# SAR ALTIMETRY at 80 Hz

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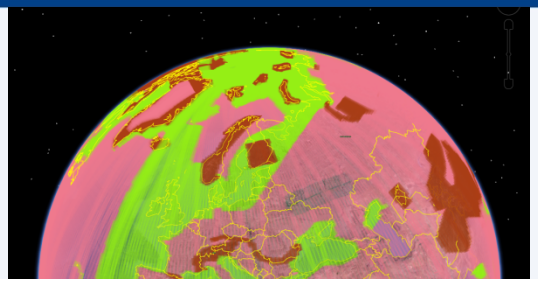
# OUTLINE

The presentation is structured in the following points:

- Introduction
- Concept
- 80 Hz L1b and examples of Concept Application (inland water)
- 80 Hz L2 over open sea and coastal zones
- Conclusions

# ESRIN KNOW HOW and SAR DATA PRODUCTION

ESRIN EOP-SER Section, for validation purposes and preparation to Sentinel-3 mission (**SAR Retracker Algorithm Definition**), implemented an ESRIN SAR Processor Prototype in order to Delay-Doppler process CryoSat FBR data and re-track Delay-Doppler Echoes



- SAR/SARin FBR/L1b DATA Archiving and Cataloguing
- SAR/SARin L1b & L2 Processor Prototype

-Input: CRYOSAR SAR FBR DATA

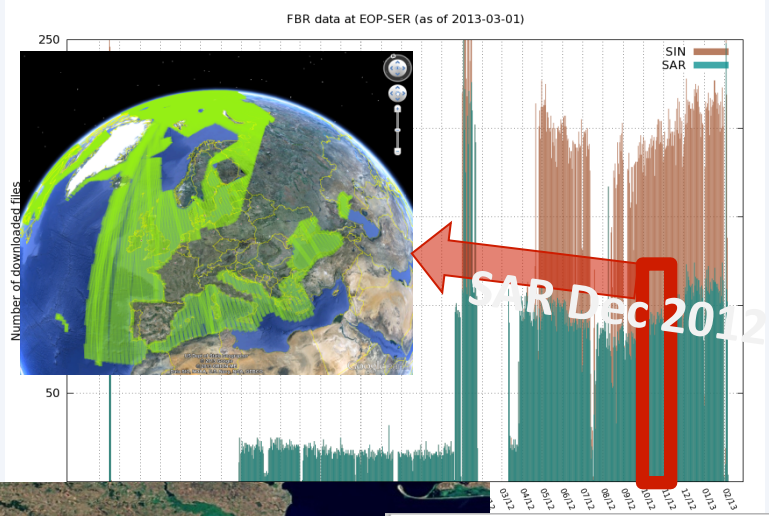
-Coding Language: MATLAB

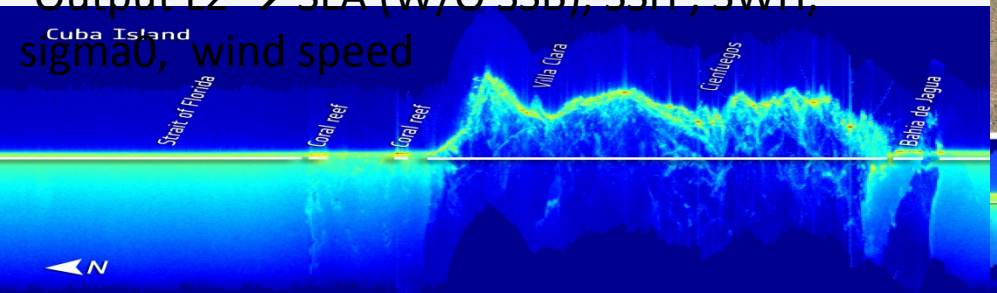
-At L1b, Standard Delay-Doppler Processing (**description online in** https://wiki.services.eoportal.org/tiki-download_wiki_attachment.php?attId=2540)

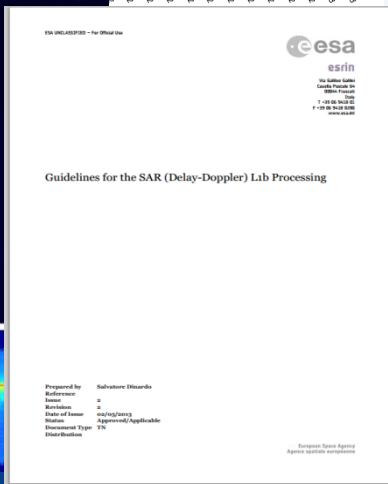
-At L2, Re-tracker with SAMOSA-Analytical Model using Levmar Least Square Estimator

