Starlab Space

CP4O – Open Presentation

SAR for Open Ocean

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ESRIN
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Starlab
Living Science

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WP4000 Context

- SAMOSA model to be upgraded in view of Round Robin validation exercise
- North East Atlantic area for validation
- 3rd January – 16th January 2012
  - Over 30 CryoSat-2 L1B tracks to be analysed
- Track selected for bench marking exercise:
  CS_OPER_SIR1TKSA0__20120107T225227_20120107T225900_0001.DBL.DOP10.RES.DOP1B.RESDOP20.RES
- SAMOSA Model updates
- Data Processing for Round Robin exercise
  - SAR Pacific Patch, July 2012 & January 2013

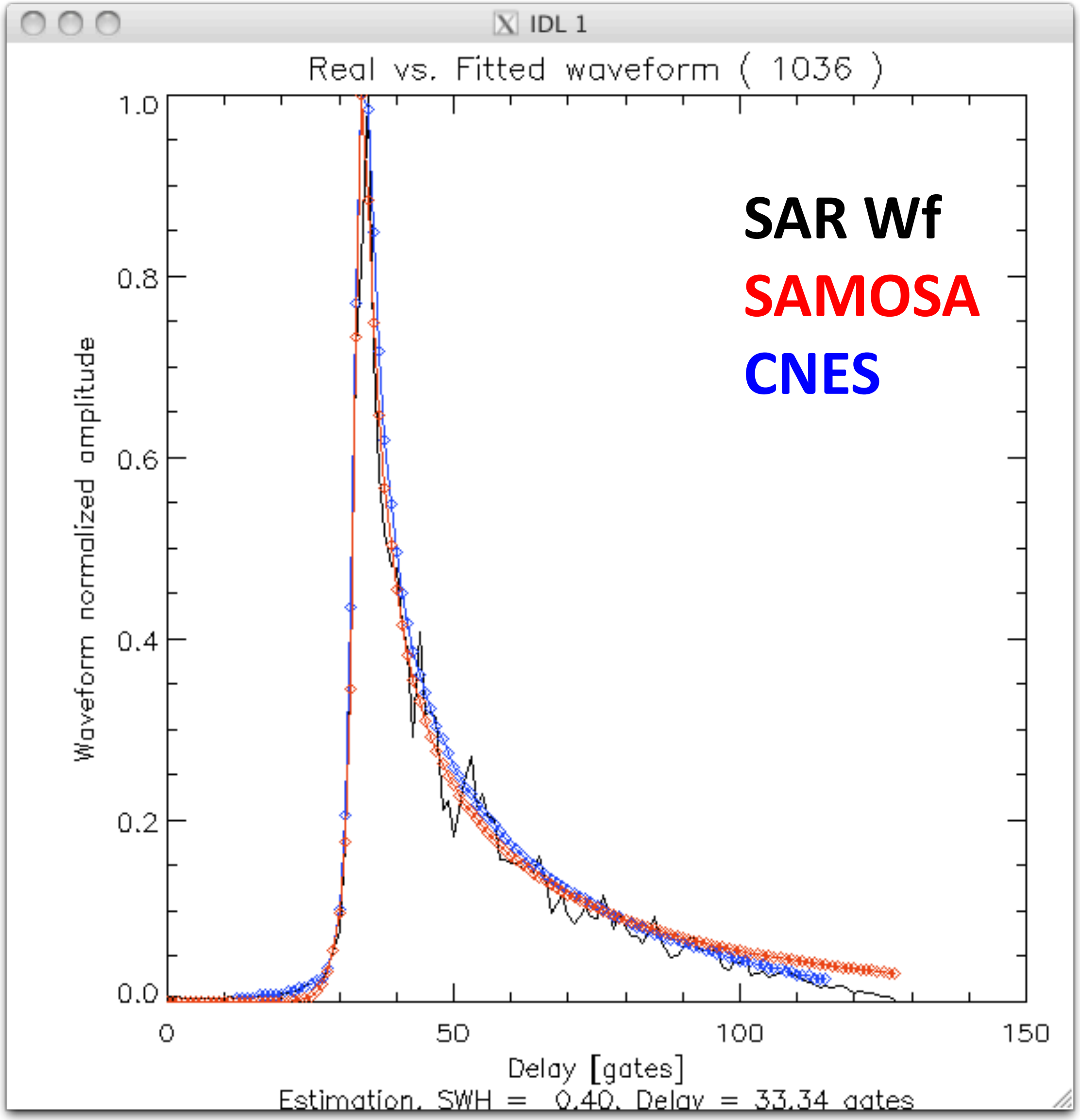
SAMOSA Retracking Algorithm

- SAMOSA Model
  - Fully Analytical SAR Waveform model
  - LMS minimization process based on a Levenverg-Marquardt Algo.
    - Simultaneous fit of sigma_z and SSH

- Algorithm Implementation based on Look-Up Tables for fast computation
  - Comparison between both methods show good correspondence between LUT and full analytical model:
    - RMSE < 1mm for SSH, RMSE < 1cm for SWH

- Starlab's implementation:
  - IDL full retracking implementation
  - CPP reader translated to IDL for data processing automatization
  - Through the bench marking exercise it was determined that ESRIN and Starlab SAMOSA retracker implementations fully aligned

L1B Wfs Retracking Example



- Cross comparison of CNES vs. Starlab retracked Waveforms
- Good correspondence on leading edge and trailing edge up to delay gate ~90
- Discrepancies on SAR Wf edges:
  - Underestimation of delay gates before the leading edge
  - Overestimation of last delay gates of trailing edge
- SAMOSA Model Updates:
  - RCMC Zero-padding (peeling effect)
  - Variable PTR width
  - Full analytical model implementation
  - Waveform Normalization and noise handling

SAMOSA Model Updates

- Boy & Moreau, OSTST Venice 2012

CNES SAR Retracking solution

❑ **Based on a full numerical Doppler model:** Numerical computation of the radar echo:

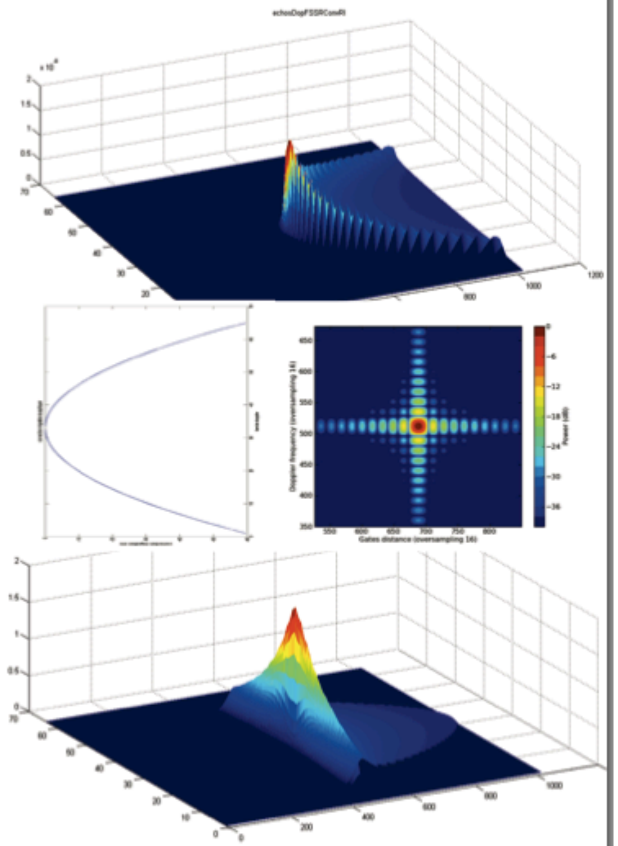
$$\mathrm{Echo} = \mathrm{FSSR} \otimes \mathrm{IRs} \otimes \mathrm{PDF}$$

