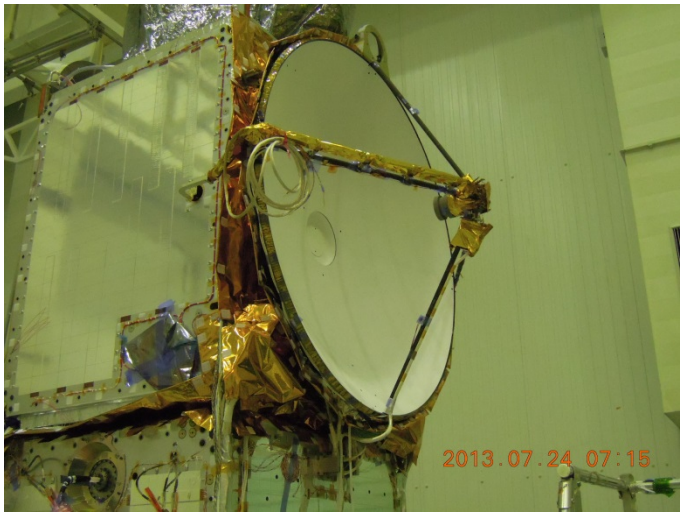
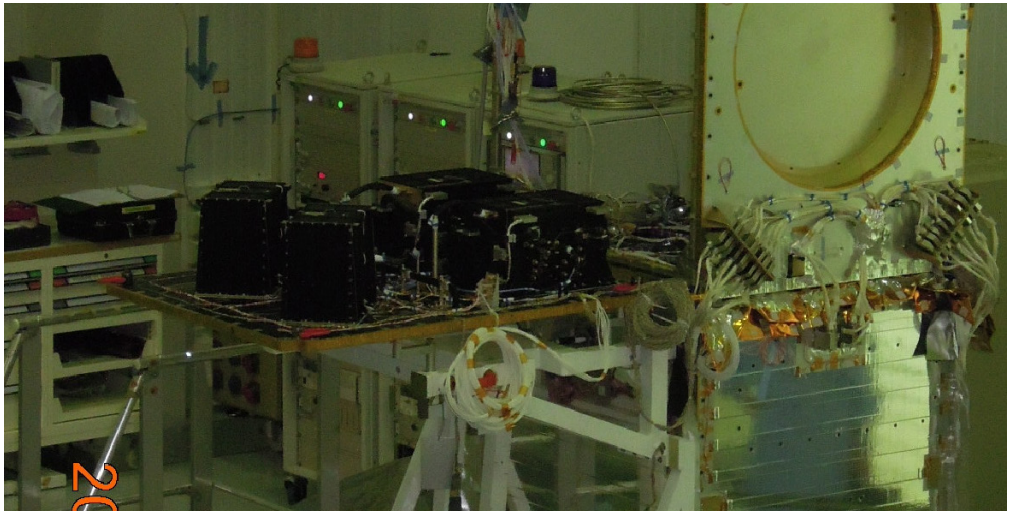
POSEIDON-3B Altimeter





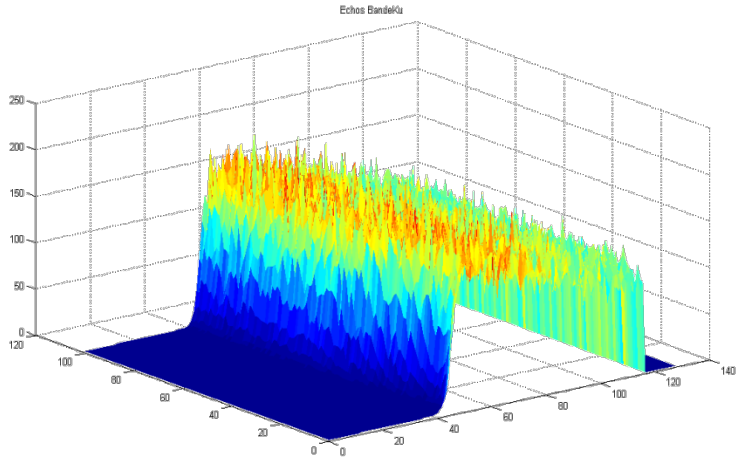
JD. Desjonquères[1], S. Legac[1], JC. Poisson[2], F. Piras[2]

[1] CNES, [2] CLS

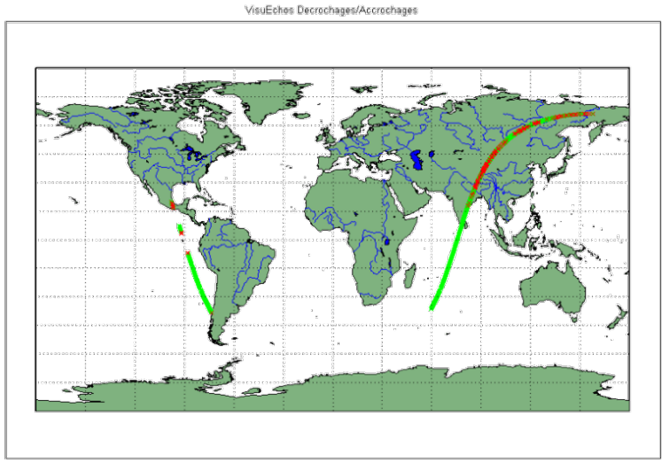
Altimeter First switch ON: 19/01/2016 @16h12

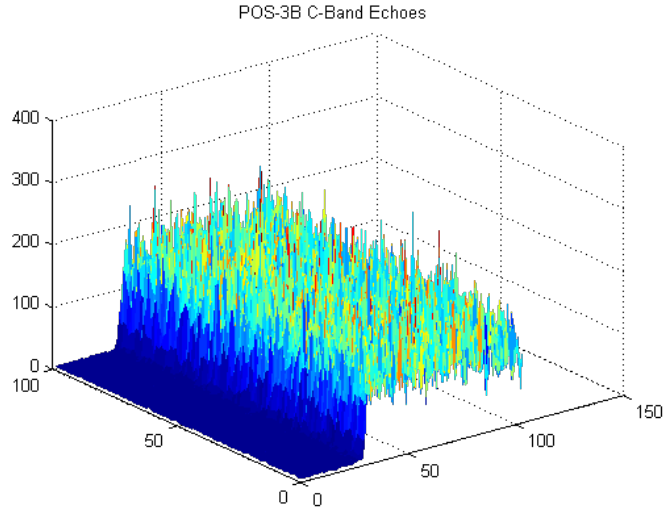
On the injection orbit ~-20 km nominal orbit 2 days after launch

(need dedicated parameters)



First Ku-Band Over Ocean Echoes





First C-Band Over Ocean Echoes

Poseidon-3B Characteristics

Radar characteristics are similar to Jason-2 / Poseidon-3 altimeter

- Ku & C band radar with BW = 320 MHz and PRF ~2060 Hz
- -> Measurement Performances are similar

Main difference: tracking

- **New: automatic transition between autonomous tracking mode (median tracker) and open loop mode (Diode/DEM coupling mode)**

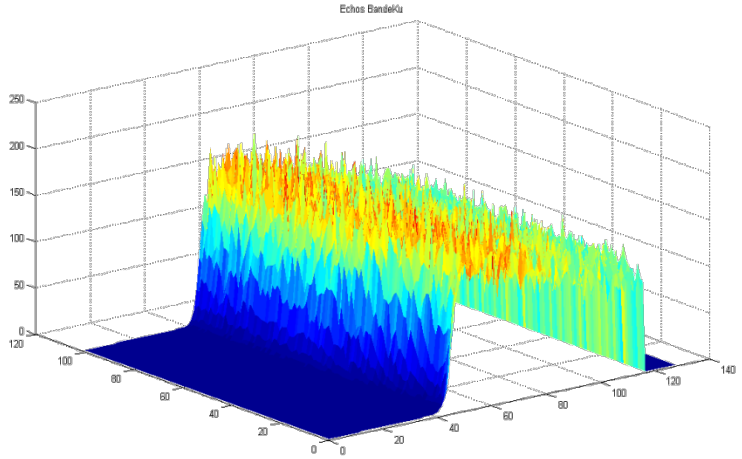
Redundant and Bi frequency Altimeter for high reliability and ionosphere delay correction	
Altimeter Measurement Accuracy	~1.6cm (1s/ 2m SWH), Ku Range (MLE-4)
Pulse Repetition Frequency	~2060Hz
Ku-Band	
Frequency	13575MHz
Bandwidth	320Mhz
C-Band	
Frequency	5300MHz
Bandwidth	320 MHz or 100MHz
Antenna	
Diameter	1200mm
Beamwidth (3dB)	1.28°

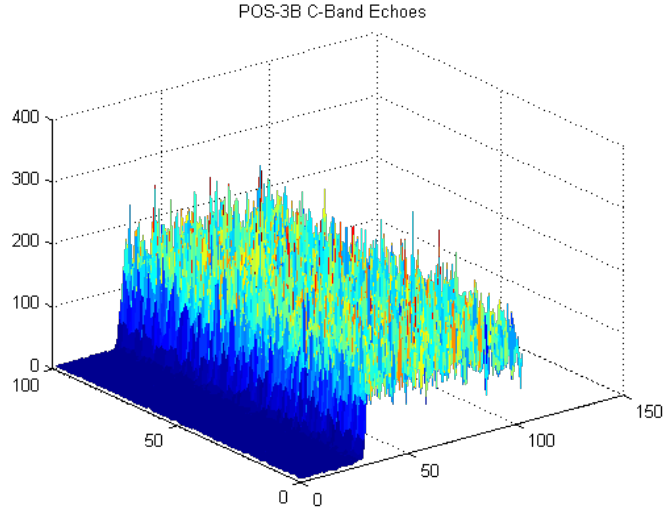
Main Conclusions

- Since the launch we have faced no altimeter anomaly.
- Altimeter availability : 100%
- Performances similar to Jason-2
  - range noise ~1.6cm (@1hz / SWH=2m)
  - excellent measurement stability
- … in addition satellite gives us the opportunity to test some exceptional procedures: switch ON / Wait mode blocking …

