Corsica: a multi-mission absolute calibration site

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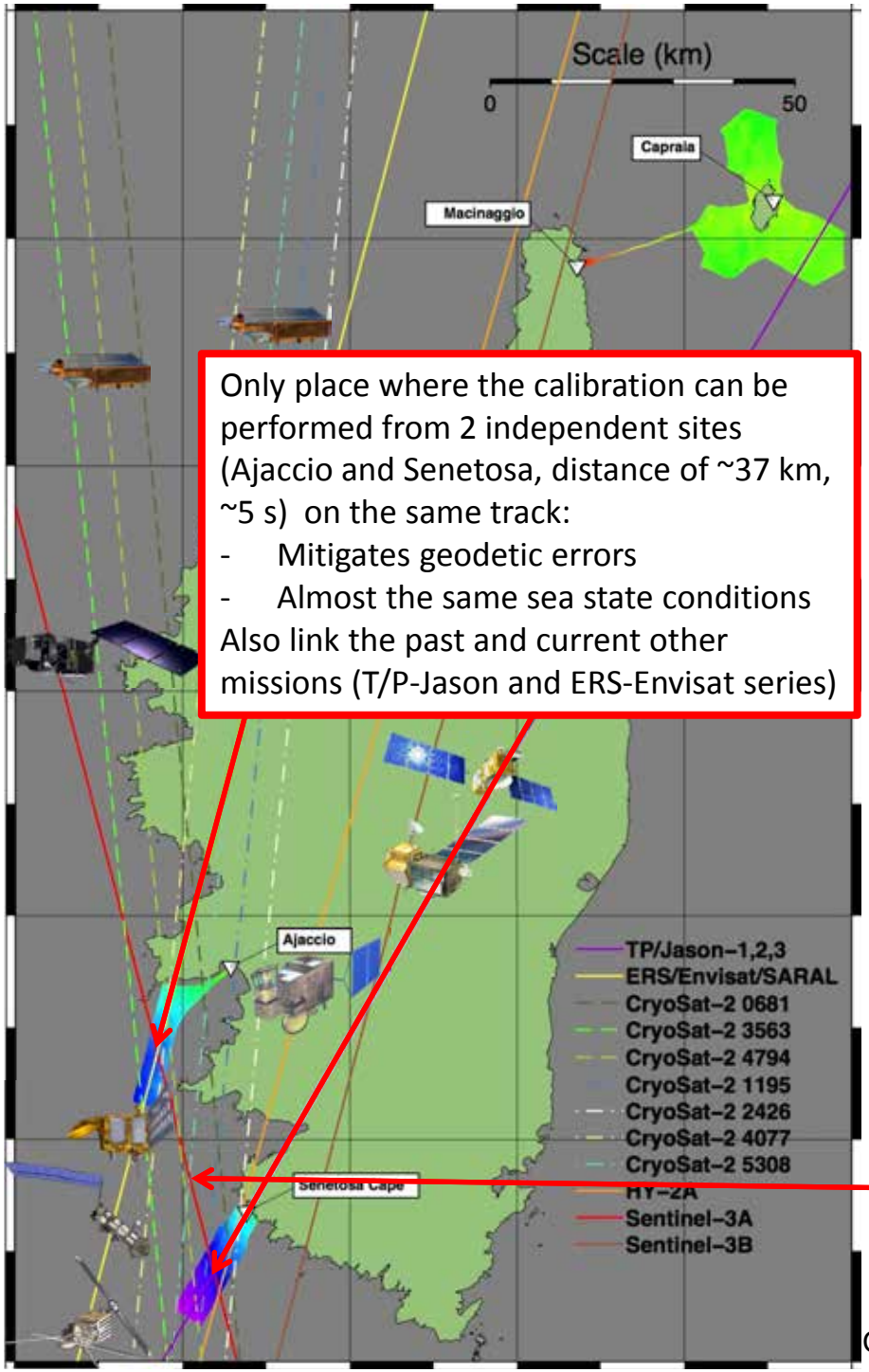
OSTST meeting – October 23-27, Miami, United States

Corsica Multi-mission Calibration Site



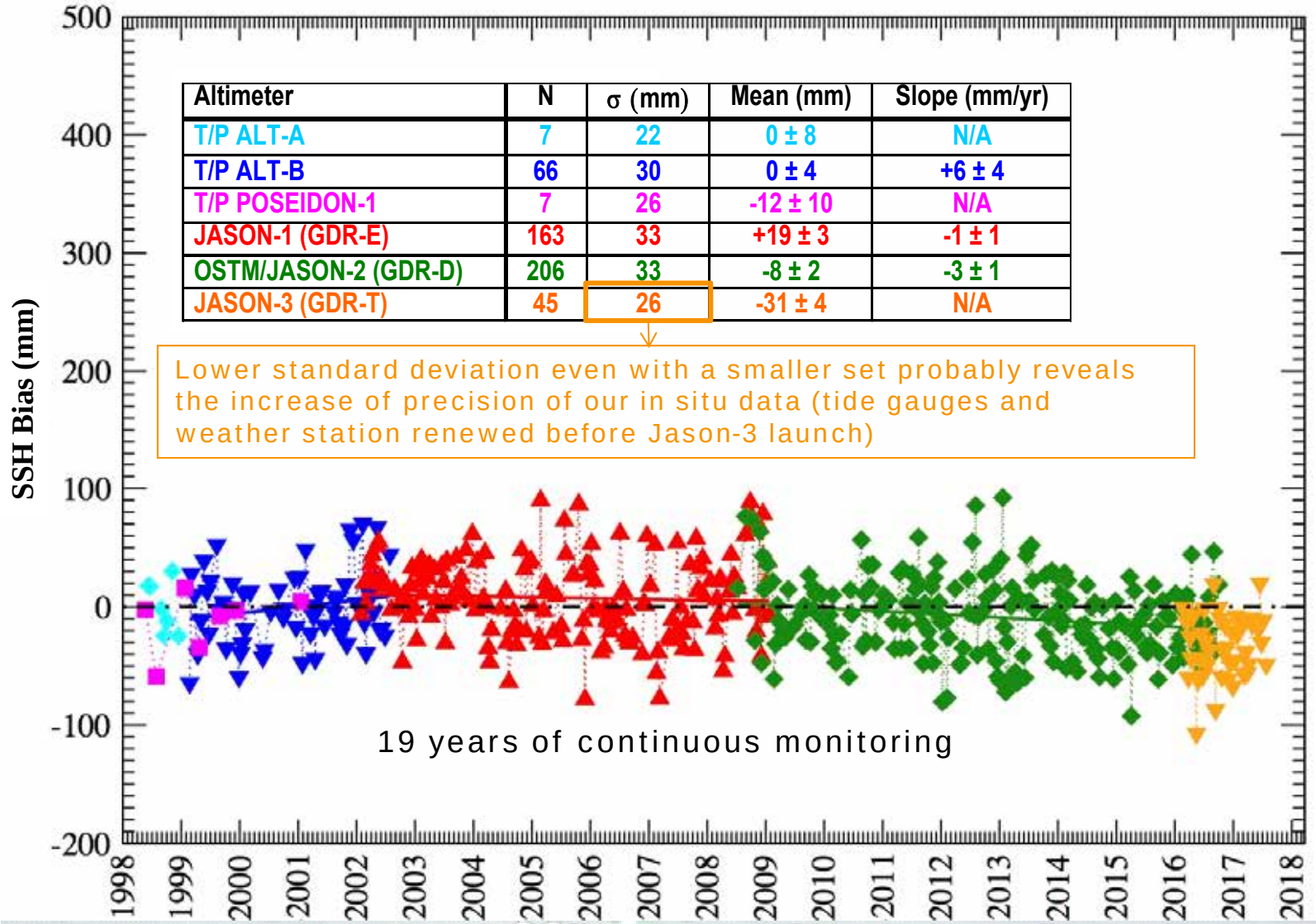
Only place where the calibration can be performed from 2 independent sites (Ajaccio and Senetosa, distance of ~37 km, ~5 s) on the same track:
- Mitigates geodetic errors
- Almost the same sea state conditions

