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Discussions

Interactive comment on "Lead detection in Arctic sea ice from CryoSat-2: quality assessment, lead area fraction and width distribution" *by* A. Wernecke and L. Kaleschke

Anonymous Referee #2

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General comments:

This study concerns the use of CryoSat-2 lead detection algorithms which are crucial to calculate Arctic sea-ice freeboard and thickness. The authors present a quality assessment by using a statistical analysis and finally provide optimized thresholds that can be used for freeboard processing algorithms. The authors find that using the maximum power of the CryoSat-2 waveform is suited best as a threshold to separate leads from ice. They also show that a combination of different thresholds, though commonly used in literature, does not provide any advantages.

The instantaneous sea-surface height is derived by the interpolation of lead elevations

and then used to determine the freeboard, the height of the ice surface above the sea level. The uncertainty of the sea-surface height is caused by interpolation errors, off-nadir leads and/or erroneous detected leads. Since it is therefore also a main source of freeboard and thickness uncertainty, this study is of high interest for the CryoSat-2 community. Furthermore, the authors provide lead area fraction and lead width distributions that could be of interest also for a broader readership and other science communities.

Nevertheless, I have some questions/concerns regarding the methods used is this study. I understand that the "ground truth" represents the reference for the quality assessment. Therefore, the authors use MODIS images with a resolution of 250 m to manually pick leads. Does it mean, that leads of smaller size (<250 m) are not considered? Due to the smooth surface of leads, a radar return from an area containing ice and only a "narrow" lead (< 250 m) in nadir position can be still dominated by the reflected energy from the lead and therefore detected as a lead. If this is the case, then the optimization analysis of this study would be biased, because CryoSat-2 might have seen a true lead whereas the MODIS image cannot resolve it. In any case, uncertainties of the "ground truth" and limits of the statistical analysis should be discussed in more detail. The authors further state, that all measurements with a mixture of both classes within the footprint are excluded. But a lead could be still detected if the CryoSat-2 footprint contains both classes and therefore be a valuable tie point, given that it is not off-nadir.

Apart from that, the paper is well written and structured. In some Sections I would recommend to add some further explanation and/or clarification (see detailed comments below).

Detailed comments:

Introduction:

P2168 L15: "affects" instead of "modulates" seems to fit better here.

P2169 L15: may be replace "Not only . . ." by "Apart from the lead area, also the . . .".

P2170 L10-L18: I think here it needs a better clarification of the term "freeboard" with respect to laser and radar altimetry.

P2170 L12-13: may be replace ". . . into an ice thickness in hydrostatic equilibrium" by ". . . into ice thickness by assuming hydrostatic equilibrium".

P2170 L14: . . . from Ku band radar altimetry.

P2170 L21: It should be stated that the interferometric mode is not performed across the entire Arctic, but only in the "Wingham Box" (which is now abrogated) and the coastal areas.

Methods:

P2171 L4: Some short introduction/description of MODIS is required here from my point of view. What is the minimum size of a lead that can be detected with MODIS images?

P2171 L14: Can the authors provide a reference and short description of the MODIS data used in this study?

P2171 L20-21: Does this mean that if when MODIS shows a lead but also any fraction of ice within a CS-2 footprint, the measurement is excluded? Wouldn't this only allow leads of a remarkable size? This needs some clarification. which size is assumed for the CS-2 footprint?

P2171 L24: Can the authors provide information about the location and record time of the used MODIS granules? An additional map (may be incorporated in one of the other figures) would be beneficial.

P2172 L4-7: What do the authors mean with "elevation differences"? Large or small scale roughness? Some clarification regarding the influence of surface roughness on Ku band radar altimetry is needed here.

P2172 L17-18: But with the presence of a wet snow surface (like with the melt onset), shouldn't this favor rather narrow waveforms, because the wet layer on top prevents the radar signal from penetration which also excludes scattering within the snow layer?

P2172 L20: To which thickness is "thin ice" associated? It would be also interesting to know the fraction of frozen leads that are detected. Depending on the freeboard of the "thin ice", this could introduce a positive bias in the sea-surface hight and hence a negative bias in freeboard.

P2175 L14: Of which dimension is THETA ?

P2176 L5: Can the authors provide some more information (reference) about the Nelder-Mead simplex algorithm?

P2175-P2176 Section 2.4: A structure chart of the analysis might improve the description of this method.

Results:

P2176 L17-19: Does it mean that if there is a delay of +/-1 hour, measurements are discarded?

Figure 2a: What causes the gap between 71.3 and 71.5°N ? Is it ambiguous regarding lead or ice classification? On the image it clearly looks like ice only.

Figure 2: The color bar needs a label and units.

P2178 L26: But on the other hand the South Eastern Laptev Sea shows almost no leads which reveals the fast ice area in this region quite well!

Figure 5 and 6: Can the authors add that the data gap north of Canada is caused by the interferometric mode ("Wingham Box")?

Discussion:

P2182 L5: Can the authors specify those "deficiencies"?

P2182 L7: I think "effects" needs to be replaced by "affects".

P2183 Section 4.2: How do off-nadir leads affect the optimization? Are they completely excluded since CS-2 measurements with a mixture of classes in the footprint are discarded?

P2185 Section 4.4: Can it be that the MAX threshold is optimized only for "large" leads due to the rejection of measurements with mixtures of both classes within the CS-2 footprint as well as the limited resolution of MODIS which was used as a reference in the optimization analysis? This could also cause the small number of apparent lead widths of 300 m.