Single Looks

- ❑ Computation of the FSSR for each doppler band (64). A constant mispointing configuration can be taken into account.
- ❑ Convolution with Instrument and Azimuth Impulse Response
- ❑ Convolution with the PDF of SWH

Multi Look

- ❑ Then, range migration is performed to align each single looks
- ❑ Sum of each Singlelook migrated: multilook Doppler echo

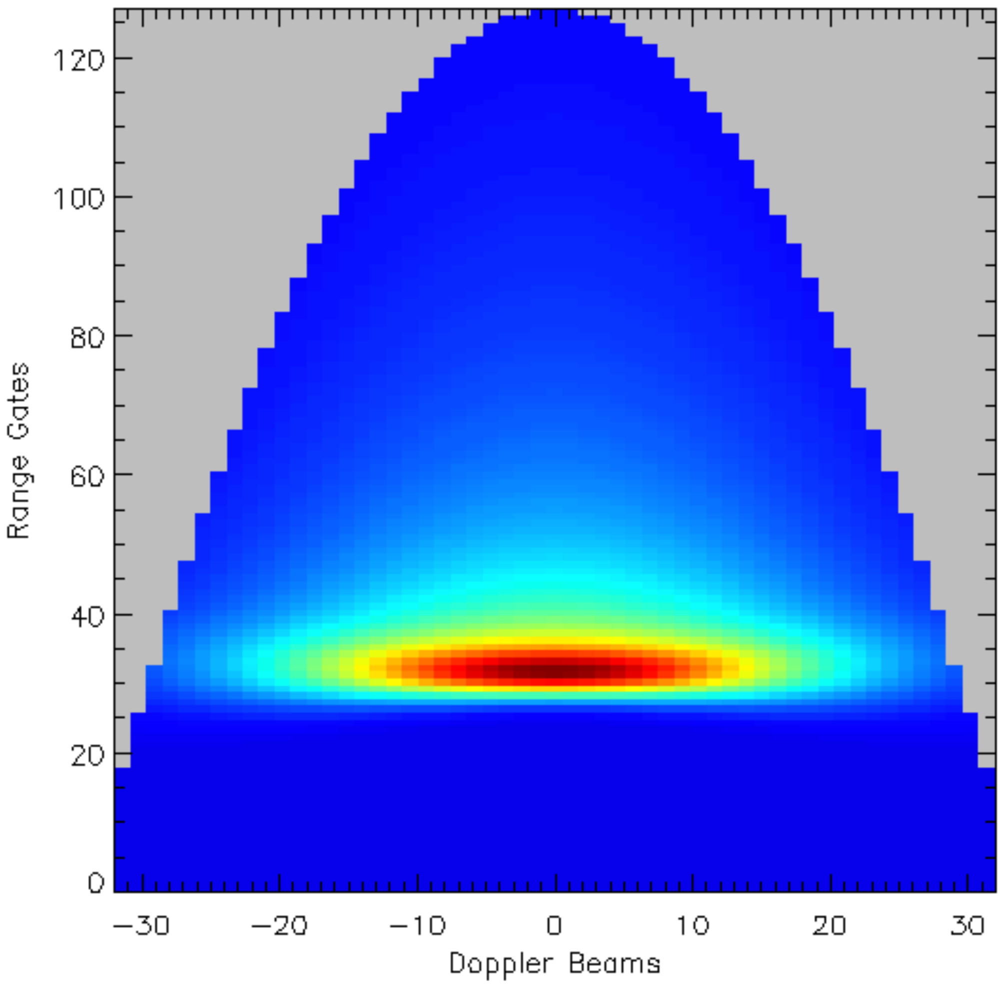


❑ Retracking: **inheritage from Jason-2 MLE3** (mispointing is not estimated but constant) **Derivatives are numerically computed**.

Mispointing configuration: 0.1° x 0.1°
(based on W. Smith *et al*, OSTST San Diego, 2011)

6 OSTST, VENICE (ITALY), Sept-2012

RCMC Zero Padding (aka Peeling effect) (i)



•The Zero-padding of the waveforms is an effect of the Range Cell Migration Correction:

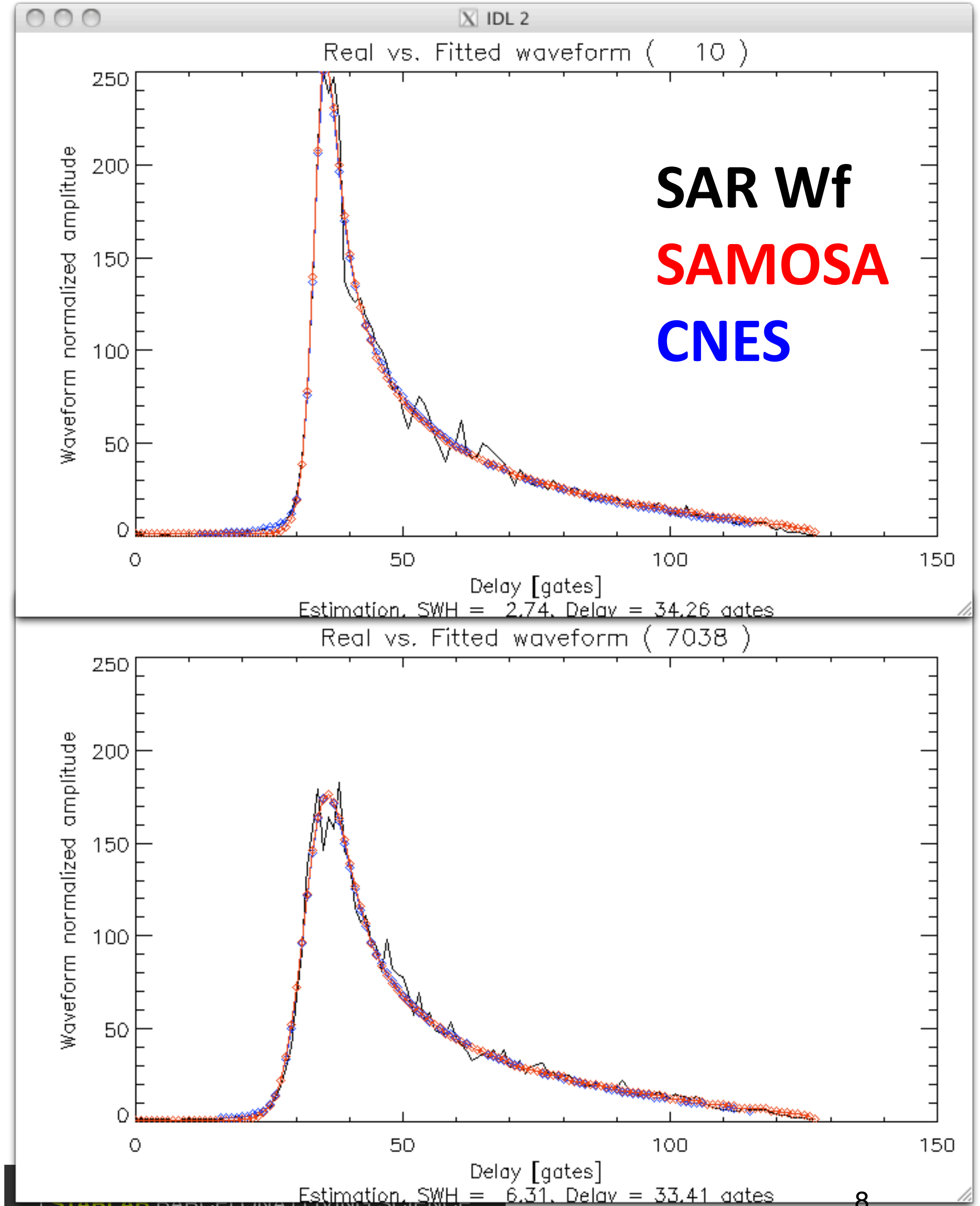
– Range gates with are Range Cell Migrated are set to zero

