Starlab Space

Improvements to the SAMOSA re-tracker Implementation and Evaluation – Optimised Thermal Noise Estimation

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Outline

- Purpose, Scope, and Goals.
- Background.
- Optimisation of the Noise floor calculation.
- Validation activities.
- Conclusions.

Purpose, Scope and Goals

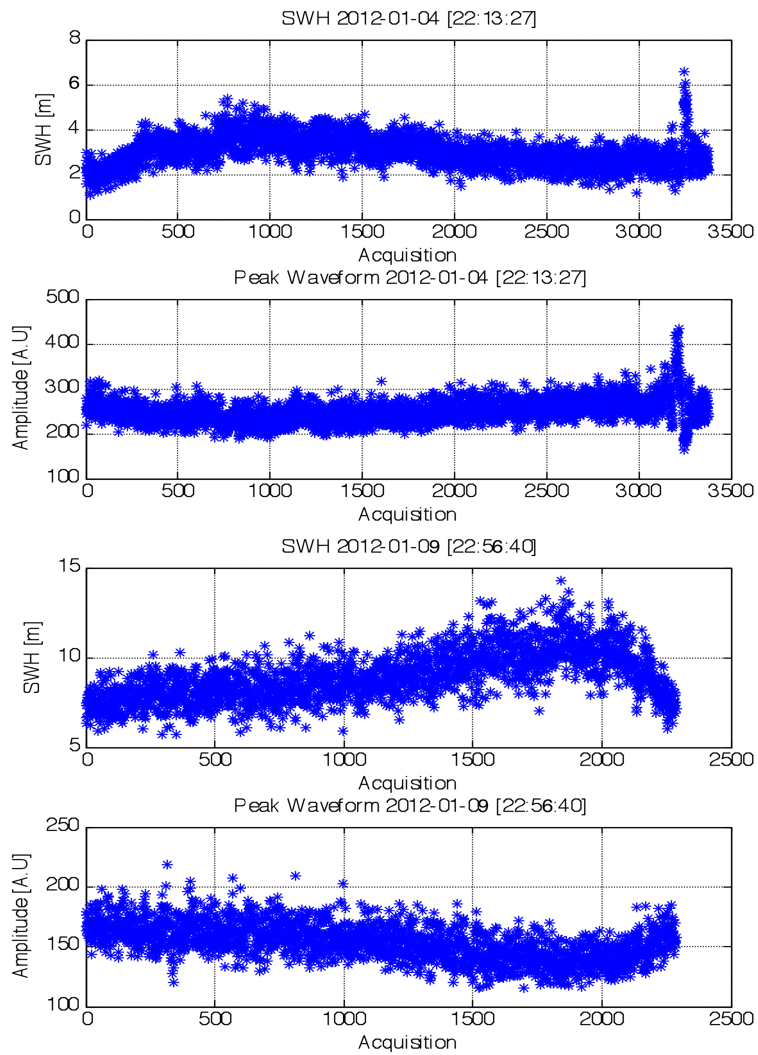
- The objective of the WP3000 of the CCN01 D.3.1 is to provide an optimized method for the estimation of the thermal noise on the SAR waveforms, that will be implemented in the operational SAMOSA retracker.
- Thermal noise is a key parameter in the retracking of the SAR waveforms, which is directly related to the estimation of the SWH (Significant Wave Height).
- Within the framework of the original CP40 contract, an initial estimation and introduction of the thermal noise on the SAMOSA was conducted by Starlab.
  - An empirical method was proposed, measuring the noise level directly in the SAR-Waveform.
- Preliminary results showed that the method needed to be optimized.

Purpose, Scope and Goals

- In this presentation,
  - The main features of the optimized SAMOSA retracker are detailed.
  - Additionally an extensive data set has been used to evaluated the performance of the optimized retracker.

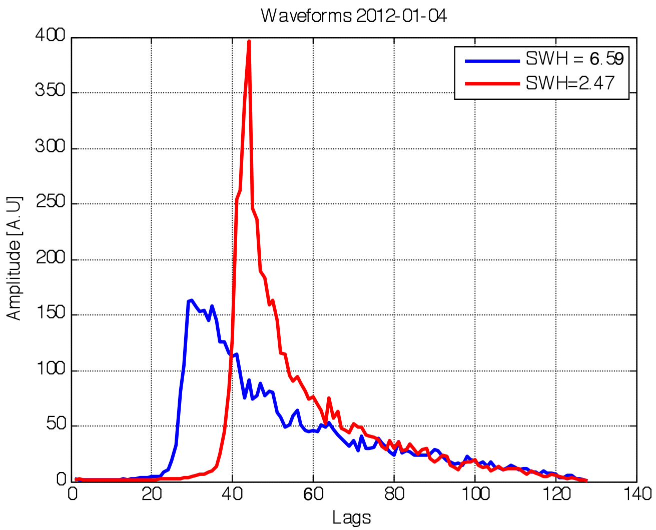
Background

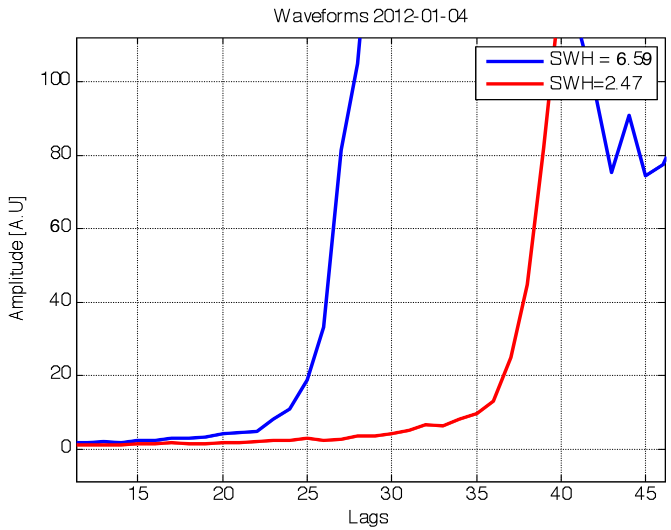
- Estimation of the thermal noise is a key parameter in the retracking of the SAR waveforms, since it affects directly the estimation of the SWH.
- Originally the noise level was obtained as the average value of the first SAR waveforms lags, typically lags 11-21.
- However, this approach does not consider the impact that the SWH can have on the leading edge and on the peak amplitude of the averaged SAR waveform



