Validation Exercise over German Bight (Open Sea)

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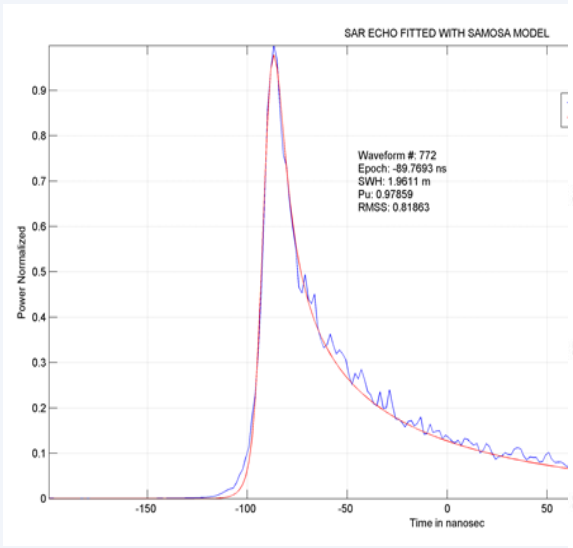
OUTLINE

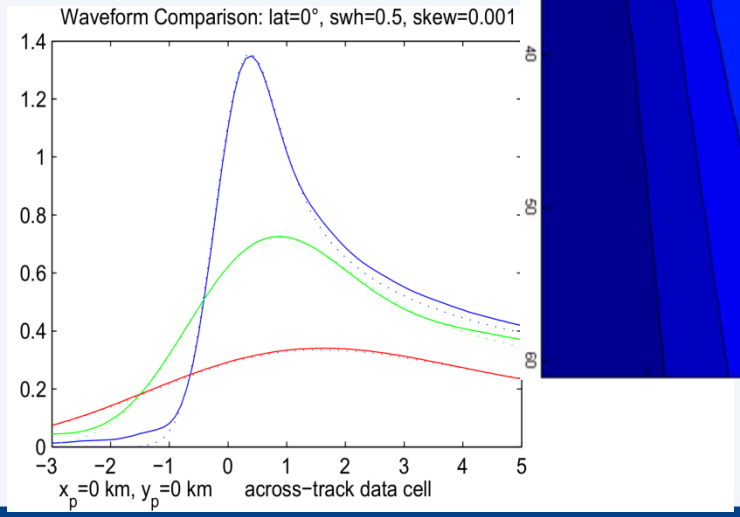
The presentation is structured in the following points:

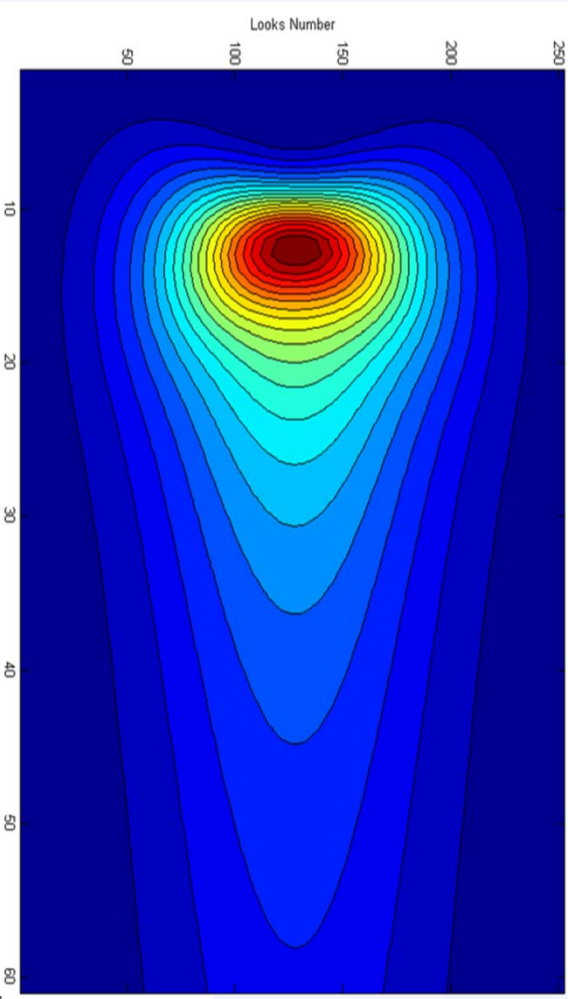
- Introduction/Heritage
- Dataset Used
- Validation Methods
- Results
- Conclusions

SAMOSA HERITAGE

- **SAMOSA MODEL**: Physically-based model developed by Starlab from first principles
- Analytical **(by Bessel Functions)** solutions to model the Delay Doppler Maps (DDM) for the full span of Doppler Frequencies
- Model depends on epoch, significant wave height, Pu, surface rms slope, and mispointing angle(s),
- The model independent variables are the Doppler Frequency and the Time Delay
- The waveforms are retracked by Bounded Least- Square Fitting Algorithm (**Levenberg-Marquard**)

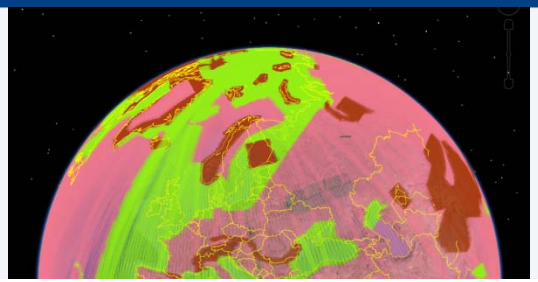






ESRIN KNOW HOW and SAR DATA PRODUCTION

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

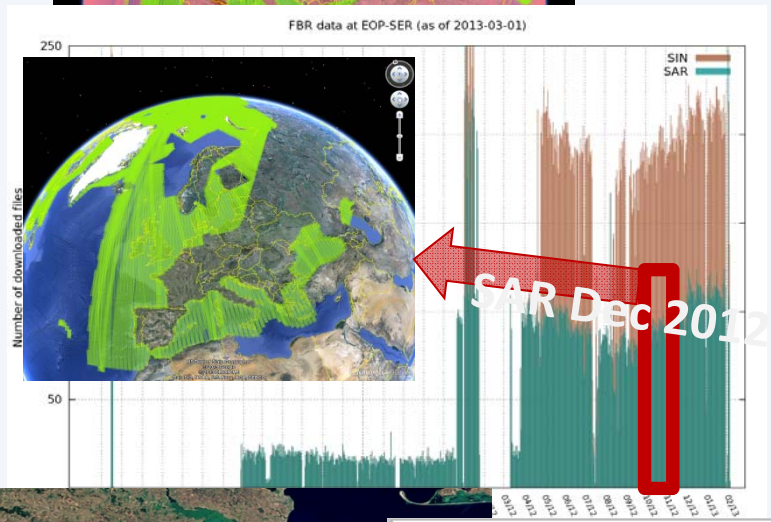
-Coding Language: MATLAB

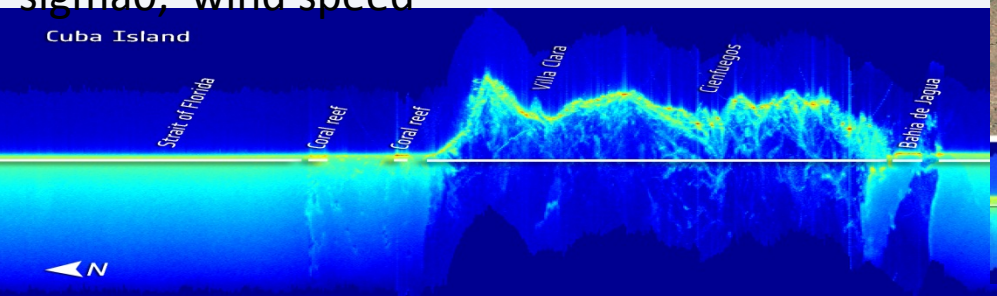
-At L1b, Standard Delay-Doppler Processing (**description on line in** https://wiki.services.eoportal.org/tiki-download_wiki_attachment.php?attId=2540)

