Corsica: a multi-mission absolute calibration site

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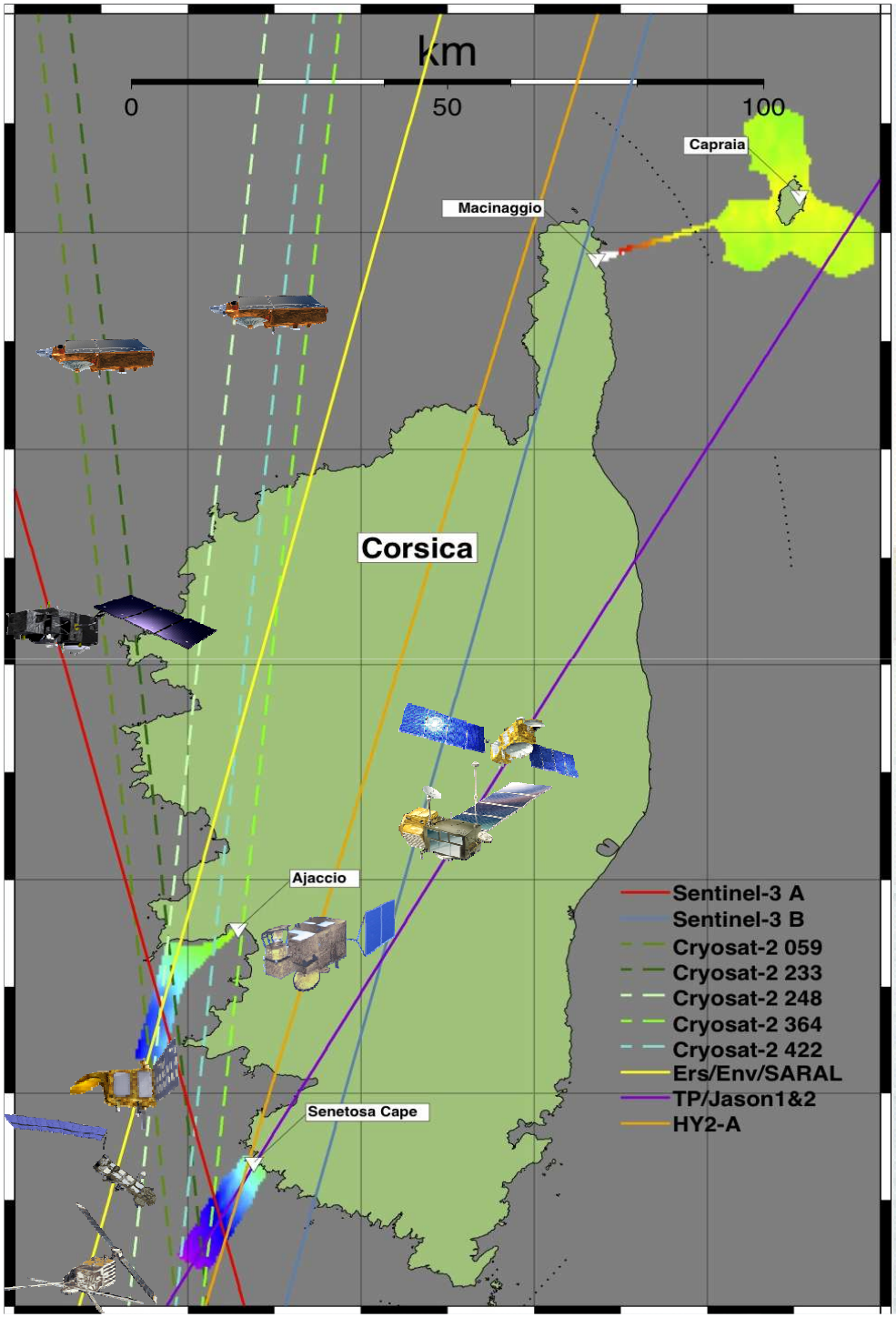


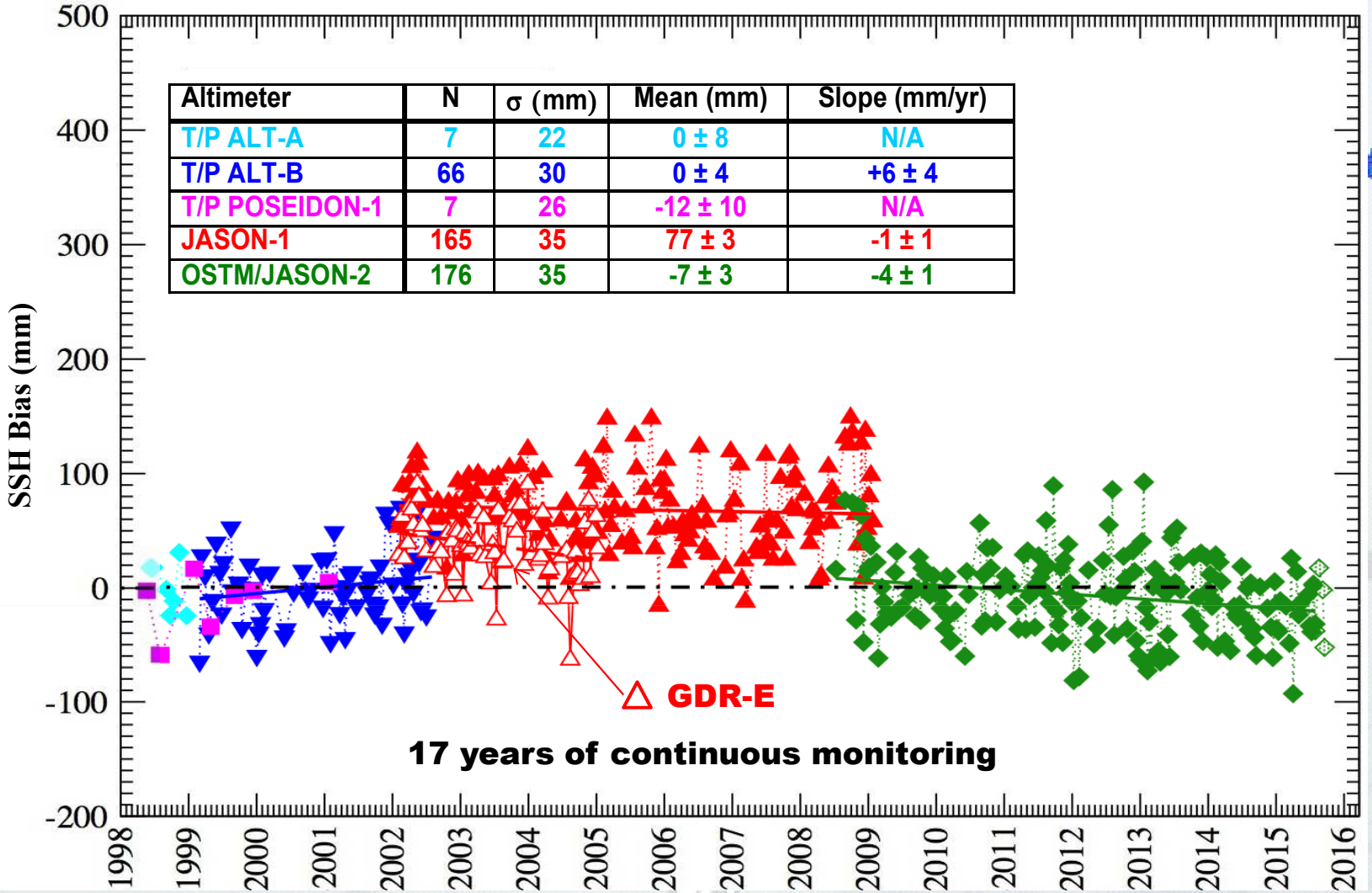
Corsica Calibration Site

Corsica Absolute Altimeters Calibration

- **Senetosa CNES calibration site established in 1998 (equipped with 4 pressure tide gauges.)**
  - **Supports continuous monitoring of Jason-2 (and formerly T/P and Jason-1)**
- **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)**
  - **Open-ocean verification location for GPS zodiac deployments.**
- **Ajaccio configuration**
  - **Supports continuous monitoring of SARAL/ALtiKa (and formerly ERS-2, Envisat)**
  - **Fiducial point near Ajaccio equipped with GPS/FTLRS/DORIS.**
  - **Ajaccio radar tide gauge (SHOM)** ***New one since 2009/09/16 (moved on 2012/04/03)***

SITE DESCRIPTION

Altimeter	N	σ (mm)	Mean (mm)	Slope (mm/yr)
T/P ALT-A	7	22	0 ± 8	N/A
T/P ALT-B	66	30	0 ± 4	+6 ± 4
T/P POSEIDON-1	7	26	-12 ± 10	N/A
JASON-1	165	35	77 ± 3	-1 ± 1
OSTM/JASON-2	176	35	-7 ± 3	-4 ± 1



