Corsica: linking historical and current missions with Sentinel-3A

P. Bonnefond[1], P. Exertier[2], O. Laurain[2], F. Boy[3], A. Guillot[3] , T. Guinle[3] , N. Picot[3] , P. Féménias[4], S. Labroue[5], M. Raynal[5]

(1) Observatoire de Paris/SYRTE, Paris, France

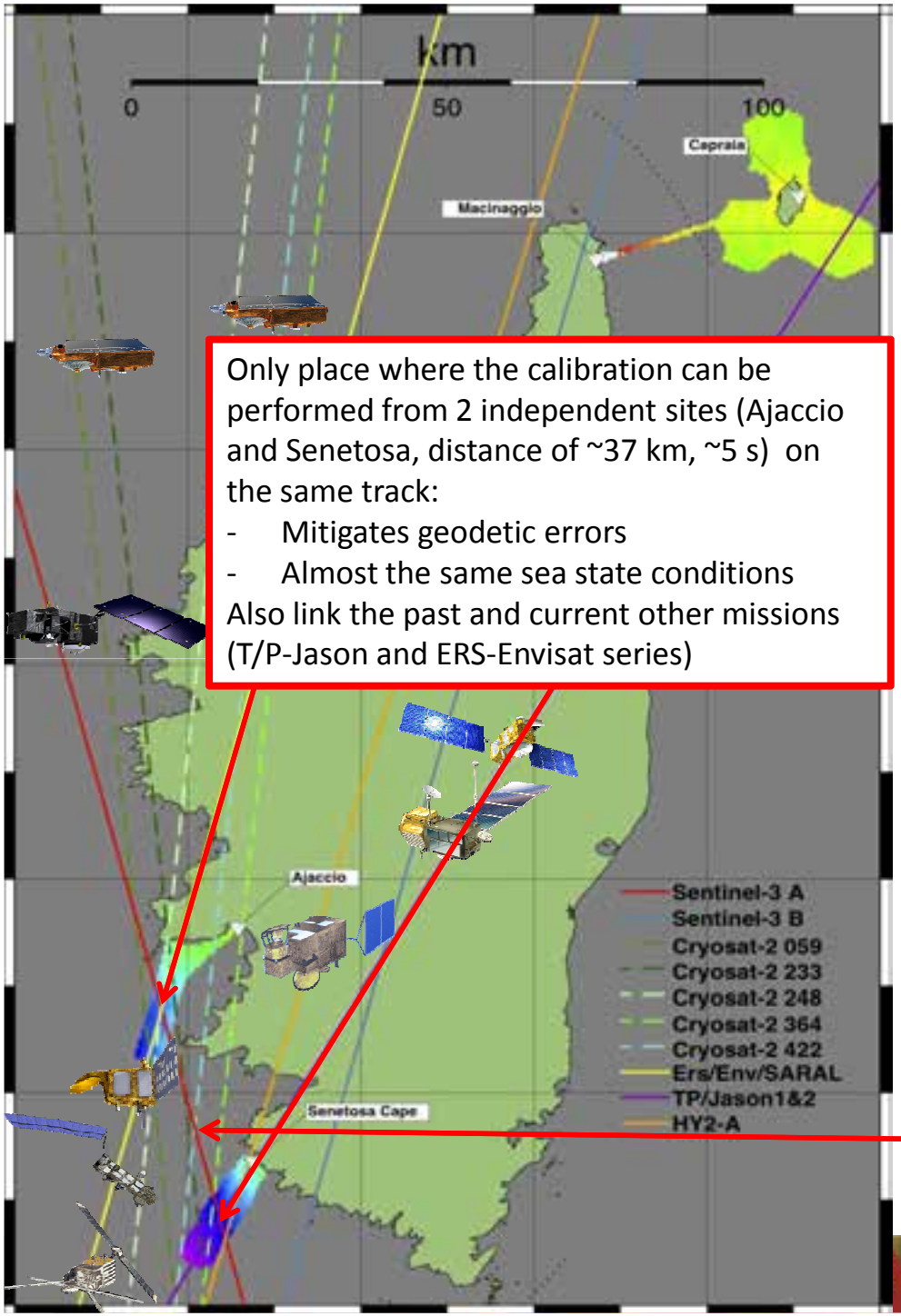
(2) OCA/Geoazur, Sophia-Antipolis, France

(3) CNES, Toulouse, France

(4) ESA/ESRIN, Frascati, Italy

(5) CLS, Toulouse, France

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**

Data used

- *Data sources*

  S3-PDGS: http://archive.eumetsat.int/usc/ (IPF-SM-2 05.03.16)

  S3PP: PEACHI V1.0 from CNES

- *Sentinel-3A SRAL data processing for SARM and PLRM*

  Correction applied

  - *Dry tropo. -> model*
  - *Wet tropo. -> model (PDGS,radiometer absent, c.f. Anomaly #5*)*
  - *Iono. -> model (PDGS, dual wrong for some 20Hz (Anomaly #3*) and bias (Notice #3*))*
  - *SSB -> 3.5% of SWH (PDGS, model absent, c.f. Anomaly #5*)*
  - *Solid, loading and pole tides*