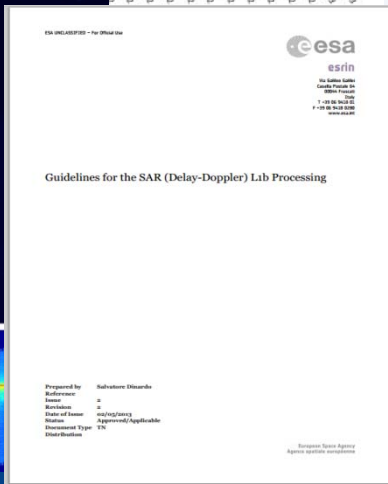
-At L2, Re-tracker with SAMOSA-Analytical Model using Levmar Least Square Estimator

-Output L1b → Radar Echogram

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



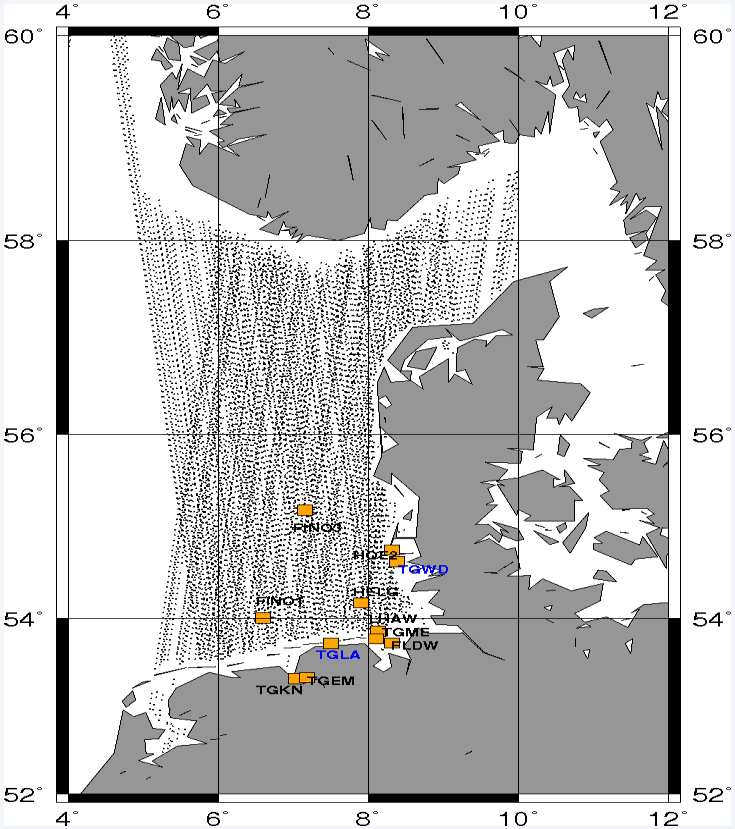




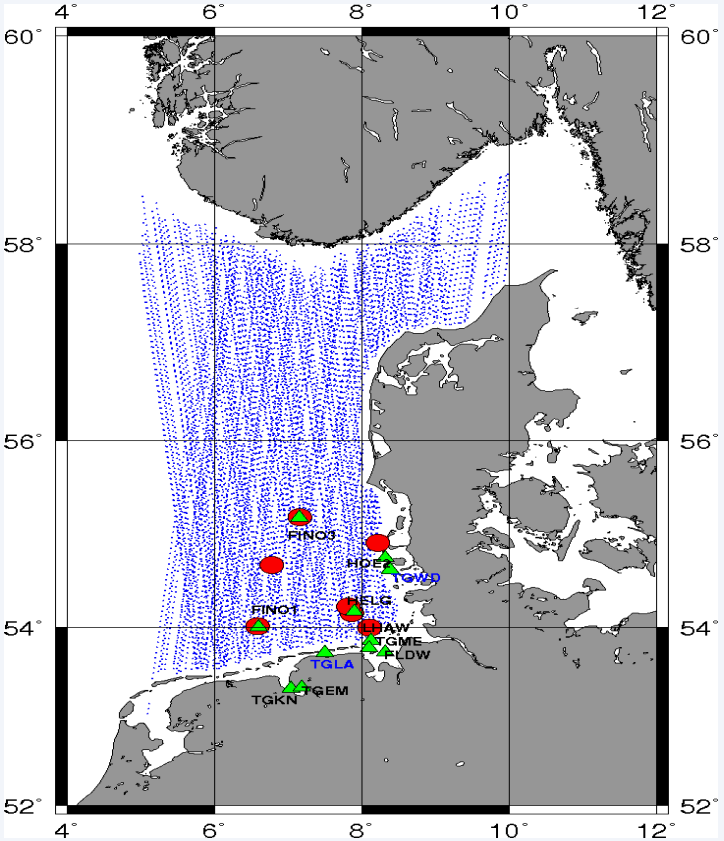
DATASET USED in the Validation

DATASET USED in GERMAN BIGHT

RADS PLRM (PSEUDO-LRM) 2011-2012



ESRIN SAR 2011-2012



- WE COMPARE ALTIMETERIC PARAMETERS (SLA, SWH, U10) IN SAR MODE (from ESRIN Processing) and IN PLRM MODE (from RADS Database) for 2011-2012 time
- DATA IN OPEN OCEAN ONLY (> 10 KM FROM COAST)

PROCESSING CONFIGURATION

ESRIN SAR PROCESSING CONF AT L1b

- A Pre-FFT Zero-Padding in range is applied in order to avoid aliasing for low-SWH conditions (Jansen's sampling)
- A Doppler weighting (Hamming) is applied only over land and in coastal zone (Distance to land >10 km => weighting off,Distance to land <10 km => weighting on)
- Noisy Stack Looks ruled out from the multi-looking (stack thresolding)
- Multilooked waveform posted at same time tag than in CryoSat-2 Kiruna PDGS products