-Output L1b → Radar Echogram

-Output L2 → SLA (W/O SSB), SSH , SWH, sigma0, wind speed

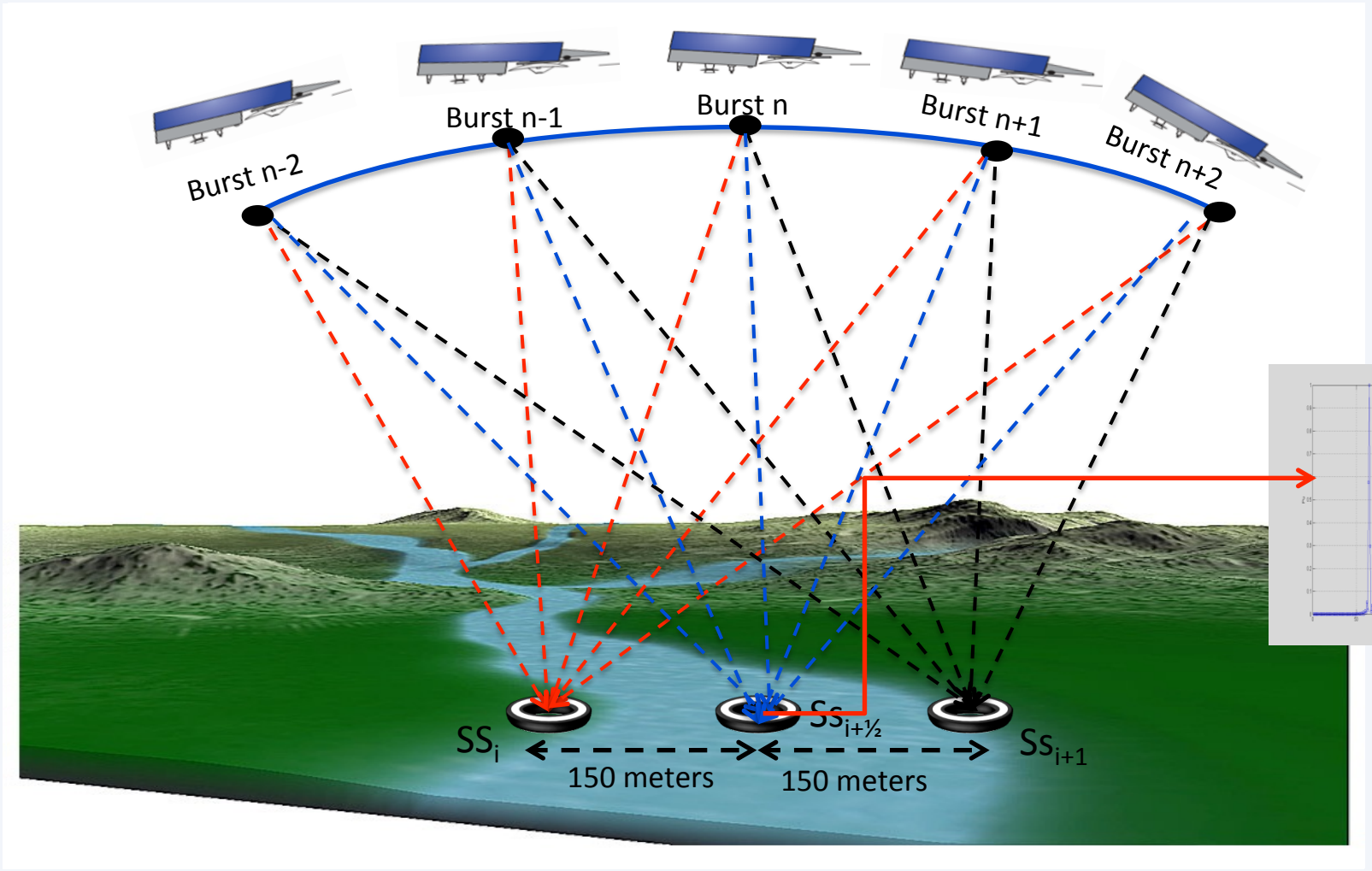




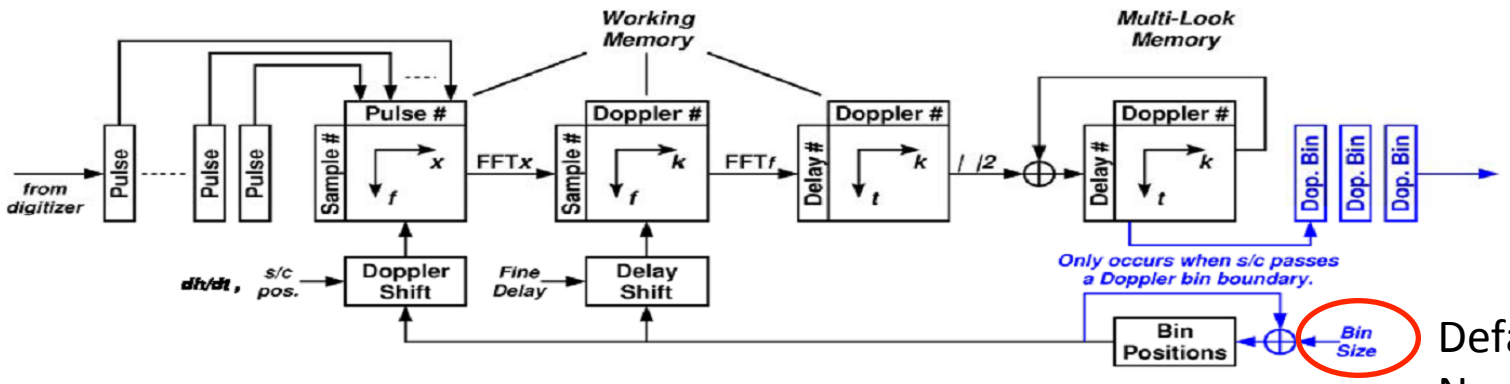
# THE CONCEPT

# SPOTLIGHTED ALTIMETRIC MEASUREMENT



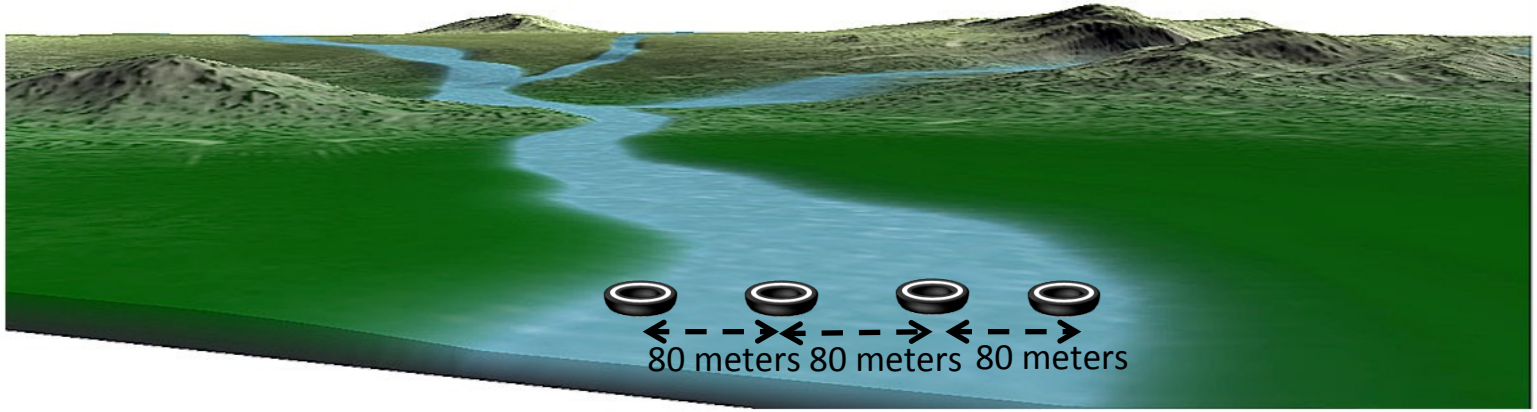

**WE CAN HAVE A SAR ALTIMETRIC MEASUREMENT IN ANY GROUND POINT ALONG THE TRACK !**

# SAR ALTIMETRIC MEASUREMENT @ FINER GRID STEP




Default 300 m