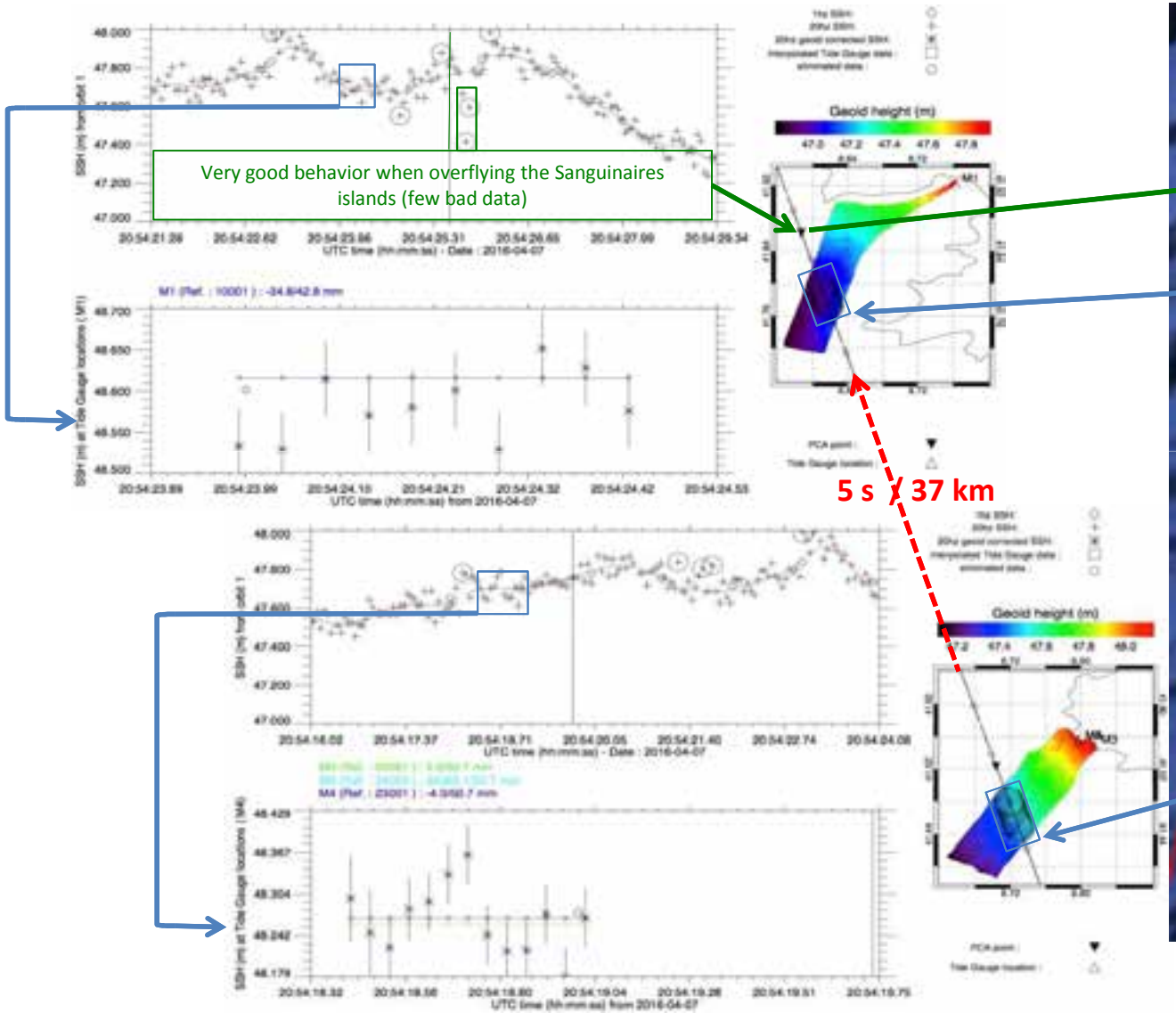
  Range bias applied for cycle 2 (PDGS, 59.3mm, c.f. Notice #8)*

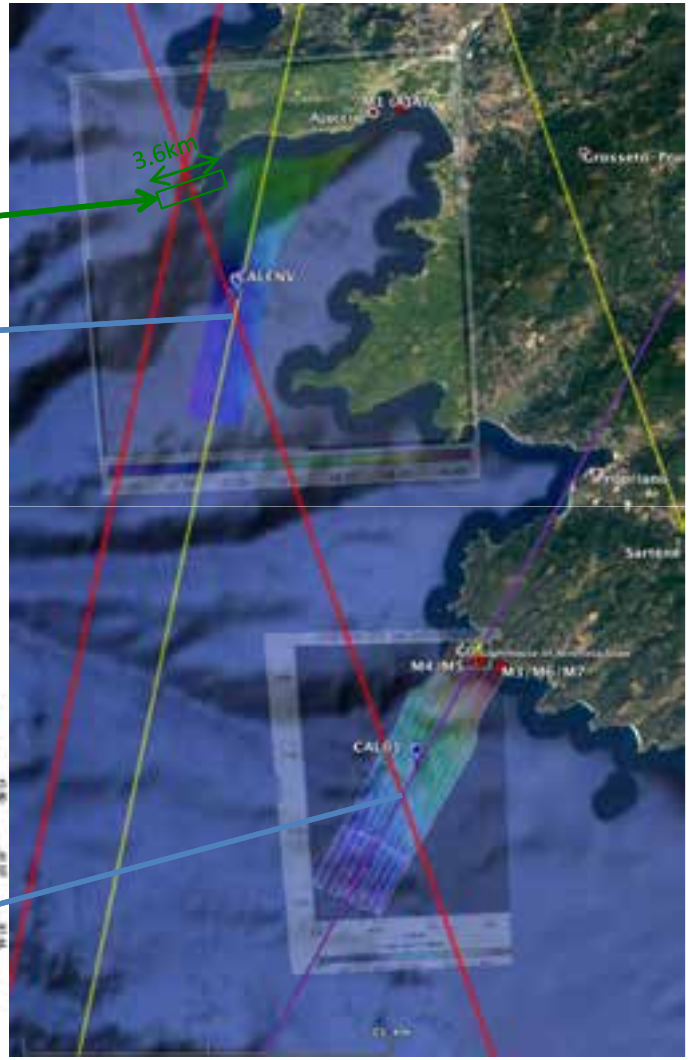
- *In situ data*
  - *Ajaccio: SHOM radar tide gauge data in real time*
  - *Senetosa: pressure tide gauges (data retrieved end of September)*