$$e^{i2\pi\beta\left(\frac{\alpha x_l^2}{ch}-\frac{2sx_l}{c}\right)\tau_n}$$

•In order to take this into account in the model, those range cell migrated range gates beyond lag 128 should be set to zero in the final DDM

•The final 2D DDM presents the characteristics parabolic shape of the target migration

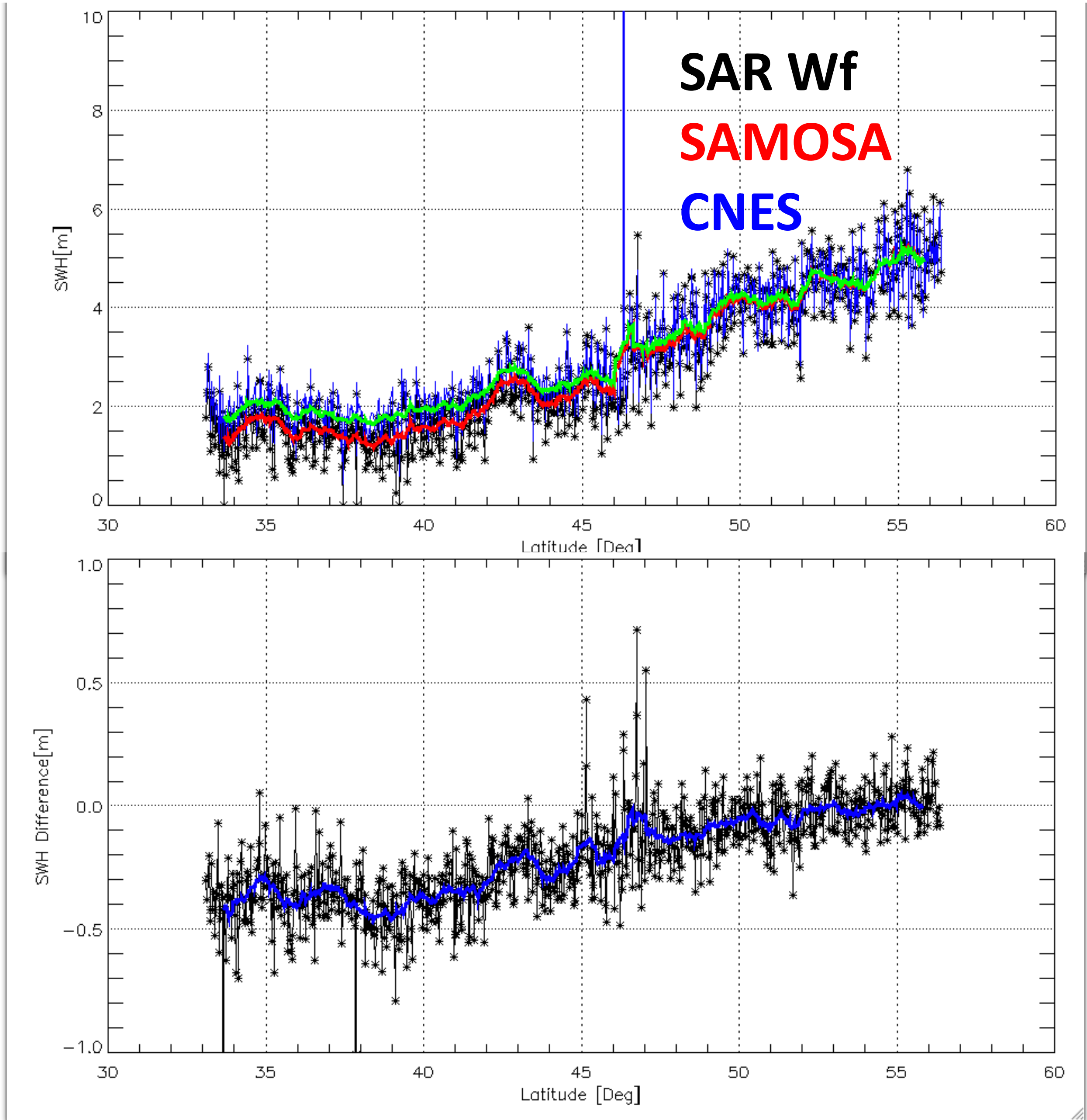
RCMC Zero Padding (aka Peeling effect) (ii)



- The effect of this is that the waveform tail decays to zero, as the number of waveforms to be averaged is also lower

- The comparison of CPP data, CNES numerical model, and SAMOSA model showed very good correspondence both in the waveform leading and trailing edges

RCMC Zero Padding (aka Peeling effect) (iii)

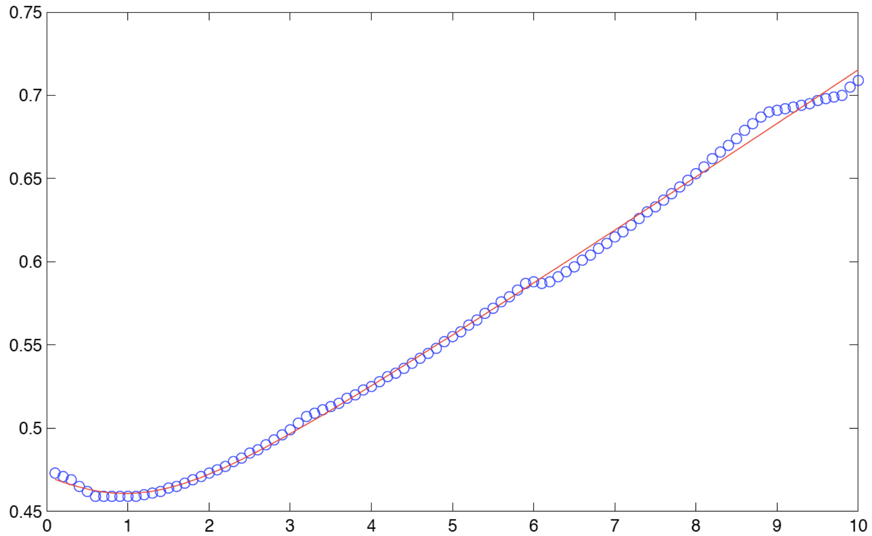


- Despite of the good SAR-Waveform match, …

- An important error was observed in the estimation of SWH between CPP and SAMOSA retracking outputs