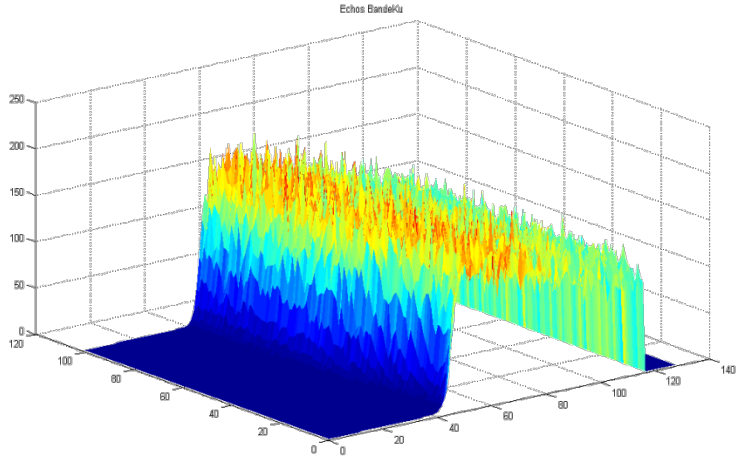
Development Backstage

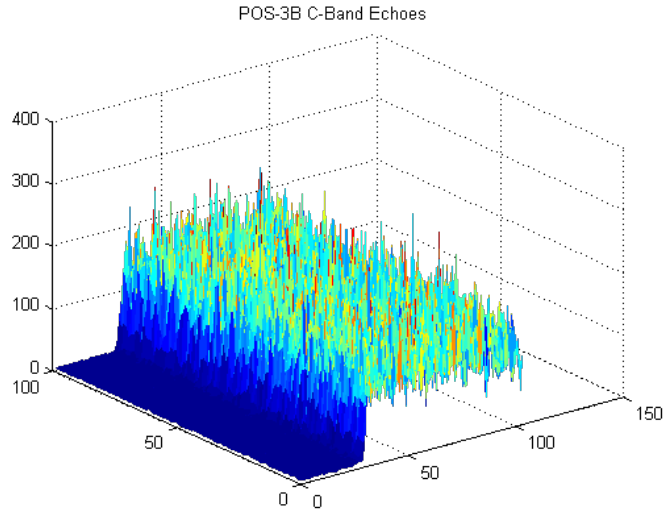
in-flight echoes



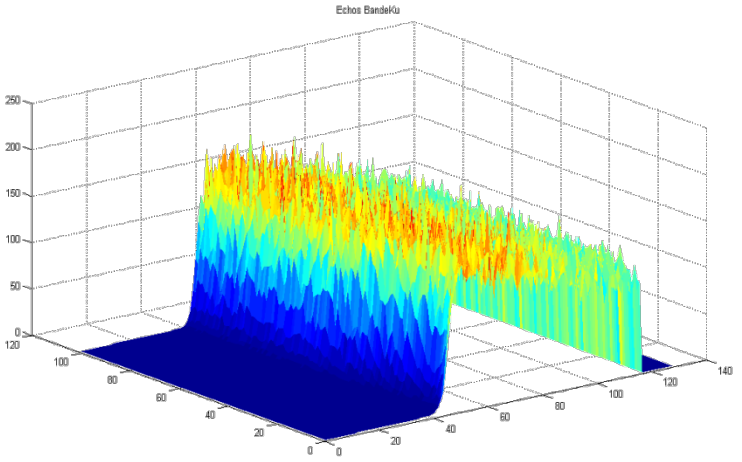


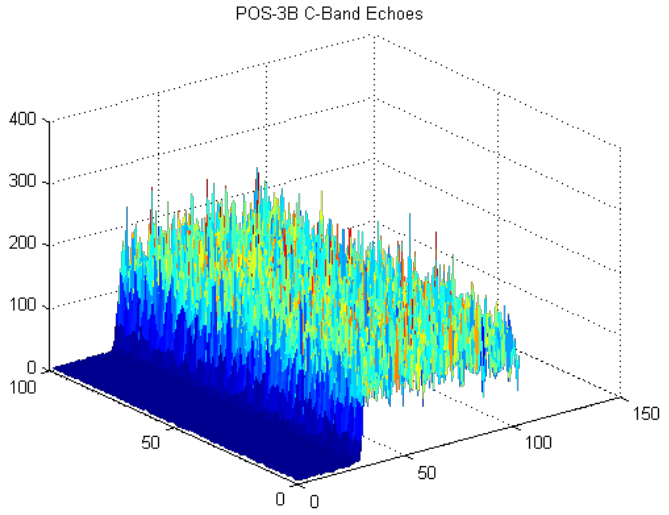
in-flight echoes





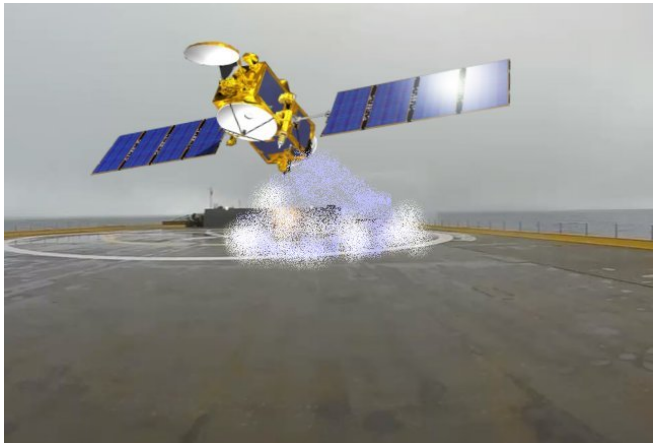
simulated echoes





#SPACEX Le satellite franco-américain de SpaceX rate son atterrissage et explose sur une barge en mer

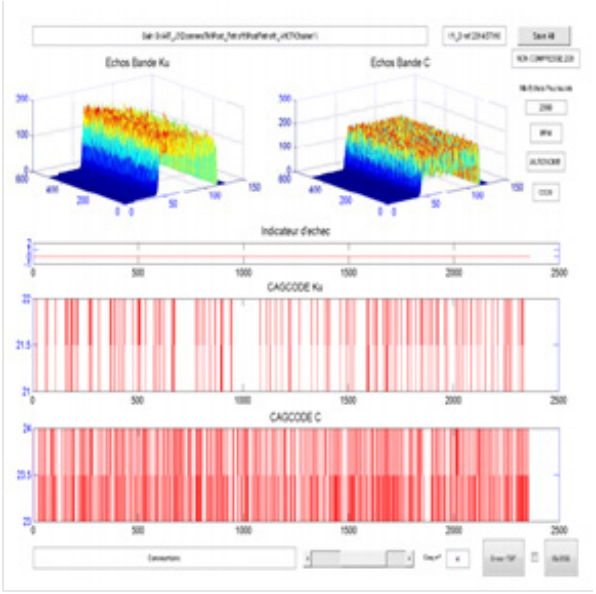
Publié le 18/01/16 à 11:32



Copyright : T. Lafon

NouvelObs (french paper)

Altimeter functioning and performances simulations

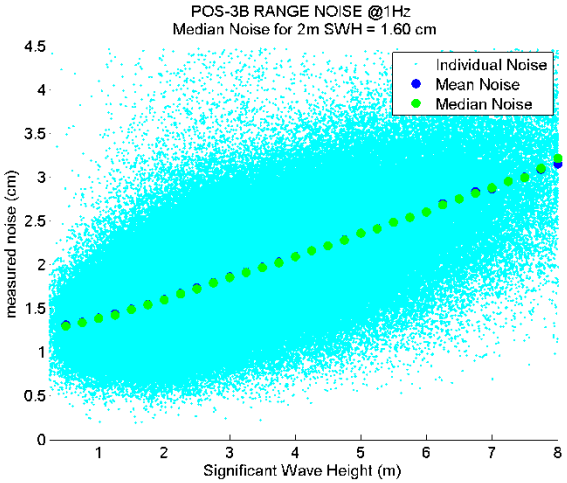


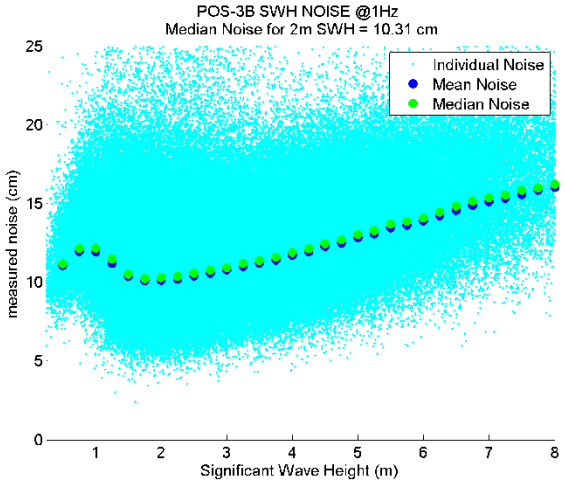

SPAC

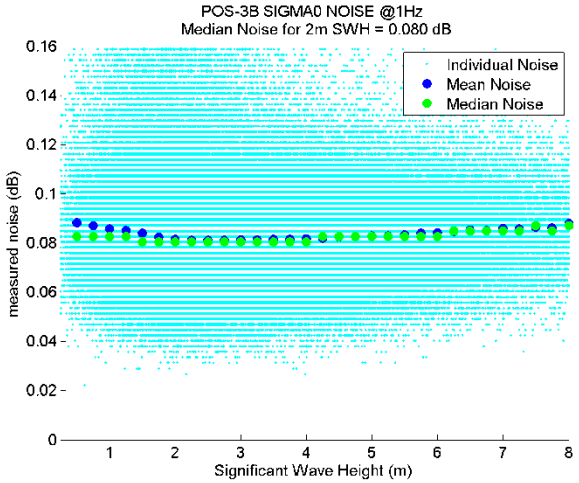

SPAC

back to in-flight results

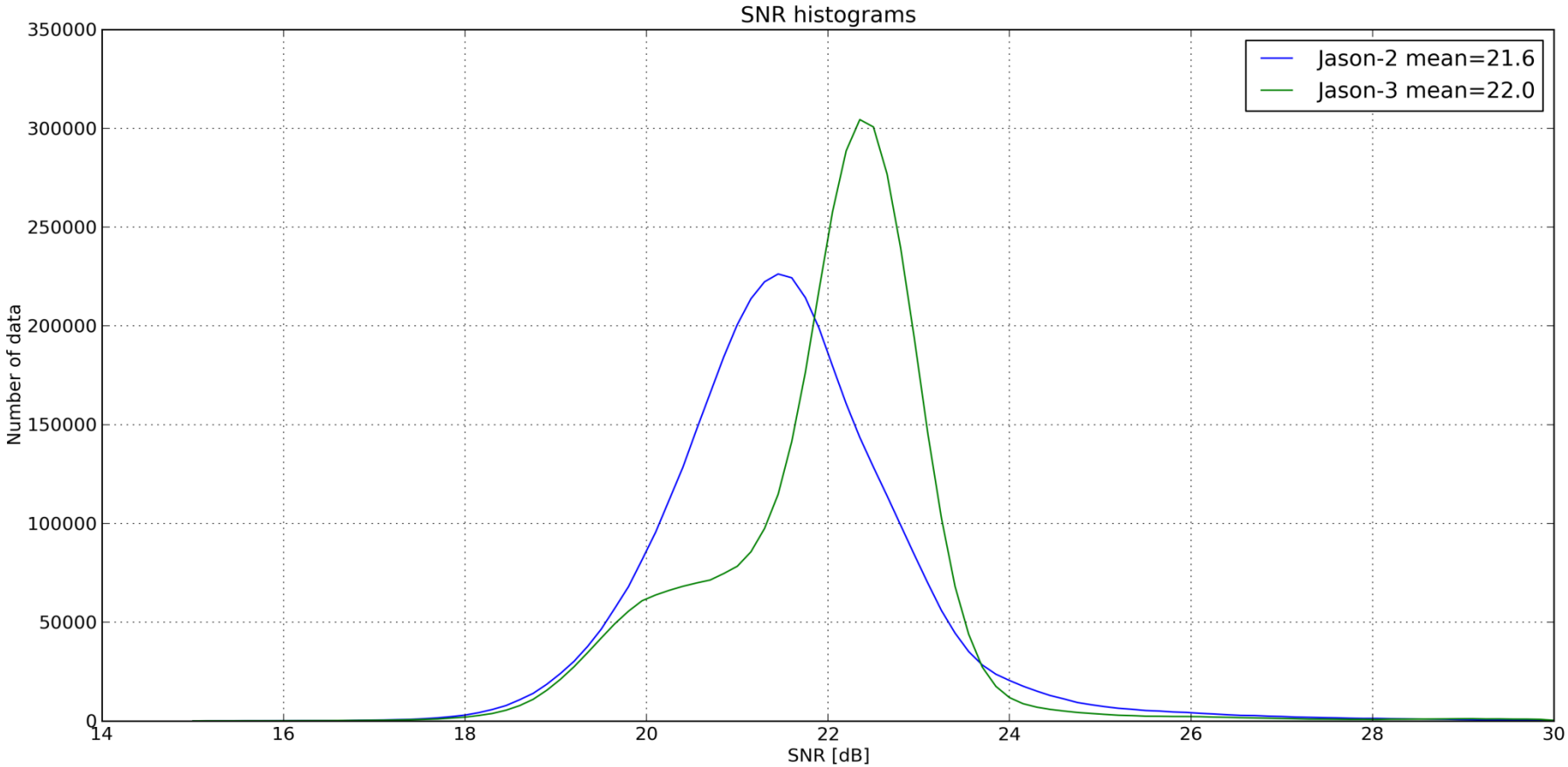
Measurement Performances







	H 1/3 = 2 m	H 1/3 = 4 m	H 1/3 = 6 m	H 1/3 = 8 m
Requirement for **Range (cm)**	**1.7**	**2.4**	**2.8**	**3.3**
InFlight Noise Estimation with MLE4 Retracking for Range (cm)	**1,603**	**2,095**	**2,605**	**3,218**
Requirement for **SWH (cm)**	**50**	**50**	**60**	**80**
InFlight Noise Estimation with MLE4 Retracking for SWH (cm)	**10,31**	**11,9**	**14,11**	**16,23**
Requirement for **Sigma0 (dB)**	**0,7**	**0,7**	**0,7**	**0,7**
InFlight Noise Estimation with MLE4 retracking for Sigma0 (dB)	**0,080**	**0,081**	**0,083**	**0,087**



SNR histograms for J2 (blue) and J3 (green)

