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

Results of Jason-1 and Jason-2 Formation Flight Phase

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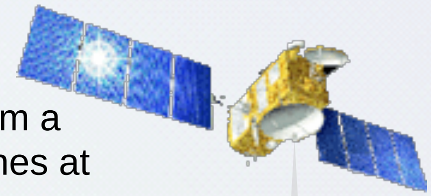
OSTST Meeting

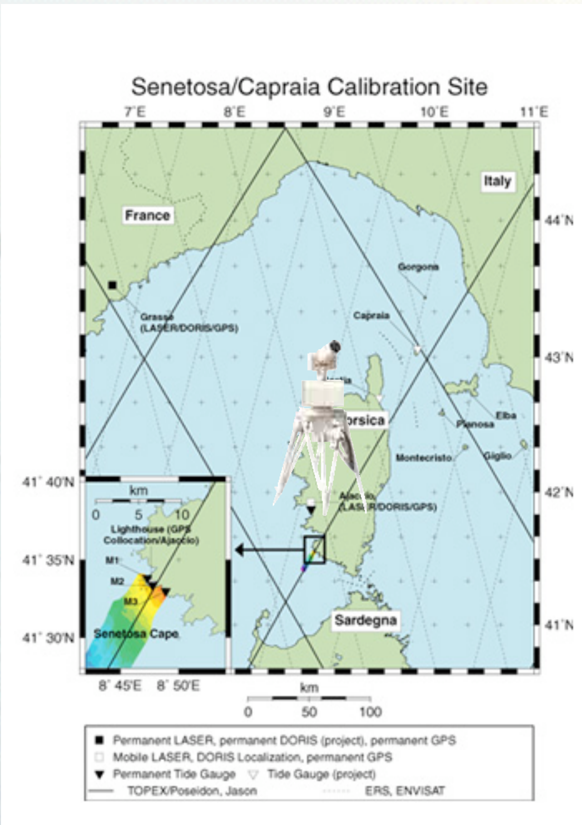
Seattle, 22-24 June 2009

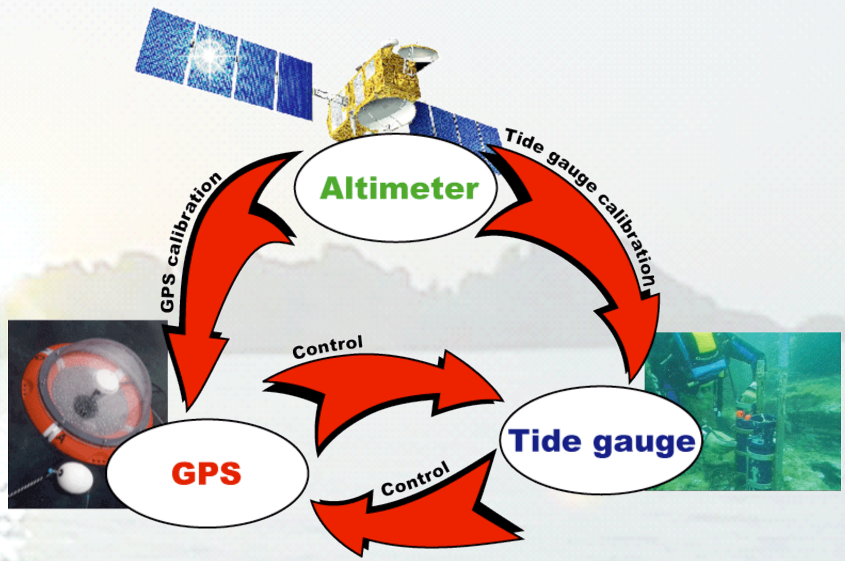
The absolute calibration site in Corsica is based on a double configuration:



- **A geodetic site at Ajaccio: FTLRS has been settled** in 2002, 2005 and **2008**.
- **An in-situ site at Senetosa cape** under the track N°85

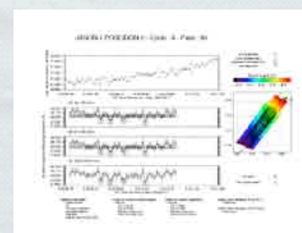
The Senetosa site allows to perform altimeter calibration from **tide gauges** as well as from a **GPS buoy**. All **geodetic measurements** have been redone in **2009** and confirm **1999** ones at the **mm level**





<u>**Products used for the study:**</u>

- **Jason-1: IGDR-C, GDR-C**
- **Jason-2: IGDR-C, GDR-C**
- **T/P: MGDR+ (TMR & orbit), and retracked products**



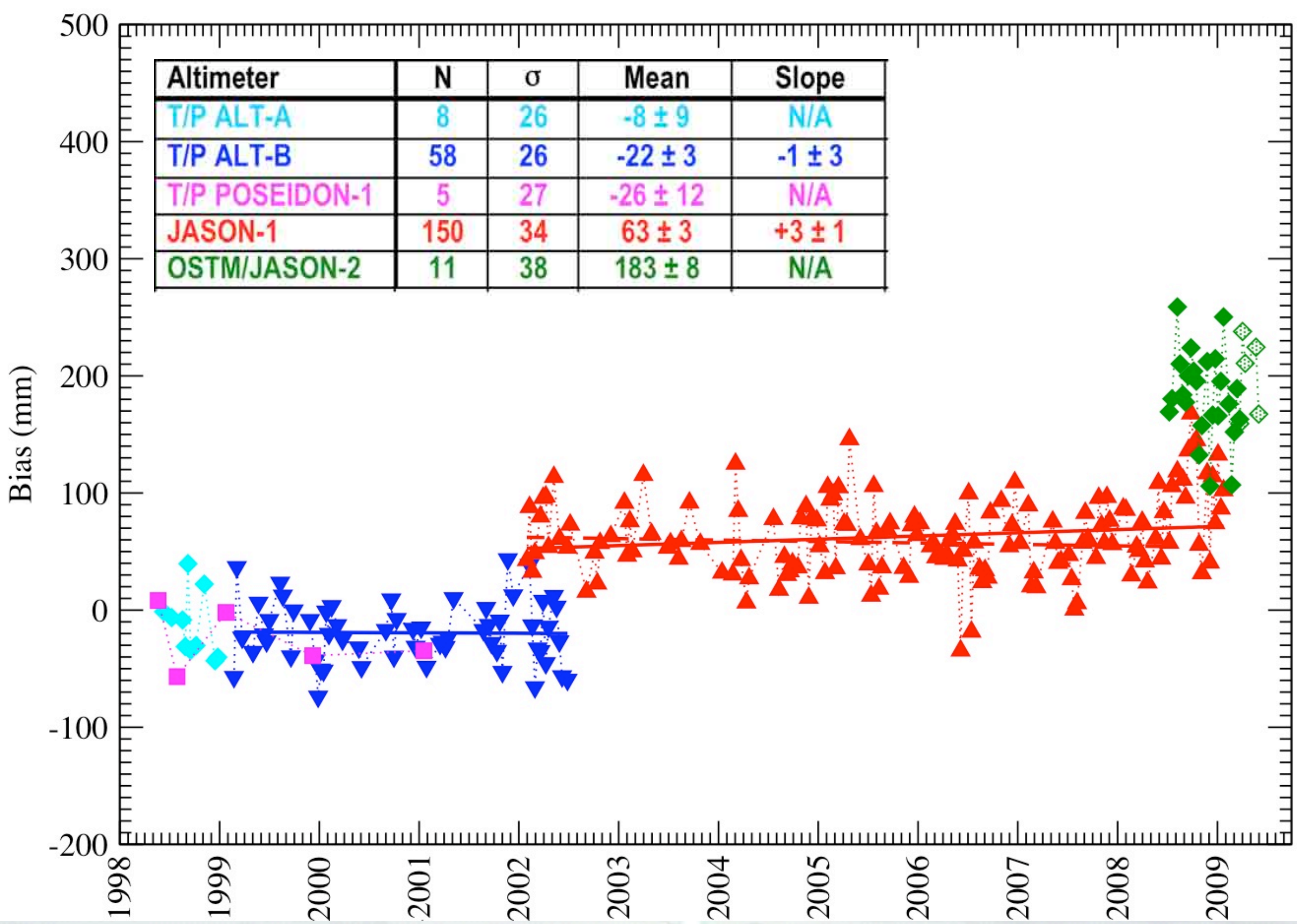
<u>**Definition of altimeter bias calibration:**</u>

sea height bias = altimeter sea height - in situ sea height

Sea height bias < 0 meaning the altimetric sea height being too low (or the altimeter measuring too long)
Sea height bias > 0 meaning the altimetric sea height being too high (or the altimeter measuring too short)

CORSICA

Results of Jason-1&2
Formation Flight Phase



Altimeter	N	σ	Mean	Slope
T/P ALT-A	8	26	-8 ± 9	N/A
T/P ALT-B	58	26	-22 ± 3	-1 ± 3
T/P POSEIDON-1	5	27	-26 ± 12	N/A
JASON-1	150	34	63 ± 3	+3 ± 1
OSTM/JASON-2	11	38	183 ± 8	N/A

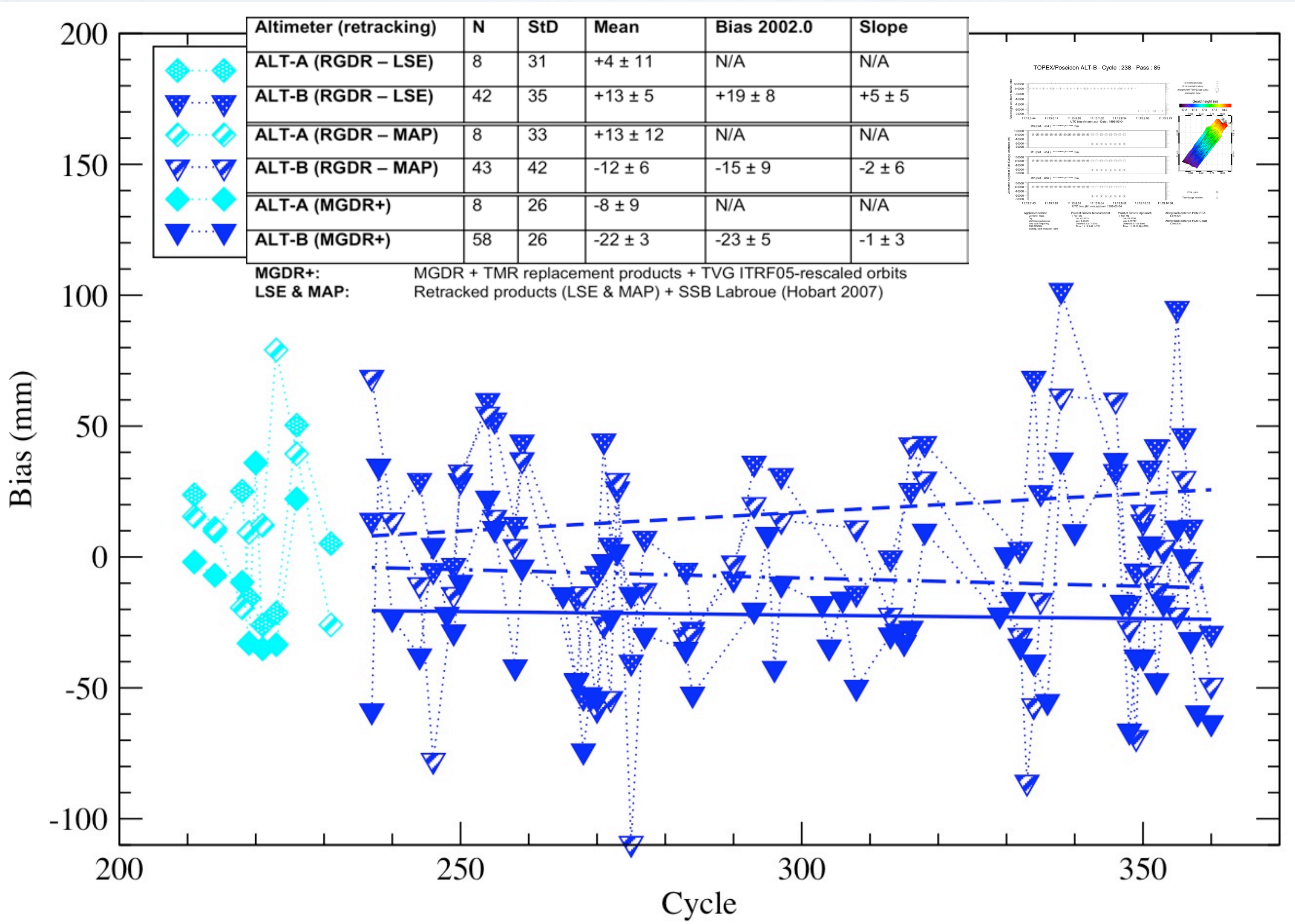
BiASES TIME SERIES

Products used:

T/P: MGDR + TMR replacement products + TVG ITRF05-rescaled orbits
Jason-1: GDR-C (cycle 1 to 259)
Jason-2: GDR-C (cycle 0 to 26)

The relatively high slope of Jason-1 (+3 mm/yr) is due to last data since Jason-2 launch: when this period is excluded the slope is not statistically significant (+1 ±1 mm/yr).