- Possible causes for this could be:
  - Noise handling (unlikely)
  - Wrong Attitude (unlikely)
  - PTR width (maybe…)

Point Target Response as a Function of SWH (i)



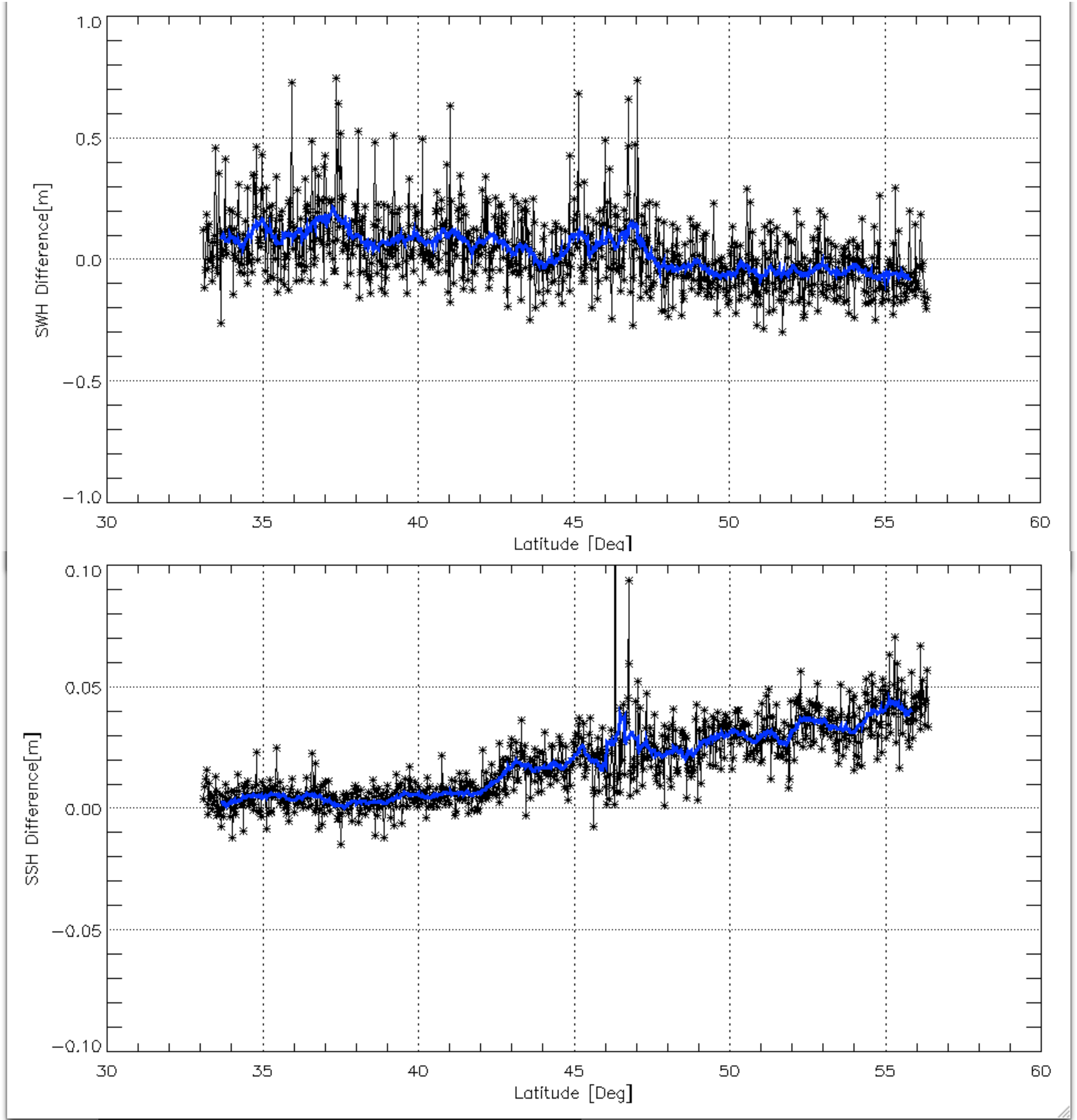
- Salvatore Dinardo proposed a solution for the error on the estimation of SWH based on a variable width of the PTR:
  - The alpha_p value would be mapped as a function of the SWH
  - Implemented by means of a LUT

- Derivation of an analytical formula for a straight-forward integration with the model:

$$\boxed{\sigma_g = A + \sqrt{B + \left(\frac{H_s - C}{D}\right)^2}}$$

- With
  - A = 0.4178
  - B = 0.0019
  - C = 0.9689 m
  - D = 30.6673

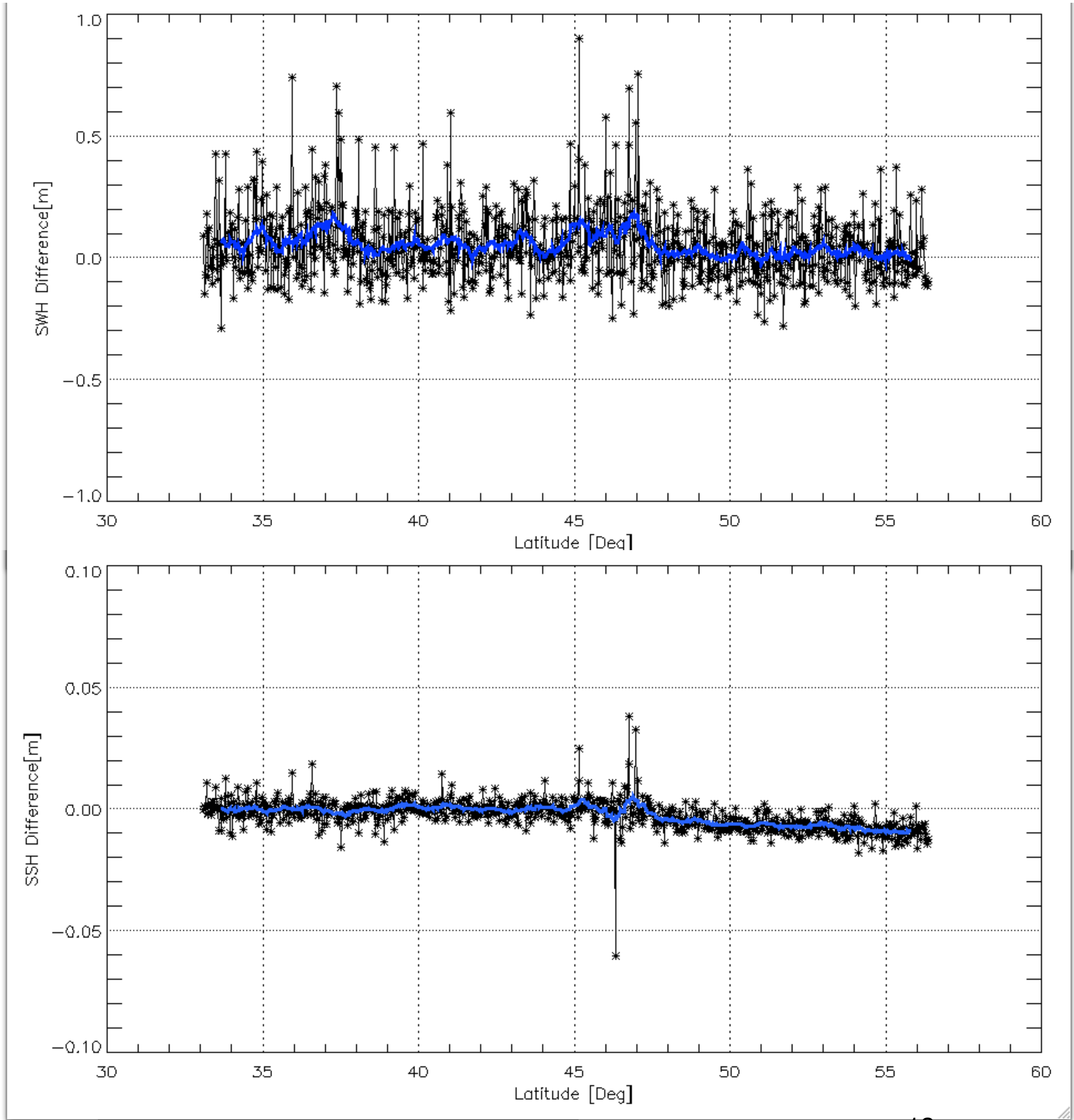
Point Target Response as a Function of SWH (ii)



