Classification of Altimeter Waveforms for an Improved Estimation of Water Level Time Series over Inland Water

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Introduction

The estimation of water level time series over smaller inland water is a challenging task because of the large footprint of satellite altimeters of several kilometers which may lead to a contamination of the altimeter waveforms by land. The waveform shapes vary between brown-like shapes in the center of larger lakes and quasi-specular waveforms for rivers. There is a steady and uniform transition of the waveform shape at the water`s edges.

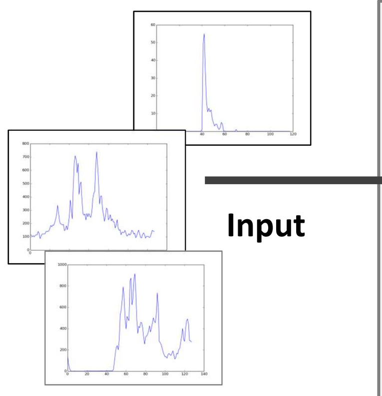
An identification of disturbed altimeter observations can be used to reject these measurements or to apply a class-dependent handling such as the usage of special retracking algorithms in order to achieve more realistic ranges and finally an improved water level time series of the investigated inland water body.

In this poster, an approach for the classification of altimeter waveform is presented which separates different waveform shapes into different classes such as ocean-like, single-peak, etc. Hereby, statistical criteria such as kurtosis, skewness, etc. are used as features.

Hereby, altimeter waveforms and water levels (Ice-1 product) of the Envisat mission (2002-2010) from OpenADB (Schwatke et al., 2014) serve as input data for the classification. Results are presented for the Amazon basin.

Methodology of Classification

The classification of altimeter waveforms is based on applying selected thresholds on waveform related statistical parameters which are shown in the right figure. In detail, features such as skewness, kurtosis, peakiness, signal to noise ratio, and max. power of altimeter waveforms are used.



Skewness

$$skew = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{w_i - \overline{w}}{s}\right]^3$$

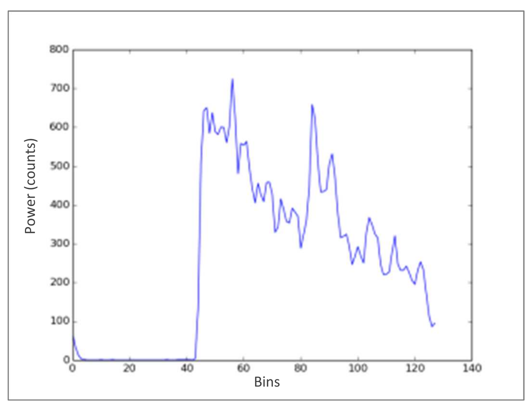
Kurtosis:

$$kurt = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{w_i - \overline{w}}{s}\right]^4$$

$\boldsymbol{w}$: *vector of waveform power*
$\overline{w}$: *average waveform power*
s: *standard deviation of waveform power*
n: *number of waveform bins*

Peakiness:

$$peak = \frac{max(\boldsymbol{w})}{\overline{w}}$$



Max. Power:

$$max\_power = max(\boldsymbol{w})$$

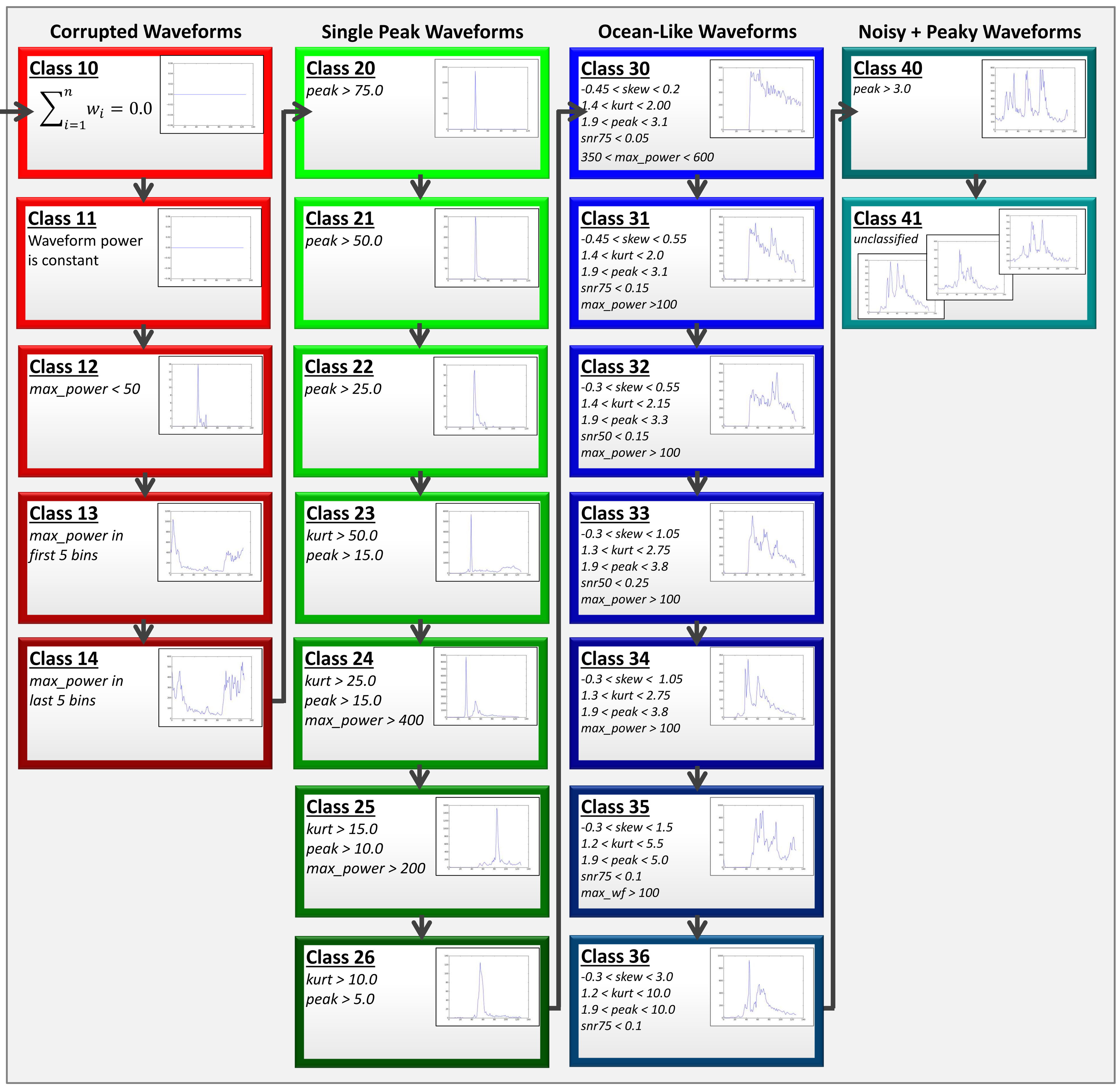
Signal to Noise Ratio:

$$snr_{xx} = \frac{1}{m}\sum_{i=1}^{m-5} w_i$$

m: *first bin where* $w_i > max(w) * \frac{threshold\ in\ \%}{100}$

The classification is separated into the four major classes '***Corrupted***', '***Single Peak***', '***Ocean-Like***' and '***Peaky + Noisy***'. Each major class is subdivided in further sub-classes. The class '***Corrupted***' includes damaged waveforms which should not be used for further investigations. The class '***Single Peak***' contains pure quasi-specular waveforms which become more degenerated (e.g., single peak with noise) with increasing class numbers. The class '***Ocean-Like***' includes typical brown-like waveforms which occur mostly over ocean. The higher the class number is the more affected the waveforms are by land (e.g. brown with peak). In the last class '***Peaky + Noisy***', all remaining waveforms are classified for which a decision between the classes '***Ocean-Like***' and '***Single Peak***' was not possible.

The procedure of the classification starts with an initial step in which the five characteristics features (see above) of the unscaled waveform are computed. Afterwards, the values of the features are compared with the thresholds display in the box of each class starting with class 10 followed by the successive classes. If all thresholds of a tested class are fulfilled, then the investigated waveform is assigned successfully to a class and the classification is finished. If not, the comparison of threshold will be continued with the next class.