Analysis of the T/P retracked products



Altimeter (retracking)	N	StD	Mean	Bias 2002.0	Slope
ALT-A (RGDR – LSE)	8	31	+4 ± 11	N/A	N/A
ALT-B (RGDR – LSE)	42	35	+13 ± 5	+19 ± 8	+5 ± 5
ALT-A (RGDR – MAP)	8	33	+13 ± 12	N/A	N/A
ALT-B (RGDR – MAP)	43	42	-12 ± 6	-15 ± 9	-2 ± 6
ALT-A (MGDR+)	8	26	-8 ± 9	N/A	N/A
ALT-B (MGDR+)	58	26	-22 ± 3	-23 ± 5	-1 ± 3

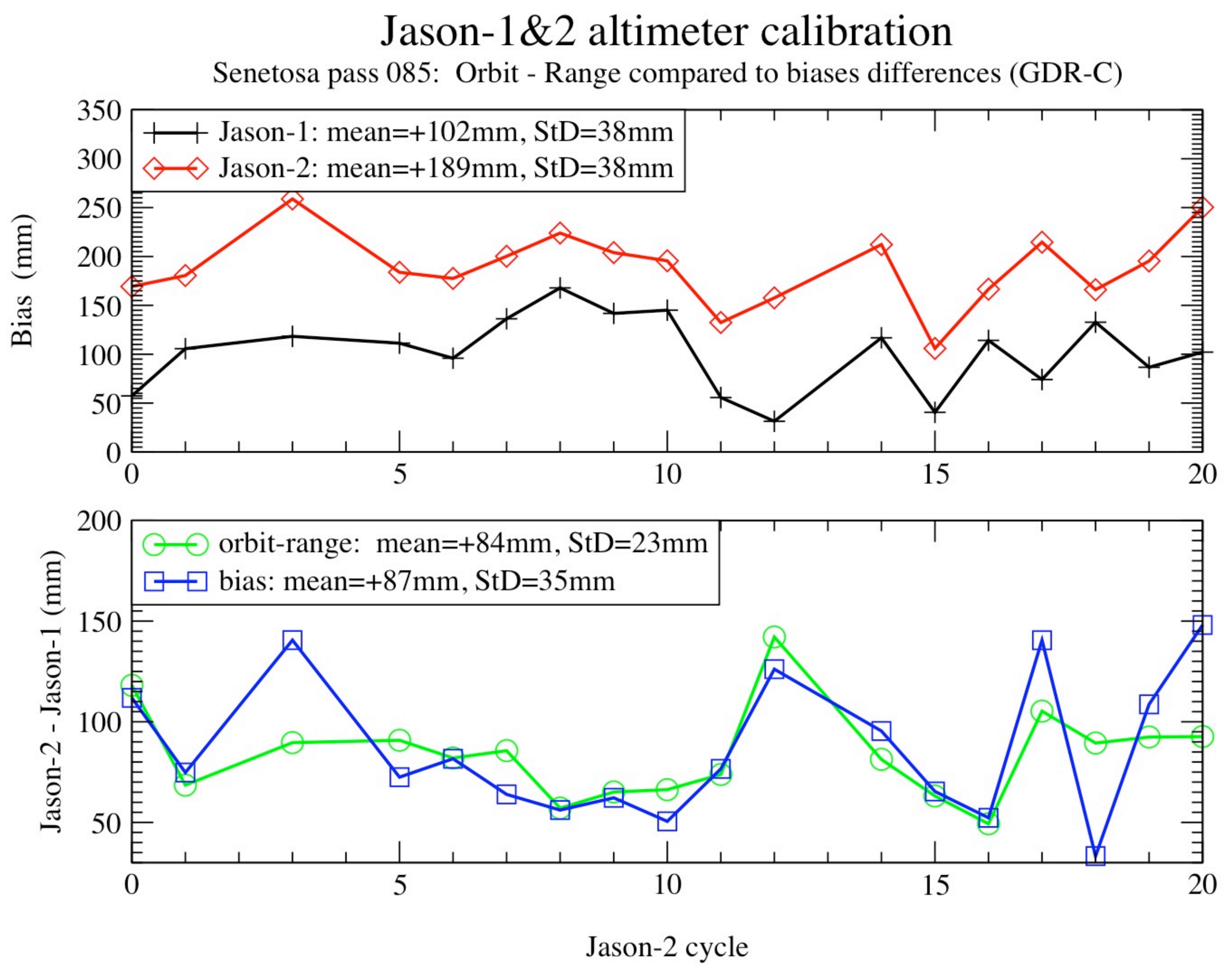
MGDR+: MGDR + TMR replacement products + TVG ITRF05-rescaled orbits
LSE & MAP: Retracked products (LSE & MAP) + SSB Labroue (Hobart 2007)

T/P BIASES

Main impact, using **LSE**:

- the T/P (ALT-B) **bias is increased by 35 mm** (from negative to positive value)
- the **standard deviation is increased by 23 mm** (square root)
- the **slope** isn't negligible **+5 mm/yr**

Track SGT



Results of Jason-1&2
Formation Flight Phase

J A S O N | 1 & 2 B I A S E S

Orbit minus Range (OMR) a little **higher than global analysis** from JPL (+77mm):
Very good agreement of bias differences and OMR: 3 mm (correction impact)
Very **small impact** on the bias if using <u>other POEs</u> (CNES, GSFC, JPL)

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
Recalibrated JMR (cycle 228 to 259) **has no significant impact** (mean=-1mm / StD=2mm)
Better agreement between GPS and Coastal path delays from AMR (2 mm)

Other environmental parameters:

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

JASON-1&2 CORRECTIONS

Calibration from Corsica

<u>Absolute bias 18 four common overflights:</u>

Jason-2: +183 mm *(174 from Harvest)*
Jason-1: +102 mm *(92 from Harvest)*

<u>Relative bias from 18 common overflights:</u>

Jason-2 - Jason-1: +87 mm *(82 from Harvest)* **(84 mm from orbit-range)**
In good agreement JPL global analysis (77 mm)

<u>Corrections:</u>

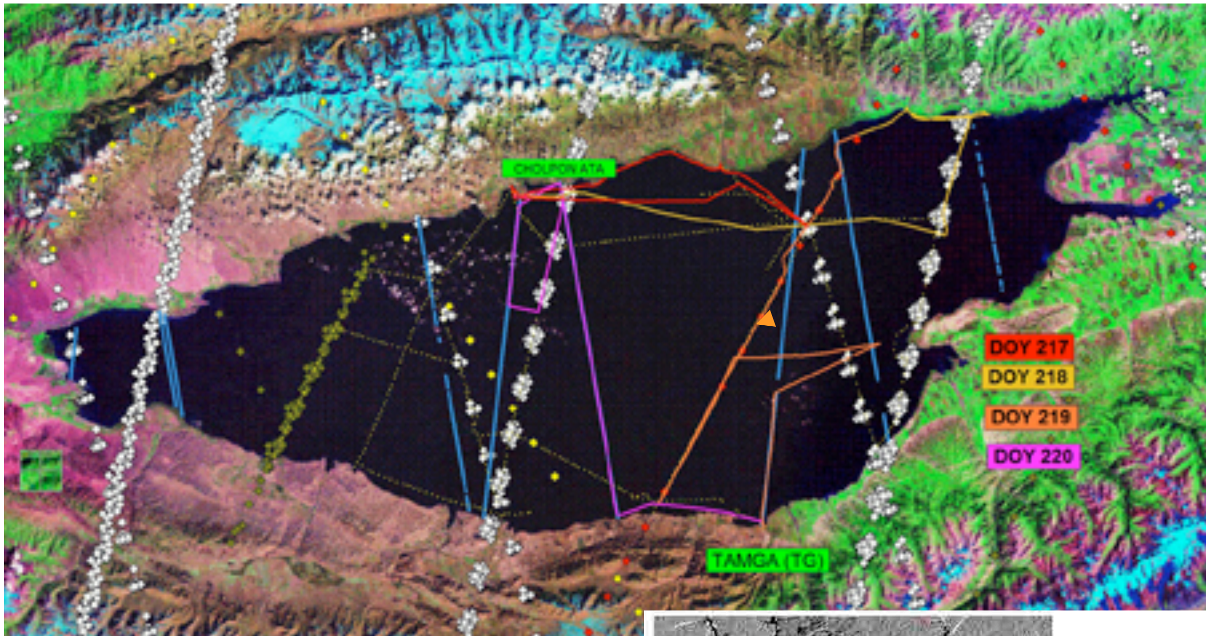
\- **Wet tropo. from radiometers show a bias of -6 mm (JMR dryer)**
GPS shows that both AMR and JMR are dryer
No significant drift detected from JMR/GPS comparisons**.**
Recalibrated JMR (cycle 228 to 259) **has no significant impact**
Better agreement between GPS and coastal path delays from AMR (2 mm)
=> Jason-2 bias increases by ~10mm
\- **Dual Ionospheric corrections exhibit a bias of +8 mm** (Jason-2 - Jason-1).
Compared to GIM biases are respectively -5 mm and -13 mm for Jason-2 and Jason-1

C O N C L U S I O N

<u>T/P MGDR+:</u>

10 mm decrease of the T/P ALT-B bias compared to MGDR (-3 mm from TMR and -7 mm from orbit)
Jason-1 (GDR-C) - T/P (ALT-B, MGDR+): +85 mm (11 common overflights)
(78 from Harvest)

Using **LSE retracked products increases T/P ALT-B bias by 35 mm**
and induces **a slope of 5 mm/yr**



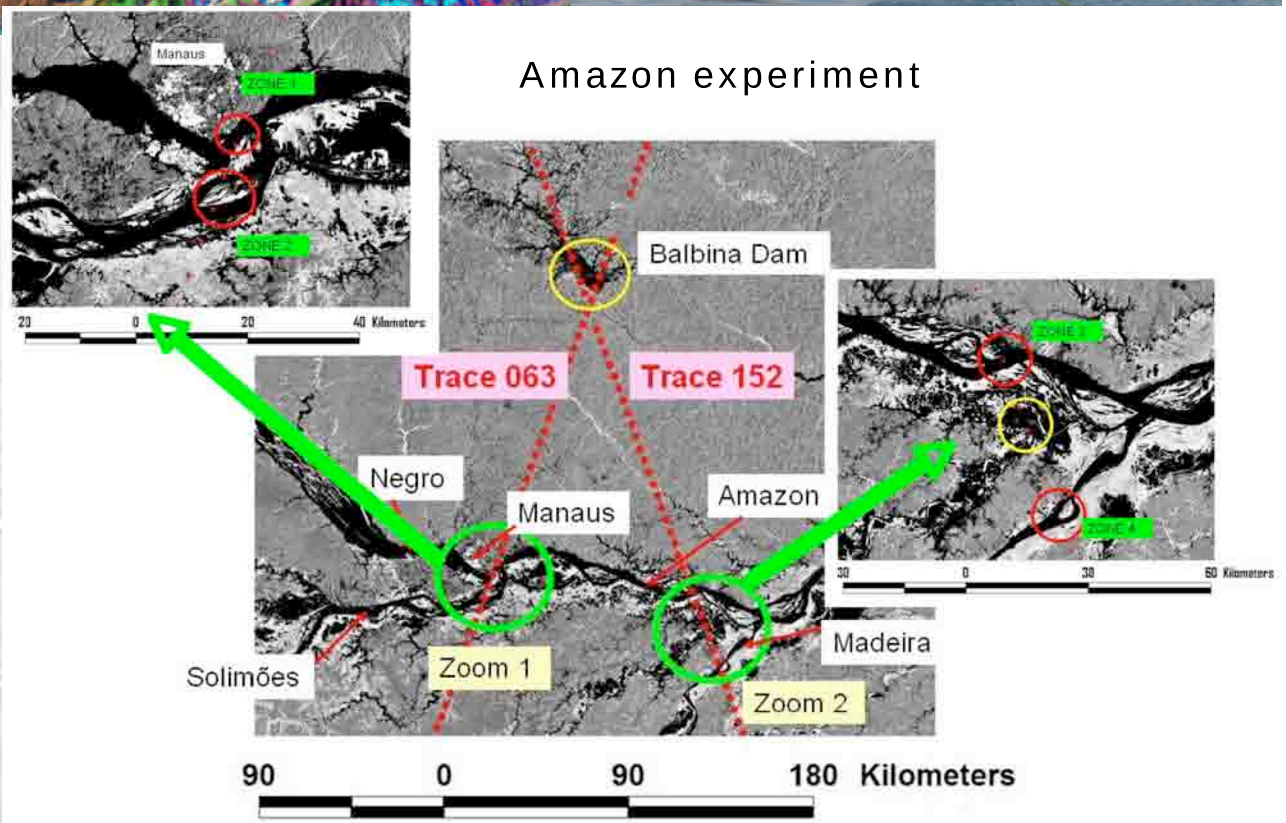
Lake Issyk-kul

Jason pass 131

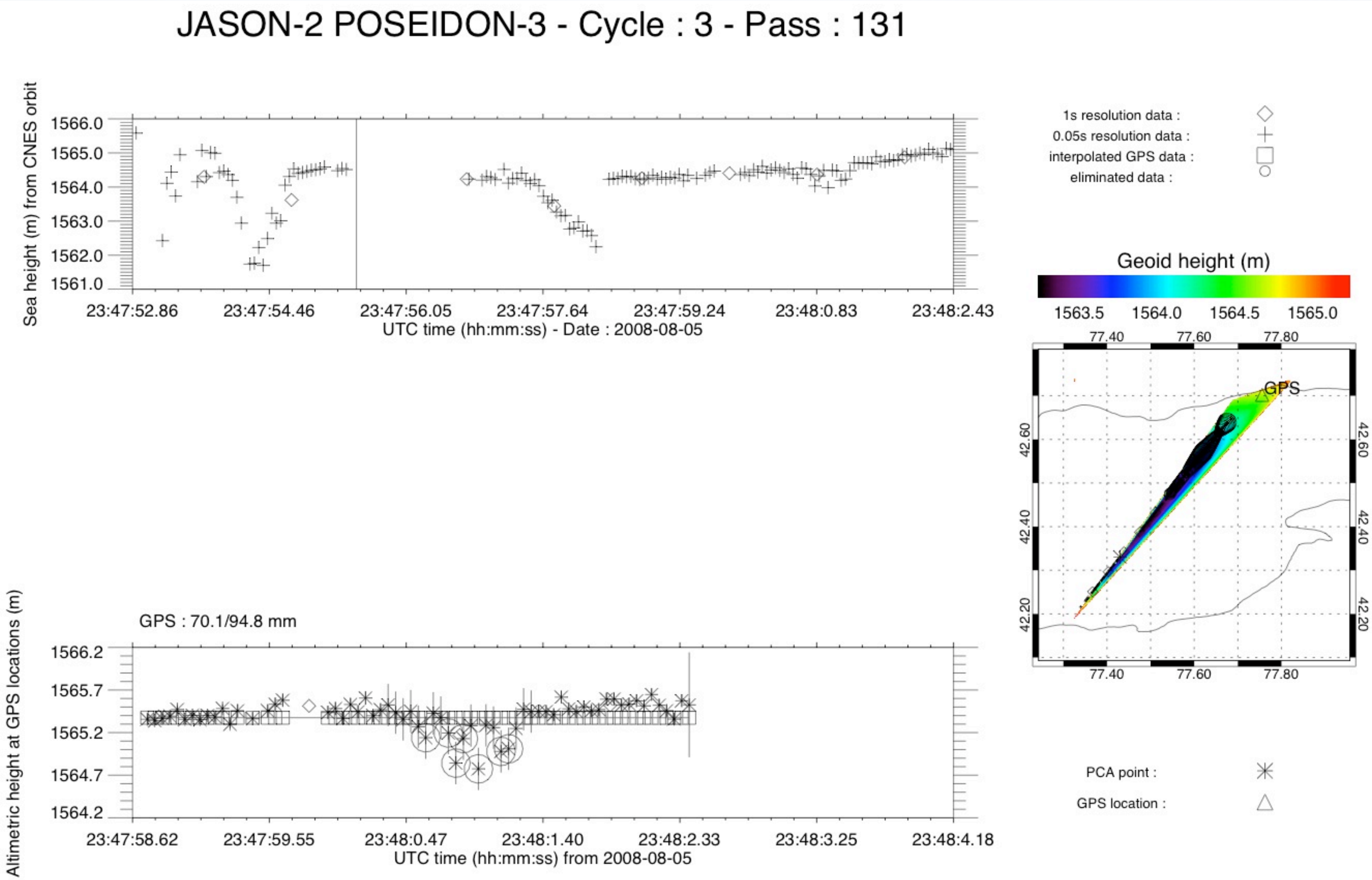
Calibration over Inland waters

CAL/VAL activities on rivers and lakes enable to **avoid the contributions of the Sea Surface Bias (SSB)** and liquid tides in the range calibration and to **address other problems** such as the performance of the various **tracking/retracking algorithms** and more globally assess the quality of the geophysical corrections.