*From S-3 Product Notice S3MPC.PN-STM.001, 25/07/2016

Processing

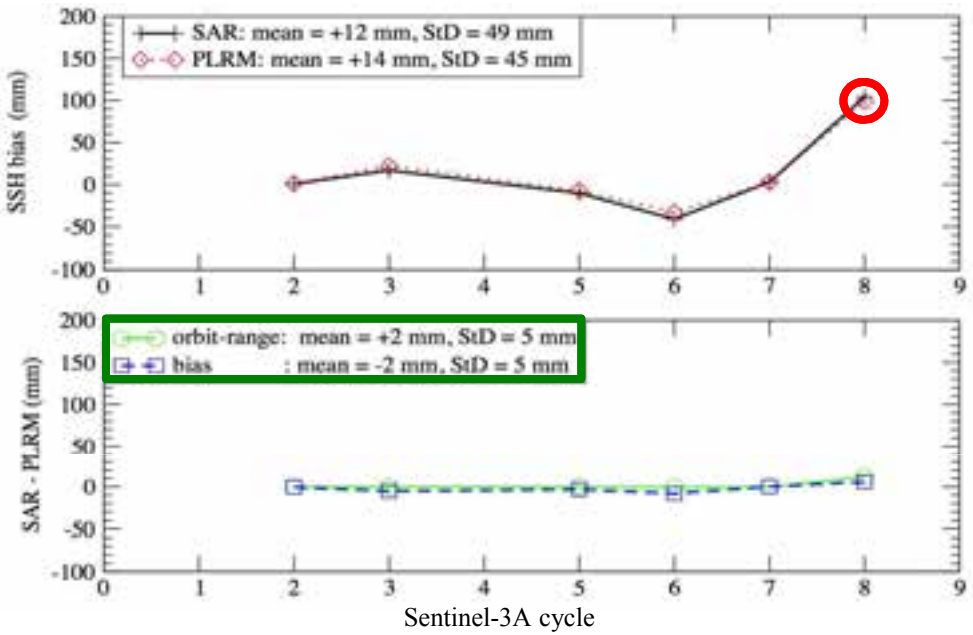
Sentinel-3A, SAR mode
Pass 741, Cycle 2, 2016-04-07 20:54

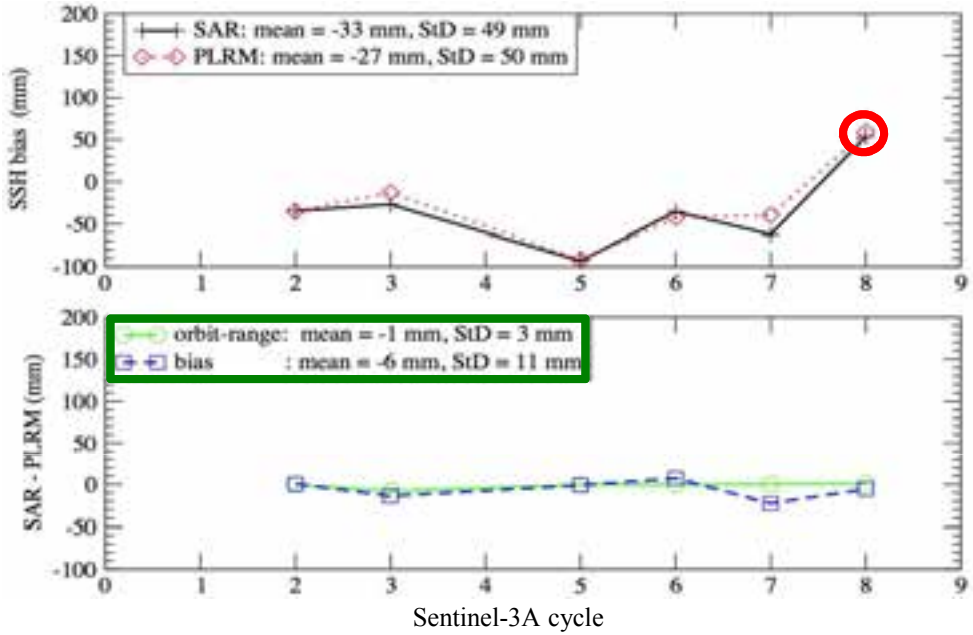




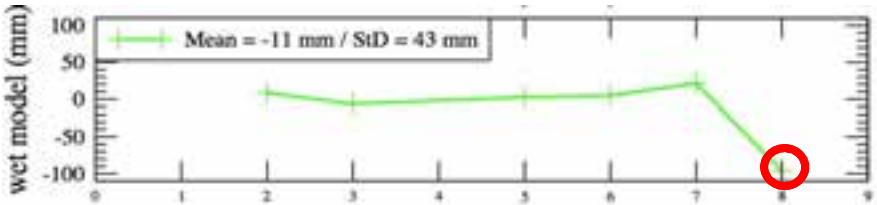
Absolute SSH biases (PDGS: SARM & PLRM)

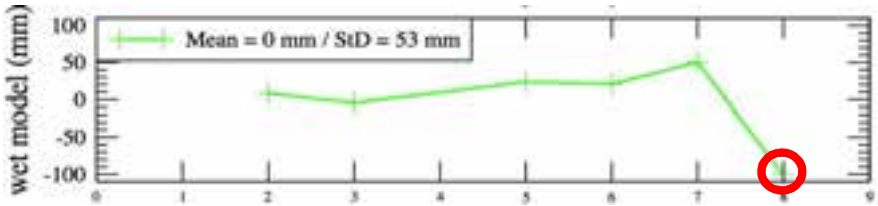
Senetosa ---------- 5 s / 37 km ----------> Ajaccio





- **Negligible and very stable difference between SARM and PLRM modes**
- **Cycle 8 outlier due to erroneous wet correction**
- Difference of ~40 mm for SARM and PLRM between Ajaccio and Senetosa (see next slide)

