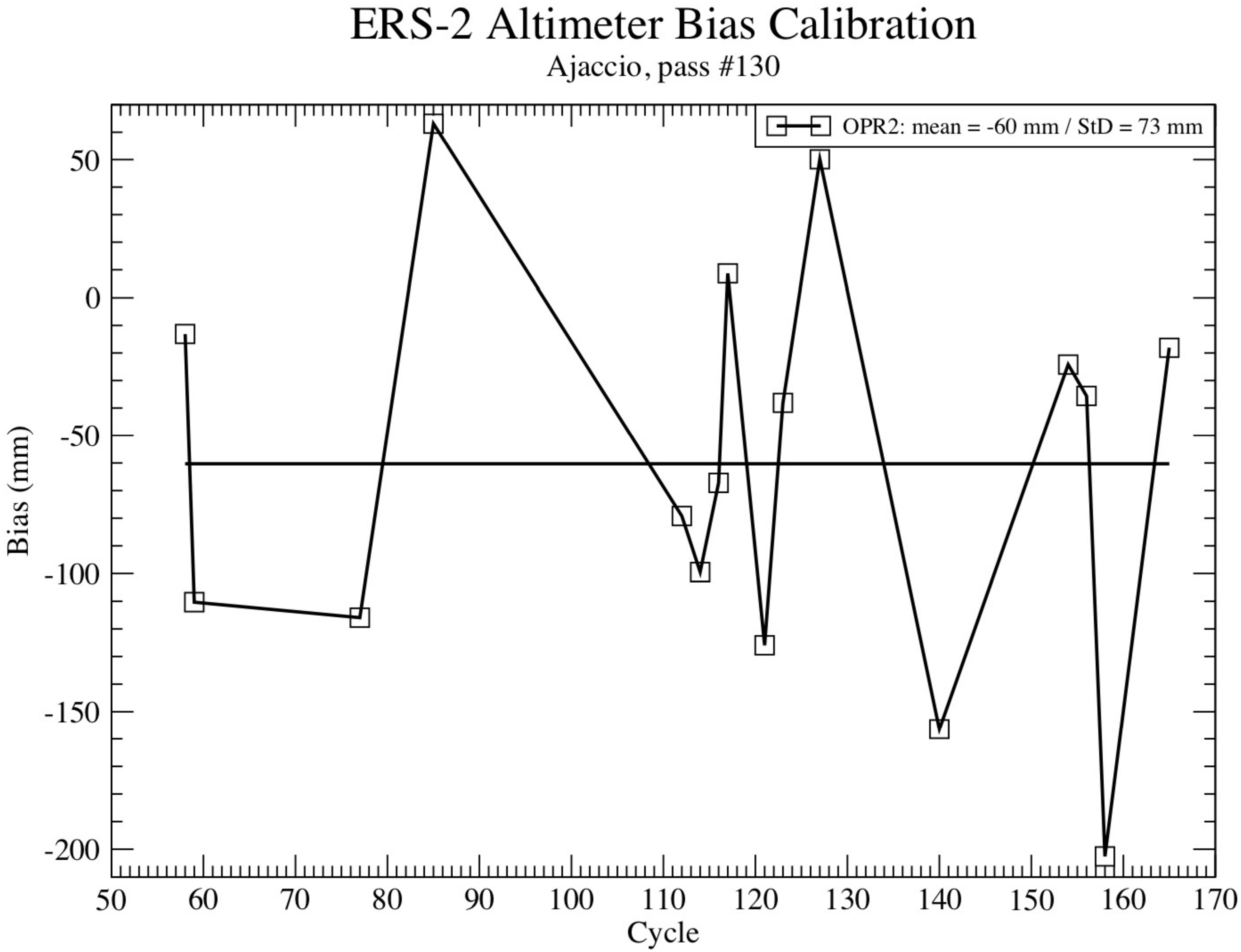
AMR and JMR exhibits strong jumps and drops due to Sardinia overflight
The Enhanced Path Delay products reduce these effects (more visible on AMR)
TMR is less affected by land contamination...

However, both AMR and JMR EPDs show an improvement when compared to GPS



All the cycles reprocessed in GDR-C standard and corresponding to the period where the S-band was available (<65) has been used and compared to the previous data set (GDR-A&B)

Little change on the mean (-6mm) but standard deviation increases (but comparable to T/P & Jason process)

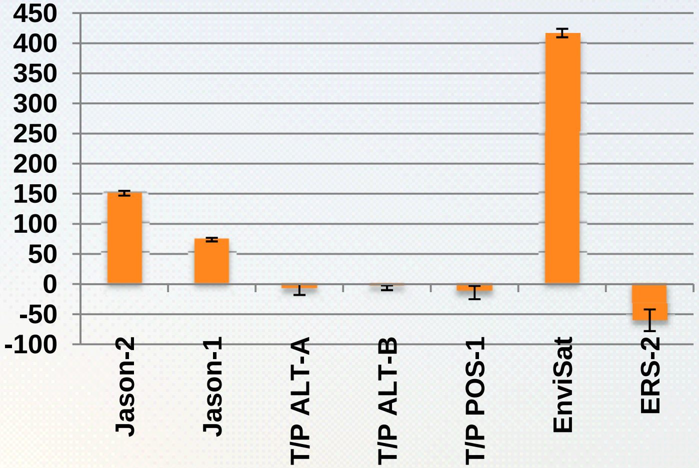


All the OPR-2 cycles since the Ajaccio tide gauge installation (2000) have been processed

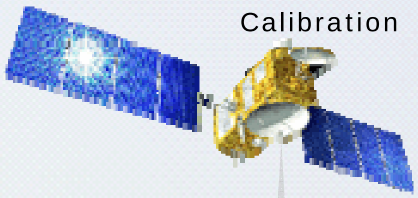
The mean bias is -60 mm but with high standard deviation (twice those of T/P, Jason and EnviSat process)

E R S - 2 B I A S

Calibration from Corsica



Corsica
Absolute
Altimeters
Calibration



Absolute biases over the whole data sets:

Jason-2: +150 ±4 mm (GDR-C)
Jason-1: +74 ±3 mm (GDR-C)
T/P ALT-A: -9 ±9 mm (MGDR++)
T/P ALT-B: -6 ±4 mm (MGDR++)
T/P POS-1: -14 ±11 mm (MGDR++)
EnviSat: +417 ±7 mm (GDR-C)
ERS-2: -60 ±18 mm (OPR-2)

Relative biases over common overflights:

Jason-2 – Jason-1: +87 mm (+86 mm from orbit-range)
Jason-1 – T/P: +93 mm (+84 mm from orbit-range)

Corrections:

Wet tropo.

Wet tropo. from radiometers show a bias of -5 mm (JMR dryer), close to 0 with EPDs
GPS shows that both AMR and JMR are dryer at the Corsica approach
No significant drift detected from JMR/GPS and AMR/GPS comparisons**.**
Better agreement between GPS and coastal path delays (EPD) from AMR and JMR
=> With EPD Jason-2 bias increases by ~12 mm (=> +162 mm, *176 from Harvest***)**
=> With EPD Jason-1 bias increases by ~18 mm (=> +92 mm, *89 from Harvest***)**

Iono.

Apparent drift of the Jason-2 ionospheric correction relatively to GIM

Orbits:

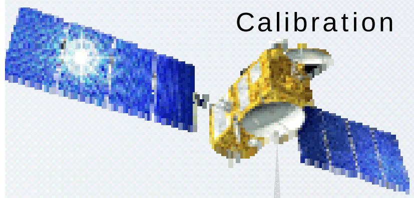
Millimetric impact of the latest set of orbits
("GDRD" from CNES, tst1110 from GSFC and rlse11a from JPL)

T/P MGDR++:

9 mm decrease of the T/P ALT-B bias compared to MGDR (-3 mm from TMR and -6 mm from orbit)
Using LSE retracked products **increases T/P ALT-B bias by 18 mm**
and induces **a slope of 7 mm/yr**

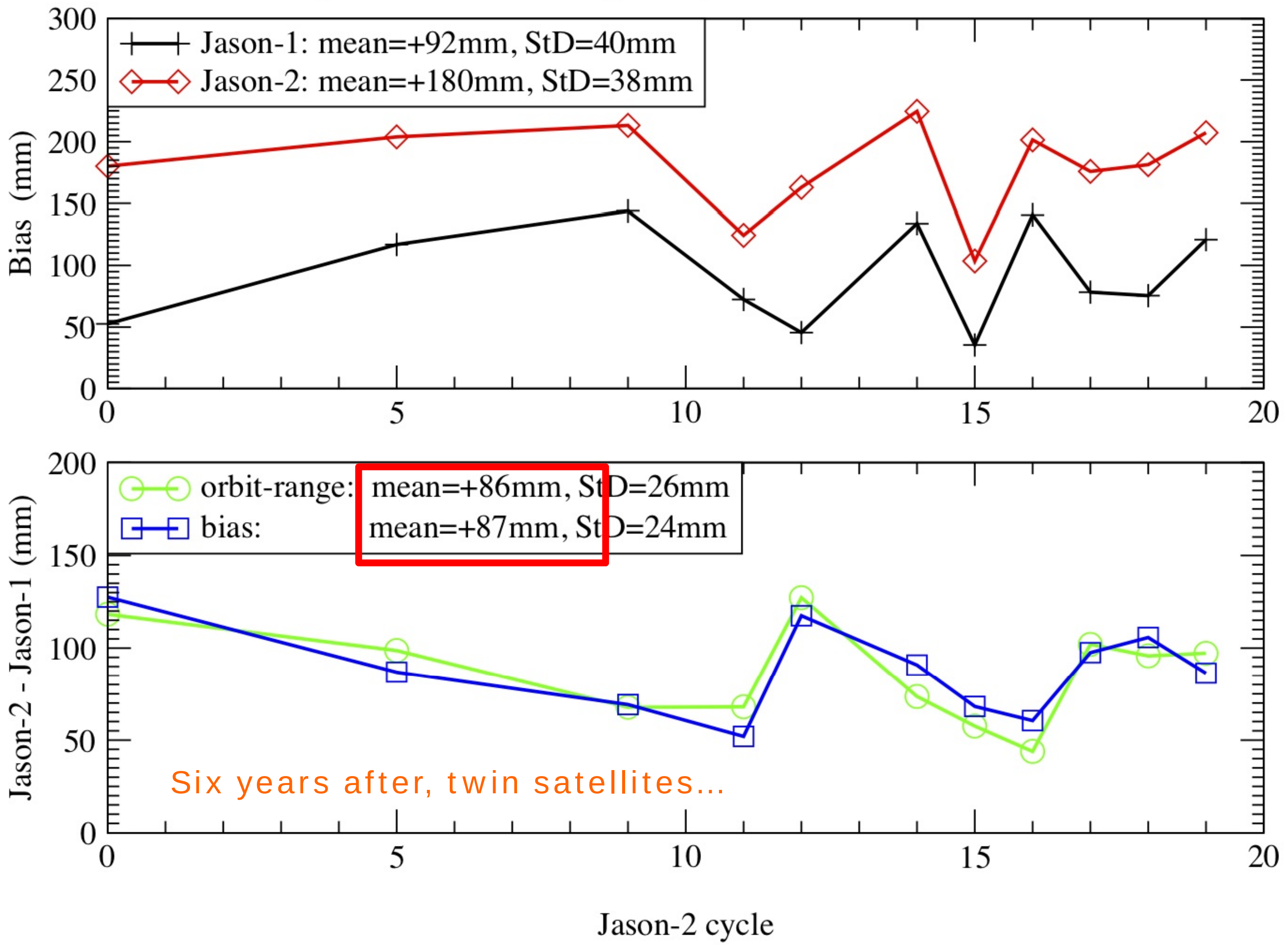
C O N C L U S I O N

Corsica Absolute Altimeters Calibration



Jason-1&2 altimeter calibration

Senetosa pass 085: Orbit - Range compared to biases differences (GDR-C)



Almost the same relative bias between T/P and Jason-1, and between Jason-2 and Jason-1.
Same results obtained with differences of absolute biases.
However, FFP give more insights on the corrections and the geographically correlated errors.