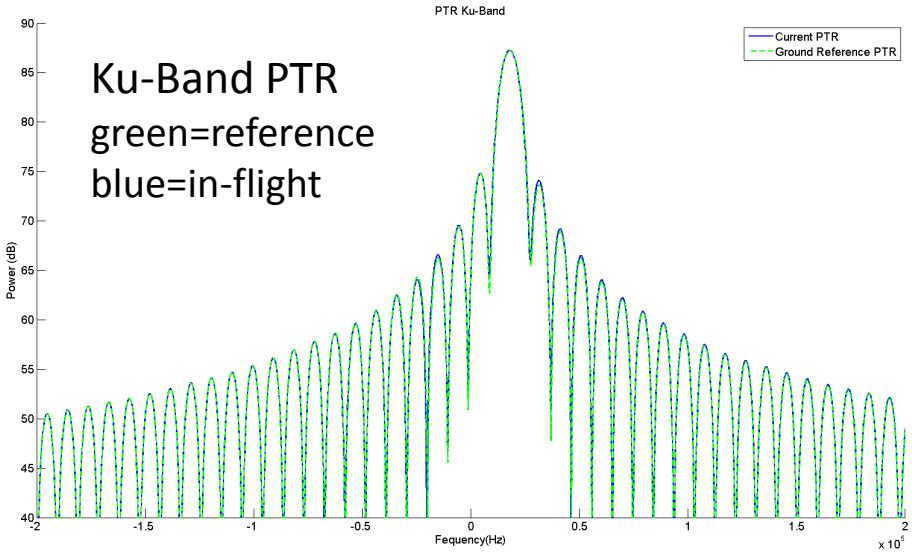
SNR mean as expected

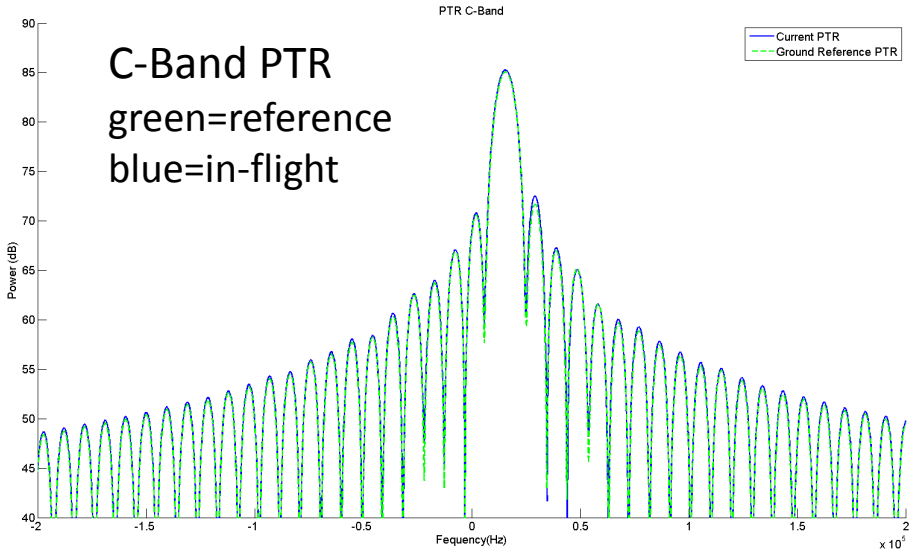
range noise ~ speckle noise only

Altimeter Calibrations

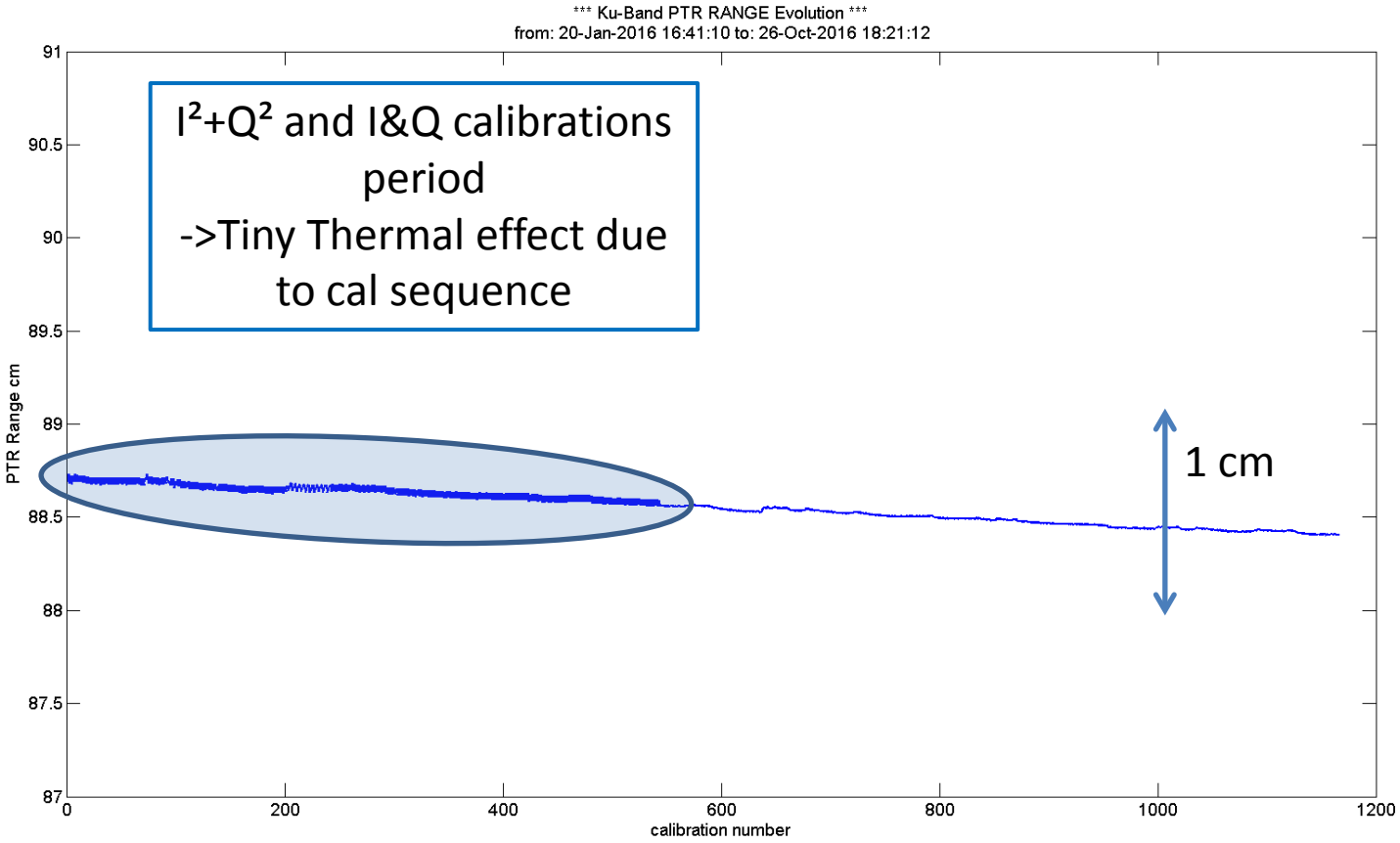
lot of calibrations activities during satellite assessment phase

PTR calibrations

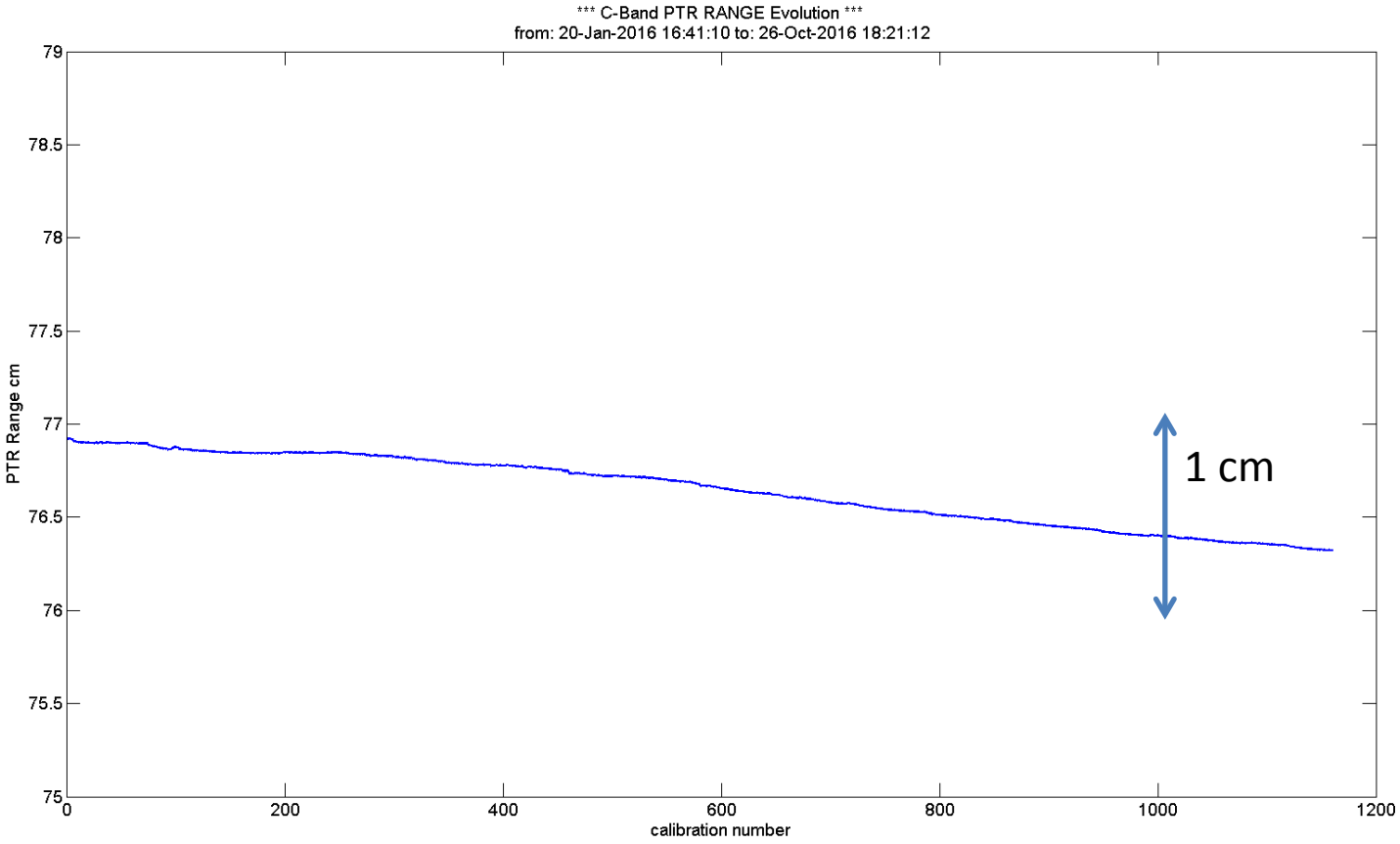




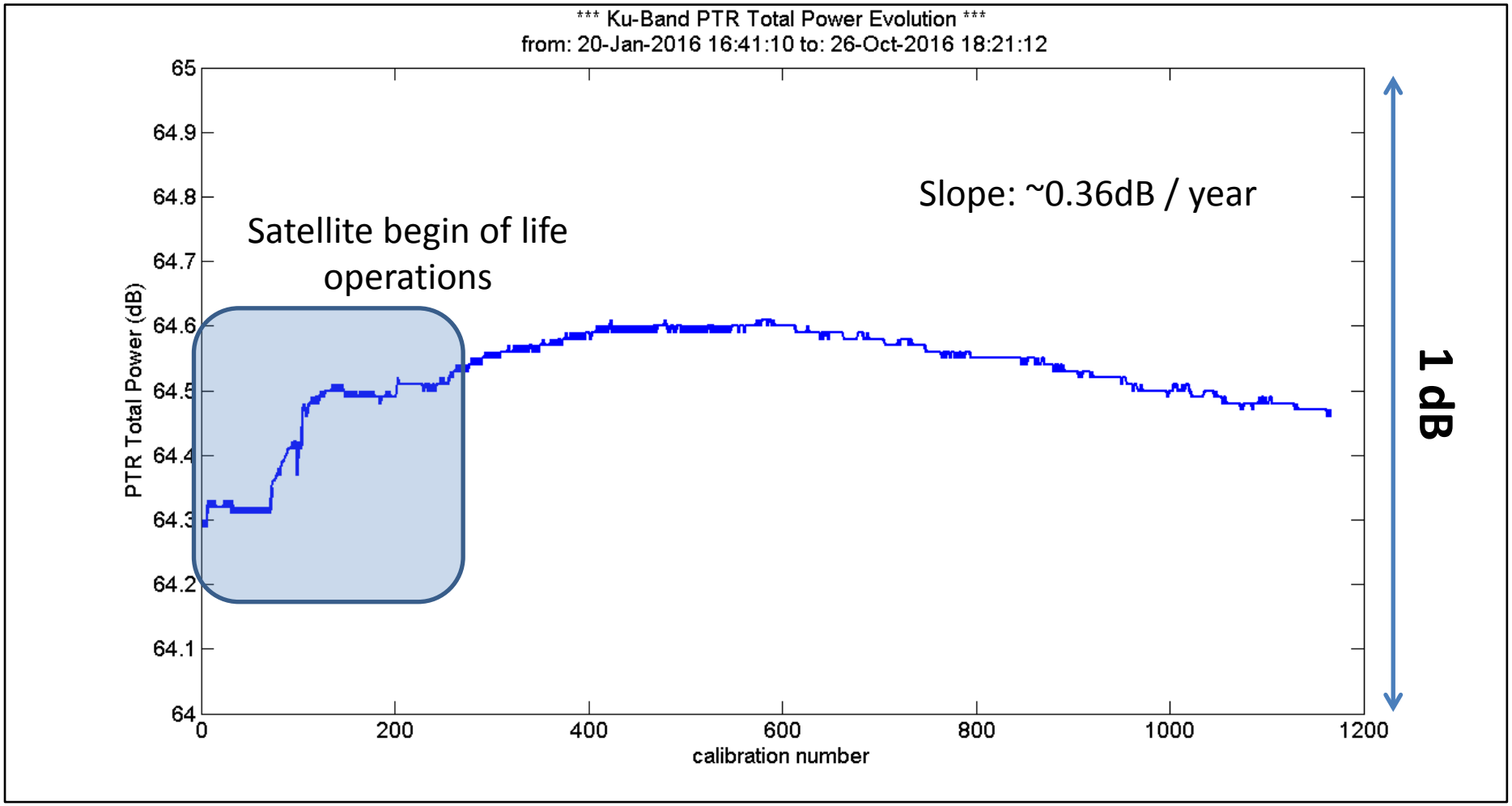
- PTR very clean and close to ground measurement
- very **stable calibrations** with smooth evolution -> accurate range after calibration correction
- I^2+Q^2 and I&Q (phase) calibrations sequence until 31/03/16, I&Q only after (very similar results / better accuracy in I&Q mode)



