Retracking and validation of pulse-limited and SAR altimetry in costal zone

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Introduction

Improved methods of re-tracking and the new SAR technique allow the use of altimeter data in the coastal zone.

We investigate the quality of altimeter data at distances of less than 10 Kilometers from the land. The altimeter waveform are first classified and based on the classification are processed with different retrackers to derive the improved sea level height and significant wave height. A validation of the improved data pulse-limited and SAR data is performed against in-situ data and Level 2 products in the coastal zone of the German Bight and in the Tonle Sap Lake in the Mekong area.

Data and Methodology

Satellite Altimetry

- Envisat, SARAL/AltiKa, CryoSat-2

In-situ data

- Minute-tide gauge data (TG) in 2011-2012 made available by WSV [2].

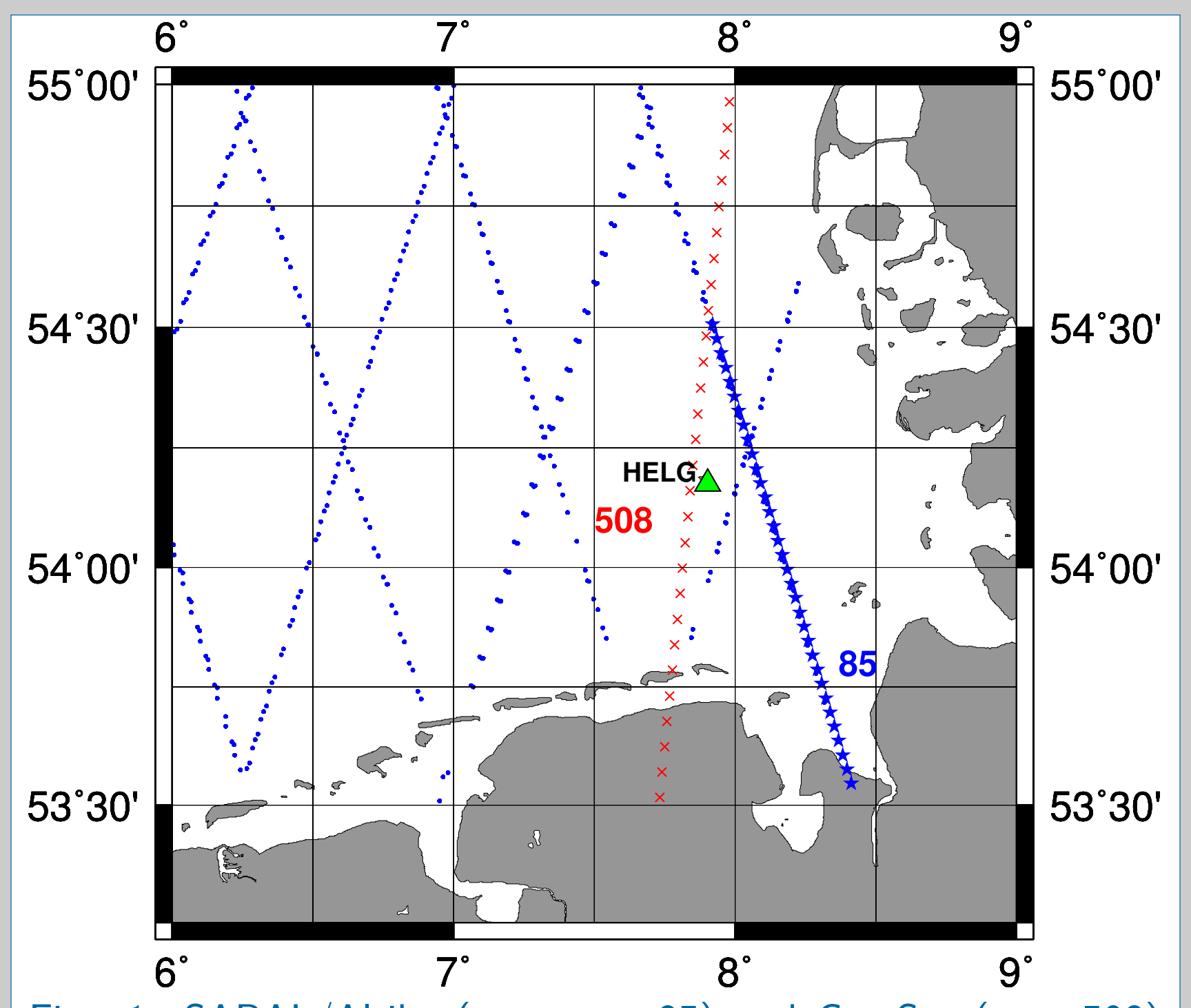

Fig. 1 SARAL/Altika (e.g. pass 85) and CryoSat (pass 508) ground tracks near the Helgoland tide gauge station