FORMATION FLIGHT PHASES

Corsica
Absolute
Altimeters
Calibration

J A S O N | 1 & 2

C O R R E C T I O N S

Jason-2 – Jason-1 (corrections):

Correction	Mean (mm)	Standard Deviation (mm)
Dry Tropo.	-0.1 (-0.2)	2.7 (2.9)
Wet Tropo. (radiometer)	-5.6 (-11.3)	6.0 (6.5)
Wet Tropo. (ECMWF)	0.0	0.5
AMR - ECMWF	*23.8*	*15.1*
JMR - ECMWF	*29.4*	*14.4*
AMR – GPS	*11.7*	*11.6*
JMR - GPS	*16.9*	*10.0*
Iono. (dual frequency)	+7.6 (+9.4)	23.6 (22.1)
Iono. (GIM)	0.0	0.0
JS2 - GIM	*-5.6*	*19.1*
JS1 - GIM	*-13.2*	*17.6*
SSB	-2.7 (-2.4)	5.8 (4.9)
Solid Tides	+0.1	0.7
Loading	0.0	0.0
Pole Tide	0.0	0.0
Total	**-0.7**	

(from IGDR)

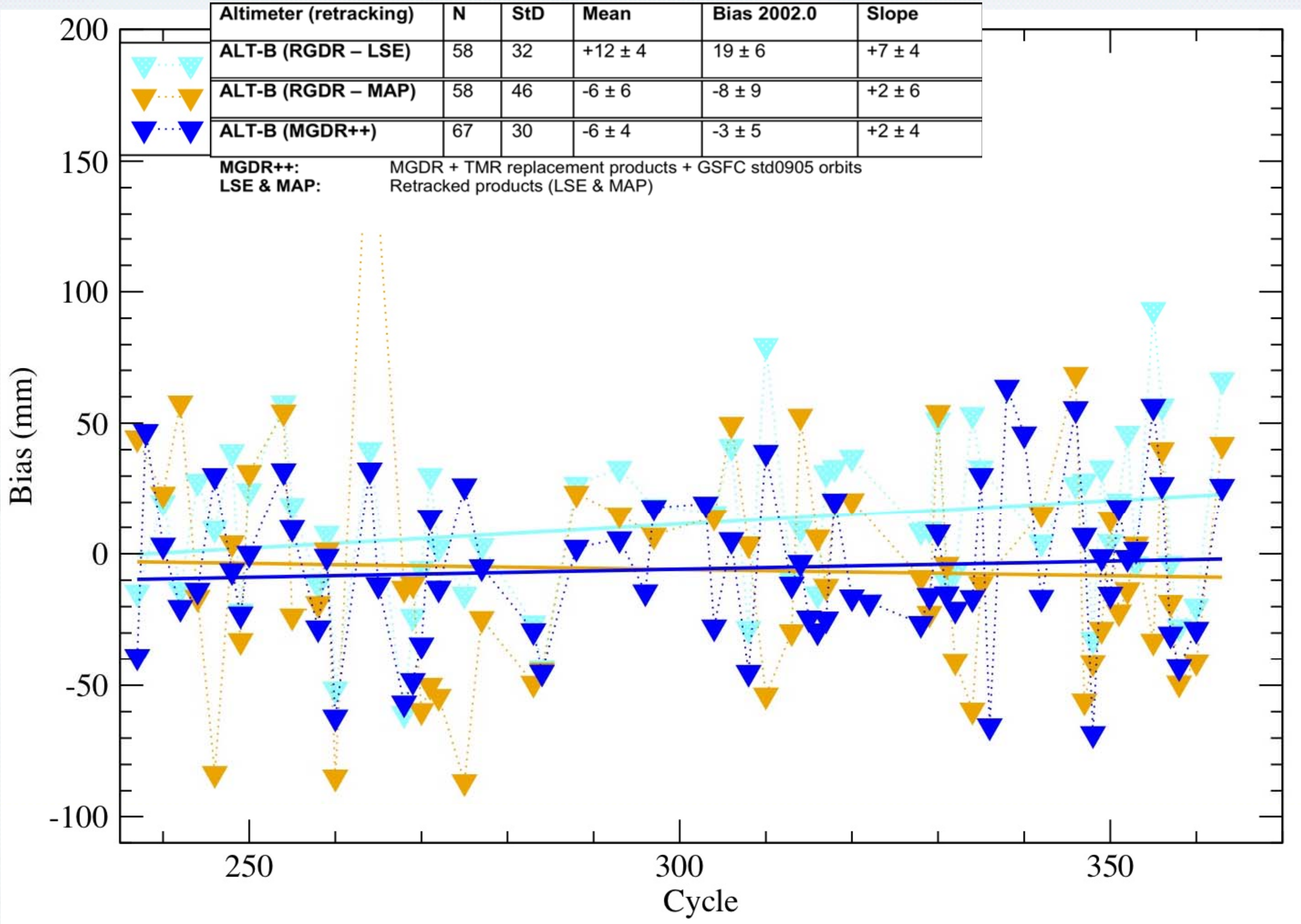
Main contribution comes from Wet tropospheric (~-6 mm) and Ionopheric (~+8 mm) corrections
Better agreement between GPS and Enhanced path delays from AMR and JMR (mm)

Other environmental parameters:
- SWH: Mean = -1 cm StD = 23 cm
- Wind Speed: Mean = +0.6 m/s StD = 0.6 m/s

Analysis of the T/P retracked products

Altimeter (retracking)	N	StD	Mean	Bias 2002.0	Slope
ALT-B (RGDR – LSE)	58	32	+12 ± 4	19 ± 6	+7 ± 4
ALT-B (RGDR – MAP)	58	46	-6 ± 6	-8 ± 9	+2 ± 6
ALT-B (MGDR++)	67	30	-6 ± 4	-3 ± 5	+2 ± 4

MGDR++: MGDR + TMR replacement products + GSFC std0905 orbits
LSE & MAP: Retracked products (LSE & MAP)

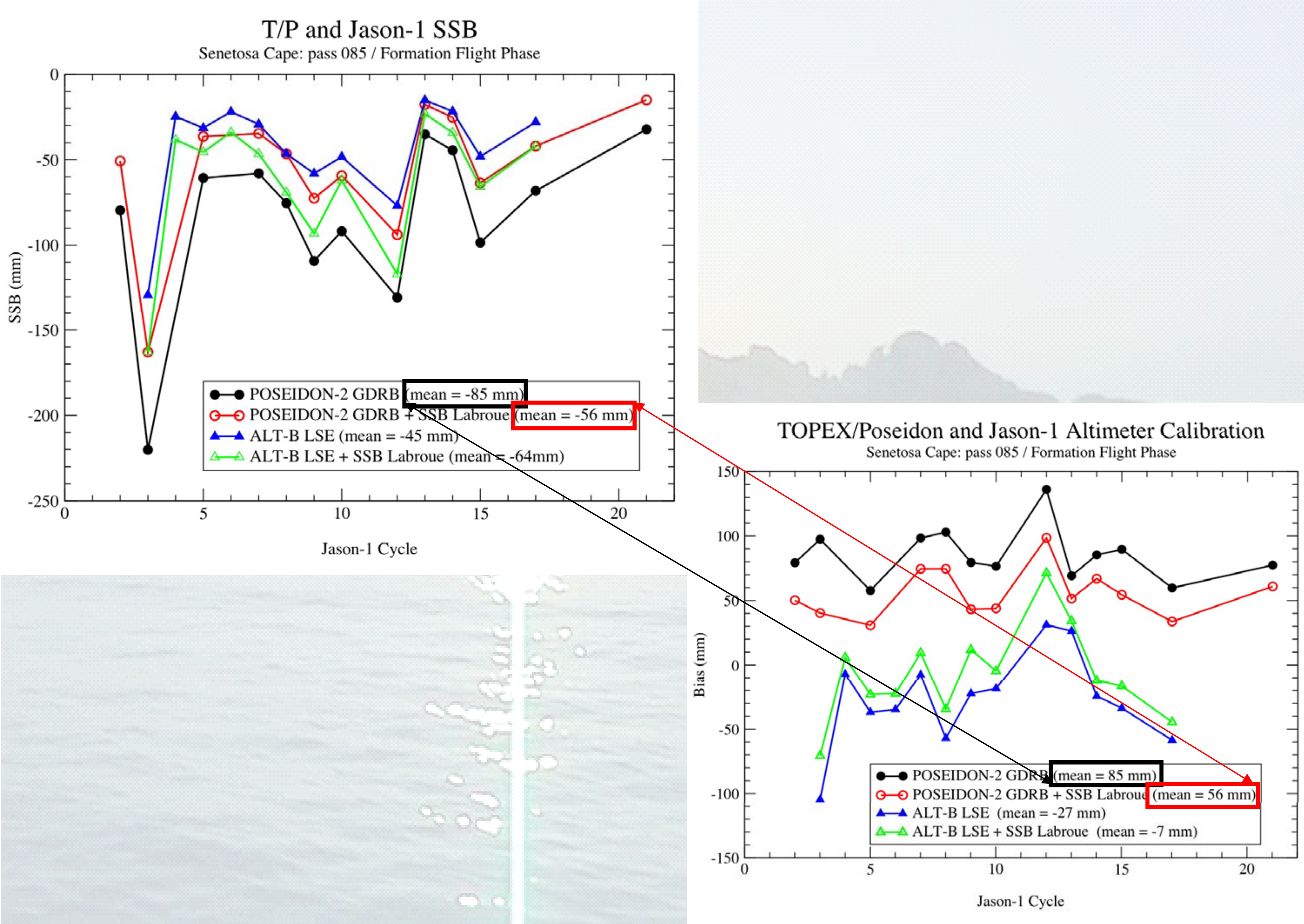


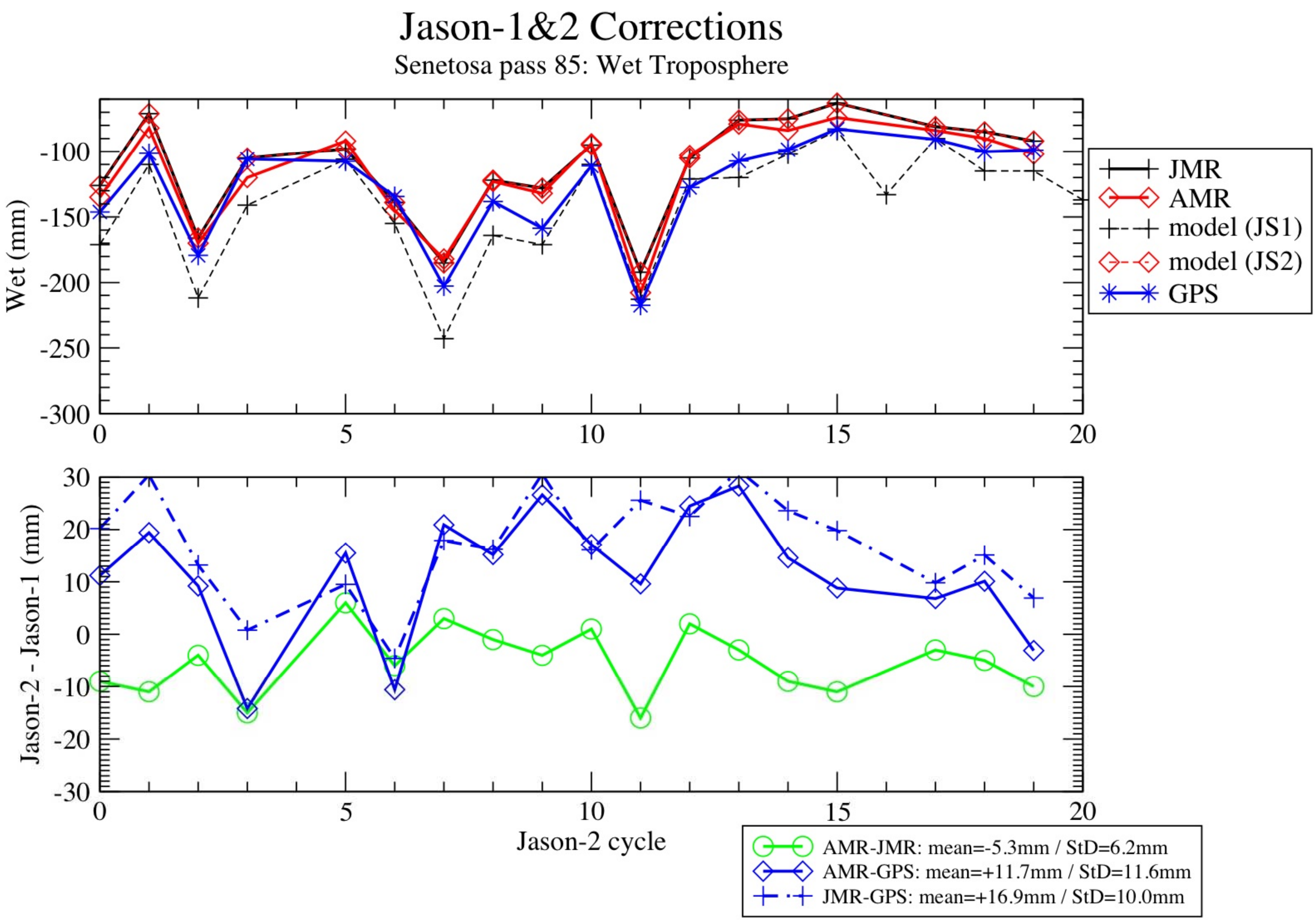
T / P BIASES

Main impact, using **LSE**:

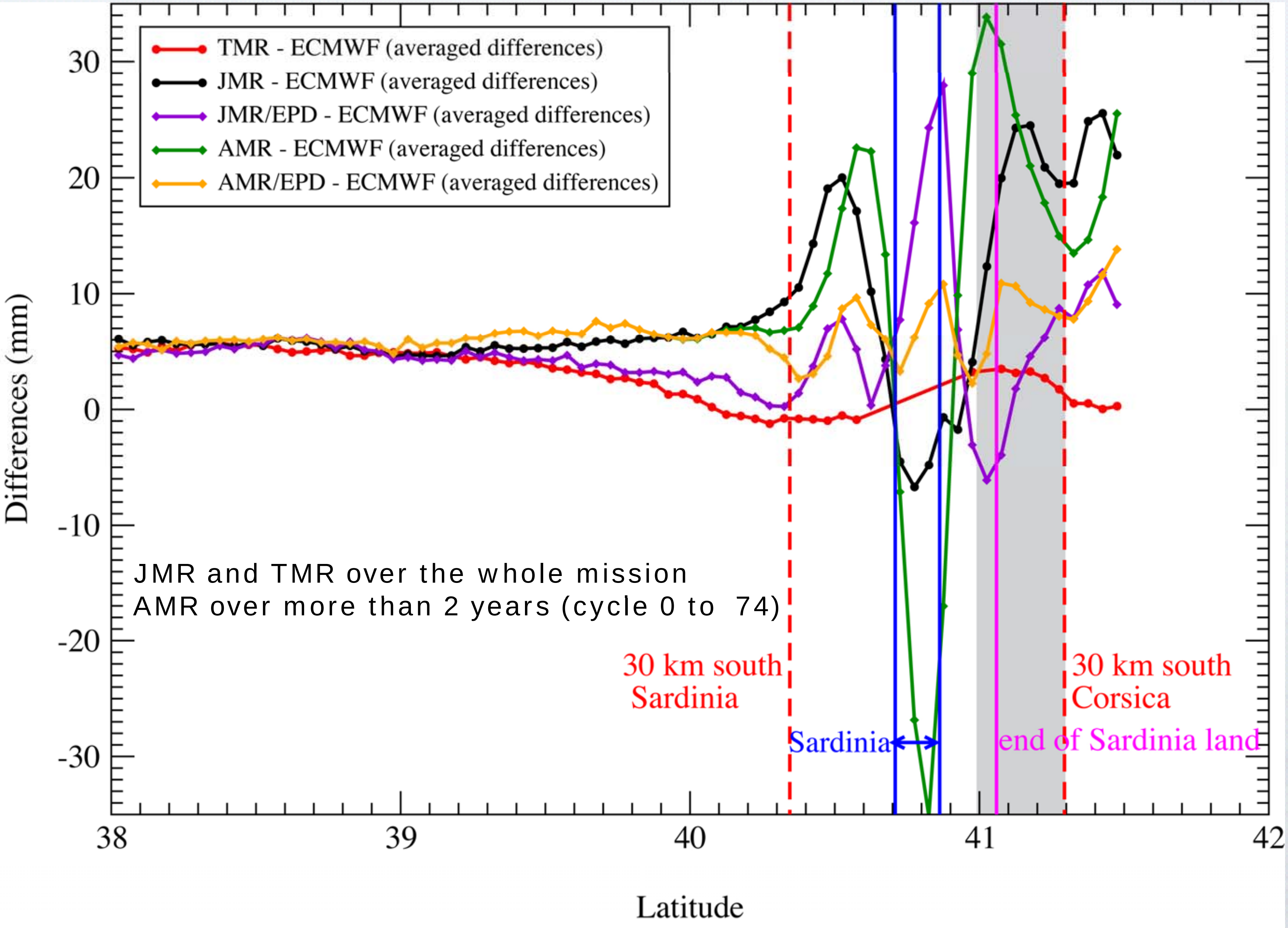
- the T/P (ALT-B) **bias is increased by 18 mm**
- the **standard deviation is increased by 11mm** (square root)
- the **slope** is huge **+7 mm/yr…**

Jason-1 (GDR-B/MLE4) and T/P (RGDR/LSE) SSB



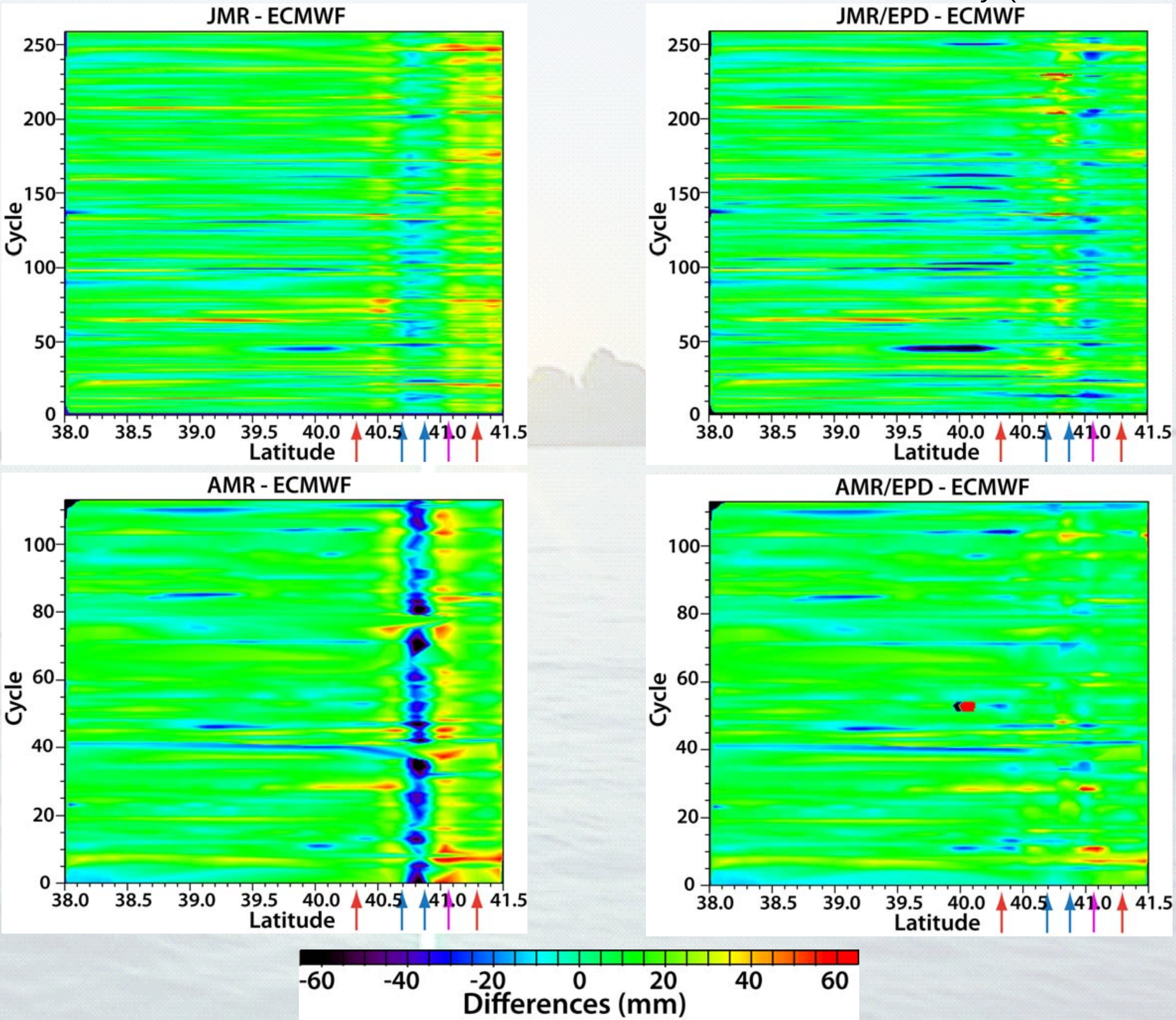

Jason-1&2 Corrections
Senetosa pass 85: Wet Troposphere
Wet (mm)
-100
-150
-200
-250
-300
0
5
10
15
20
JMR
AMR
model (JS1)
model (JS2)
GPS
Jason-2 - Jason-1 (mm)
30
20
10
0
-10
-20
-30
Jason-2 cycle
AMR-JMR: mean=-5.3mm / StD=6.2mm
AMR-GPS: mean=+11.7mm / StD=11.6mm
JMR-GPS: mean=+16.9mm / StD=10.0mm

Jason-1 & T/P Wet Tropospheric Path Delay (corrections)

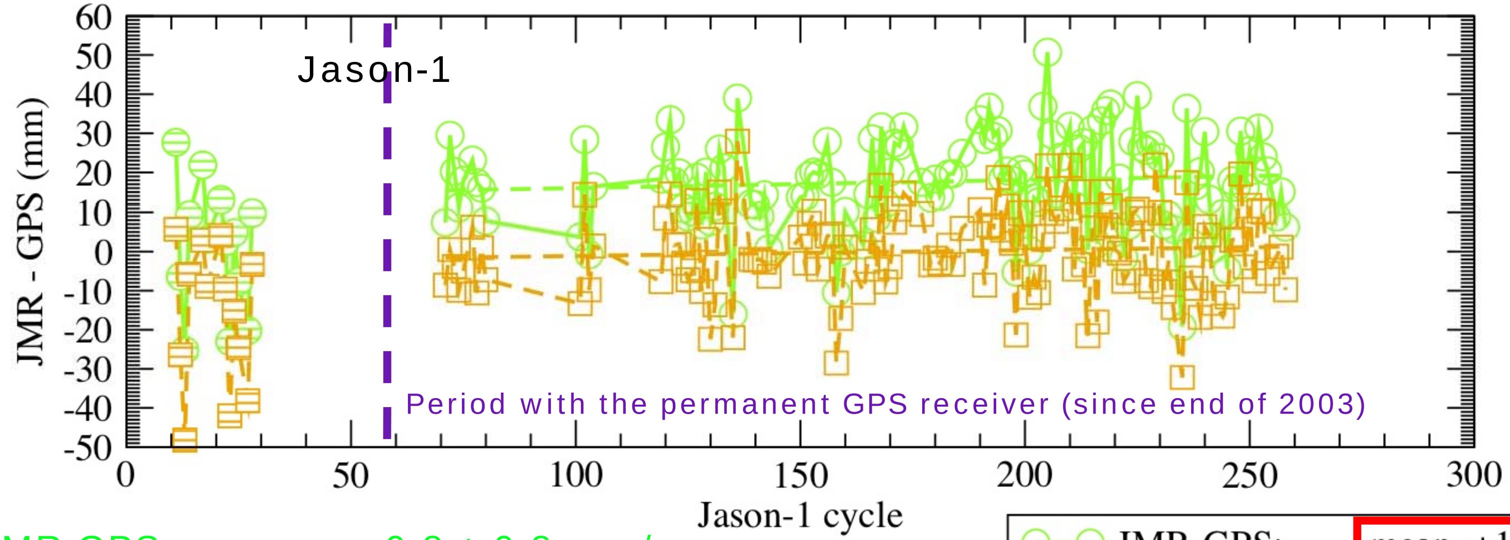


Jason-1, Jason-2 Wet Tropospheric Path Delay (whole set of available products)

Original Path Delay (GDRC) | Enhanced Path Delay (Brown et al.)