Background

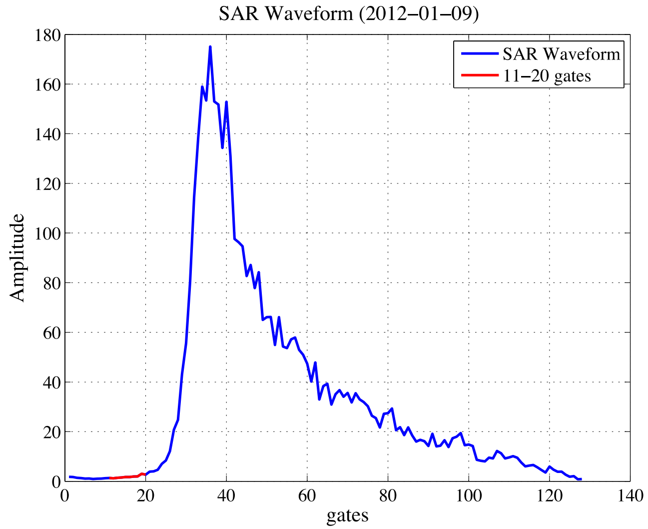
- These results suggest that the range position of the first gates of the leading edge can vary.
  - Depending on the SWH, the range position of the first gates of the leading edge can vary across **5 or more** gates.

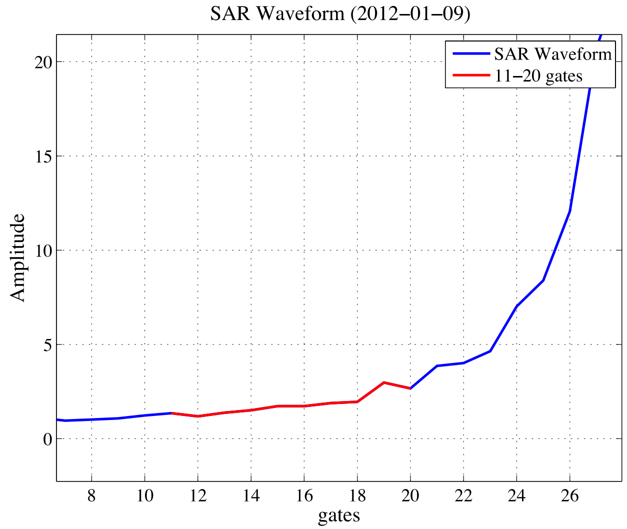




Background

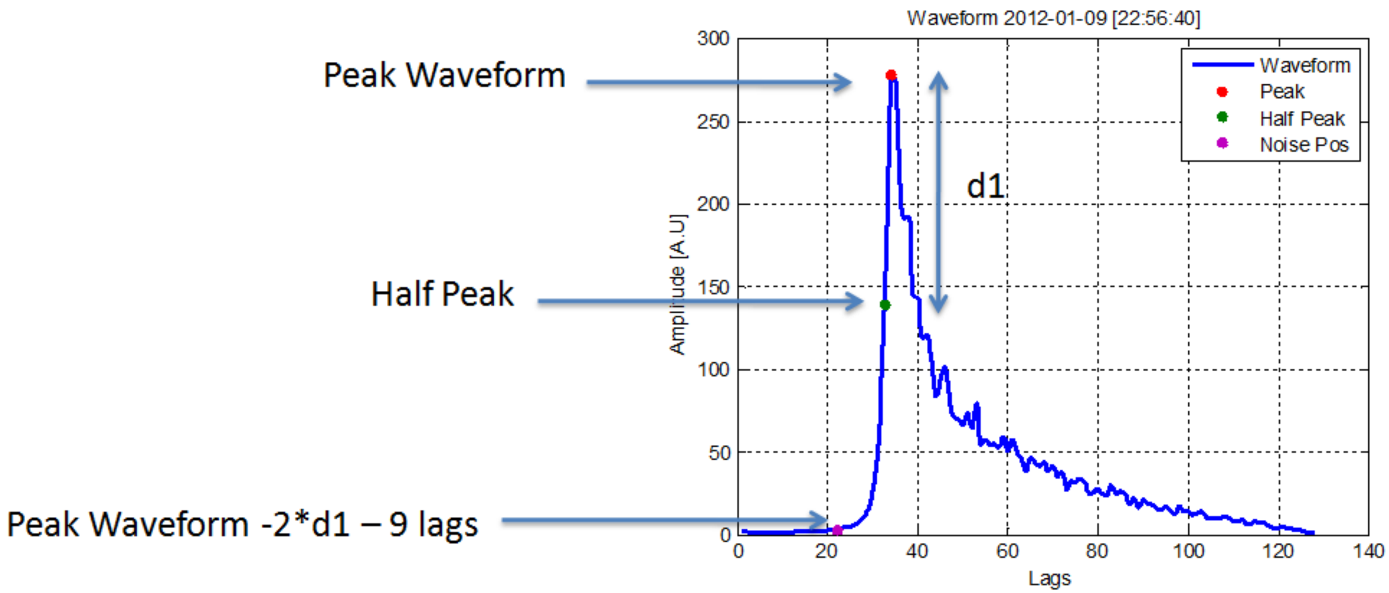
- Thus, using the noise floor averaged across a fixed range of lags(between 11 and 21), can lead an erroneous noise floor estimation.





