Corsica: a Cal/Val experiment to link offshore and coastal altimetry

→ 8th COASTAL ALTIMETRY WORKSHOP

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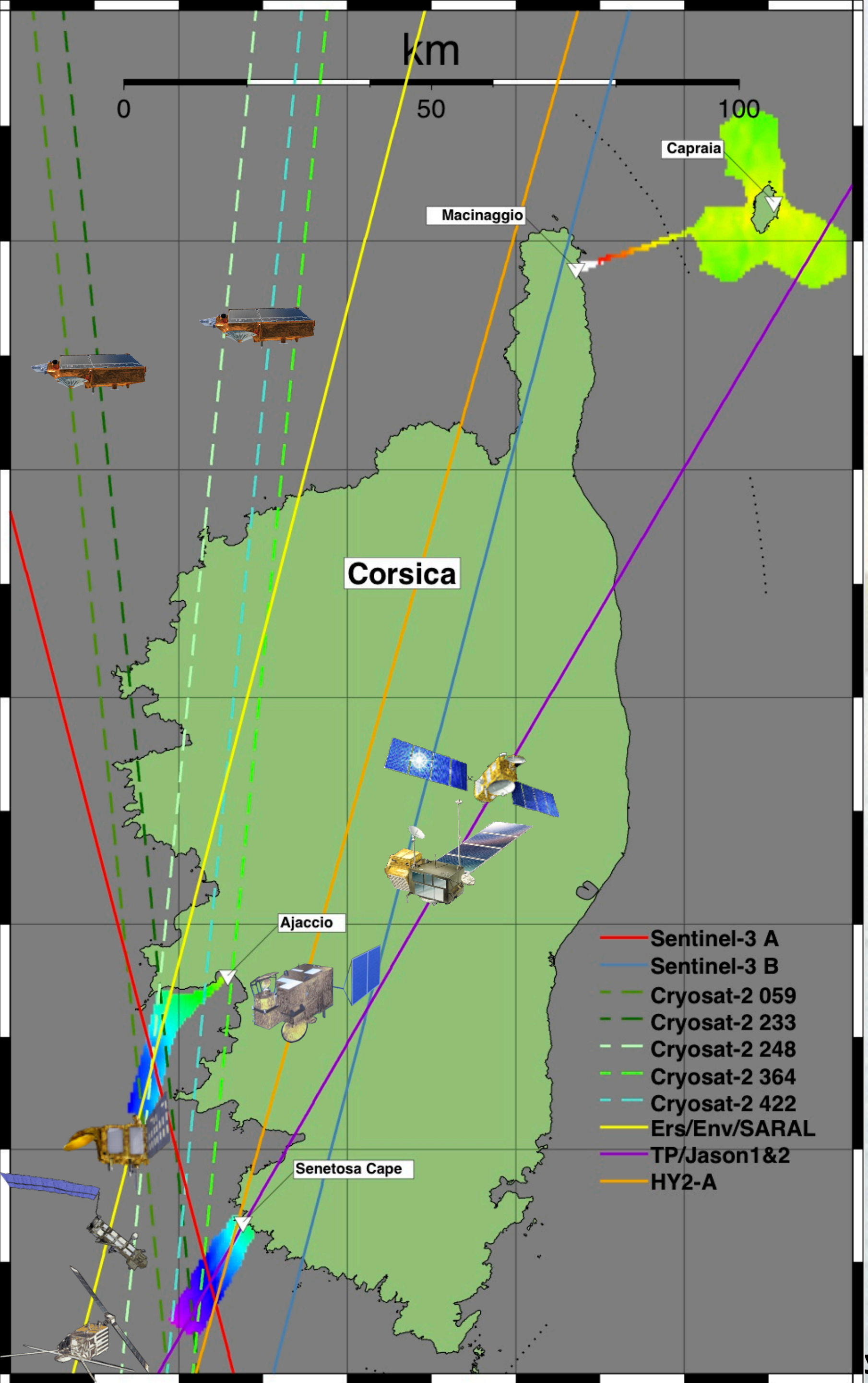
TERRE - OCÉAN - ESPACE

Corsica Calibration Site

Corsica Absolute Altimeters Calibration



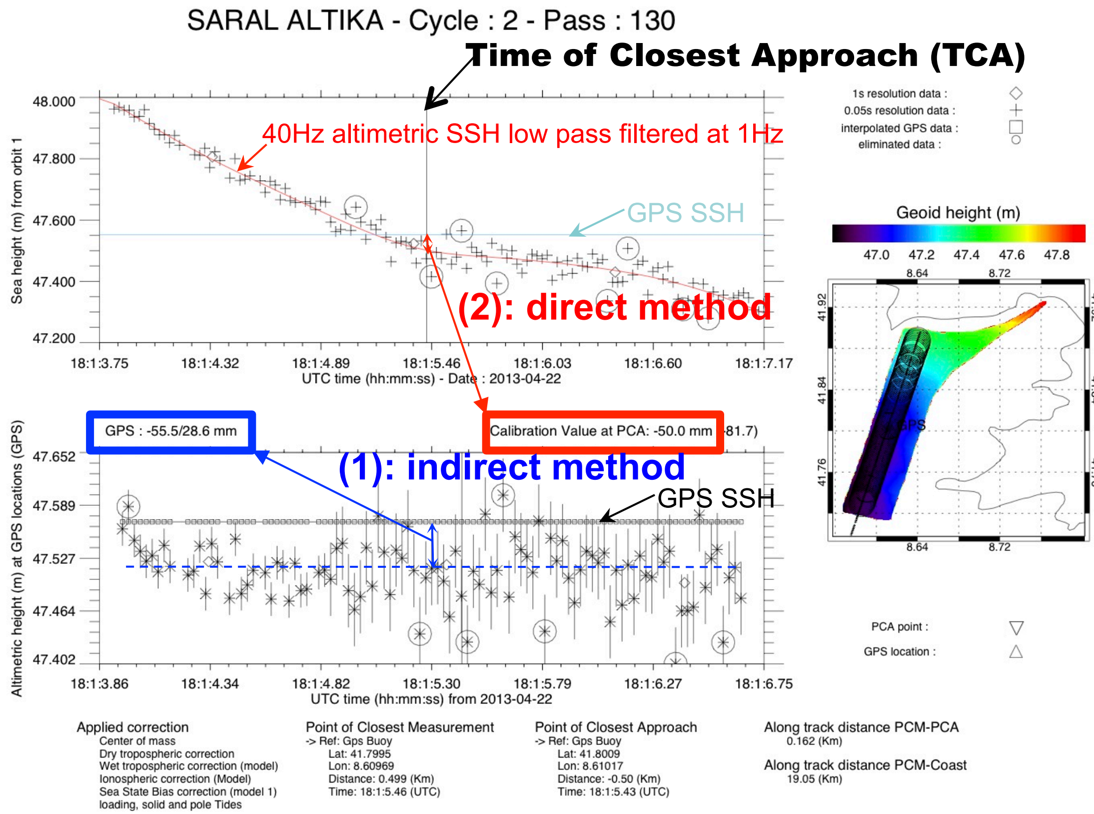
- **Senetosa CNES calibration site established in 1998 (equipped with 4 pressure tide gauges.)**
  - **Supports continuous monitoring of Jason-2 (and formerly T/P and Jason-1)**
- **Open-ocean altimeter readings connected to tide gauges via detailed local geoid model**
  - **Derived from intensive GPS 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)***

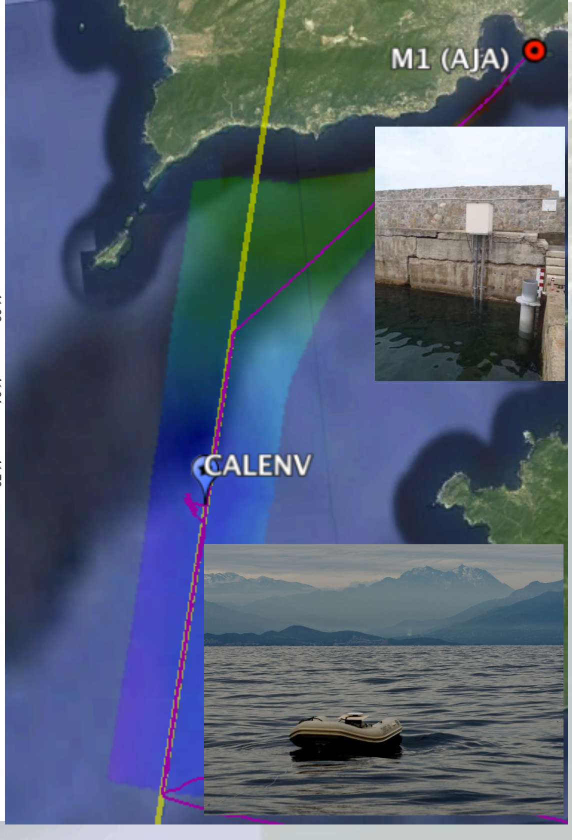
Some tracks of CryoSat-2 and HY2-A cross the geoids allowing absolute calibration