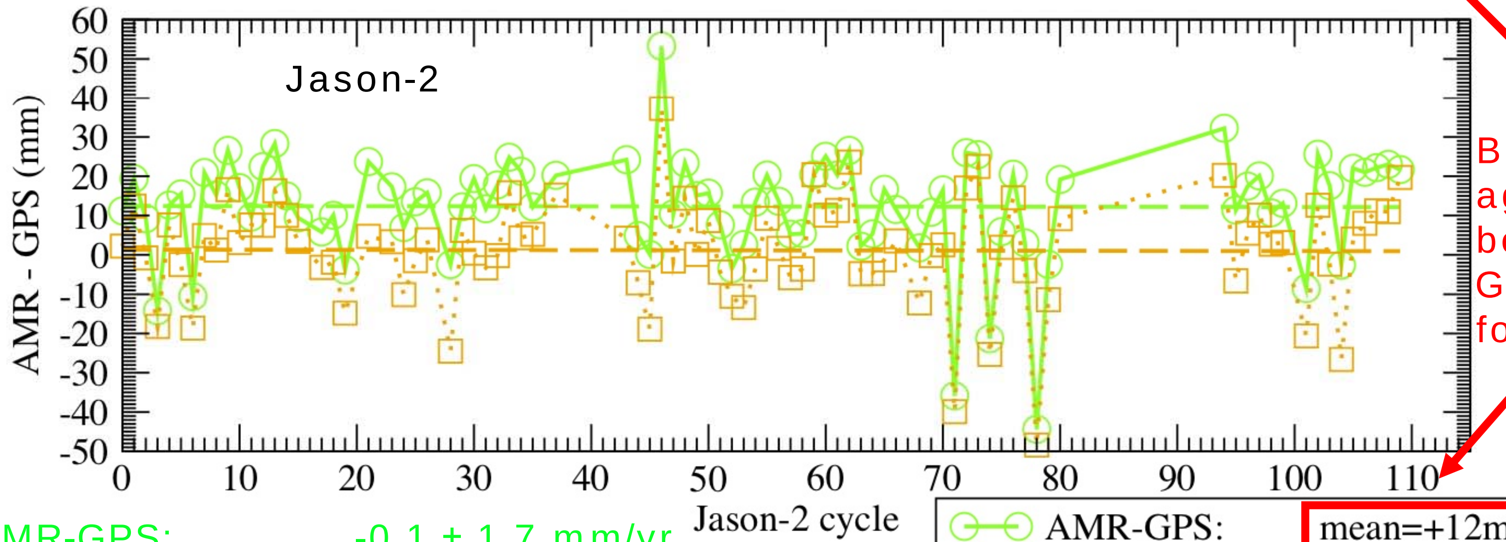


Jason-1&2 Wet Tropospheric Path Delay (corrections)
Whole set of available products



JMR-GPS: +0.8 ± 0.8 mm/yr

JMR/EPD-GPS: +0.5 ± 0.7 mm/yr

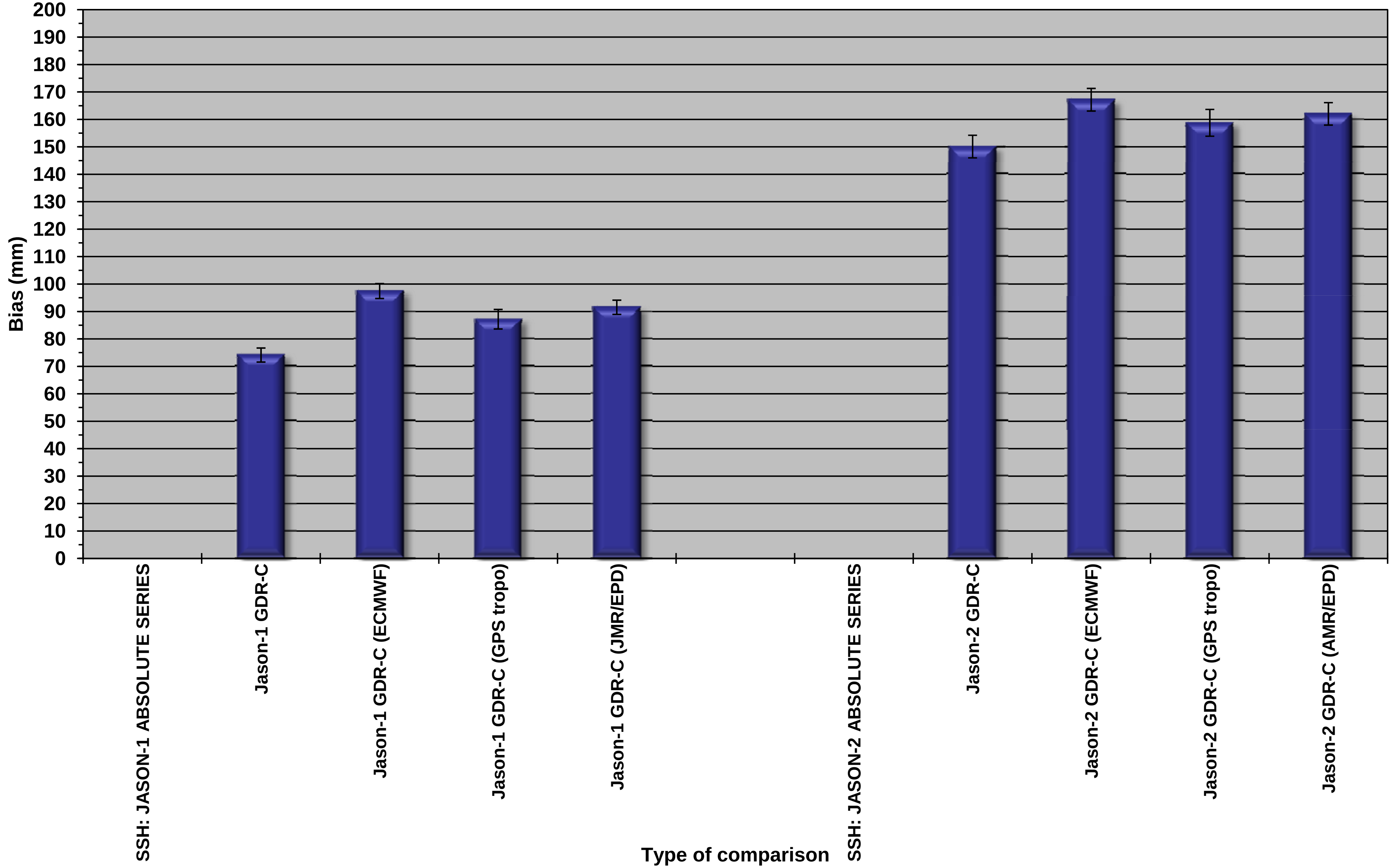


Better agreement between GPS and EPD for JMR and AMR

AMR-GPS: -0.1 ± 1.7 mm/yr

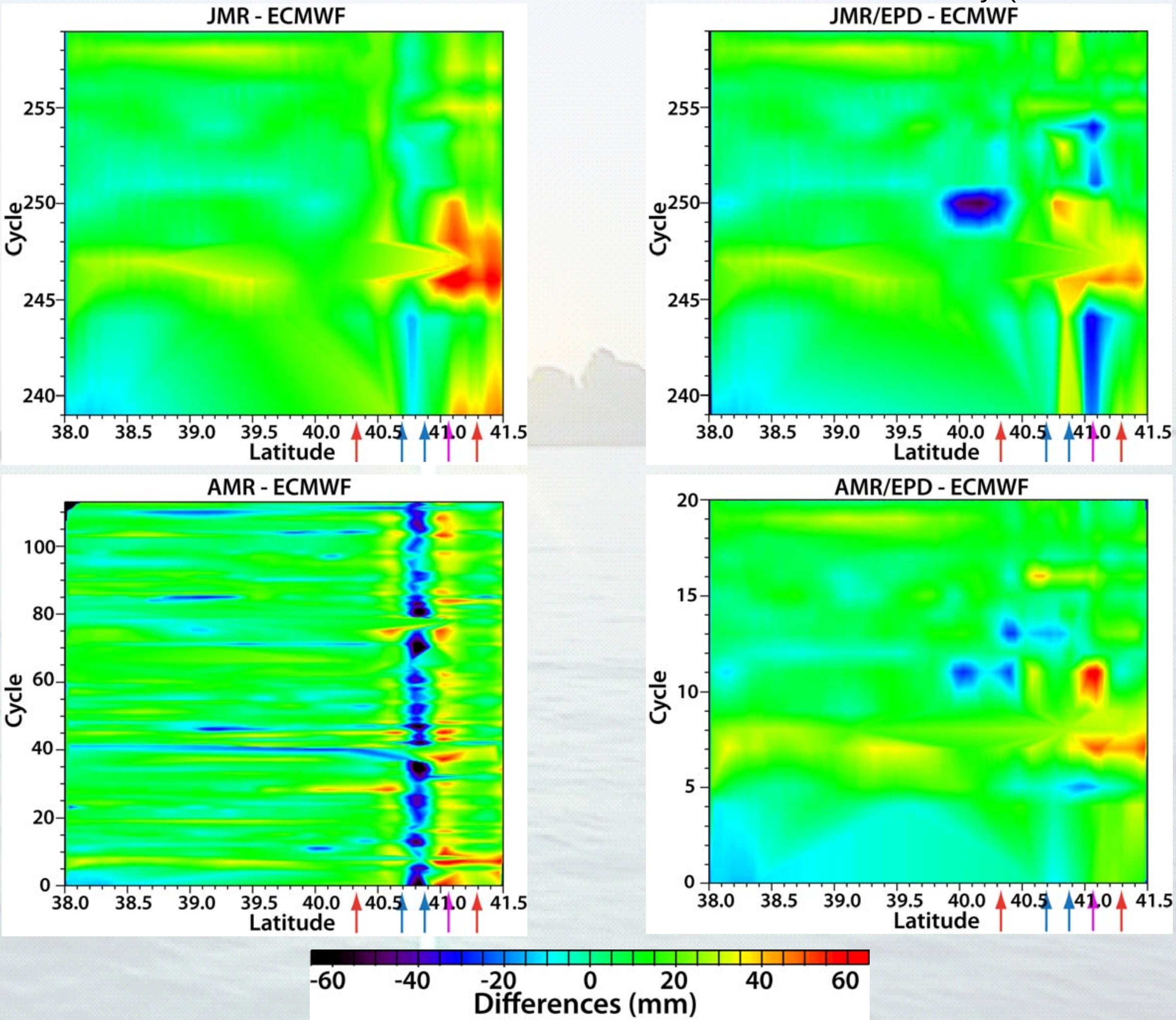
AMR/EPD-GPS: -0.1 ± 1.6 mm/yr

Jason-1&2 biases with different Wet Tropospheric Path Delay (corrections)