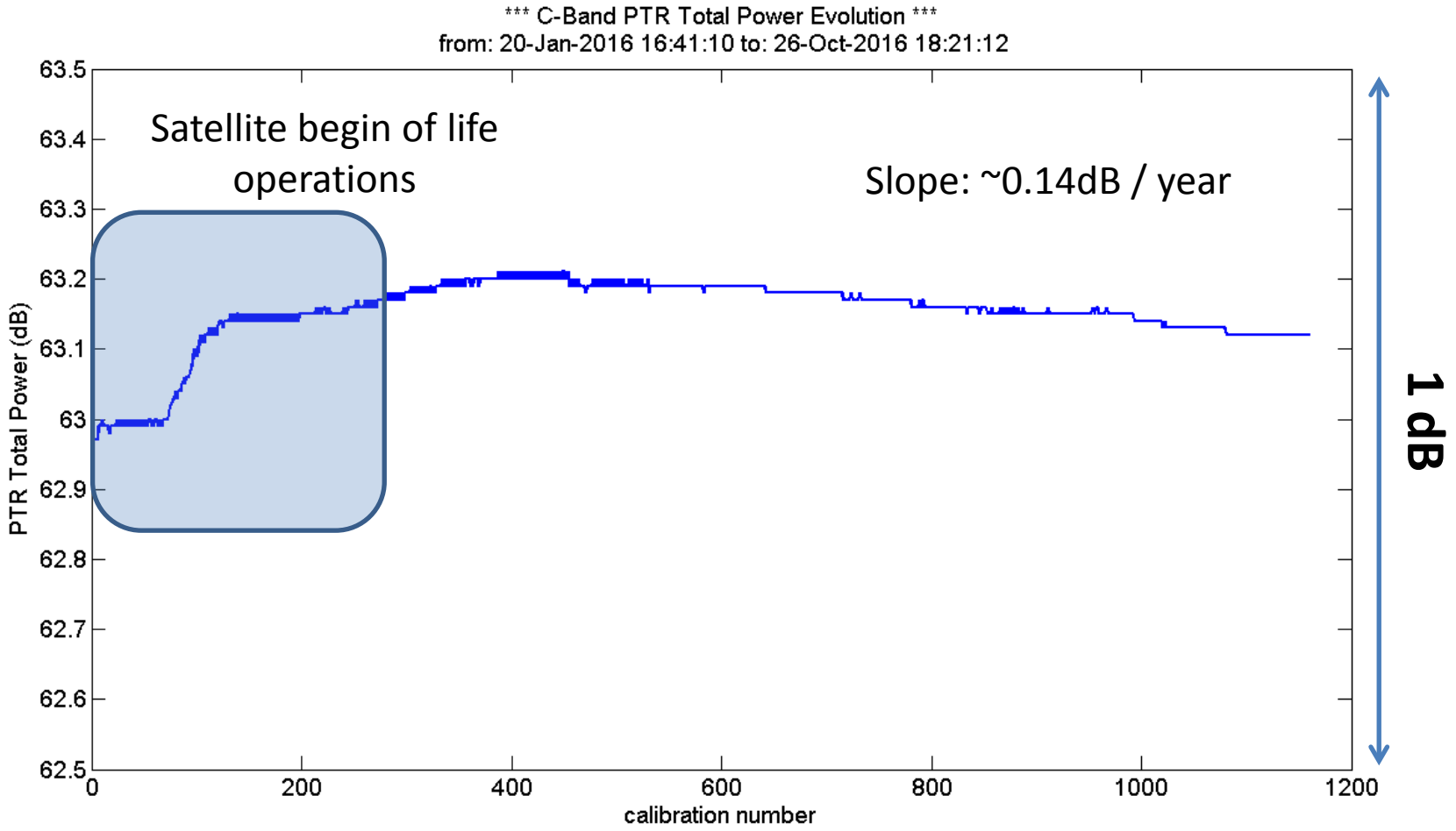
Ku-Band PTR range evolution



C- Band PTR range evolution

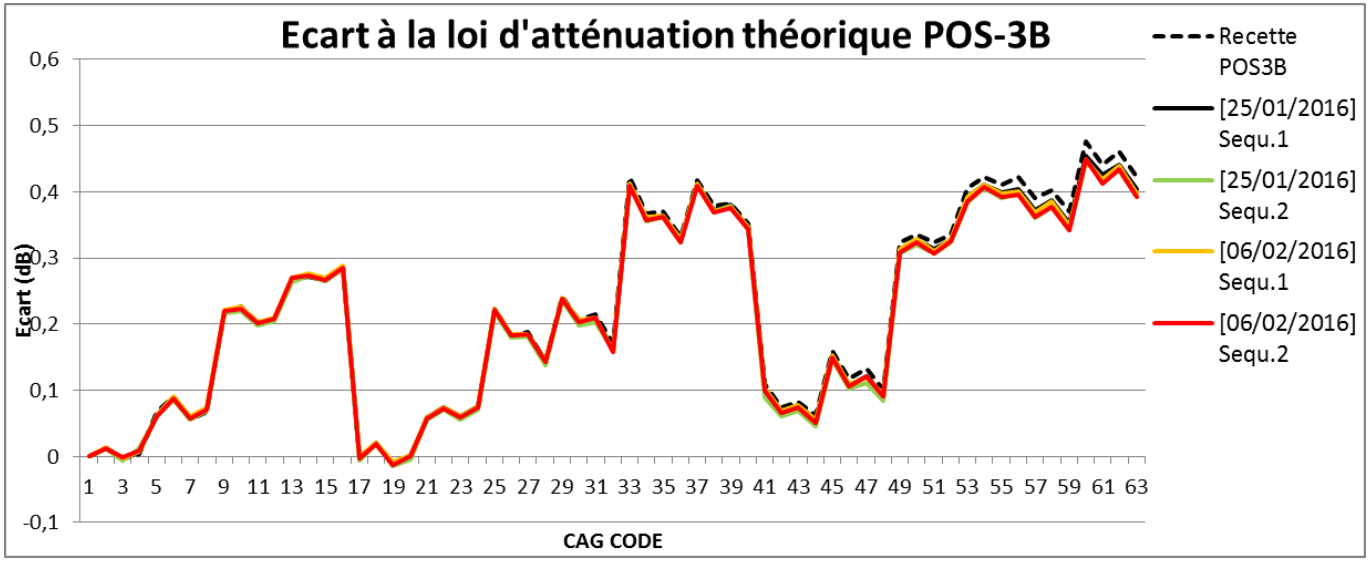


Ku-Band PTR Total Power evolution



C-Band PTR Total Power evolution

Automatic Gain Control Calibrations

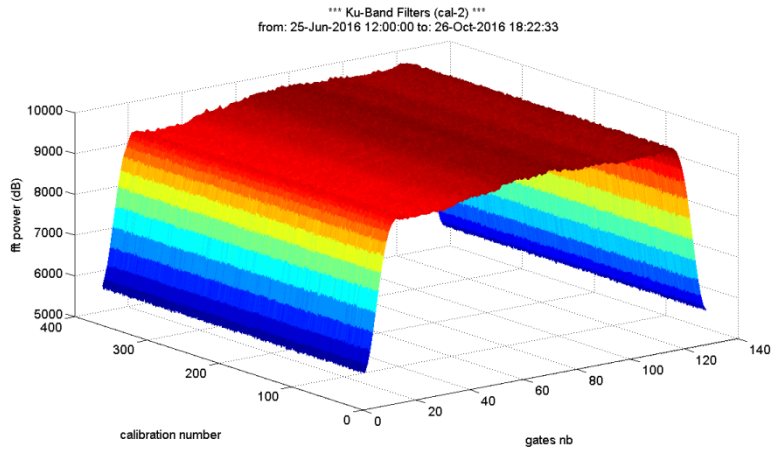


AGC Calibrations Comparison

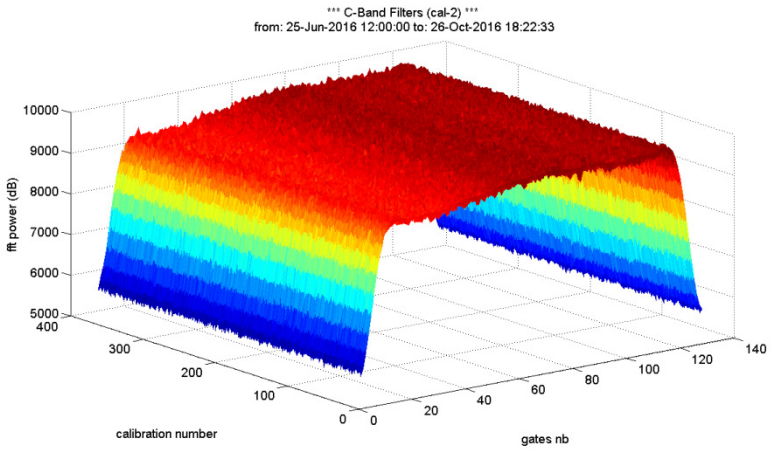
Method = sequence of PTR calibrations using several gains
-> excellent calibration accuracy using I&Q PTR calibrations
-> better than 0.01dB

Filter (Cal-2 calibration)

Also very stable calibrations -> Averaging of calibrations over 30 days to reduce calibration noise (become not significant)