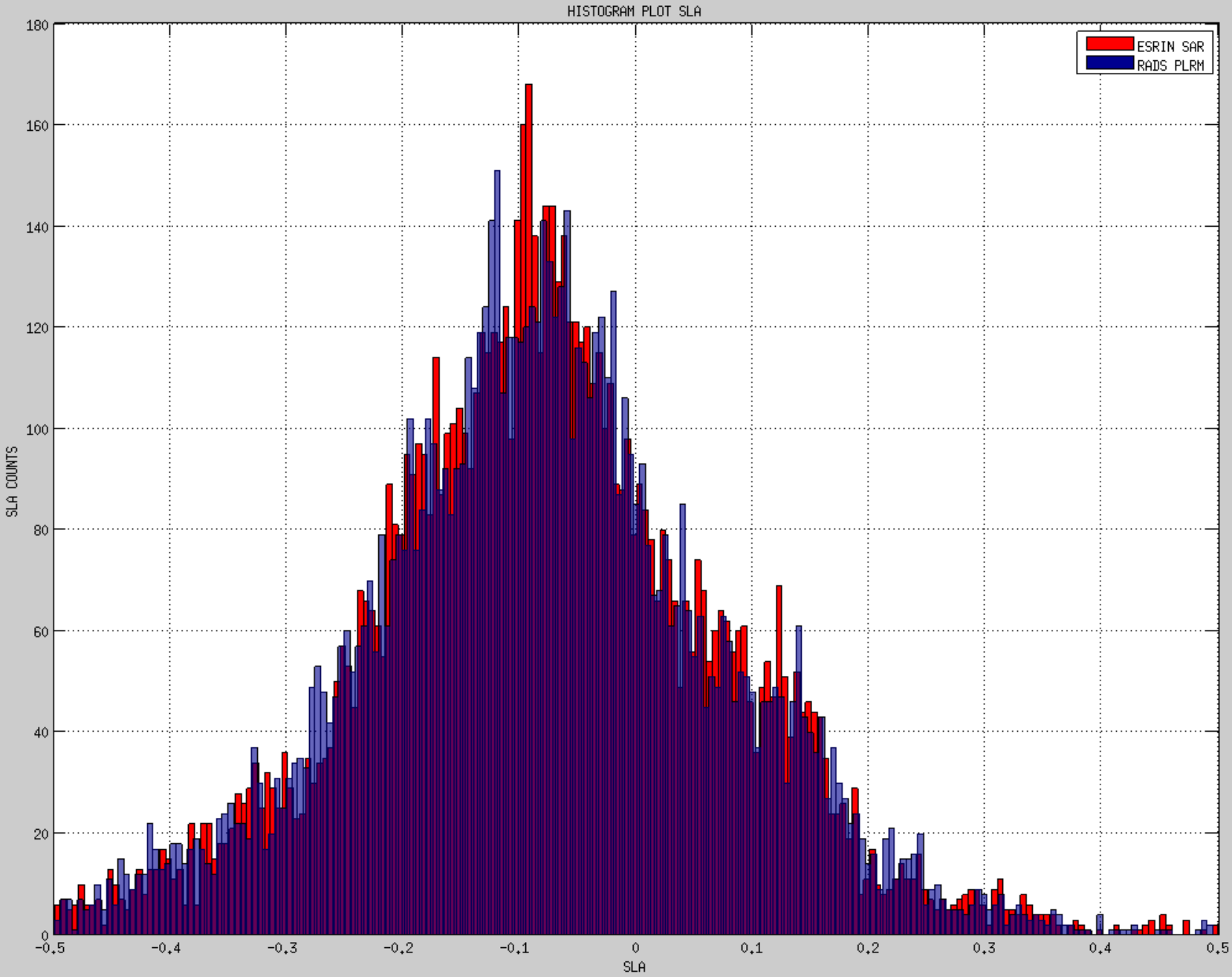
ESRIN SAR PROCESSING CONF AT L2

- SAMOSA Model generation: SAMOSA v3 (see last slide for ref)
- Roll/Pitch mis-pointings (from platform) in input to retracking scheme and platform values are compensated for biases
- Thermal Noise estimated a priori and fed as input in the re-tracking algorithm
- SAR Multilooked Echo Model generated using the same number of looks used in generating the SAR input Waveform
- Range PTR Alpha_p set to 0.513 (RADS PLRM Value)
- Slope/Vertical Speed Effect Switched on

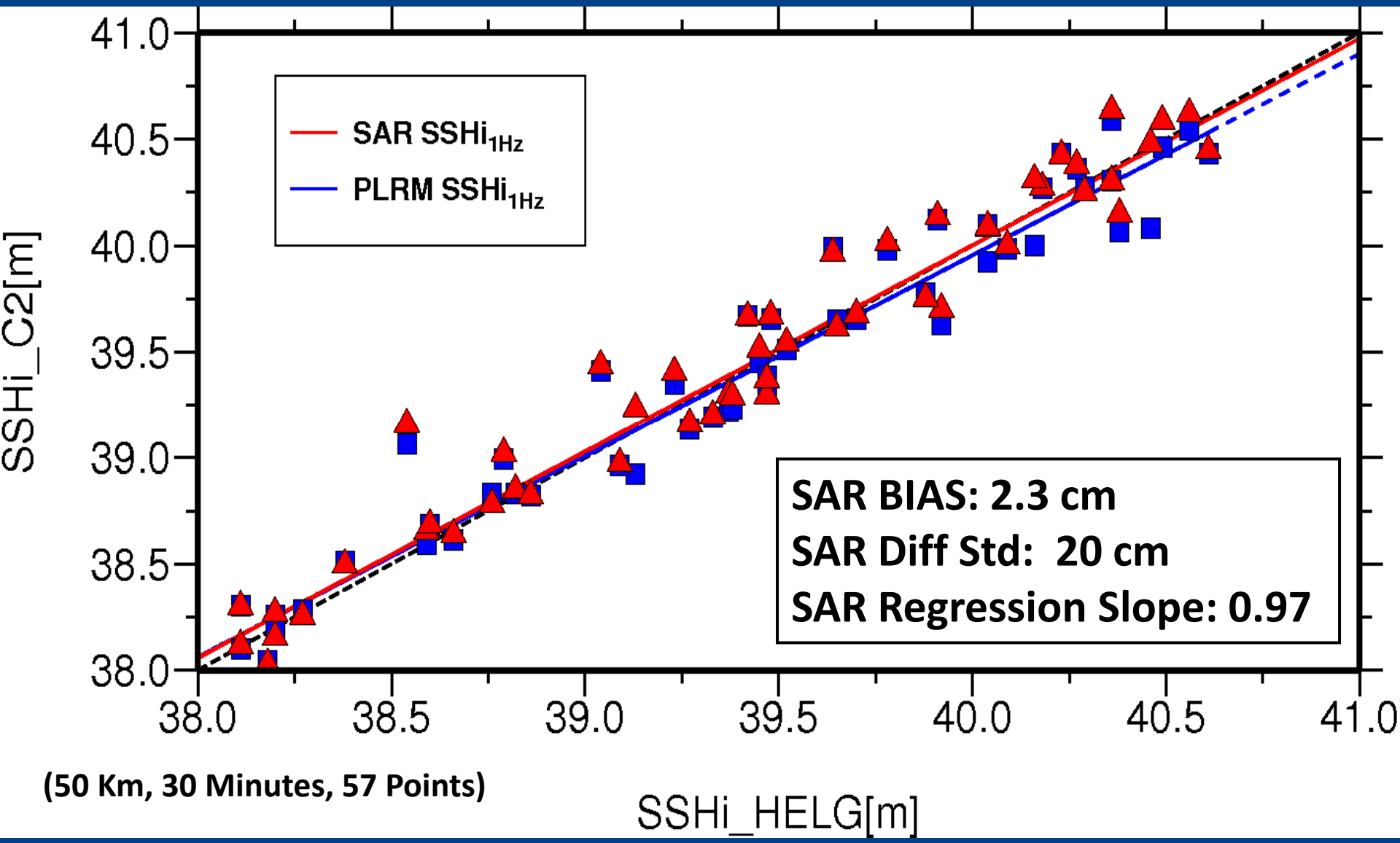
Method of regional comparison

- **We compare:**
  - SSH/SLA,
  - SWH,
  - WIND SPEED (U10),
- **Inter-comparison of Altimetry Data**:
  - C2/PLRM (extracted from RADS database) versus C2/SAR (processed in house at ESRIN) along tracks
- **Co-location between RADS PLRM and ESRIN SAR measuremet can not be perfect** (i.e. 1 Hz PLRM and SAR meaurement not posted at same time and position)
  - Max permitted time difference is ± 0.5 second
- **In-situ data**:
  - SWH C2 versus in-situ SWH AWAC data (Acoustic Wave and Current Meter, FINO-3 Platform,)
  - SSH C2 versus in-situ GPS@TG at Helgoland tide gauge