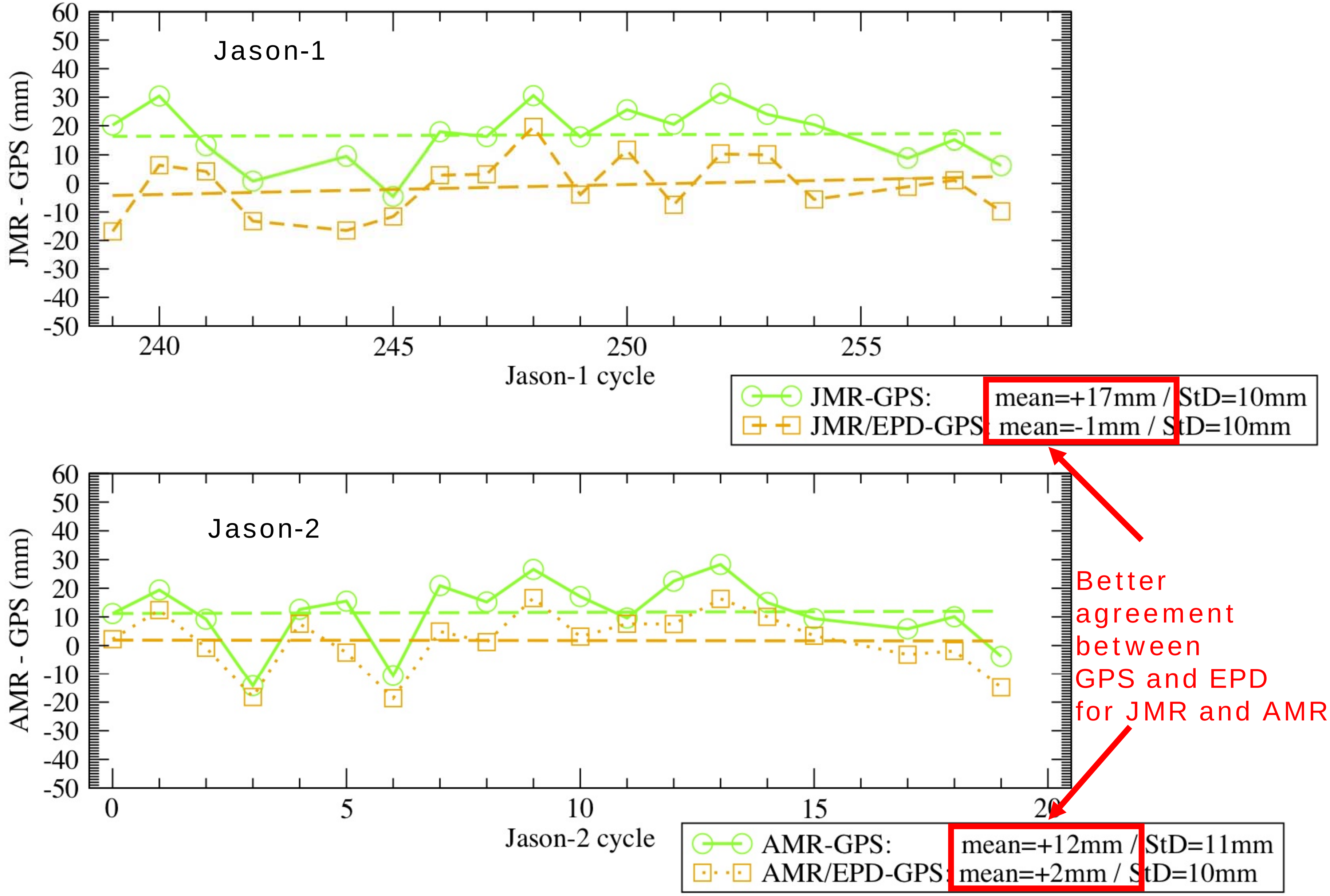


Jason-1, Jason-2 Wet Tropospheric Path Delay (Formation Flight Phase)

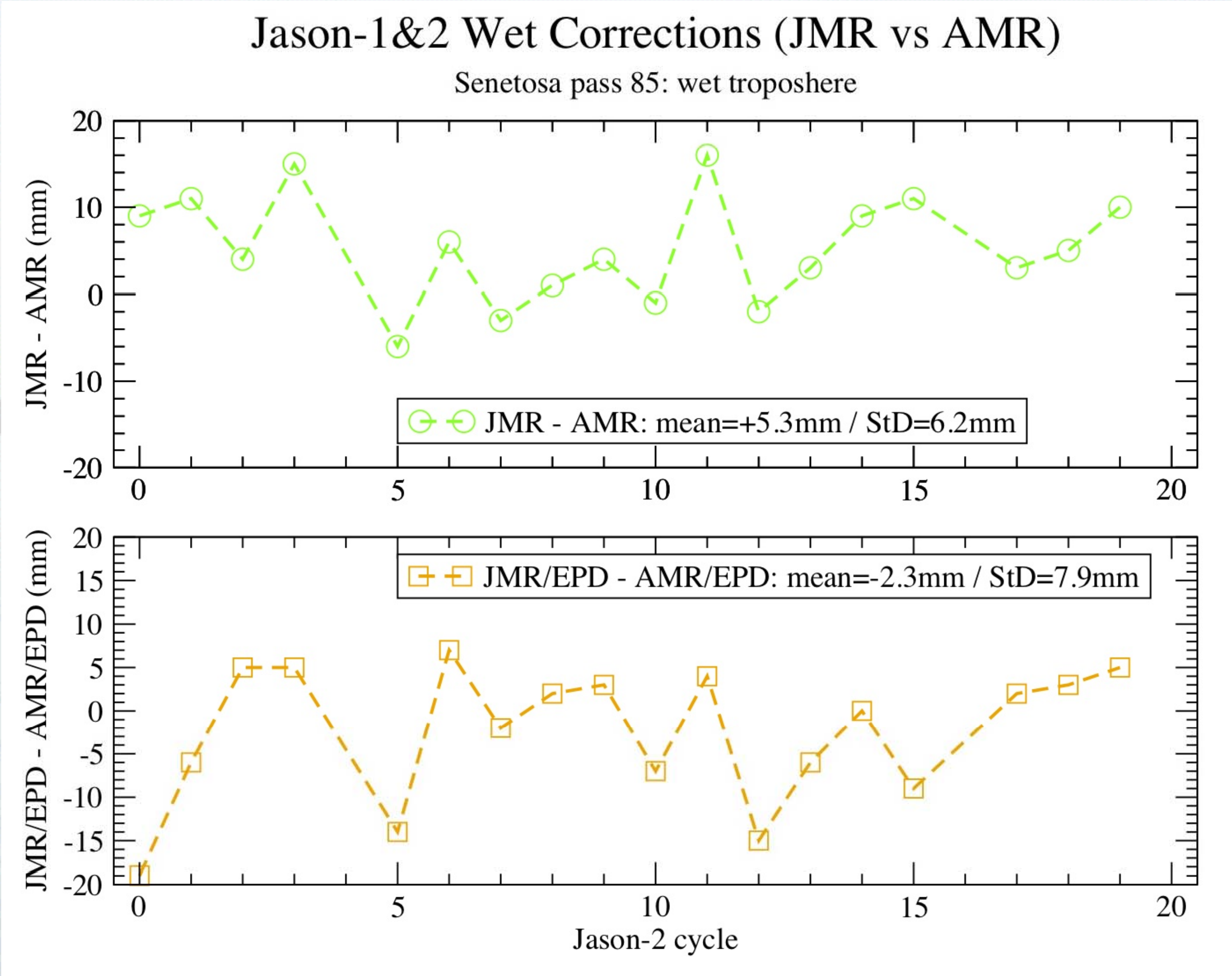
Original Path Delay (GDRC) | Enhanced Path Delay (Brown et al.)

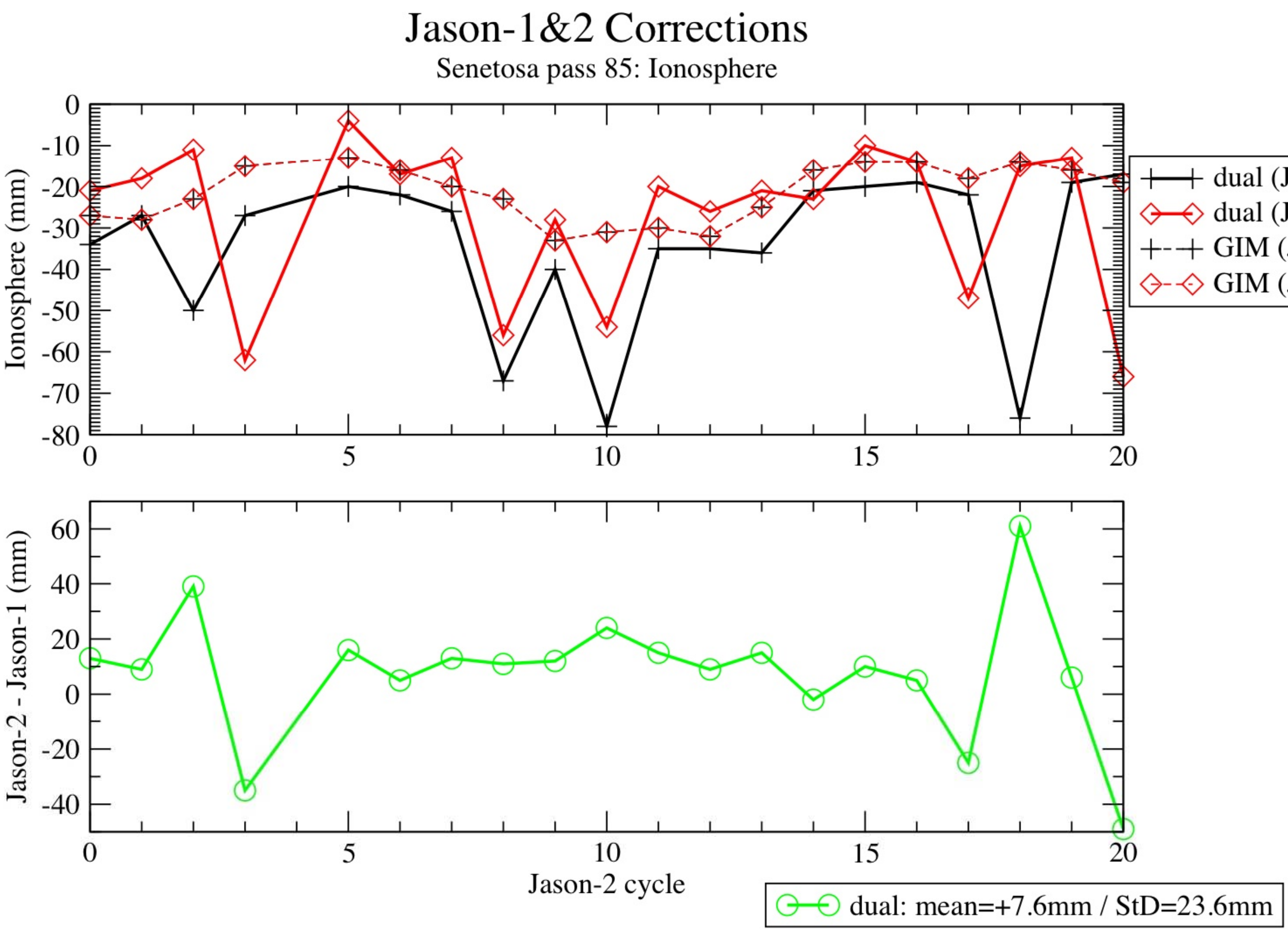


Jason-1&2 Wet Tropospheric Path Delay (corrections)
Formation Flight Phase



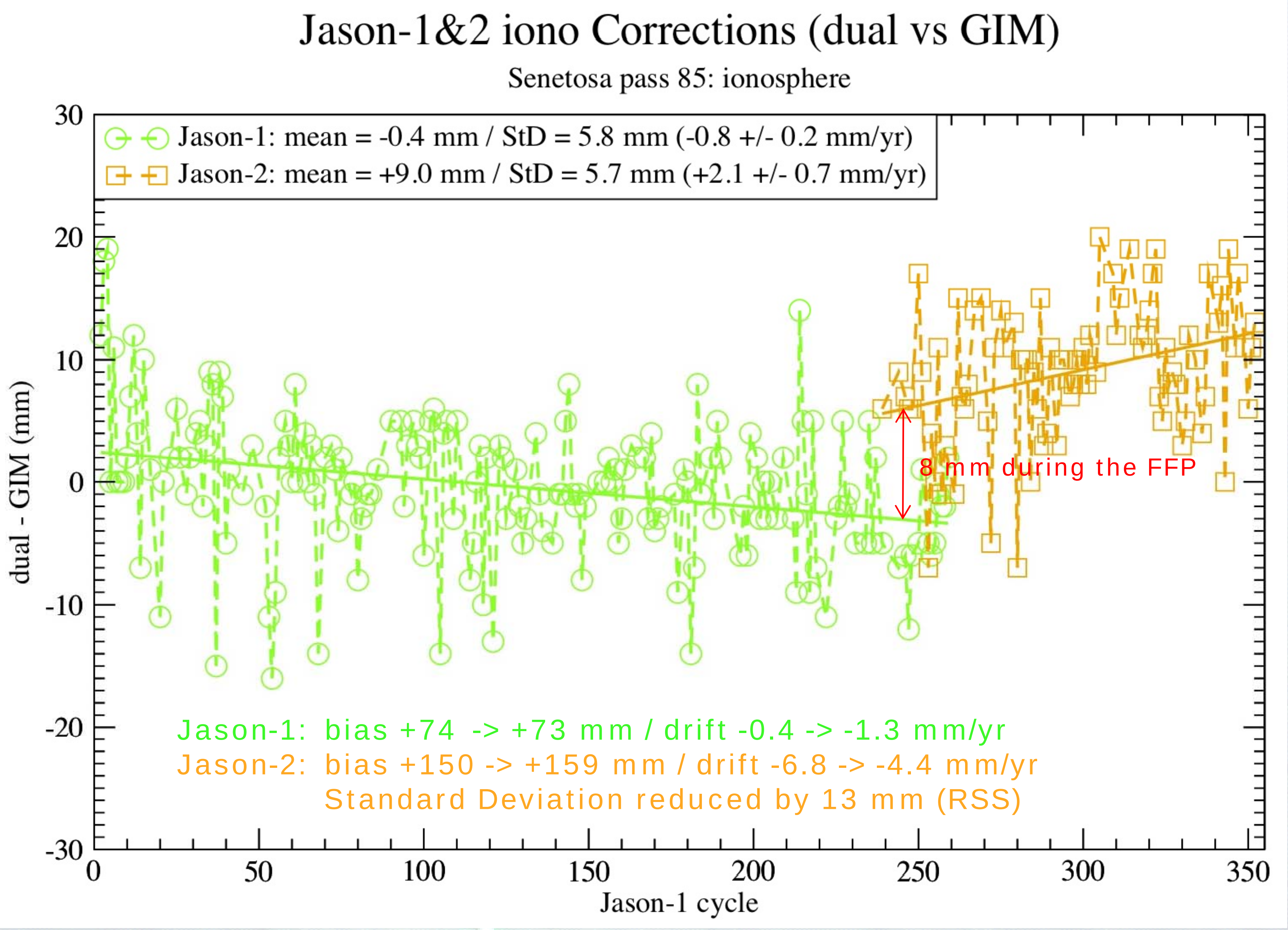
Jason-1&2 Wet Tropospheric Path Delay (corrections)
Formation Flight Phase