SITE DESCRIPTION

Corsica Absolute Altimeters Calibration

METHODS & INSTRUMENTS





2 Methods to compute SSH bias:

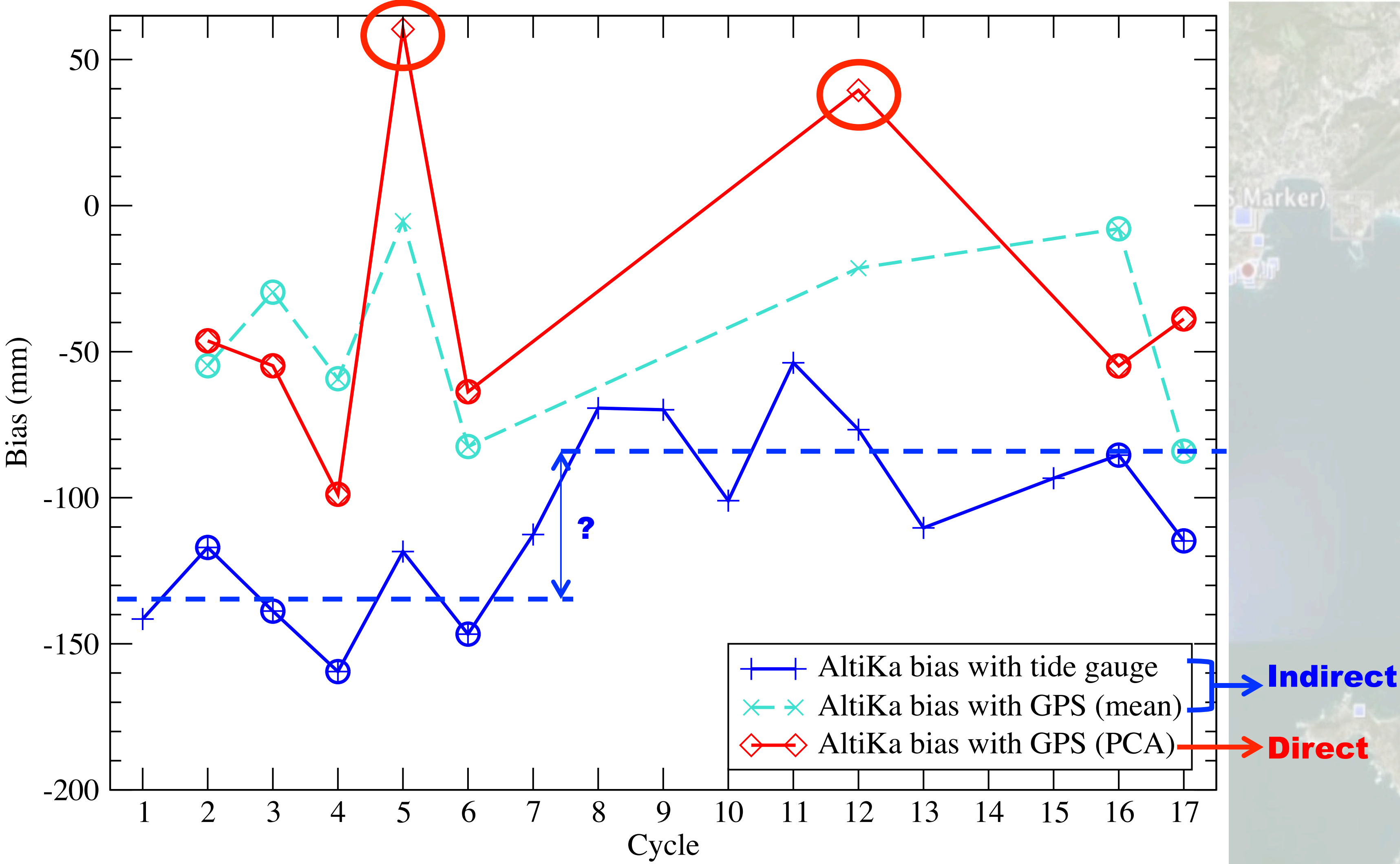
- **Indirect: need to correct from geoid slope** and potential ocean dynamics effects between in situ and altimetric measurements
- **Direct:** in situ **instrument** needs to be as **close as possible from altimetric measurement** to avoid any geoid slope and potential ocean dynamics effects

2 independent instruments to compute SSH bias:

- From **tide gauge**:
  - **(0) SSH from altimetry needs to be corrected for geoid**
- From **GPS measurement** (GPS aboard a zodiac located under the track, CALENV):
  - **(1) Using geoid correction to average all the altimetric SSH** (noted GPS-mean)
  - **(2) Computation at the Point of Closest Approach = no need to correct from geoid** (noted GPS-PCA)

Corsica Absolute Altimeters Calibration

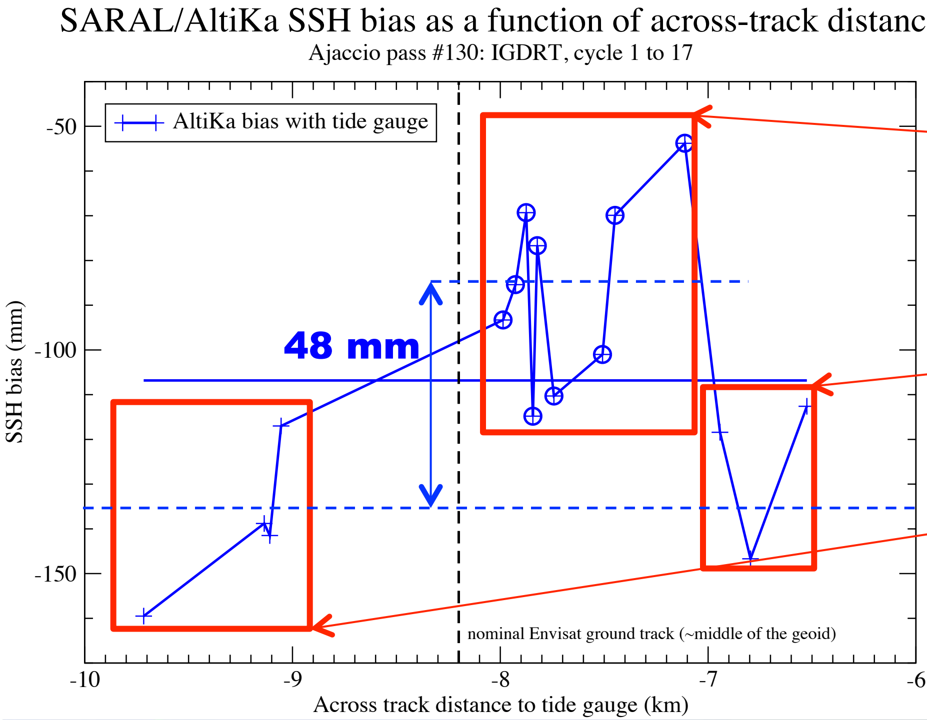
COMPARISONS

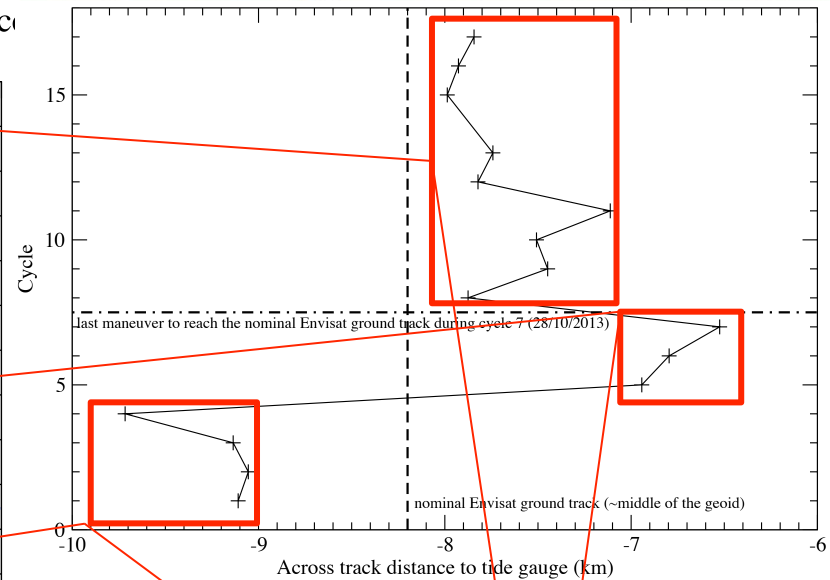


Averaged SSH bias with IGDR-T products (6 common cycles)

Tide gauge	GPS (mean)	GPS (PCA)
-127 mm (s=27 mm)	-53 mm (s=30 mm)	-60 mm (s=21 mm)

~-70 mm differences: instrumental bias? geoid or oceanic signal from tide gauge to offshore? All together?