Background

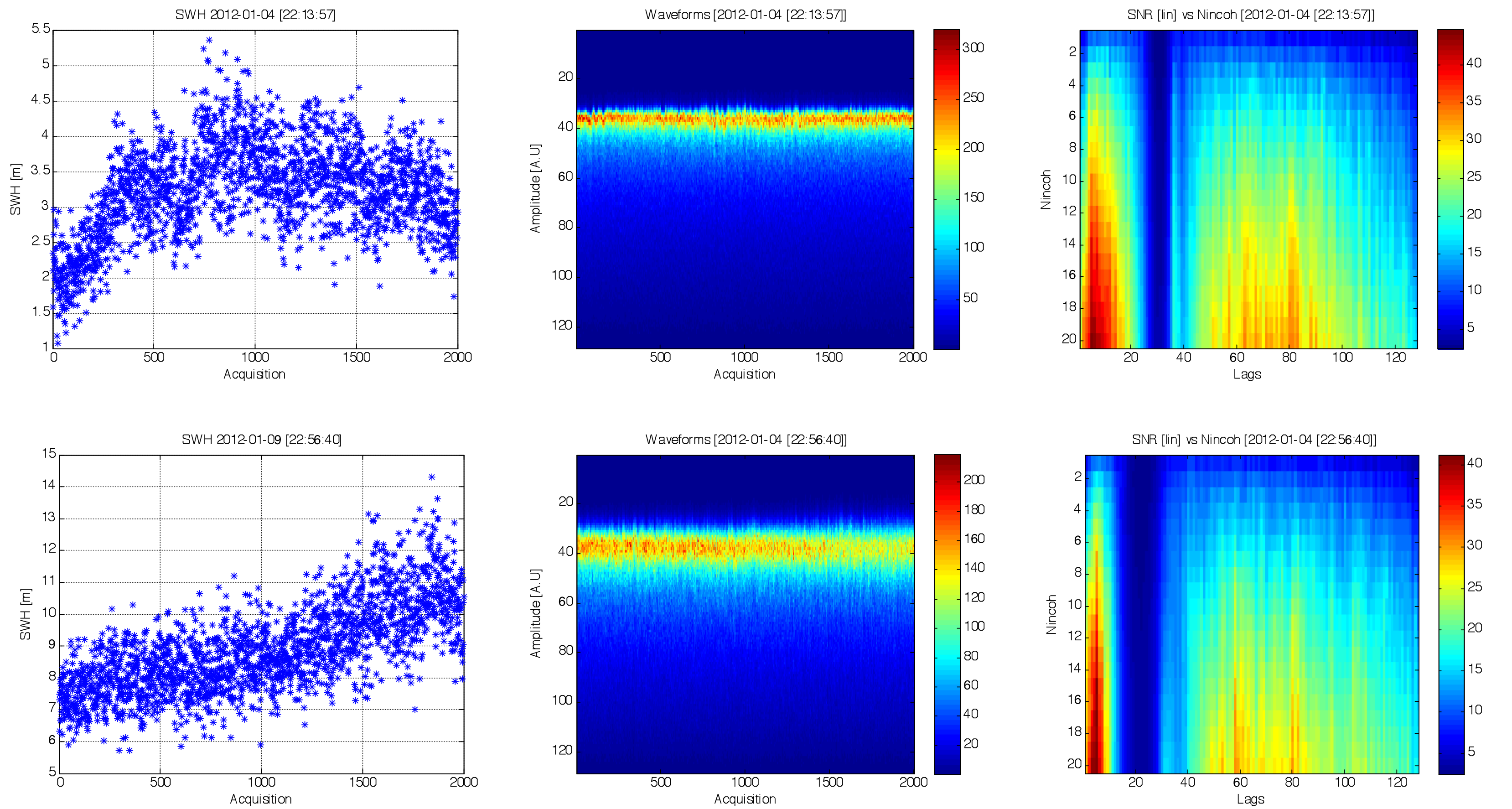
- These results suggest that SWH should be considered in the estimation of the noise.
- in the framework of the CP40 project, an empirical model was proposed for the computation of the thermal noise.



Optimisation of the Noise floor calculation

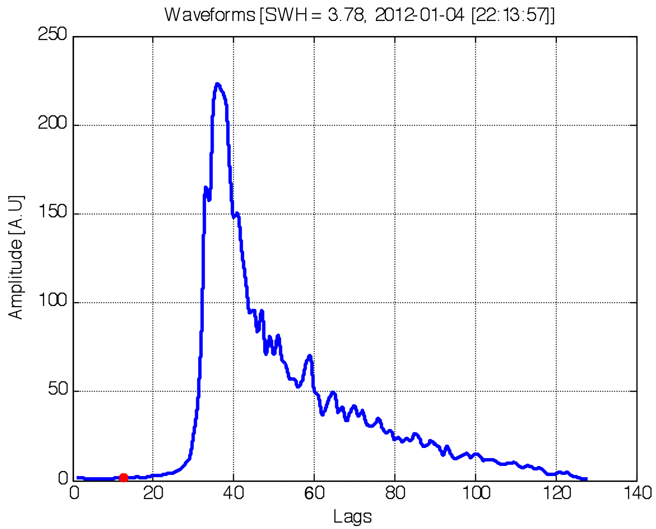
- In order to define properly the margin (initially defined as 9), an approach based on the uncorrelated characteristics of the thermal noise have been used as supplementary tool.
- It is based on the assumption that as thermal noise is fully uncorrelated,
  - SNR increases proportionally to the number of independent SAR waveforms, in the region where the thermal noise dominates.

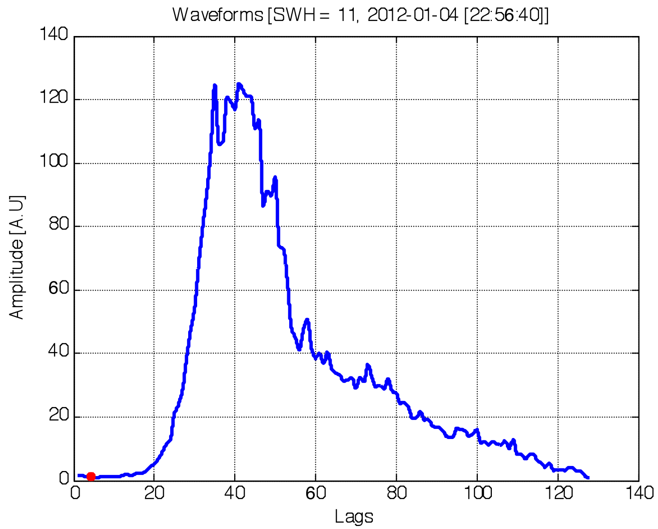
Optimisation of the Noise floor calculation



Optimisation of the Noise floor calculation

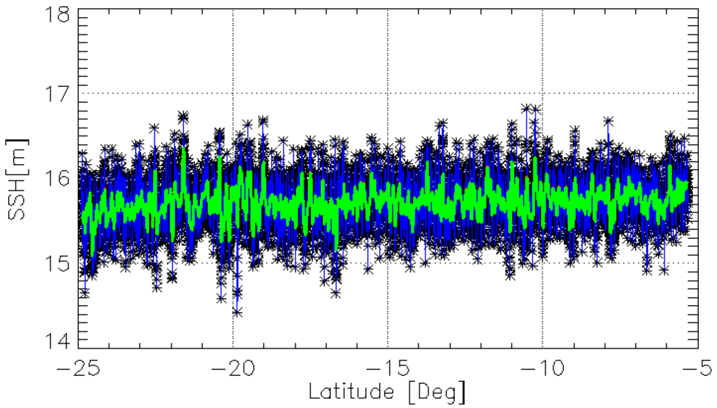
- An initial margin of 14-16 lags, and a width length of 2 lags could be a safe implementation option for the estimation of the noise floor