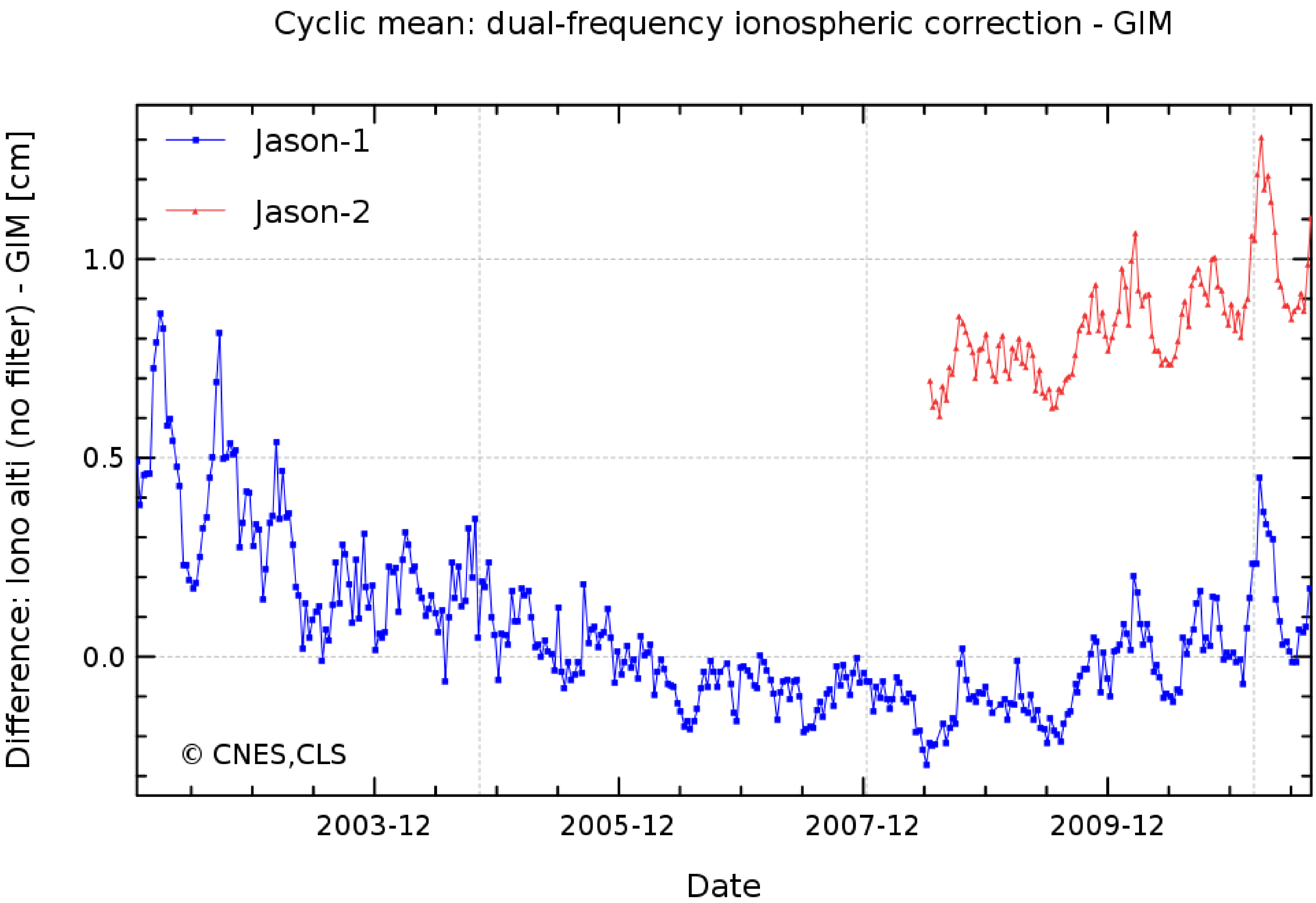


Jason-1&2 Corrections
Senetosa pass 85: Ionosphere
Ionosphere (mm)
0
-10
-20
-30
-40
-50
-60
-70
-80
0
5
10
15
20
dual (JS1)
dual (JS2)
GIM (JS1)
GIM (JS2)
Jason-2 - Jason-1 (mm)
60
40
20
0
-20
-40
Jason-2 cycle
dual: mean=+7.6mm / StD=23.6mm

Jason-1&2 Ionospheric Path Delay (correction)

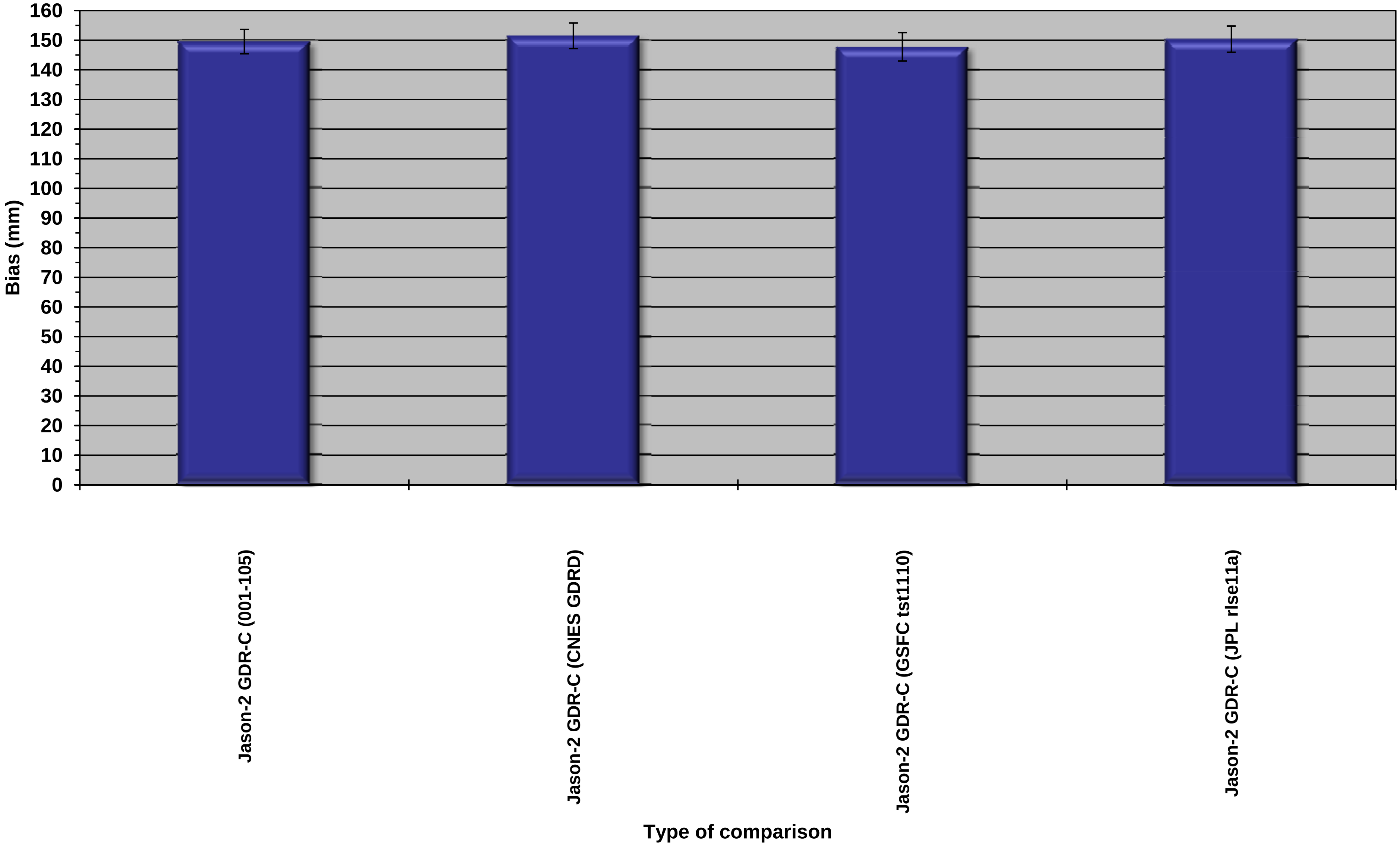


Jason-1&2 Ionospheric Path Delay (correction)
Global analysis from CLS (S. Philipps)



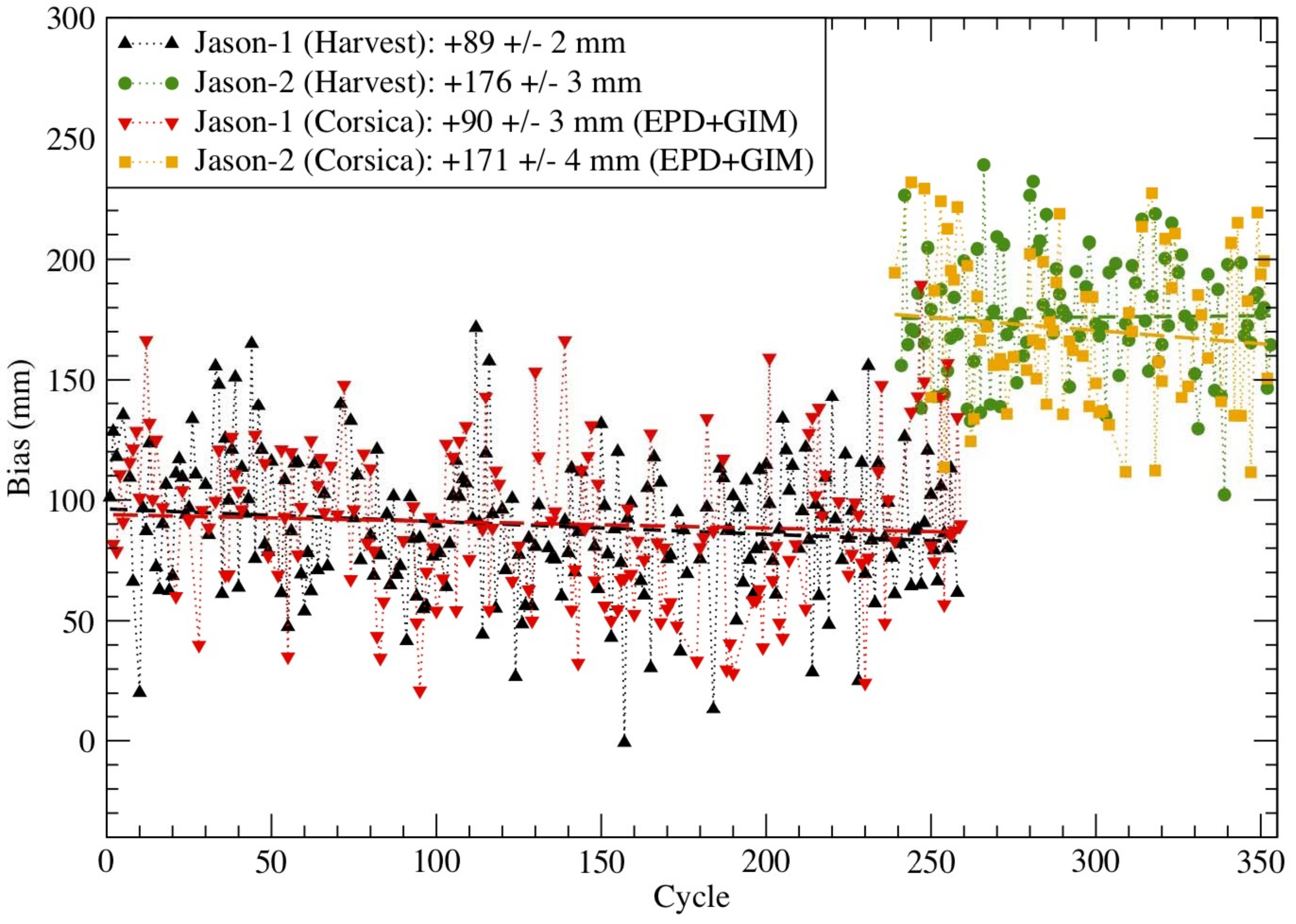
Jason-2 absolute bias from different POEs