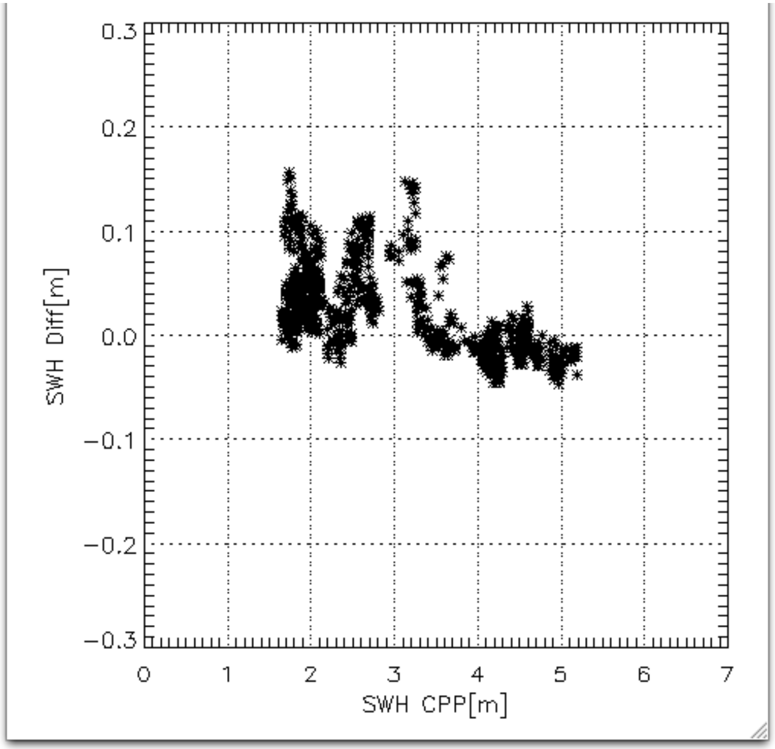
•Trend in the SWH is mitigated

•However, in SSH the comparison of SAMOSA and CPP data shows a clear trend also dependent on SWH

Implementation of the Full SAMOSA Analytical Model (i)



- The first order function term (f1) has been up until now disregarded due to the small effect that it has in comparison to the zeroth order term (f0)
  - The effect was estimated to be in the order of 1%, which is significant for the level of accuracy we are targeting...



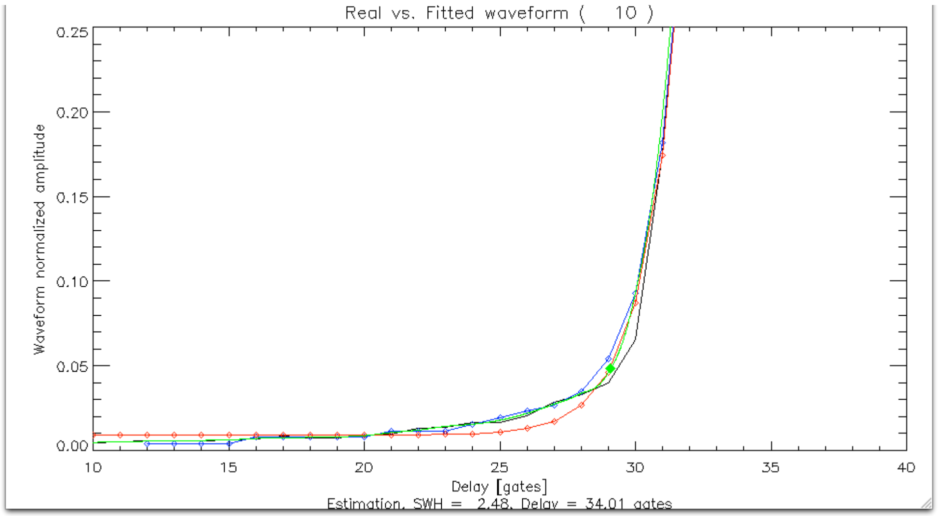
Noise Floor Calculation (i)

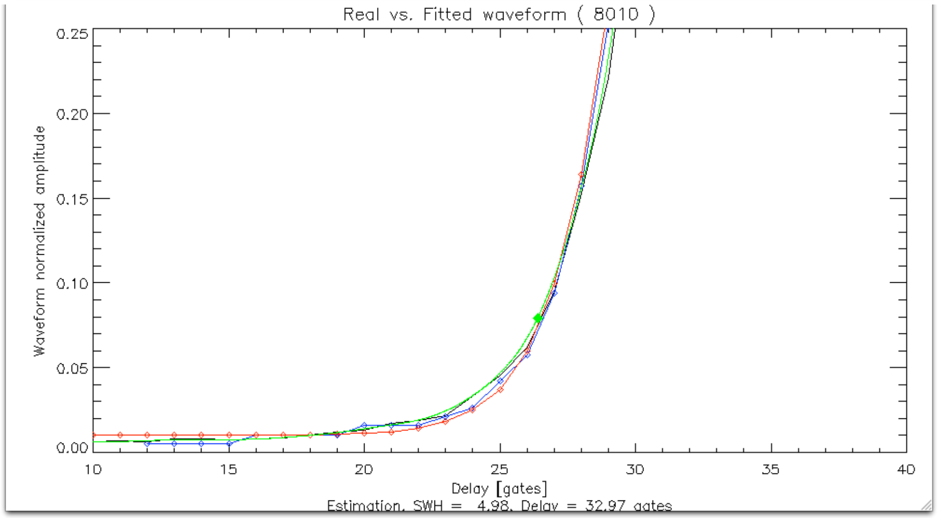
- The cause on the trend on the estimation of SWH was linked to the calculation of the thermal noise

•The noise was obtained as the average value of the first SAR waveform lags, typically lags 11-21