Amazon experiment



Jason's overflights over lake Issyk-kul on August, 5th



Applied correction
Center of mass
Dry
Wet tropo radiometer
Iono dual-frequency
SSB BM4
loading, solid and pole Tides

Point of Closest Measurement
-> Ref: Gps Buoy
Lat: 42.3249
Lon: 77.4256
Distance: 49.95 (Km)
Time: 23:47:55.35 (UTC)

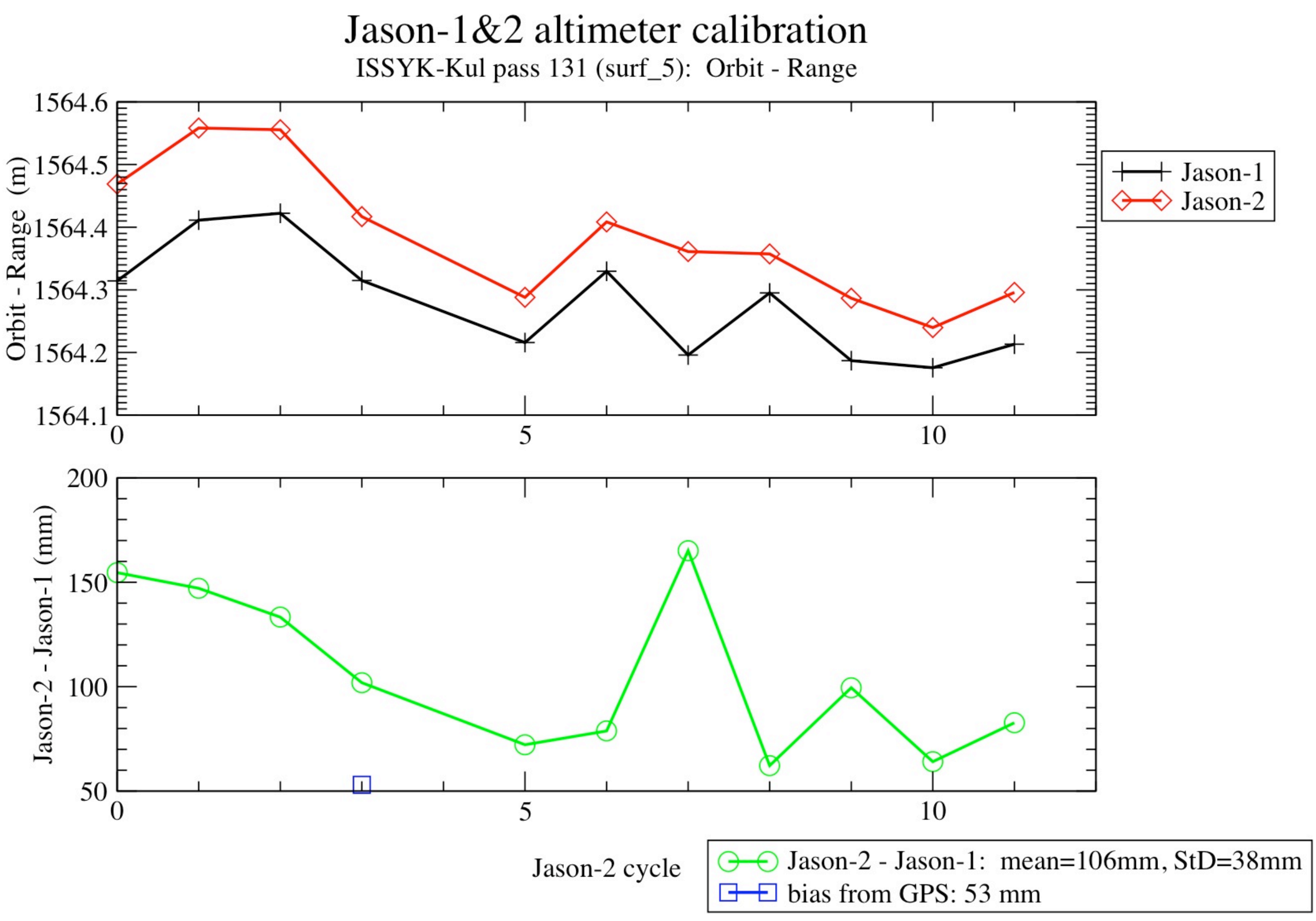
Point of Closest Approach
-> Ref: Gps Buoy
Lat: 42.3302
Lon: 77.4298
Distance: -0.02 (Km)
Time: 23:47:55.47 (UTC)

Along track distance PCM-PCA
0.677 (Km)

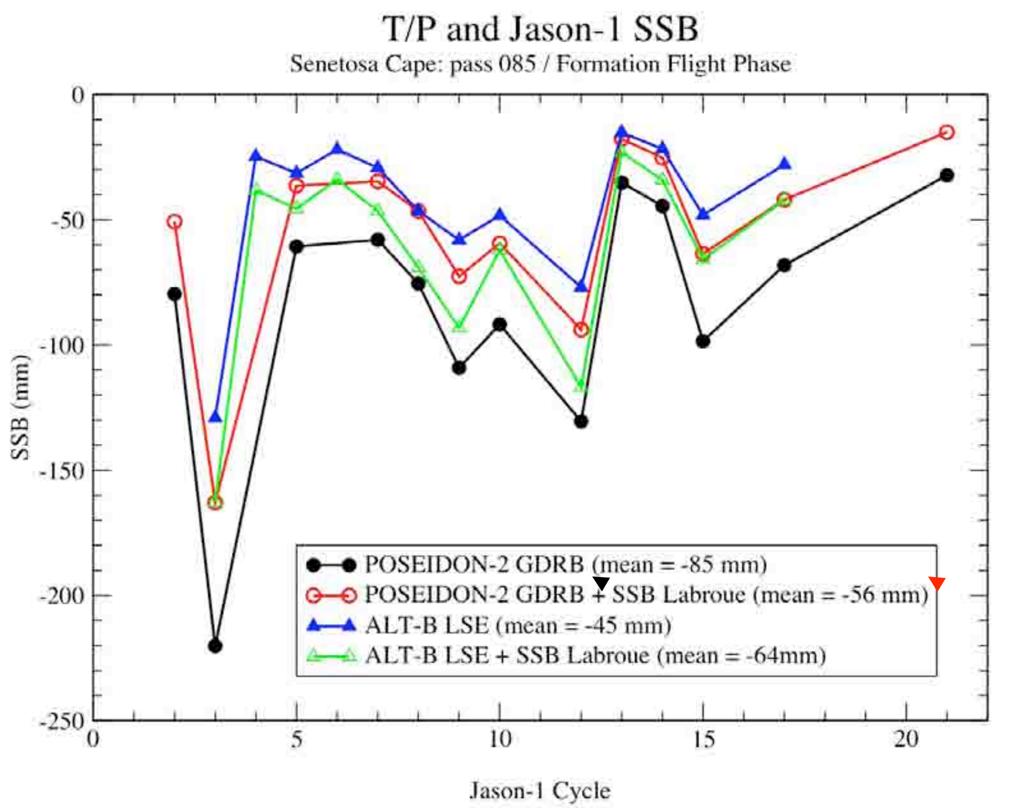
Along track distance PCM-Coast
50.91 (Km)

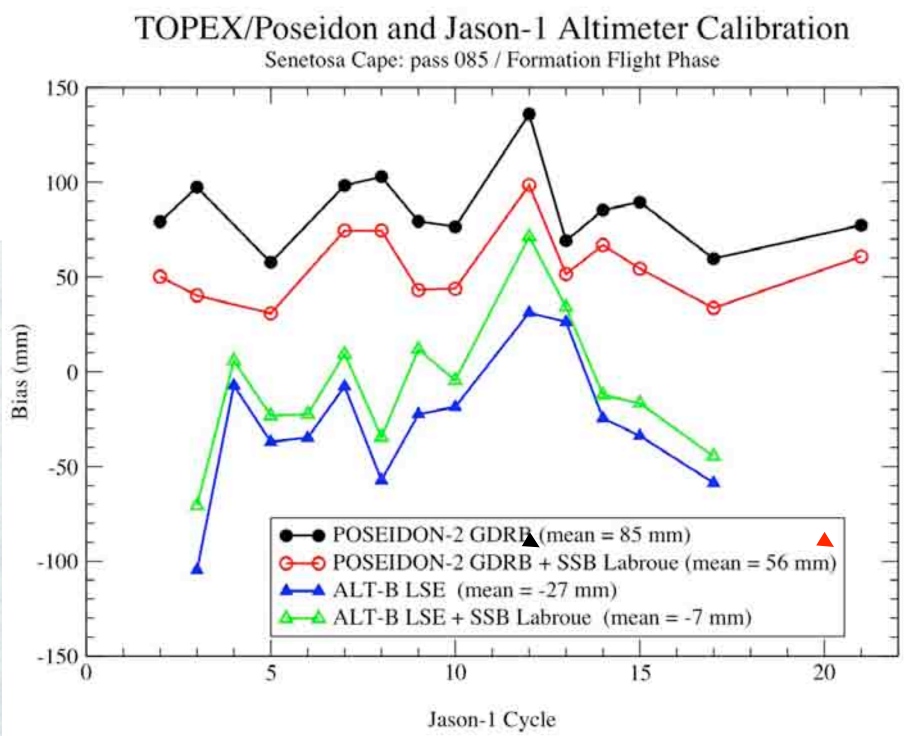
NO SSB APPLIED: Jason-1 bias = 17 mm / Jason-2 bias = 70 mm