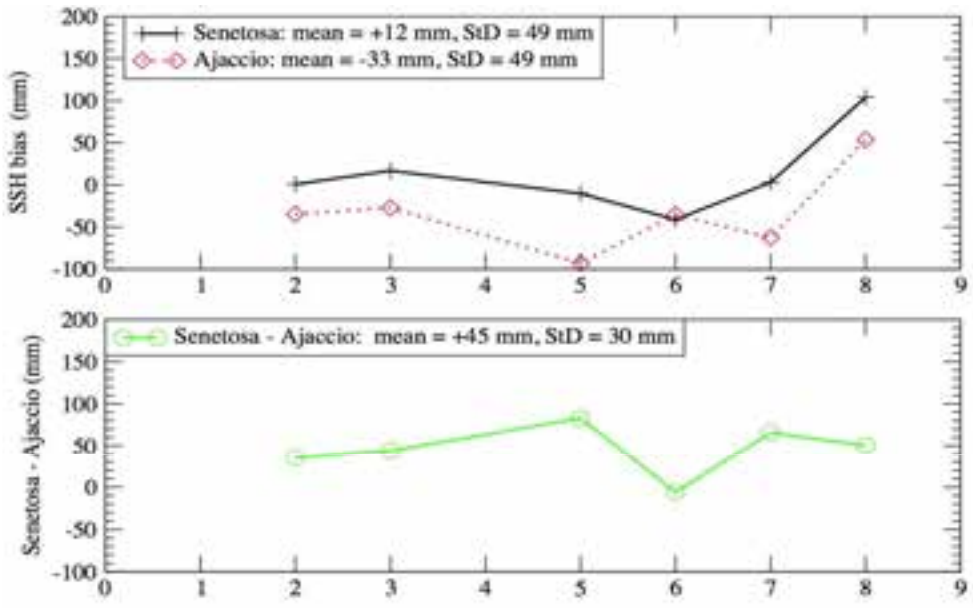




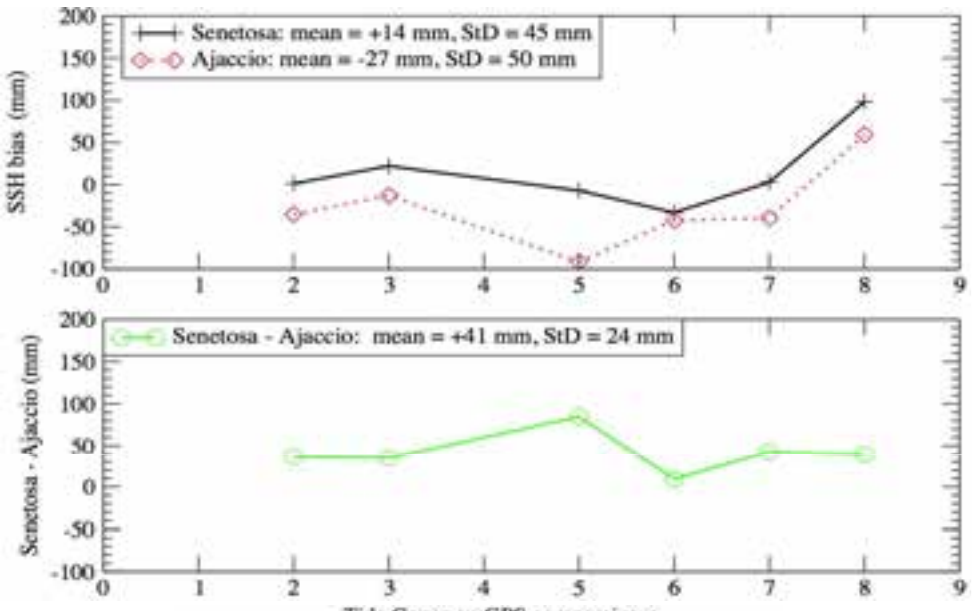
PGDS – S3PP Wet model correction: ~10 cm error for cycle 8

Absolute SSH biases (Senetosa-Ajaccio)

PDGS Products (SARM mode)



PDGS Products (PLRM mode)



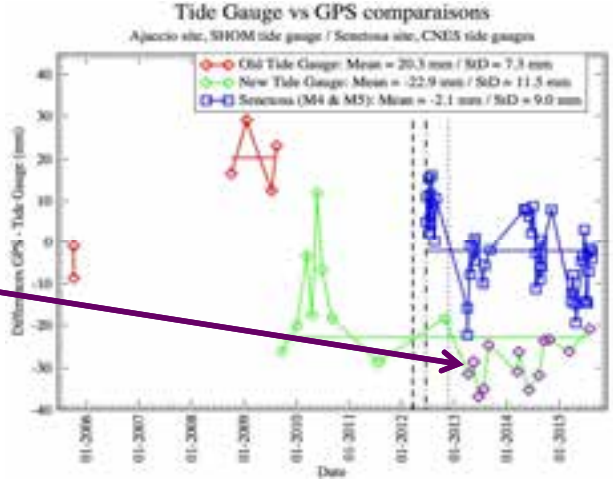
SSH bias differences (Senetosa minus Ajaccio) from PDGS and S3PP

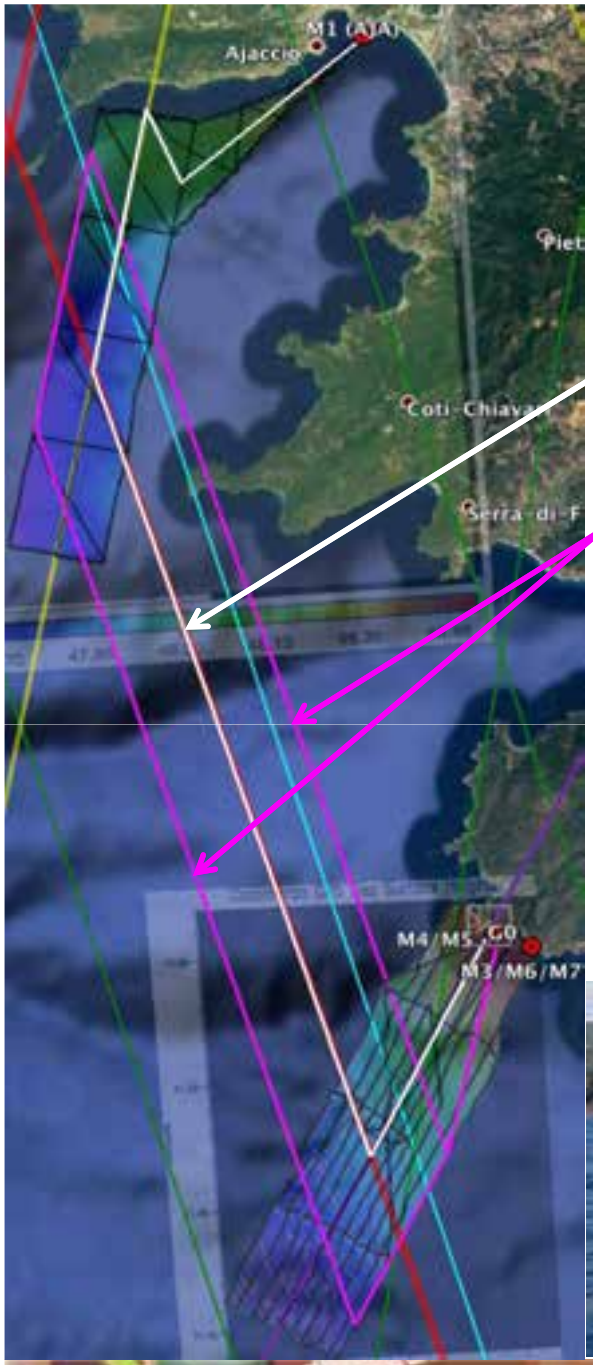
	PDGS SSH bias (mm)	S3PP SSH bias (mm)	Mean (mm)
SARM	+45	+27	+36
PLRM	+41	+37	+39
Mean (mm)	+43	+32	+38