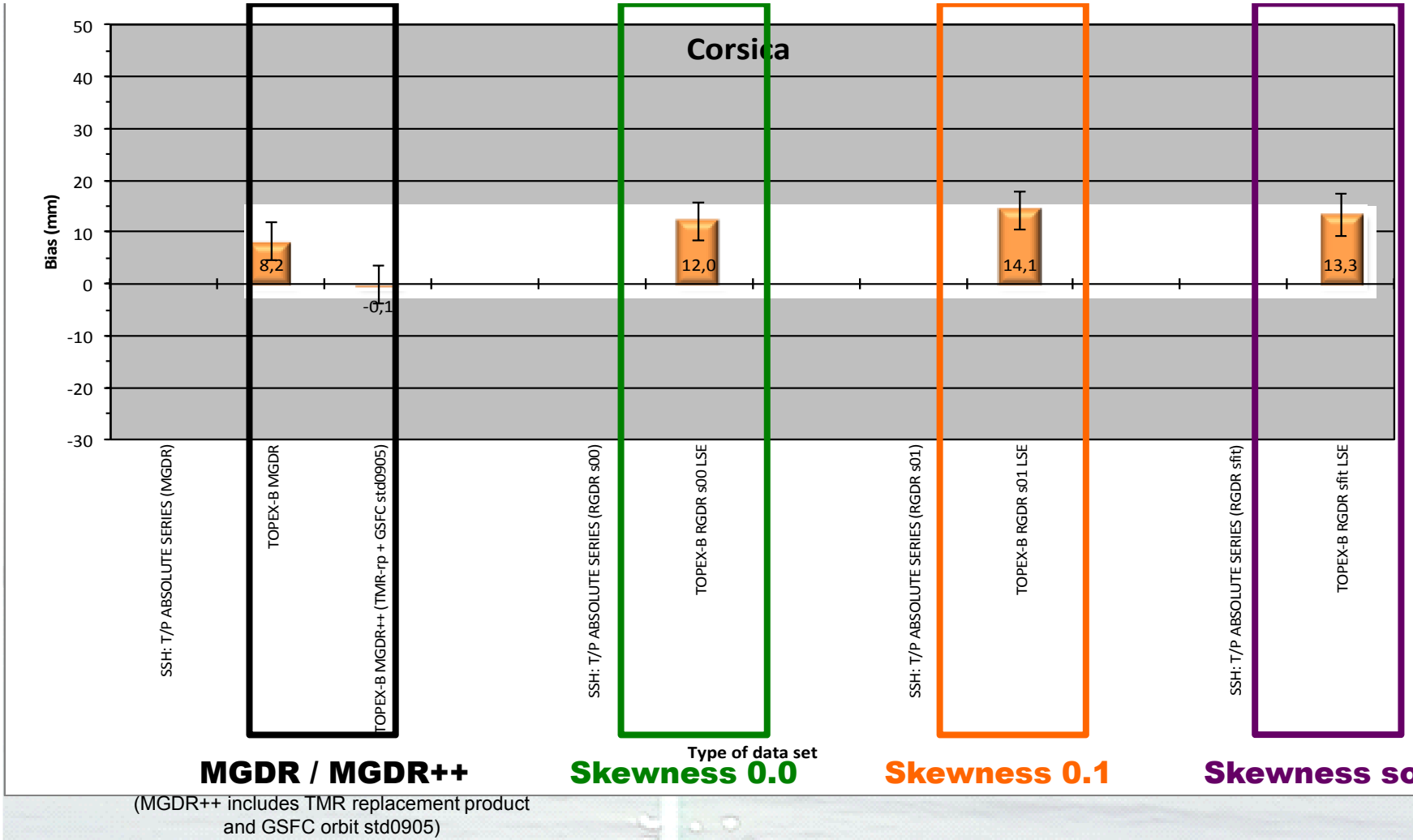
Corsica Absolute Altimeters Calibration

BIASES TIME SERIES

Jason-2 time series now longer than Jason-1 ones, time to launch Jason-3…

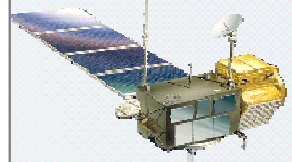
Products used:

T/P: MGDR + TMR replacement products + std0905 orbits (GSFC)
Jason-1: GDR-C (cycle 1-259) / GDR-E (cycle 1-110)
Jason-2: GDR-D (cycle 1-260) MLE4 = -7 ±3 mm
Jason-2: GDR-D (cycle 1-260) MLE3 = +17 ±3 mm => ≠ by 24 mm (mainly SSB)



(MGDR++ includes TMR replacement product and GSFC orbit std0905)

Corsica Absolute Altimeters Calibration



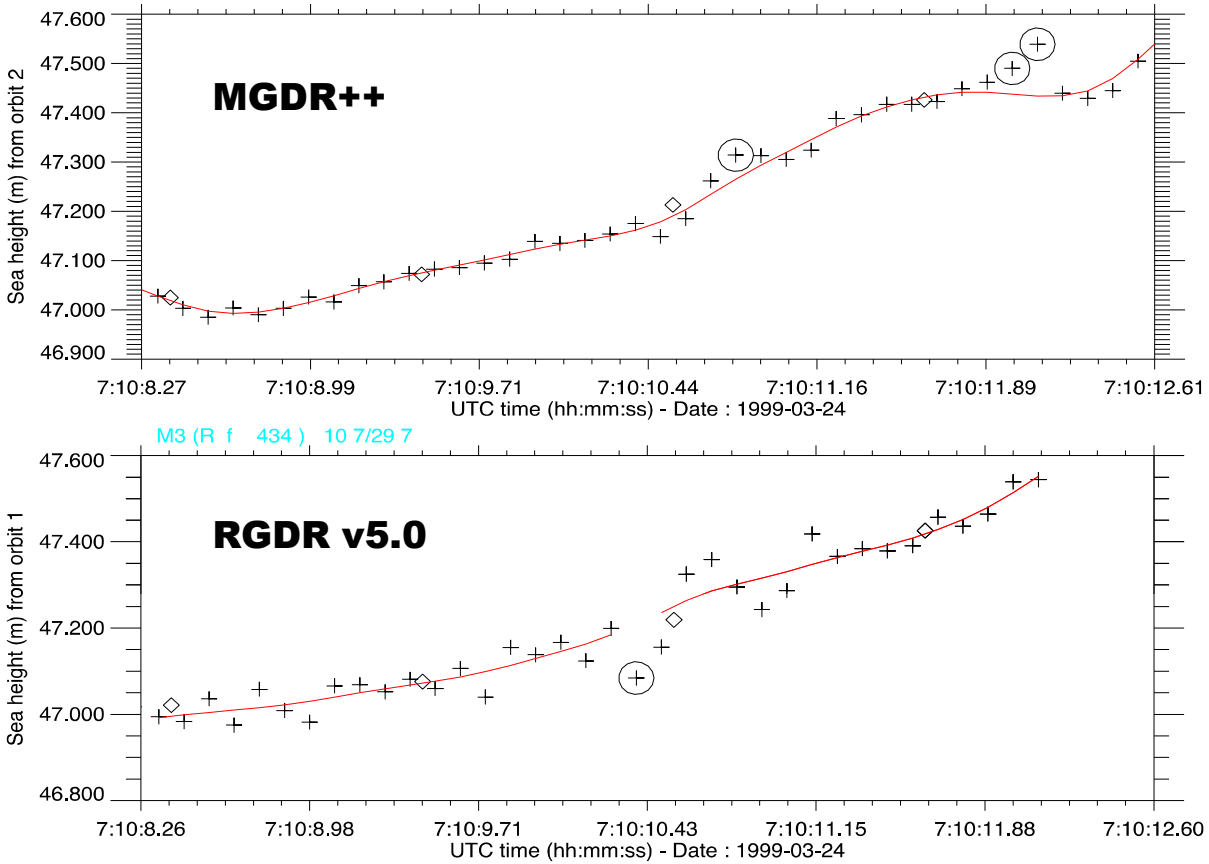
T/P REPROSECING V5.0

The **mean ALT-B* SSH bias increases by 12-14 mm** but it is due to the fact that the 15 mm bias applied in MGDR products was not applied in this **RGDR (V5.0) data set**.