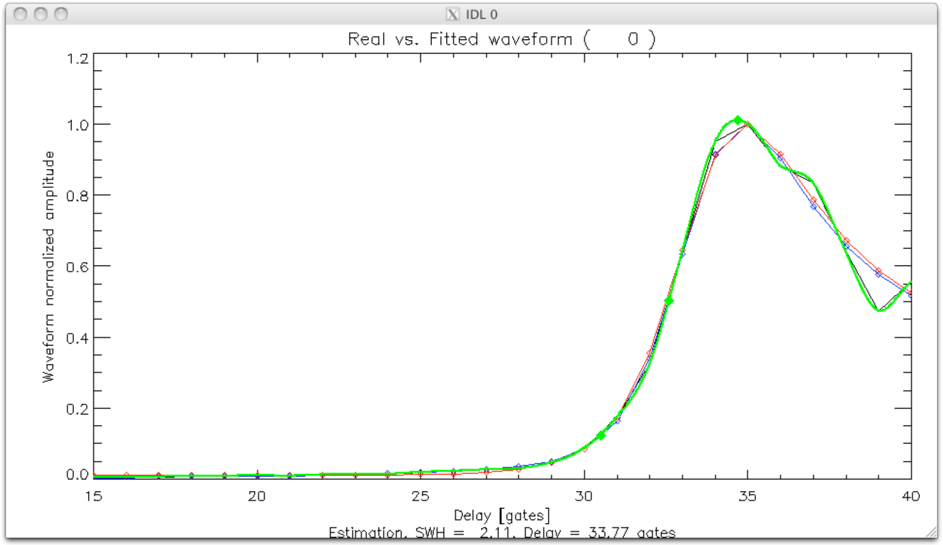
•However, this led to erroneous noise floor estimation

•Depending on the SWH and range the position of the first gates of the leading edge can vary as much as 5 gates (or more)...therefore the range gates used to calculate the noise should vary accordingly.





Noise Floor Calculation (ii)



- An empirical algorithm was developed to determine the beginning of the waveform leading edge:

```
leading_edge_span = 2*(waveform_peak_pos - half_power_pos)
leading_edge_starting_pos = waveform_peak_pos - leading_edge_span
```

- optimal position for noise calculation is:

```
noise_calculation_position = leading_edge_starting_pos - 9
```

- The noise floor is then calculated as:

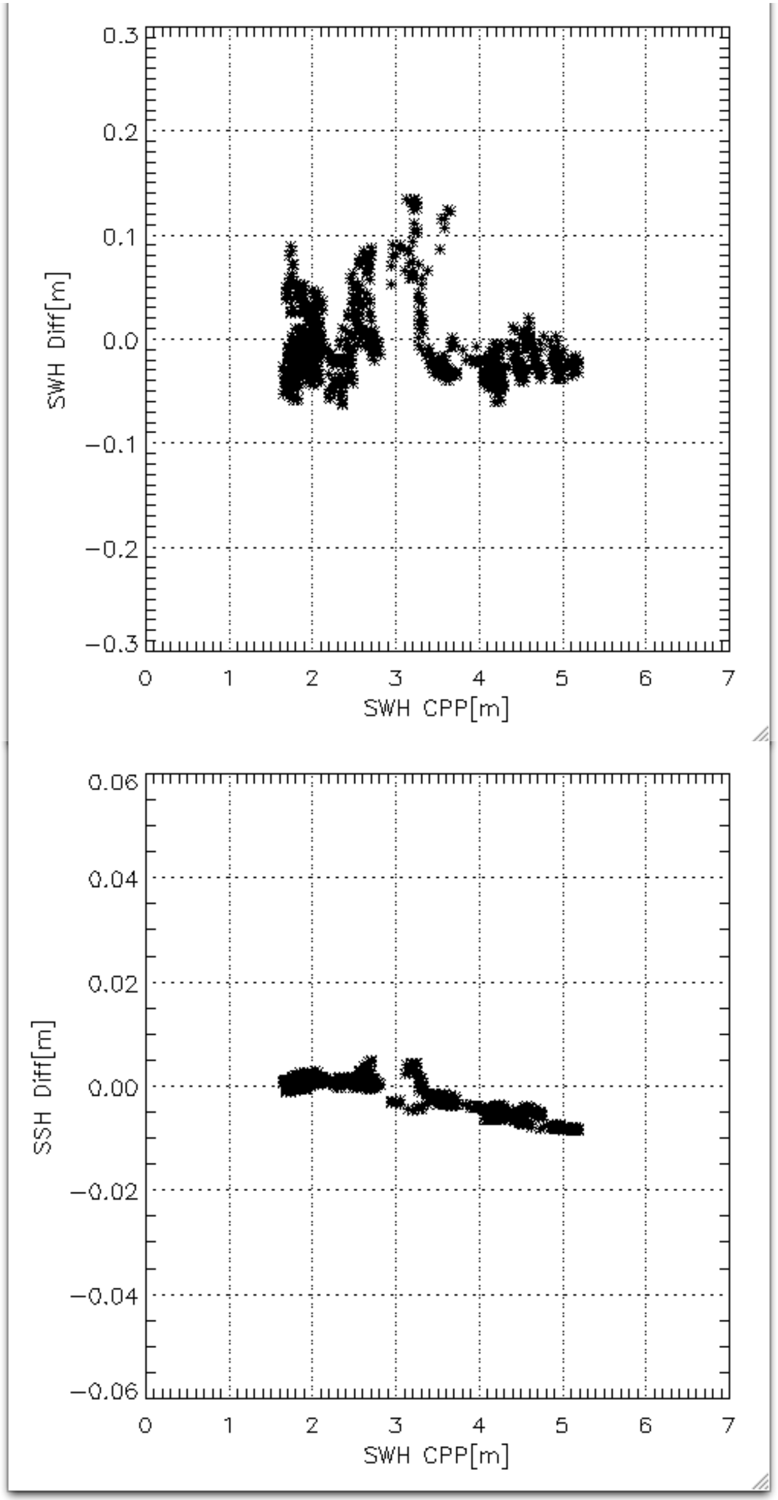
```
noise_floor = mean(Waveform[noise_calculation_position - 1 :
                            noise_calculation_position + 1])
```

Noise Floor Calculation (iii)

- The new method for calculating the noise floor eliminates SWH trend and improves the performance in the estimation of SWH and SSH with respect to CPP