Jason-1&2 relative calibration from lake Issyk-Kul

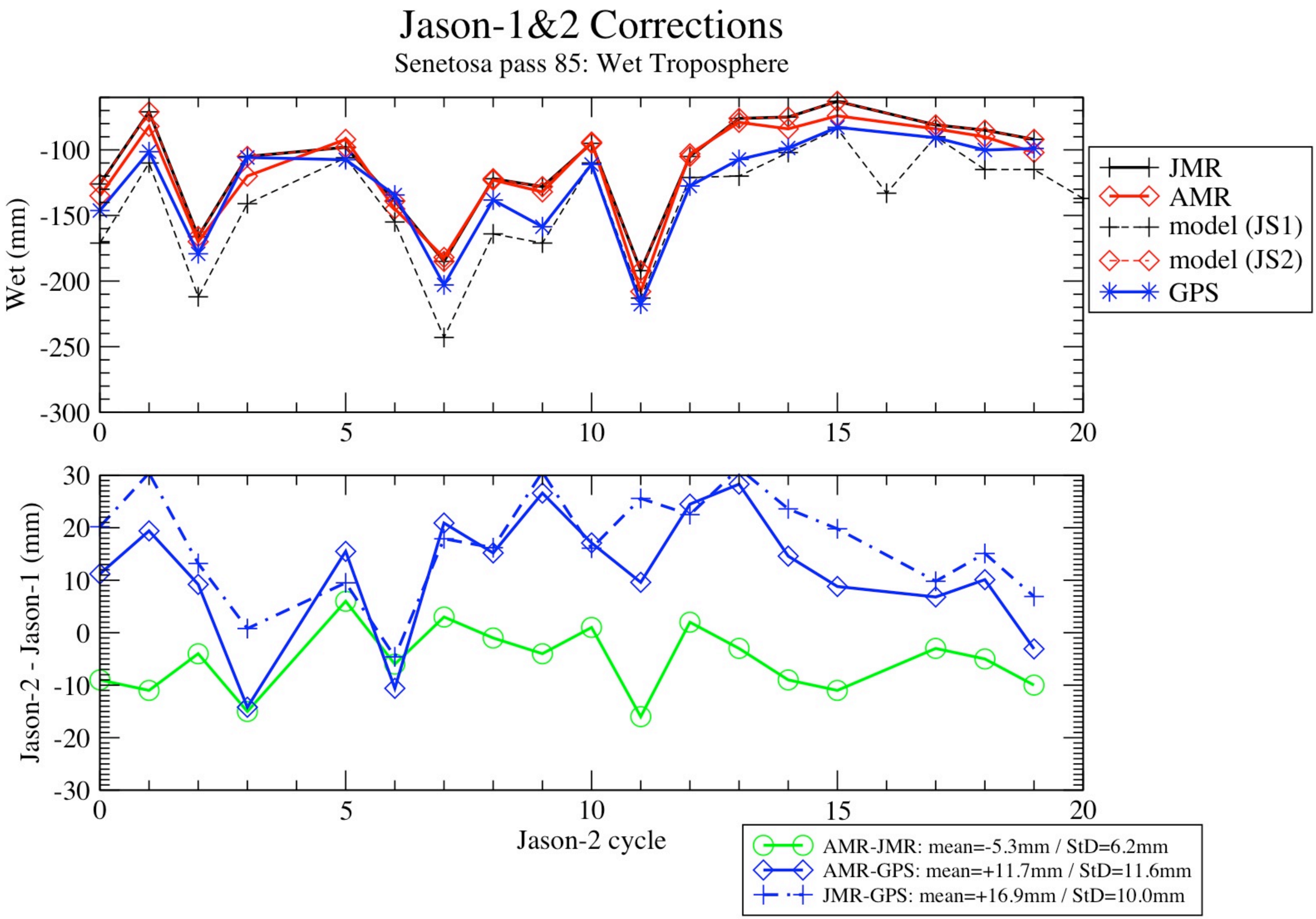


Jason-1 (GDR-B/MLE4) and T/P (RGDR/LSE) SSB

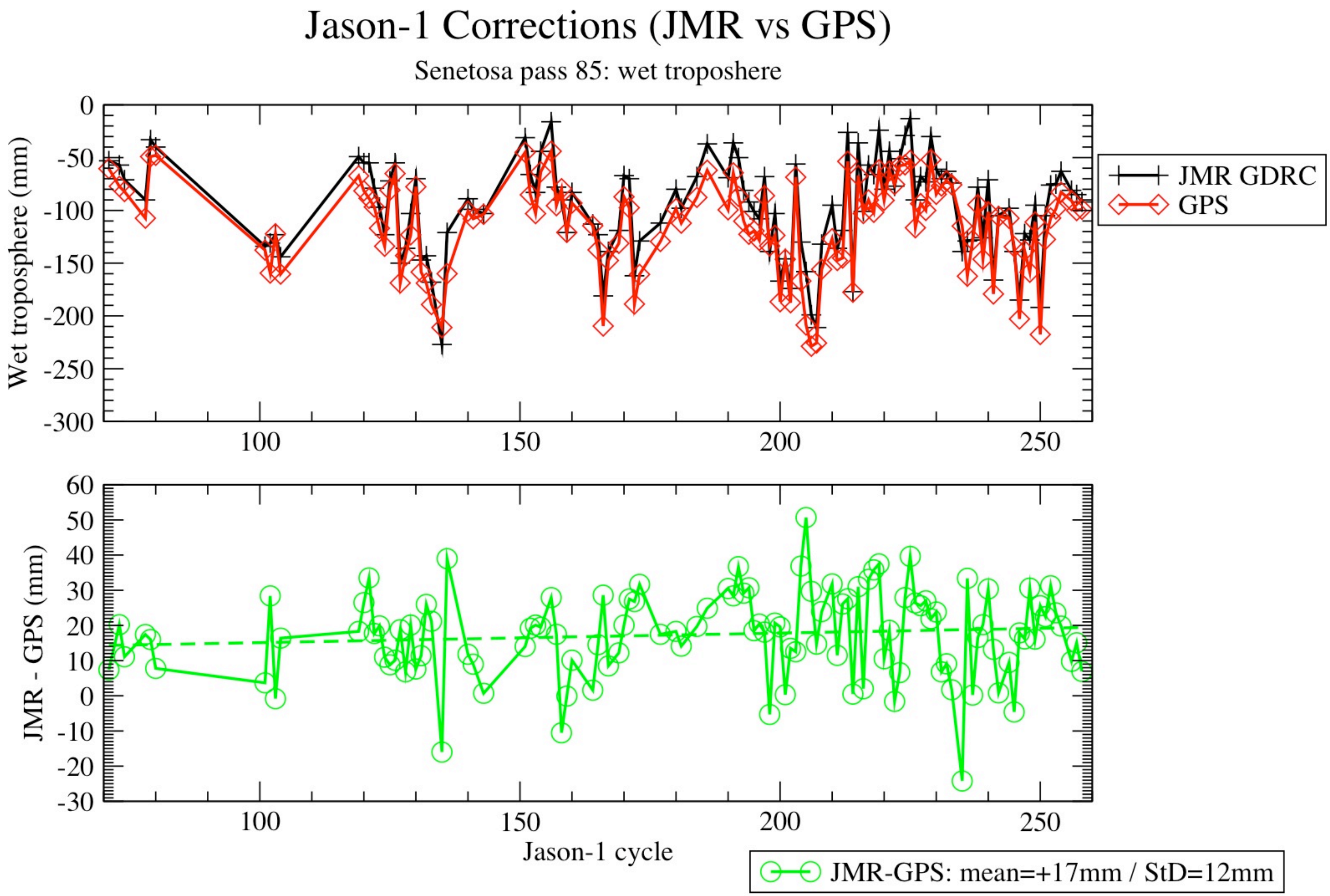




Jason-1&2 Wet Tropospheric Path Delay (corrections)

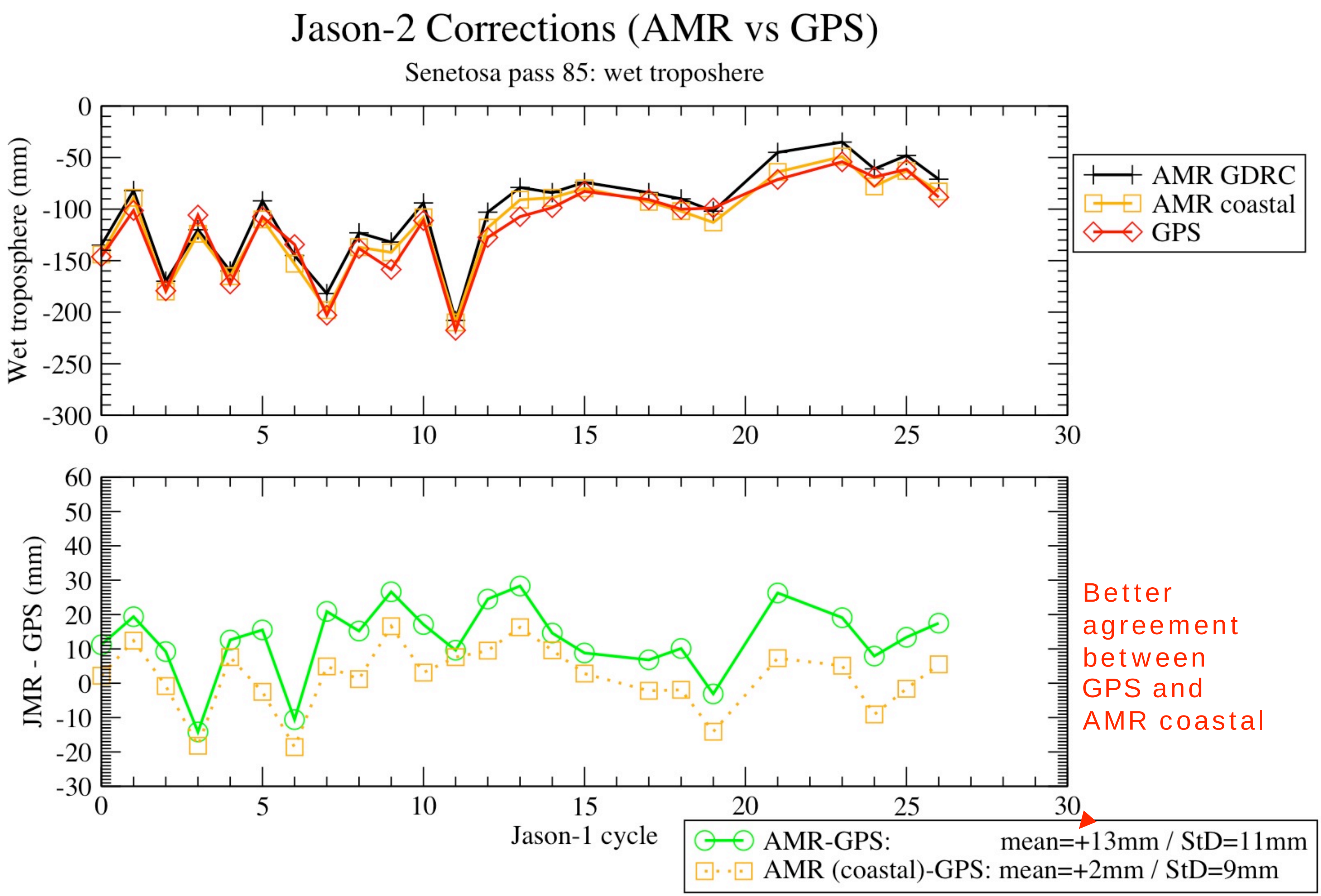


Jason-1 Wet Tropospheric Path Delay (corrections)



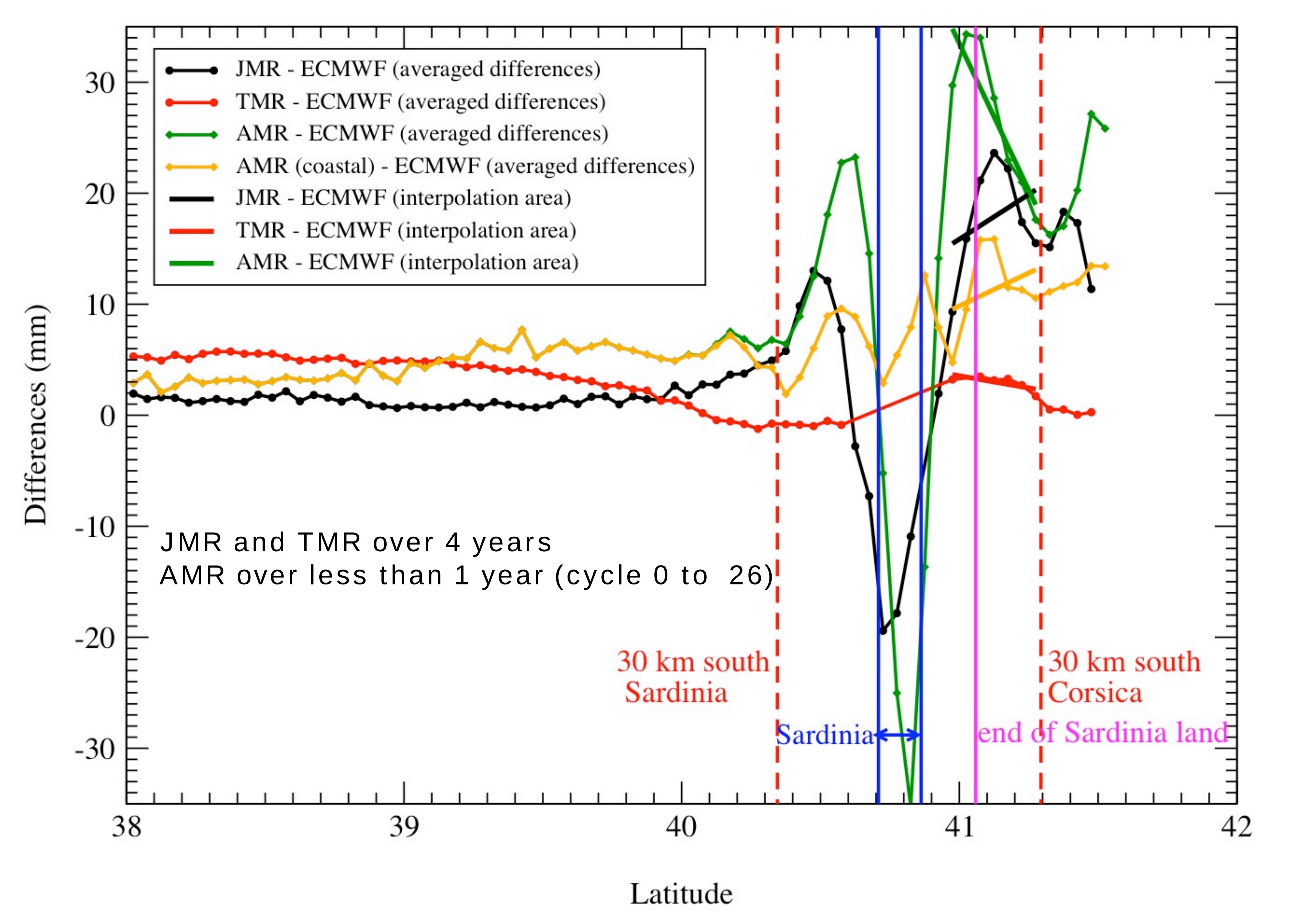
Slope: +1 ±1 mm/yr

Jason-2 Wet Tropospheric Path Delay (corrections)

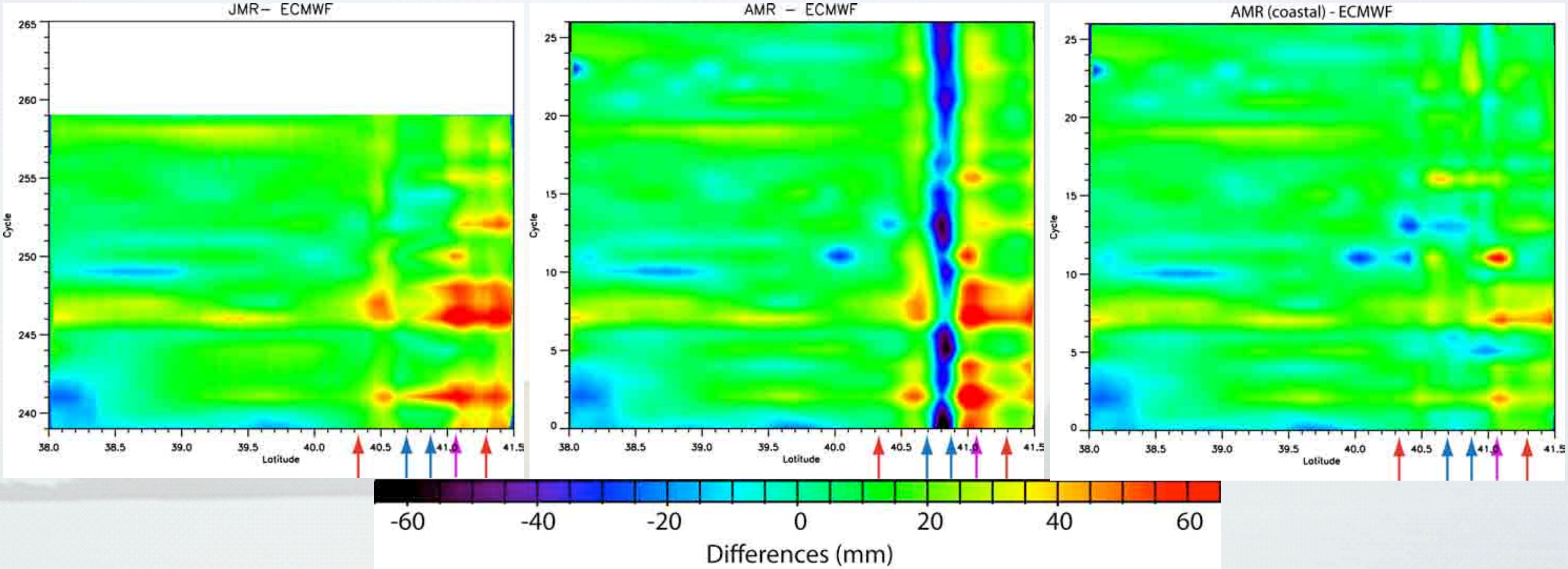


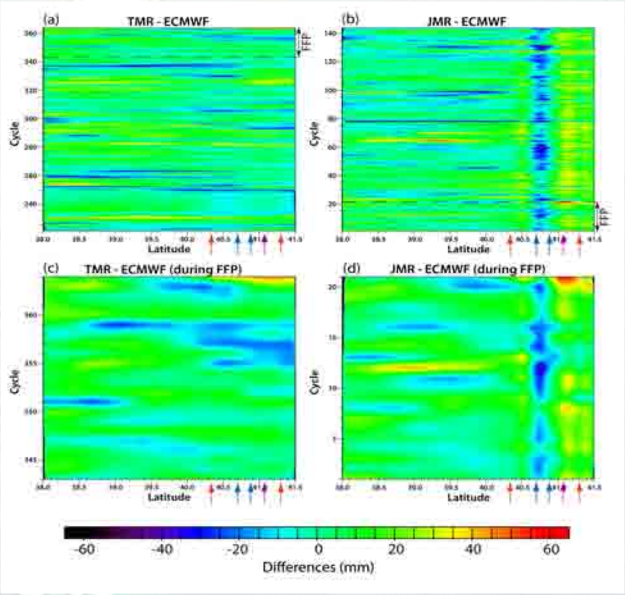
Better agreement between GPS and AMR coastal