Ajaccio tide gauge:

=> difference of -30 ± 5 mm found thanks to GPS-tide gauge comparisons

This confirms previous results notably with SARAL/AltiKa





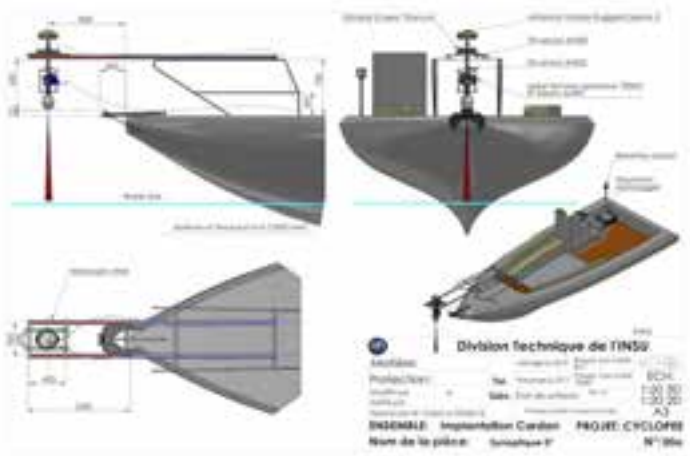
Planned connection between Senetosa and Ajaccio site

1. The first step will be realized in 2017 by linking the two existing local geoids at Senetosa and Ajaccio following the Sentinel-3A ground track (see white line).
2. In a second step, two lines will be measured on both sides (± 3 km, see magenta lines) of the Sentinel-3 ground track in order to be able to correct the full altimeter footprint from cross-track geoid gradient.

Two GNSS instruments will be used

CalNaGeo (floating sheet)

Cyclopee (GNSS+Radar)



Absolute SSH biases (PDGS-S3PP)

Statistics from PDGS product:

	Range	
	SSH bias / StD in mm	Orbit - Range in mm
Ajaccio		
SARM	-33 ± 20	
PLRM	-27 ± 20	
SARM-PLRM	-6 ± 5	-1 ± 1
Senetosa		
SARM	+12 ± 20	
PLRM	+14 ± 18	
SARM-PLRM	-2 ± 2	+2 ± 2

Statistics from S3PP product:

	Range	
	SSH bias / StD in mm	Orbit - Range in mm
Ajaccio		
SARM	-22 ± 7	
PLRM	-63 ±13	
SARM-PLRM	+38 ± 9	+41 ± 11
Senetosa		
SARM	+5 ± 6	
PLRM	-26 ± 6	
SARM-PLRM	+29 ± 9	+29 ± 8

SARM-PLRM averaged SSH bias differences from PDGS product:

	SSH bias differences (mm)	Orbit – Range differences (mm)
SARM-PLRM	-4 ± 2	+1 ± 2

No significant difference between SARM and PLRM for PDGS

SARM averaged SSH bias differences from PDGS-S3PP:

	SSH bias (mm)	Orbit – Range (mm)
SARM	-4 ± 19	-2 ± 4

No significant difference for SARM between PDGS and S3PP

SARM-PLRM averaged SSH bias differences from S3PP product:

	SSH bias differences (mm)	Orbit – Range differences (mm)
SARM-PLRM	+34 ± 6	+35 ± 10

+35 mm difference in range between SARM and PLRM for S3PP

Conclusion

- Averaged SSH bias from PDGS and S3PP (SARM and PLRM)

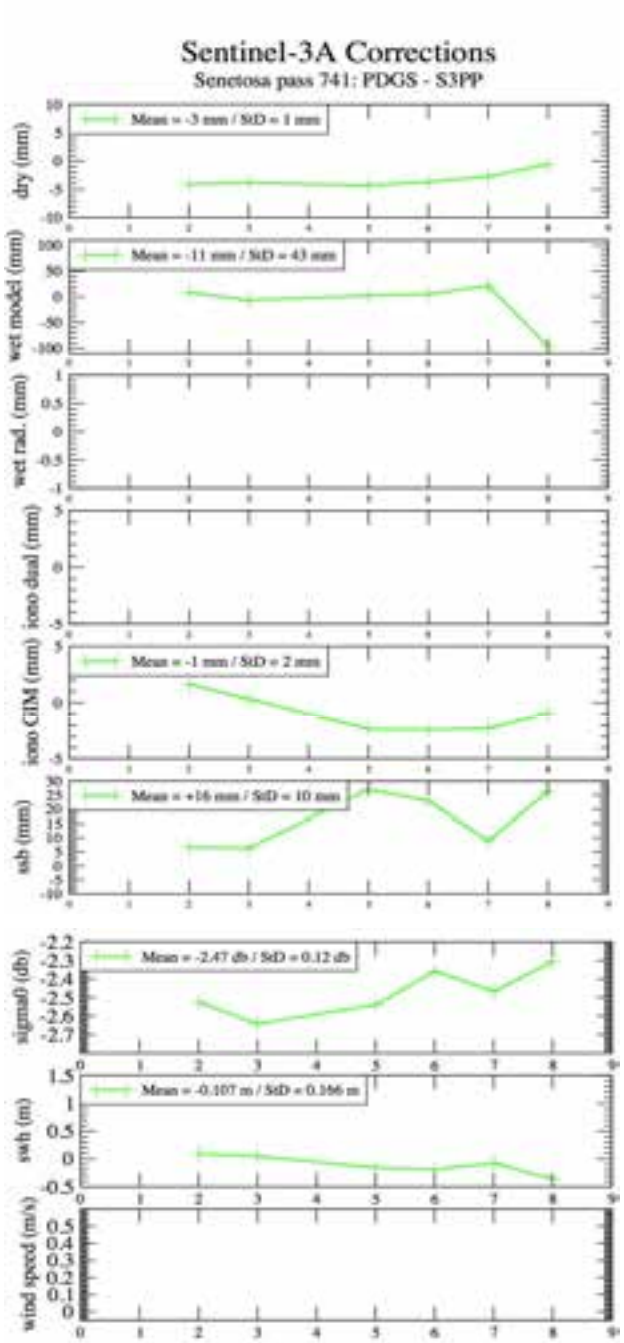
  (average from Ajaccio and Senetosa with a 30 mm correction for Ajaccio tide gauge)