Now fixed at 80 m

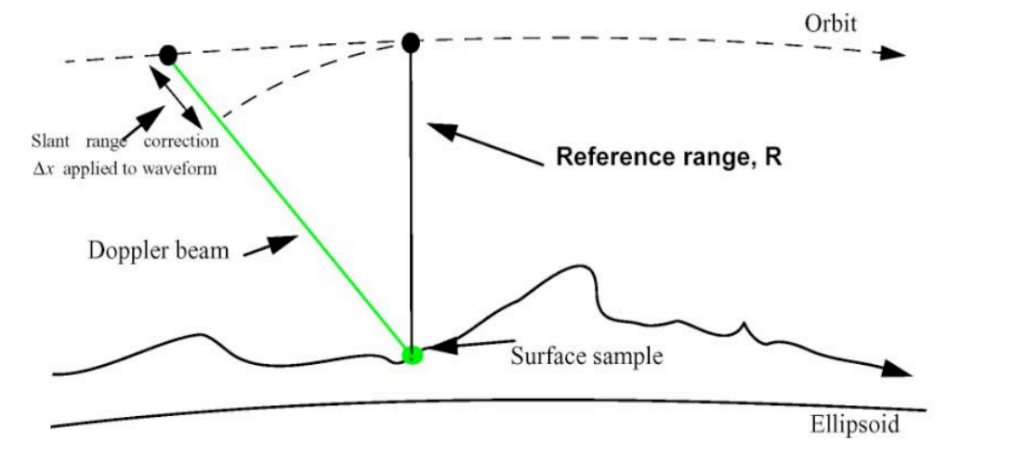
Above Image from Keith Raney




**WE DONT CHANGE THE ALONG TRACK RESOLUTION, ONLY THE GRID STEP SIZE!**

# Why 80 Hz posting rate?

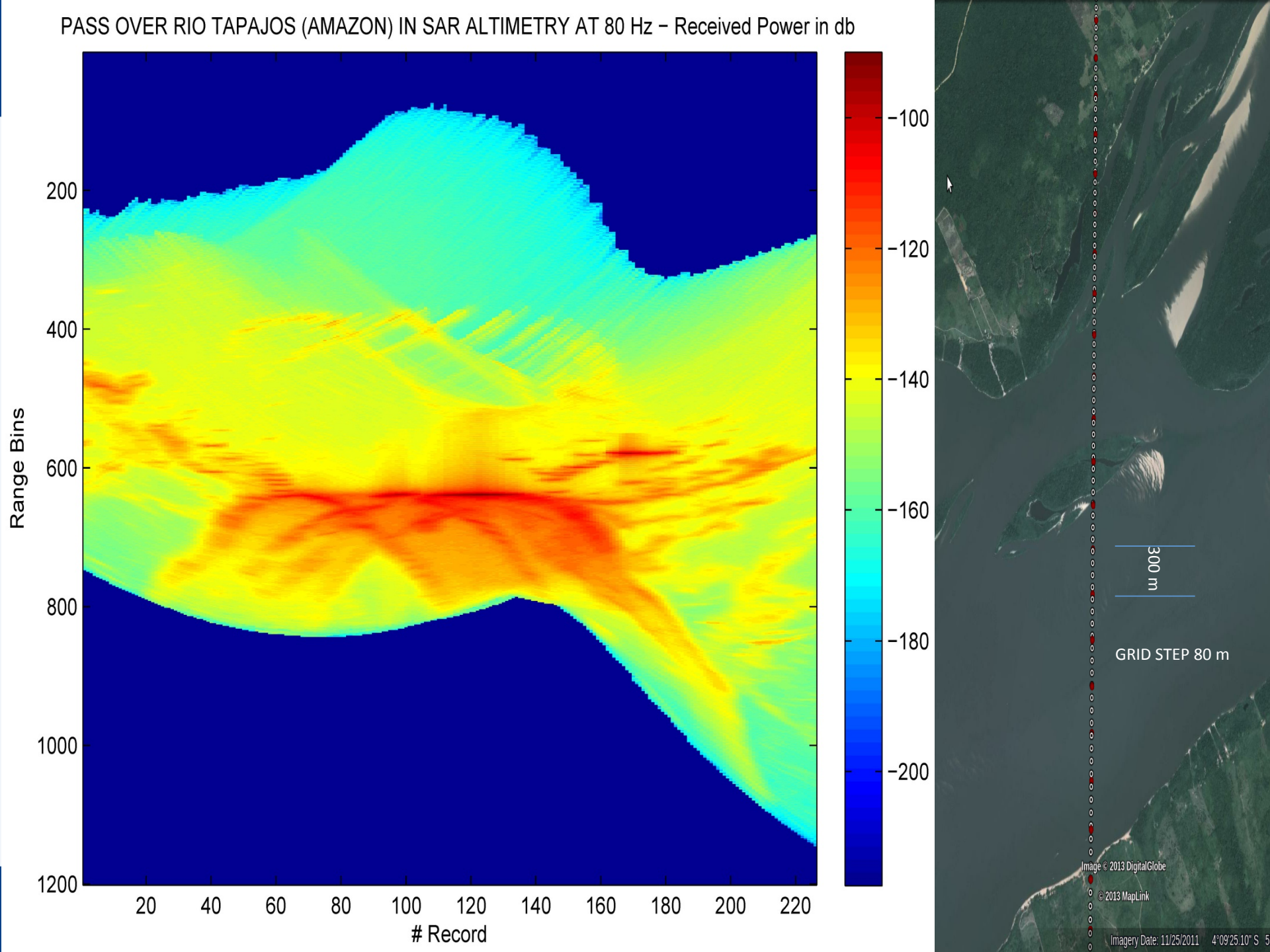
The orbit height at 20 Hz are provided by means of an interpolation operation