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

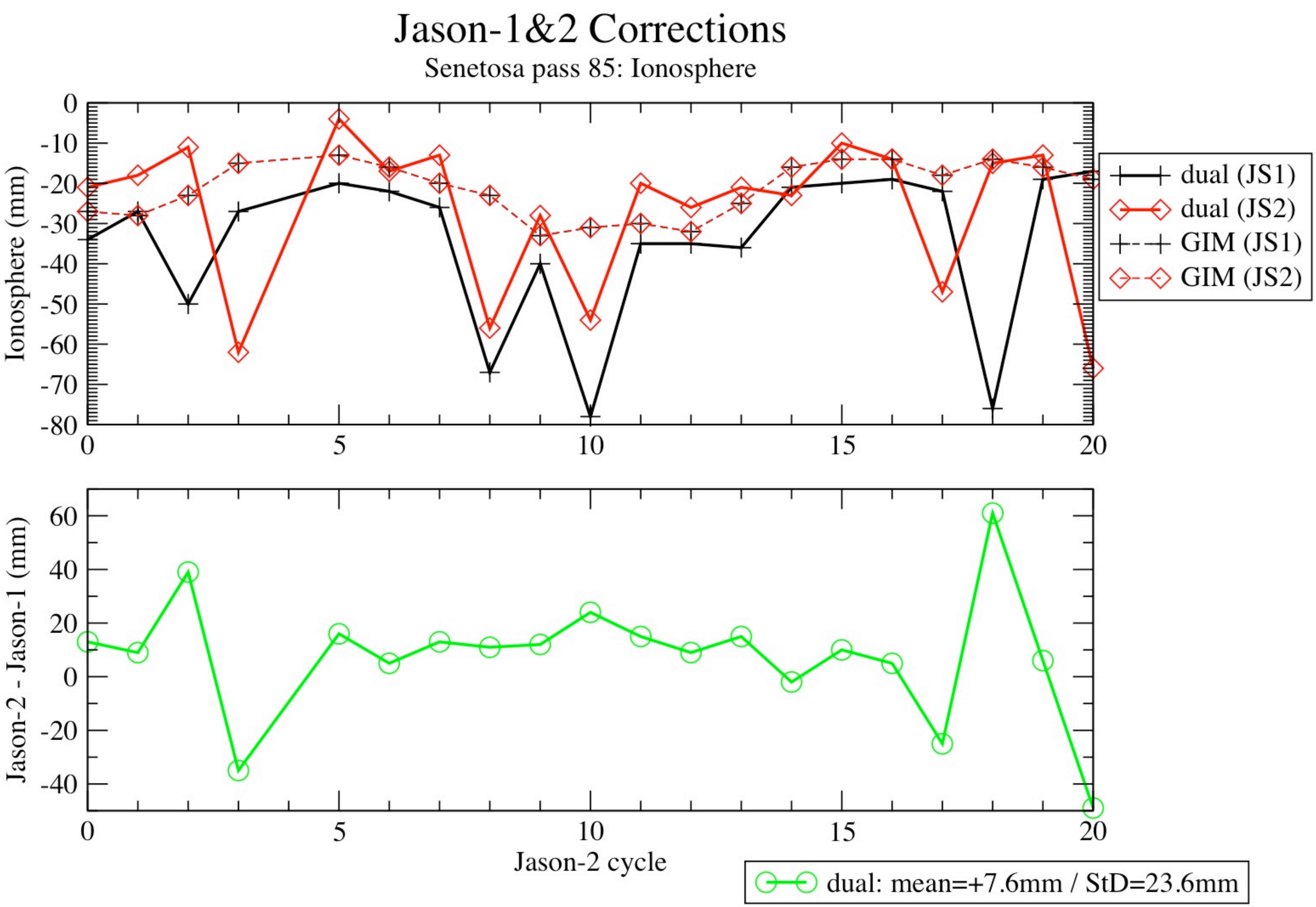


Jason-1, Jason-2 & T/P Wet Tropospheric Path Delay



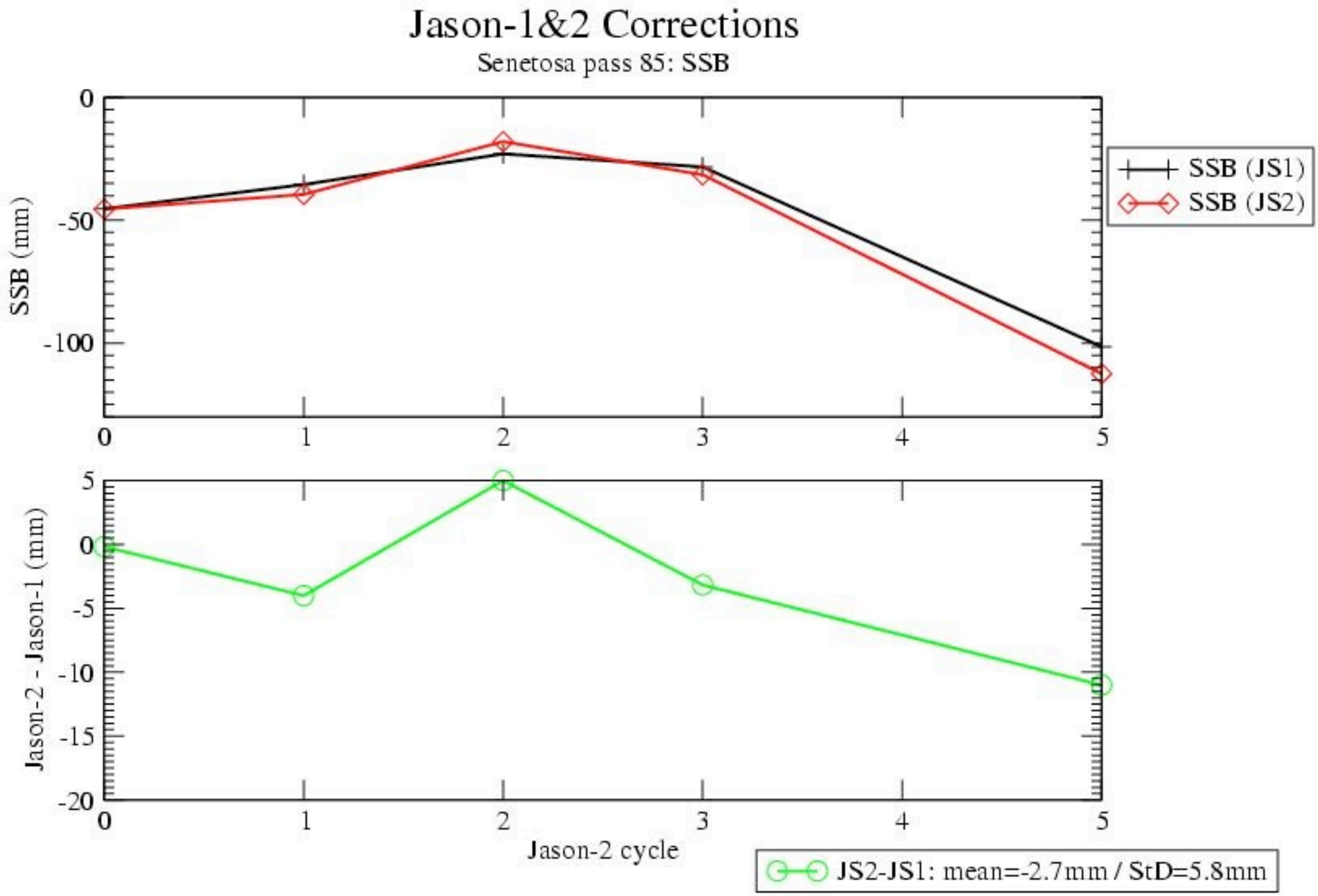


Jason-1&2 Ionospheric Path Delay (correction)



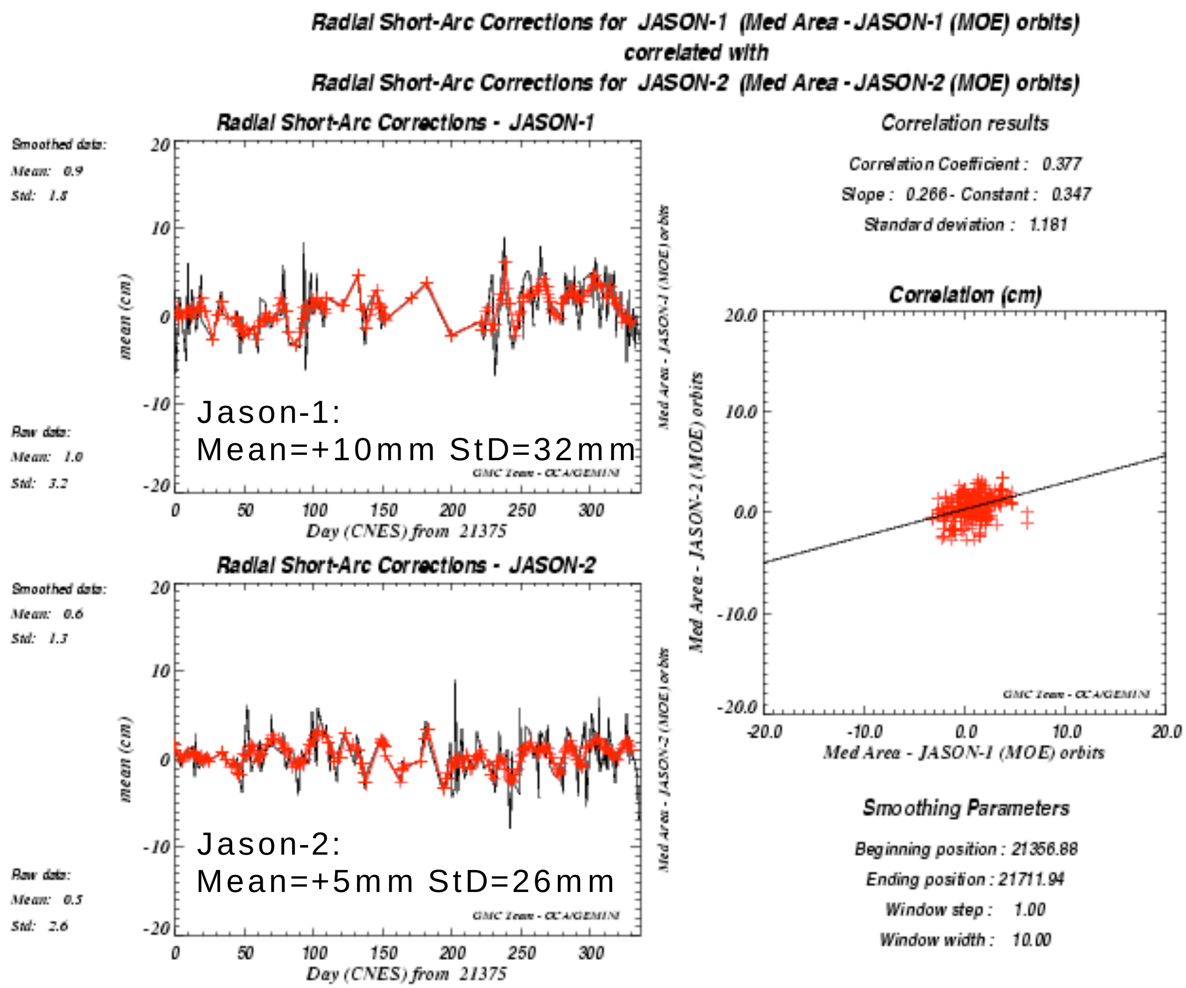
Jason-1&2 Sea State Bias

Statistics are for common cycles and include cycle 2 (sigma bloom)