Ku-Band filters

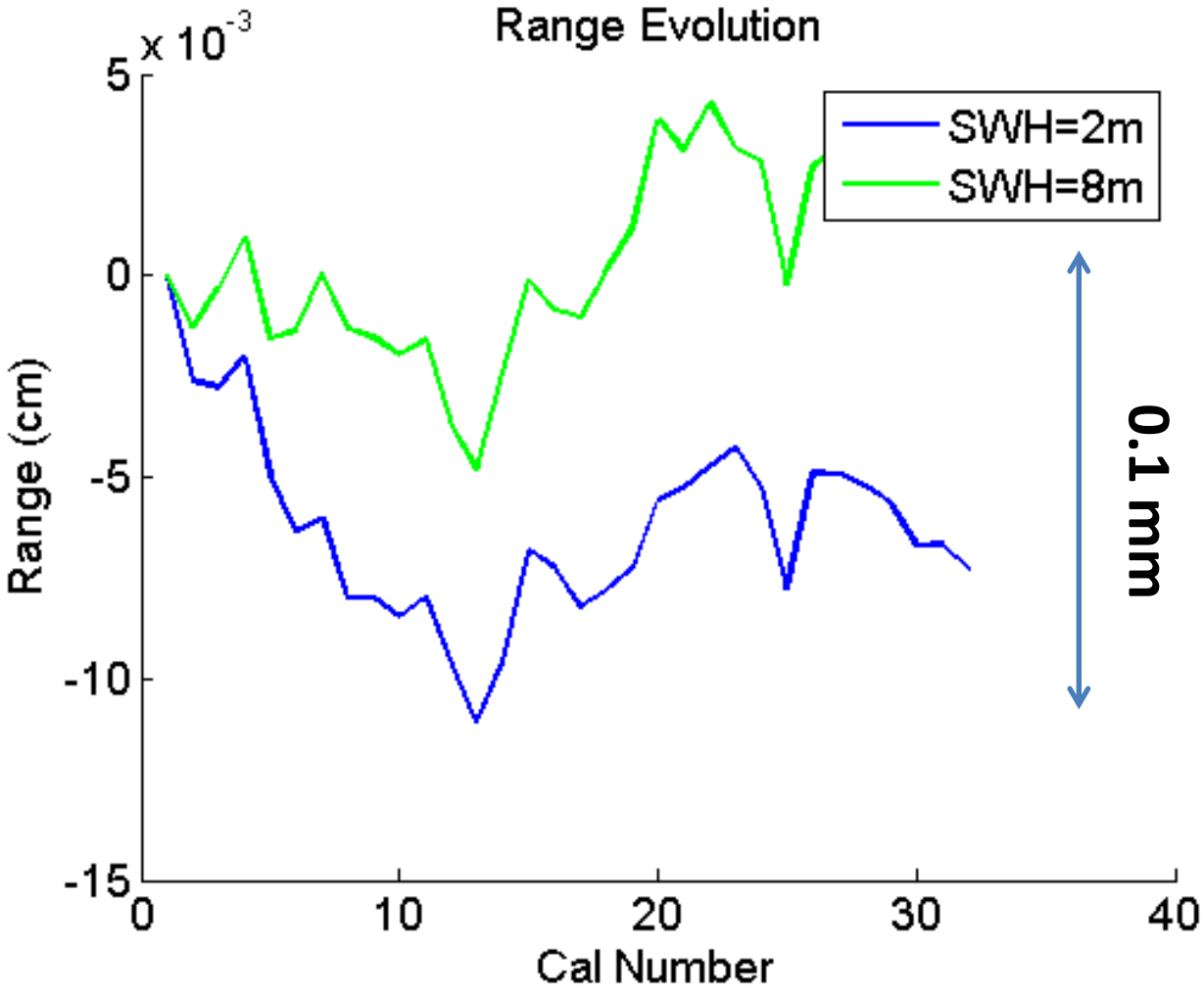


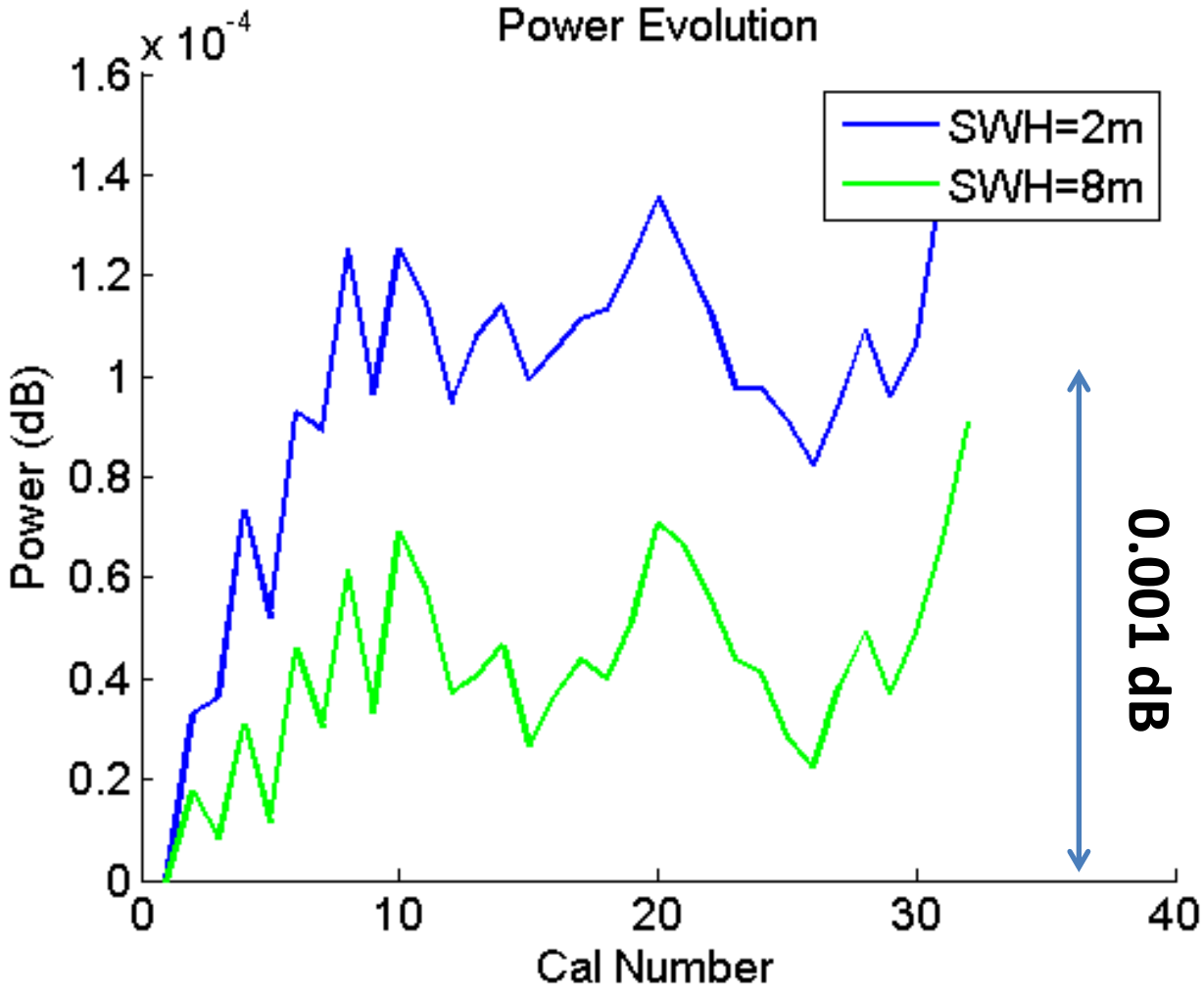
C-Band filters

along orbit calibration

- Orbital thermal signature
  -> only impact not corrected by calibration
  -> check that effect on measurements is negligible

- 30 sequences of CAL1 (in I&Q and in I^2+Q^2) & CAL-2 -> 5hours (around 3 full orbits)


Range Evolution
x 10^-3
5
0
-5
-10
-15
Range (cm)
0
10
20
30
40
Cal Number
SWH=2m
SWH=8m
0.1 mm


Power Evolution
x 10^-4
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Power (dB)
0
10
20
30
40
Cal Number
SWH=2m
SWH=8m
0.001 dB

Despite worst case conditions …

(repetitive calibrations sequence degrades the instrument thermal stability)

Range stability better than 0.1 mm

Power stability better than 0.001 dB

Diode/DEM Mode With Automatic Transitions

Motivation: return of experience of Jason-2 & SARAL/ AltiKa

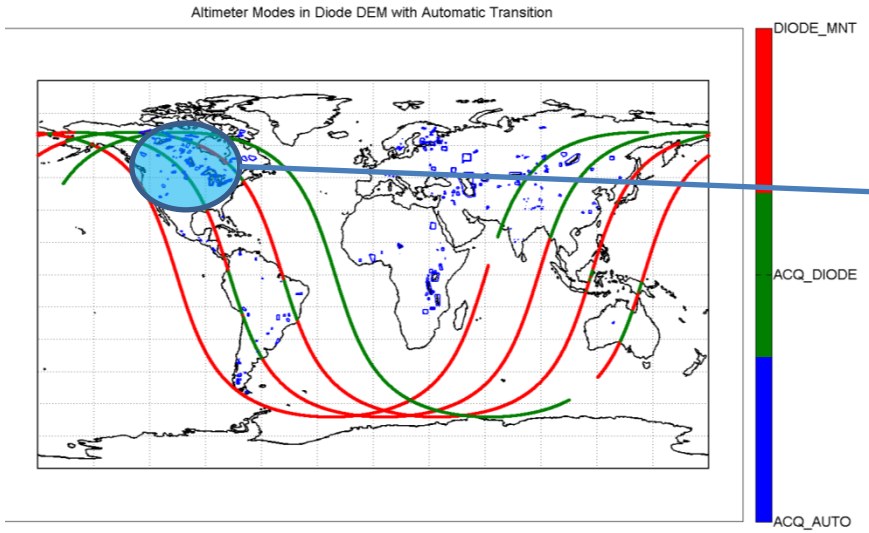
Autonomous mode and Diode/DEM mode are very complementary

- Autonomous mode (= median tracker)
  - + : is able to track signals almost everywhere -> “statistical efficiency”
  - - : there is no control on the tracked surface (top or bottom of a hill?)
  - - : in case of tracking loss -> acquisition duration before next measure
- Diode/ DEM mode (= open loop)
  - + : no acquisition duration -> benefit for coastal zones
  - + : theoretically tracking is always good if the a priori altitude is good enough (ie error < ~10 m) -> no possible tracking loss over oceans
  - - : if the a priori altitude is not good -> target never measured
  - + : possibility to select a target to track -> this mode is “ target oriented”
  - - : need more work and human resources

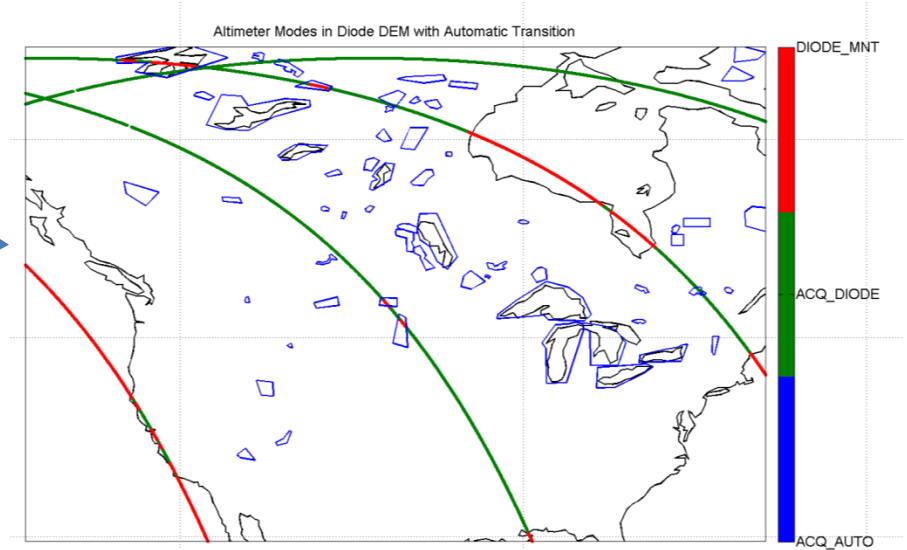
New: POSEIDON-3B has now the capability to switch automatically depending on the satellite position

- Trade OFF for mode selection:
  - Diode/DEM mode where a priori altitude is known and autonomous mode is not always efficient
  - Autonomous mode: otherwise
- DEM v2.0 definition:
  - Oceans -> better for coastal region and no sensitivity to ice/ bloom/ …
  - Lakes and Rivers from LEGOS Hydroweb Database
  - Dedicated Rivers Database over France and Congo River (from Sylvain Biancamaria & Stephane Calmant, LEGOS)
  - Transponder Positions

The Diode/DEM Mode with automatic transition is now the nominal functioning mode for JASON-3 / POSEIDON-3B