Small impact (mm) on the absolute value

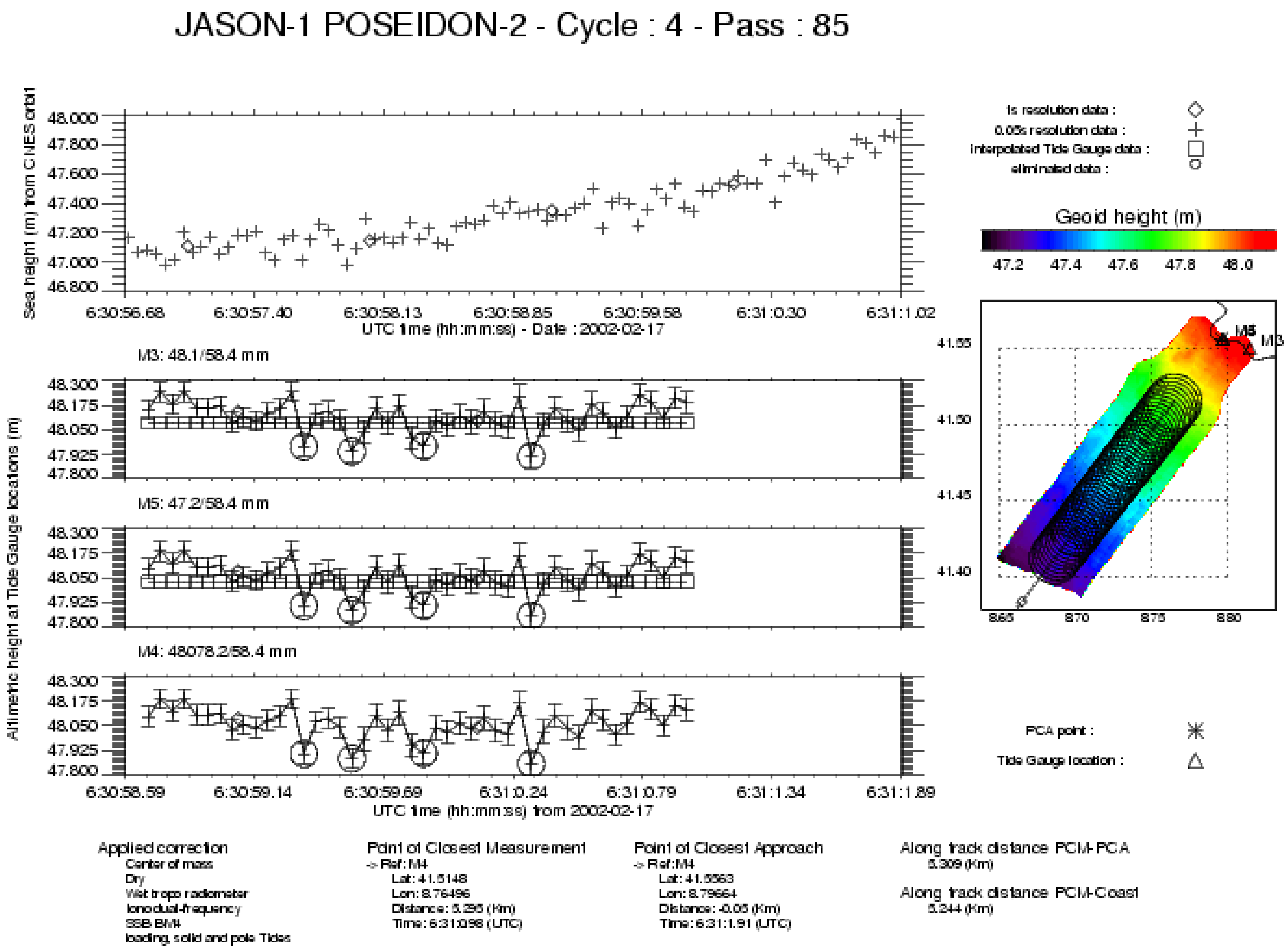


Jason-1 & Jason-2 absolute bias from Harvest and Corsica

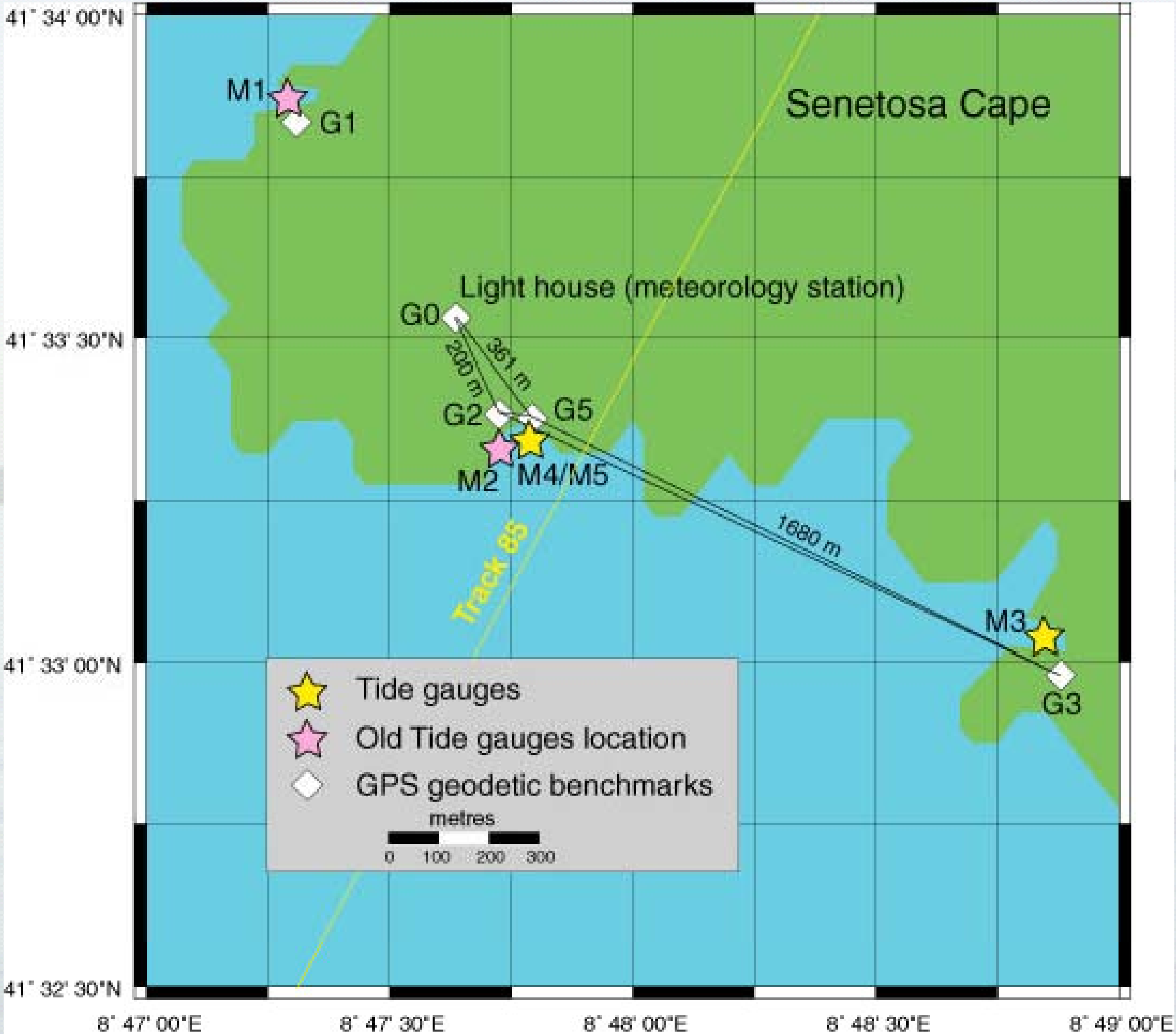
Applying Enhanced Path delay + GIM



Methodology

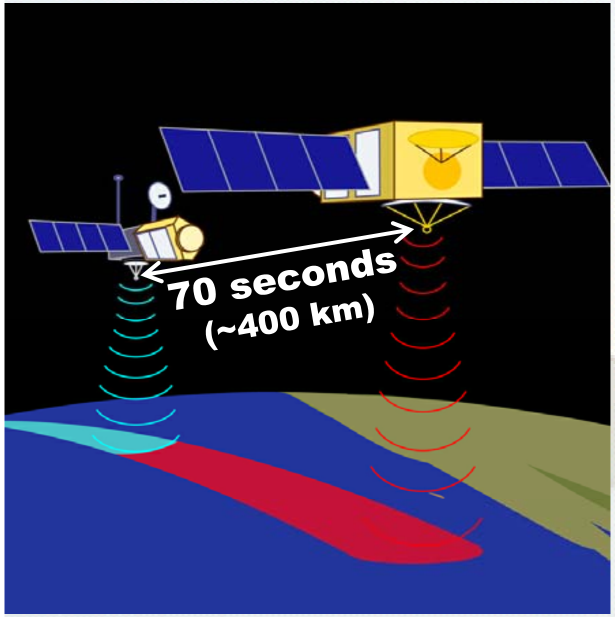


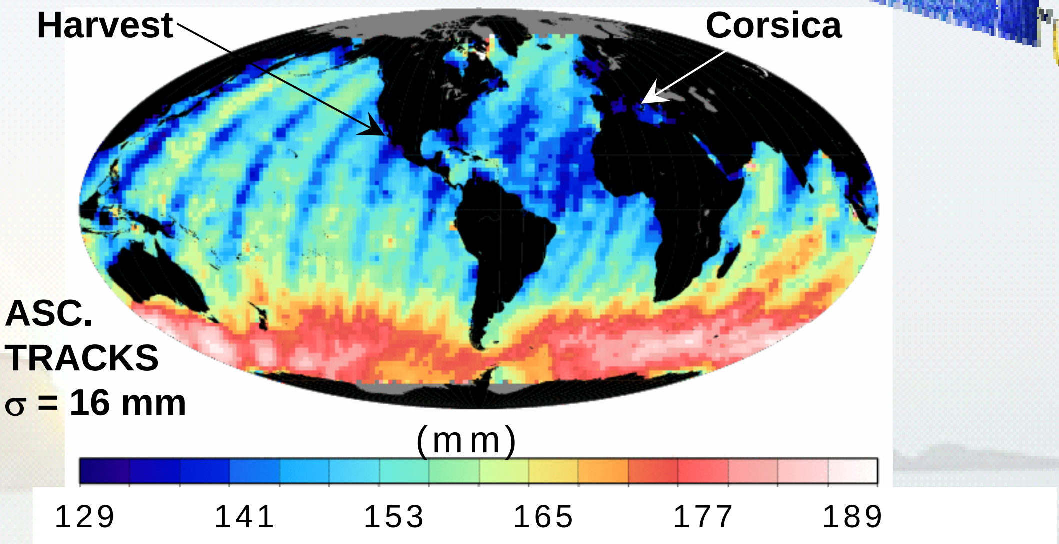
Senetosa Situation

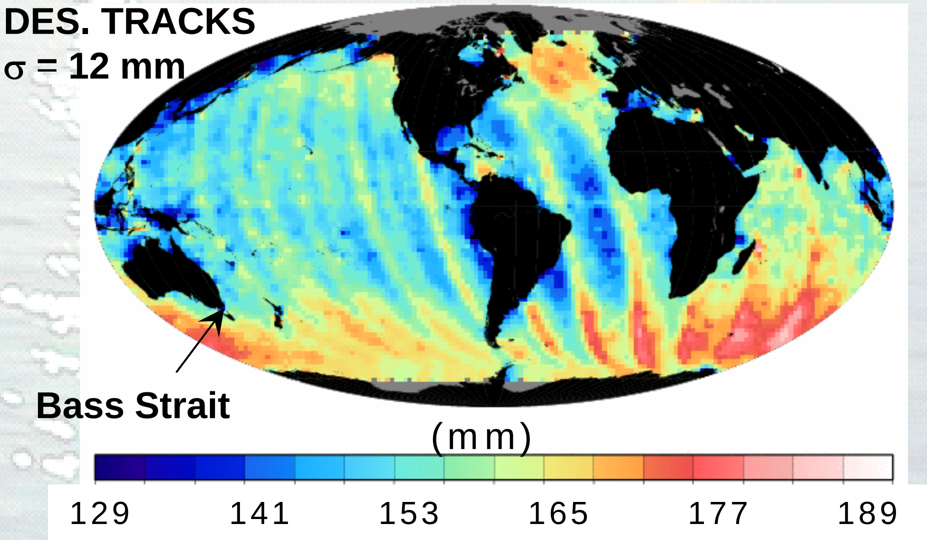


A unique opportunity to cross compare all the corrections and the derived Sea Surface Height