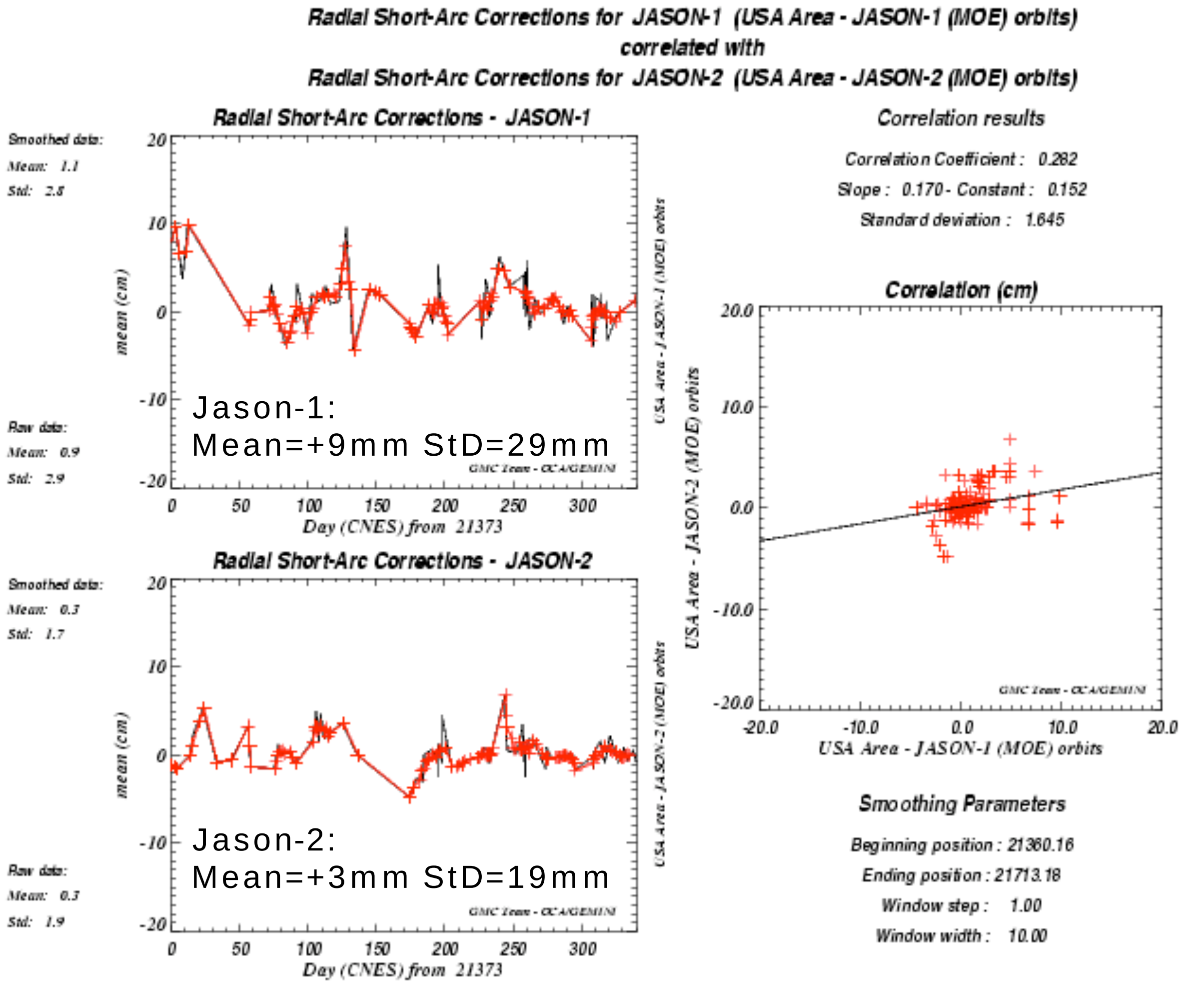
Jason-1&2 MOE orbit validation by the laser-based Short-Arc Technique

Radial orbit errors estimation over Europe



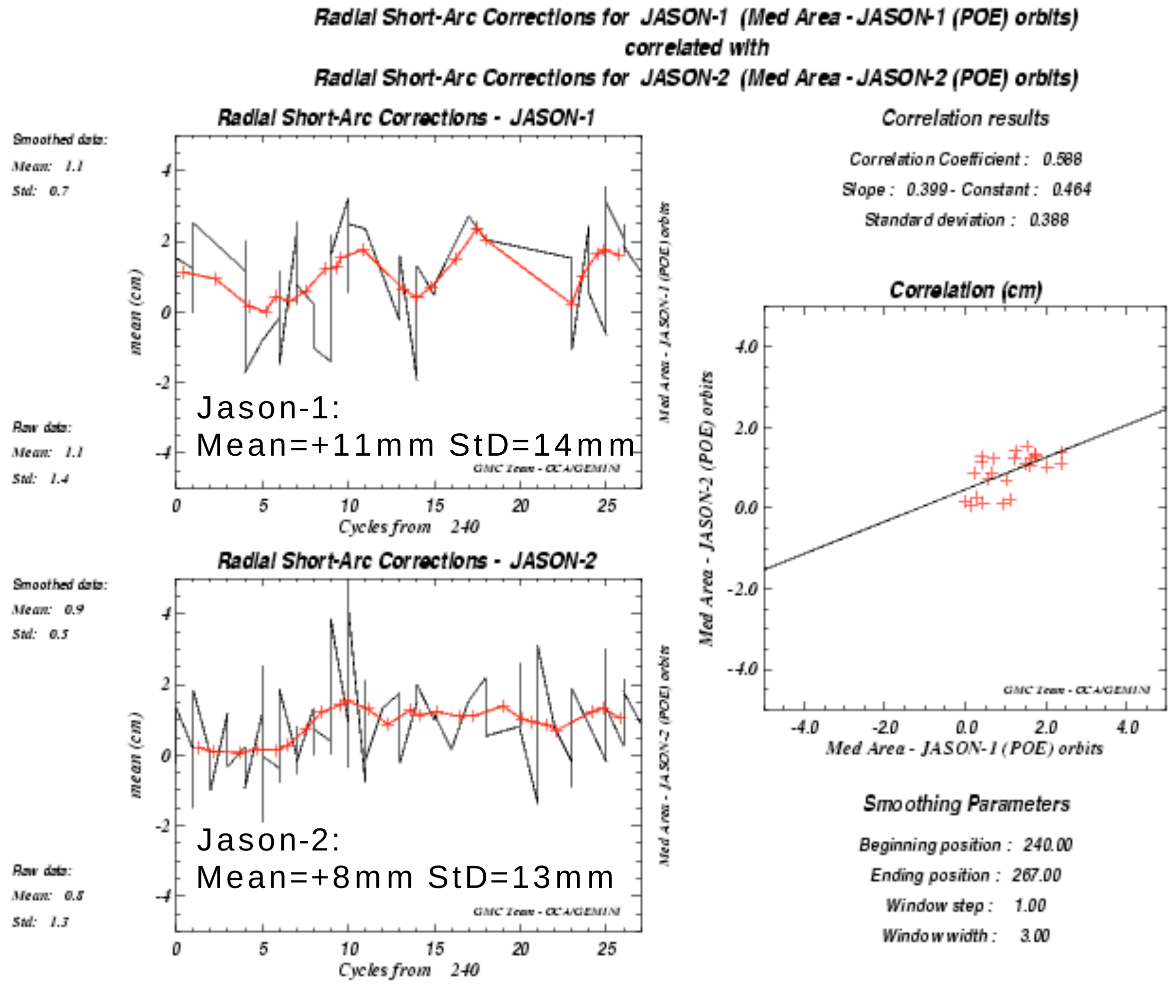
Jason-1&2 MOE orbit validation by the laser-based Short-Arc Technique

Radial orbit errors estimation over USA



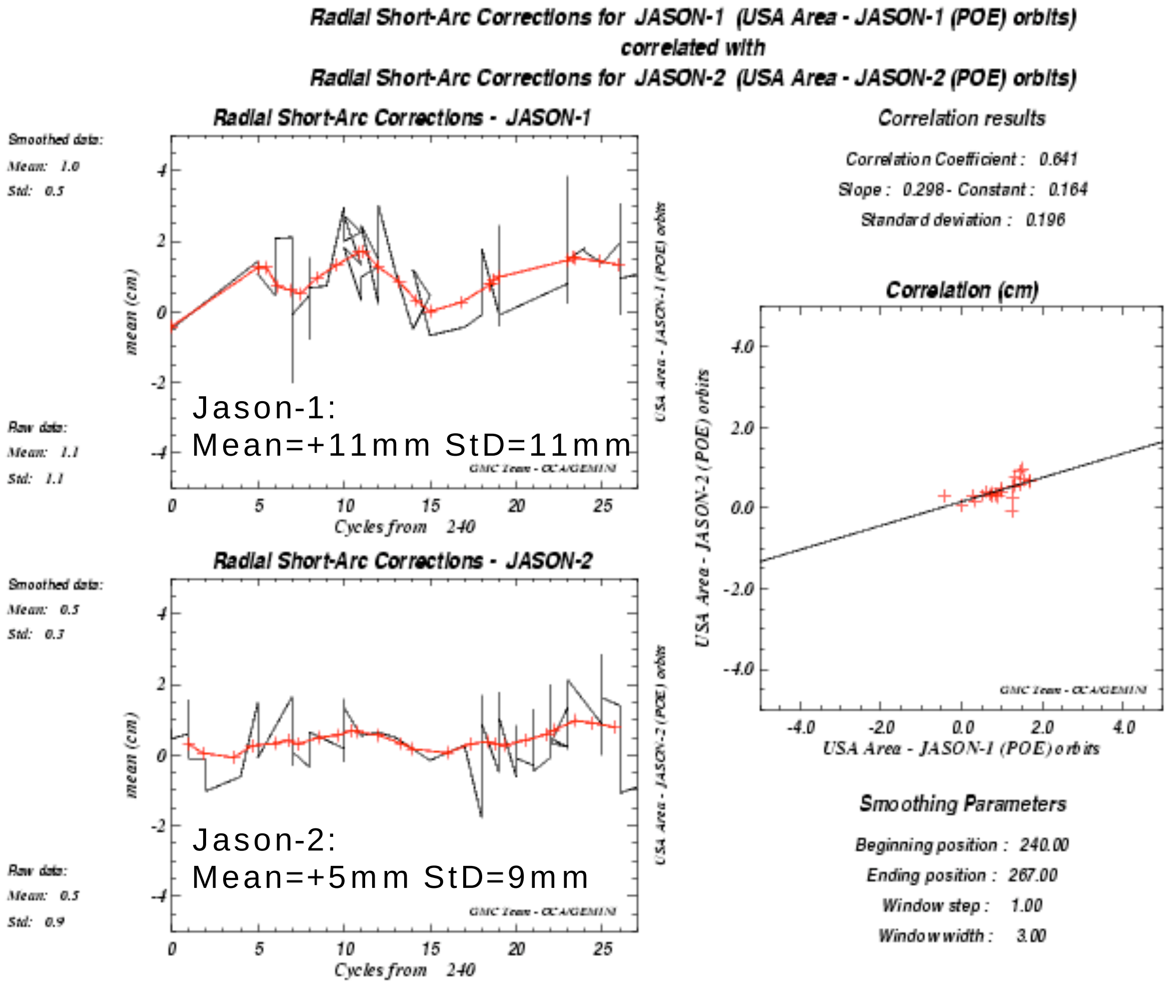
Jason-1&2 POE orbit validation by the laser-based Short-Arc Technique

Radial orbit errors estimation over Europe



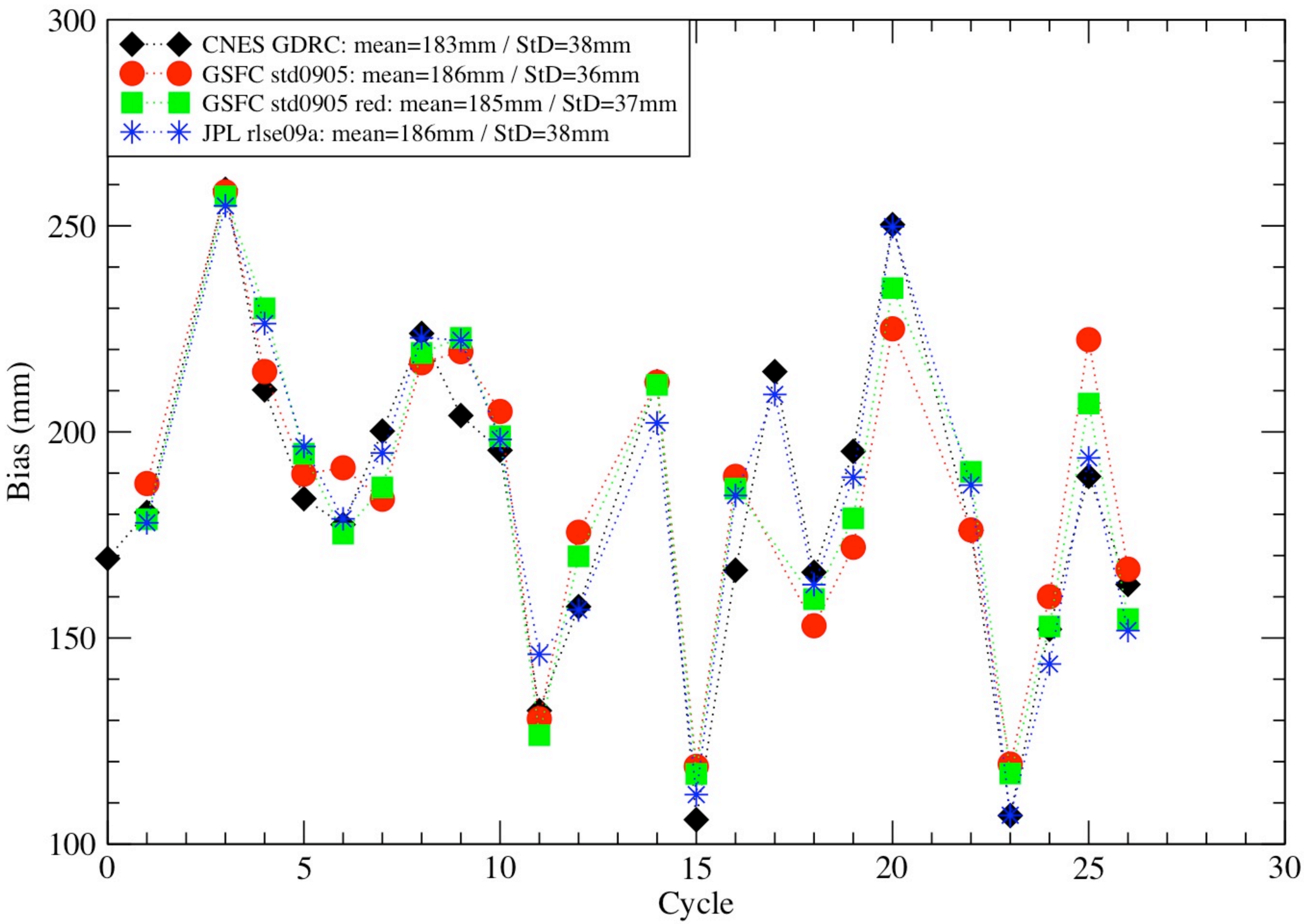
Jason-1&2 POE orbit validation by the laser-based Short-Arc Technique