Also link the past and current other missions (T/P-Jason and ERS-Envisat series)

- **Senetosa CNES calibration site** established in 1998
  - Supports continuous monitoring of Jason-2&3 (and formerly T/P and Jason-1)
  - Equipped with 4 pressure tide gauges leveled to the permanent GPS receiver
- **Ajaccio configuration** established in 2000
  - Supports continuous monitoring of SARAL/ALtiKa (and formerly ERS, Envisat)
  - Fiducial point near Ajaccio equipped with GPS/SLR(FTLRS)/DORIS.
  - Equipped with a radar tide gauge (SHOM) leveled to the permanent GPS receiver
- **Corsica multi-mission calibration site: existing facilities also used for CryoSat-2, HY-2A and Sentinel-3A**
- **Open-ocean altimeter readings** connected to tide gauges via detailed **local geoid model**
  - Derived from intensive GPS buoy and catamaran surveys along ground track (in 1999 for Senetosa). Extension to Ajaccio (2005) and Capraia (2004)
  - Open-ocean verification locations for GPS-based SSH measurement systems deployments.
  - **Planned connection of the Ajaccio and Senetosa local geoids along the Sentinel-3A track**

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 (GDR-E)	163	33	+19 ± 3	-1 ± 1
OSTM/JASON-2 (GDR-D)	206	33	-8 ± 2	-3 ± 1
JASON-3 (GDR-T)	45	26	-31 ± 4	N/A

Lower standard deviation even with a smaller set probably reveals the increase of precision of our in situ data (tide gauges and weather station renewed before Jason-3 launch)



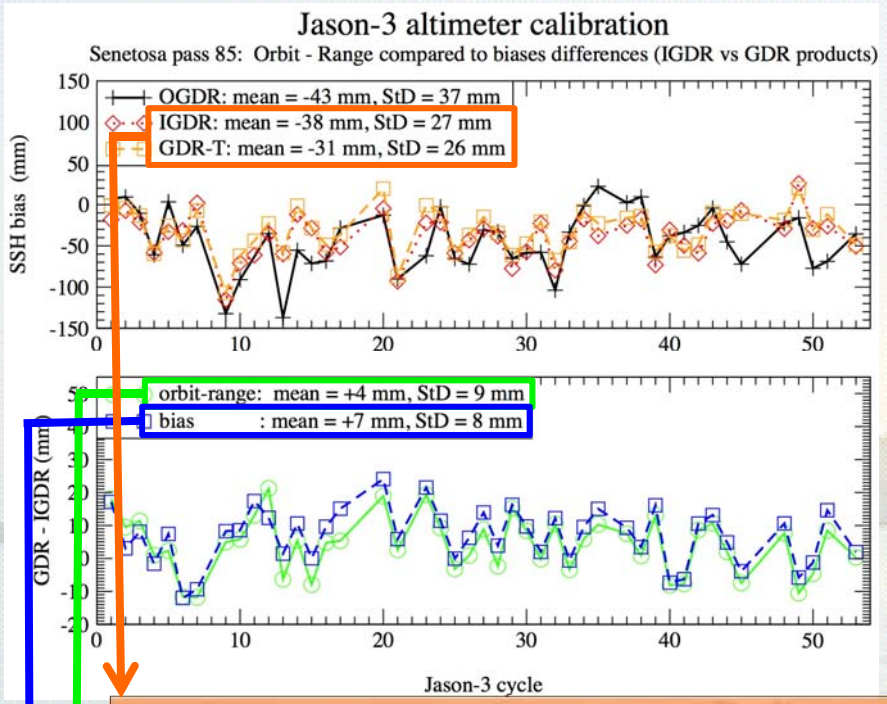
Corsica Absolute Altimeters **Calibration**

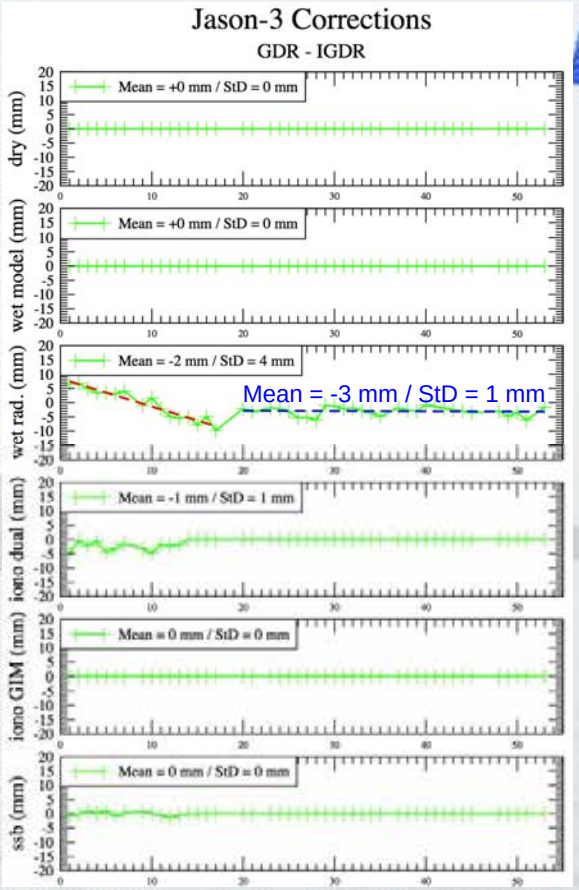
BIASES TIME SERIES

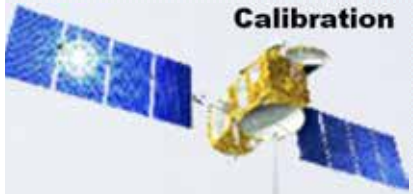
Products used:

T/P: MGDR + TMR replacement products + std0905 orbits (GSFC)
Jason-1: GDR-E (cycle 1-259)
Jason-2: GDR-D (cycle 1-305) (MLE3 = +16 ±3 mm => ≠ by -24 mm (mainly SSB))
Jason-3: GDR-T (cycle 1-053) (MLE3 = -16 ±5 mm => ≠ by -15 mm (mainly SSB))

Jason-3 SSH biases: OGDR, IGDR and GDR products







GDR-IGDR SSH bias differences is +7 mm
Slightly better standard deviation for GDR