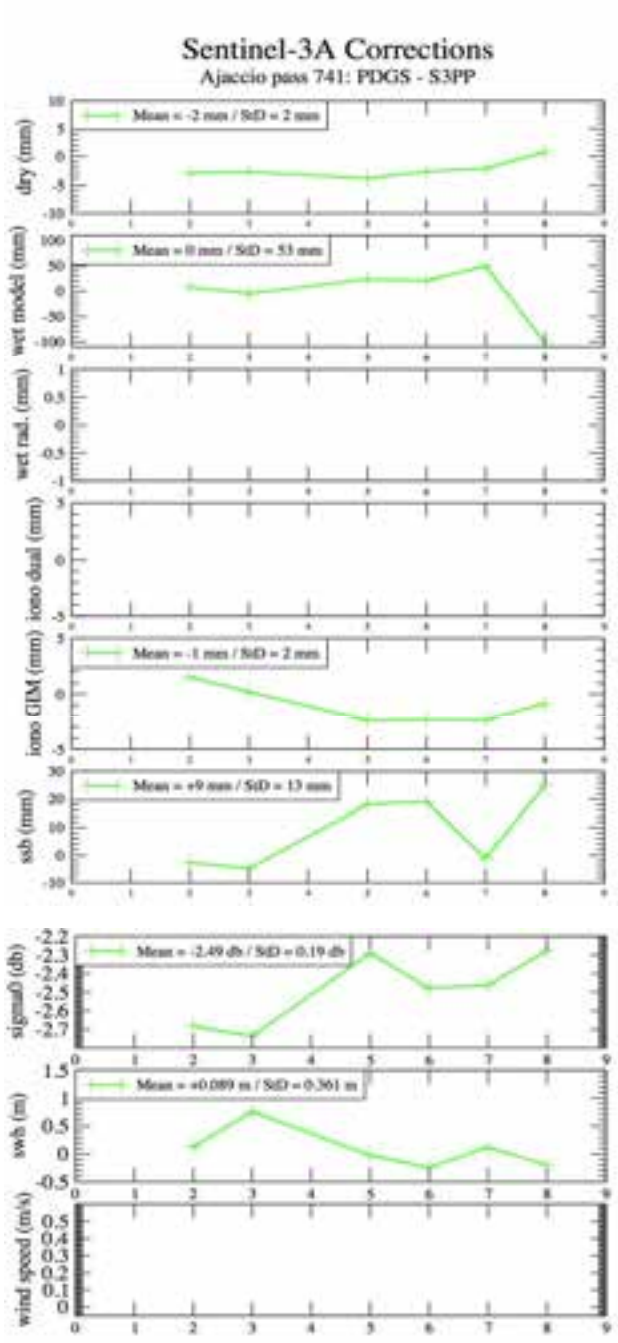
	PDGS SSH bias (mm)	S3PP SSH bias (mm)
SARM	+5 ± 14	+6 ± 5
PLRM	+8 ± 13	-30 ± 7

- SSH bias equivalent for SARM and PLRM modes for PDGS product
  - ⇒ **The SSH is «unbiased » in PDGS product (SARM and PLRM mode) without clear dependency with SWH**
  - ⇒ On the same time period, Jason-2 and Jason-3 SSH biases are -10 ±9 mm and -50 ±8 mm respectively (see dedicated presentation on Wednesday at 14:45)
- +34 mm SSH bias difference for SARM and PLRM modes for S3PP product
  - ⇒ **The SSH from PLRM is lower by 34 mm in S3PP product (anomaly identified and corrected, reprocessing ongoing)**
- Other differences between PDGS and S3PP come from corrections (mainly SSB and wet tropo.)

	Senetosa	Ajaccio
Correction	Mean / Standard Deviation	Mean / Standard Deviation
Wet tropo.	-11 / 43 mm	0 / 53 mm
SSB	+16 / 10 mm	+9 / 13 mm
Sigma0	-2.47 / 0.12 dB	-2.49 / 0.19 dB
SWH	-0.107 / 0.166 m	+0.089 / 0.361 m

Backup Slides

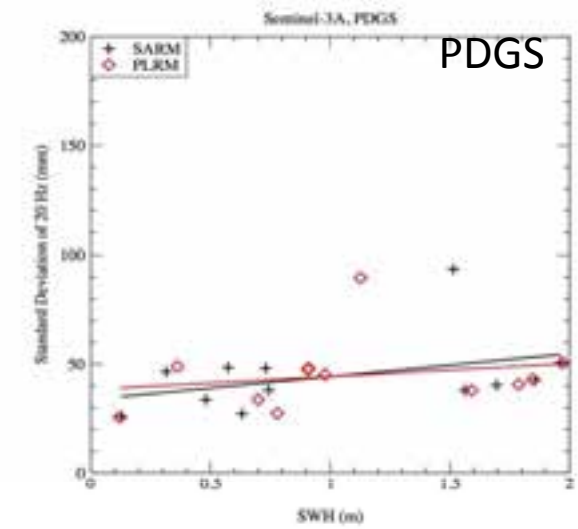

Sentinel-3A Corrections
Senetosa pass 741: PDGS - S3PP
dry (mm)
Mean = -3 mm / StD = 1 mm
wet model (mm)
Mean = -11 mm / StD = 43 mm
wet rad. (mm)
iono dual (mm)
iono GIM (mm)
Mean = -1 mm / StD = 2 mm
ssb (mm)
Mean = +16 mm / StD = 10 mm
sigma0 (db)
Mean = -2.47 db / StD = 0.12 db
swh (m)
Mean = -0.107 m / StD = 0.166 m
wind speed (m/s)