Radial orbit errors estimation over USA

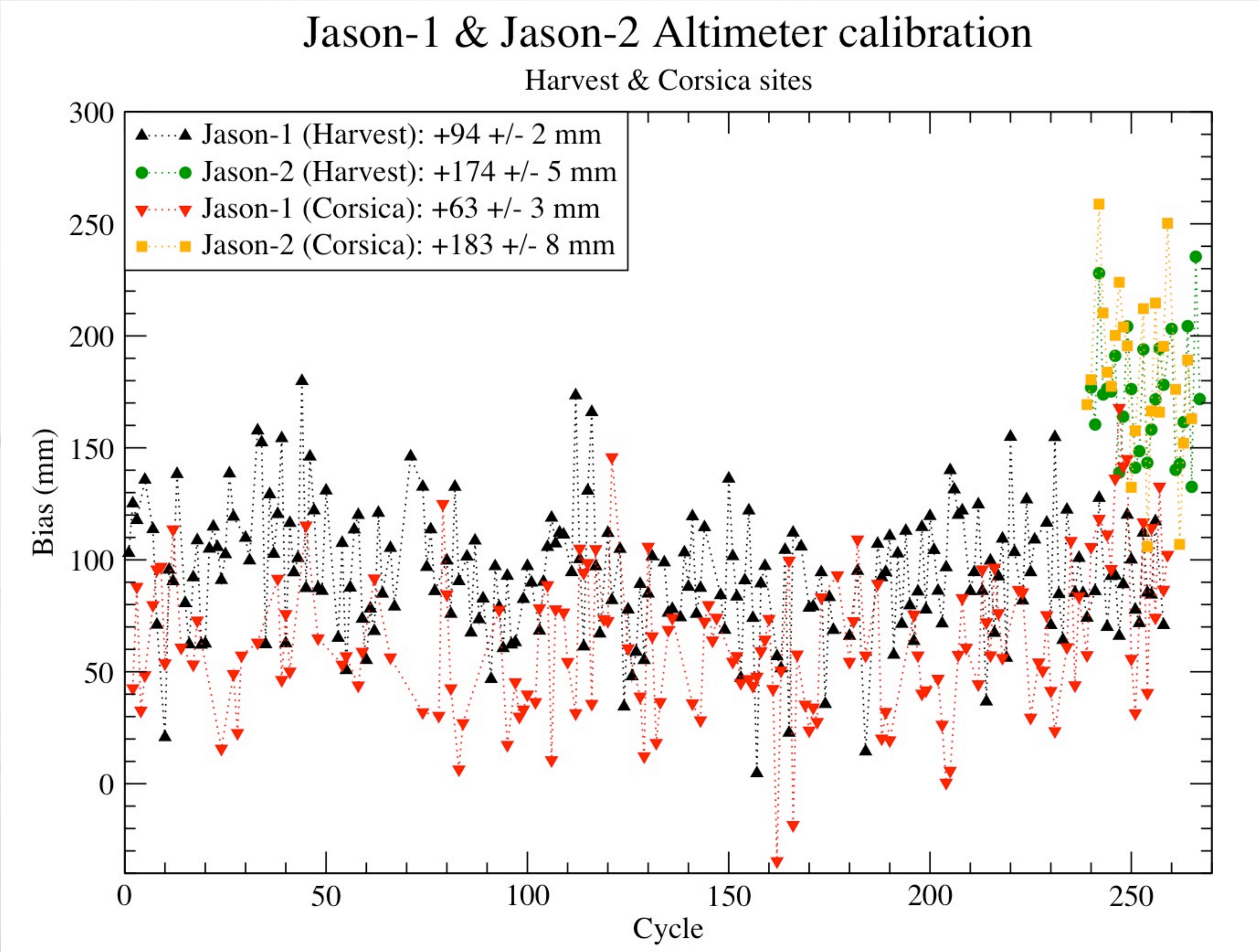


Jason-2 absolute bias from different POEs

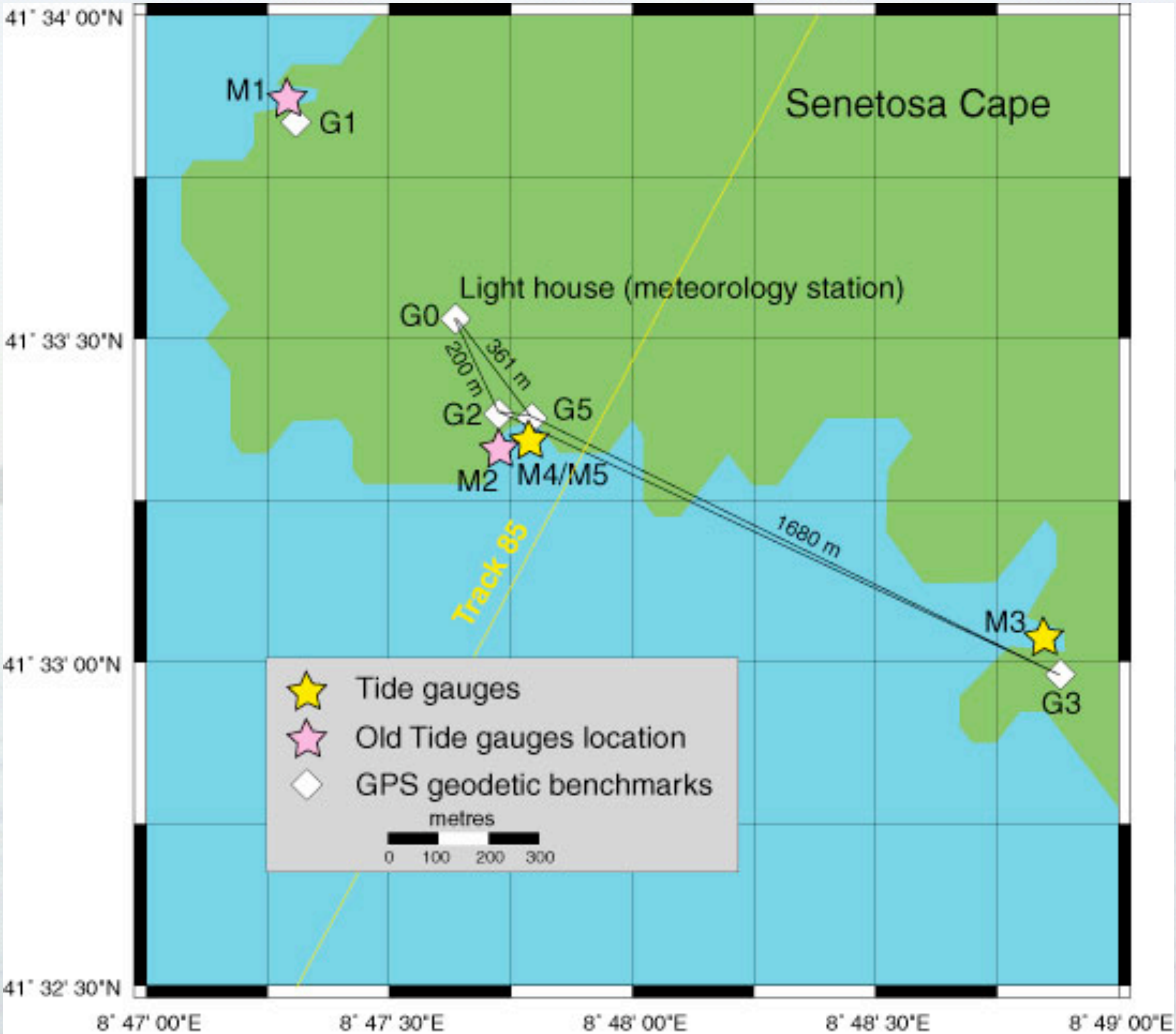
Small impact (mm) on the absolute value except for the reduced dynamic from GSFC



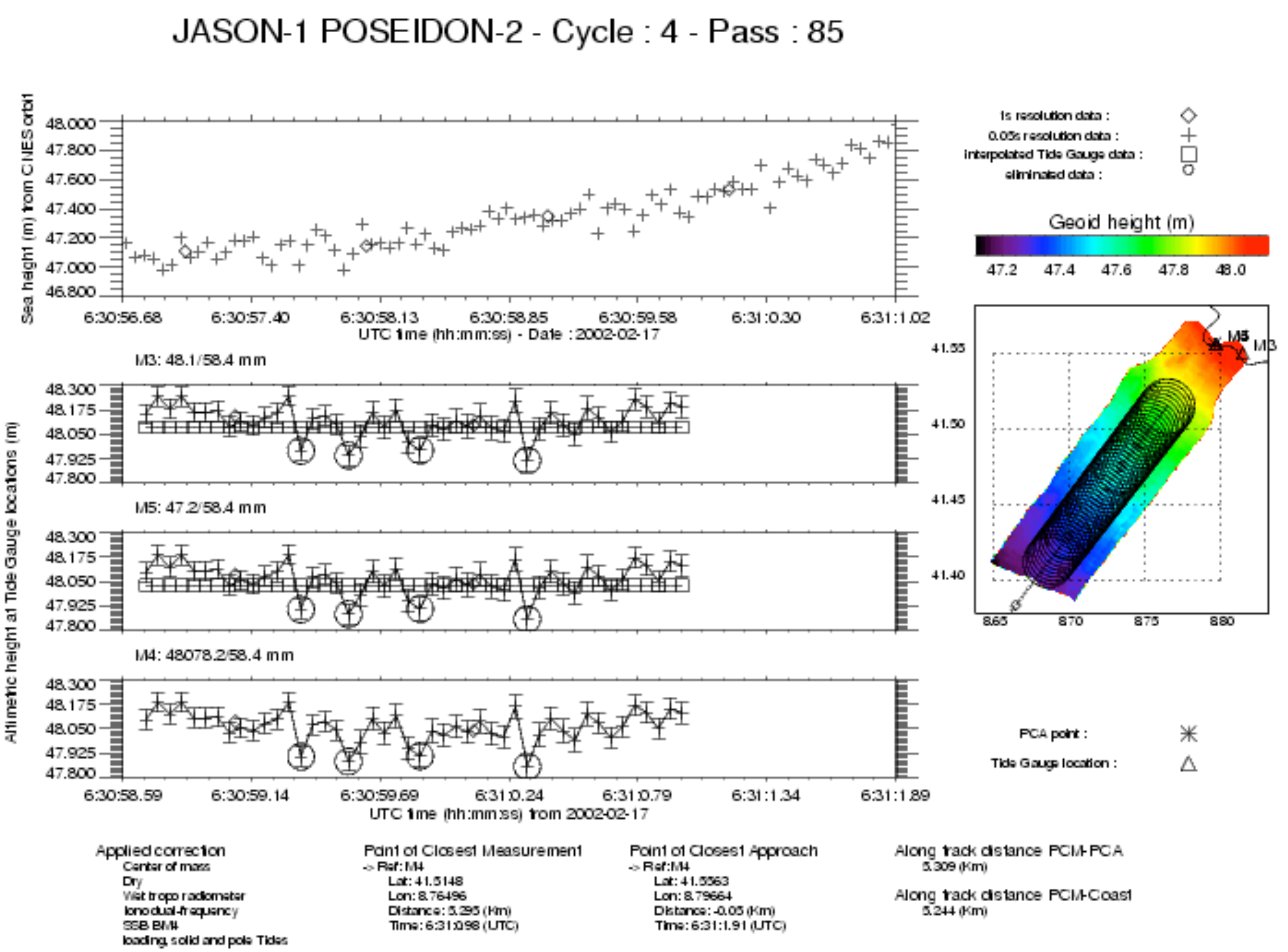
Jason-1 & Jason-2 absolute bias from Harvest and Corsica