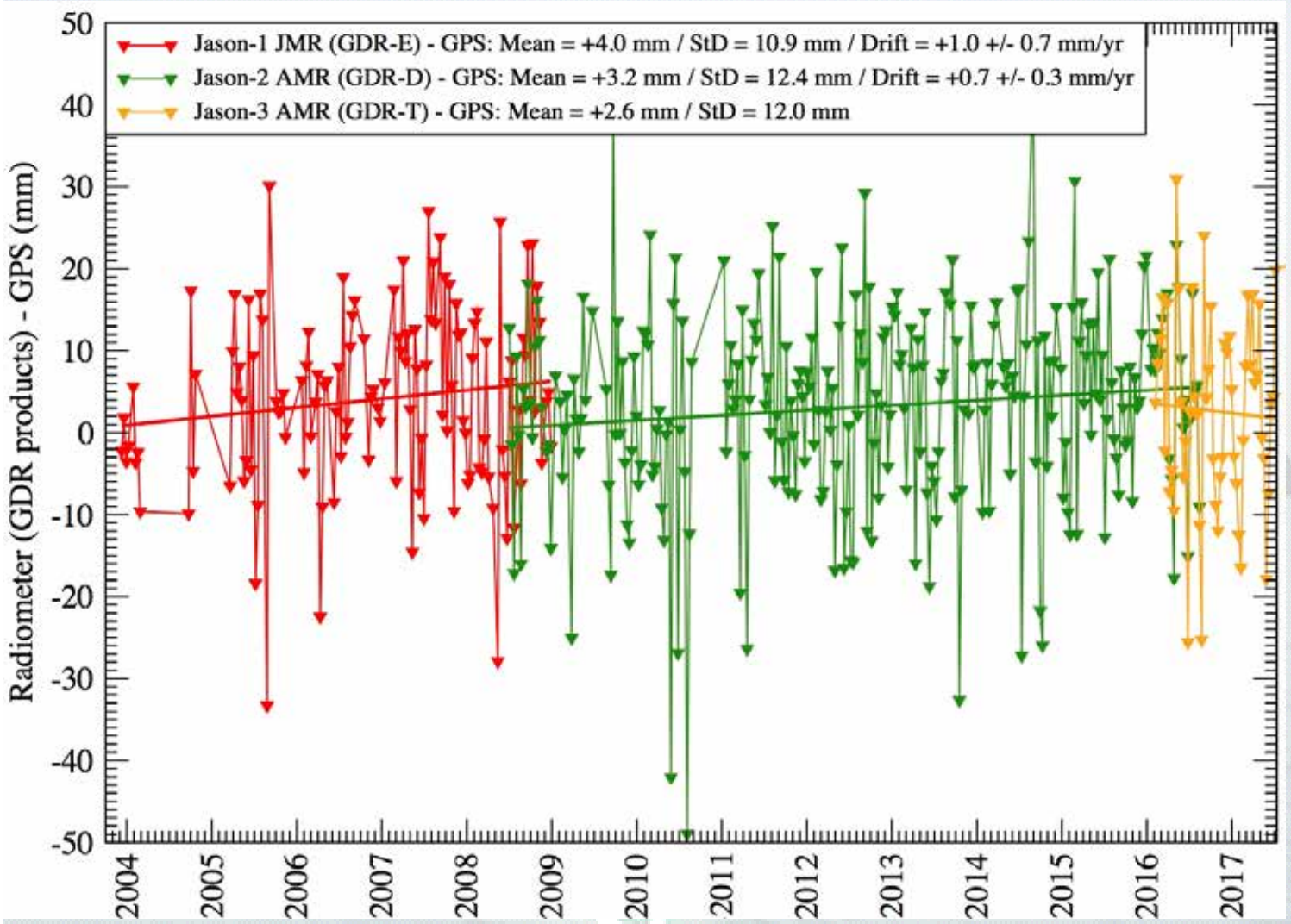
Most of the SSH bias differences come from the orbit-range (+4 mm) suggested that it comes from the orbit (range unchanged between IGDR and GDR).

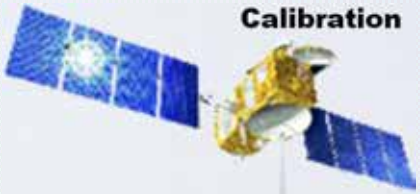
Except the orbit bias, differences between GDR and IGDR SSH bias are due to small correction contribution (-3 mm on average). Observed trend on radiometer differences during the Formation Flight Phase disappear. SSB and iono dual differences are much more stable since cycle ~14.

At the Corsica location the Jason-3 SSH bias is -31 ± 4 mm (GDR-T)

JASON-3 SSHBIAS

Radiometer Wet Tropospheric Correction compared to GPS





WET TROPO JMR & AMR

The permanent GPS receiver installed at Senetosa since 2004 also provide monitoring of the wet tropospheric correction:

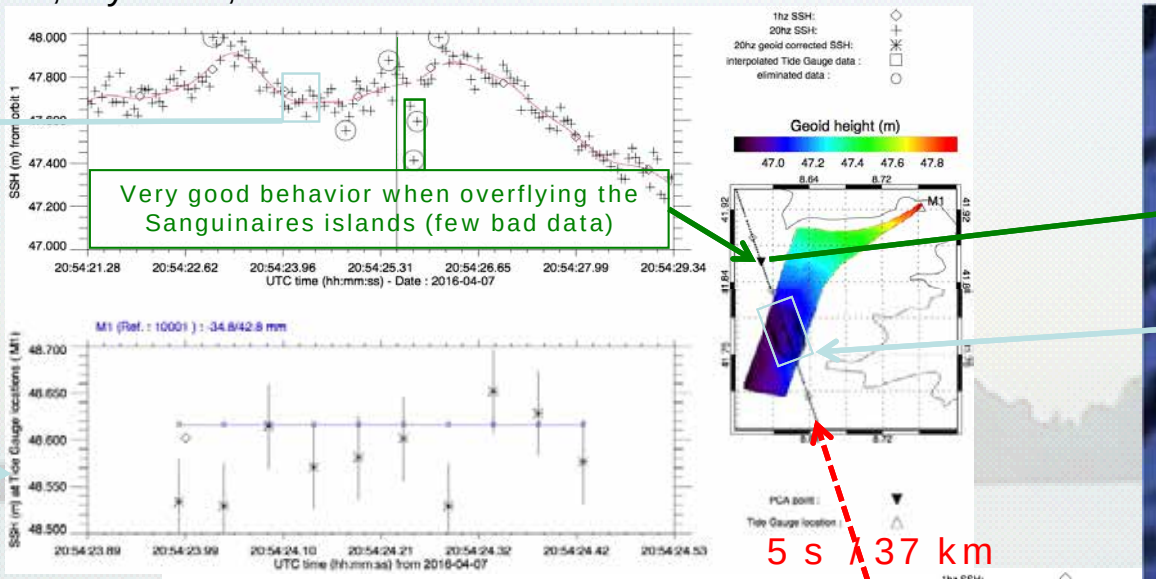
- No significant biases observed
- Drifts are below 1 mm/yr

Processing (use the latest homogeneous NTC data set from PDGS: IPF 06.07)