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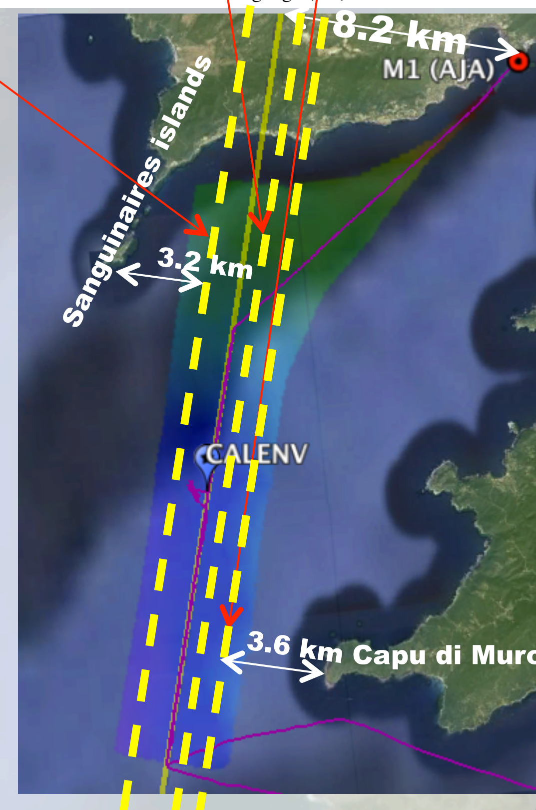


ACROSS TRACK IMPACT

Several maneuvers were needed to reach the nominal ground track, it can be divided into 3 parts:

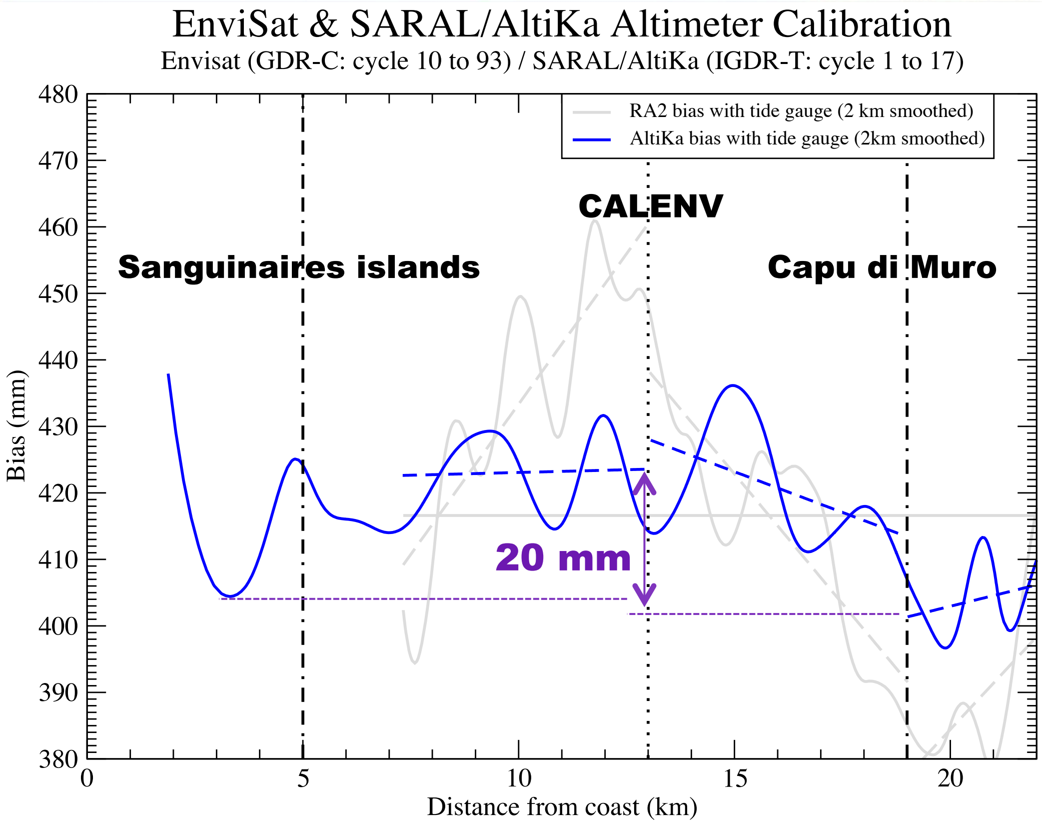
1- cycle 1 to 4: ground track located in the western part
=> contamination from "Sanguinaires islands"

2- cycle 5 to 7: ground track located in the eastern part
=> contamination from "Capu di muro"

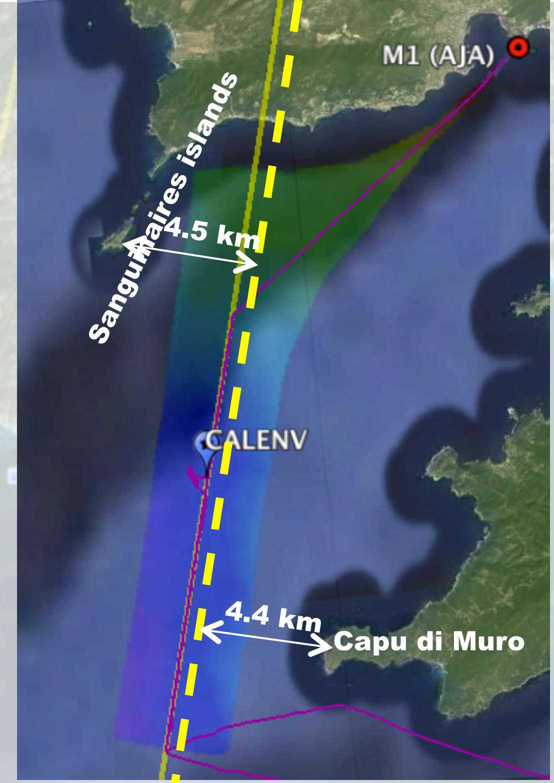
3- from cycle 8: ground track located in the center part
=> no a priori contamination except very close to the coast in the northern part

Impact on the averaged SSH bias: 48 mm
(SSH bias cycles 1-7 compared to cycles 8-17)

Better stability since cycle 8: 20 mm rms
(31 mm rms on the whole set)



To make the comparison easier the AltiKa SSH bias has been shifted to the RA2 SSH bias by the difference of their SSH biases (523 mm).



Averaged ground track since cycle 8 (~500m eastward from Envisat nominal track)