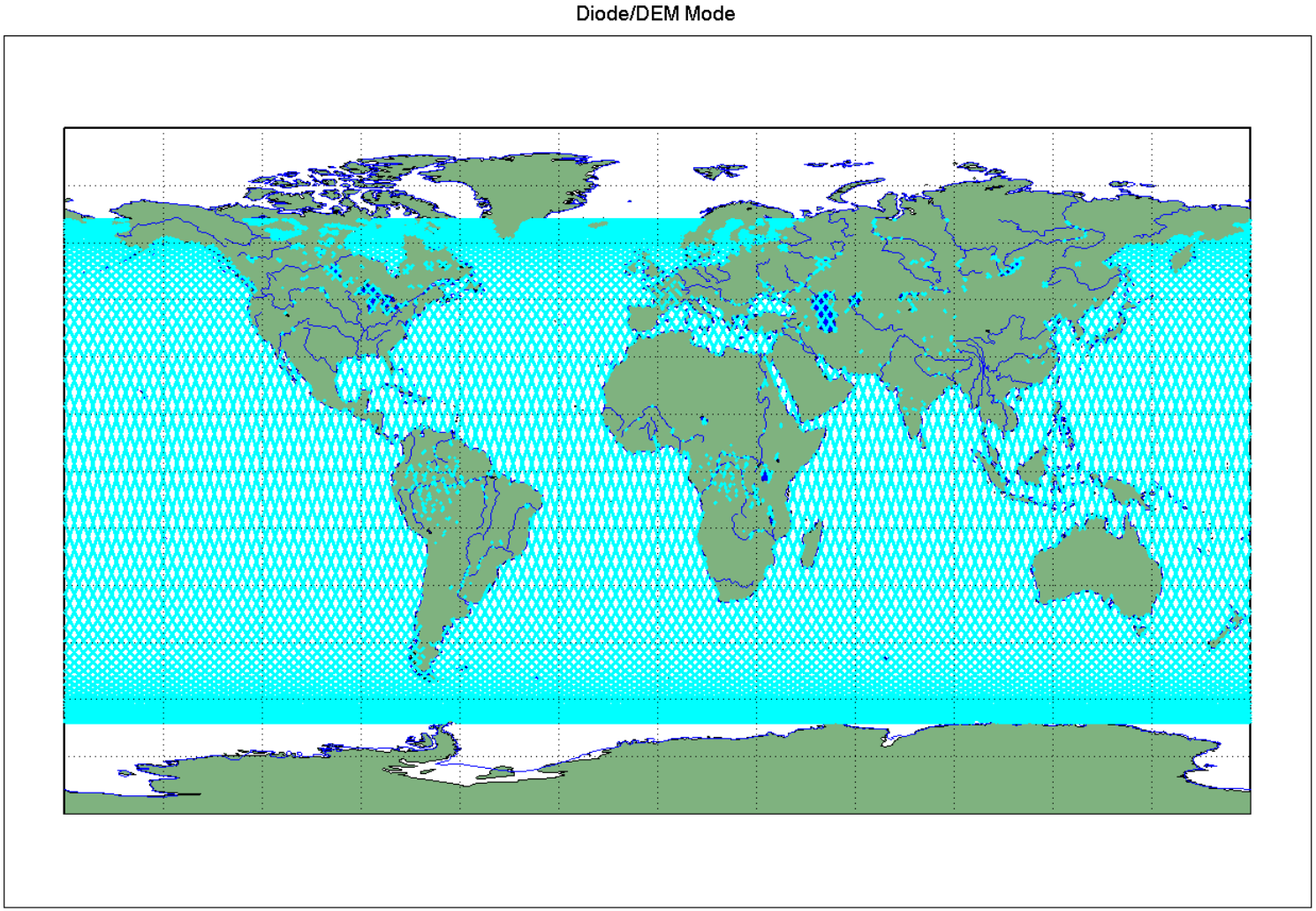


Diode/DEM mode over oceans



Diode/DEM mode over Lakes
Autonomous mode over land surfaces
-> generaly no transitions tracking loss

First results highlight very good performance in diode/DEM mode over oceans and river & lakes from LEGOS (with **95 % of tracked target vs 50% in autonomous** mode)



Diode/DEM mode points in on-board DEM v2.0

Altimeter Mode vs J3 cycles

Cycle	Altimeter Tracking Mode	Comment
0	Autonomous	Test of Diode/DEM mode for altimeter assessment(15/02/2016 08h00 to 14h00)
1 to 5	Autonomous	
6	Diode/DEM	DEM v1.0 with adjustment of echoes centering prior to cycle 6
7	Autonomous	
8	Autonomous	Upload of DEM v2.0 (02/05/16)
9	Diode/DEM	DEM v2.0
10	Autonomous	
11 to 19	Diode/DEM	
20	Autonomous	
21 and further	Diode/DEM	

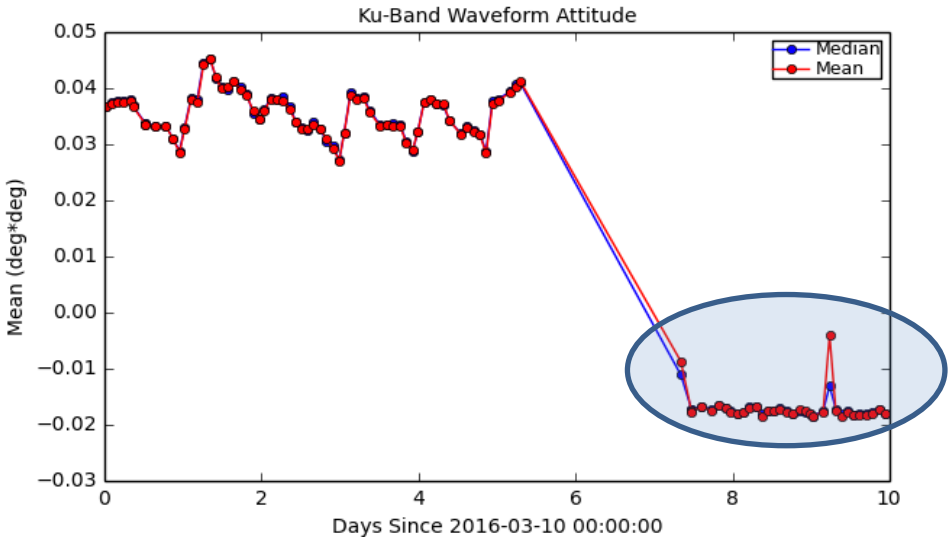
Diode/DEM conclusions

- The Diode/DEM mode (=open loop mode) gives excellent results
- It is currently the Jason-3 nominal mode
- On board DEM update are easier for J3 than for J2
  - minimize operations and mission interruptions
  - more flexibility for altitude change and/or add of new targets -> scientific request

1 upsetting point
“Mispointing Anomaly”

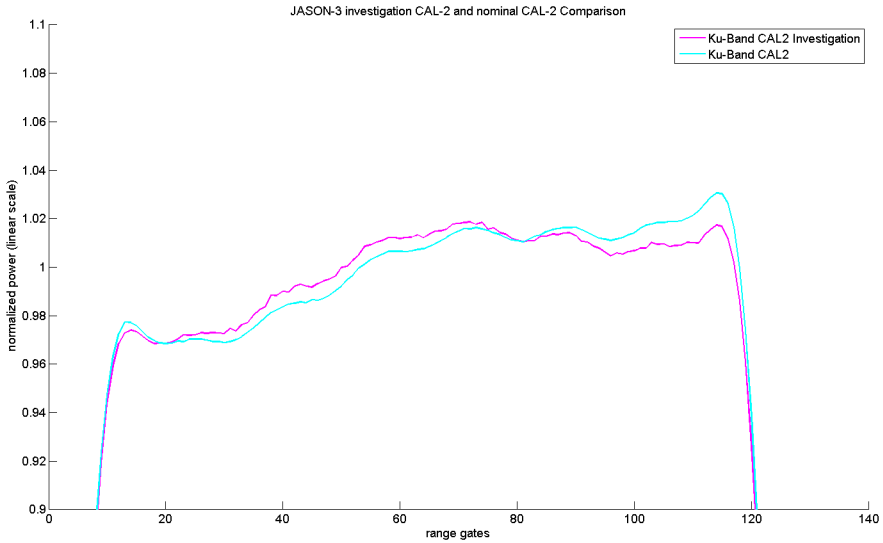
-> artificial apparent negative altimeter mispointing (~-0.015°²)

- detected after J3 attitude correction (no more real attitude bias)

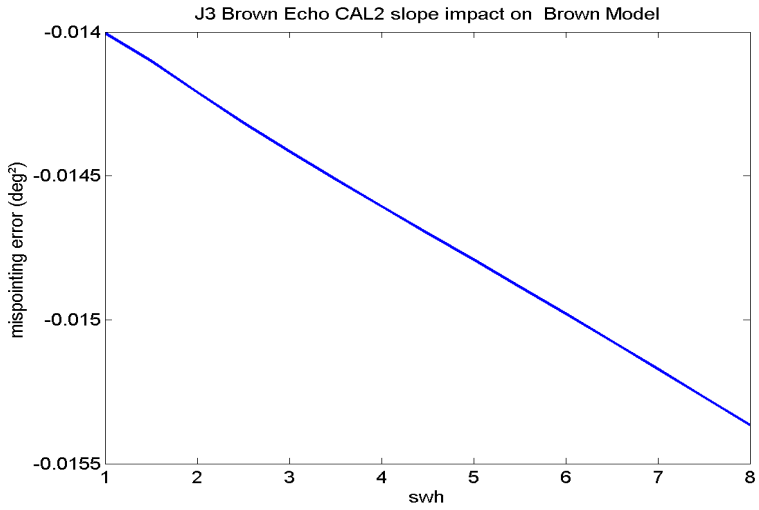


J3 altimeter mispointing from NRTAVS

- Became “cal-2 anomaly” : mispointing root cause -> trend of the filter shape
- Explained: gain used for cal-2 calibration different from gain for echoes measurement-> discrepancy not previously observed (REX for others missions)



Filter shape depending of used gain



simulation of impact on mispointing

End of problem

- Corrected : calibration sequence modified using typical tracking gain in calibration (Ku & C Bands)

-> no more apparent mispointing

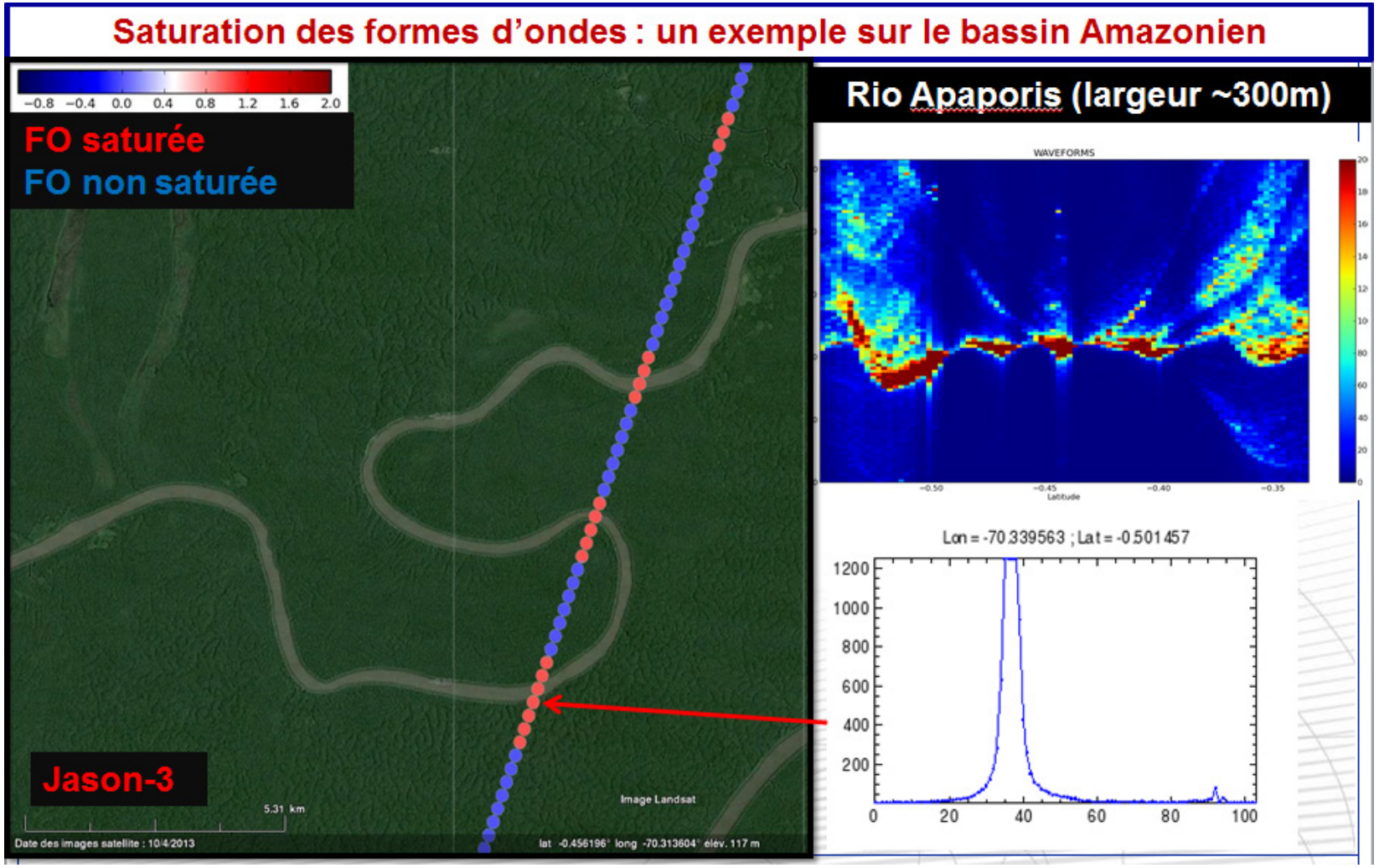
- Slight impact on range/swh/sigma0 (windspeed)