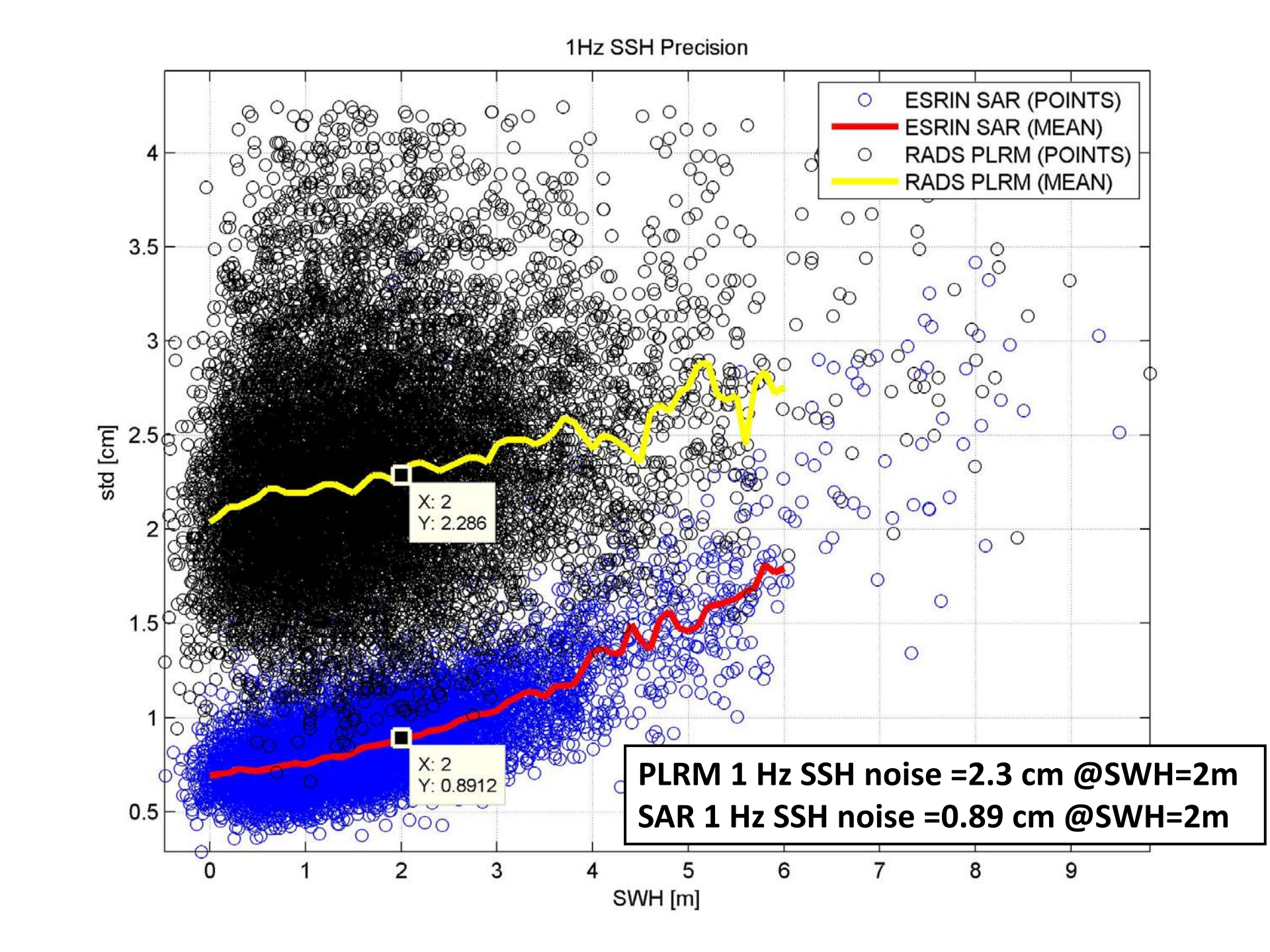
RESULTS OVER OPEN SEA: Sea Level Anomaly


HISTOGRAM PLOT SLA
ESRIN SAR
RADS PLRM
SLA COUNTS
SLA
0
20
40
60
80
100
120
140
160
180
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5