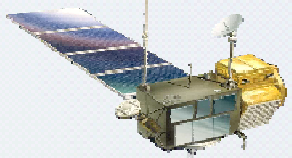
Concerning the **drift**, it **is increased by about 2 mm/yr whatever the skewness parameter** but is already over and badly estimated for ALT-B from Corsica using MGDR++ (5.6 ±3.5 mm/yr) due to the small length of the record. **Increase of the SSH bias drift means that the GMSL rise will be overestimated.**

***Results on ALT-B period (too short time series for ALT-A in Corsica)**

TOPEX/Poseidon ALT-B - Cycle : 240 - Pass : 85



Corsica Absolute Altimeters Calibration

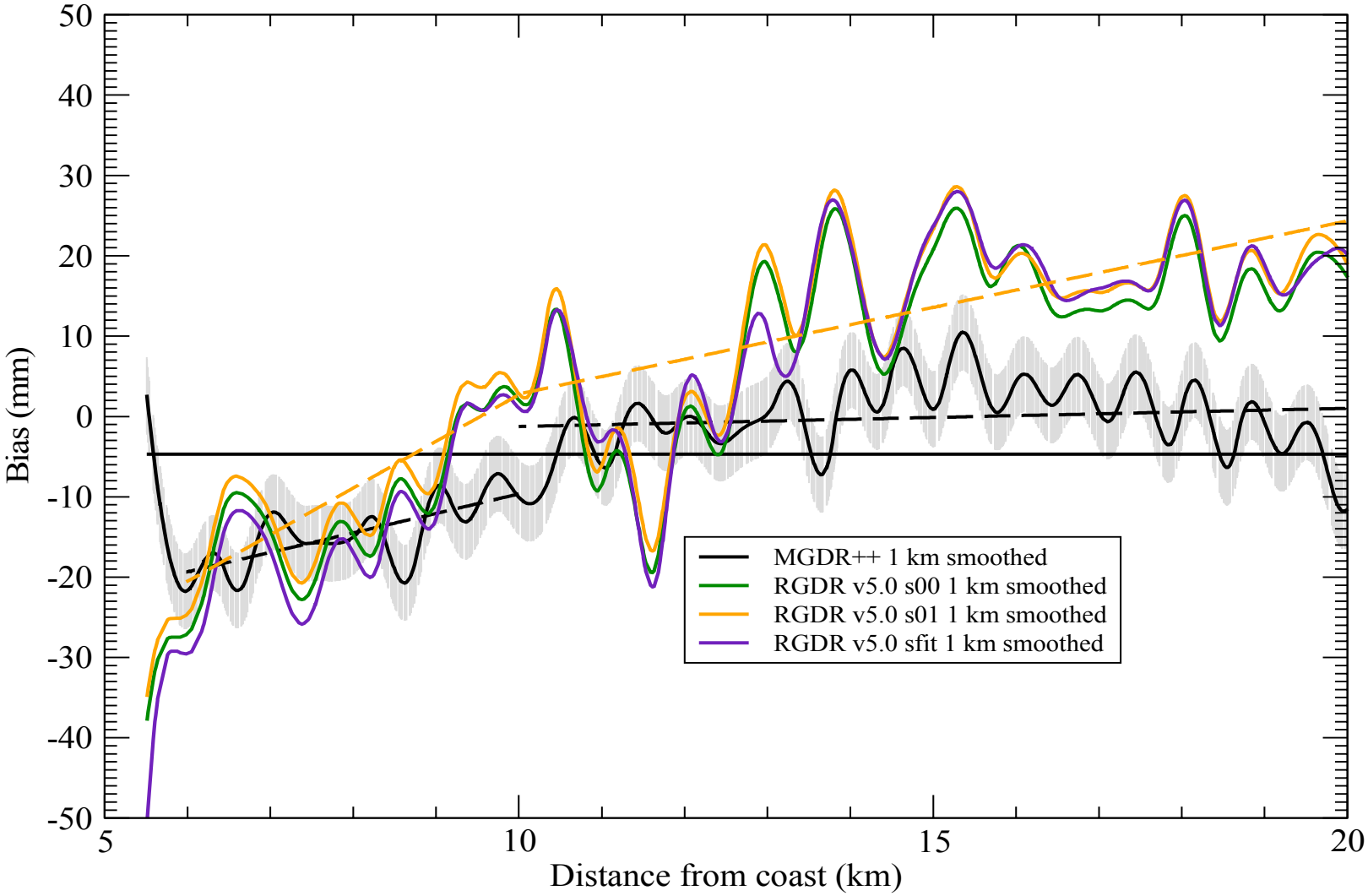


T/P REPROCESSING V5.0

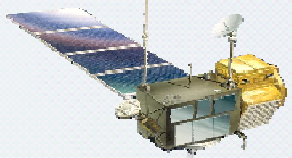
On average for all the studied cycles (237-365) the **standard deviation of 10Hz data is 44 mm** whatever the skewness **compared to 35 mm for MGDR++**