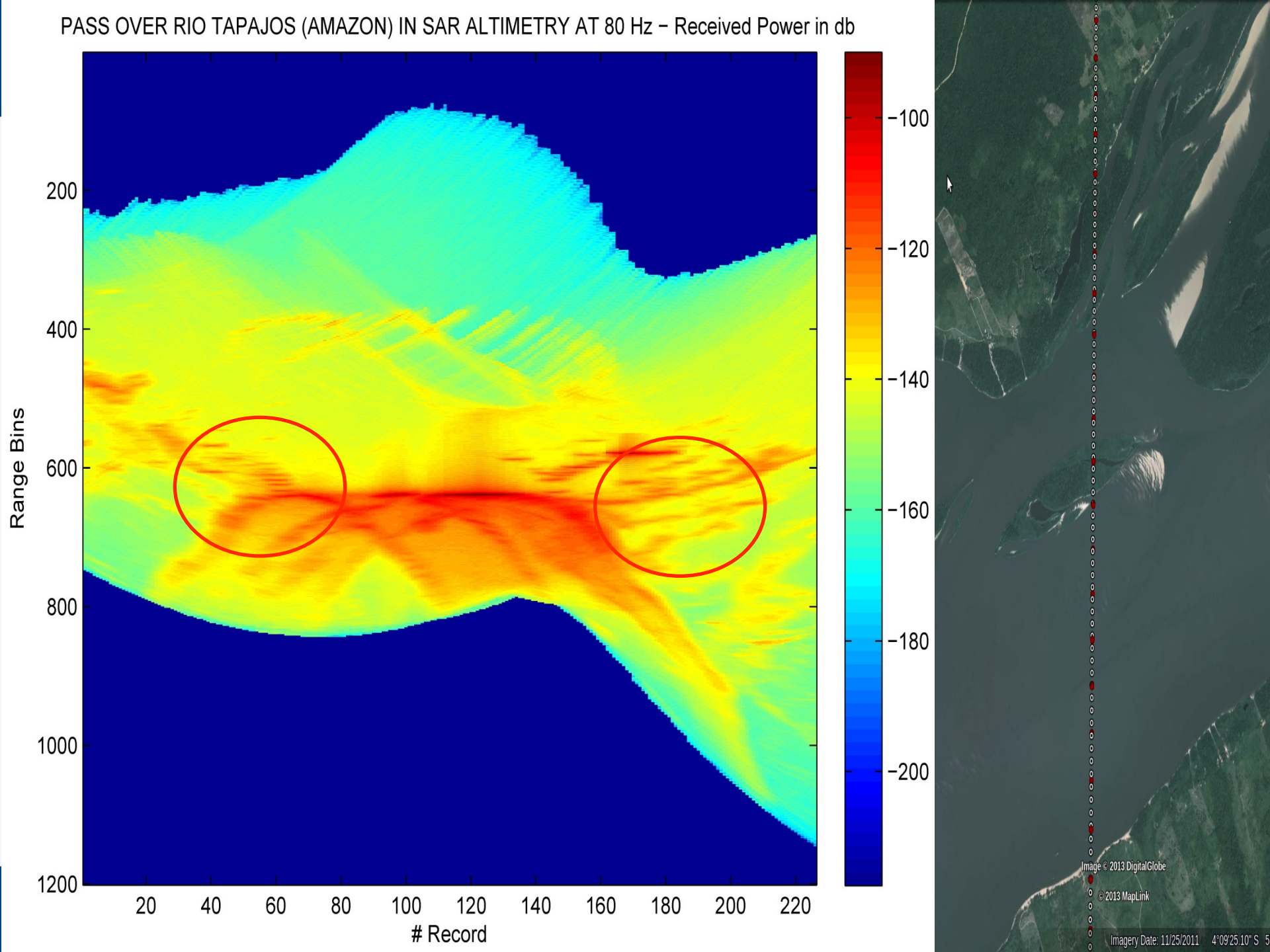


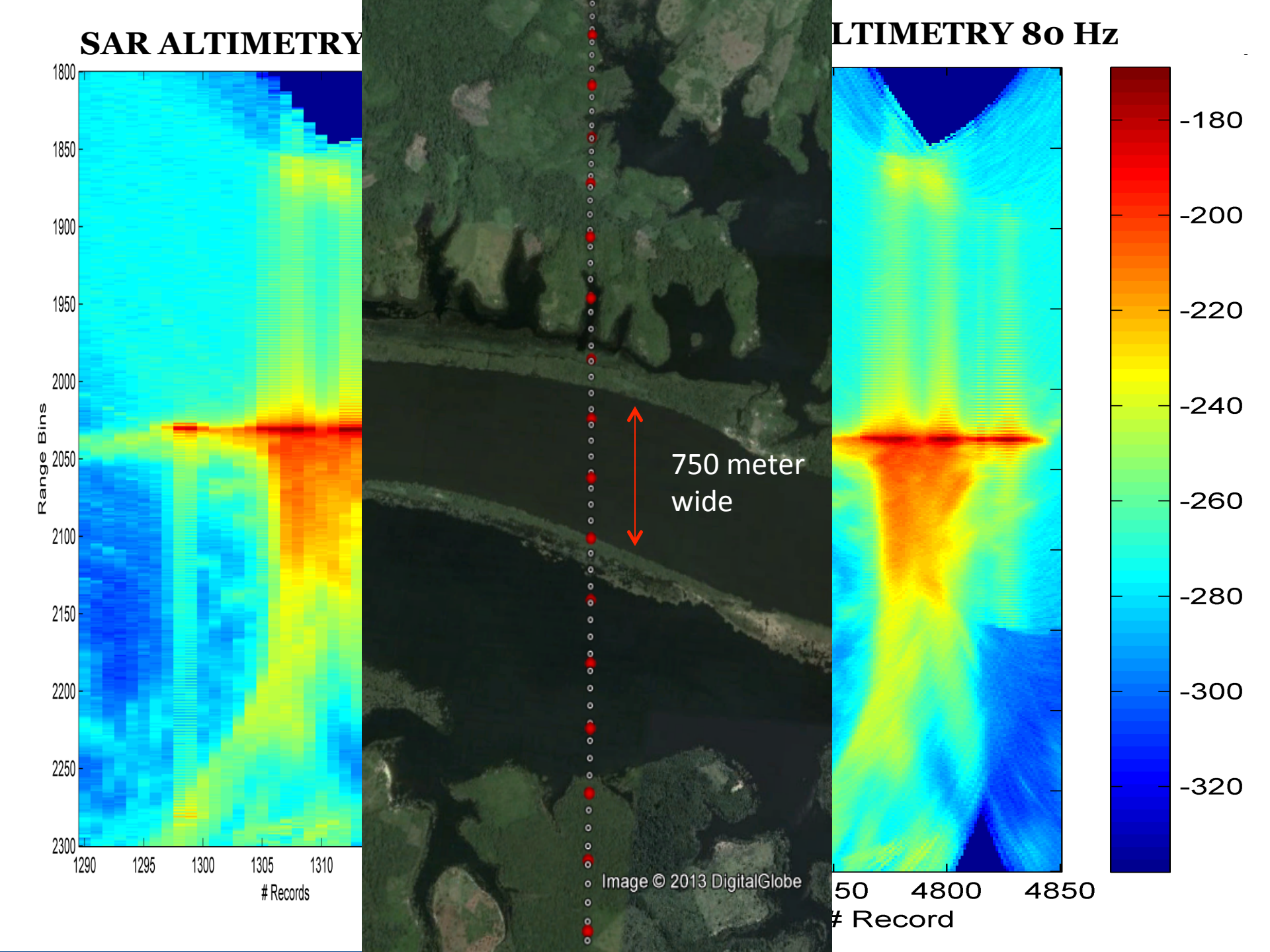

Fixing the grid at rate of ≈ 80 Hz, **the grid cell is co-located with the burst center**. This allows to skip the cumbersome interpolation operation because the orbit and geo-location information are already given at each burst center in the FBR data products

# Frequently Asked Questions

- Beamforming approximated
- Total Number of looks don't change (220-230)
- Gridding is pretty uniform
- The price to pay is to have 4 times bigger data volume and 4 slower computational time
- We can do all this just because we have FBR data downlinked to ground !