Systematic sea-surface height errors revealed by flying Jason-1 in formation with TOPEX/POSEIDON (for ~200 days)







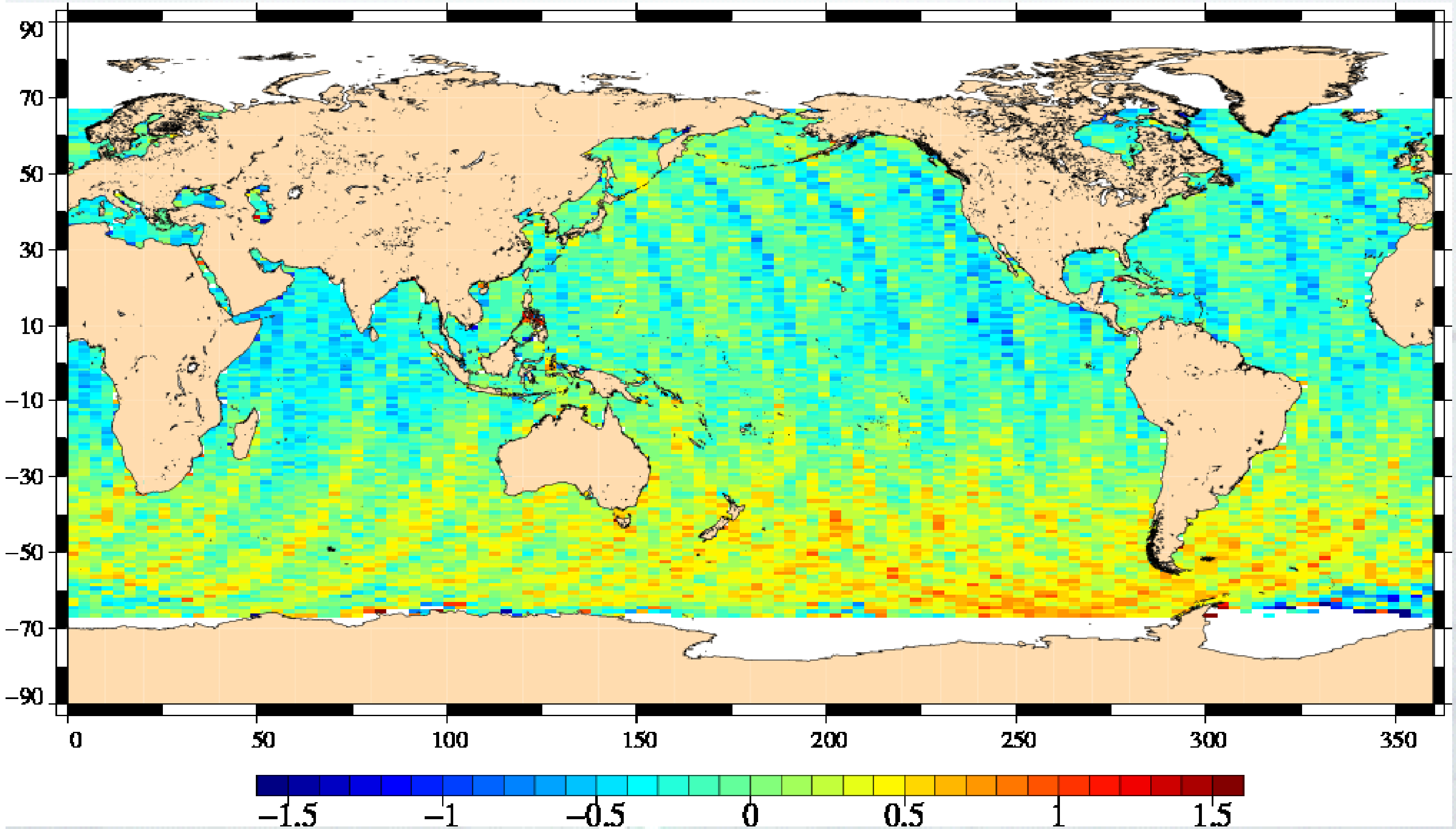
Same strategy for the first six month of OSTM/Jason-2 mission

Jason-2 has been placed ~60 seconds behind Jason-1

A unique opportunity to cross compare all the corrections and the derived Sea Surface Height

Systematic sea-surface height errors revealed by flying Jason-2 in formation with Jason-1 (for ~200 days)

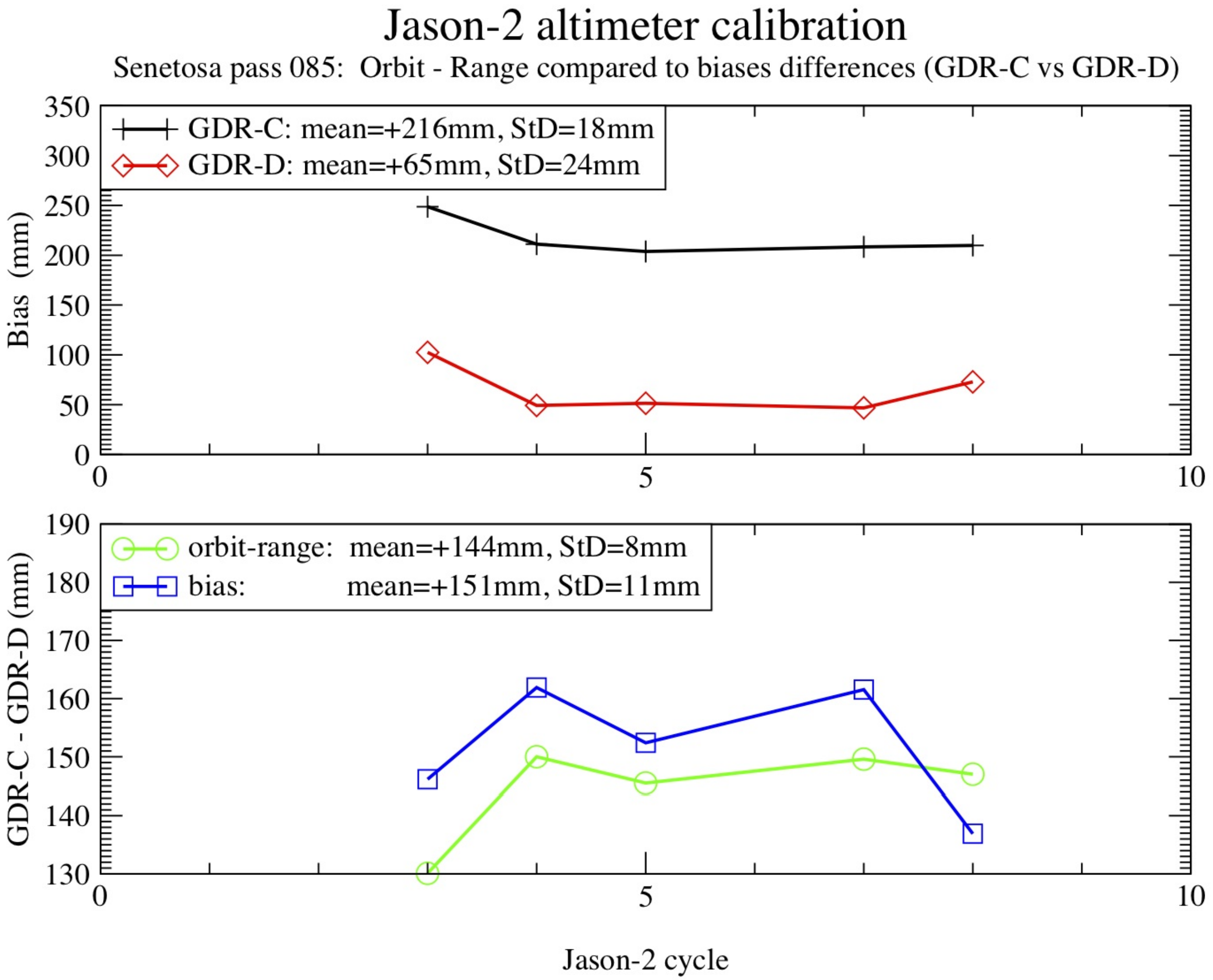
Corsica Absolute Altimeters Calibration

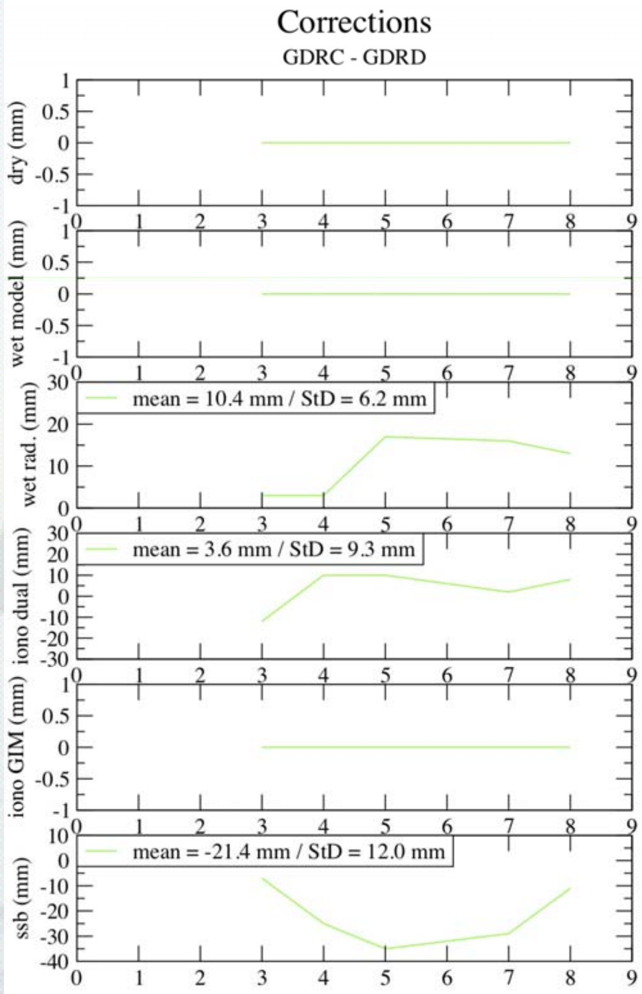


SLA Differences (mm)

F O R M A T I O N F L I G H T

Jason-2 absolute bias from GDR-C and GDR-D





The value of the Jason-2 bias (GDR-C) over this period was higher by about 66 mm compared to the mean value over the whole period (150mm).

This means that we expect to have a zero bias with GDR-D over the whole period

New CNES GDR-D test orbits change the mean by only 2 mm

On the average the corrections account for 7 mm.