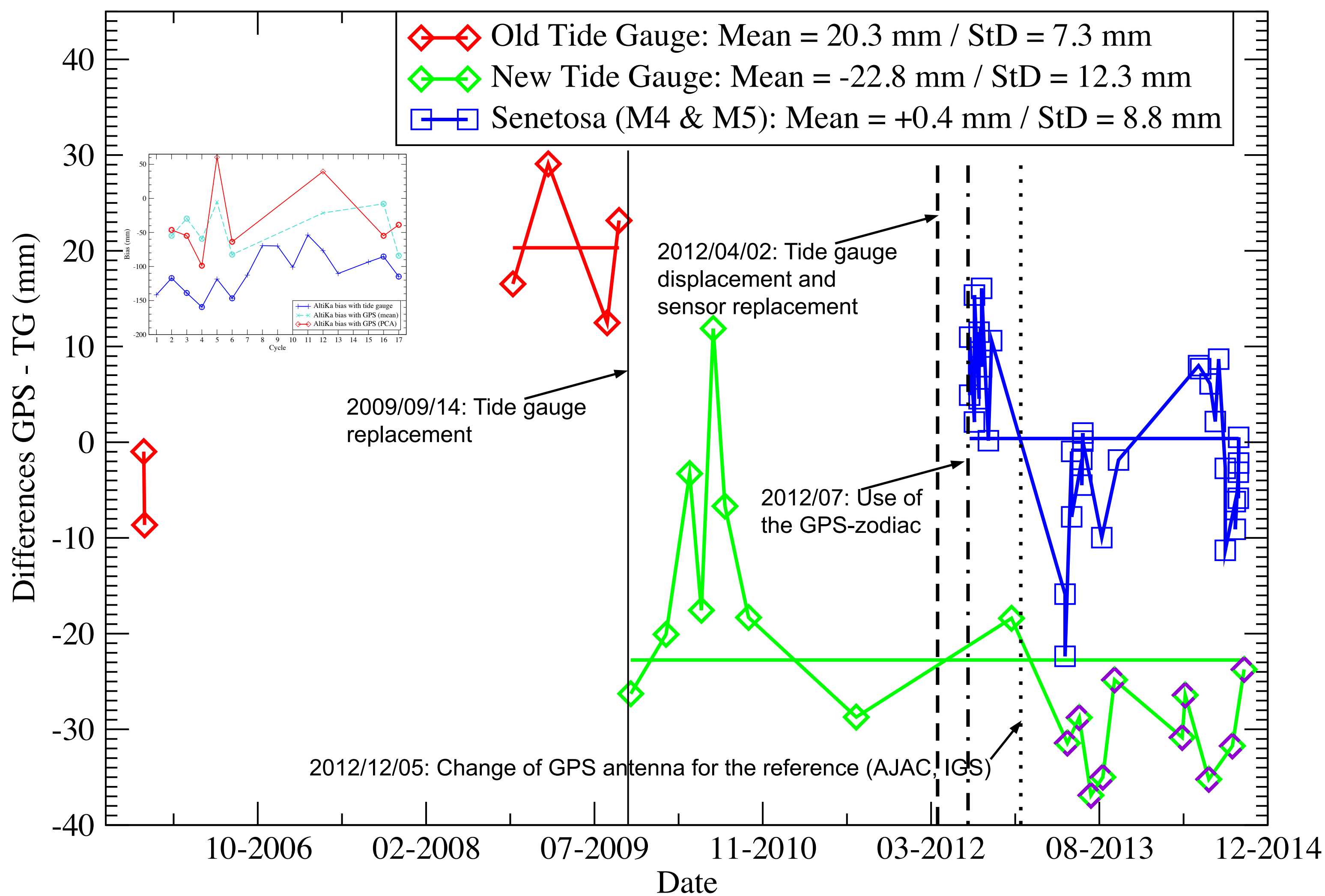
Corsica Absolute Altimeters Calibration

ALONG TRACK IMPACT

This plot shows the average SSH bias in function of the distance to the coast:

Even if the **land contamination is much smaller than for the Envisat** (RA2) altimeter, it is estimated to be **at the level of 20 mm** in vicinity of the “Sanguinaires islands” and “Capu di Muro”: the theoretical AltiKa footprint radius is 4 km, so AltiKa should not been theoretically impacted…

However, **even by selected data from cycle 8, the structures identified in the above figure remain.**



Corsica Absolute Altimeters Calibration

GPS / TIDE GAUGE

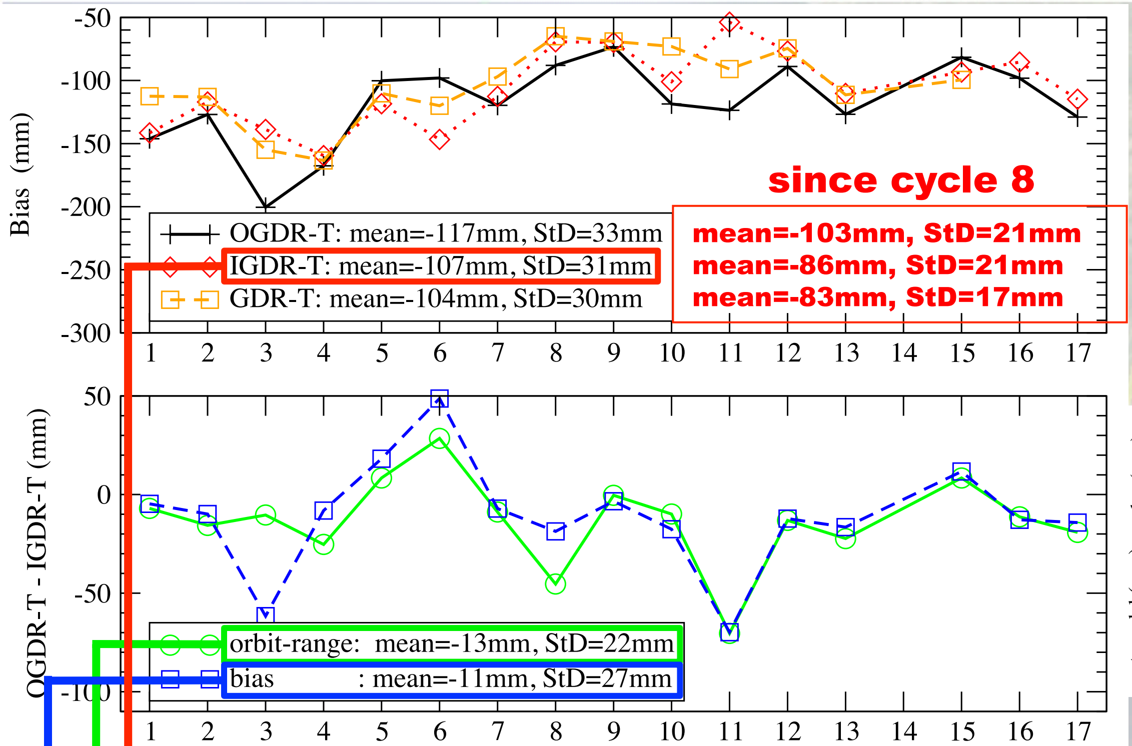
@ Tide gauge location, a clear instrumental bias has been identified from the 2 instruments

- ✓**-23 mm** (after tide gauge replacement in september 2009).
- ✓**-30 mm since the SARAL/AltiKa launch (very stable, only 5 mm rms)**.

⇒ **This bias remains unsolved:**

✓ **AJAC antenna change should not have impact (taken into consideration in the processing)**

✓ **Comparisons with the same GPS-zodiac @ Senetosa site do not exhibit any bias**



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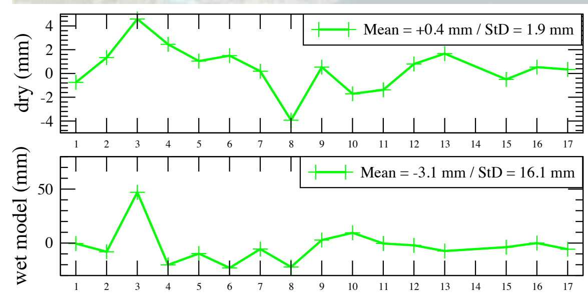
I/OGDR-T: in patch P2 since cycle 11
GDR-T: whole set in patch P2

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



OGDRT / IGDRT / GDRT

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 (31 mm) compararable to 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 (-20 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 3 mm between IGDR-T and GDR-T

Absolute SSH biases from tide gauge since cycle 8:

OGDR-T: -103 ±7 mm (9 cycles)
IGDR-T: -86 ±7 mm (9 cycles)
GDR-T: -83 ±6 mm (7 cycles)

Comparison between tide gauges and GPS-zodiac (IGDR-T):

Tide gauge: -86 ±7 mm (indirect method)
GPS (mean): -53 ±12 mm (semi-indirect method)
GPS (PCA): -60 ±9 mm (direct method)

⇒ **26 mm difference between tide gauge and GPS (PCA) methods/instruments**

- ✓ **30 mm comes from instrumental differences (comparisons @ tide gauge location): this remains unsolved**
- ✓ **Other effects: ocean dynamics? A high resolution model is in development to estimate the impact but it should be small**

CONCLUSION

SWH monitoring using GPS:

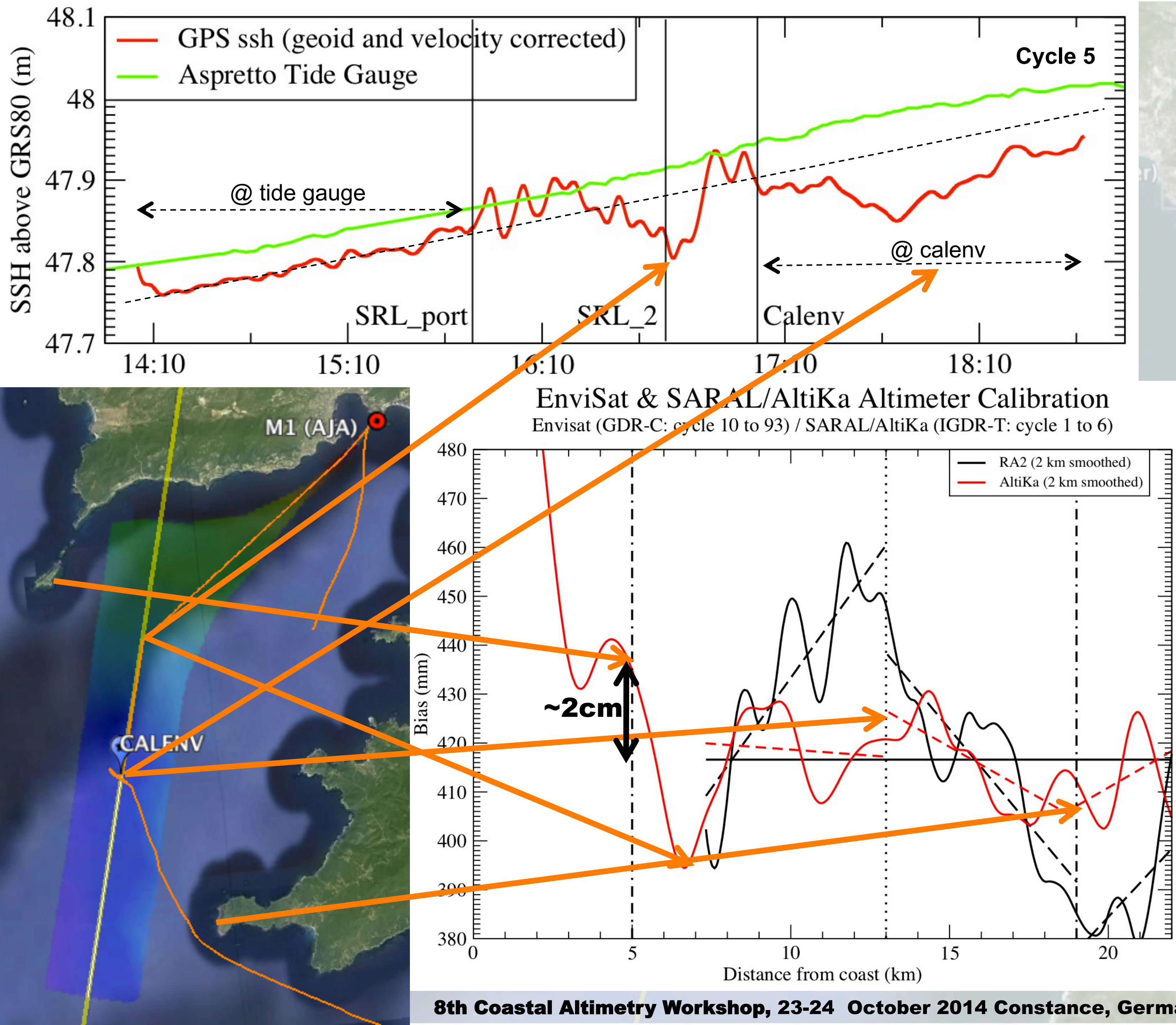
- ✓ **Altimeter SWH higher by ~7 cm**

Radiometer monitoring using GPS:

- ✓ **Radiometer dryer by ~10mm (mainly land contamination)**

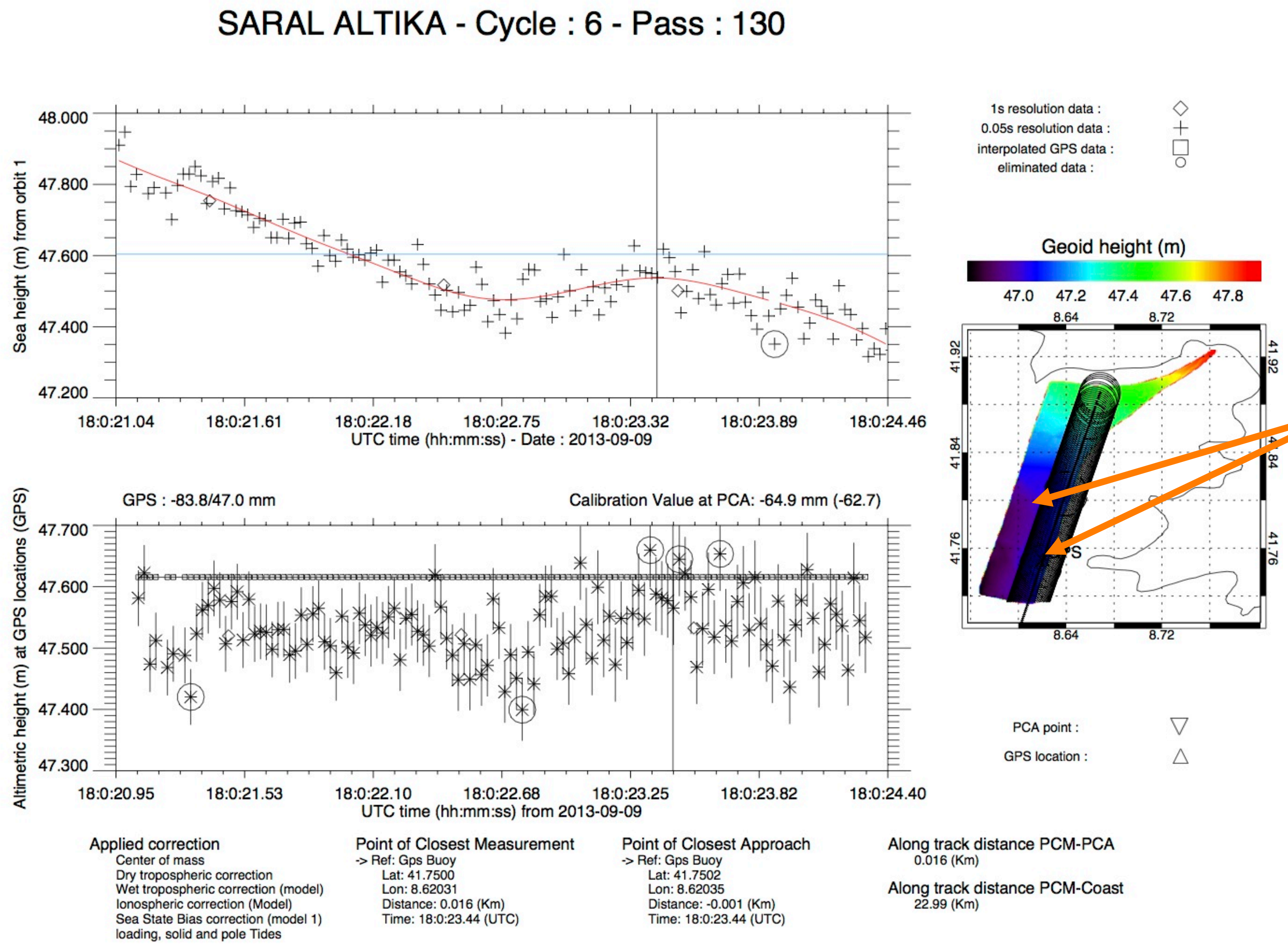
Rain impact:

- ✓ **No major impact on the SSH bias even during the Cleopatra storm (2013/11/18) but radiometer is wetter by ~50 mm**