T/P Altimeter Calibration

ALT-B (MGDR++ & RGDR v5.0): cycle 235 to 365

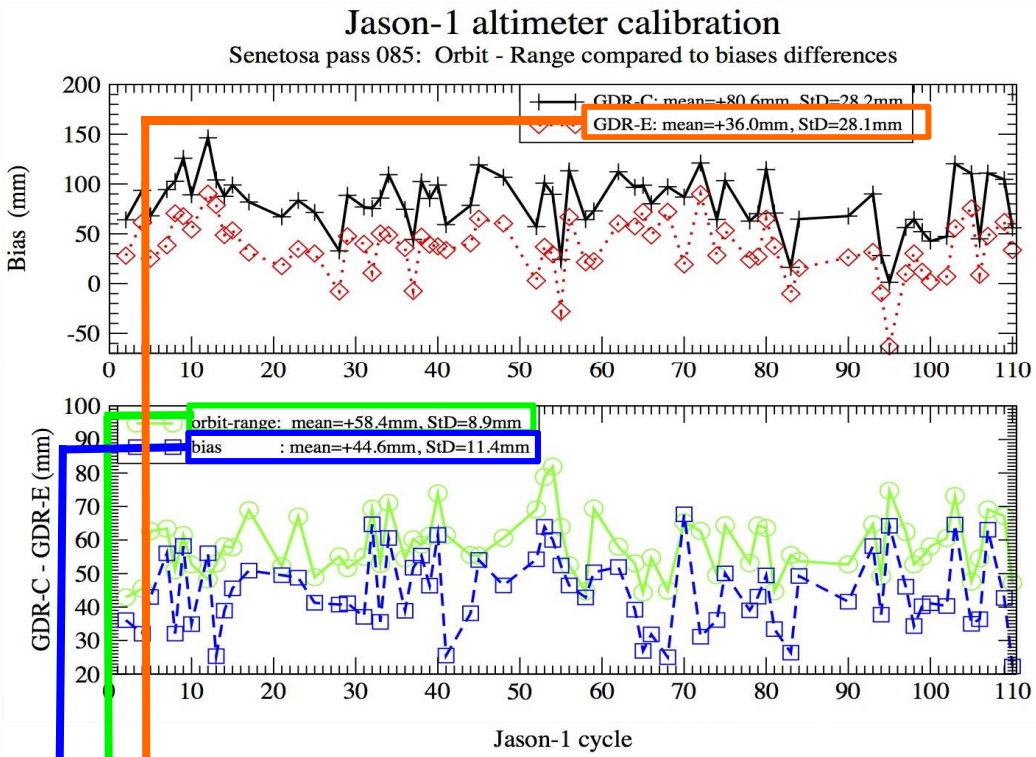


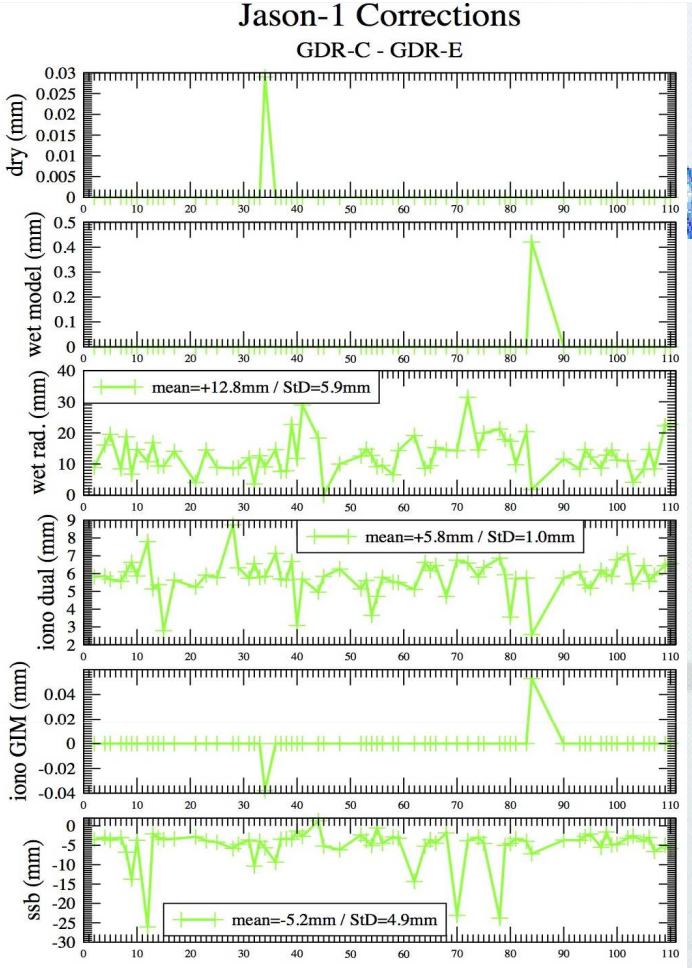
Corsica Absolute Altimeters Calibration

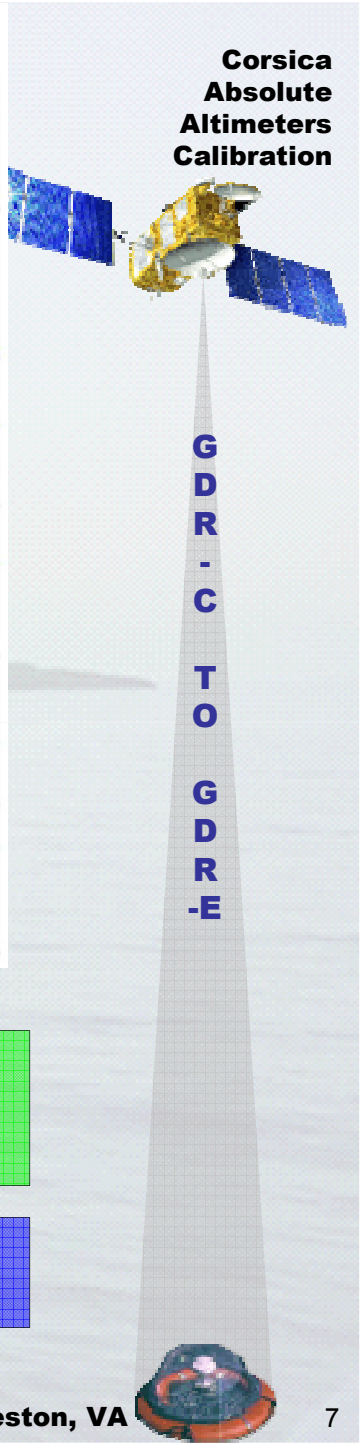


T/P REPROSECING V5.0

The SSH drop observed from 10 km offshore is increased in comparison to MGDR++ (5.8 mm/km for RGDR compared to 2.4 mm/km for MGDR++) and is closer to what was found for Jason (~8 mm/km). This indicates a higher coastal contamination that prevents to use T/P data at less than 10 km from the coast. **Moreover the number of valid 10 Hz data also decreases when approaching the coast with RGDR V5.0.**







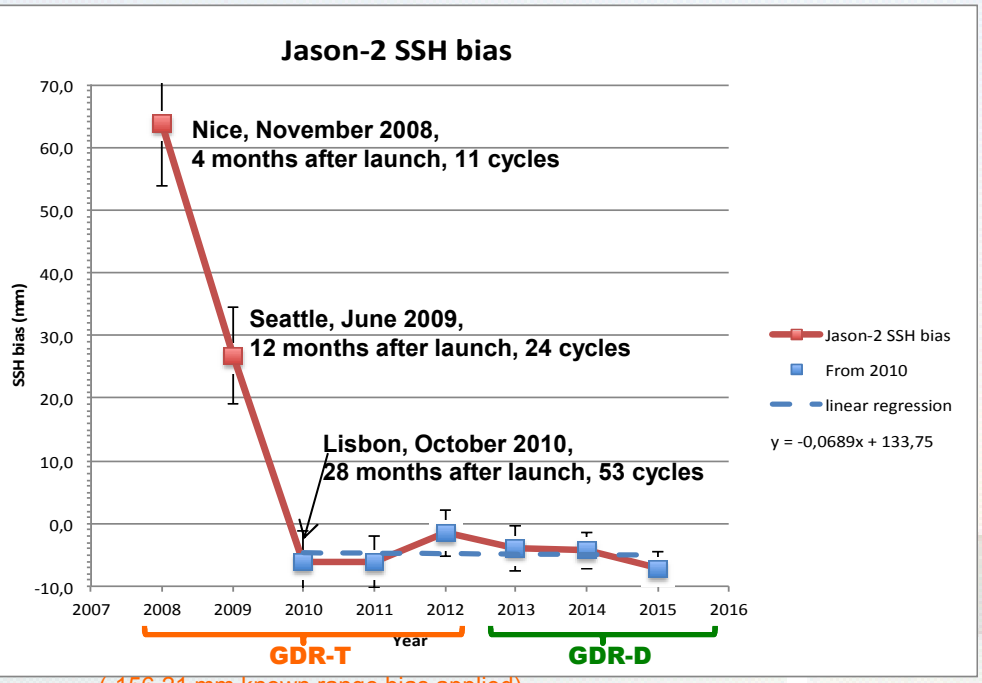
SSH bias decreases by ~45 mm.
Standard deviations very close

Close to the applied range correction and datation bias (~60mm @ Corsica), so radial orbit differences between GDR-C and GDR-E are less than 2 mm in average with a standard deviation of 9 mm

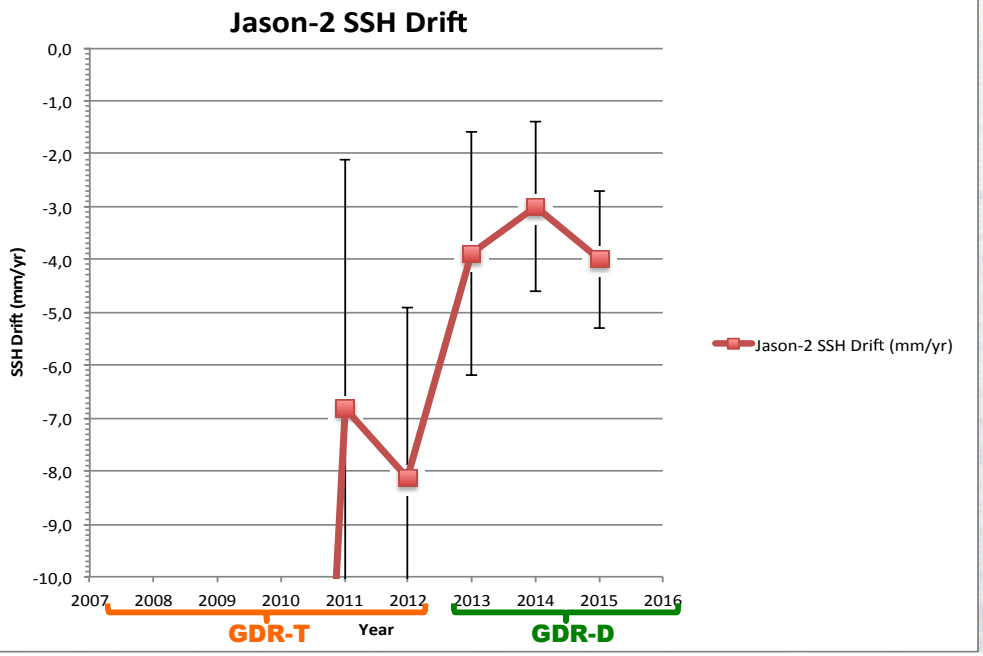
Except the range bias, differences between GDR-C and GDR-E SSH bias are due to SSB (-5.2 mm), iono (+5.8 mm) and wet tropo (+12.8 mm)

In GDR-E, Jason-1 SSH remains significantly biased by ~36mm

History of the Jason-2 SSH bias from Corsica



(-156,21 mm known range bias applied)



Corsica Absolute Altimeters Calibration

SSH bias

-SSH bias took **~2 years to stabilize**, mainly affected by unexplained high values of the SSH bias for the early cycles (probably erroneous tide gauges data)

-**After these 2 years**, **very stable (standard deviation of 2 mm)** and no significant drift of the averaged values given at each OSTST meeting (<0.1 mm/yr)