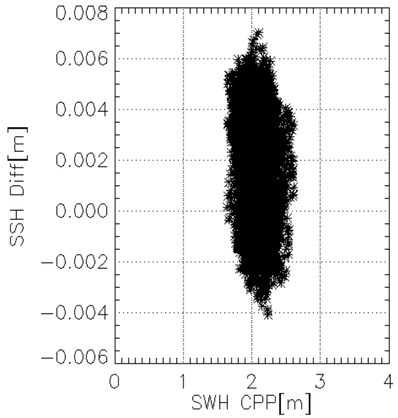


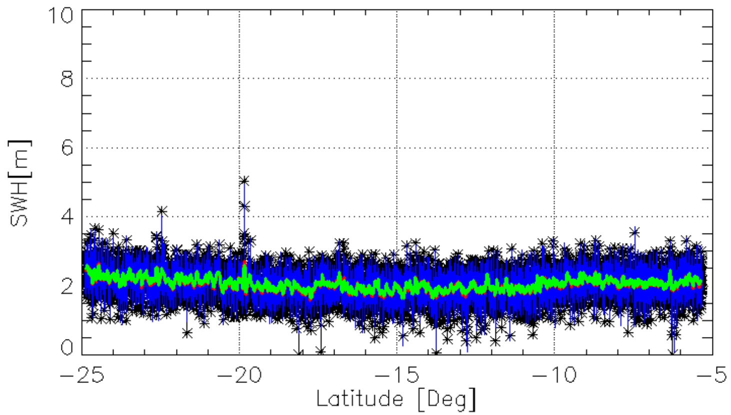


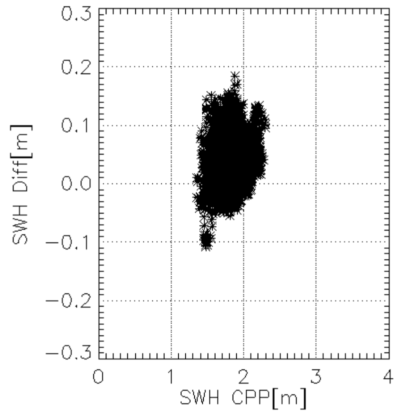
Optimisation of the Noise floor calculation

- An initial validation has been conducted for single tracks.
  - Cover more than 20 latitude degrees and SWH ranges between 2 and 4+ meters.