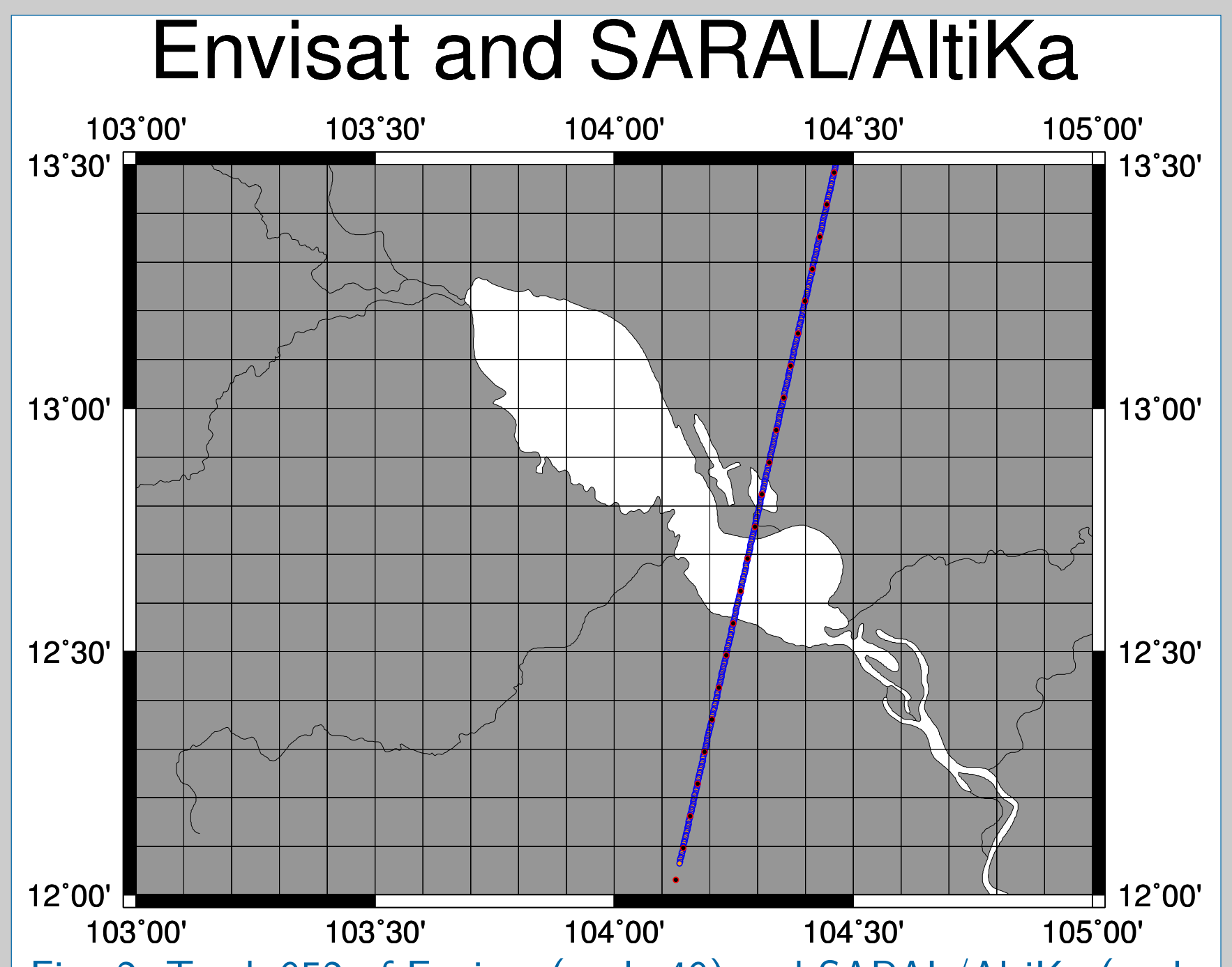

Fig. 2 Track 952 of Envisat (cycle 49) and SARAL/AltiKa (cycle 1) Tonle Sap Lake (2006.07.30)

Methodology

- Analysis of water height variation in coastal area and inland water from standard altimeter products
- Retracking the waveforms to obtain improved ranges and wave heights
- Validation of sea surface heights (SSH) with in-situ data

Finding the optimal retracker

To identify the optimal retracker we simulate waveforms of the two most common classes in inland water (Class12/Class21). These echos were retracked with a number of different retracker to test the ability to reconstruct the parameters of the simulated signals. We use the root mean square error (RMSE) which is averaged over 300 Monte Carlo runs to rate the retracking funtions. An example for each class with their parameter is given in Table 1 and Figure 3 and 4 [3].

Class	Amplitude	Epoch τ	SWH	off nadir angle ξ	Peakamplitude	Peakposition	Peakwidth	Asymetrycoefficient γ
21	130	96.875	0:0.5:12m	0.15	200	234.375	9.375	0.3
12	130	96.875	0:0.5:12m	0.15	200	106.25	9.375	0.3

Tab 1: Two parameter examples of synthesis waveforms for Class12 and Class21

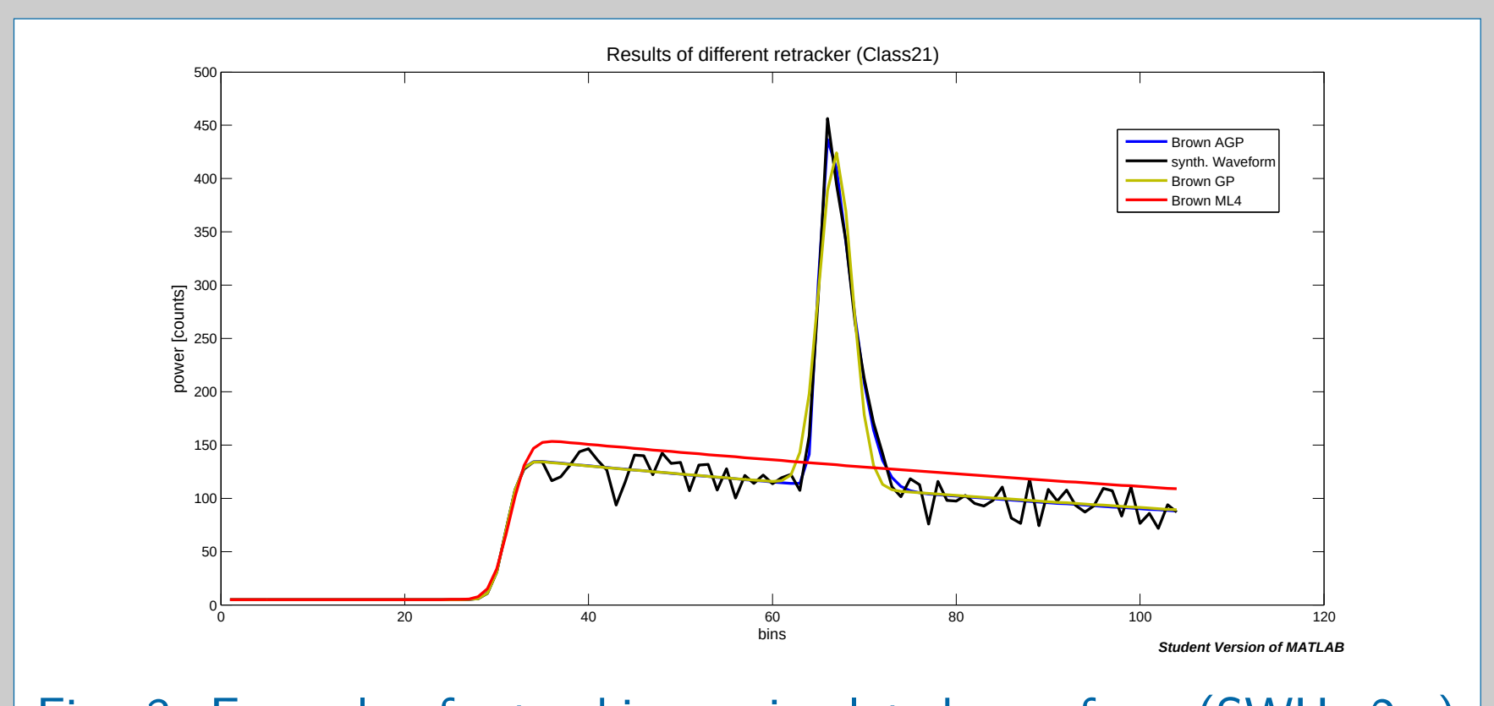

Fig. 3 Example of retracking a simulated waveform (SWH=2m) to find the optimal retracker for Class 21