Corsica Absolute Altimeters Calibration

ALTIMETER CONTAMINATION

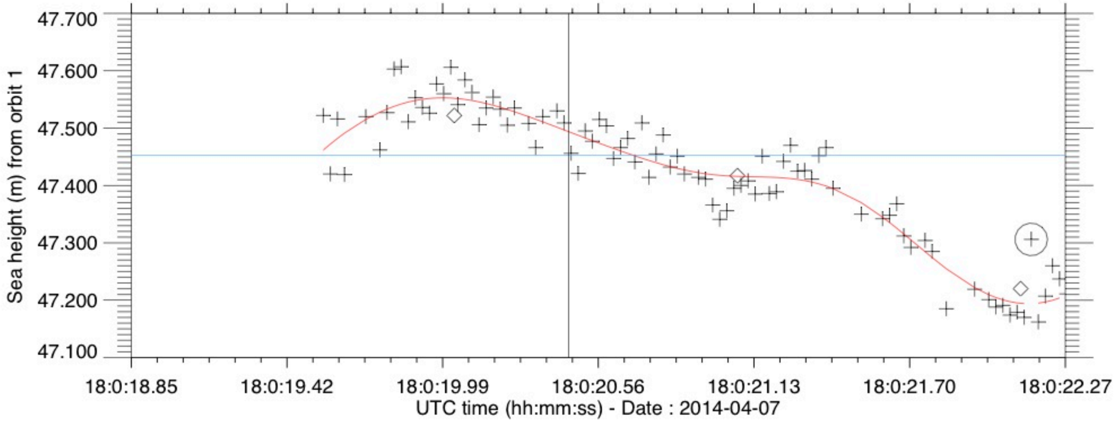


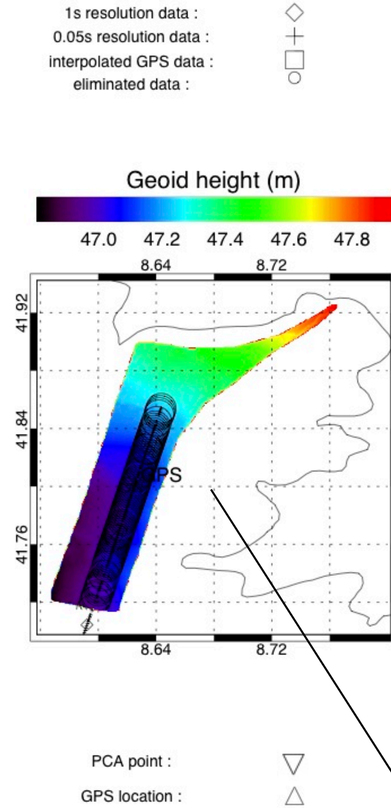
C R O S S T R A C K E F F E C T

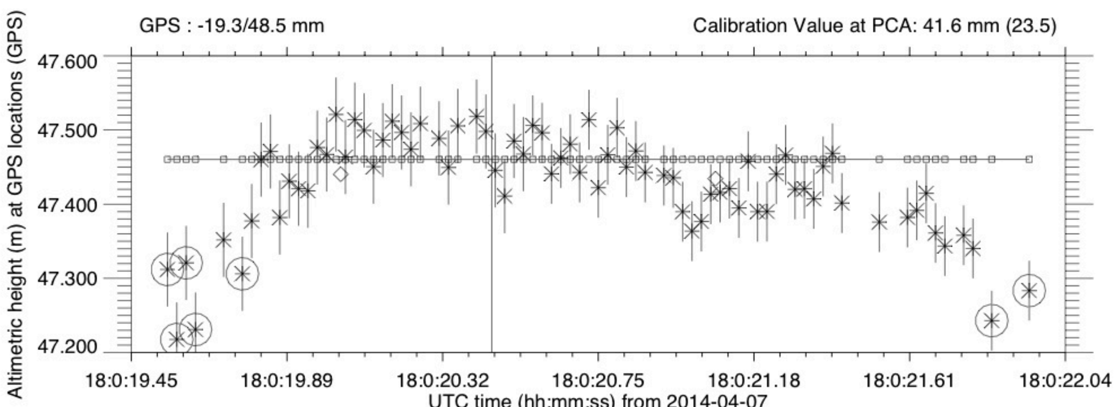
SARAL/AltiKa ground track shifted by ~2.5 km across-track toward east after the maneuvers performed end of July 2013