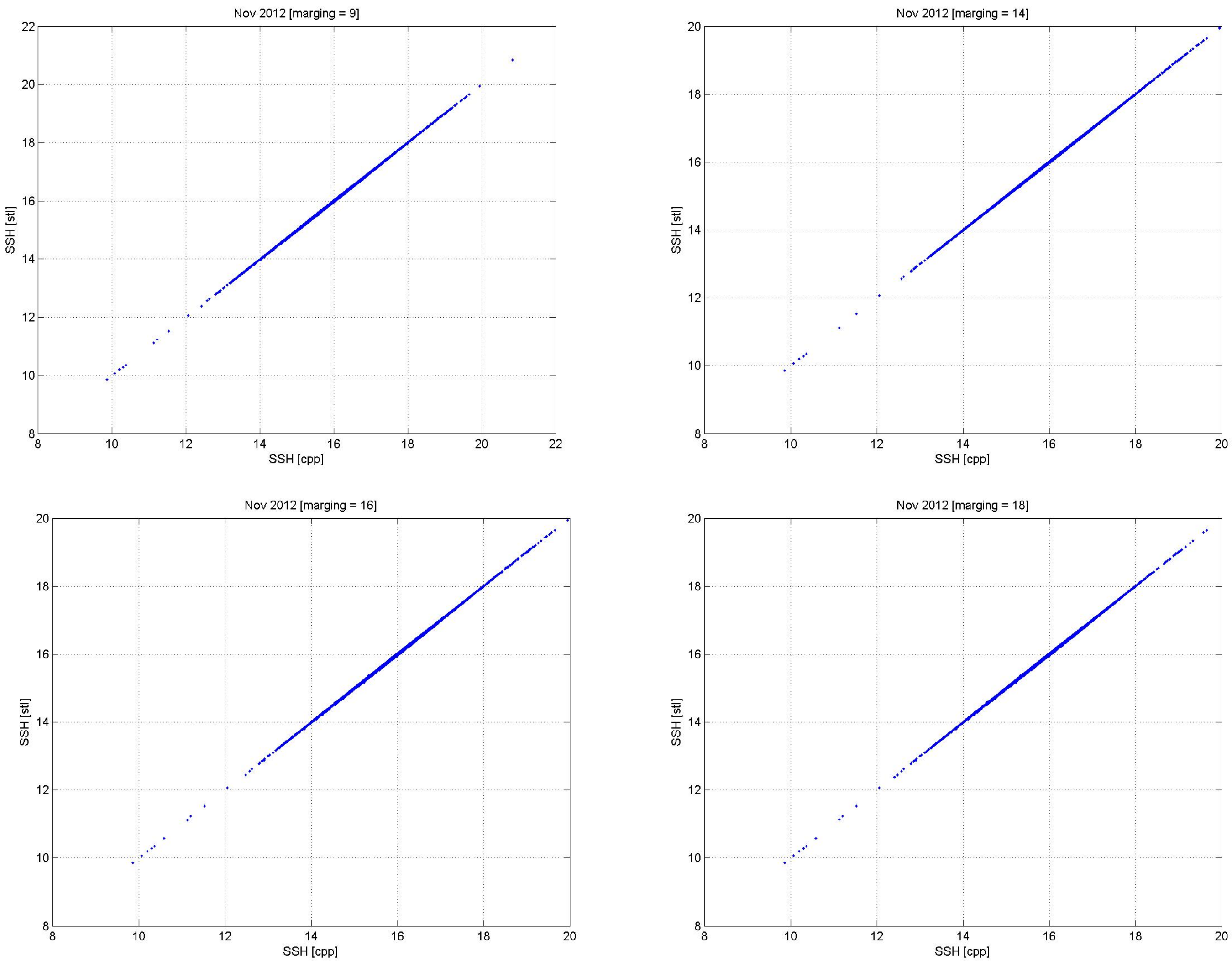




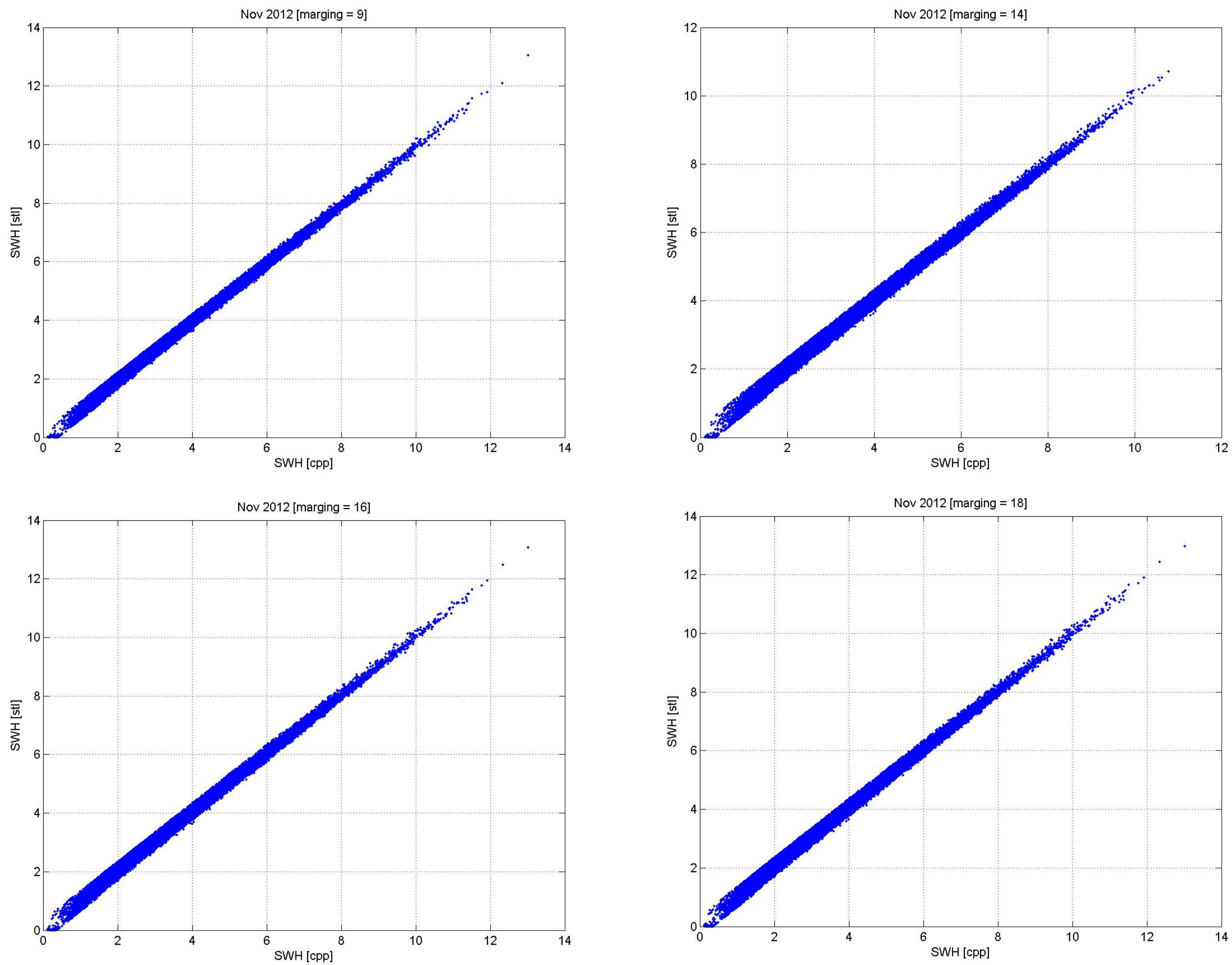
Optimisation of the Noise floor calculation

- In order to provide a more robust solution, additional margins (i.e 9, 14, 18
- An initial analysis was performed considering one month of data provided from Cryosat-2 CNES-CPP L1b (v14).
- This analysis allows a comparison of
  - The retrieved Sea Surface Height (SSH),
  - Significant Wave Height (SWH),
  - Power Units (Pu).
- Additionally, different window lengths have been also analysed.

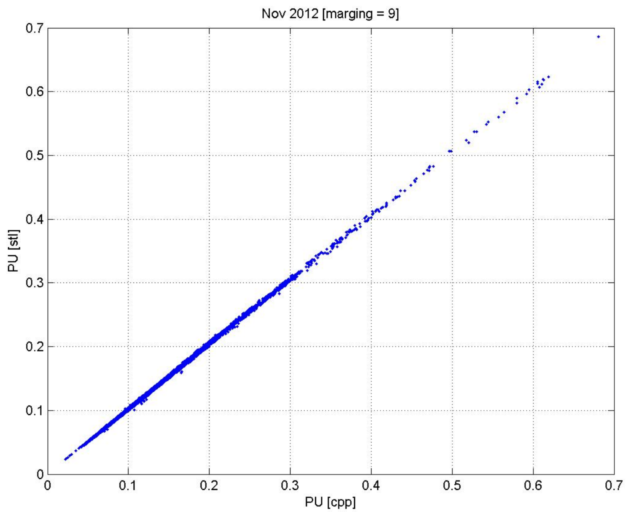
Optimisation of the Noise floor calculation

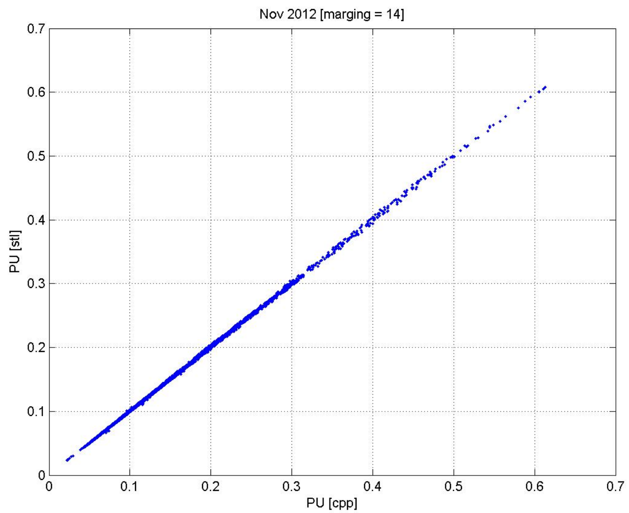


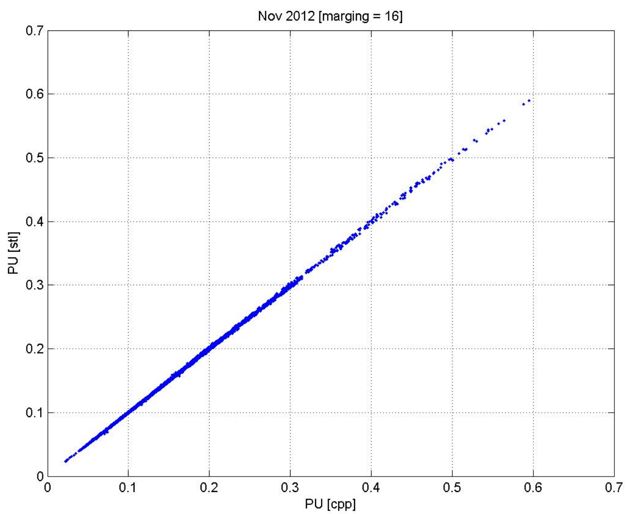
Optimisation of the Noise floor calculation