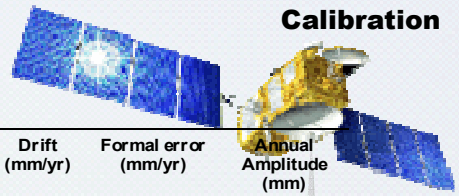
SSH bias drift

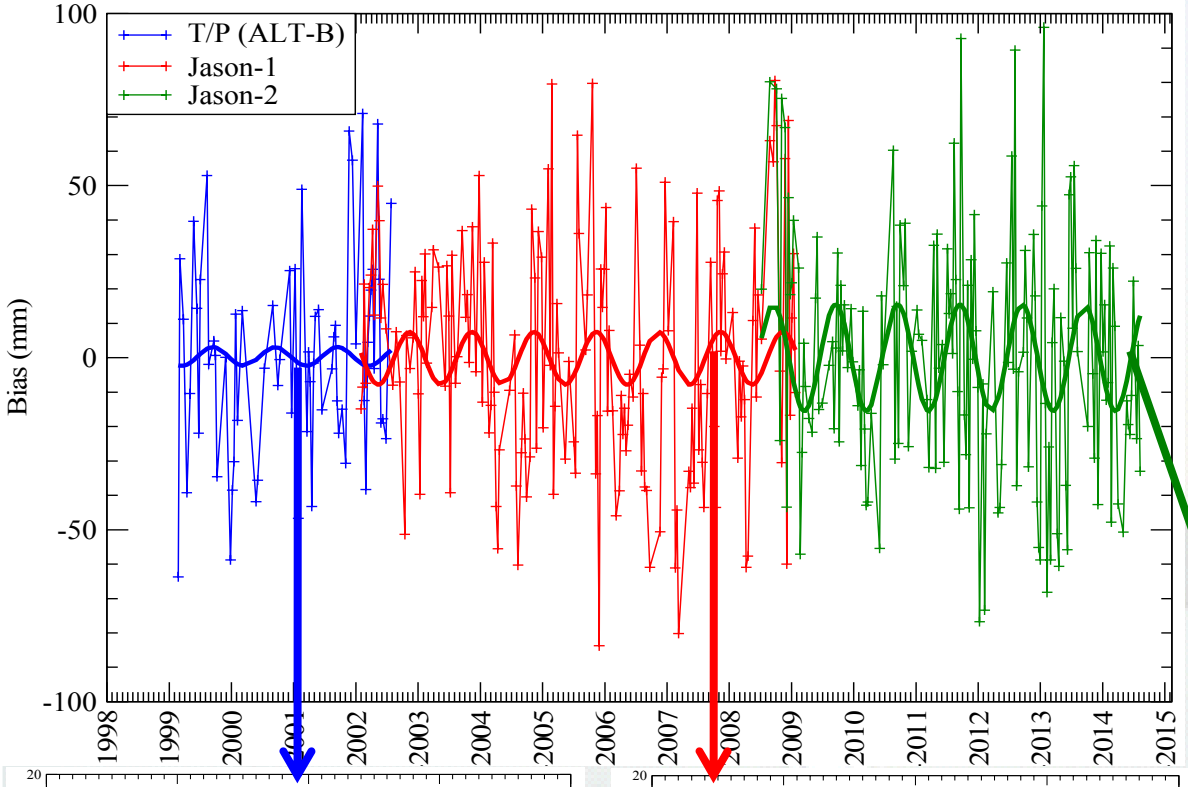
- SSH bias drift took **~5 years to stabilize**
- The **yearly drift estimation remains unstable at the 1 mm/yr level**, impact of seasonal signals?

STABILITY OF THE BIAS

Recall of last year study

Corsica Absolute Altimeters Calibration





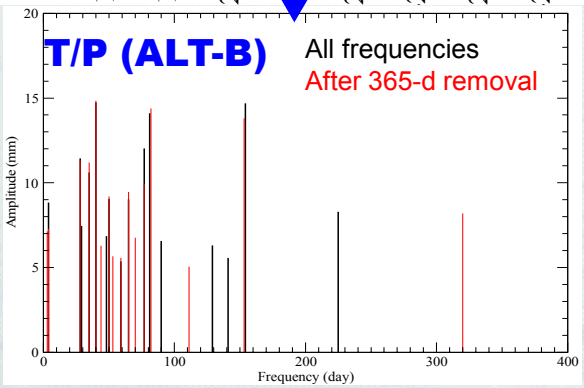
Drift with/without annual cycle removal

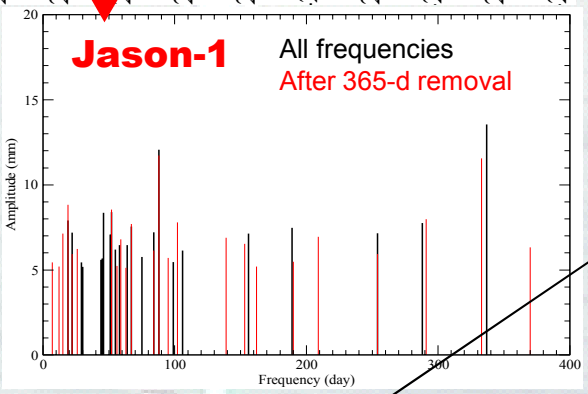
Altimeter	Drift (mm/yr)	Formal error (mm/yr)	Drift (mm/yr)	Formal error (mm/yr)	Annual Amplitude (mm)
	Without annual cycle removal		With annual cycle removal		
T/P - ALT-B	5.6	3.5	5.7	3.5	2.7
Jason-1 - Poseidon-2	-1.0	1.3	-1.3	1.3	7.7
Jason-2 - Poseidon-3	-3.0	1.6	-2.6	1.6	15.4

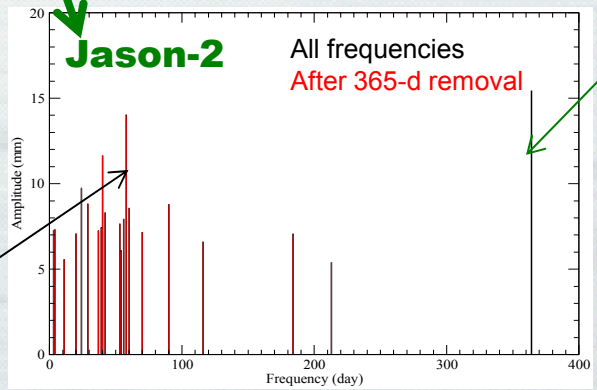
Removing the annual signals changes the drift by 0.3-0.4mm/yr for Jason-1&2 and leads to less discrepancy between both satellites

The annual signal in Jason-2 bias time series is reduced from 17mm to 15mm since last year analysis but still there. This needs to be further investigated: Corrections? => Nothing seen from neither wet or iono corrections (using differences with model)

FREQUENCY ANALYSIS



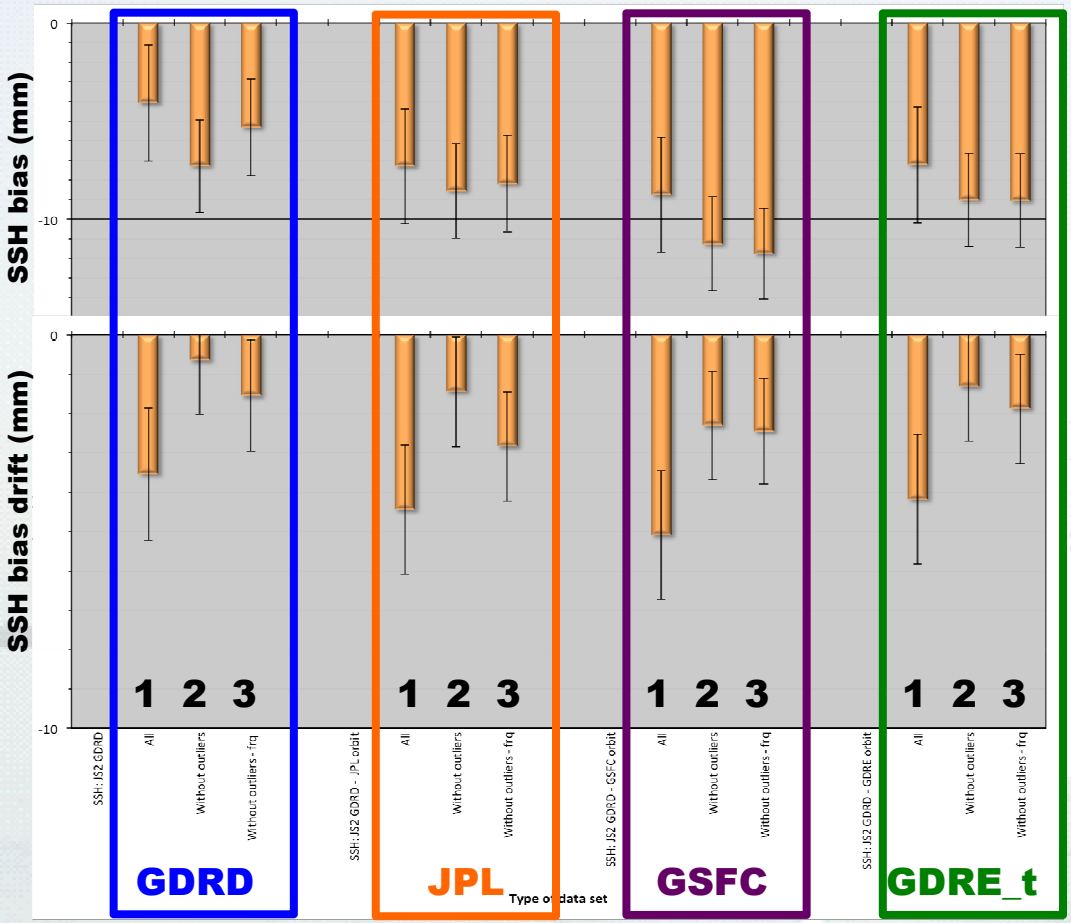




No clear 59-d neither annual signal (365-d) for neither T/P nor Jason-1

The 59-d frequency remains even after removing the annual signal (365-d)