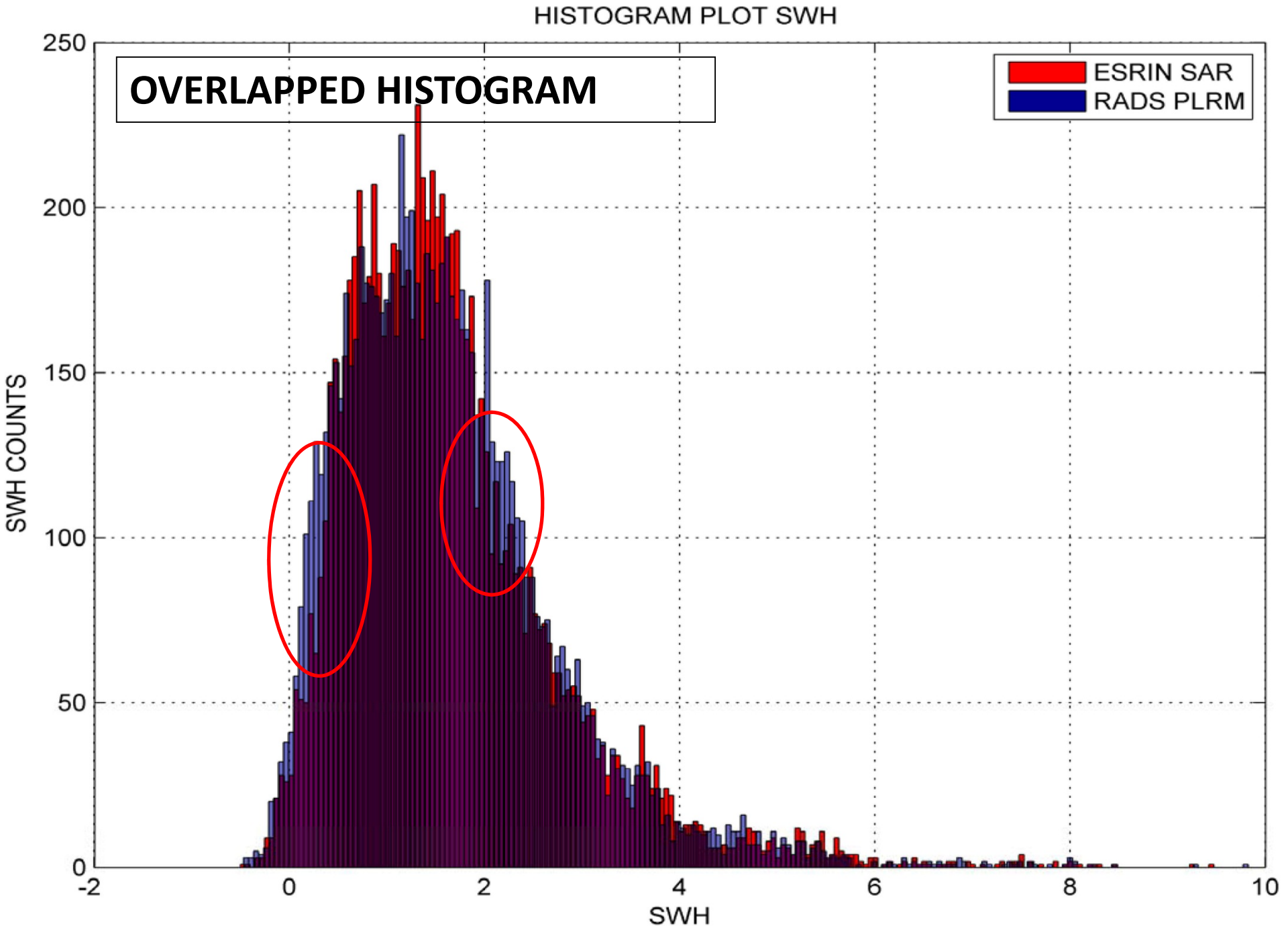
Validation against in situ data: SSH



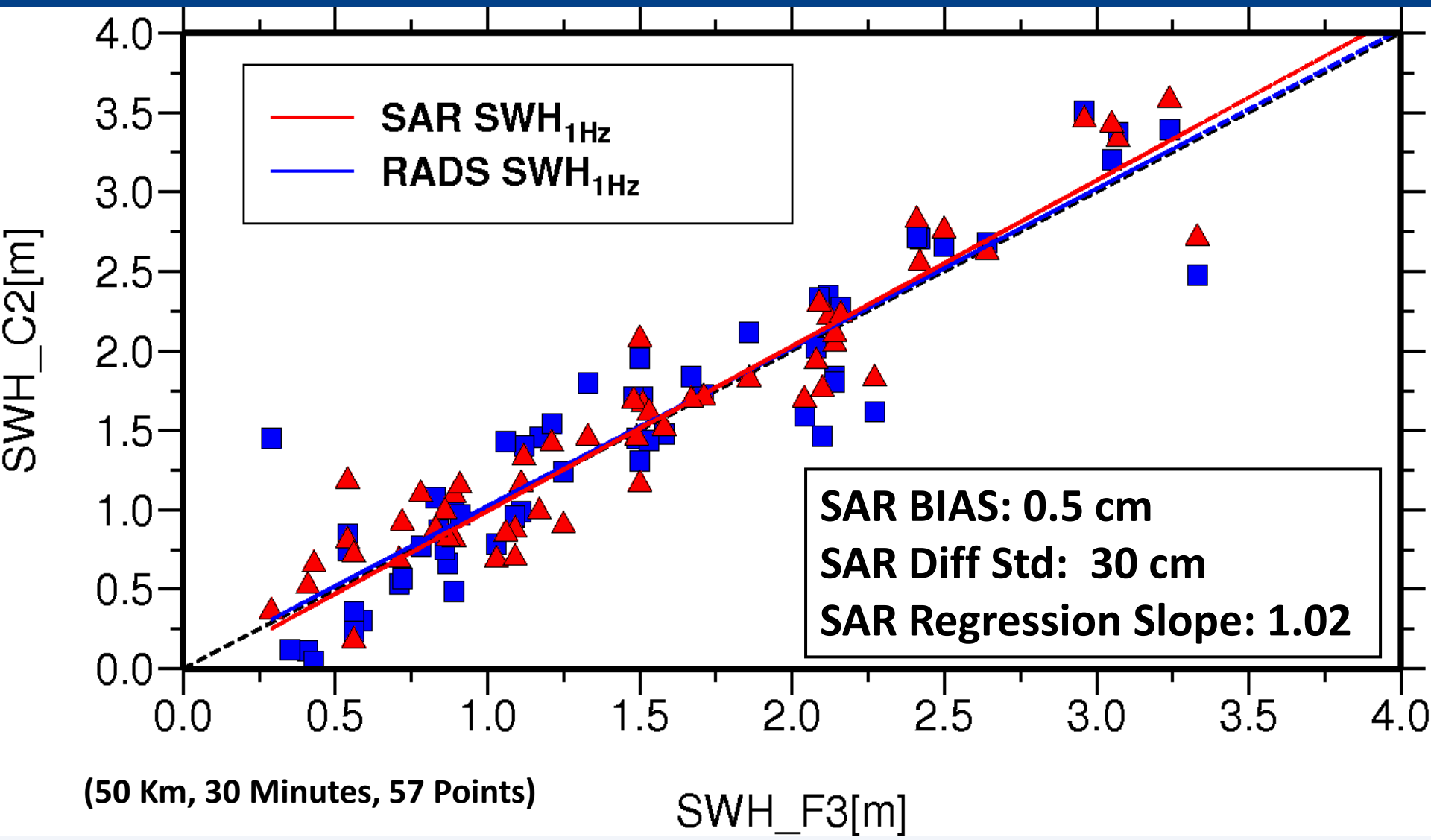
(50 Km, 30 Minutes, 57 Points)


1Hz SSH Precision
ESRIN SAR (POINTS)
ESRIN SAR (MEAN)
RADS PLRM (POINTS)
RADS PLRM (MEAN)
X: 2
Y: 2.286
X: 2
Y: 0.8912
std [cm]
SWH [m]
0.5
1
1.5
2
2.5
3
3.5
4
0
1
2
3
4
5
6
7
8
9
PLRM 1 Hz SSH noise =2.3 cm @SWH=2m
SAR 1 Hz SSH noise =0.89 cm @SWH=2m