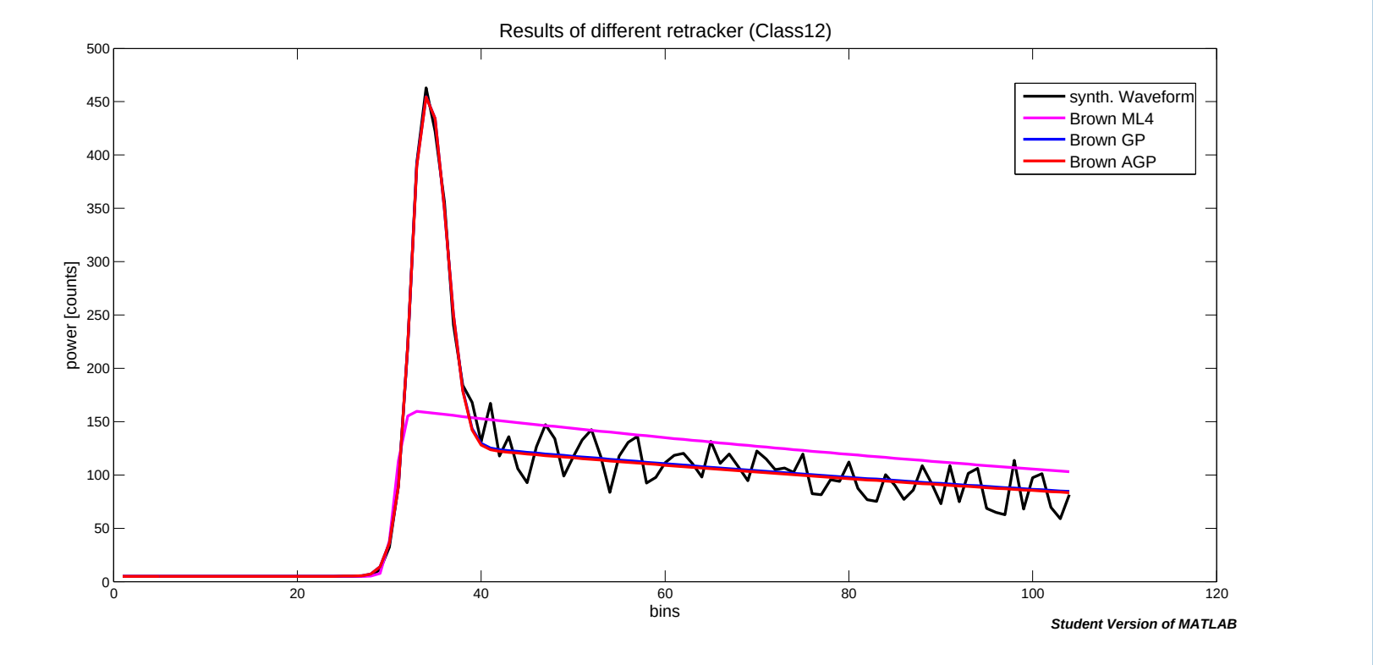

Fig. 4 Example of retracking a simulated waveform to find the optimal retracker for Class 12

Classification of Waveforms

Aim of the classification is to group similar waveforms and to use the best retracker for each considered class. We classify the waveforms according to their shape by using the maximum Likelihood Classificator [4]. We consider the 11 most frequently classes that we numerate according to PISTACH [1]. Table 2 gives an example of a classification and the retracker selected.

Class	Number	Percentage	Description	Retracking Method
1	0	0	Brown Waveform	MLE4 retracker
2	30	12.5	Specular Peak	Threshold 50
6	0	0	Very large Peak	Threshold 50
12	10	4.2	Brown + Peak at LE	Brown AGP
15	0	0	Brown and decreasing TE	MLE4
16	158	65.8	Brown and fast decreasing TE	MLE4 (E-Retracker for EnviSat)
21	9	3.8	Brown and peak on TE	Brown AGP
23	18	7.5	noisy peak echo	Improved Threshold
24	0	0	Class12 with increasing TE	Brown MLE4
212	8	3.3	Brown with more than one peak	Brown AGP
99	7	2.9	Noise	No Retracking

Tab 2: Results of classification of SARAL/AltiKa (Track 952, cycle 1) waveforms over Tonle Sap lake

Conclusions

- our new retracking algorithms retain more usable SSH in coastal zone and near the lakeside.
- Altimetric water height from SARAL and EnviSat show a similar behavior over the short common interval with better resolution for SARAL/AltiKa (higher data frequency and smaller footprint).
- The in-situ validation identify biases for both SARAL/AltiKa and Envisat
- Inland water observations from Envisat and SARAL/AltiKa agree to few cm in seasonal cycle
- Outlook:
  - In German Bigh: validation with previous mission data to detect errors and uncertainties in long-term sea level change
  - In Mekong: improved retracking and validation

References

[1] *Coastal and Hydrology Altimetry products Handbook*.

[2] P. Goffinet, J Blasi, A. Sudau, and G. Liebsch. National Report of Germany. *GLOSS-Report*, pages 1–5, April 2011.

[3] A. Halimi and J.Y. Tourneret. Parameter Estimation for Peaky Altimetric Waveforms. *IEEE Transactions on Geoscience and Remote Sensing*, 51:3, 2013.

[4] C. Williams and D. Barber. Bayesian Classification With Gaussian Processes. *IEEE Transactions on pattern analysis and machine intelligence*, 20:12, 1998.

Coastal zone in the German Bight

We retrack SARAL/AltiKa ascending pass 85 and Cryosat data pass 508. The Waveforms in Figs. 5,6 have been divided by the maximum count for each waveform and multiplied by 1000. Near coast the differences between retracked and GDR 20 Hz SARAL/AltiKa SSHs are higher than for CryoSat-2 data (Figs. 7,8).