Jason-2 analysis



Orbit used:
- **GDRD: directly from GDR-D products**
- **JPL: rlse14a**
- **GSFC: std1404**
- **GDRE_t: CNES preliminary GDR-E orbit**

Corsica Absolute Altimeters Calibration

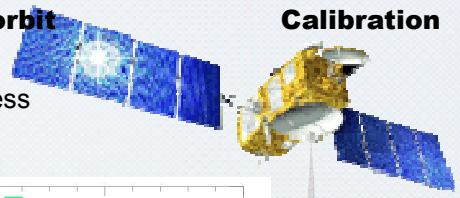
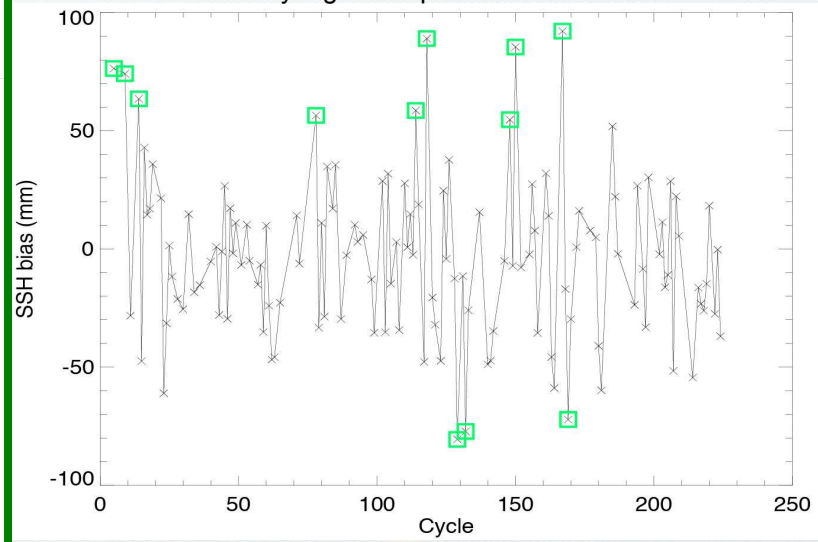


Illustration of the outliers detection process (based on iterative robust mean): outliers marked by a green square

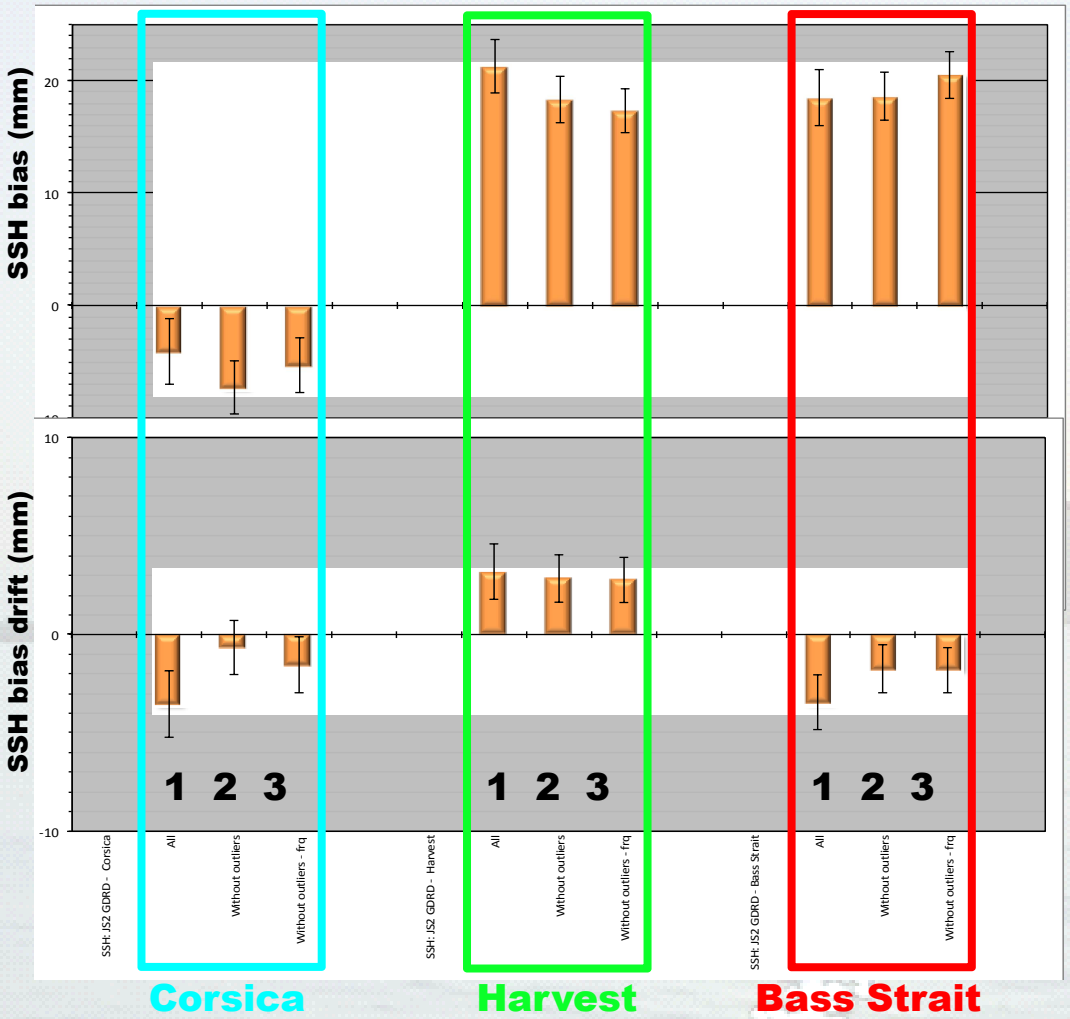


FREQUENCY ANALYSIS

1- whole data set
2- with outliers removal
3- with outliers removal and seasonal signals removal

- **very small impact of the outliers on the mean value of the SSH bias** (few millimeters) but **strong improvement of the standard deviation** (reduced by ~10 mm)
- the **impact of outliers (~15%) is about 3 mm/yr on the SSH bias drift**
- the **impact of periodic signal removal** (mainly the annual) can be at the **1 mm/yr level**
- The **new generation of orbits gives very close results** (JPL, GSFC and GDRE)

Jason-2 analysis



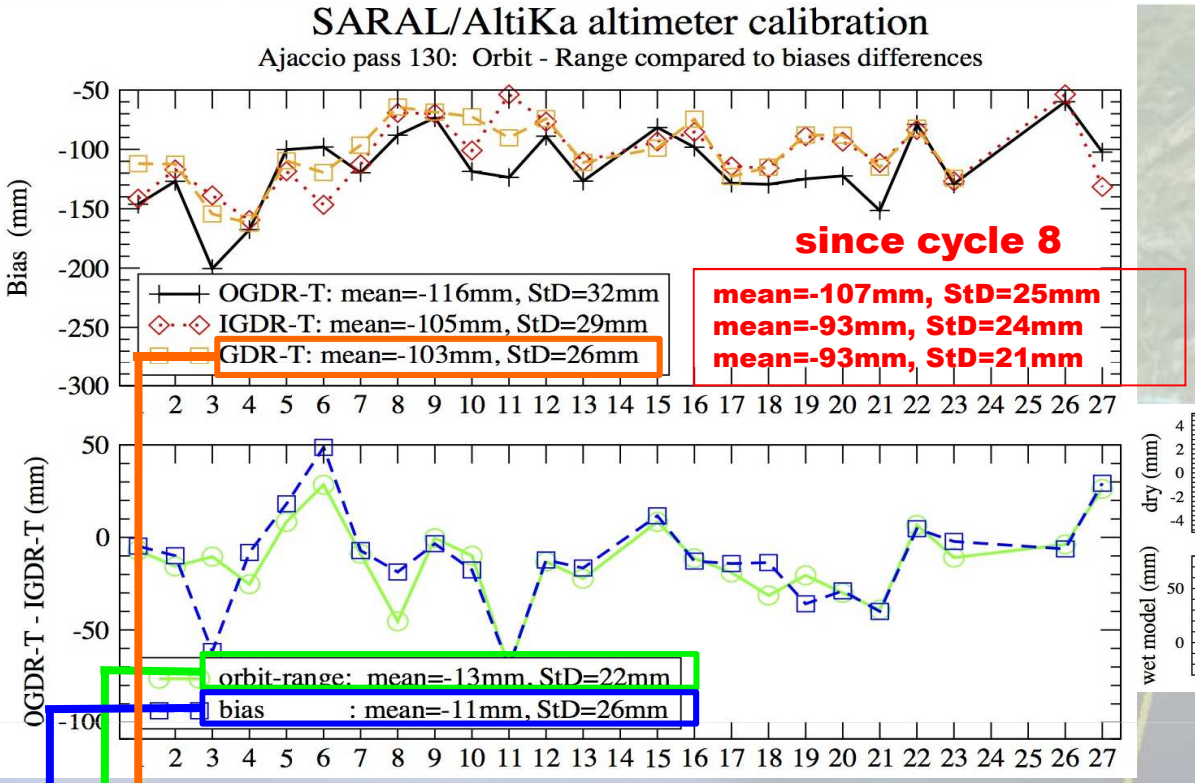
1- whole data set
2- with outliers removal
3- with outliers removal and seasonal signals removal