=> Use of real ground track prediction to plan the GPS-zodiac deployment

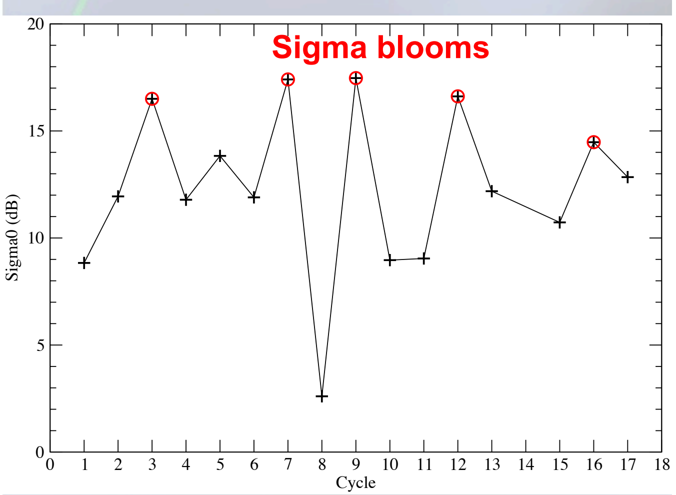
Corsica Absolute Altimeters Calibration

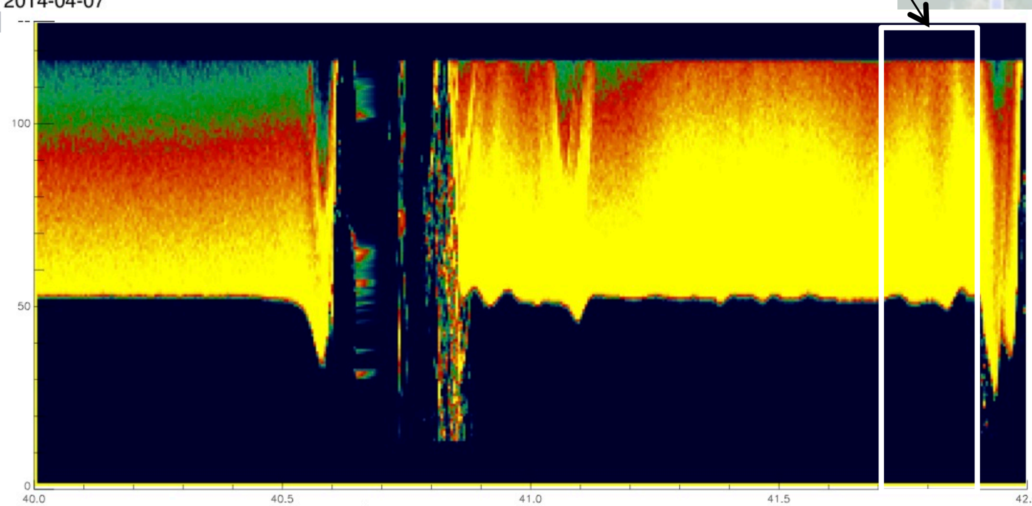




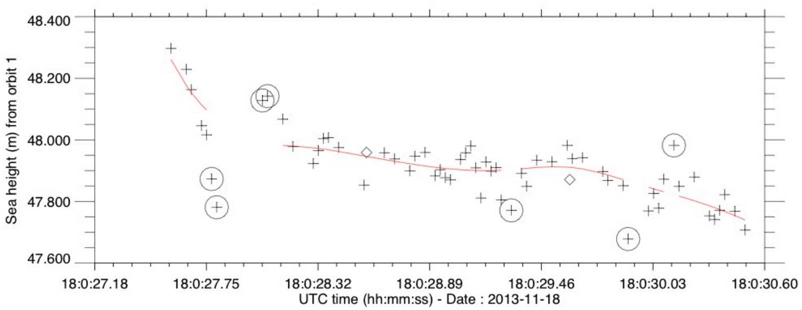


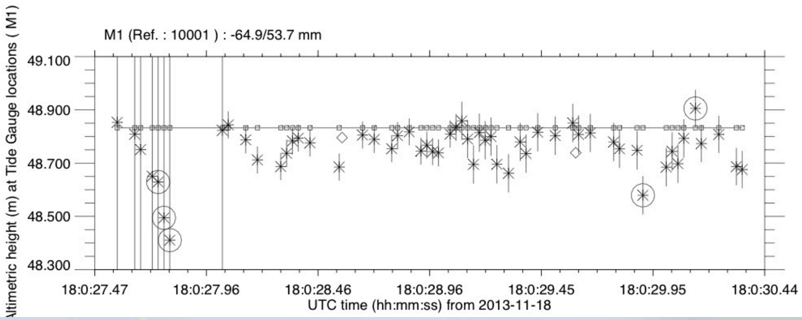
C Y C L E 1 2

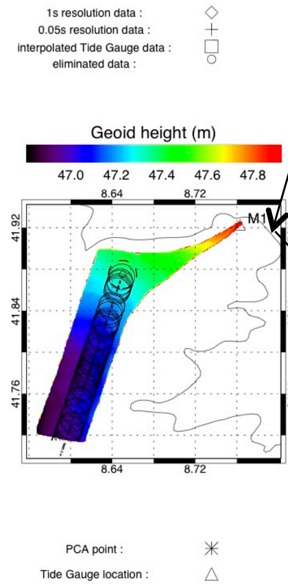




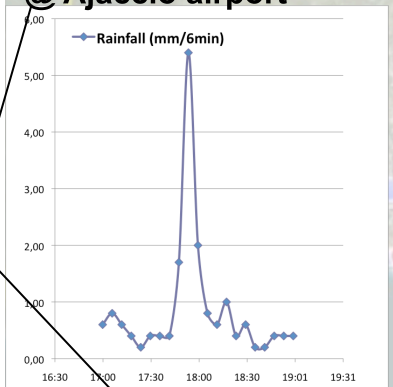
SARAL ALTIKA - Cycle : 8 - Pass : 130







Rainfall recorded @ Ajaccio airport



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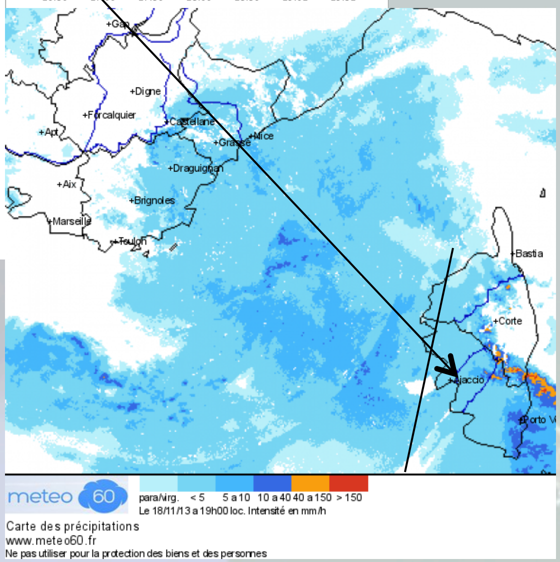
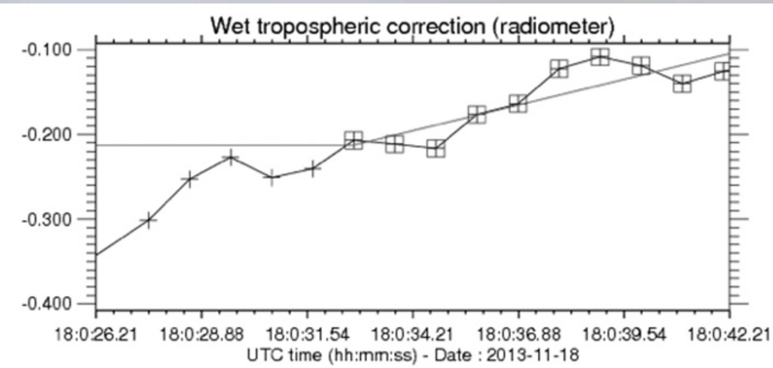
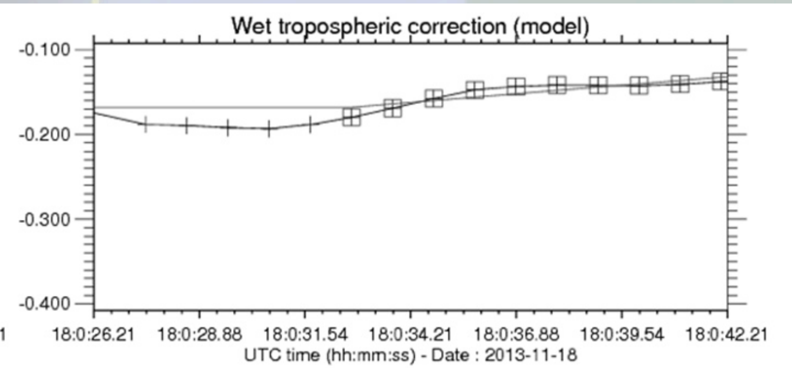


RAIN IMPACT

Cleopatra storm (2013/11/18):

- **20 mm/h @ overflight time (18h00)**
- **Some missing data but no clear impact on the SSH bias**
- **More impact on the radiometer**
    - **~50 mm wetter than GPS and model**
    - **Slope ~3 times stronger than model**





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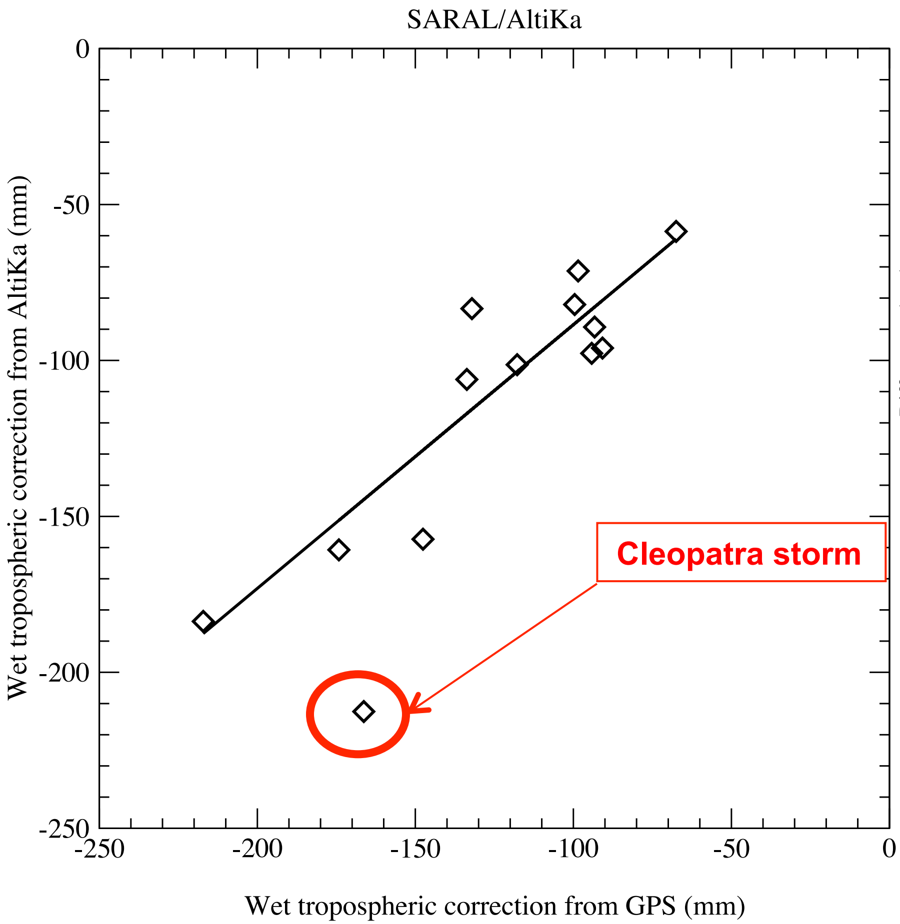
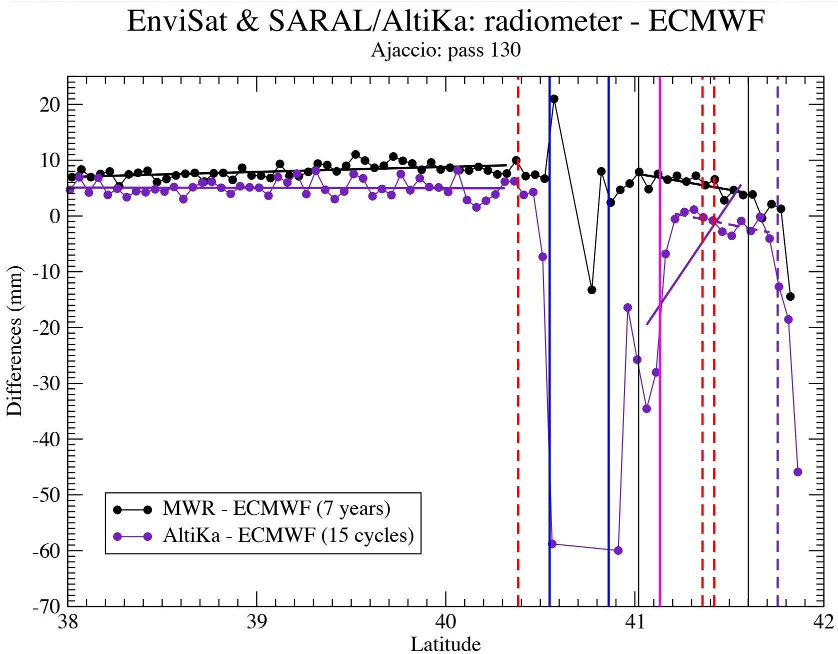
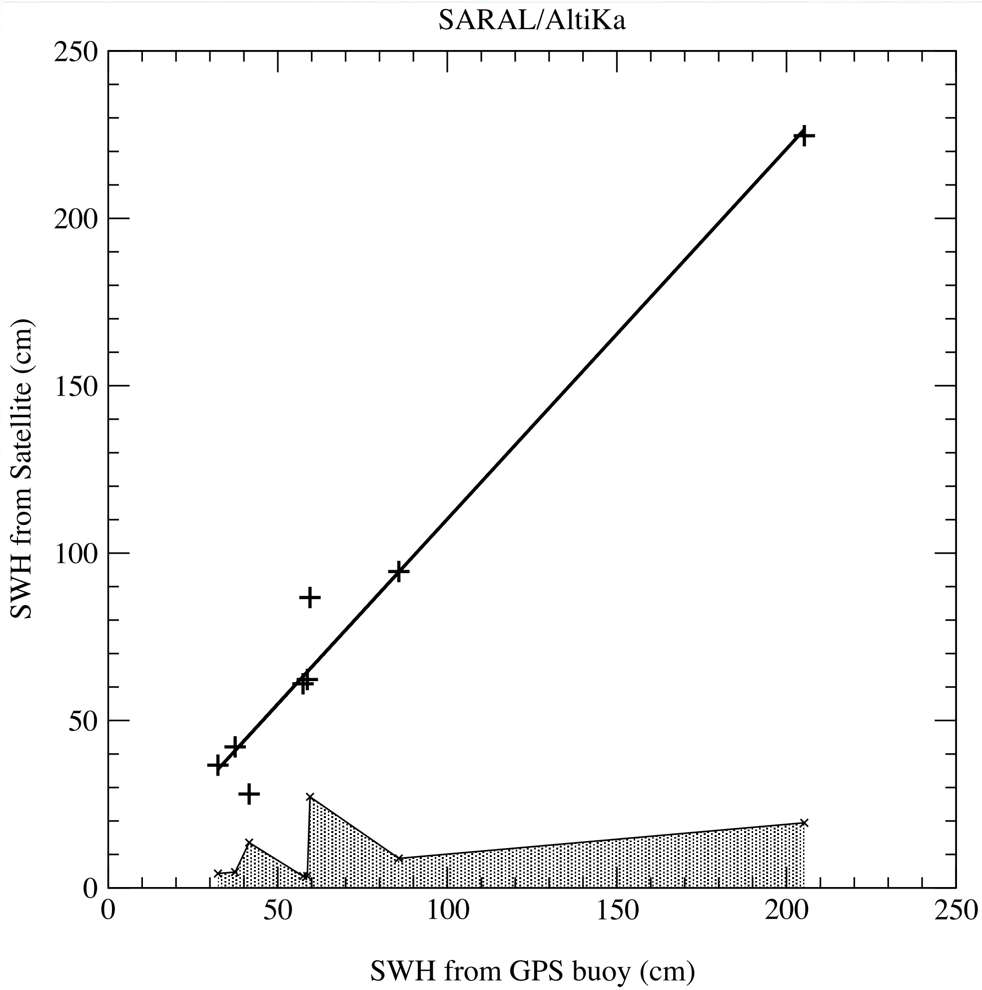
RADIOMETER VS GPS