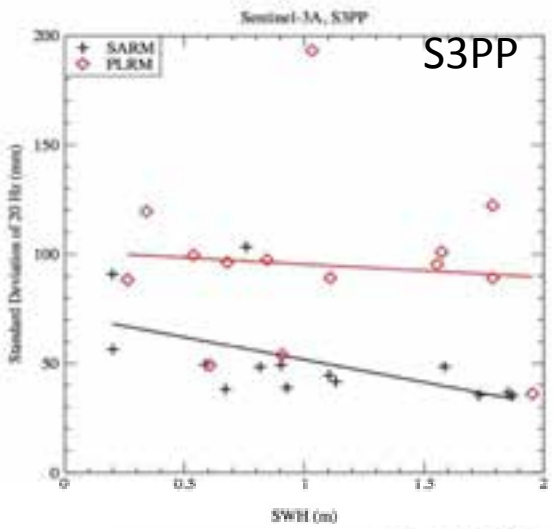

Sentinel-3A Corrections
Ajaccio pass 741: PDGS - S3PP
dry (mm)
Mean = -2 mm / StD = 2 mm
wet model (mm)
Mean = 0 mm / StD = 53 mm
wet rad. (mm)
iono dual (mm)
iono GIM (mm)
Mean = -1 mm / StD = 2 mm
ssb (mm)
Mean = +9 mm / StD = 13 mm
sigma0 (db)
Mean = -2.49 db / StD = 0.19 db
swh (m)
Mean = +0.089 m / StD = 0.361 m
wind speed (m/s)

Standard deviation of 20 Hz data

	Mean of StD of 20 Hz (mm)	
	PDGS	S3PP
Ajaccio		
SARM	52 ± 8	59 ± 10
PLRM	52 ± 8	109 ± 14
Senetosa		
SARM	36 ± 4	43 ± 3
PLRM	38 ± 4	81 ± 13
Both		
SARM	44 ± 5	51 ± 6
PLRM	45 ± 5	90 ± 10

SWH dependency





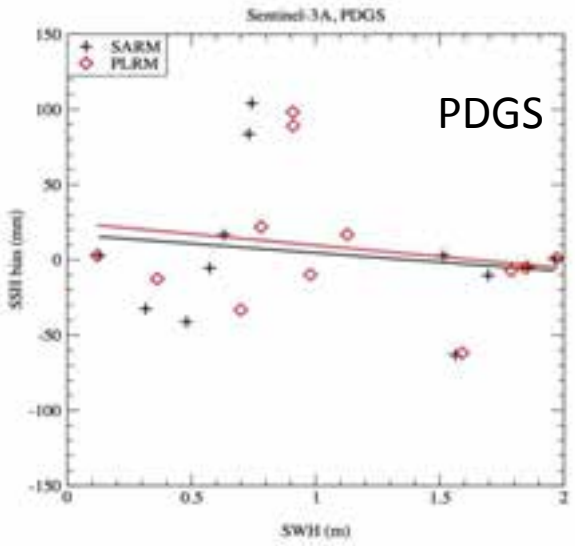
Standard Deviation

No clear dependency of the Standard Deviation of the 20 Hz data as a function of SWH

However, SARM and PLRM have similar standard deviation for PDGS product while PLRM standard deviation is higher for S3PP (as expected)