Same exercise using GDRD orbits over:
- **Corsica**
- **Harvest**
- **Bass Strait**

Corsica Absolute Altimeters Calibration

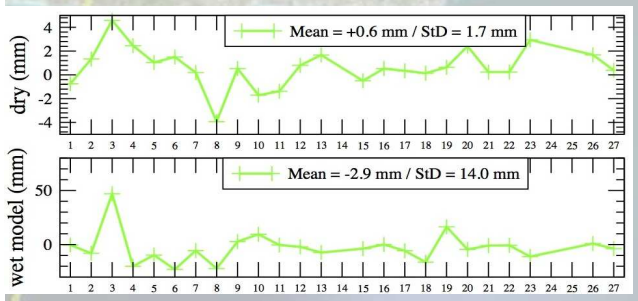
FREQUENCY ANALYSIS

- **very small impact of the outliers on the mean value of the SSH bias** (few millimeters) but **strong improvement of the standard deviation** (reduced by ~10 mm)
- **Significant impact of outliers on the SSH bias drift over Corsica and Bass Strait but not over Harvest**



I/OGDR-T: in patch P2 since cycle 11
GDR-T: whole set in patch P2

Corrections used:
- GIM for ionosphere
- Wet troposphere model
- Product SSB



The continuous time series of the tide gauge is very useful to study the stability of the SSH bias as well as to cross-compare the different products

Standard deviation (26 mm) far better than typical Jason-2 one (~35 mm)

Mean radial orbit differences between DIODE and MOE (-13 mm): comparable to orbit errors analyzed over Europe using short-arc orbit technique (-18 mm)

Differences between OGDR-T and IGDR-T SSH bias are due to dry and wet tropo and linked to differences between predicted and computed ECMWF model

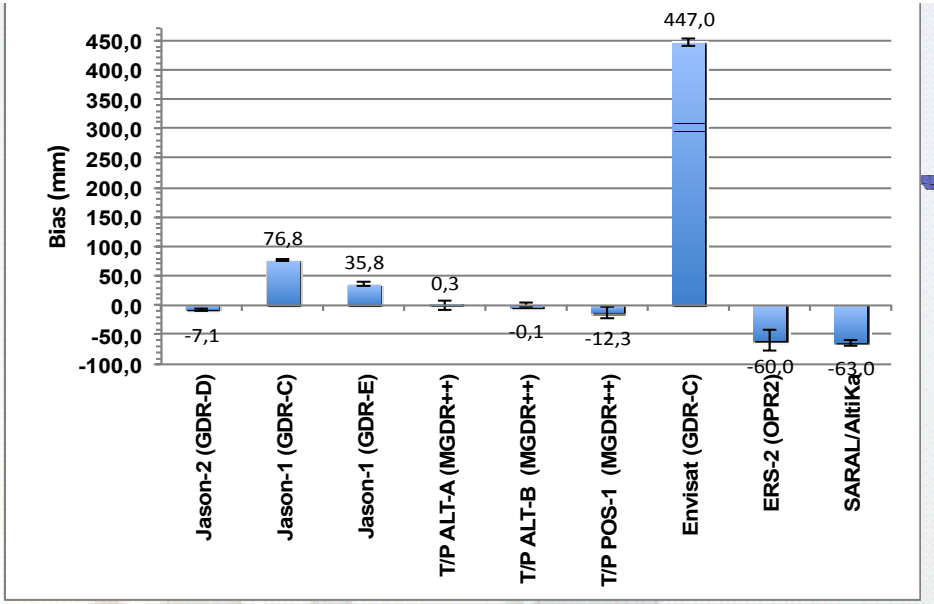
A SSH bias difference of only 2 mm between IGDR-T and GDR-T

OGDRT / IGDRT / GDRT

Calibration from Corsica

Absolute biases over the whole data sets:

Jason-2: -7 ±3 mm (GDR-D)
Jason-1: +77 ±3 mm (GDR-C)
Jason-1: +36 ±3 mm (GDR-E)
T/P ALT-A: 0 ±8 mm (MGDR^{++})
T/P ALT-B: 0 ±4 mm (MGDR^{++})
T/P POS-1: -12 ±10 mm (MGDR^{++})
Envisat: +447 ±7 mm (GDR-C)
ERS-2: -60 ±18 mm (OPR-2)
SARAL: -63 ±5 mm (IGDR-T)*



Corsica Absolute Altimeters Calibration

CONCLUSION

Range:

•**Very stable Jason-2 SSH bias** from year to year
•Jason-1 GDR-E range correction improved the consistency of the T/P-Jason legacy but **Jason-1 SSH (GDR-E) remains significantly biased** (~4cm). SSB maybe needs to be revisited?
•**T/P reprocessing is very encouraging** but needs to be fully validated.

Wet tropospheric corrections:

Jason-1&2

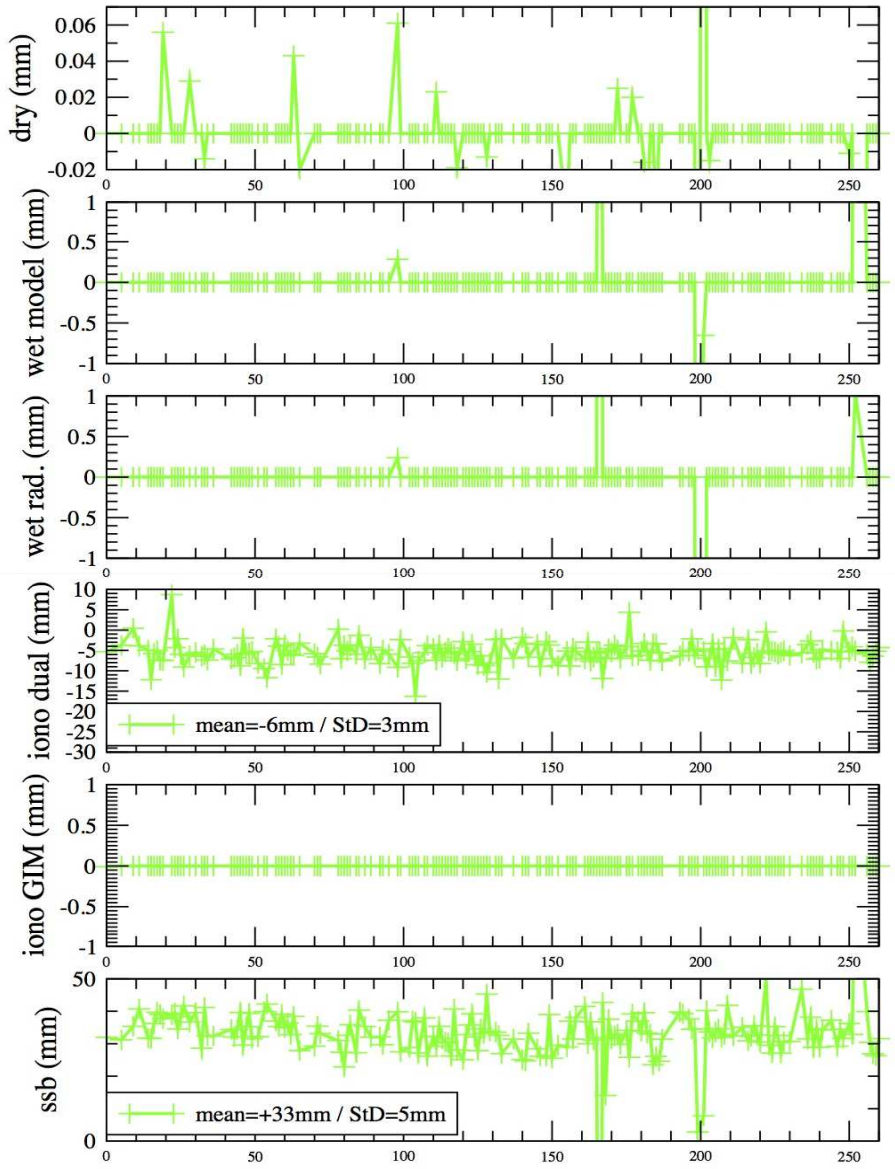
No significant drift detected from JMR/GPS and AMR/GPS comparisons.
Better agreement between GPS and coastal path delays (EPD) from AMR and JMR