Using GPS data from permanent receiver (AJAC) and pressure from Ajaccio weather station, the wet tropospheric correction is computed and compared to radiometer (no GPS data for cycle 1):

- **Cycle 8 clearly departs from the series: heavy rain during the Cleopatra storm**
- **Without cycle 8, Correlation: 91% (slope = 0.85 / bias at origin = -4 mm)**
- **Without cycle 8 radiometer exhibits a -10mm bias (dryer) compared to GPS; relatively strong standard deviation (~24 mm) compared to Jason-2 AMR (14 mm) but the number of cycle is small**



GPS buoy measurements also provide the sea height variations due to waves. The standard deviation on the GPS buoy sea height residuals (σ_{shr}) is the root square sum of σ_{gps} and σ_{wave} where σ_{wave} is the standard deviation of GPS buoy measurements due to waves and σ_{gps} the internal error of GPS buoy measurements; the GPS buoy internal error was estimated by processing kinematically a quasi-static session and is at the level of 2.6 cm (σ_{gps}).

$$\sigma_{shr}^2 = \sigma_{gps}^2 + \sigma_{wave}^2;\ \text{so},\ \sigma_{wave} = \sqrt{(\sigma_{shr}^2 - \sigma_{gps}^2)}.$$

SWH (or H1/3) is then deduced from the formula below (Stewart, 2008):

$$\mathbf{SWH_{buoy} = 4.\sigma_{wave}}$$

GPS BUOY FOR SWH

<u>SWH monitoring using GPS (±5min at overflight time):</u>

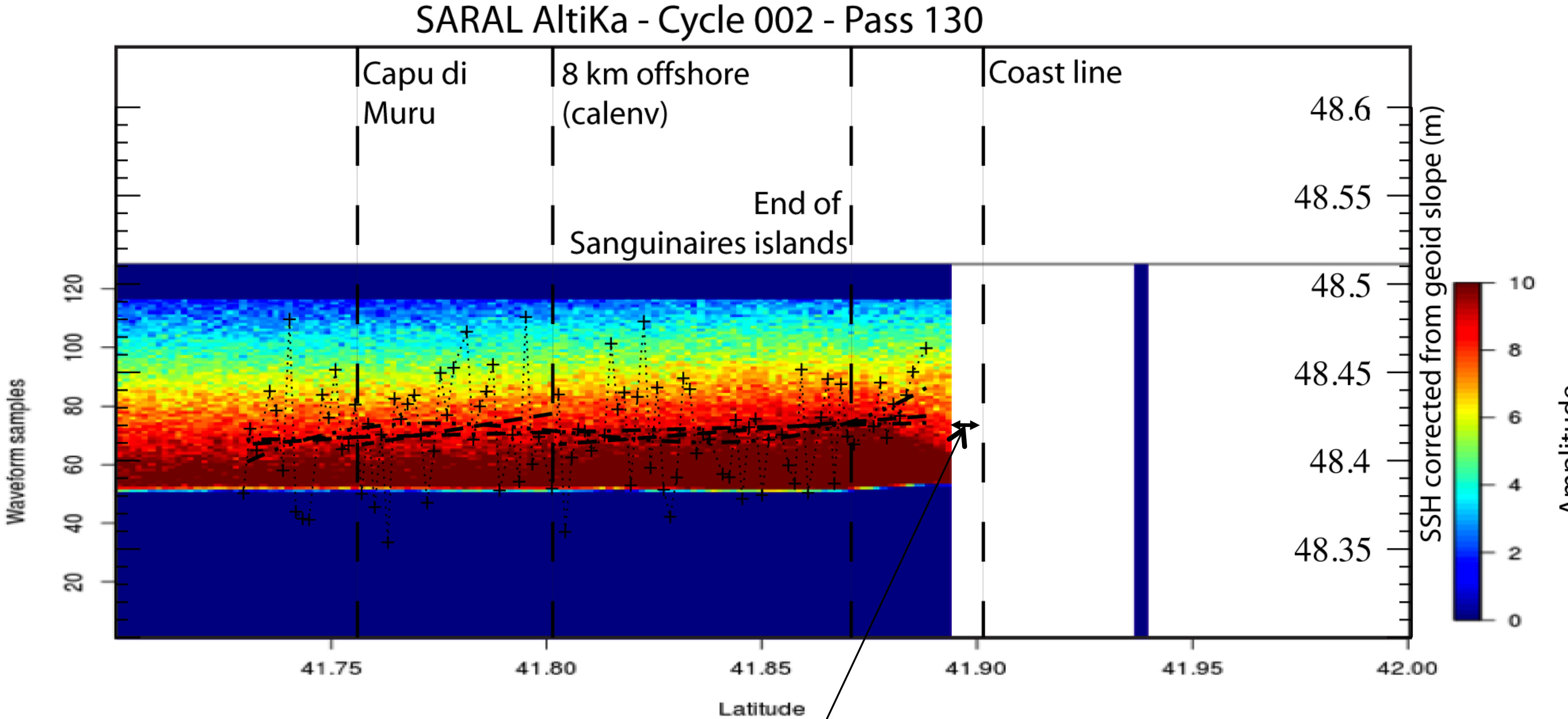
Differences (GPS-altimeter): -7 cm SWH bias (12 cm standard deviation)

Correlation: 99% (slope = 1.11 / bias at origin = 0 cm)

With such a correlation, the GPS-buoy that was primarily dedicated to measure the absolute sea surface height bias appears to be also an interesting solution to validate SWH from altimeters with enough precision.

Corsica Absolute Altimeters Calibration

DATA CLOSER TO THE COAST



- ✓ **~18% of valid (and good) data @ 2-3 km**
- ✓ **~46% @ 3-6 km**
- ✓ **~83% @ >6 km**