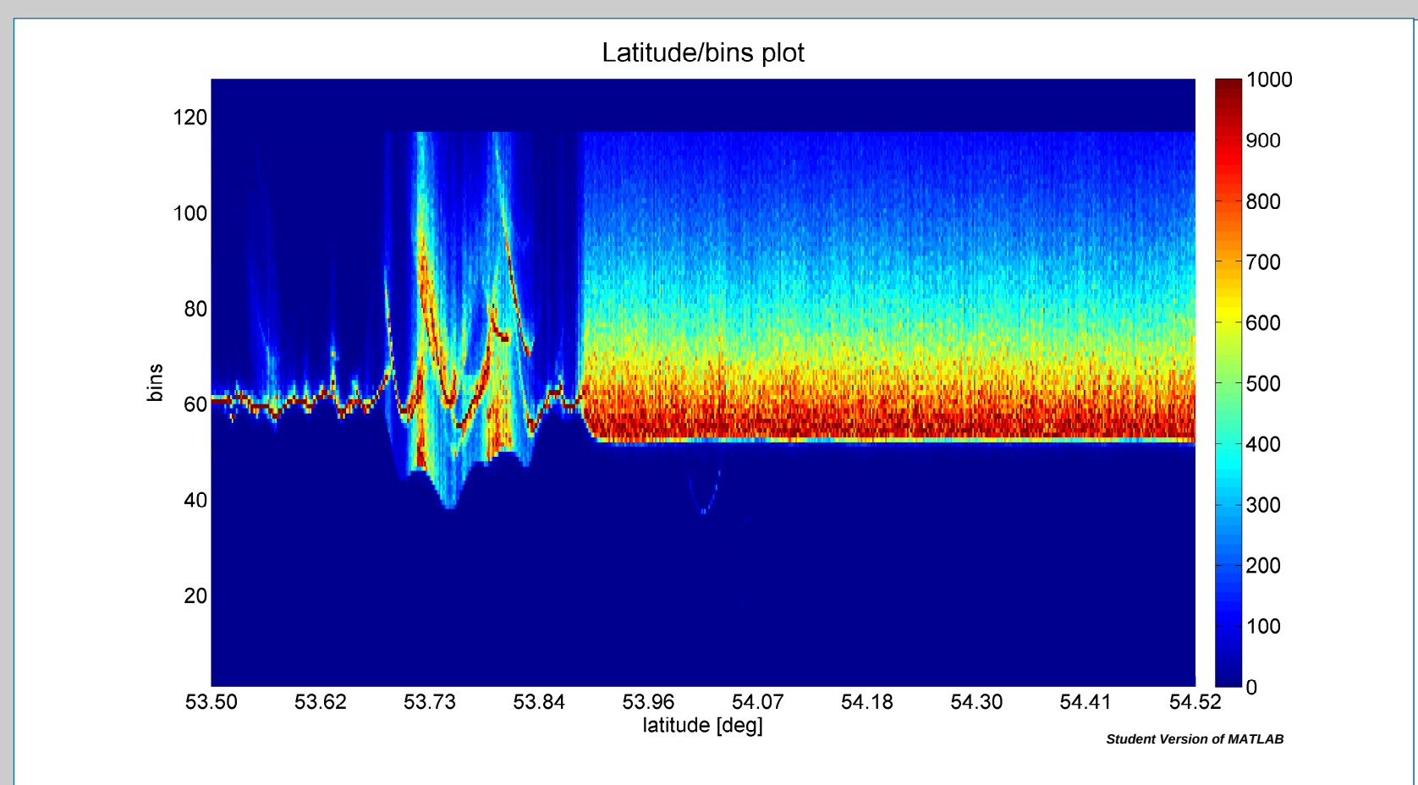

Fig. 5 SARAL/AltiKa waveforms pass 85 cycle 2

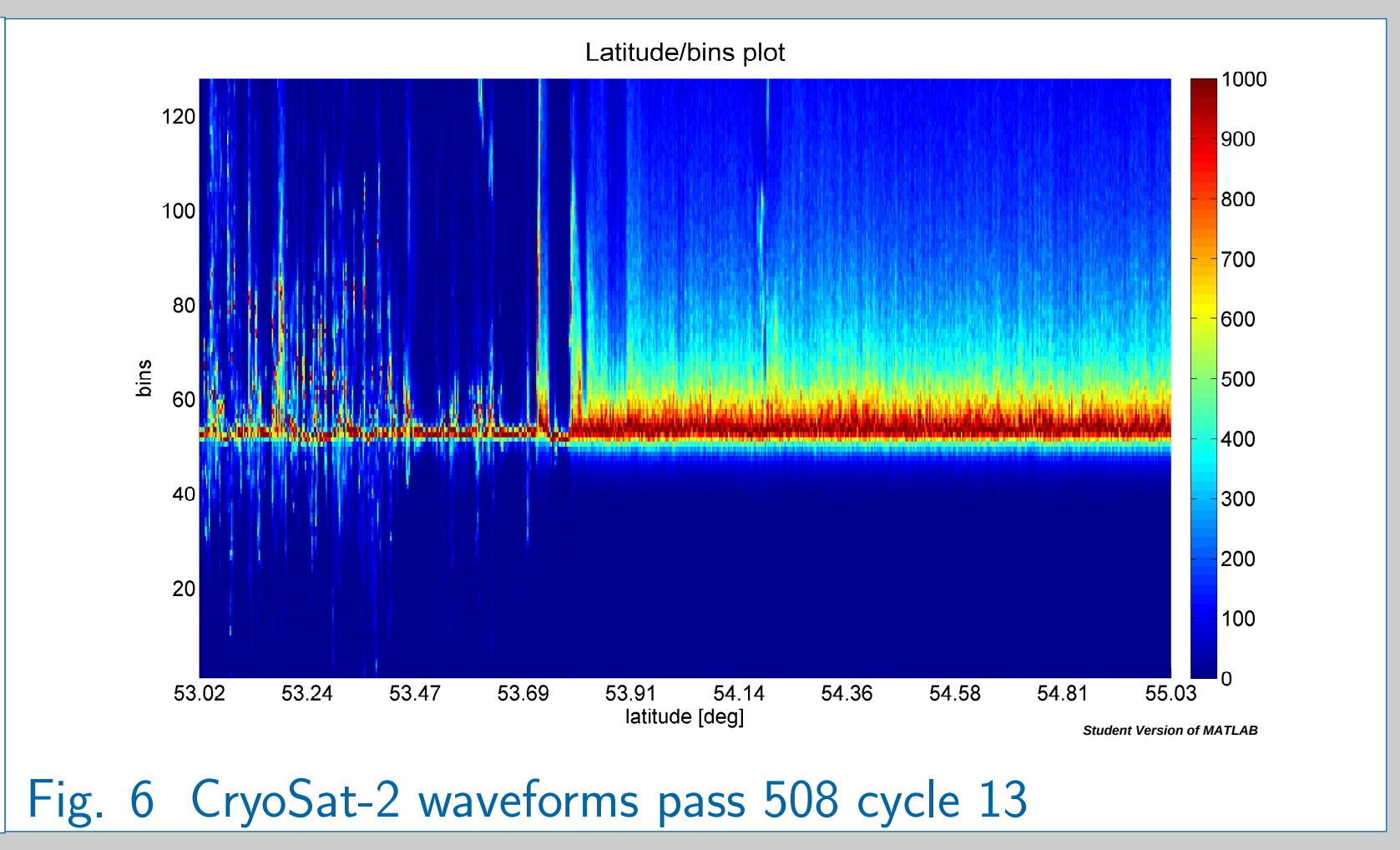

Fig. 6 CryoSat-2 waveforms pass 508 cycle 13

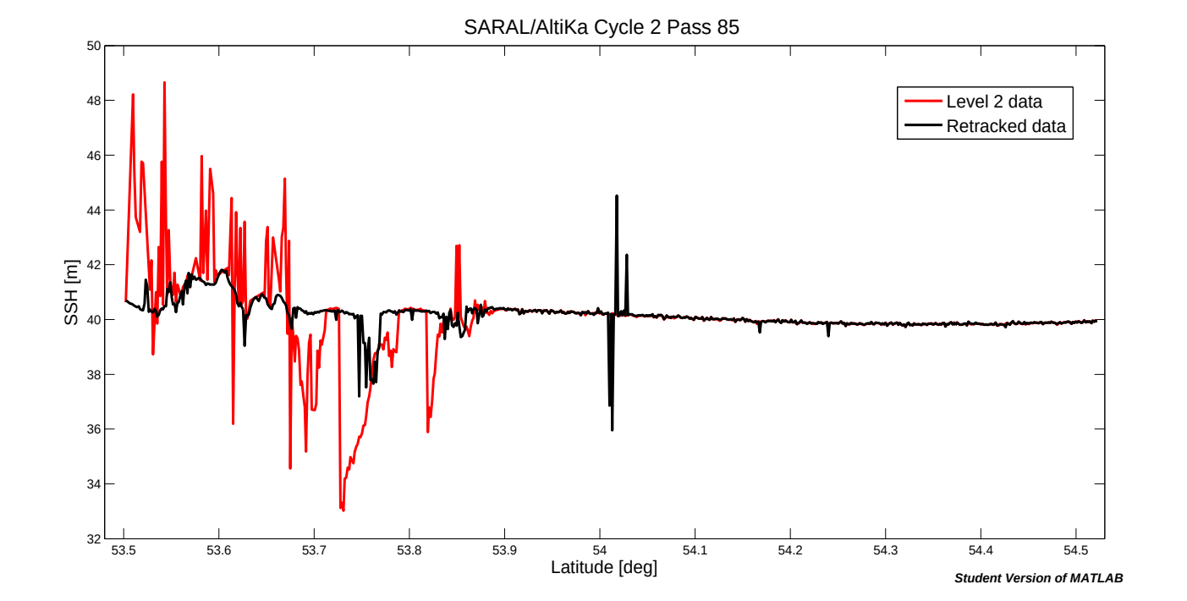

Fig. 7 SARAL/AltiKa SSH pass 85 cycle 2

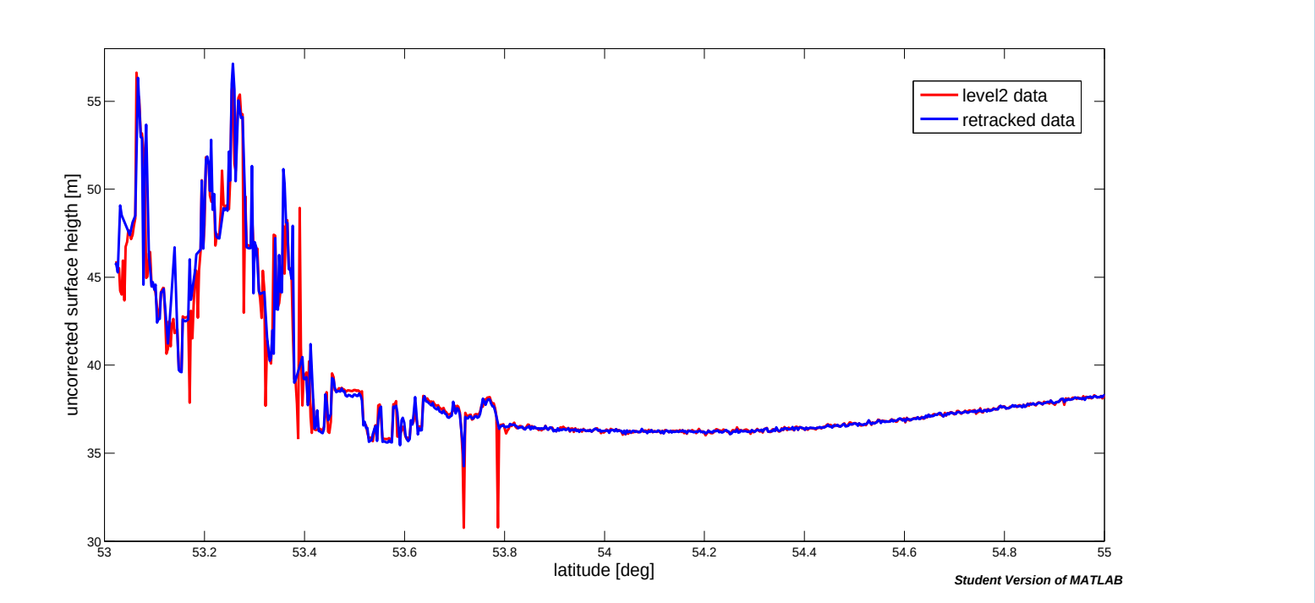

Fig. 8 CryoSat-2 SSH pass 508 cycle 13

Instantaneous 1Hz SSH are validated against SSH in-situ at the Helgoland tide gauge station (GPS and tide gauge data). The scatterplots in Figs. 9, 10 show a good consistency for both satellites (standard deviation of the differences is 14 and 16 cm respectively, see Table 3) and different biases. Biases are 4 cm for SARAL/AltiKa and 62 cm for CryoSat-2.