Single site is affected by the GCE and local systematic errors
⇒Multiple calibration sites are needed

‼ ***SARAL AltiKa SSH bias value (since cycle 8) is from tide gauge data accounting for an instrumental bias of 30 mm**

Jason-2 Corrections

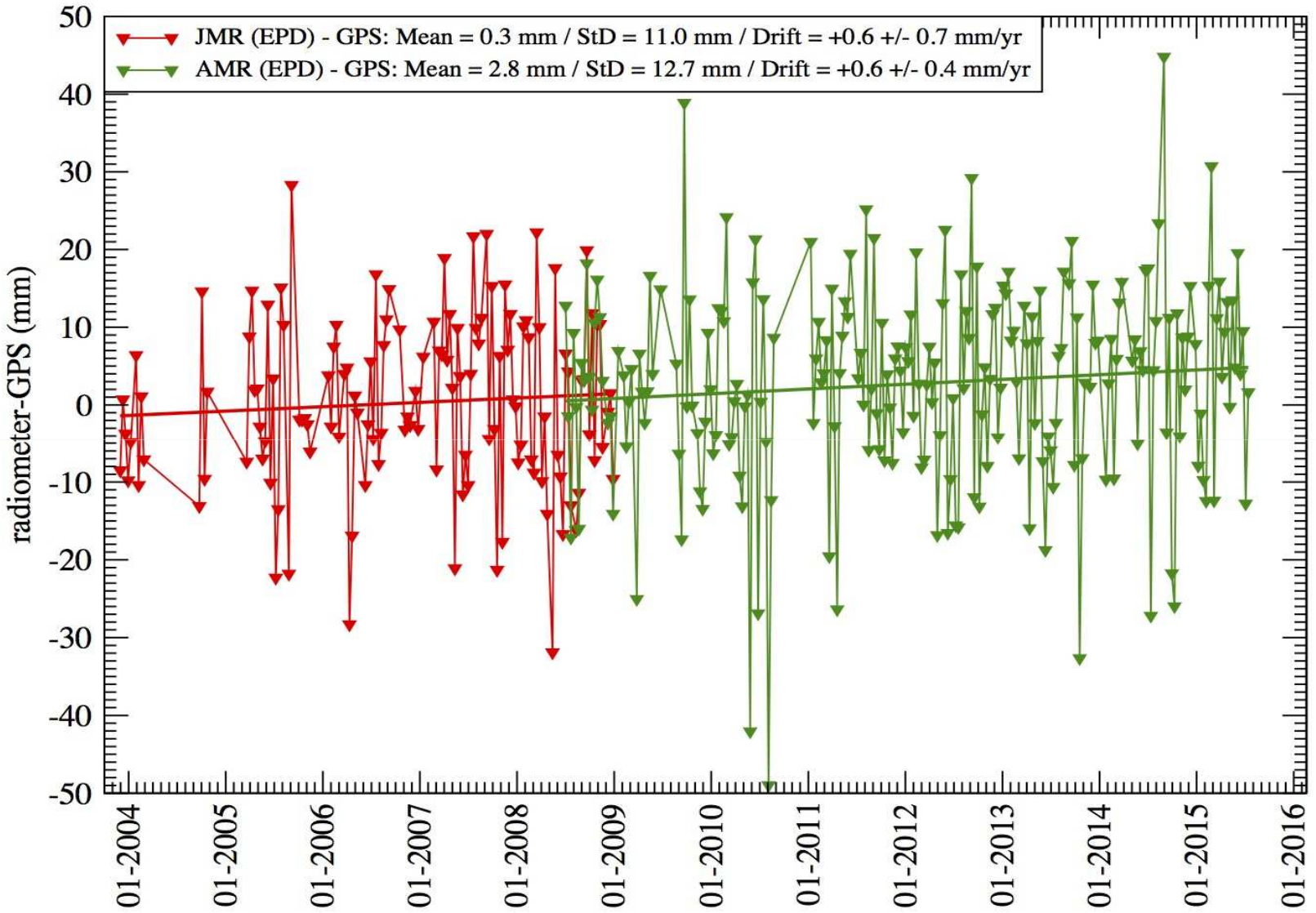
GDRD (MLE4 - MLE3)



Corsica Absolute Altimeters Calibration

GDR-D MLE4 vs MLE3

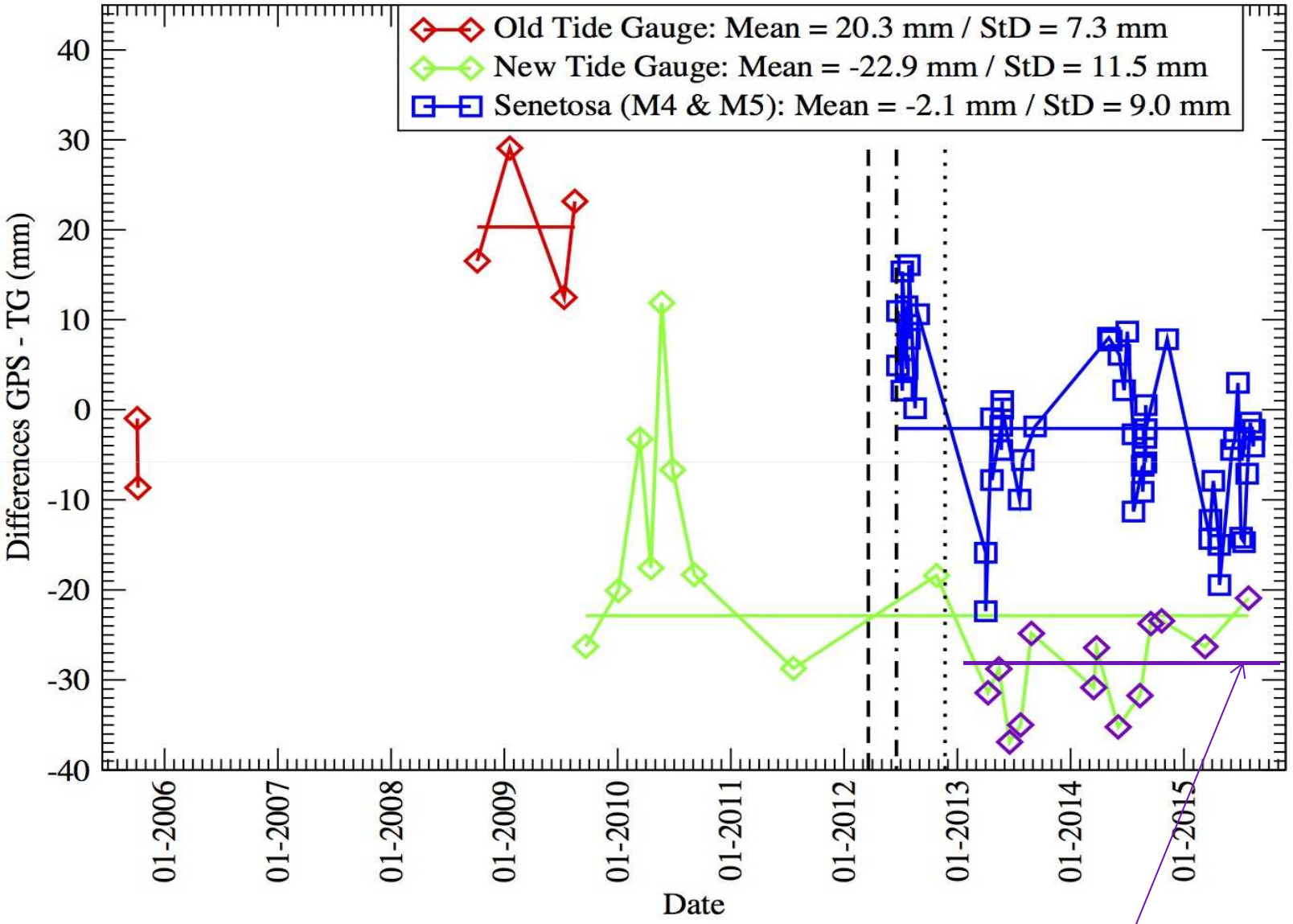
Radiometer Wet Tropospheric Correction compared to GPS



WET TROPO JMR & AMR

Tide Gauge vs GPS comparaisons

Ajaccio site, SHOM tide gauge



Corsica Absolute Altimeters Calibration

GPS - TIDE GAUGES

On SARAL/AltiKa period: Mean = -28.9 mm / StD = 5.1 mm