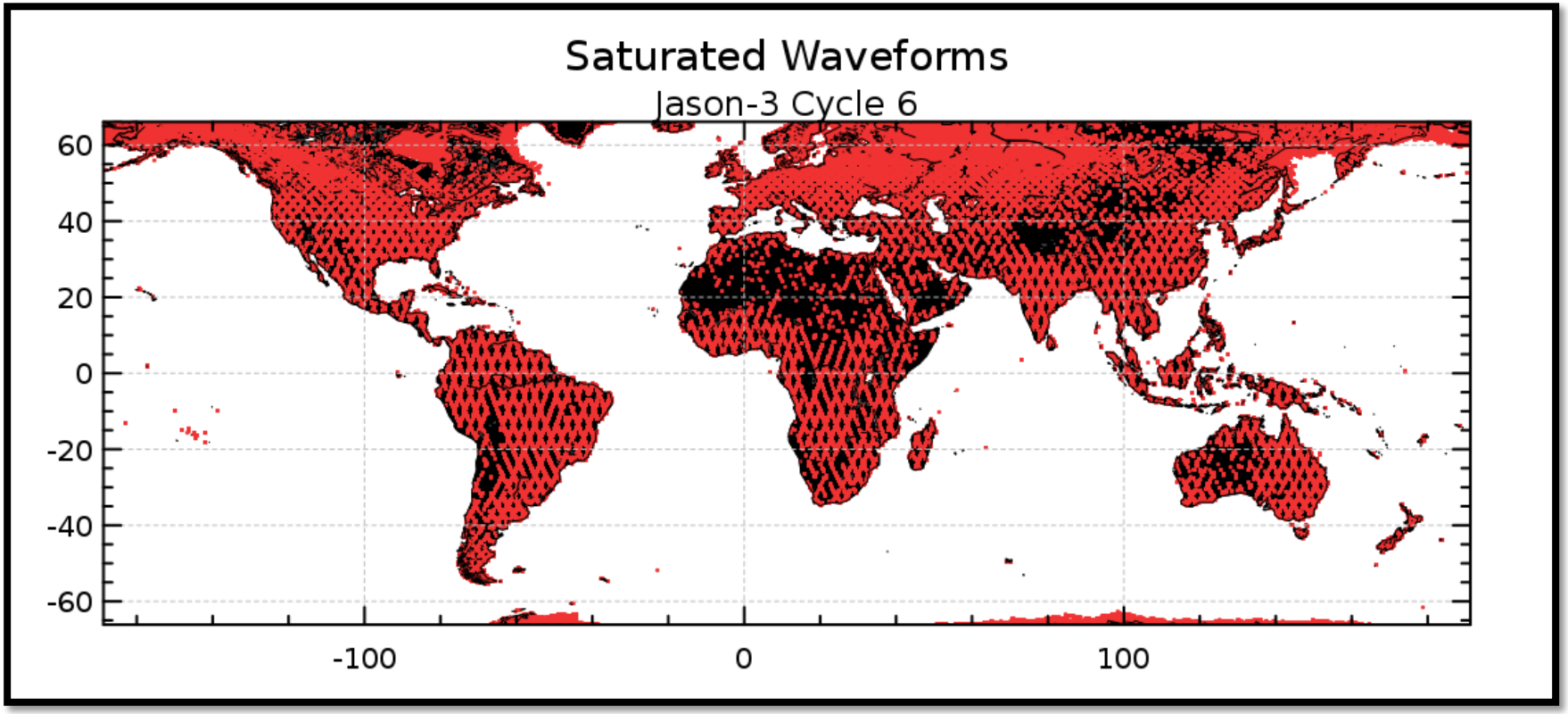
-> OGDR & IGDR data have been impacted by this issue

-> GDR not impacted (only cal-2 with tracking gains is used)

Gain Control Modification

-> to limit the echoes saturation case





Global concern

Main echoes saturations occur in hydrological areas and in ice areas

	Before Modification		After Modification	
Ku-Band % of echoes with saturation	all latitudes	|latitudes| < 50°	all latitudes	|latitudes| < 50°
Jason-3	3,189%	1,815%	2,211%	1,265%
Jason-2	3,328%	1,896%	3,488%	1,932%

Global Ku-Band Echoes Saturation Reduction : ~32%

	Before Modification		After Modification	
C-Band % of echoes with saturation	all latitudes	|latitudes| < 50°	all latitudes	|latitudes| < 50°
Jason-3	2,986%	1,461%	1,963%	0,951%
Jason-2	3,131%	1,566%	3,296%	1,591%

Global C-Band Echoes Saturation Reduction : ~36%

Altimeter tuning

- **PRF modification** wrt orbits during orbit acquisition period
- **A new DEM** has been upload
- ->to add the “France River Data base” from Sylvain Biancamaria + Complementary Lakes Data Base from Stephane Calmant (LEGOS)
- -> with geoid correction
- The **centering of echoes in Diode/DEM mode** has been adjusted (before first cycle using Diode/DEM mode)
- The parameters for **altimeter gain control** have been optimized for peaky echoes (better efficiency in case of ice/bloom or river echoes)
- **Calibrations scenario** has been modified
  - Gains for CAL-2 (filter)
  - I&Q PTR only

Conclusion

- Poseidon-3B Range Accuracy is very good
- The stability is excellent (Internal Calibrations)
- New mode with automatic transitions provides capability to take advantage of both autonomous and Diode/DEM mode
- "altimeter mispointing anomaly" -> solved
- Global behavior consistent with Poseidon-3 on Jason-2

…Even for range

Last estimation for J3/J2 Bias

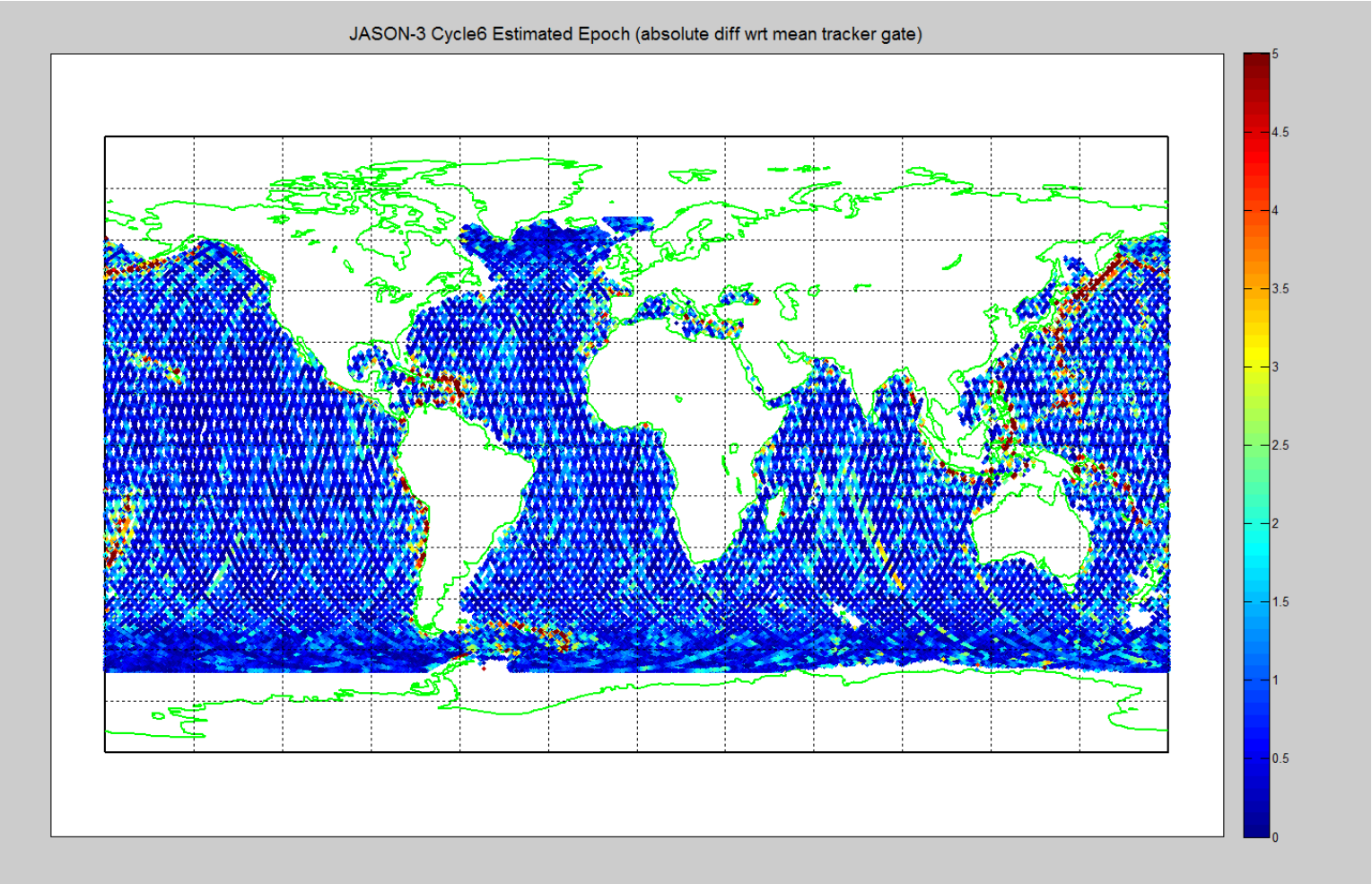
from GDR-T products

Ku band: ~2.3 cm

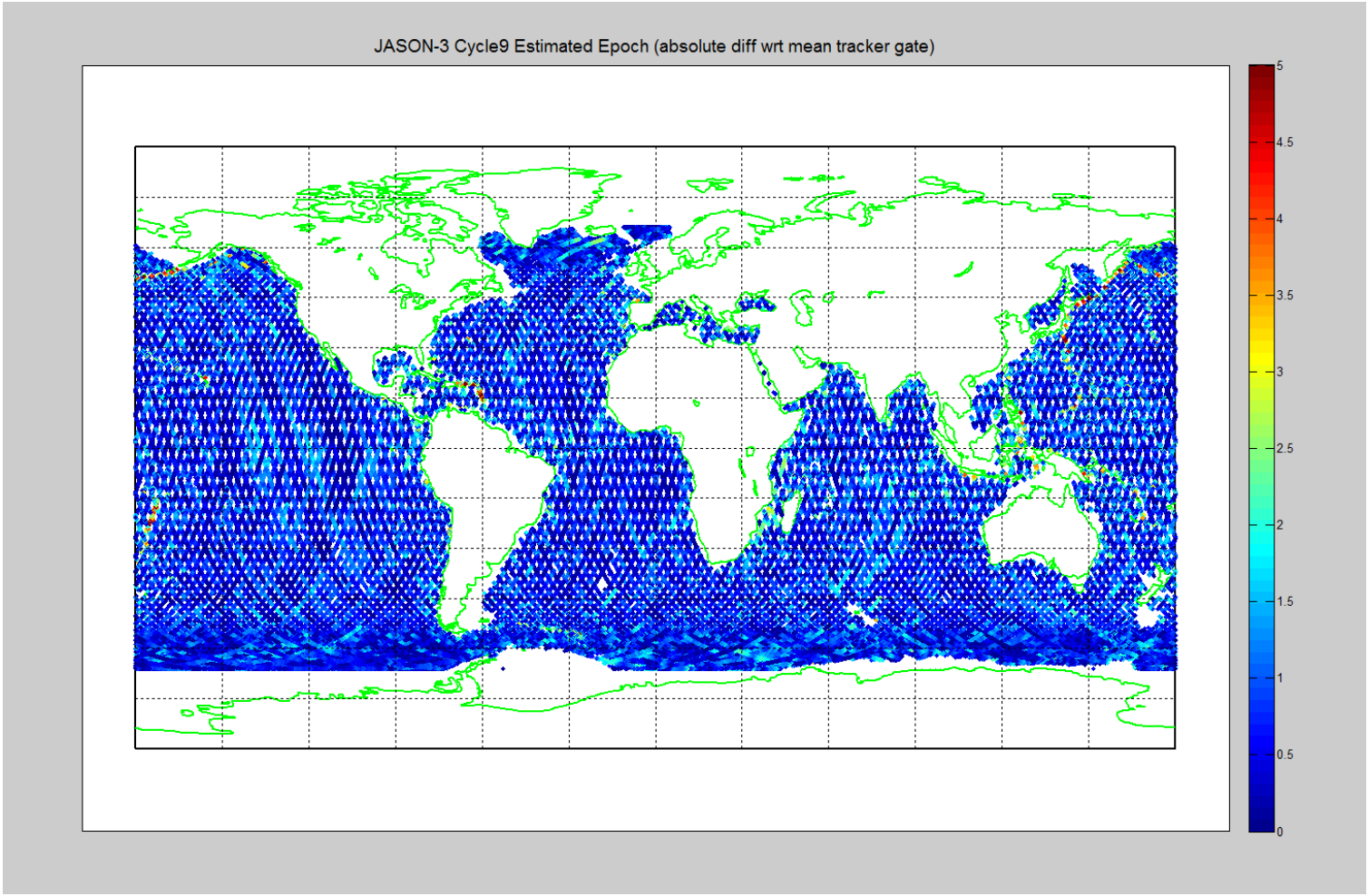
C-Band : ~8/9 mm

(in the altimeter characterization error budget)