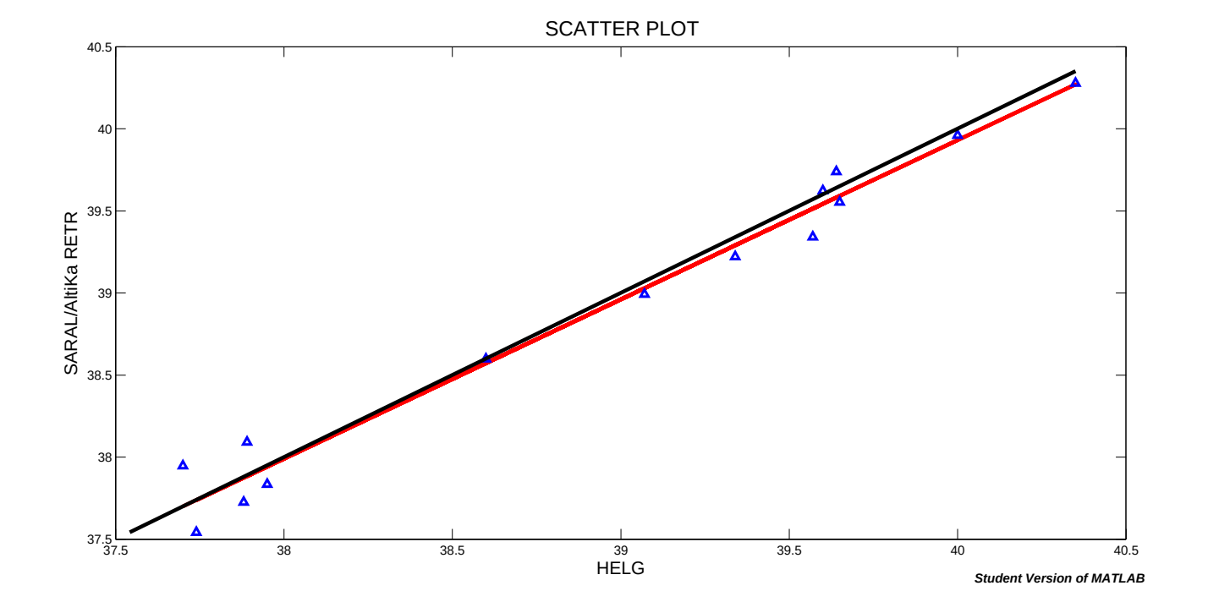

Fig. 9 In-situ validation at Helgoland tide gauge of instantaneous SSH from SARAL/AltiKa

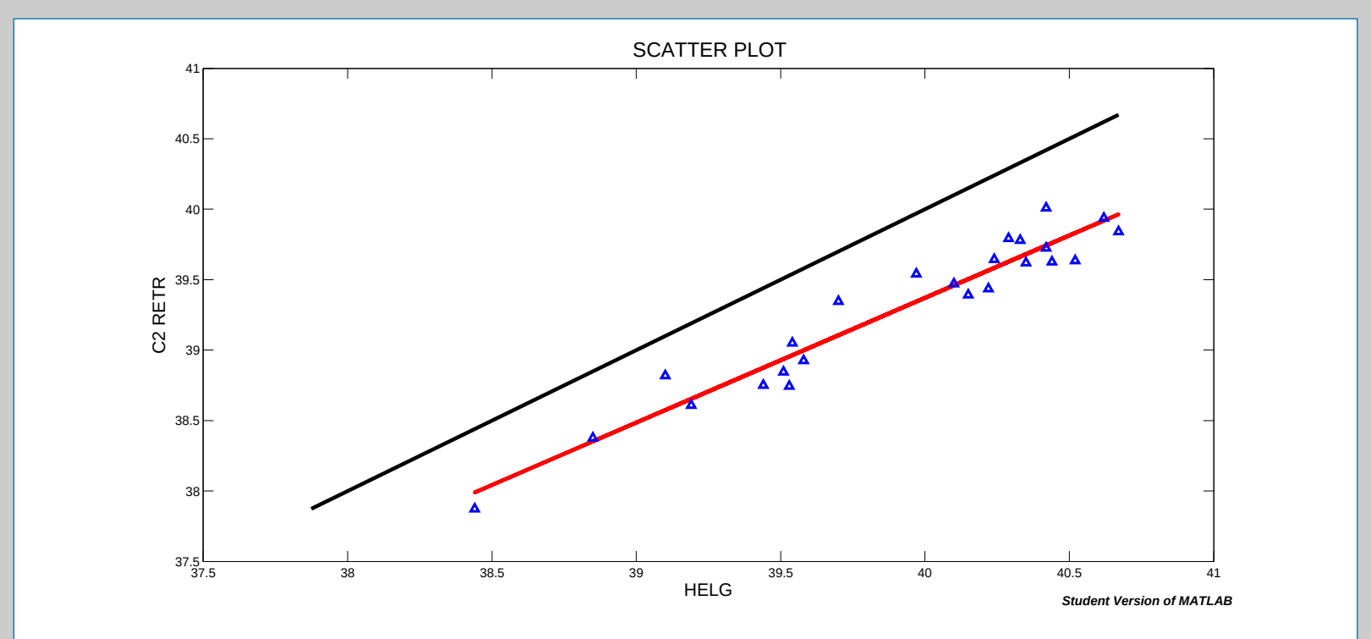

Fig. 10 In-situ validation at Helgoland tide gauge of instantaneous SSH from CryoSat-2

Satellite	mean	std	slope	samples
SARAL/AltiKa	0.038	0.14	0.97	12
CryoSat-2	0.618	0.16	0.89	24

Tab 3: In-situ validation at Helgoland GNSS tide gauge station

Inland water in the Tonle Sap Lake

We consider Track 952 of both Envisat (N1) and SARAL/Altika (SA). The corresponding waveforms, scaled as above described, are shown in Figures 11 and 12.

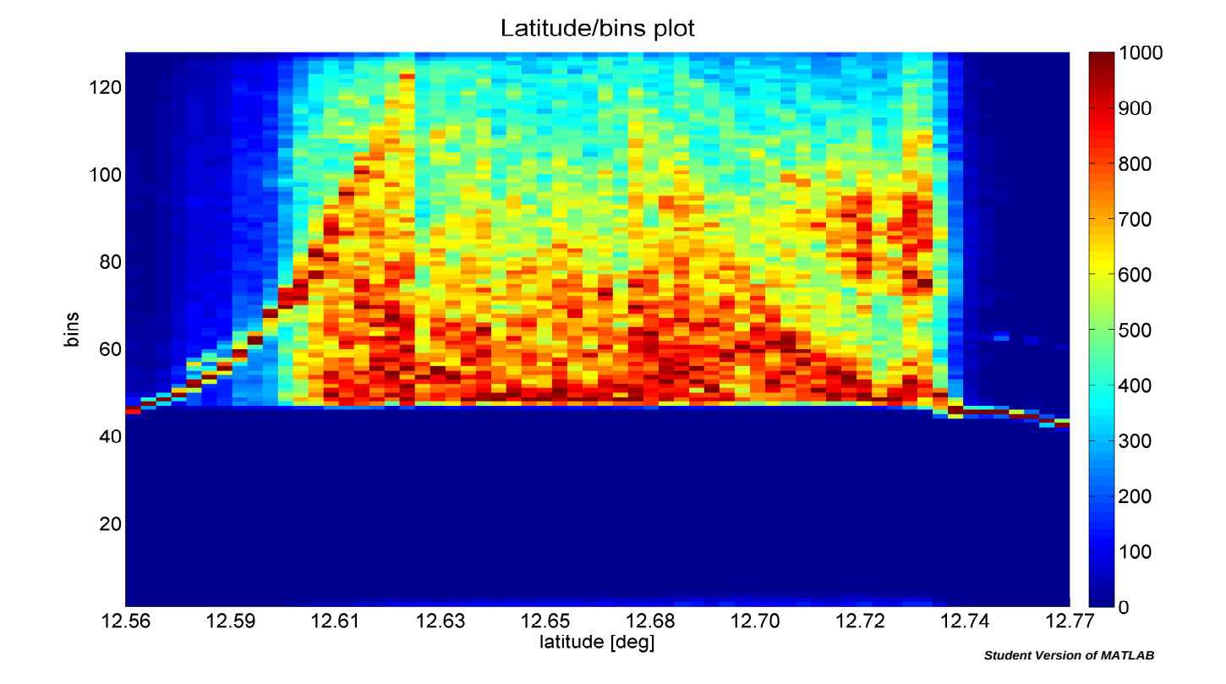

Fig. 11 Waveforms from Envisat pass 952 cycle 47 over Tonle Sap Lake (2006.05.21)