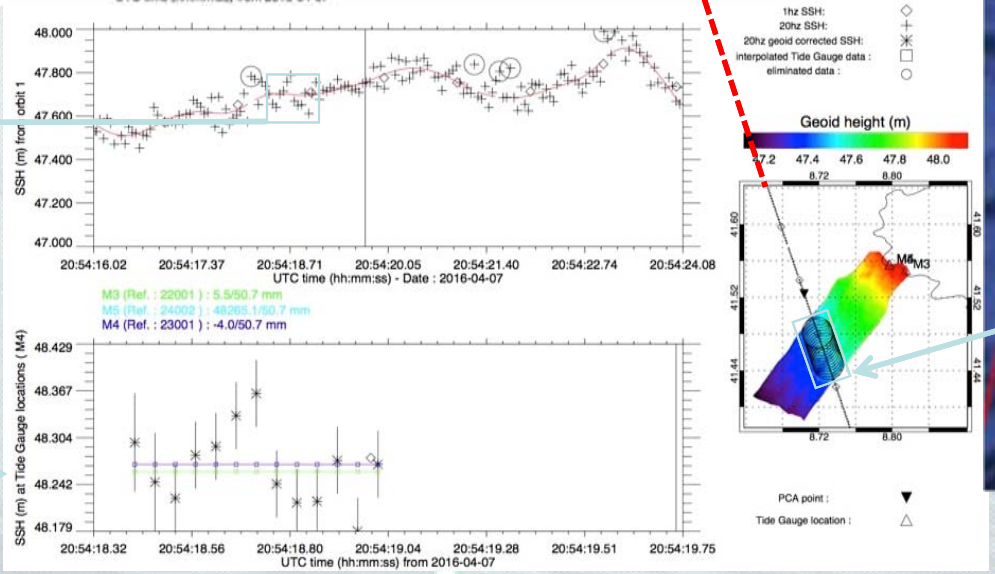
Sentinel-3A, SAR mode

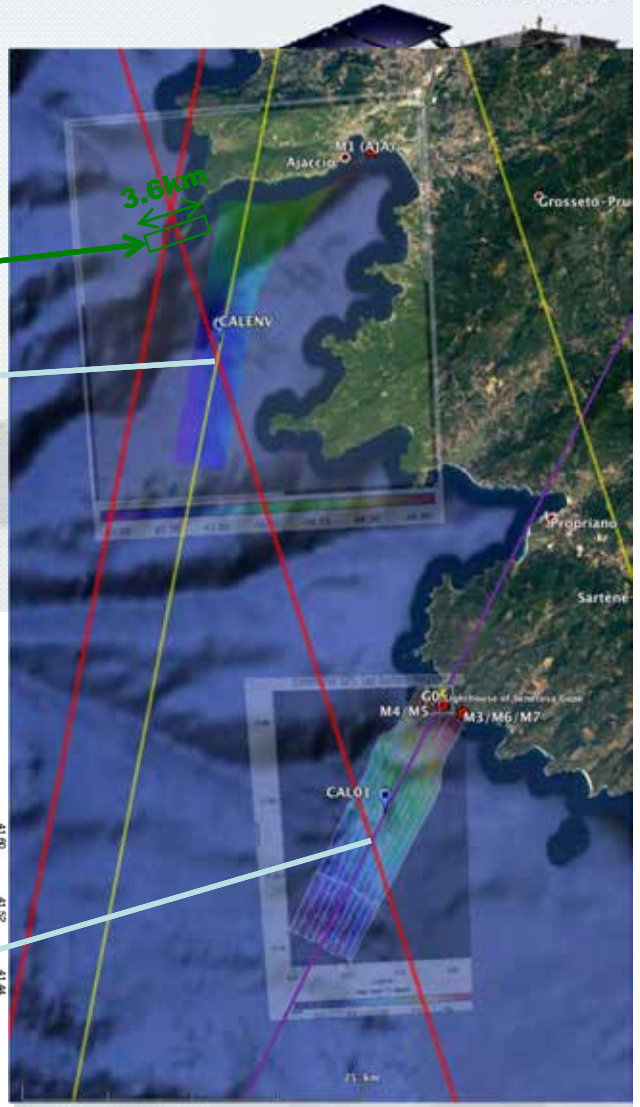
Pass 741, Cycle 2, 2016-04-07 20:54

Corsica Absolute Altimeters Calibration



5 s / 37 km

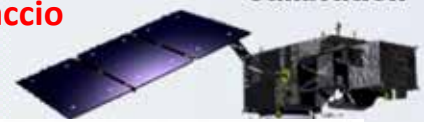


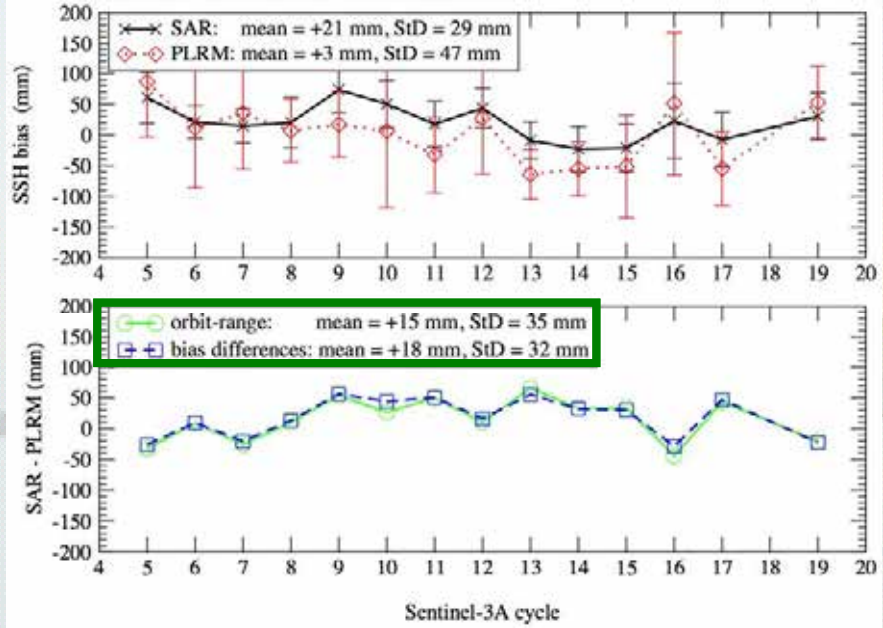


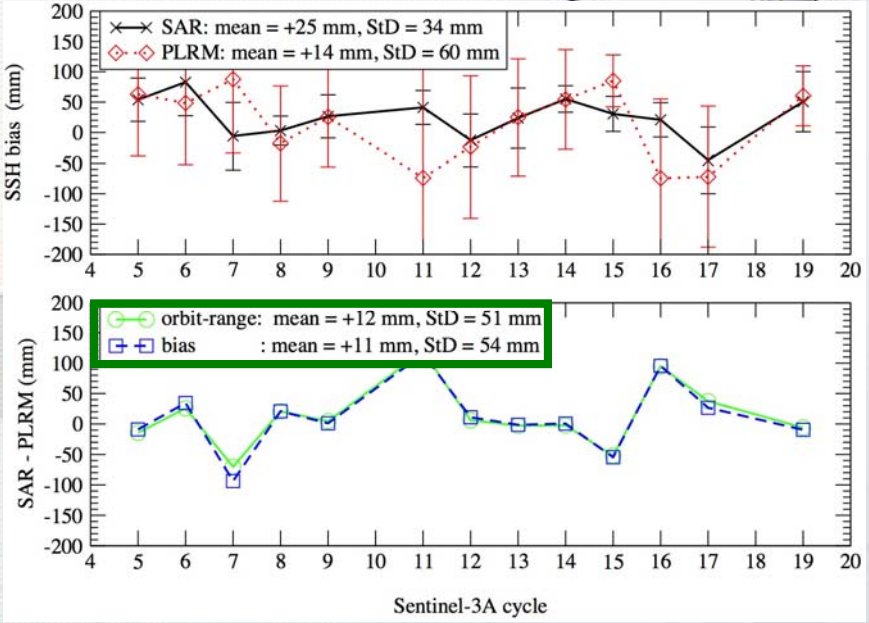
Absolute SSH biases (PDGS: SARM & PLRM)