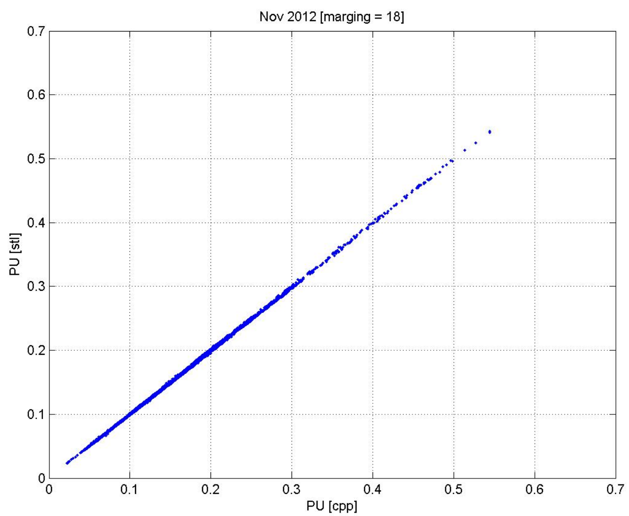


Optimisation of the Noise floor calculation









Optimisation of the Noise floor calculation

- In general terms for the different parameters, there is a high correlation (higher than 99% for all the cases).
- The largest differences are seen in the SWH for the lower values, where the estimation provided with the Starlab retracker is a bit noisier.

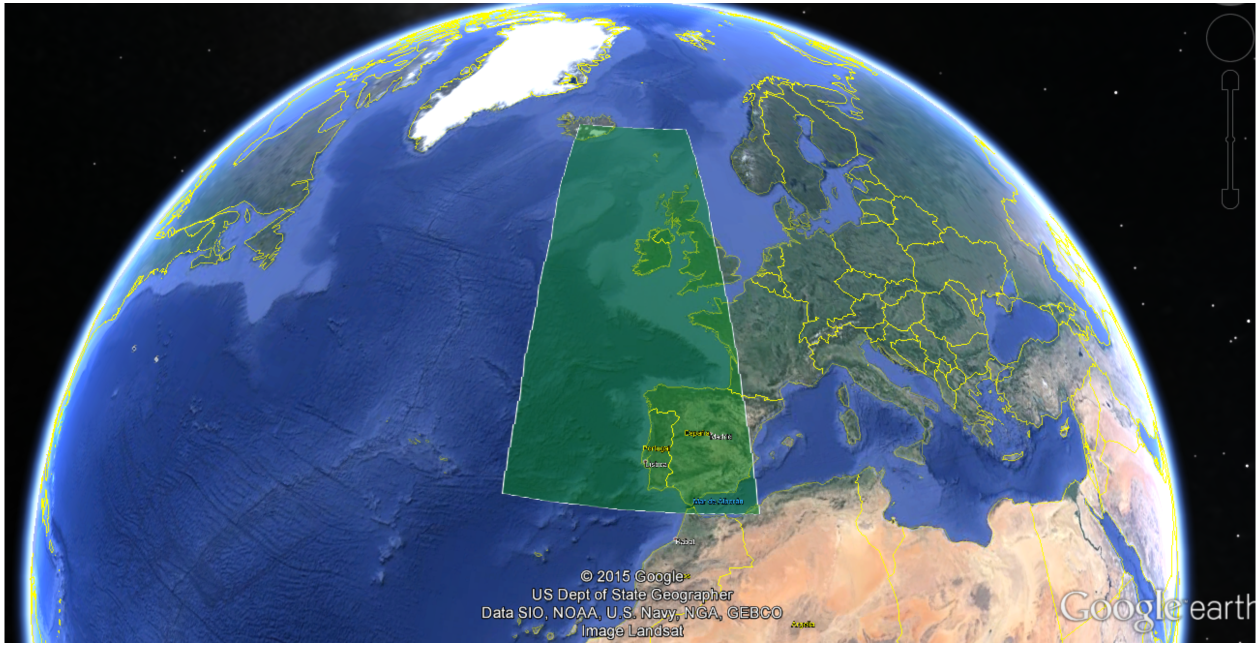
	SSH		SWH		Pu	
	Bias	**Std**	**Bias**	**Std**	**Bias**	**Std**
9	0.0047	0.0054	0.0795	0.0872	-0.0019	9.71e-4
14	**0.0055**	**0.0054**	**0.0092**	**0.0875**	**-2.78e-4**	**5.03e-4**
16	**0.0058**	**0.0058**	**-0.007**	**0.1**	**8.30e-5**	**4.77e-4**
18	0.0059	0.0058	-0.0191	0.1019	3.54e-4	4.75e-4

Optimisation of the Noise floor calculation

	SSH		SWH		Pu	
	Bias	**Std**	**Bias**	**Std**	**Bias**	**Std**
1	0.0058	0.0058	-0.0071	0.1002	8.572e-5	**4.908e-4**
2	0.0058	0.0058	-0.007	0.1	8.30e-5	4.77e-4
3	0.0058	0.0058	-0.0068	0.1	7.969e-5	4.7e-4
4	0.0058	0.0058	-0.0068	0.1	7.8129-5	4.68e-4