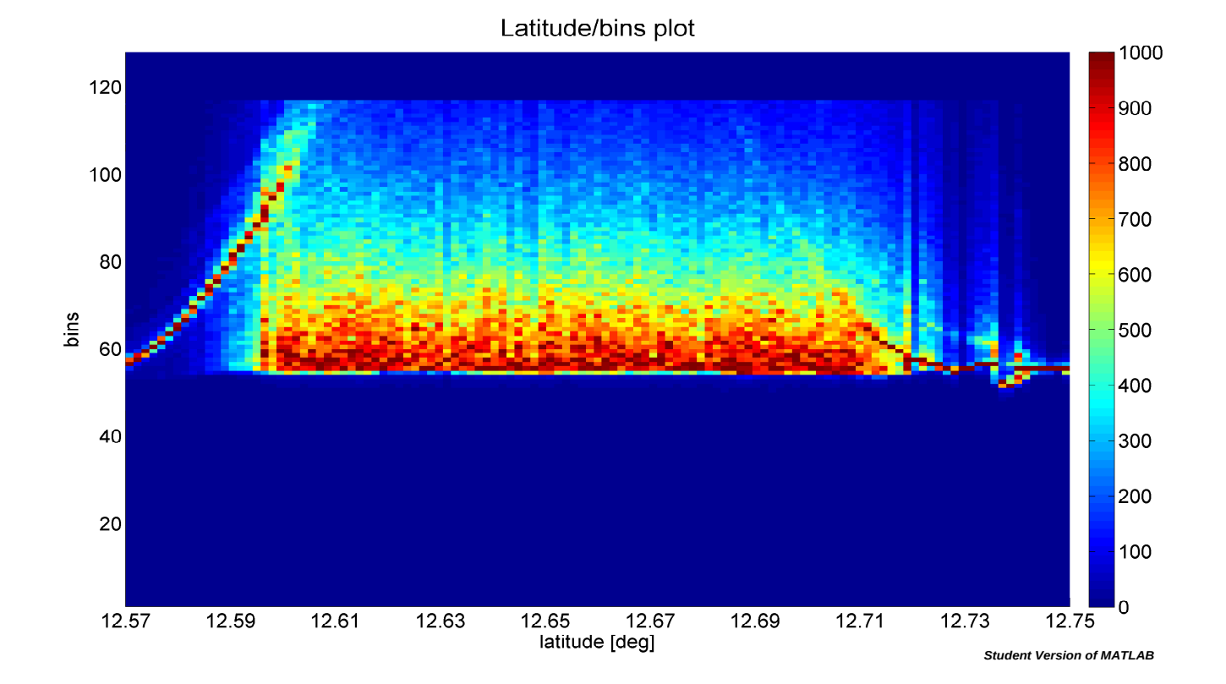

Fig. 12 Waveforms from SARAL/Altika pass 952 cycle 1 over Tonle Sap Lake (start cycle 16.04.2013)

Near lake shore our retrackers retain more valid measurements than GDR (Fig. 13). In the centre of the lake GDR provide better SSH than our retracking.

We use only SARAL/AltiKa data retracked with MLE4 in the GDR and compute mean and standard deviation of the SSHs between latitude 12.6 and 12.7 for cycles 2,3,4 (April to May 2013). We do the same for the same months in 2006 for Envisat.

The cycle averages of retracked and GDR SARAL/AltiKa data differ by 1-3 cm (Table 4).