Corsica Absolute Altimeters Calibration

Senetosa ---------- 5 s / 37 km ----------> Ajaccio





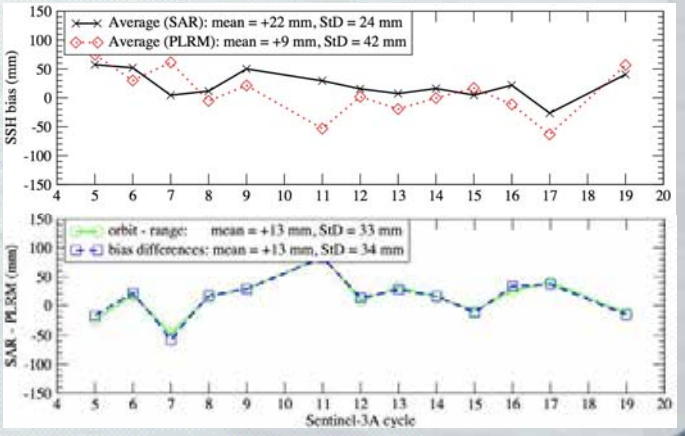


- **Most of the difference between SARM and PLRM modes is due to range**
- **Remaining differences in SSH bias come mainly from SSB (SWH and wind speed differences between SARM and PLRM)**
- **Compared to Senetosa, Ajaccio time series looks slightly noisier for SARM and much more for PLRM (more possible land contamination)**
- **Averaged SSH bias from PDGS (SARM and PLRM) from Ajaccio and Senetosa sites (using dual freq. iono and radiometer)**

SARM: +22 ± 7 mm (13 cycles)

PLRM: +9 ± 12 mm (13 cycles)

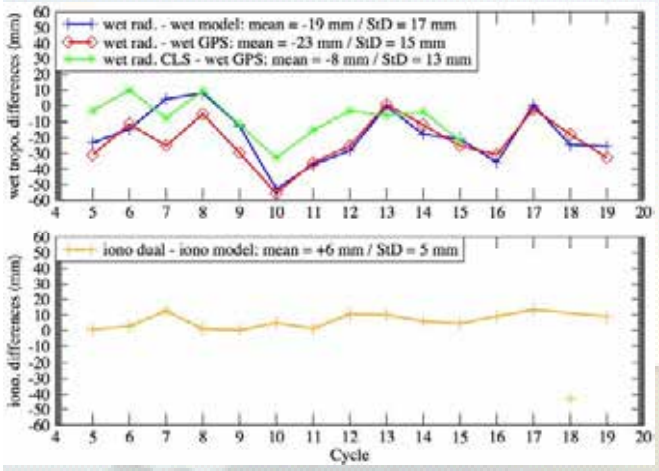
- **SSH bias for SAR is very stable**
- **13 mm difference between SARM and PLRM coming mainly from range**



Analysis of the corrections

Corsica Absolute Altimeters Calibration

Senetosa ---------- 5 s / 37 km ----------> Ajaccio



Wet tropo.:

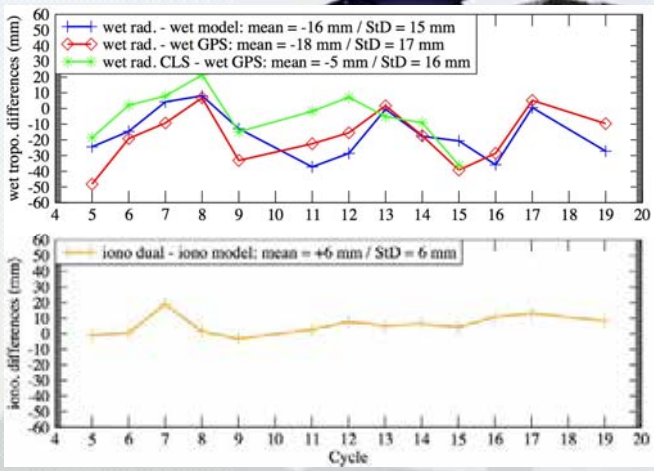
-For this study the wet tropo. is interpolated in the Senetosa area (less contamination)

-Comparisons of radiometer correction with GPS (red) or model (blue) reveal a ~2 cm bias at both Senetosa and Ajaccio

-Differences reduced at few mm level when using the correction developed by CLS (green)

Iono.:

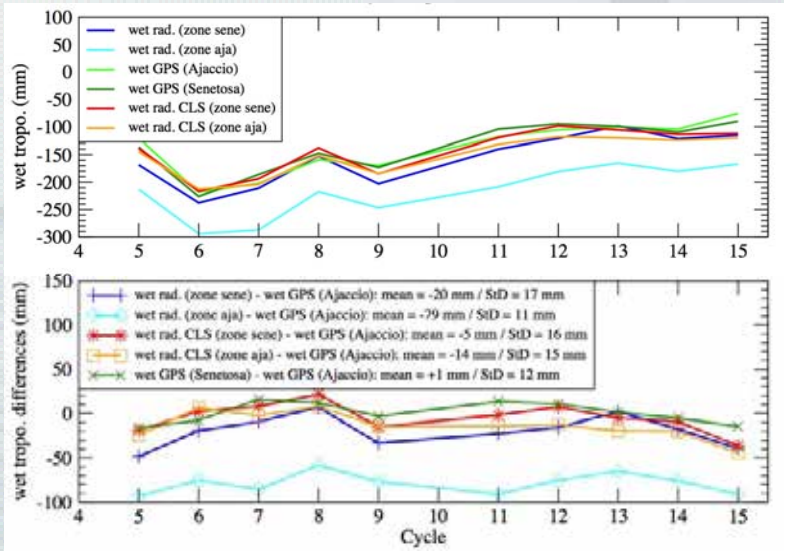
-A very small and stable bias (6 mm) between dual and model at Ajaccio and Senetosa