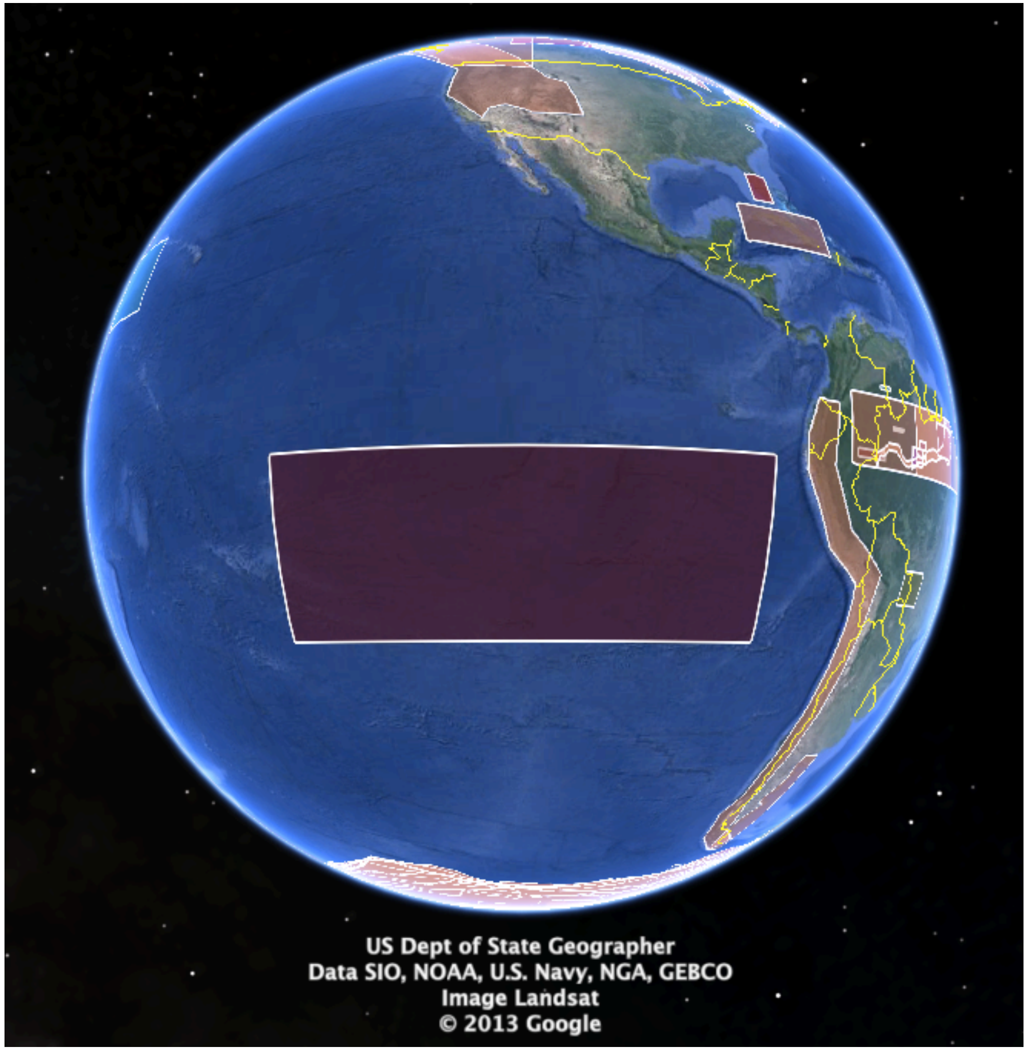
- Errors with respect to CPP estimation:
  - SSH Error bias = -0.0013 [m]
  - SSH Error std = 0.0034 [m]
  - SWH Error bias = -0.0031 [m]
  - SWH Error std = 0.038 [m]

- This configuration was finally selected for the batch processing of the Round Robin exercise data

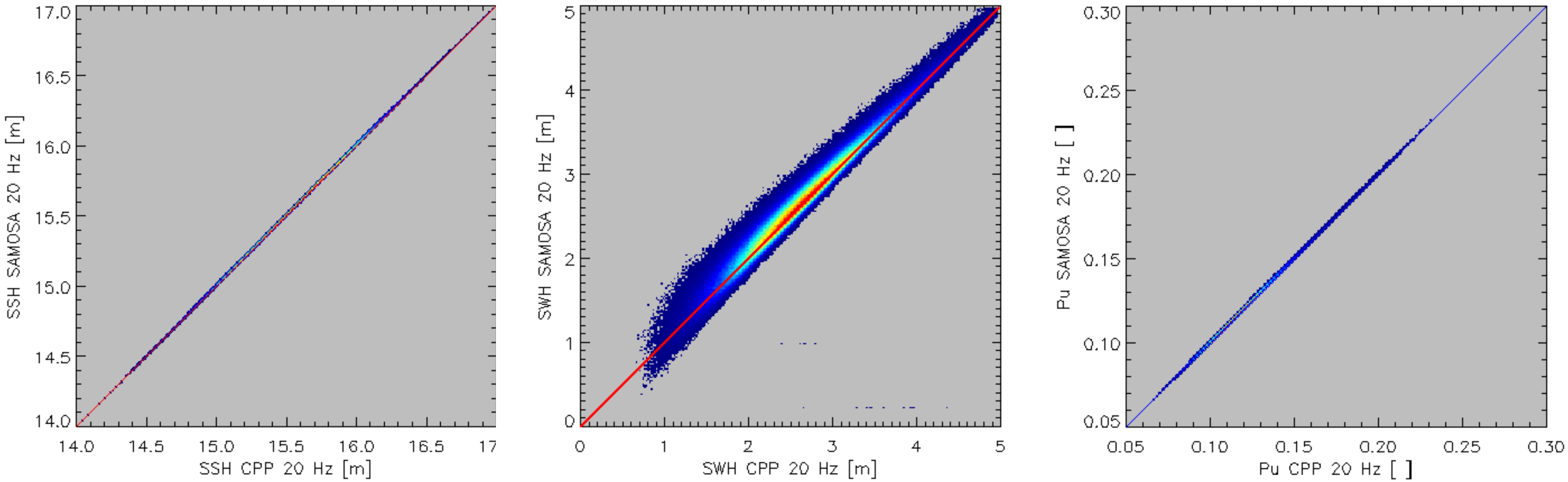


Round Robin Exercise Data Processing

- South Pacific Patch:
  - Lat: [0, 30S]
  - Lon: [220, 285]
- Observation Period:
  - Two full sub-cycles
    - July 2012
    - January 2013
- Amount of data:
  - ~1E6 SAR waveforms per sub-cycle
- Average Processing Time:
  - ~10 h / sub-cycle
  - Intel Core i7 @ 3.2 GHz, 6 cores, 2 threads/core



Round Robin Exercise Results (i)
July 2012



20 Hz - SAMOSA vs CPP, error Statistics

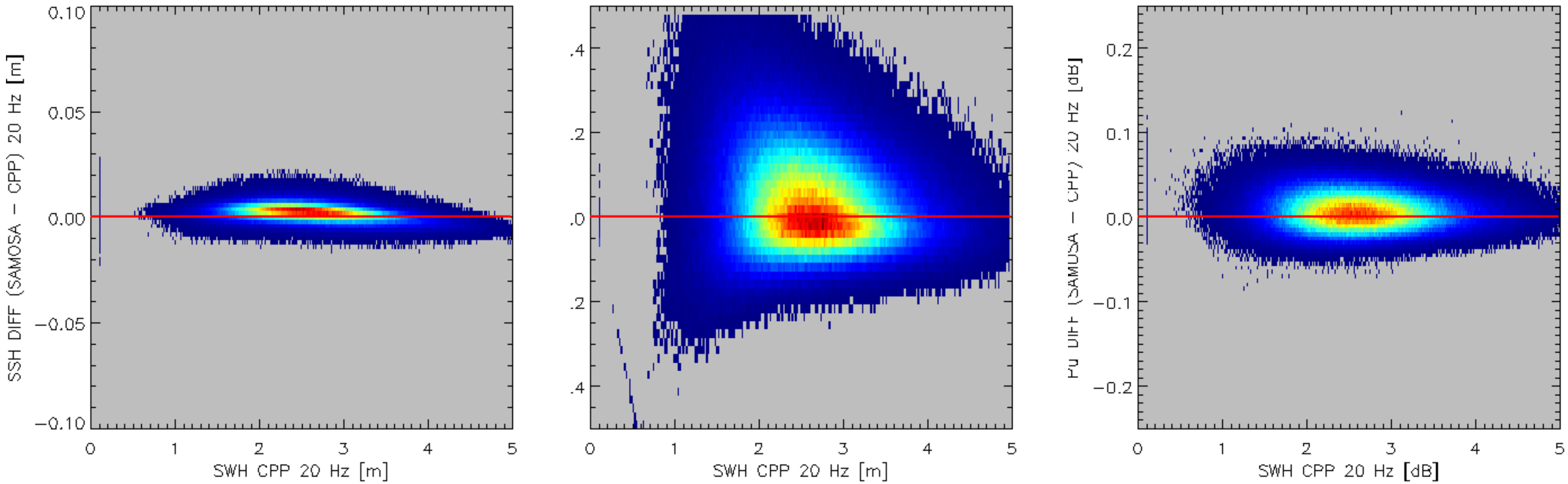
SSH Error bias	=	0.0030 [m]
SSH Error std	=	0.0141 [m]
SWH Error bias	=	0.0063 [m]
SWH Error std	=	0.1238 [m]