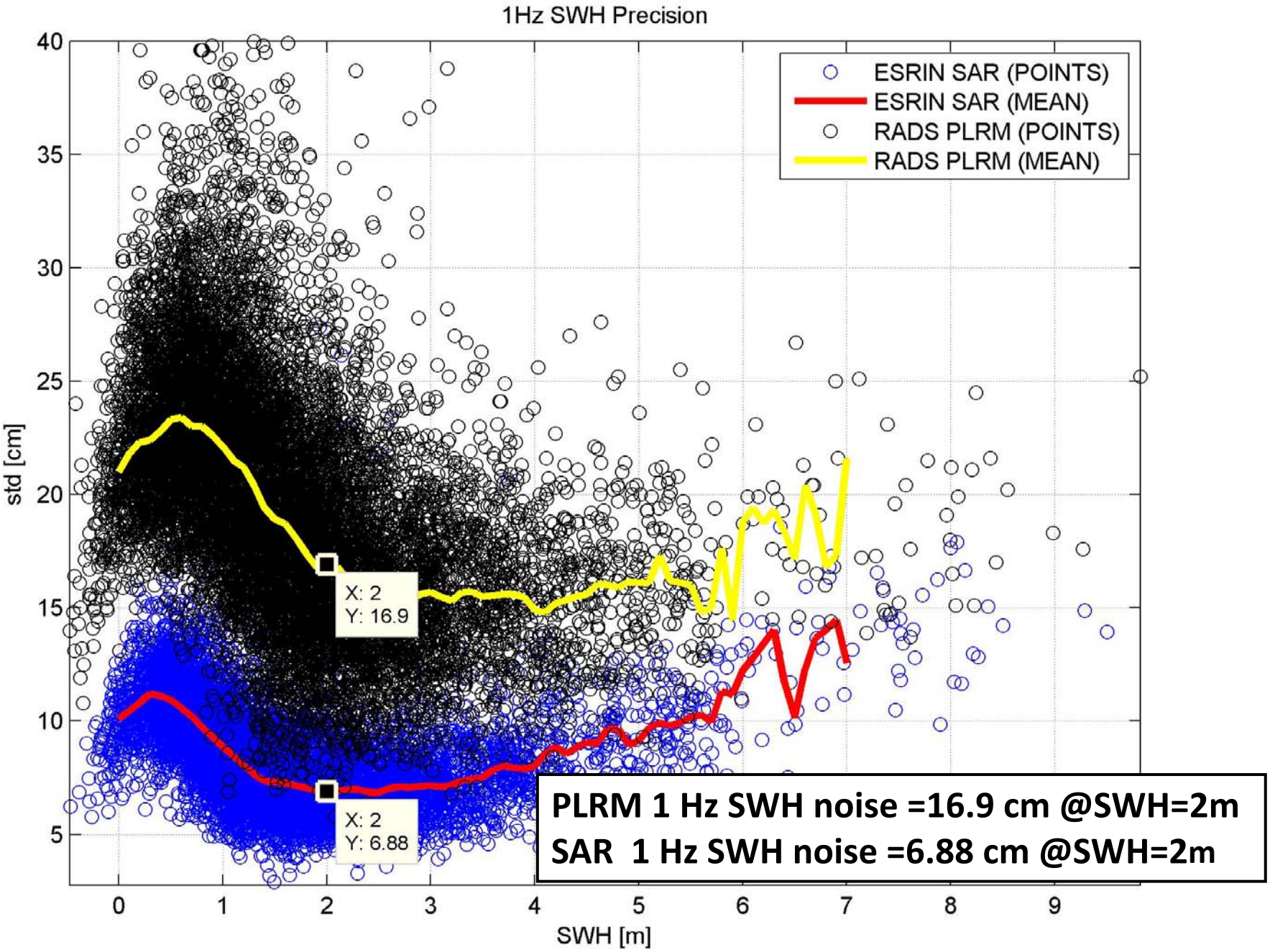
RESULTS OVER OPEN SEA: Wave Height


HISTOGRAM PLOT SWH
OVERLAPPED HISTOGRAM
ESRIN SAR
RADS PLRM
SWH COUNTS
SWH
250
200
150
100
50
0
-2
0
2
4
6
8
10

Validation against in situ data: SWH



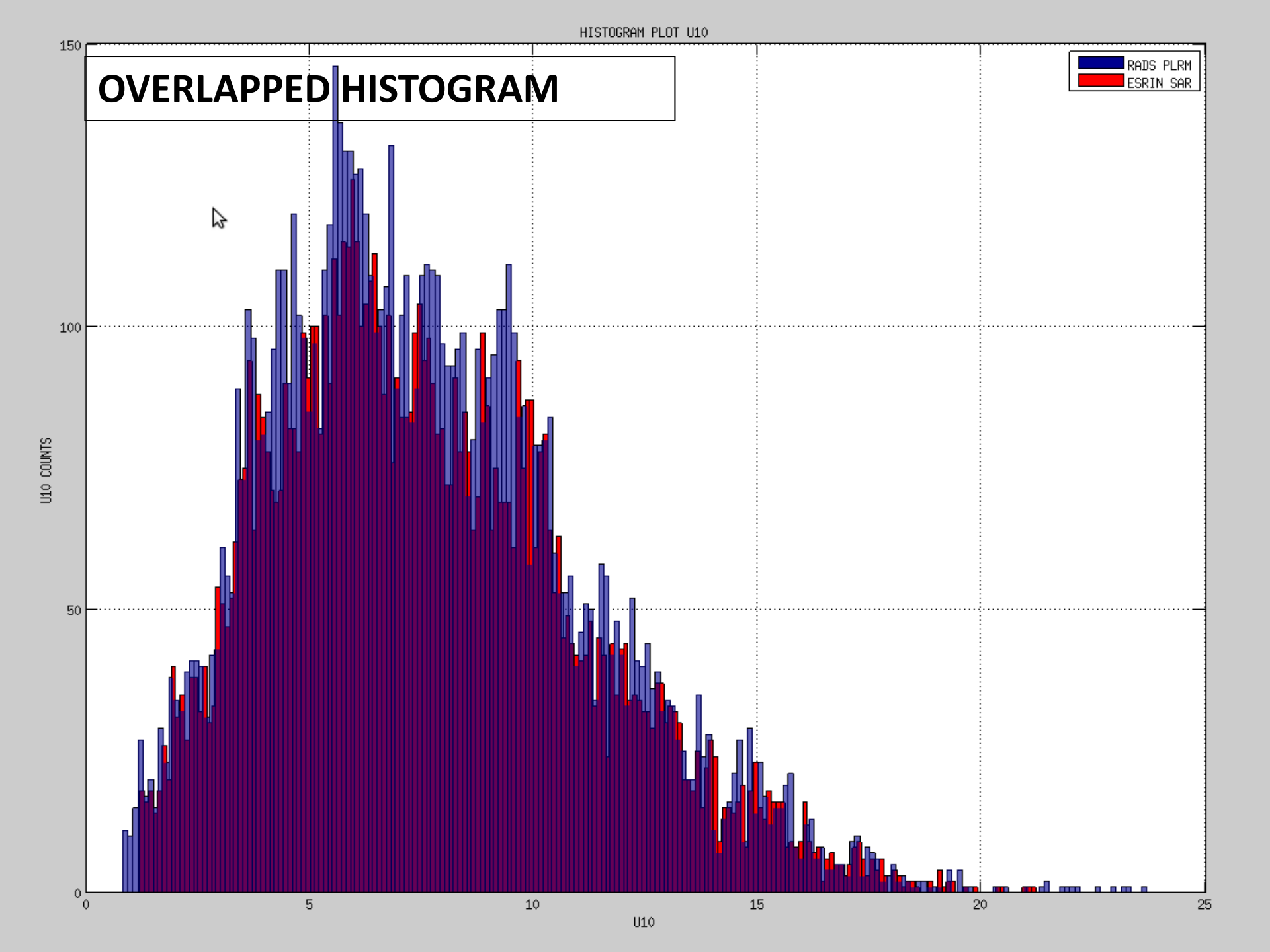
(50 Km, 30 Minutes, 57 Points)


1Hz SWH Precision
ESRIN SAR (POINTS)
ESRIN SAR (MEAN)
RADS PLRM (POINTS)
RADS PLRM (MEAN)
X: 2
Y: 16.9
X: 2
Y: 6.88
std [cm]
SWH [m]
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
PLRM 1 Hz SWH noise =16.9 cm @SWH=2m
SAR 1 Hz SWH noise =6.88 cm @SWH=2m