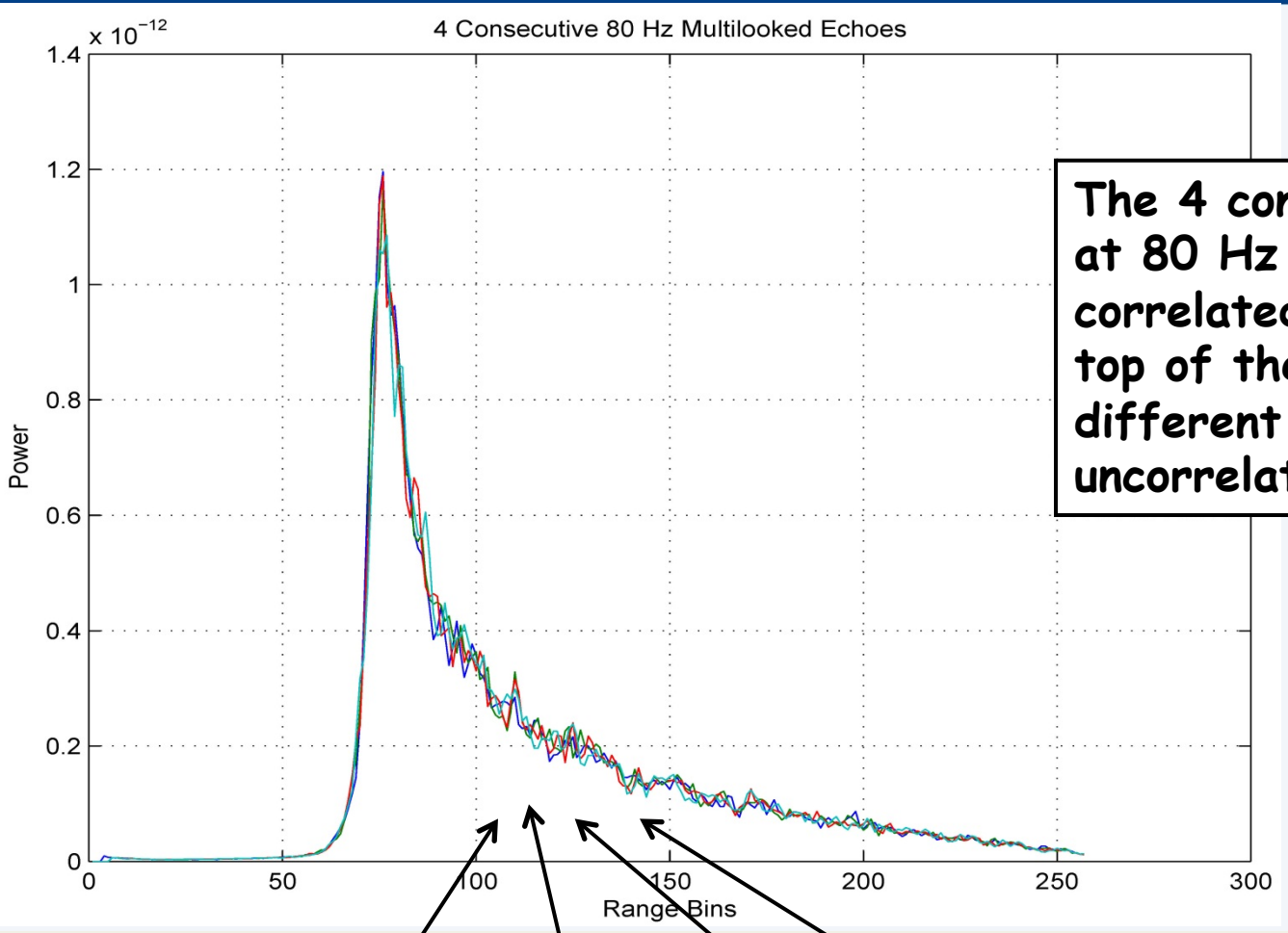

PASS OVER RIO TAPAJOS (AMAZON) IN SAR ALTIMETRY AT 80 Hz – Received Power in db
Range Bins
200
400
600
800
1000
1200
20
40
60
80
100
120
140
160
180
200
220
# Record
−100
−120
−140
−160
−180
−200
300 m
GRID STEP 80 m
Image © 2013 DigitalGlobe
© 2013 MapLink
Imagery Date: 11/25/2011 4°09'25.10"S 5


PASS OVER RIO TAPAJOS (AMAZON) IN SAR ALTIMETRY AT 80 Hz – Received Power in db
Range Bins
200
400
600
800
1000
1200
20
40
60
80
100
120
140
160
180
200
220
# Record
-100
-120
-140
-160
-180
-200
Image © 2013 DigitalGlobe
© 2013 MapLink
Imagery Date: 11/25/2011 4°09'25.10" S 5

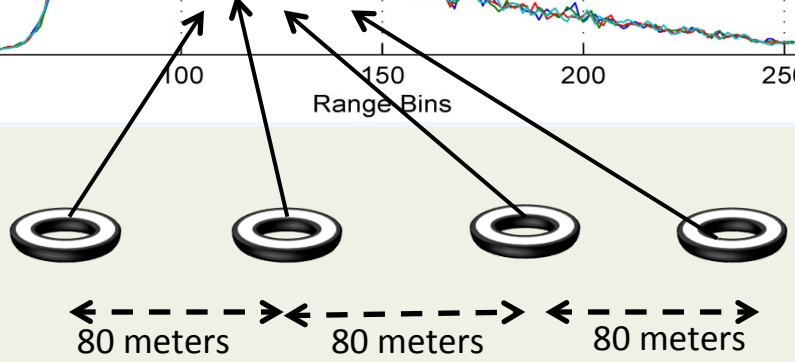

SAR ALTIMETRY
LTIMETRY 80 Hz
Range Bins
# Records
# Record
750 meter wide
Image © 2013 DigitalGlobe

# 80 Hz L2 in open sea

# 4 Consecutives SAR Echoes posted at 80 Hz (open sea)




The 4 consecutive SAR Echoes at 80 Hz are not fully correlated ! ! Speckle noise on top of them is slightly different .. Echoes partially uncorrelated



- Over open sea, we retrack the SAR Multilooked Echoes at 80 Hz and then we generate the altimetric geophysical parameters (Sea Level Height, Significant Wave Height and Wind Speed) **at 80 Hz**

Therefore, what we are implementing is to carry out a sub-pixel (sub-footprint) re-tracking of the SAR Echoes (i.e. retracking SAR echoes at 80 m whereas the SAR space resolution is 300 m in along track direction).

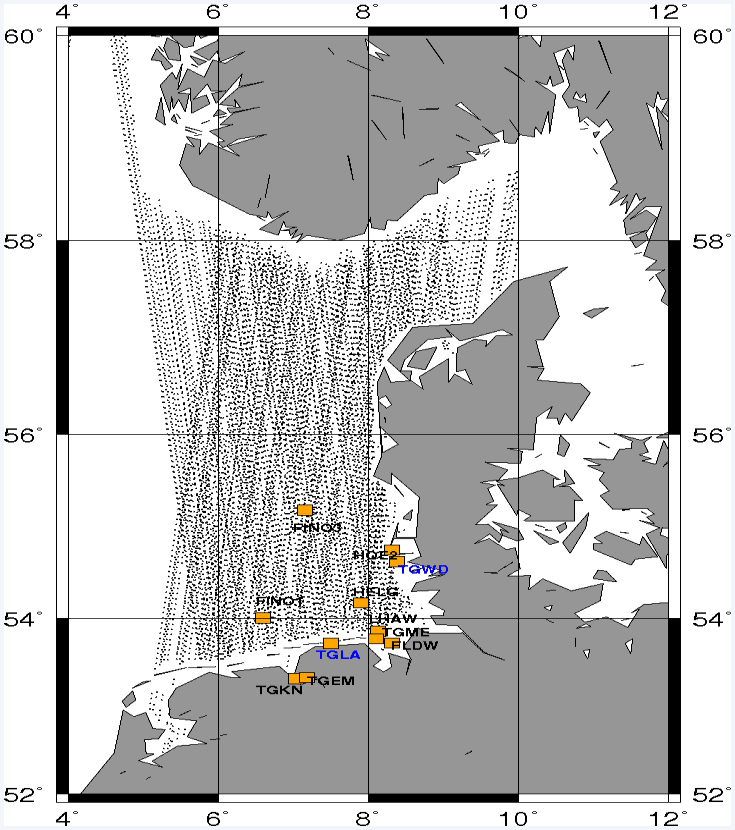
This is in line with Pulse-limited (LRM) altimetry wherein the retracking is operated at 20 Hz (300 m) whereas the instrument resolution (pulse-limited circle diameter) is varying between 1.5 km (flat sea) - 7 km (at SWH=10) i.e. 5Hz-1 Hz

That makes sense: by Nyquist' s Theorem, if you have a signal at resolution of 300 meters, you have to sample at least at half of the resolution (150 m) to represent properly the signal' s dynamic

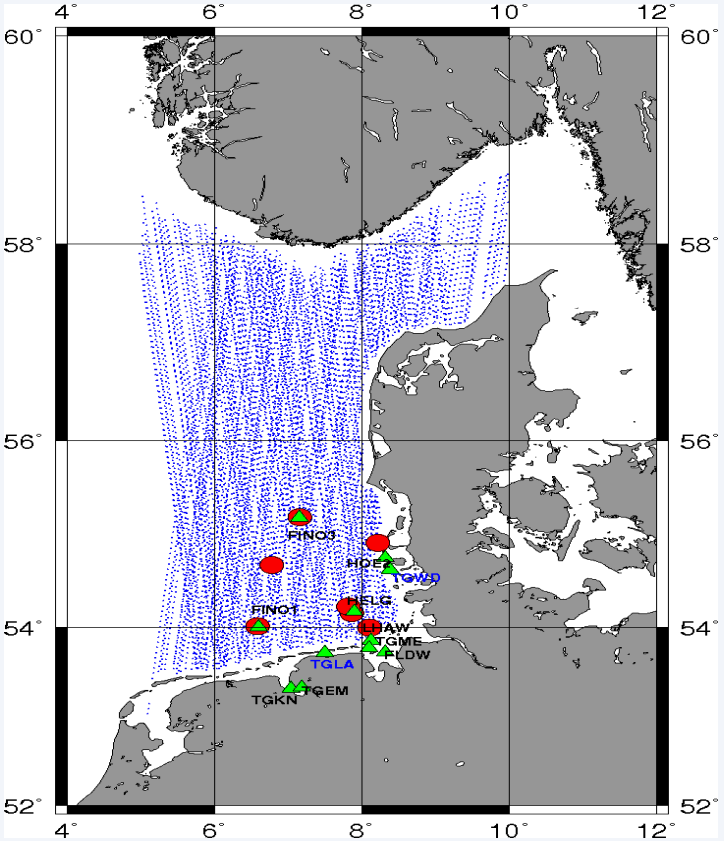
- Over open sea, to generate 20 Hz geophysical parameters (SSH, SWH, U10), we average 4 consecutive values of SSH, SWH, U10