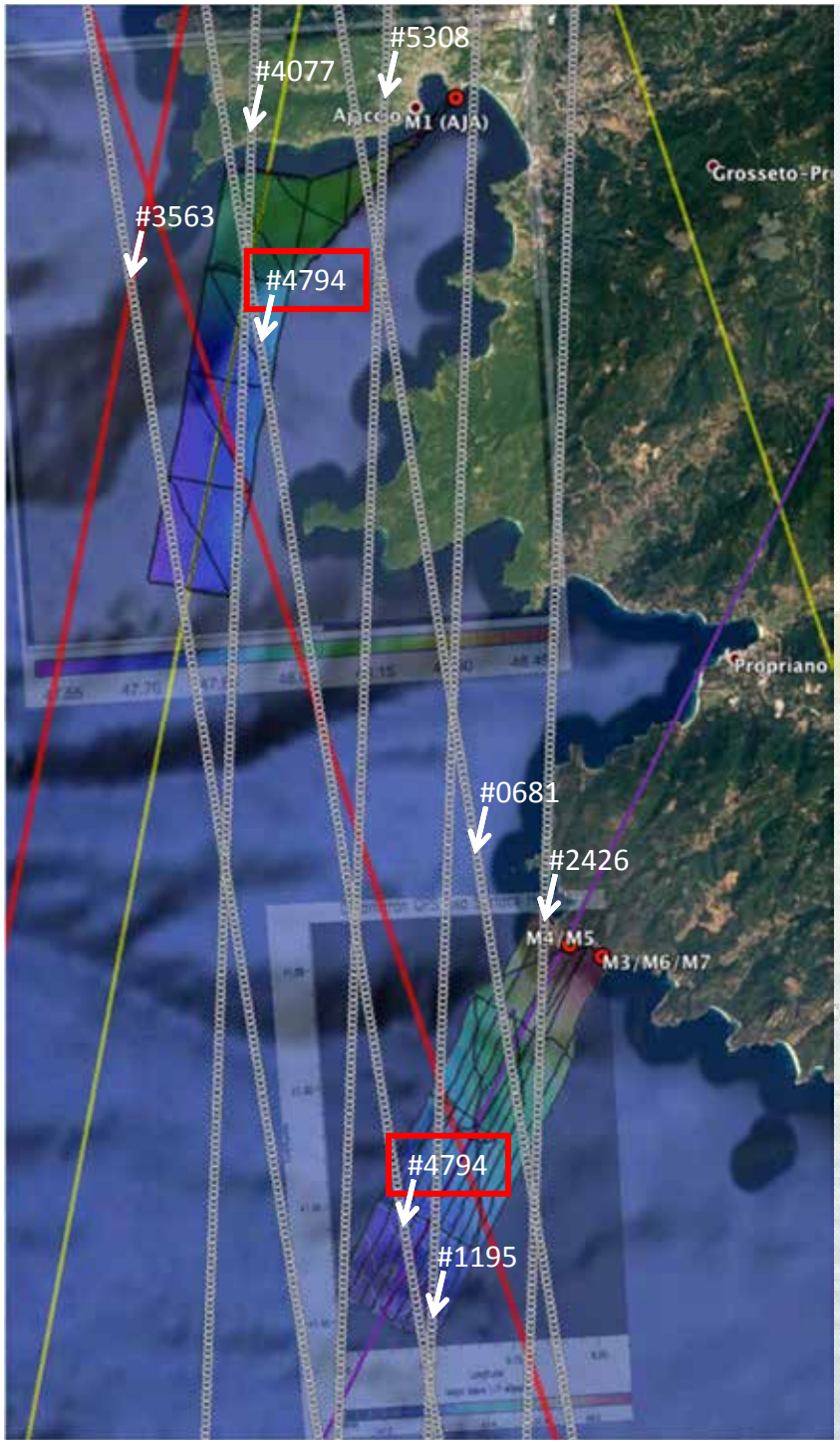


A second study has been conducted for Ajaccio using the Ajaccio interpolation area that should be more sensitive to land contamination:

-The wet tropospheric correction is biased by ~80 mm (light blue)

-The CLS correction clearly makes a great improvement even if a residual bias of -14 mm still exists (orange)





Configuration of the CryoSat-2 passes

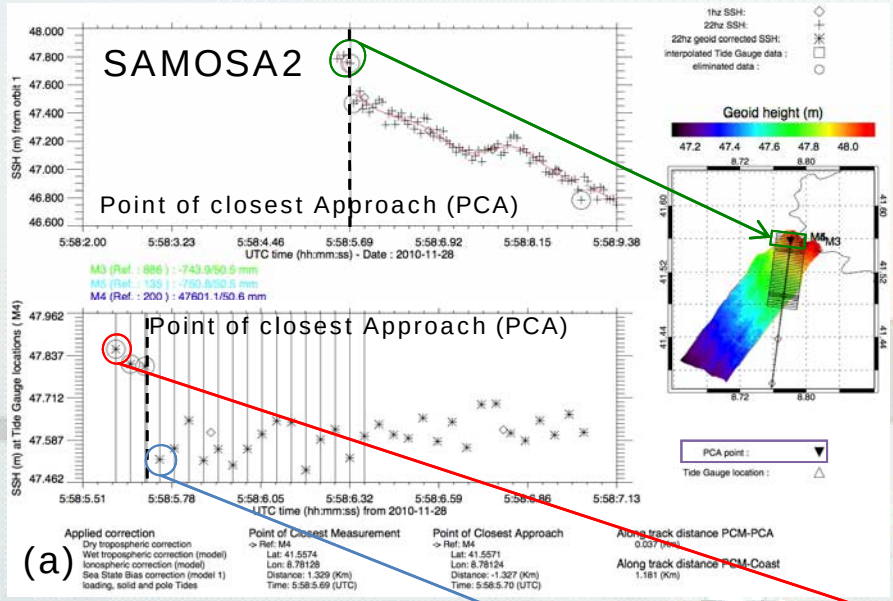
Corsica Absolute Altimeters Calibration

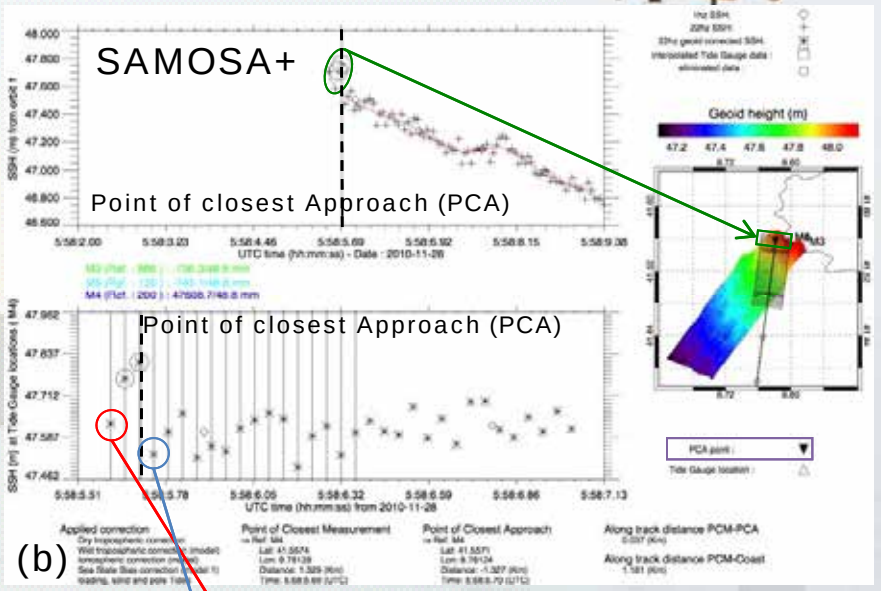
- 8 passes cross the geoid areas mapped at Ajaccio and Senetosa
  - 4 at Ajaccio but only 2 usable (#4077 and #4794)
  - 4 at Senetosa (#0681, #1195, #2426 and #4794)
  - 1 crosses both Ajaccio and Senetosa (#4794): configuration similar to Sentinel-3A (5s, 37km distance)
- Data from GPOD used with SSB=3.5% of SWH and 2 flavors:
  - SAMOSA2 retracker
  - SAMOSA+ retracker