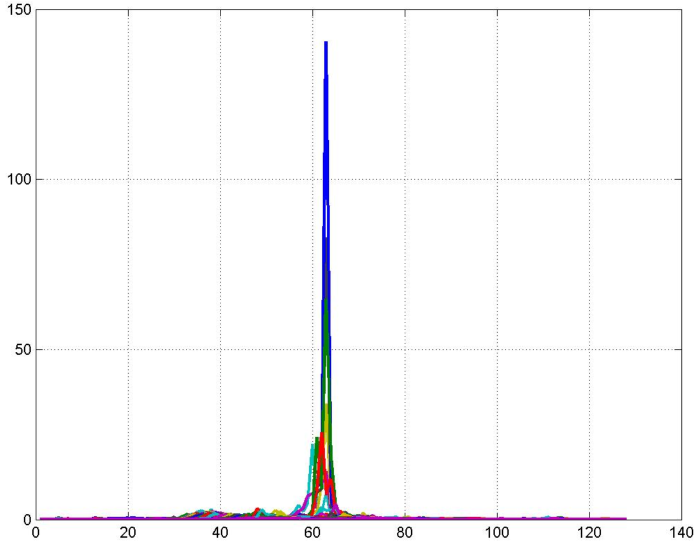
Validation Activities

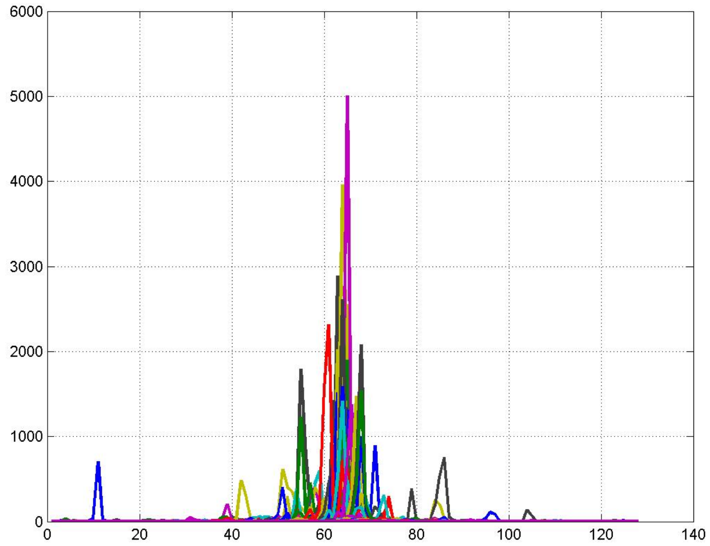
- Data from Cryosat-2 CNES-CPP L1b (v14) have been used as input to evaluate the different margins and window lengths for the thermal noise.
- Analysis was focused on the area where in situ data (wave buoy data) are available (30º-65ºN and 20º-0º W), and for the period 01/11/2012.



Validation Activities

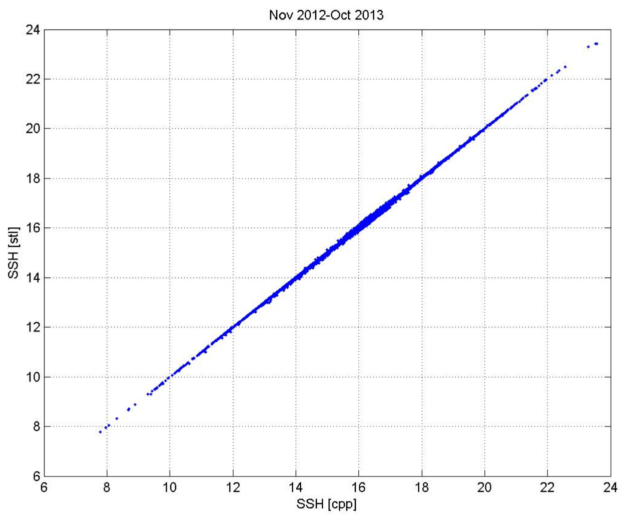
- Wrong data have been removed from the dataset used.

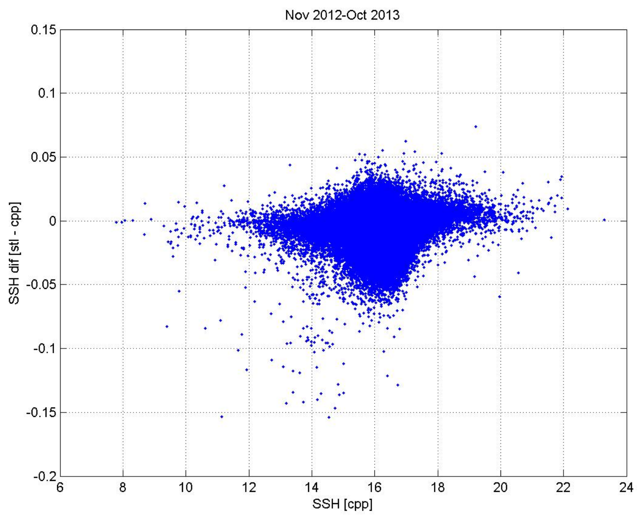




Sea Surface Height Error Analysis

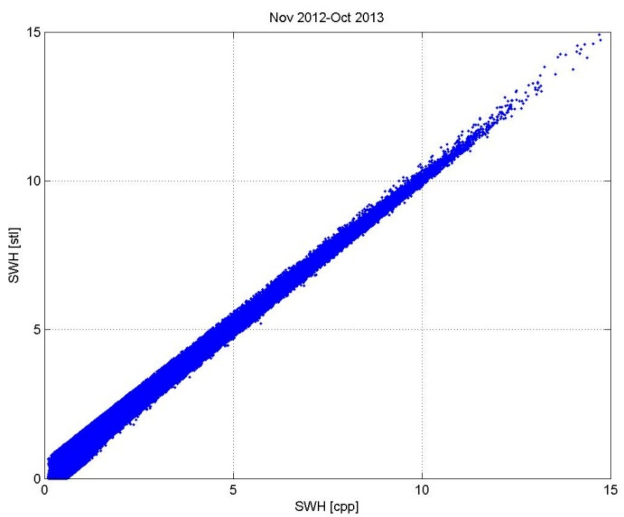
- In general terms the density plots shows the distributions around zero for the whole SSH.
- The 20 Hz error bias obtained is about 3 mm, with a standard deviation of 7 mm.

