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Interactive comment on "Waveform analysis of airborne synthetic aperture radar altimeter over Arctic sea ice" *by* M. Zygmuntowska et al.

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We would like to thank the first reviewer, Christian Haas, for the comments and suggestions which helped to improve the quality of our manuscript. Below we will address each concern in a point by point answer. Corrections of single words and typos are not mentioned here but all considered in the revised manuscript.

COMMENT: Title: Would Waveform Classification be a better term than Waveform analysis?

ANSWER: We thank for this suggestion and changed the title into: 'Waveform classification of airborne synthetic aperture radar altimeter over Arctic sea ice.' It is indeed a better title as the term 'Waveform analysis' might be misleading.

COMMENT: P 1219: L11: north of Greenland AND CANADA

ANSWER: This has been changed accordingly.

COMMENT: Chapter 2.2: Have you tried other waveform shape parameterizations as well? Were they unsuccessful?

ANSWER: The used parameters are commonly used to describe the radar waveform. We also investigated the skewness and kurtosis of the waveform, but both parameters result in a worse classification.

COMMENT: P1224, L 7: this is a little confusing here, mention that you mean MYI and FYI (?) as the two evaluated sea ice types

ANSWER: We mean FYI and MYI and added this information for clarification.

COMMENT: Eq. 3: confirm that you mean #class_class in denominator, not #known_class (as in Eq.2)?

ANSWER: We mean #class_class as written in the manuscript. #known_class would imply that equation (3) = 1- equation (2) , what would not give any new information. As stated in the text it is the percentage of waveforms classified as one class which are actually belonging to another one.

COMMENT: Comparison with Drinkwater results: Maybe add an explanation that the Drinkwater results, obtained in the MIZ, probably were mostly from small floes smaller than the footprint size of the altimeter. This makes a big difference and footprint size should always be considered when comparing airborne and satellite data.

ANSWER: We added the information that the floes in the MIZ have been much smaller than in the areas investigated in our analysis. Besides the different sampling technique in his study and the synthetic aperture method used for ASIRAS data, this is another large difference between the two studies.

COMMENT: P1228, L. 11: describe more carefully: Freeboard is not the part, but the

height of the ice (or) snow surface above the water level, depending on definition.

ANSWER: We rephrased the sentence to clarify the statement.

COMMENT: When discussing applicability of the results to CryoSat or other altimeters, it would be nice to include a discussion of the importance of the narrow bin width (9 cm) of ASIRAS for the good results. Probably this narrow bin width allows much better discrimination of the wave form parameters than with coarser bins like those from CryoSat?

ANSWER: We added some paragraph explaining that the main difference between the ASIRAS data used in this study and CryoSat data is the resolution. While ASIRAS has a bin width of $\sim$9$\sim$cm and a footprint of a couple of meters, SIRAL on board CryoSat has a bin width of $\sim$45 cm and a resolution ranging from hundreds to thousands of meters. With this large footprint size it is more likely that a mixture of different sea ice types occurs within each footprint what makes a clear separation more difficult. The narrow bin width in the ASIRAS data allows for a detailed record of the returned power. For CryoSat the wide bin width allows only for a detection of large scale changes in surface structure and signal strength, while a detailed sampling is not possible.

COMMENT: Table 1: Add total length of sections over each ice type? Indicate if FYI was flat, or rough, or nilas?

ANSWER: As tracks are partly interrupted the total length might be misleading. Therefore instead of the length in km the number of waveforms is included. Reliable information about roughness is available only for one case and is presented in the 'Description' column of table 1.

COMMENT: Figure 3: I suggest to improve this figure by adding bins < 1% at both sides of the waveforms to show that LeW and TeW do not extent all the way to the beginning or end of the range window.

ANSWER: We changed the figure accordingly and added more bins on both sides of

the waveform.

COMMENT: Final remark: Although you have mentioned somewhere that indeed the classification into FYI is coarse and that there can be various different types of FYI, it would be nice to mention more explicitly that further studies of the impact of ice surface roughness and snow properties are warranted and should be done. Hopefully you will be able to perform a follow-up study using the existing extensive, coincident laser, EM, and snow data to study the effects of variations of these properties on altimeter waveforms?

ANSWER: We added some paragraph in the discussion section explaining that a detailed study is needed to analyze the impact of the different resolutions as well as the influence of snow and roughness on the SIRAL waveform. This has to include measurements from radar and laser altimeters, snow radar and EM measurements as well large scale information about surface roughness from, e.g. ASCAT scatterometer data and snow retrievals from passive microwave measurements.

First analysis of CryoSat data suggest that the power maximum is the most sensitive parameter, but, as stated above, more work is required to test this first impression.

Interactive comment on The Cryosphere Discuss., 7, 1215, 2013.