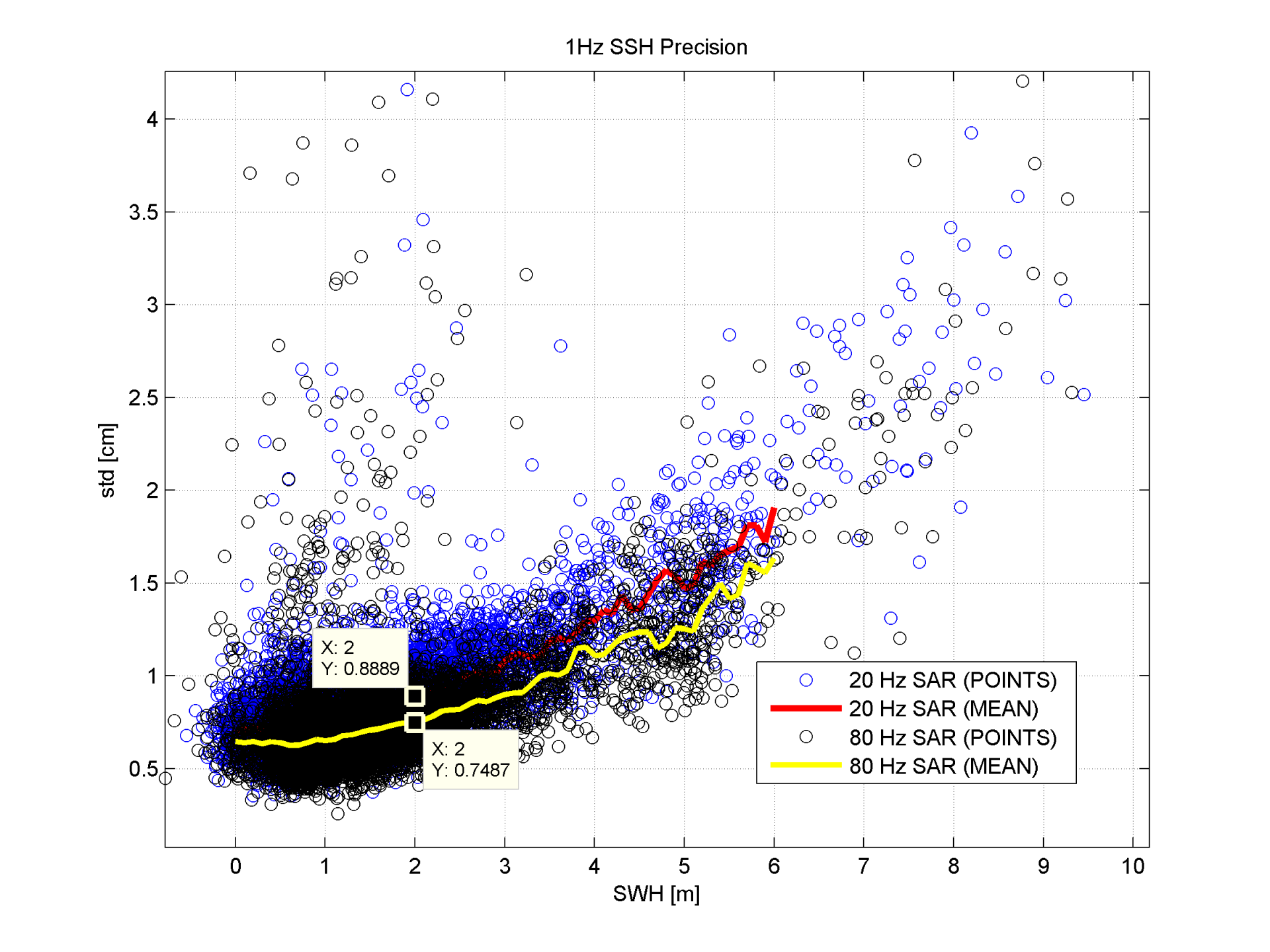
# DATASET USED in GERMAN BIGHT

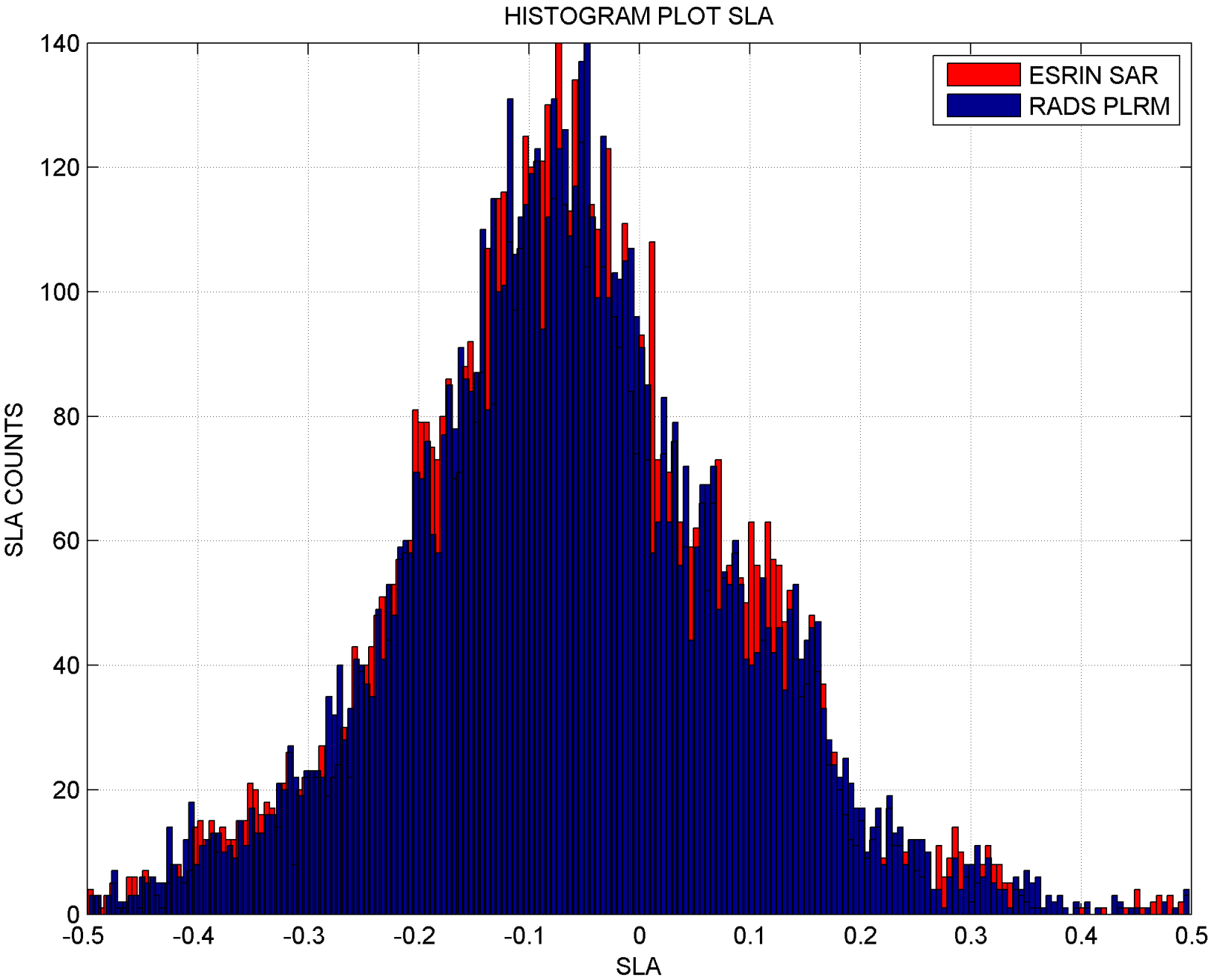
## RADS PLRM (PSEUDO-LRM) 2011-2012



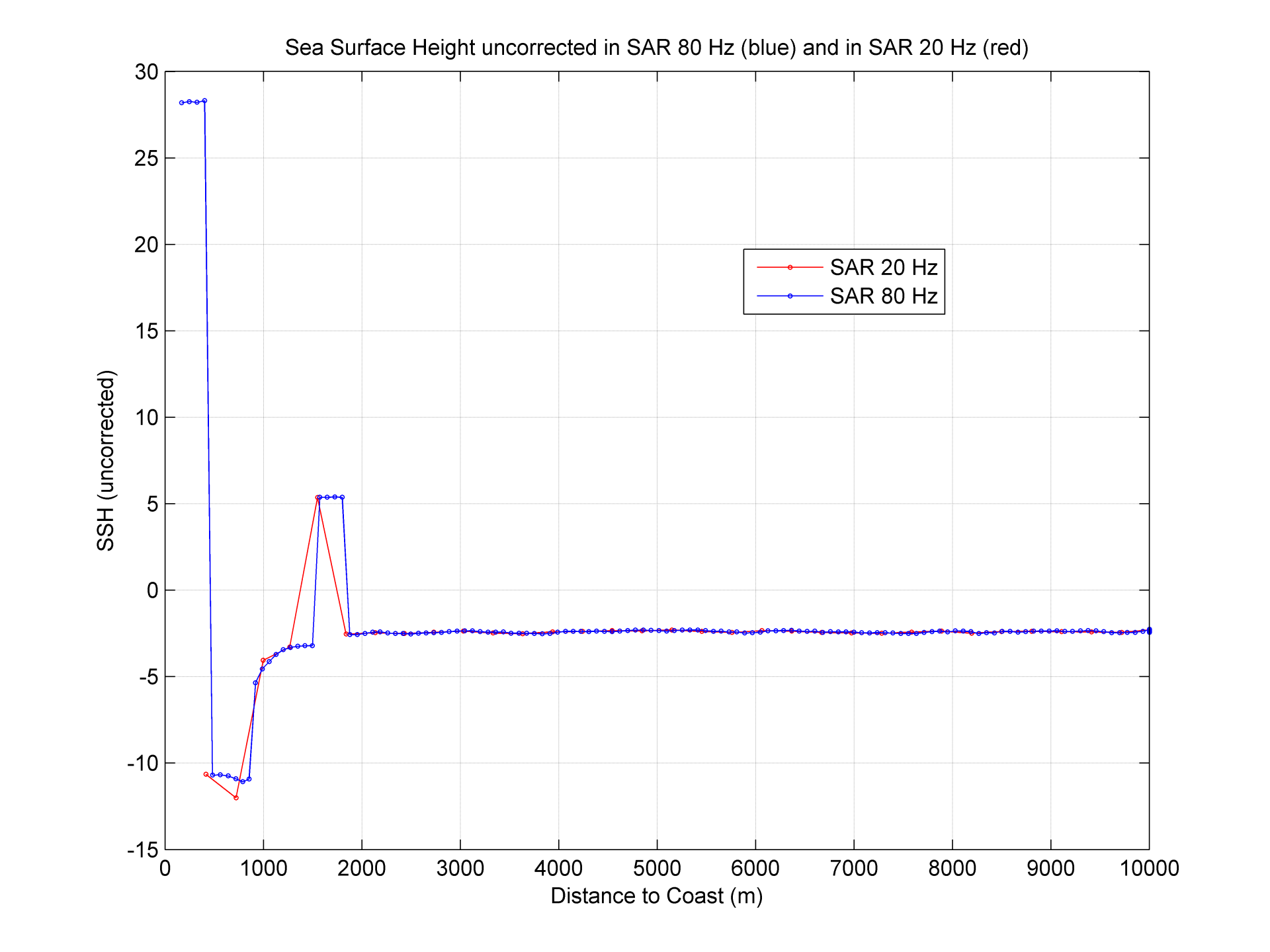

## ESRIN SAR 2011-2012

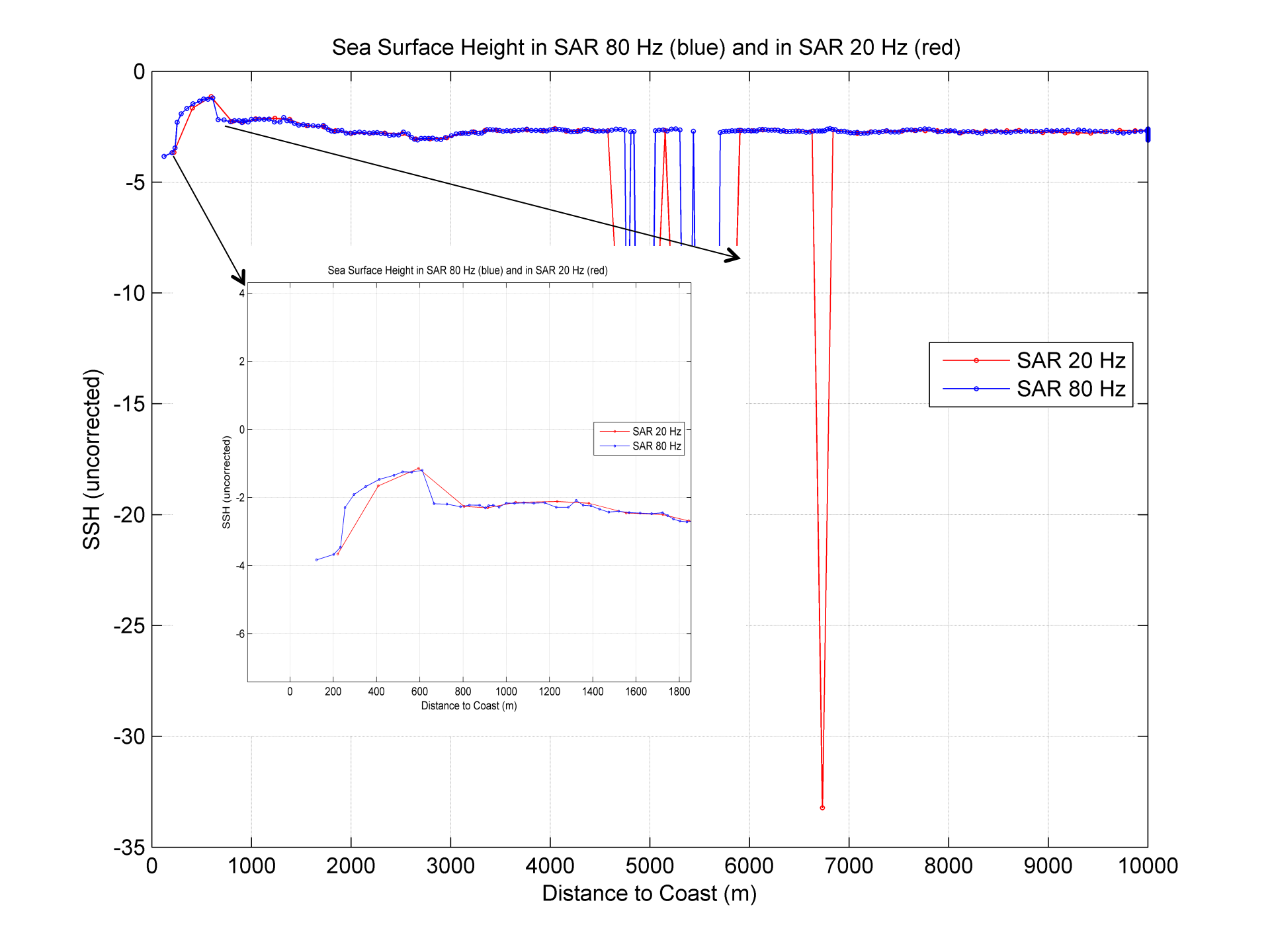


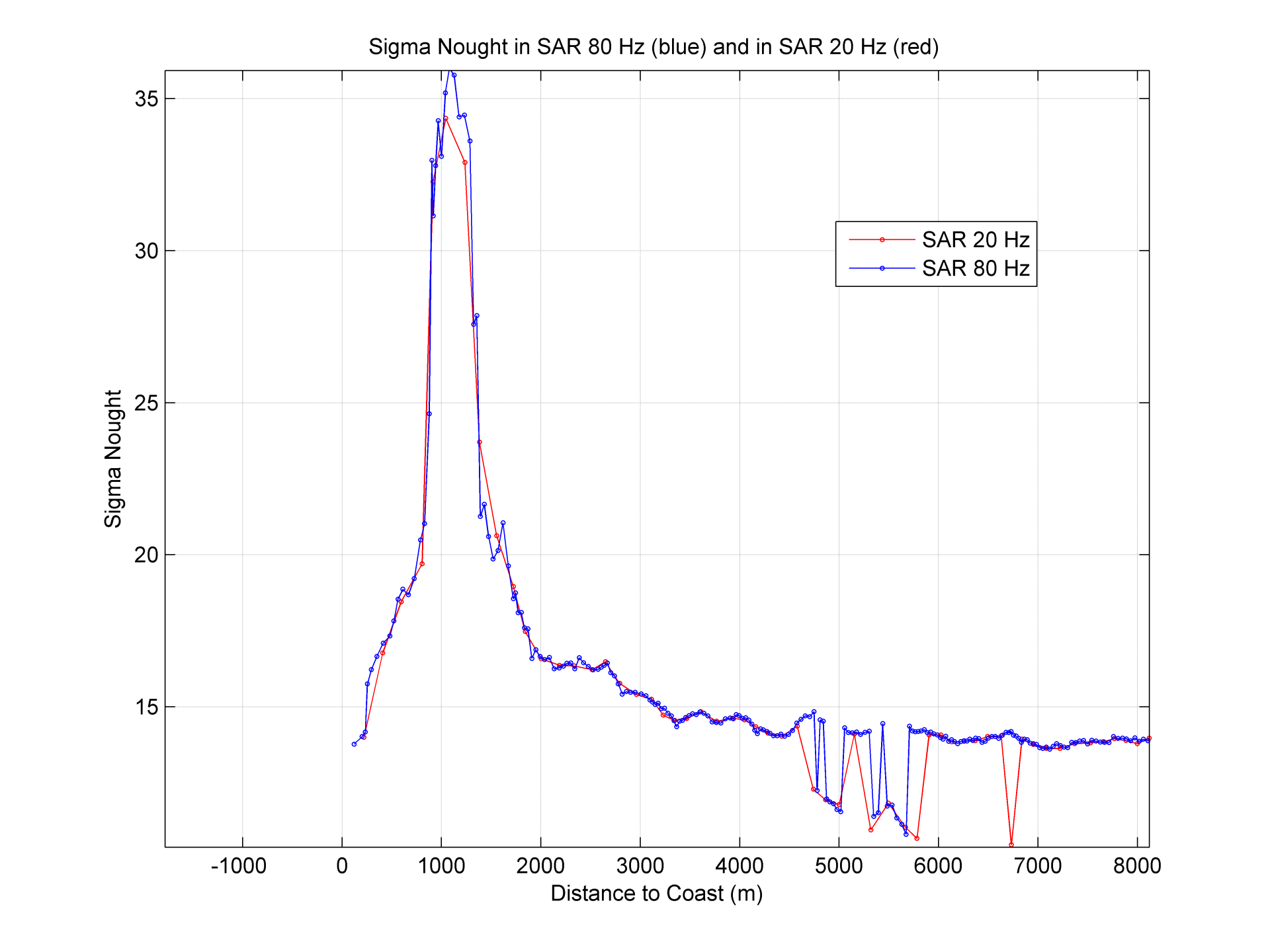

1Hz SSH Precision
std [cm]
SWH [m]
X: 2
Y: 0.8889
X: 2
Y: 0.7487
20 Hz SAR (POINTS)
20 Hz SAR (MEAN)
80 Hz SAR (POINTS)
80 Hz SAR (MEAN)


HISTOGRAM PLOT SLA
ESRIN SAR
RADS PLRM
SLA COUNTS
SLA
0
20
40
60
80
100
120
140
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5

# 80 Hz L2 in Coastal Zone


Sea Surface Height uncorrected in SAR 80 Hz (blue) and in SAR 20 Hz (red)