Example of retracking improvement

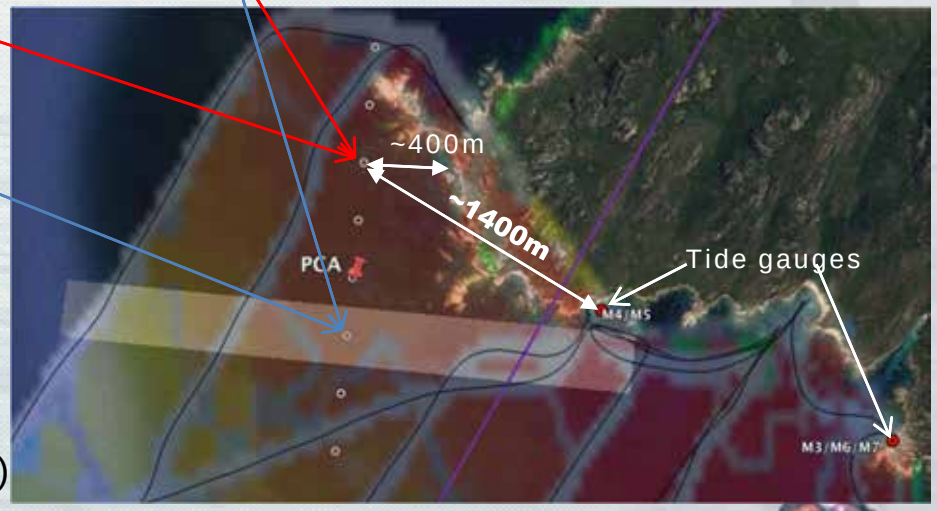
pass #2426 cycle 001

Corsica Absolute Altimeters Calibration

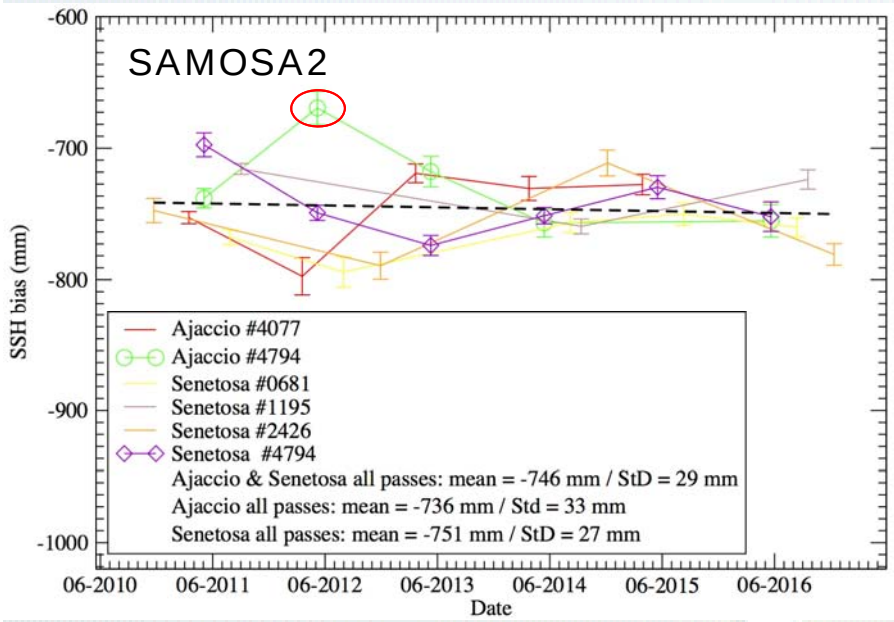


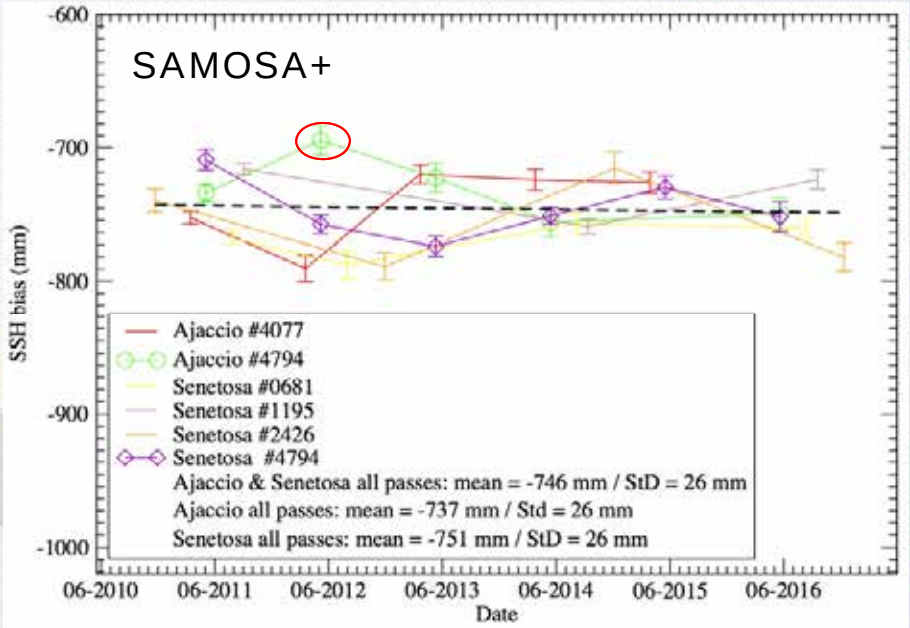


Some data very close to the coast (less than 500 m cross track, see red arrows) are clearly improved with SAMOSA+ (top frame: SSH; bottom frame: SSH corrected from geoid slope between altimetric measurement and tide gauge)