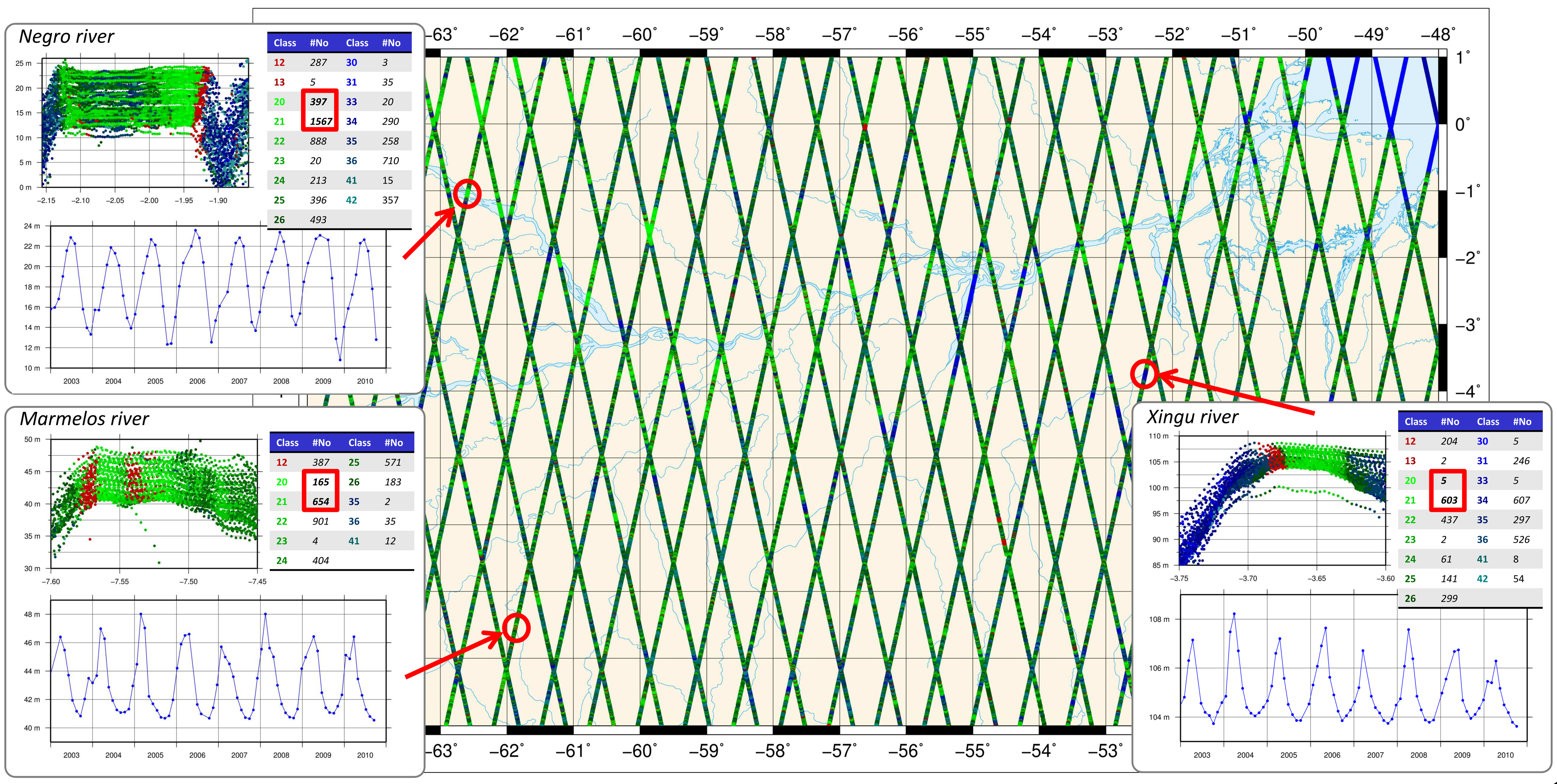
Results

The Amazon basin was selected as study area for the demonstration of the new method to classify altimeter waveform. The map of the Amazon basin shows the results of the classification for cycle 20 of Envisat. The classification shows that most waveforms have single peak shapes (class 2x) over land and in particular class 20 and 21 over river crossings. Over ocean, the waveforms have the typical brown-like shapes (class 30).

In detail, three river crossing over the Negro river, Xingu river and Marmelos river are investigated. For each river crossing all available water levels of all cycles are plotted (top) and color coded depending on the assigned class. The attached table shows the distribution of the measurements into the different classes.

Additionally, a water level time series using water levels (based on the Ice-1 product of Envisat) of classes 20 and 21 are computed and plotted (bottom) for each investigated river crossing. Hereby, a median was computed from remaining water levels for each cycle to achieve a final water level time series.

The resulting water level time series show clear seasonal variations and are rarely affected by outliers.



Negro river

Class	#No	Class	#No
12	287	30	3
13	5	31	35
20	**397**	33	20
21	**1567**	34	290
22	888	35	258
23	20	36	710
24	213	41	15
25	396	42	357
26	493		

Marmelos river

Class	#No	Class	#No
12	387	25	571
20	**165**	26	183
21	**654**	35	2
22	901	36	35
23	4	41	12
24	404		

Xingu river

Class	#No	Class	#No
12	204	30	5
13	2	31	246
20	**5**	33	5
21	**603**	34	607
22	437	35	297
23	2	36	526
24	61	41	8
25	141	42	54
26	299		

Discussion/Outlook

- The altimeter waveform classification is demonstrated successfully for the Amazon basin
- Over rivers, most waveforms are single peak waveforms which are classified mainly in class 20 and 21
- Using only water heights of class 20 and 21 (median of Ice-1 product) over a river crossing lead to reliable water level time series free of outliers
- In future, the classification algorithm can also be used for an improved class-related retracking of waveforms and for an automated detection of rivers and lakes

References

- *Schwatke C., Dettmering D., Bosch W., Göttl F., Boergens E.: OpenADB: **An Open Altimeter Database providing high-quality altimeter data and products**. Ocean Surface Topography Science Team Meeting, Lake Constance, Germany, 2014-10-30, 10.13140/2.1.1371.8728 (Poster), 2014*

Acknowledgement

OpenADB data holdings are based on altimetry missions operated by CNES/NASA (TOPEX, Jason-1), ESA (ERS-1/2, Envisat, Cryosat-2), USNavy/NOAA (GFO), CNES/NASA/Eumetsat/NOAA (Jason-2), and ISRO/CNES (Saral). The original data sets are disseminated by AVISO, ESA, NOAA, and PODAAC.

9th Coastal Altimetry Workshop, Reston, Virginia, USA, 18-19 October 2015