

Interactive comment on “Sea ice thickness, freeboard, and snow depth products from Operation IceBridge airborne data” by N. T. Kurtz et al.

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We thank the reviewer (Stefan) for his helpful and constructive comments which are beneficial in improving the manuscript. As noted in the general comments, more in-situ validation data are needed for comparison with the airborne data, but only one data set was available in 2009 and none in 2010. As mentioned in the comments and in the text of the paper, this is an ongoing area of research which will be addressed in subsequent follow-on studies through the use of data collected from in-situ surveys during the 2011 and 2012 IceBridge campaigns.

For each of the specific comments outlined below we have changed the manuscript ac-

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ordingly to address each of the points which were raised. The reviewer’s suggestions were very constructive and addressing them added to the clarity of the manuscript.

Specific comments:

P4776 L25 Is this the footprint of each shot (caused by beam size and divergence), an integration over a certain time, or the point spacing of adjacent pulses? Please clarify.

This is the size of the footprint of each shot which is set by the laser beam divergence. The text has now been updated to clarify this point.

P4777 L12 What is the range/distribution of the signal strength? Which percentage of the data does the correction apply to?

We have revised the text to report the statistics on the signal strength mean and standard deviation. Since a polynomial fit is used to apply the correction, a finite correction factor is technically applied to all data points (except those with a high signal strength as noted in the manuscript). In order to convey the overall significance of the bias We have updated the text to report on the absolute magnitude of the bias correction on the ATM elevation data over sea ice and lead surfaces used in the paper.

The following text has been inserted, “The signal strength has a mean of 931 and standard deviation of 387 for the 2009 campaign, and a mean of 1064 and standard deviation of 397 for the 2010 campaign. For the 2009 campaign, the mean value of the bias correction over sea ice covered points is 0.005 m and 0.023 m over leads. For the 2010 campaign, the mean value of the bias correction is 0.003 m over sea ice covered points and 0.032 m over leads.”

P4780 L13+ Are all ATM pulses off-nadir? Line scanners show only signal losses over open water in the outer part of the swath. My suggestion would be to tilt the ATM, if applicable, to get a higher data output over areas with specular returns.

Yes, all ATM pulses are off-nadir with approximately the same off-nadir angle set for the instrument. This is due to the instrument design which was optimized to meet specific

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science measurement goals. In subsequent IceBridge campaigns (2011 to present) a second laser system with a narrower 3 degree off-nadir angle was implemented, this allowed for much higher data output over smooth surfaces. We have added in a statement about the inclusion of the new narrow scan ATM system for subsequent IceBridge campaigns into the text.

P4783 L9 How are the thresholds determined, for a flight or for each scene?

The thresholds are determined for each scene, which are visually checked for consistency. After the initial thresholds are set they are maintained along the flight line until an error is found in the output (typically caused by discrete adjustments in the camera settings to account for changing lighting conditions). The thresholds are then updated to be consistent with the manual classification. These statements have been added into the text.

P4783 L15 Do the authors use the mean or modal of the thin ice freeboard values?

We use individual values (stated as 0 m, 0.005 m, and 0.02 m in the text) which are subtracted from each thin ice surface elevation measurement in the determination of sea surface elevation.

P4784 L4 See comment to P4776 L25: Footprint of points spacing?

This is the size of each individual ATM laser footprint on the ground. The text has been updated to clarify this.

P4795 L19 What percentage of the data is discarded?

In total, 16% of the snow depth data was discarded for the 2009 campaign, and 21% was discarded for the 2010 campaign. This statement has been added into the text.

P4797 L7 Is there any substantial in-situ data in the following years? The CryoVEx 2011 dataset might be suitable for at least a small scale validation data set for the snow depth radar.

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Yes, there were multiple overflights of in-situ surveys (e.g. CryoVEx, ICEx, BROMEX) conducted in following years which will provide valuable data for comparison of the retrieval methods developed in this study. Analysis of these data sets will be the subject of follow-on studies. We have noted this in the text.

P4802 L17 (Figure 9, Figure 10) Can the authors include an ice type product (OSI-SAF) in the map background. See also next comment.

We have remade the figures to include sea ice type in the maps using ice type data from AMSR-E. AMSR-E data was used in order to be consistent with the data used in the sea ice products.

P4803 L7+ Besides the mean snow depth for each year and ice type, I also would like to see the snow depth and ice thickness distribution for FYI and MYI in this section to improve the assessment of the data products. Given that the authors already have the classification into ice types, this should not be much work.

We have added in a new figure to show the FY and MY ice distributions for the 2009 and 2010 campaigns (see below). Note the FY ice thickness data for the 2009 campaign are primarily from the Nares Strait region and are not necessarily representative of the FY ice thickness distribution from the Arctic basin.

P4805 L21 What are the sampling rates? To my knowledge the minimum sampling rate is 1 Hz, at higher rates the temperature uncertainty will be too high for lead/thin ice discrimination

The sampling rate was 1 Hz in 2010, 0.3 Hz in 2012, and is expected to be changed to 0.1 Hz in 2013. It is still an area of ongoing investigation to determine whether a retrieval method using the KT-19 can be used to effectively discriminate leads with the same level of quality that is provided by the current method using aerial photography. We have edited the text to make this point more clear.

Interactive comment on The Cryosphere Discuss., 6, 4771, 2012.

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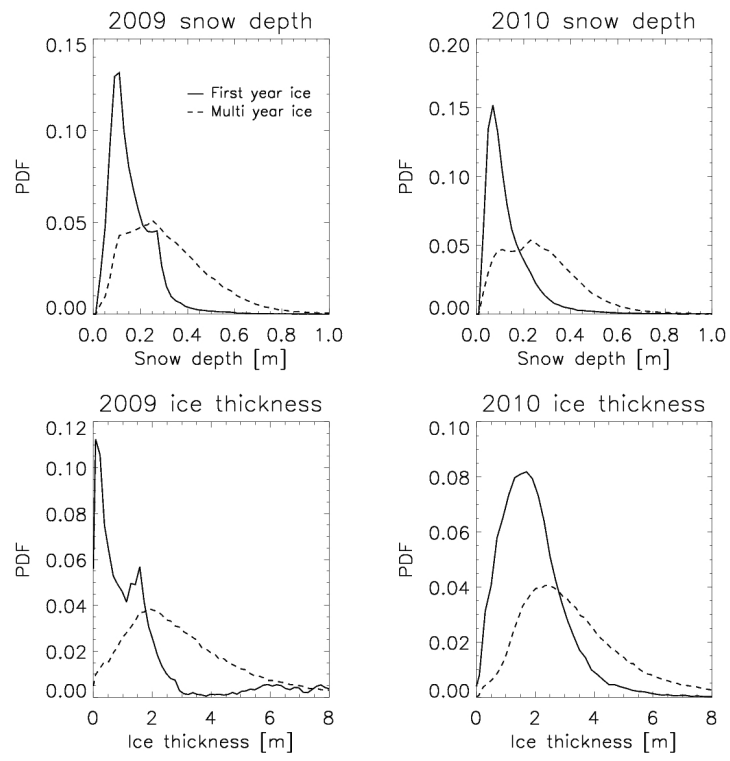


Fig. 1. New figure showing the distributions of snow depth and ice thickness for MYI and FYI. Note the FY ice thickness data for the 2009 campaign are primarily from the Nares Strait region.