Synthesis from Ajaccio and Senetosa

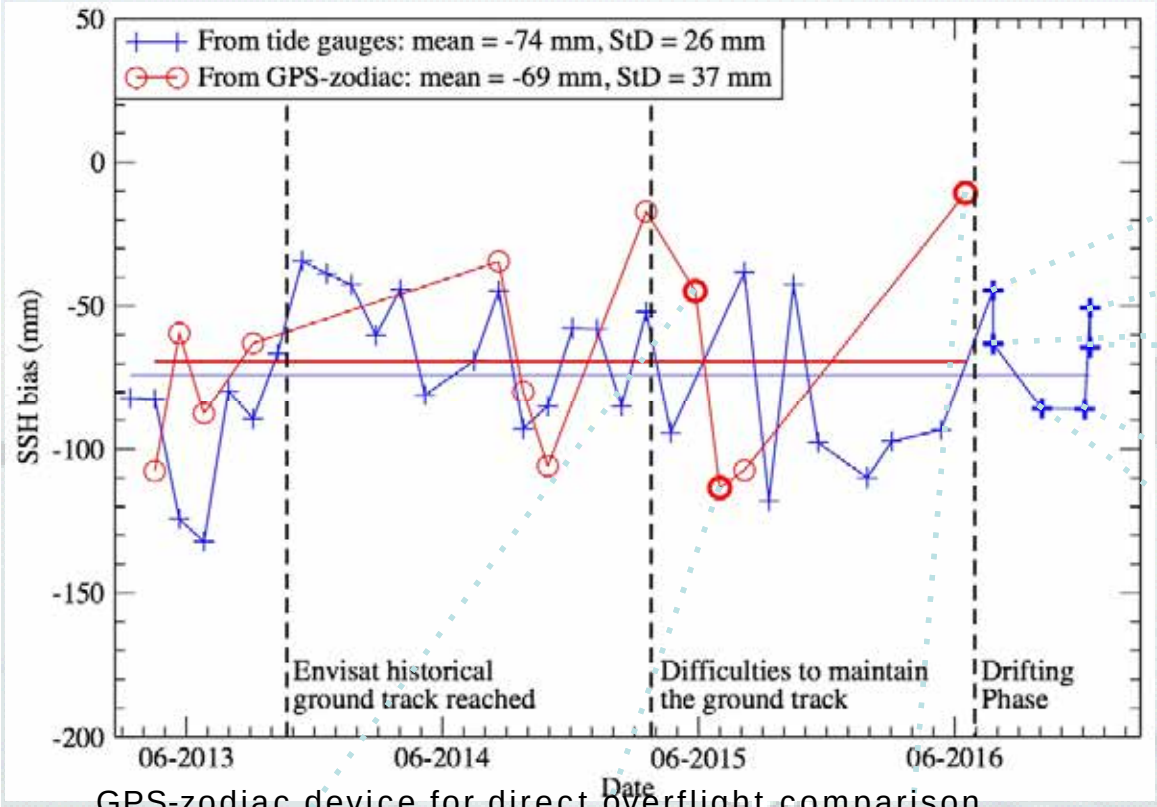




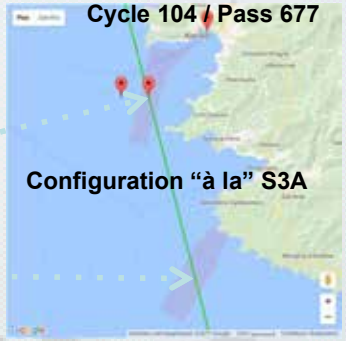
- SAMOSA+ helps to improve some outliers in the SSH computation for data very close to the coast
- Standard deviation of the SSH bias time series, for SAMOSA+, is clearly improved for Ajaccio (26 mm vs. 33 mm)
- Ajaccio and Senetosa results are coherent in average (14 mm differences), but also for individual determinations for pass #4794 that overflight Senetosa (magenta diamonds) and Ajaccio 5s later (green circle)
- From SAMOSA+, CryoSat-2 averaged **SSH bias** is **-746 ± 5 mm** (range is measuring too long)
- This looks coherent with updated Svalbard **transponder** result: **722 ± 6 mm** (standard deviation of 29 mm) (baseline B, before removing a 673 mm bias) see *Garcia-Mondejar et al., 2017. CryoSat-2: Range, Datation and Interferometer Calibration with Svalbard Transponder. Submitted to: "The CryoSat Satellite Altimetry Mission: 7 years of scientific exploitation"special issue of Advances in Space Research (in Revision)*

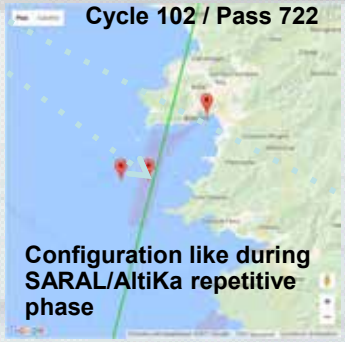
SARAL/AltiKa recent results

Corsica
Absolute
Altimeters
Calibration



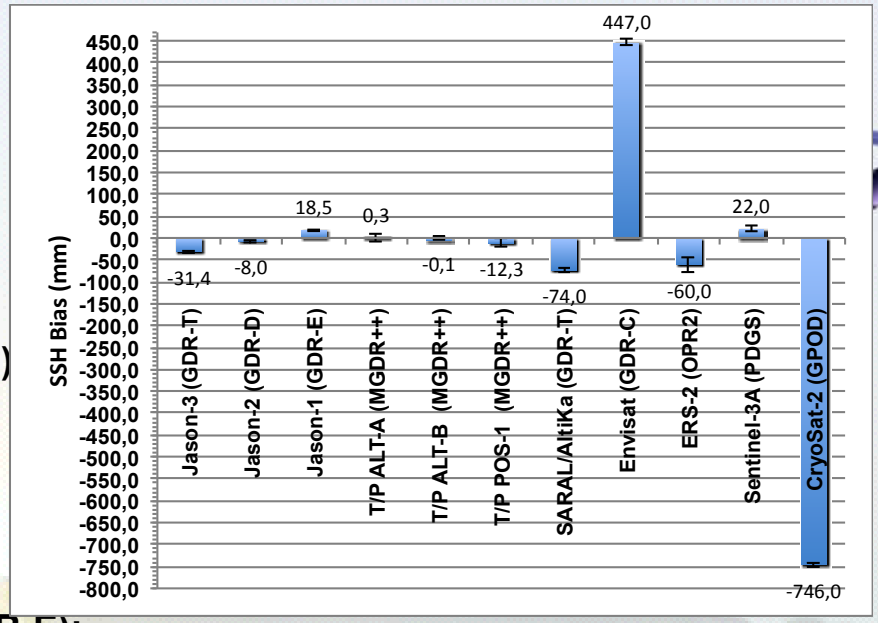
Standard tide gauge calibration





GPS-zodiac device for direct overflight comparison

Calibration from Corsica



Absolute biases over the whole data sets:

- **Jason-3: -31 ±4 mm (GDR-T)**
- **Jason-2: -8 ±2 mm (GDR-D)**
- **Jason-1: +19 ±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^{++})**
- **ERS-2: -60 ±18 mm (OPR-2)**
- **Envisat: +447 ±7 mm (GDR-C)**
- **CryoSat-2: -746 ±5 mm (GPOD)**
- **SARAL: -74 ±4 mm (GDR-T)**
- **Sentinel-3A: +22 ±7 mm (PDGS)**

Main findings for Jason-1 reprocessing (GDR-E):

- **Message from last year: a wrong standard dry troposphere correction for cycle 1-150 in some coastal areas (step of 8 mm before/after cycle 150).**

Main findings for Jason-2:

- **Nothing to declare, waiting for GDR-E…**

Main findings for Jason-3:

- **All products (OGDR, IGDR and GDR-T) are of very good quality**
- **A very stable SSH bias of -31 mm**

Main findings for Sentinel-3A:

- **A very stable SSH bias of +22 mm for SARM (mainly due to land contamination on the radiometer wet tropospheric correction)**

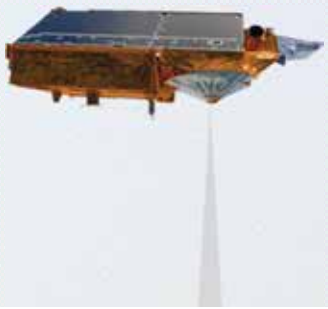
Main findings for CryoSat-2:

- **First processing of the whole CryoSat-2 data set gives a SSH bias (-746 ±5 mm for baseline B) close to the Svalbard transponder result (difference of 24 mm)**

Main findings for SARAL/AltiKa:

- **The SSH bias monitoring can continue during the drifting phase**

Example of pass #4794
Configuration « à la » Sentinel-3A



Averaging the SSH bias from Ajaccio and Senetosa overflights (5 s time lag and 37 km distance) shows a very low standard deviation (15 mm) and a bias very close to the global average -740 mm vs. -746 mm for SAMOSA+ (see previous slide)
For comparison, with similar configuration, the standard deviation over 20 cycles for Sentinel-3A is 24 mm.