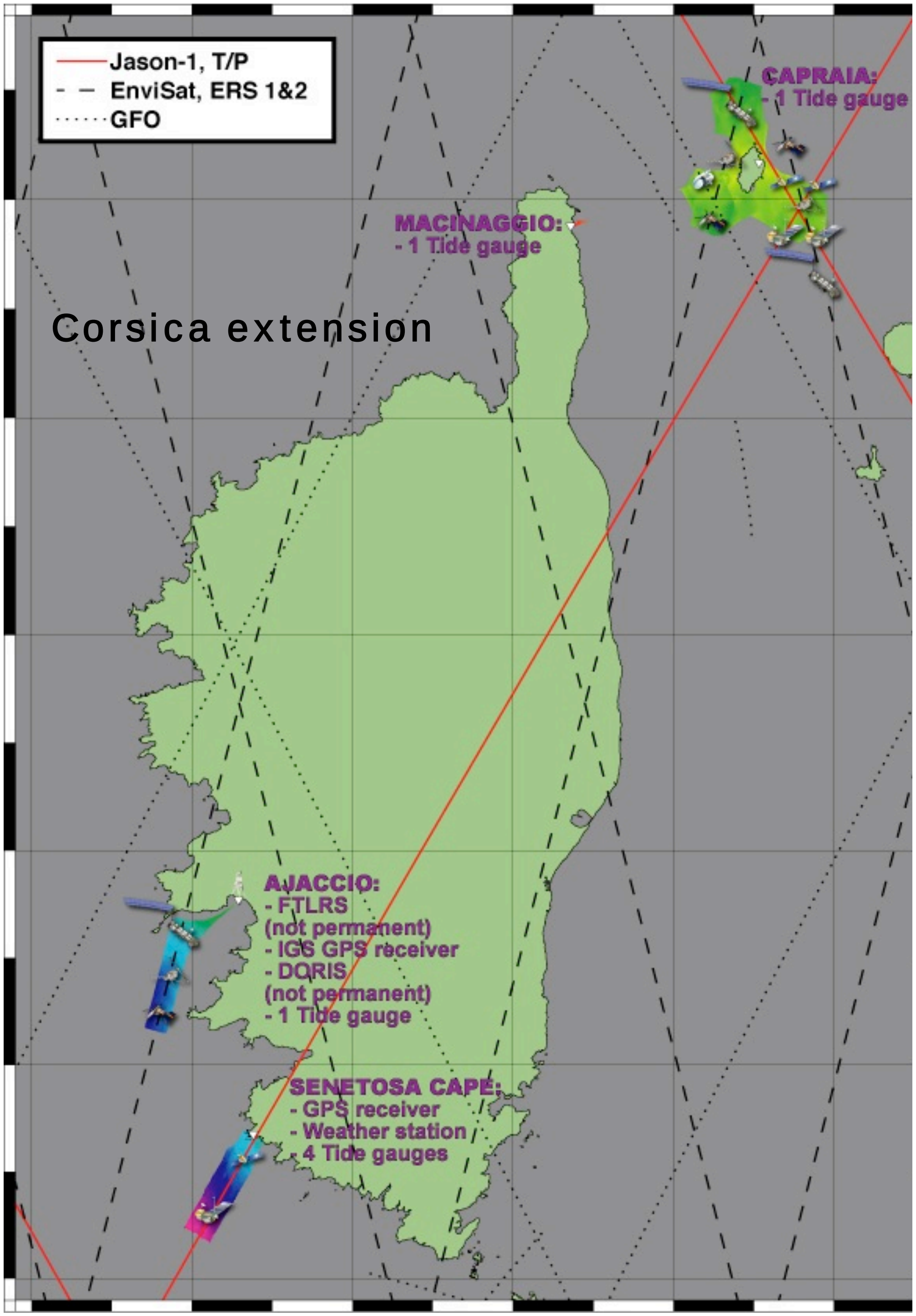


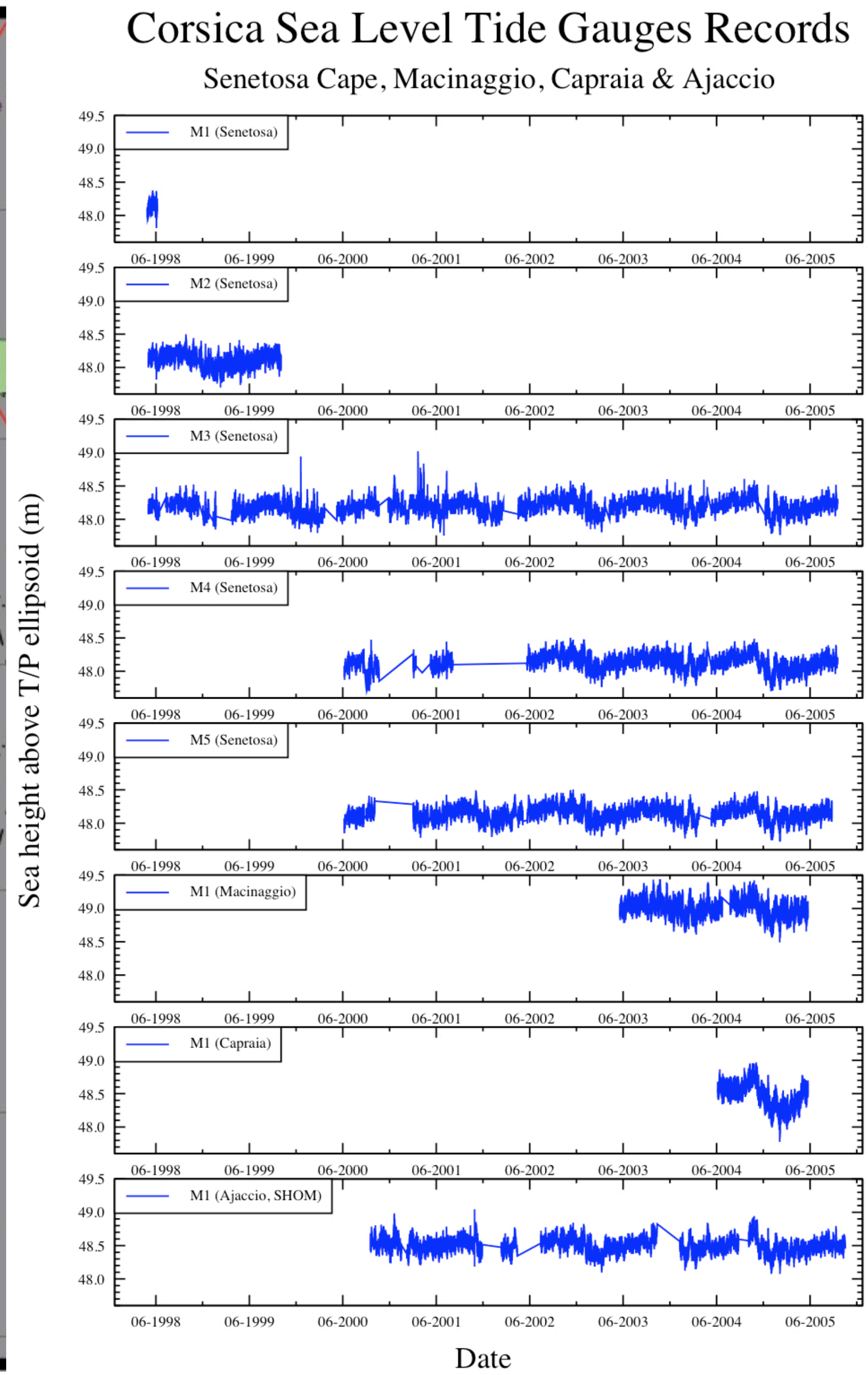
Senetosa Situation



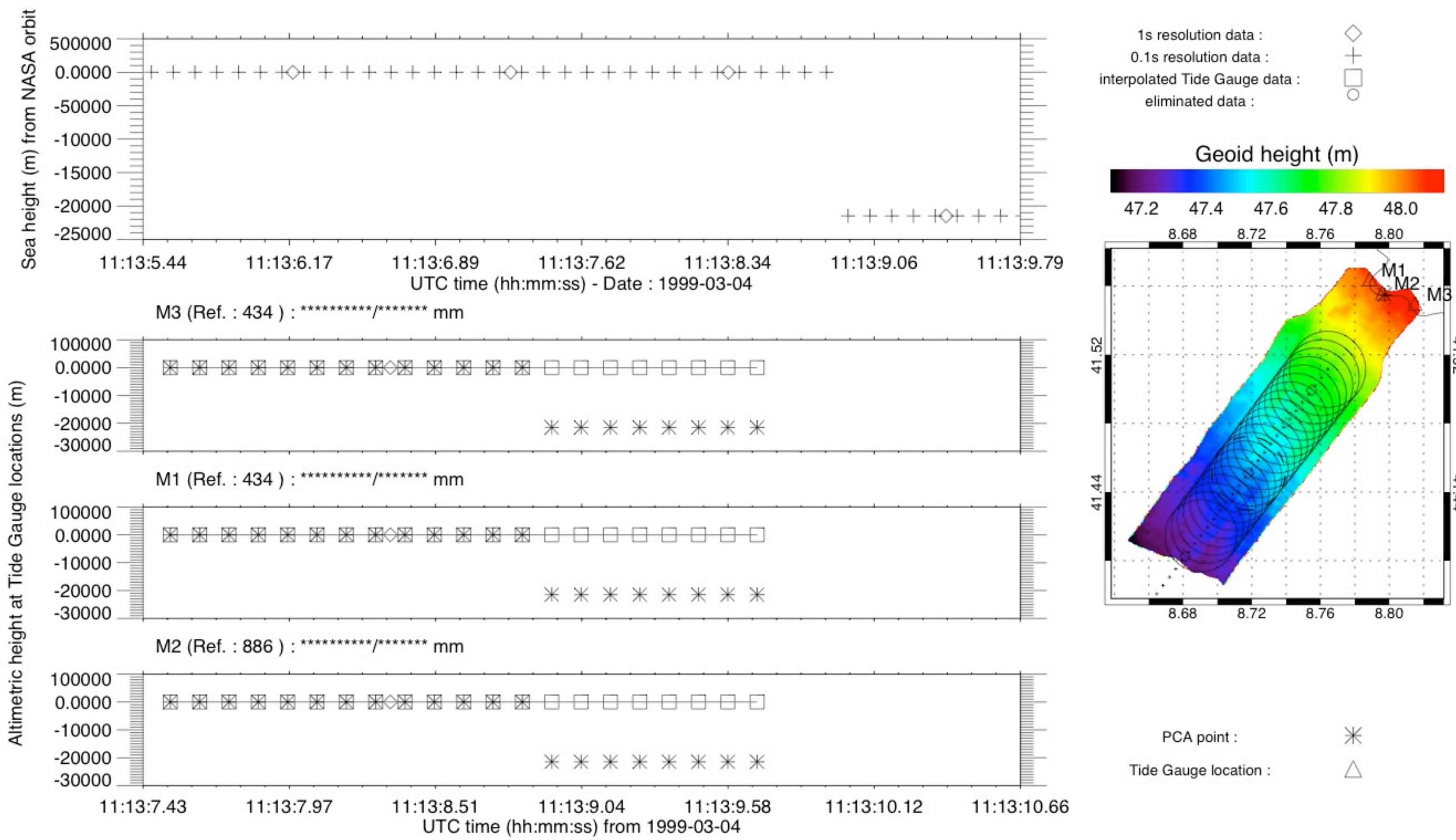
Methodology




Jason-1, T/P
EnviSat, ERS 1&2
GFO
CAPRAIA:
- 1 Tide gauge
MACINAGGIO:
- 1 Tide gauge
Corsica extension
AJACCIO:
- FTLRS
(not permanent)
- IGS GPS receiver
- DORIS
(not permanent)
- 1 Tide gauge
SENETOSA CAPE:
- GPS receiver
- Weather station
- 4 Tide gauges


Corsica Sea Level Tide Gauges Records
Senetosa Cape, Macinaggio, Capraia & Ajaccio
M1 (Senetosa)
M2 (Senetosa)
M3 (Senetosa)
M4 (Senetosa)
M5 (Senetosa)
M1 (Macinaggio)
M1 (Capraia)
M1 (Ajaccio, SHOM)
Sea height above T/P ellipsoid (m)
Date
49.5
49.0
48.5
48.0
06-1998
06-1999
06-2000
06-2001
06-2002
06-2003
06-2004
06-2005

TOPEX/Poseidon ALT-B - Cycle : 238 - Pass : 85



Applied correction
- Center of mass
- Dry
- Wet tropo radiometer
- Iono dual-frequency
- SSB MODEL
- loading, solid and pole Tides

Point of Closest Measurement
-> Ref: M2
Lat: 41.5115
Lon: 8.76414
Distance: 5.617 (Km)
Time: 11:13:9.69 (UTC)

Point of Closest Approach
-> Ref: M2
Lat: 41.5550
Lon: 8.79737
Distance: 0.158 (Km)
Time: 11:13:10.66 (UTC)

Along track distance PCM-PCA
5.570 (Km)

Along track distance PCM-Coast
5.566 (Km)

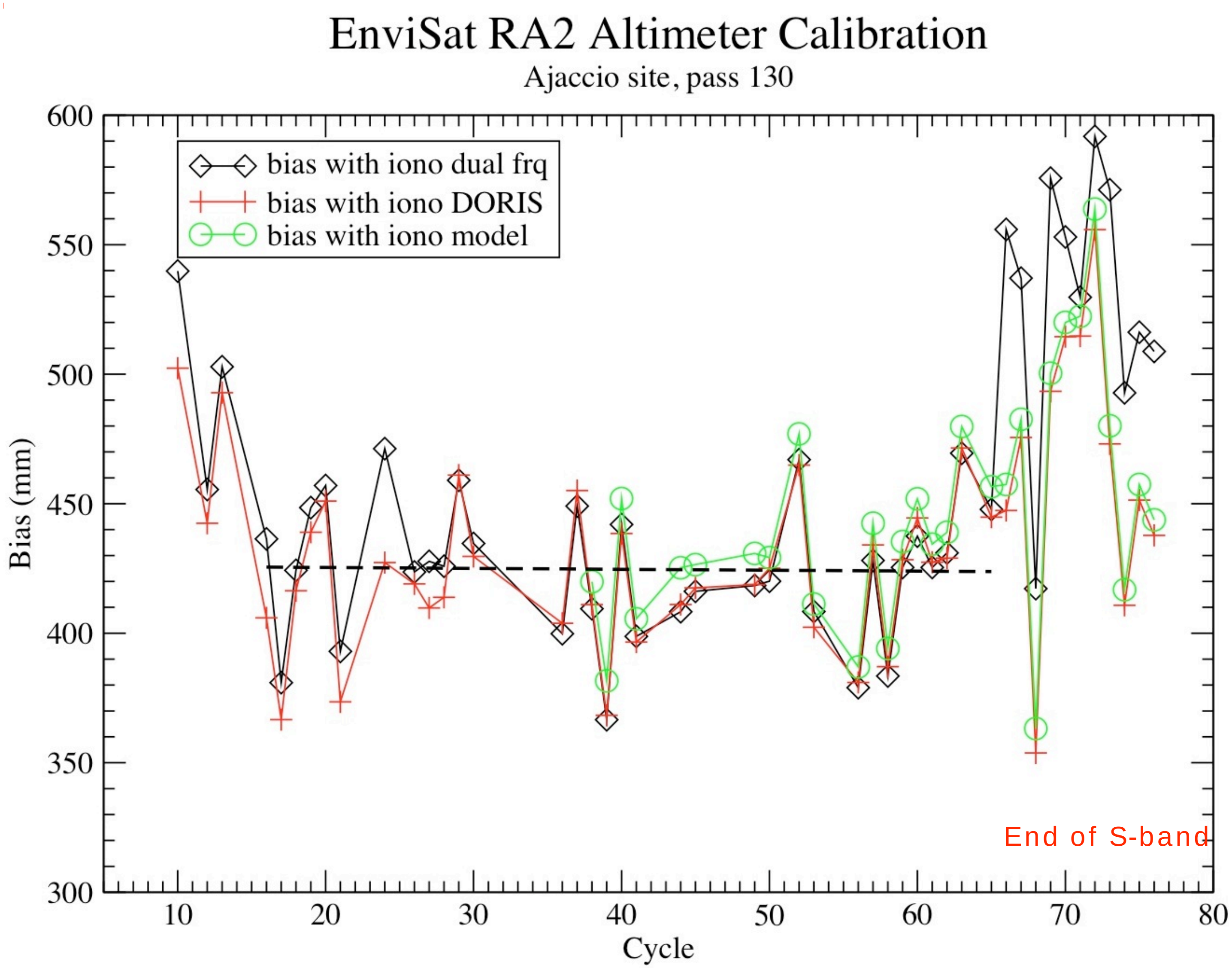


Table 1. RA2 altimeter bias at Ajaccio using different ionospheric corrections

Iono. Correction used	**Bias (mm)**	**Number of data**	**Period**
Dual frequency	425 ±5	33	cycle 16 to 65
DORIS	432 ±6	44	cycle 16 to 76
Model (GIM+IRI95)	446 ±8	38	cycle 38 to 76