SSH bias

No clear dependency of the SSH bias as a function of SWH



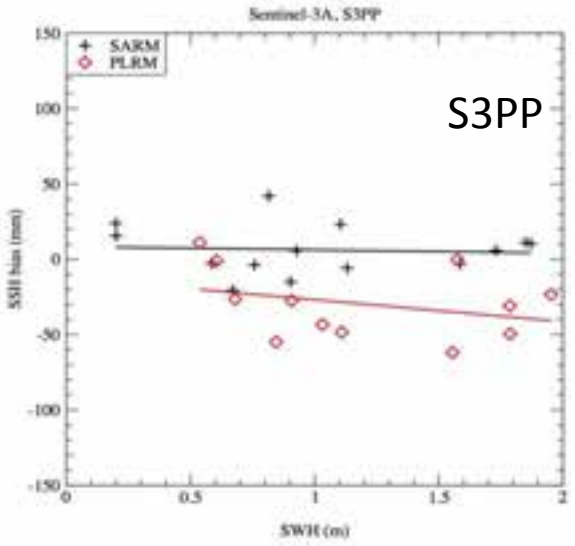
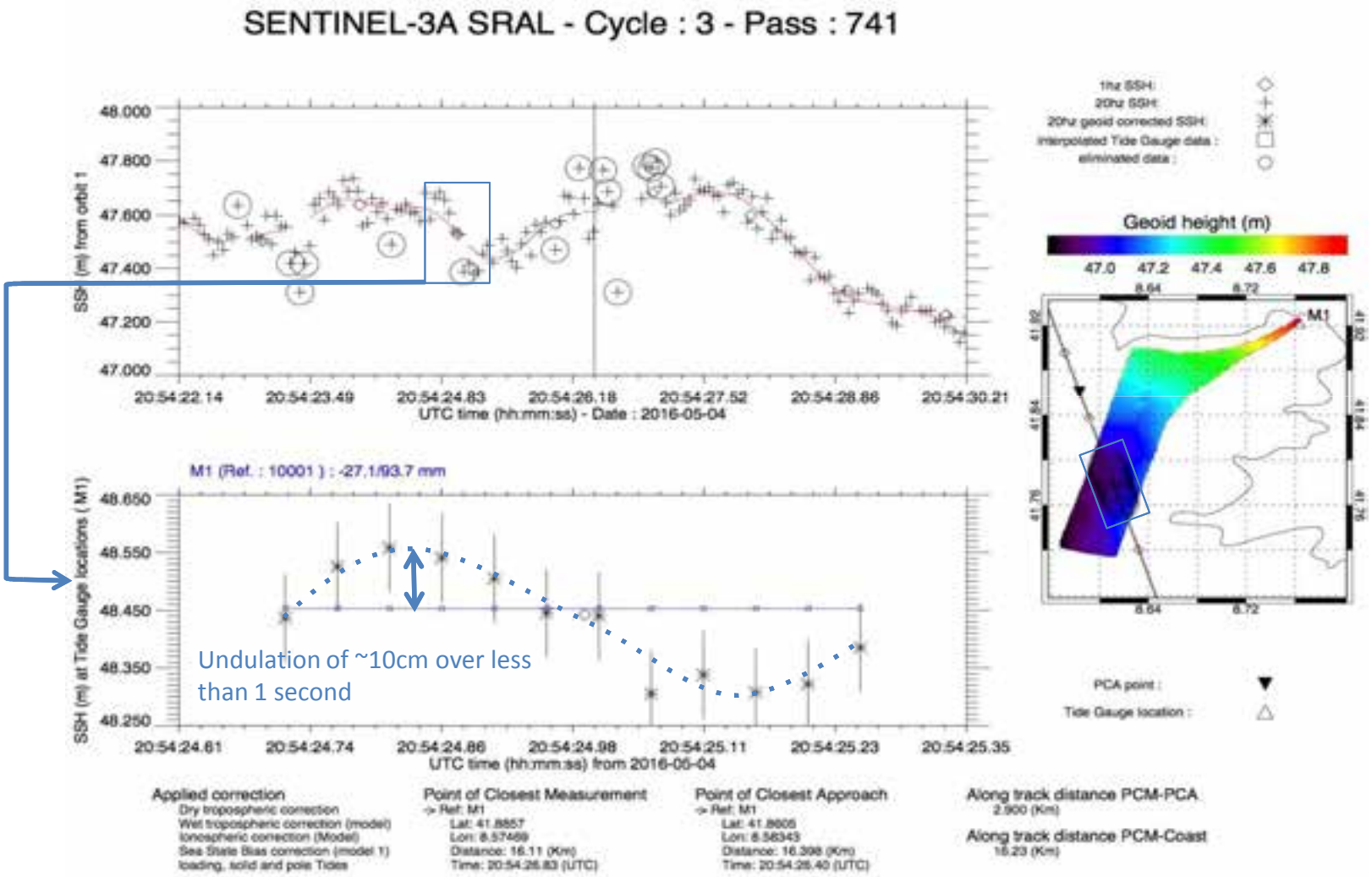
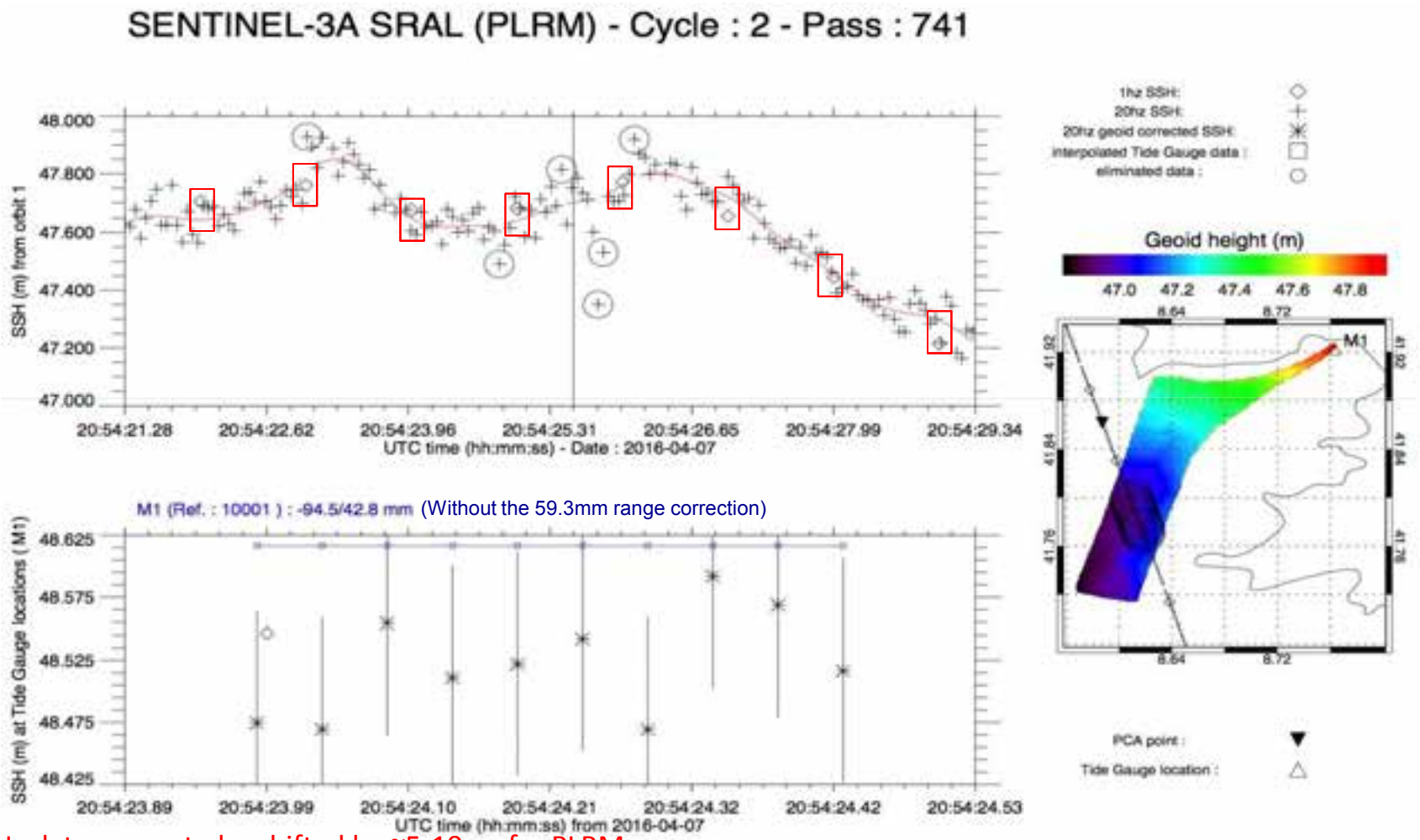


Illustration of sigma bloom



SARM vs PLRM



- Some 1Hz data seems to be shifted by ~5-10cm for PLRM
- Not the same slope between SARM and PLRM (~2.5cm over 56km => 0.5mm/km)