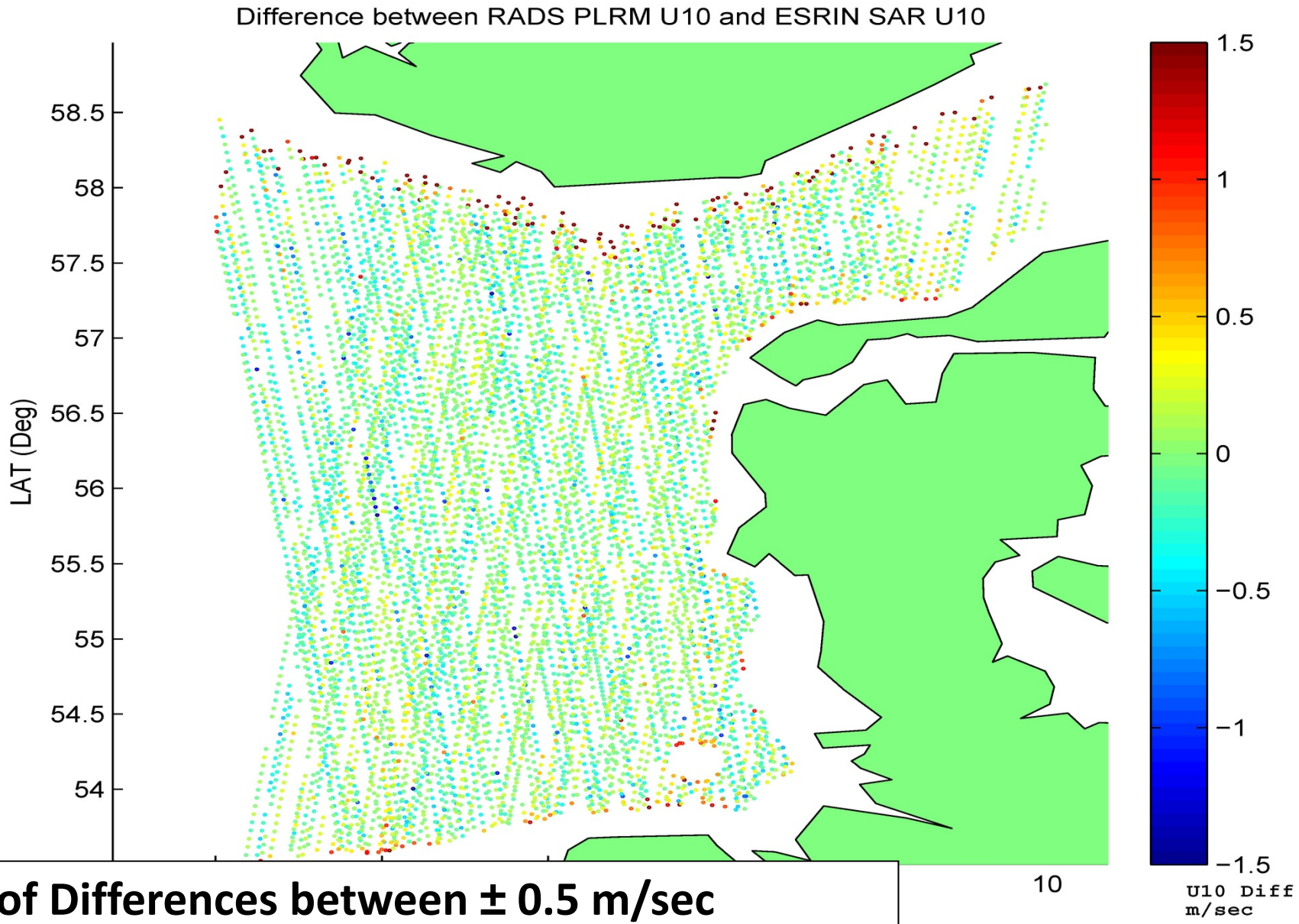
RESULTS OVER OPEN SEA: Wind Speed

WIND SPEED RETRIEVAL

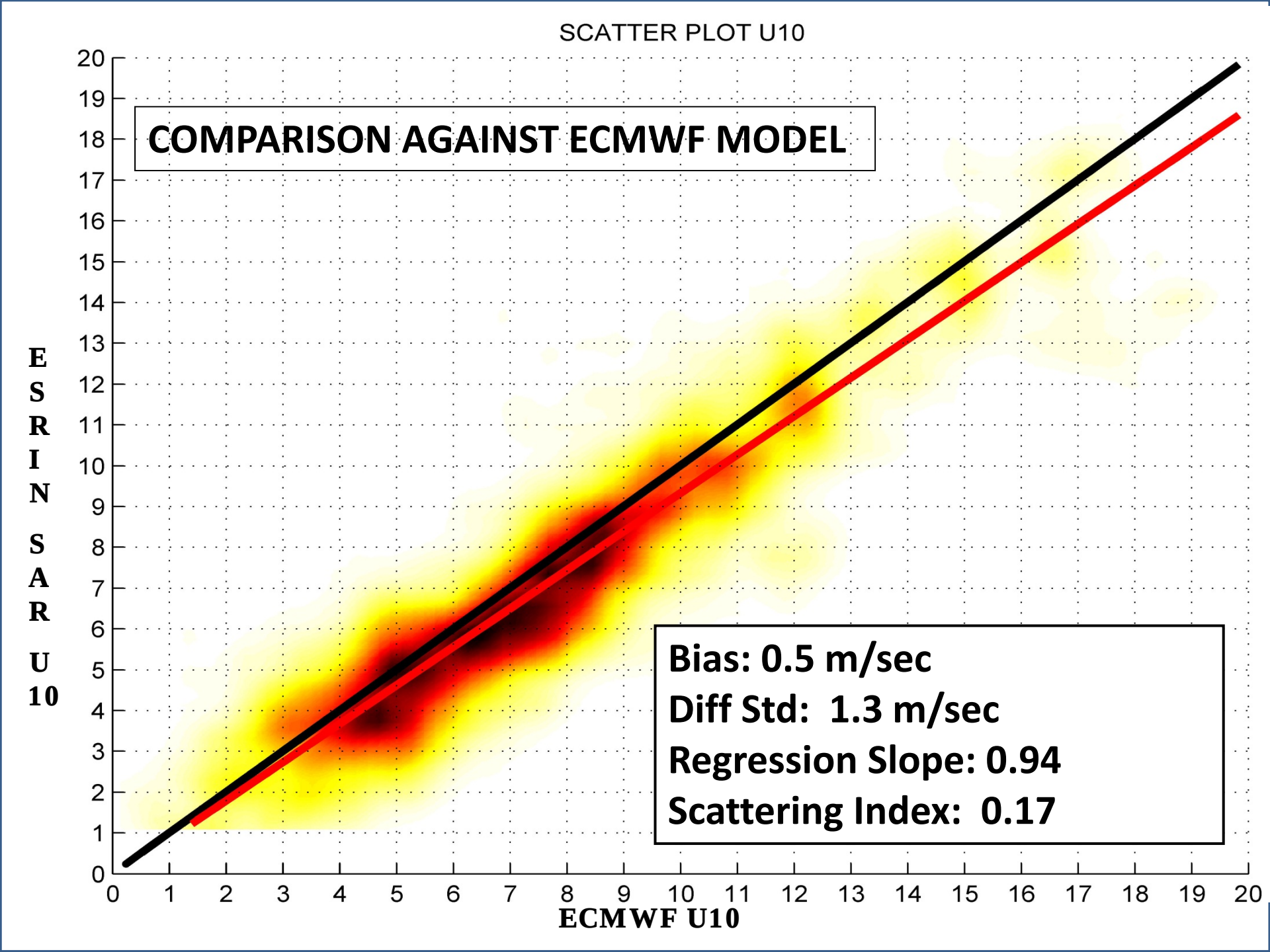
- **Received Power Level corrected for AGC, AGC setting & PTR Gain Drift**
- Sigma nought calculated from **Pu** inverting **SAR Radar Equation (i.e. now using SAR Footprint);**
- CryoSat sigma nought compensated for a bias (**-3.5 db**) to align Envisat to CryoSat mission (**Mission Inter-calibration**)
- Finally, Wind Speed extracted from sigma nought using **the same wind model than Envisat (Abdalla's Model)**