Back-up slides



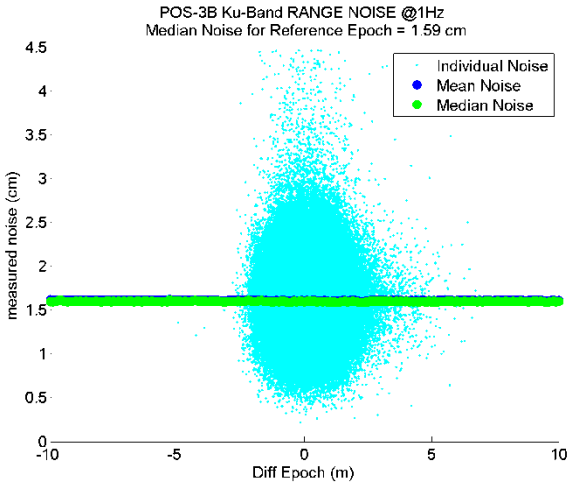
Echoes centering with DEM V1.0

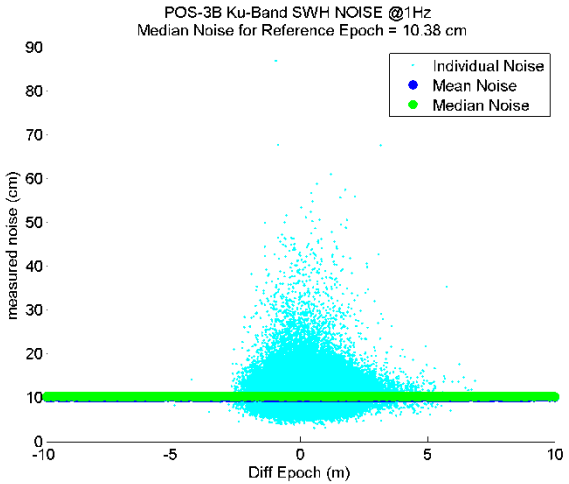


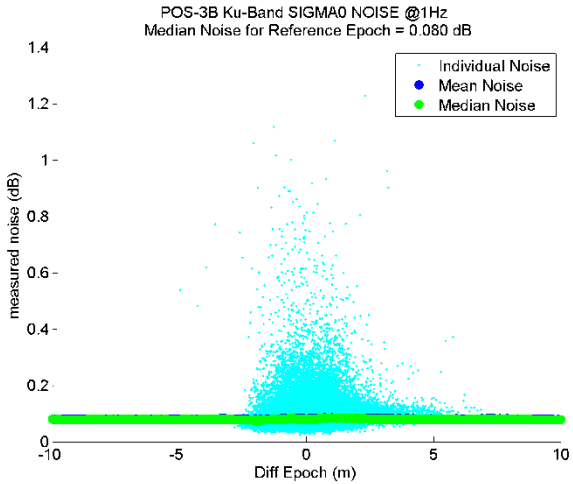
Echoes centering with DEM V2.0

Performances in Diode/DEM mode

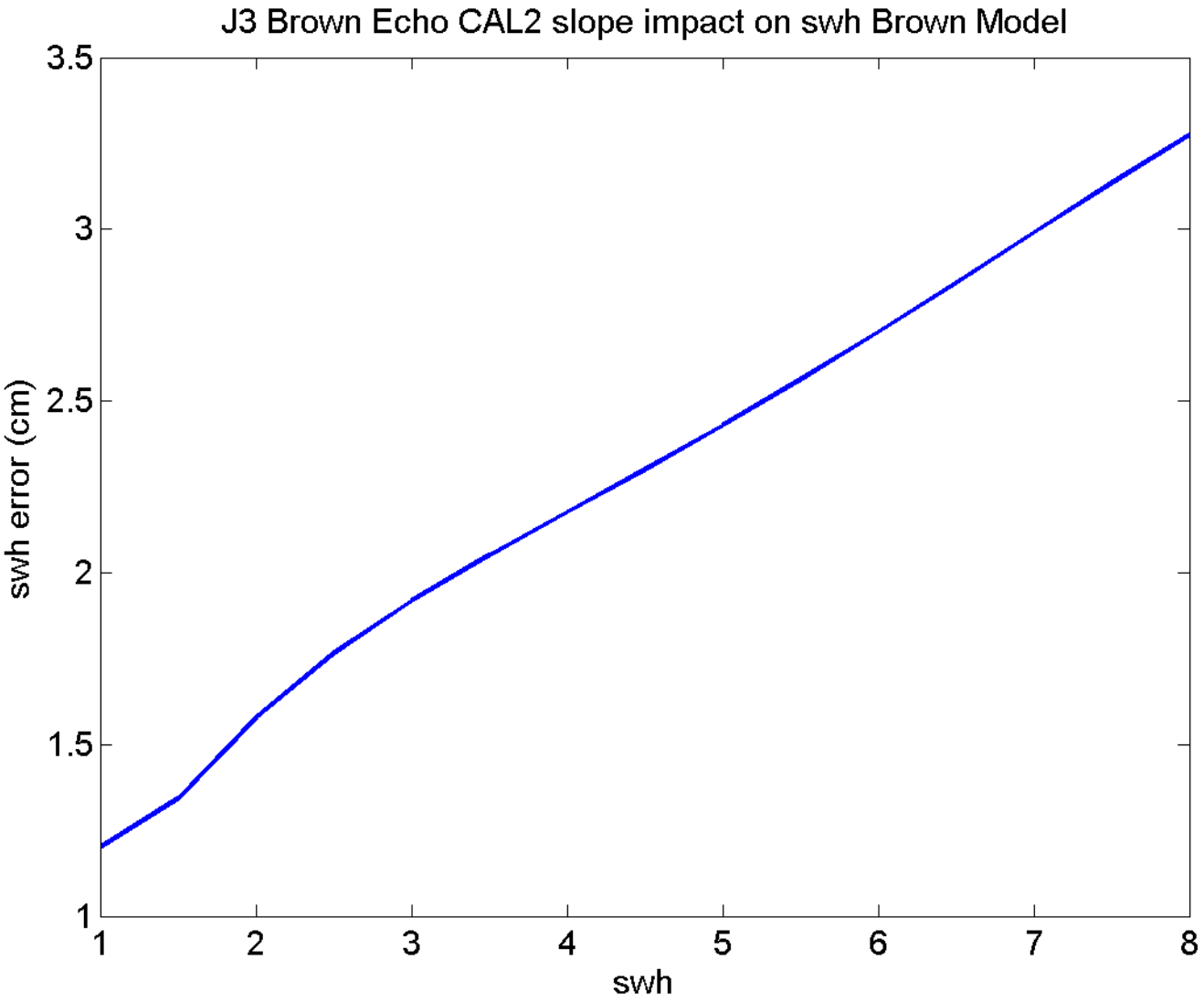
Echoes centering has no impact on the performance

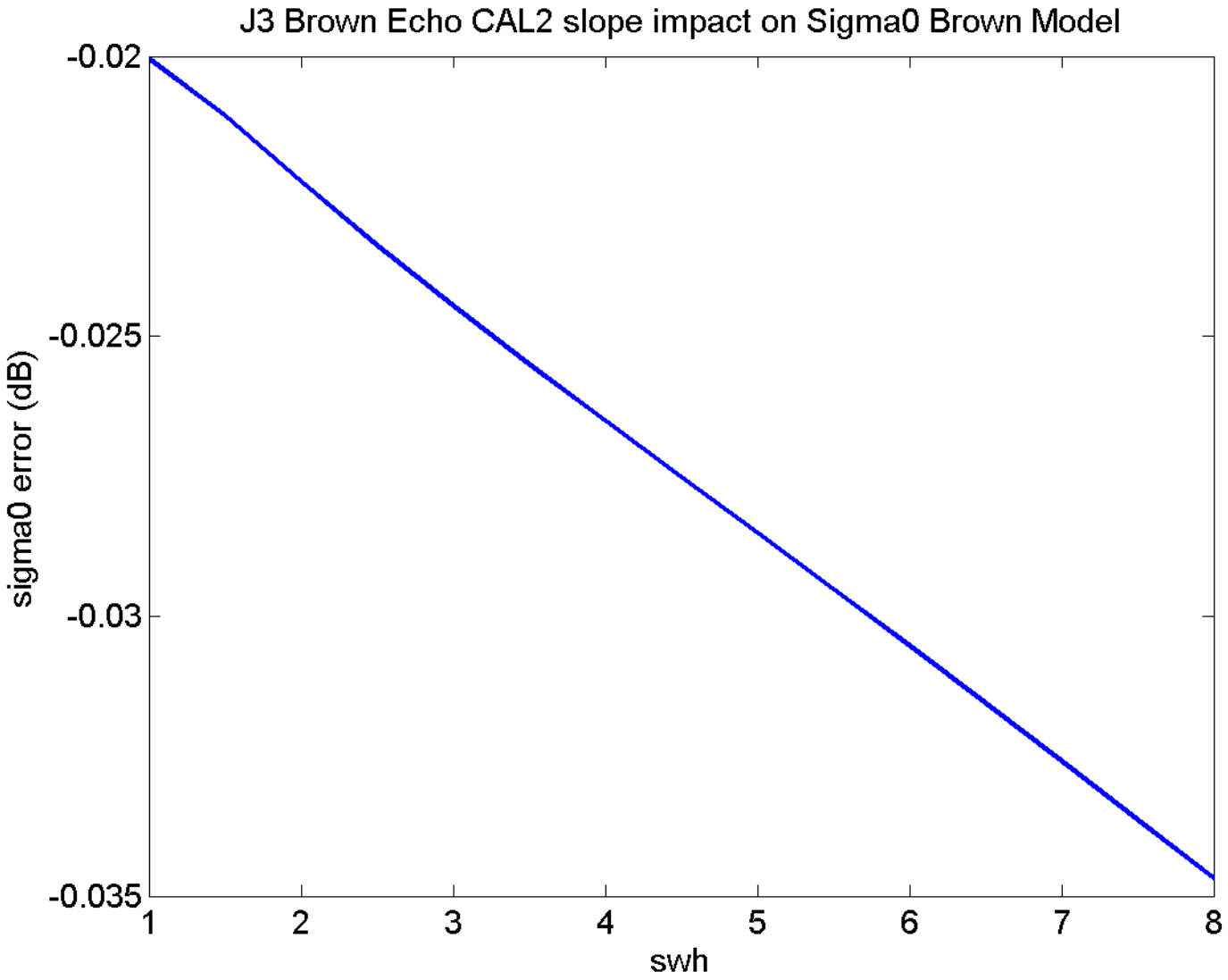







J3 Brown Echo CAL2 slope impact on range Brown Model
range error (cm)
swh
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1
2
3
4
5
6
7
8


J3 Brown Echo CAL2 slope impact on swh Brown Model
swh error (cm)
swh
3.5
3
2.5
2
1.5
1
1
2
3
4
5
6
7
8


J3 Brown Echo CAL2 slope impact on Sigma0 Brown Model
-0.02
-0.025
-0.03
-0.035
sigma0 error (dB)
1
2
3
4
5
6
7
8
swh