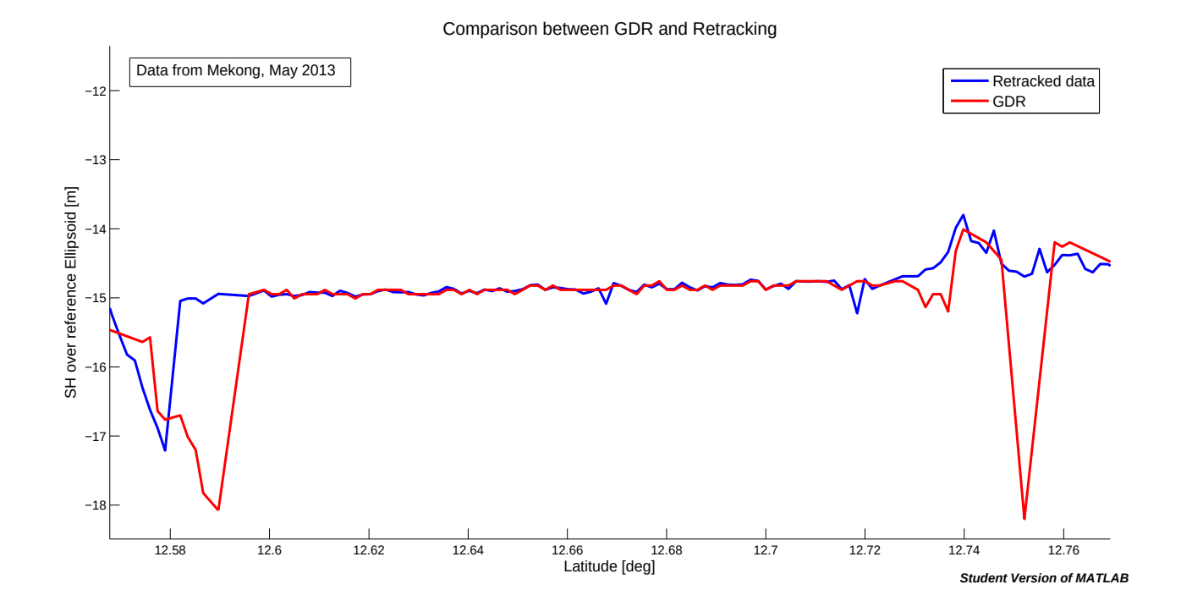

Fig. 13 Comparision of retracked and level 2 data from SARAL over Tonle Sap lake

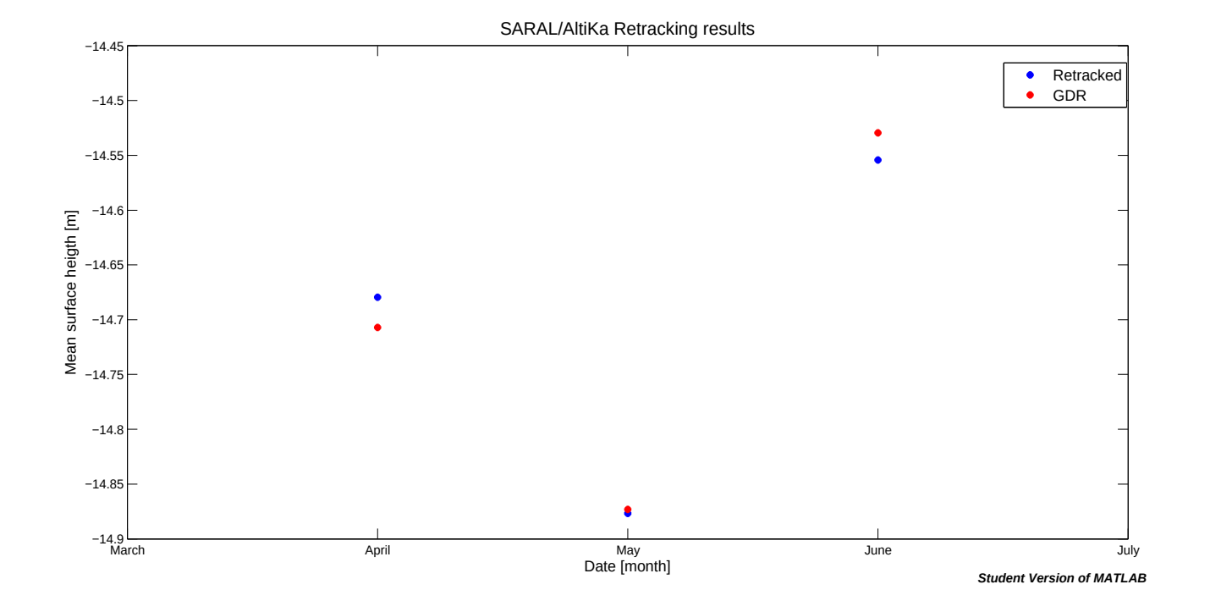

Fig. 14 Results of retracking compared with level 2 over whole Tonle Sap lake

cycle	mean SA (m)	std SA (m)	N SA	mean N1 (m)	$retr_{SA}$ - $retr_{N1}$ (m)	GDR_{SA} - $retr_{N1}$ (m)
2 RETR	-14.679	0.087	88	-14.634	0.045	
2 GRD	-14.707	0.0672	88			0.073
2 RETR	-14.8768	0.0790	82	-14.857	0.02	
2 GRD	-14.8732	0.0636	81			0.016
2 RETR	-14.5543	0.0443	45	-14.472	0.075	
2 GRD	-14.5294	0.0418	45			0.005

Tab 4: Comparison of SSH for GDR L2 and retracked data.

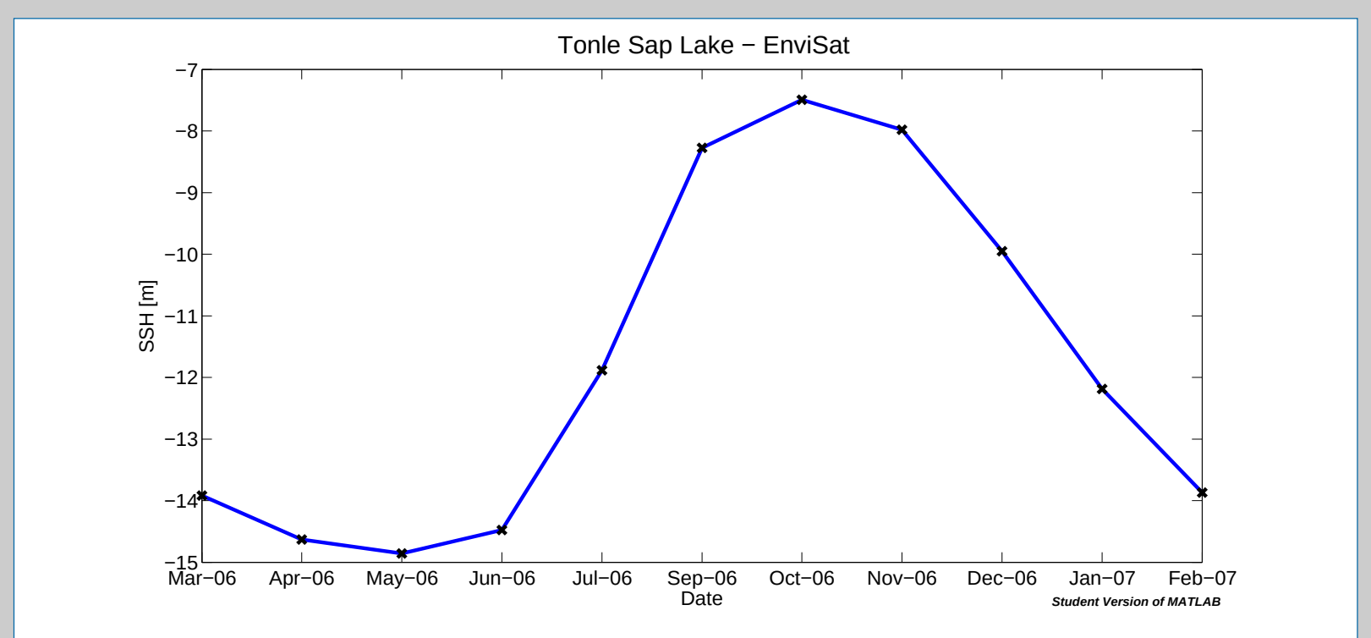

Fig. 15 SSH of Tonle Sap Lake from retracked EnviSat data

The cycle averages of the water heights obtained from Envisat retracked data have a seasonal cycle with maximum in October/November and minimum in Spring. We see in Fig. 15 the cycles means from March 2006 to February 2007. The differences in April-May-June between SARAL/AltiKa (Fig. 14) and Envisat are lower than 8 centimeters (Table 4).

Acknowledgements

We acknowledge ESA, CNES, NASA for the altimeter data. This study has been performed within the COSELE project funded by the Deutsche Forschungsgemeinschaft (DFG).

PSGD

Poster Topic 01: Technical issues in coastal altimetry
7th Coastal Altimetry Workshop
Boulder, 7-8 October 2013