1 Hz - SAMOSA vs CPP, error Statistics

SSH Error bias	=	0.0030 [m]
SSH Error std	=	0.0024 [m]
SWH Error bias	=	0.0061 [m]
SWH Error std	=	0.0367 [m]

Round Robin Exercise Results (i)

July 2012



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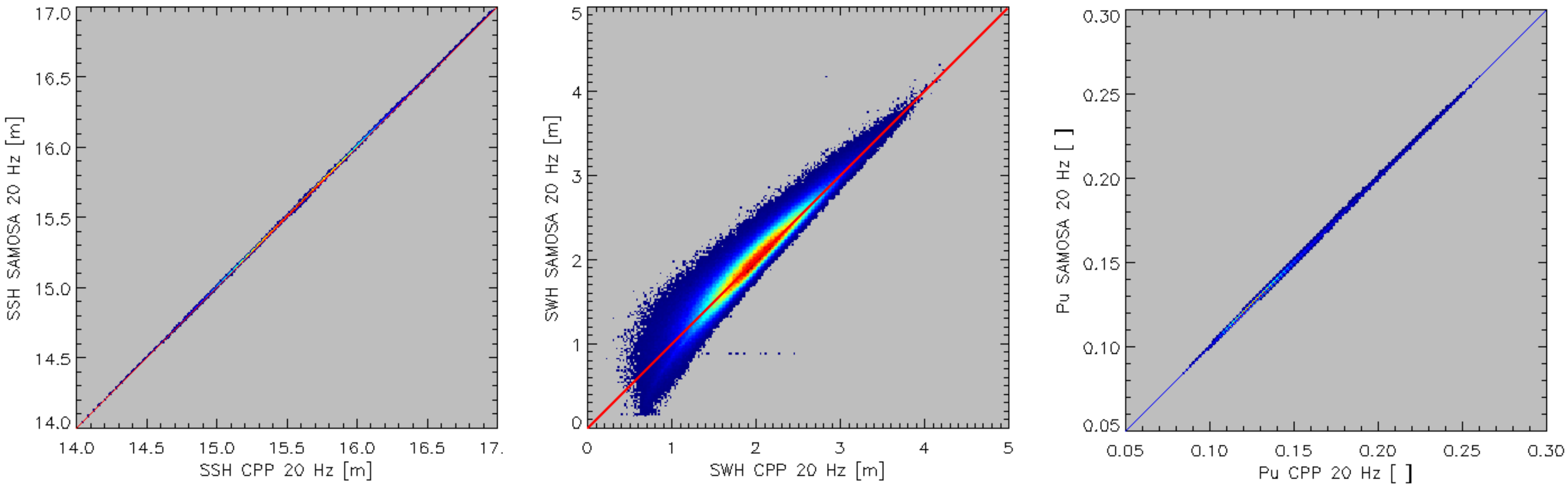
Round Robin Exercise Results (ii)

January 2013



20 Hz - SAMOSA vs CPP, error Statistics

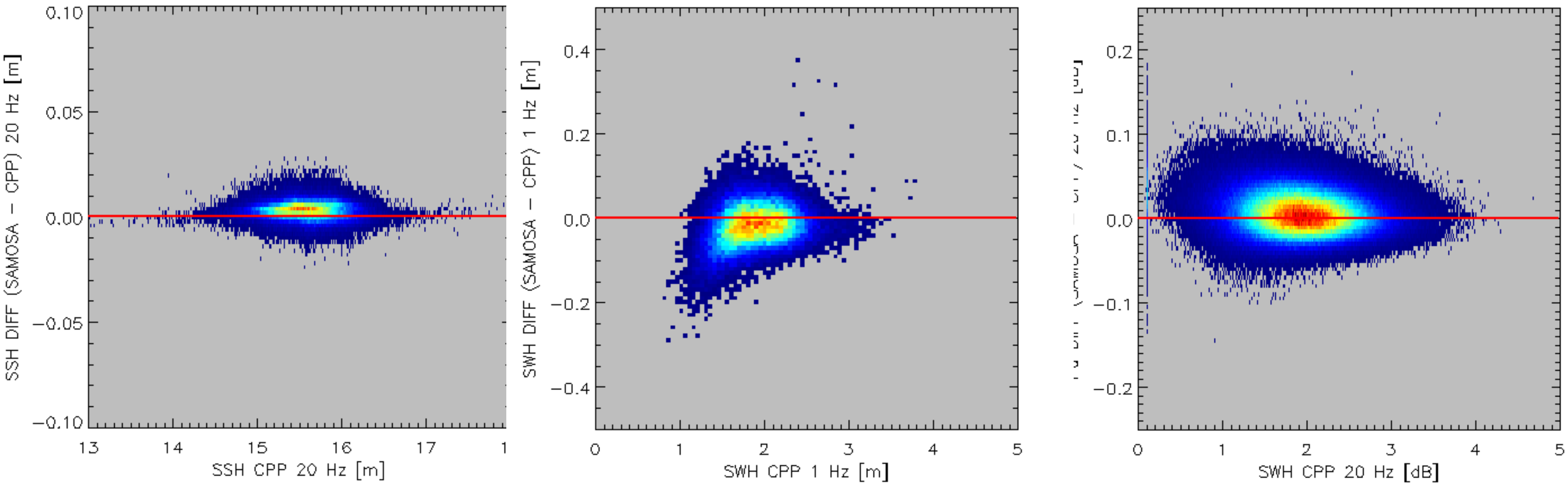
SSH Error bias	=	0.0031 [m]
SSH Error std	=	0.0063 [m]
SWH Error bias	=	-0.009 [m]
SWH Error std	=	0.1537 [m]

1 Hz - SAMOSA vs CPP, error Statistics

SSH Error bias	=	0.0031 [m]
SSH Error std	=	0.0022 [m]
SWH Error bias	=	-0.0091 [m]
SWH Error std	=	0.0457 [m]

Round Robin Exercise Results (ii)

January 2013



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Conclusions

- Within CP4O WP4000 – SAR for Open Ocean, the SAMOSA-3 model was significantly updated
- The updates in the model were cross-compared with CPP data both in the NE Atlantic and the South Pacific SAR Patch
- The updates on the model included:
  - RCMC Zero-padding effect
  - PTR with as a function of SWH
  - Full SAMOSA analytical model implementation
  - Thermal noise calculation
- For WP5000 – Round Robin Exercise, 2 full sub-cycles for the South Pacific Patch were processed
  - The comparison with CPP data shows good and consistent results for both 2012/07 and 2013/01
  - The updated SAMOSA model is a reliable tool for geophysical parameters estimation
- Further updates on the model could be envisioned

Thank you for your attention

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