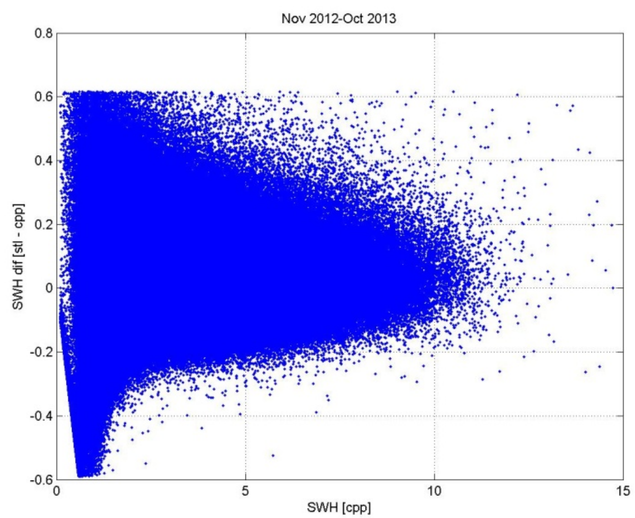




Waveform Power Error Analysis

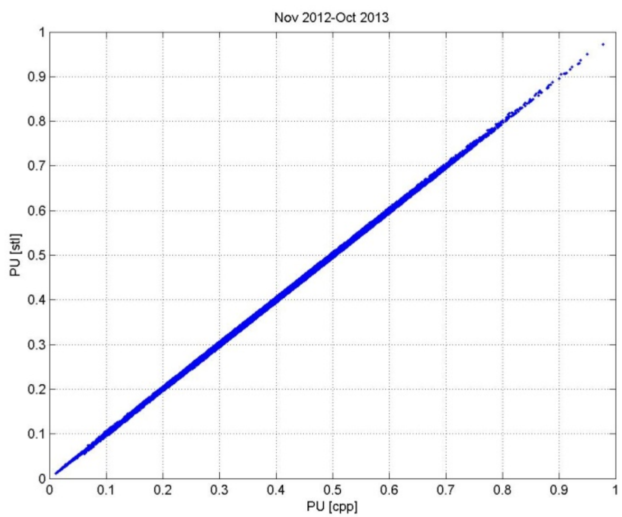
- Main SWH differences are obtained at low SWHs.
- In any case the SWH error bias obtained is -1.27 cm, whereas the error standard deviation is about 20 cm.

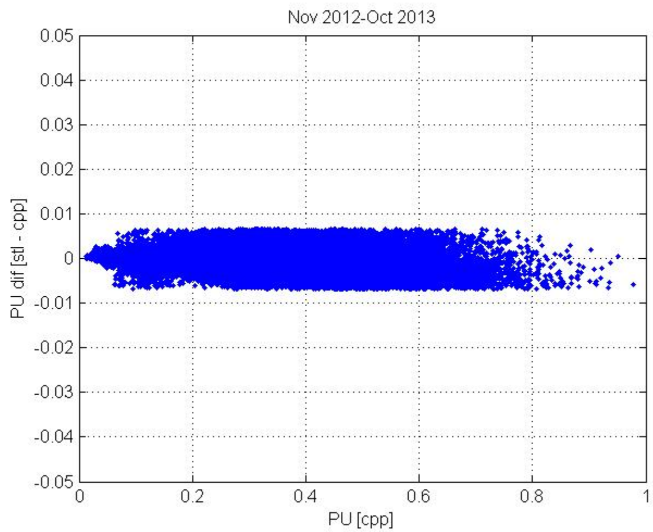




Significant wave Height Error Analysis

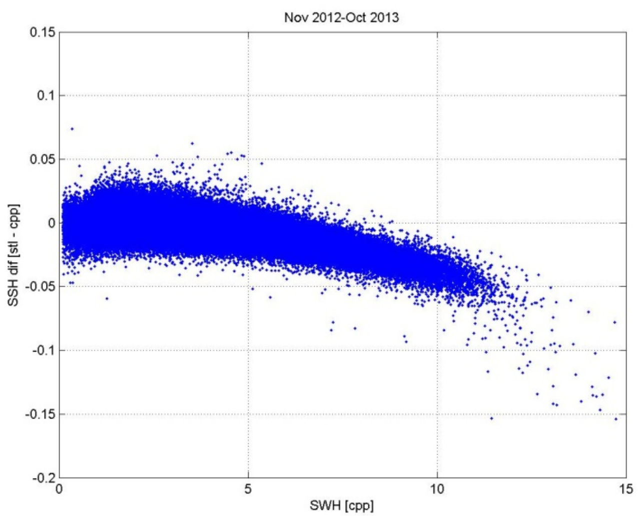
- Pu estimated by Starlab, is perfectly aligned with the one estimated by CPP.
- Differences are quite low, an error bias of 1.0479e-04, and an error standard deviation of 6.5914e-04 are obtained.

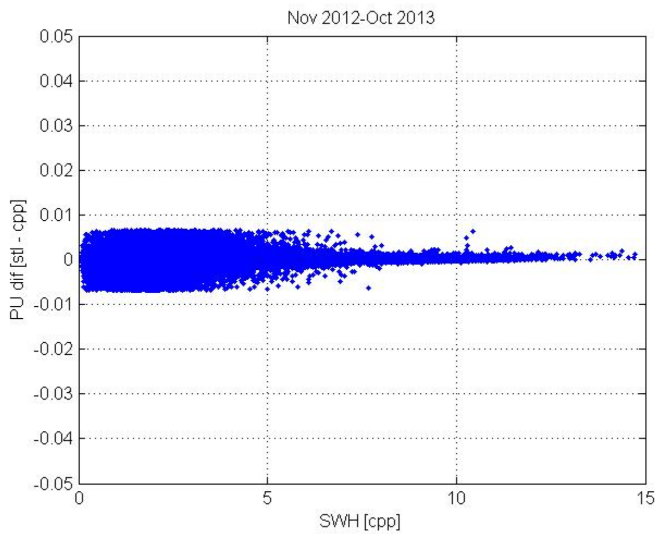




SSH and Pu differences

- As final step the SSH and Pu differences are analysed as a function of the SWH estimated by CPP, in order to identify possible dependencies of the errors on the SWH.





Summary Error Analysis

- In general terms, the parameters retrieved with the optimised SAMOSA retracker, shows a good agreement with those retrieved by the cpp retracker.
  - with a correlation higher than 99%.
- This new configuration improves the previous one for the estimation of the SWH and Pu, showing lower error bias and std, and a similar performance in terms of SSH.
- The analysis has also shown that errors in the retrieved parameters are higher for lower SWHs.

	SSH		SWH		Pu	
	Bias	Std	Bias	Std	Bias	Std
16,2	0.0039	0.0070	-0.012	0.201	1.04e-4	6.59e-4

Conclusions

- An improved version of the Thermal Noise estimation for the SAMOSA retracker was developed in the framework of the WP3000 of the Cryosat Plus for Ocean (CP40).
- The approach was a development of an empirical method, which estimated the beginning of the leading edge and then added a fixed extra margin.
- Different margins and number of lags have been tested using Level-1b CPP products, and the SSH, SWH, and Pu values provided by the CPP products.
  - Best results were obtained using a margin of 14-16 lags and a window length of 2-3 lags.
- In order to perform a statistically representative comparison, one year of CryoSat data was used.

Conclusions

- The main results show a consistent equivalence between the 20 Hz products obtained from the SAMOSA and CPP retracker.
  - An error bias of about 3 mm , with a standard deviation of 1 mm was obtained for the estimation of the SSH.
  - The equivalent error bias for SHW was close to 1 cm for SWH, and quite low (0.0001 units) for the Pu.
  - Major discrepancies between the SAMOSA and CNES retracker were found in low SWH conditions.

Recommendations :

- Further analysis to establish the cause of large percentage of bad records
- Further characterisation of the errors in retrieval at low SWH.