SSH (uncorrected)
Distance to Coast (m)
SAR 20 Hz
SAR 80 Hz
30
25
20
15
10
5
0
-5
-10
-15
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000


Sea Surface Height in SAR 80 Hz (blue) and in SAR 20 Hz (red)
SSH (uncorrected)
Distance to Coast (m)
SAR 20 Hz
SAR 80 Hz
0
-5
-10
-15
-20
-25
-30
-35
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Sea Surface Height in SAR 80 Hz (blue) and in SAR 20 Hz (red)
SSH (uncorrected)
Distance to Coast (m)
SAR 20 Hz
SAR 80 Hz
4
2
0
-2
-4
-6
0
200
400
600
800
1000
1200
1400
1600
1800


Sigma Nought in SAR 80 Hz (blue) and in SAR 20 Hz (red)
SAR 20 Hz
SAR 80 Hz
Sigma Nought
Distance to Coast (m)
35
30
25
20
15
-1000
0
1000
2000
3000
4000
5000
6000
7000
8000

# Things to do

- Spectral Analysis of SSH at 80 ! (to be done !)

# CONCLUSIONS

- **The SAR Radar images (Radar Echogram) over inland water scenarios at 80 Hz appear much more sharp rather than at 20 Hz**
- **Gridding with a space step of 80 meter allows to sample more properly high-variable surfaces and distinguish better short scale-signals ( expecially in land water domain and coastal zones)**
- **Slight Margin of improvement in term of range precision over open sea**
- **For details and further discussion, poster in the room (poster number 1)**