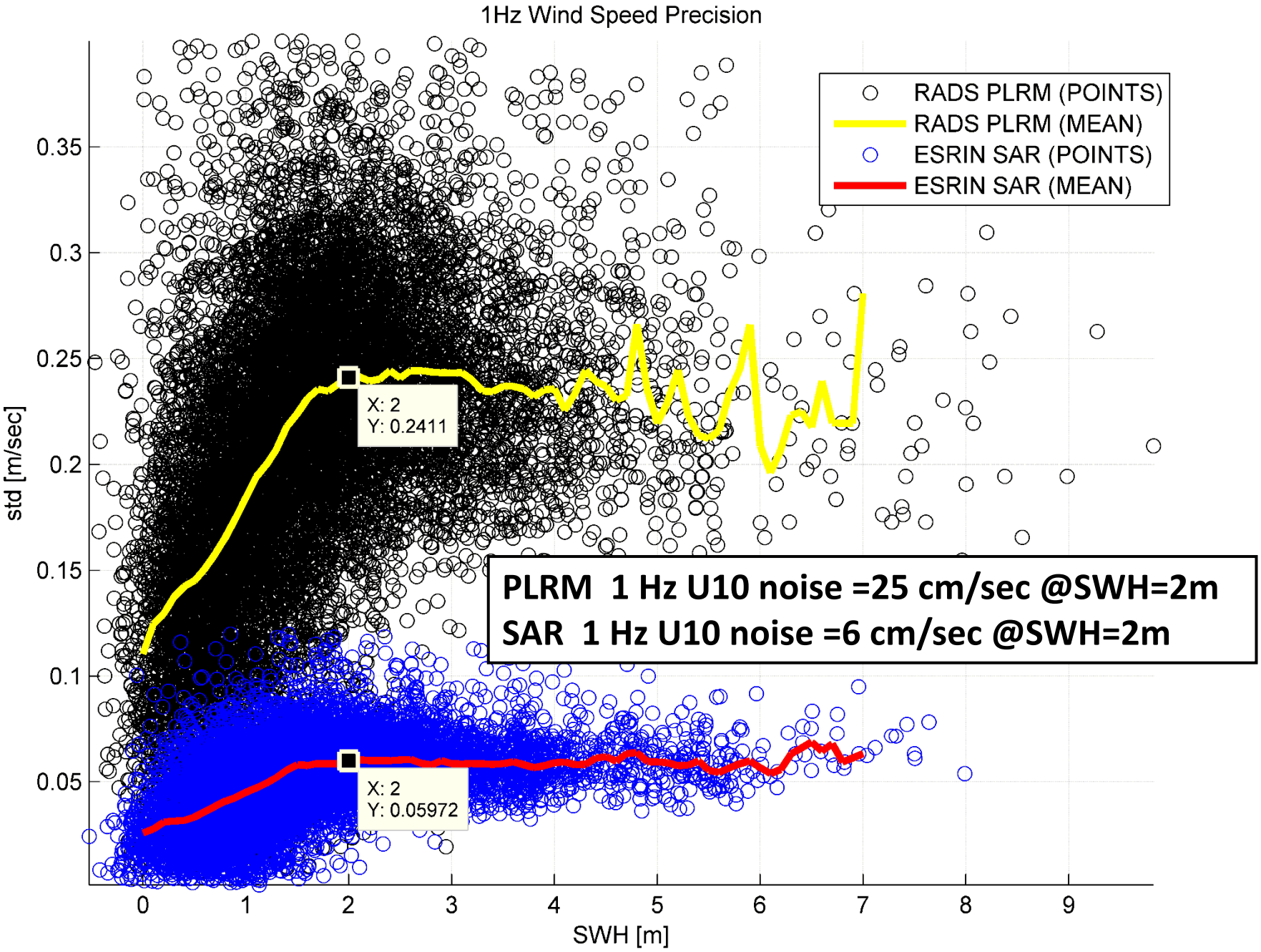

HISTOGRAM PLOT U10
OVERLAPPED HISTOGRAM
RADS PLRM
ESRIN SAR
U10 COUNTS
U10
0
50
100
150
0
5
10
15
20
25

MAP of Wind Speed Diff. SAR vs. PLRM



MOST of Differences between ± 0.5 m/sec


SCATTER PLOT U10
COMPARISON AGAINST ECMWF MODEL
ESRIN SAR U10
ECMWF U10
Bias: 0.5 m/sec
Diff Std: 1.3 m/sec
Regression Slope: 0.94
Scattering Index: 0.17


1Hz Wind Speed Precision
RADS PLRM (POINTS)
RADS PLRM (MEAN)
ESRIN SAR (POINTS)
ESRIN SAR (MEAN)
X: 2
Y: 0.2411
X: 2
Y: 0.05972
PLRM 1 Hz U10 noise =25 cm/sec @SWH=2m
SAR 1 Hz U10 noise =6 cm/sec @SWH=2m
std [m/sec]
SWH [m]
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
2
3
4
5
6
7
8
9

Things to do

- ❑ Spectral Analysis
- ❑ Release SAR L2 Data to the community (ESA GPod Service + SandBox Concept)
- ❑ Calculation of look-up table correction (LUT) for range and SWH (to mitigate impact of squared sinc PTR‘s approximation to a gaussian function)
- ❑ Minor SAMOSA SAR Echo Model Update (to improve fit with the input waveform)
- ❑ S-3 SAR Retracker DPM (v2.3.0) delivered to S-3 PAD Team (Pierre Femenias) with the configuration followed during the validation exercise

CONCLUSIONS

❑ **ESRIN SAR 1Hz Noise @SWH=2m:**

- 0.89 cm for SSH
- 6.8 cm for SWH
- 0.077 db for Sigma nought
- 6 cm/sec for U10

❑ **RADS PLRM 1Hz Noise @SWH=2m:**

- 2.3 cm for SSH
- 16.9 cm for SWH
- 0.31 db for Sigma nought
- 25 cm/sec for U10

❑ **SSH/SLA**

Good consistency between SAR and PLRM (bias 1cm, std 6 cm, slope 0.97)
Std wrt in-situ data at comparable level in SAR mode (19.8 cm) than in PLRM mode (20 cm)

❑ **SWH**

Good consistency between SAR and PLRM (bias 3 cm, std 27 cm, slope 0.98)
Std wrt in-situ data at comparable level in SAR mode (30 cm) and in PLRM mode (33 cm)

❑ **U10**

Very Good consistency between SAR and PLRM (std 40 cm/sec, slope 1.00)