The Cryosphere Discuss.,
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The Cryosphere
Discussions

Interactive comment on "Estimating Early-Winter Antarctic Sea Ice Thickness From Deformed Ice Morphology" *by* M. Jeffrey Mei et al.

Anonymous Referee #3

Received and published: 22 August 2019

Dear TC editor and authors of the manuscript TC-2019-140,

The topic of the manuscript is interesting and the content useful for sea ice research. A neural network has been applied to sea ice thickness (SIT) estimation from lidar surface elevation. The introduction section is quite comprehensive. It is mentioned that it may be possible that the introduced method may be used to improve SIT estimation by lower resolution / larger footprint laser instruments (ICESat-2). The results have mostly been presented nicely and comprehensively.

The first referee already submitted quite comprehensive comments on the manuscript, and I'll just try to complement his comments. I agree with him that a major review is still required before publication.

Here are some comments trying to improve the manuscript:

General comments:

1) I agree with the reviewer 1 that more results of the DCNN approach could be included.

2) Also a more detailed technical description of the applied methods (DCNN) would be preferable, as already suggested by referee 1. This could be a Section of its own (not an Appendix). Also include the information of numbers of DCNN neurons used at each layer and how these numbers were selected.

3) Regarding e.g. icesat-2 data, it would be nice to have some experiments or at least approximation related to the effect of resolution to SIT estimation using the proposed method.

More detailed comments:

S. Introduction P5, L17-18 "... detailed snow depth measurement": Also include already here by which method the snow depth measurements were made (not in detail).

S. Data P6, L12 and L22: instruments are named, also include references to their technical specs, and also shortly write on the principle of the snow measuring device.

S. Data P 6-7: Division of the data sets used into training and test data sets (possibly also validation data set) could be clearly described in the data section already. Were the data sets the same for all the performed experiments? This seems to be described later in the deep learning section for the DCNN.

S 3.1.1 P9, L18-19: Rather say "...Thickness of the level ice (L) forming a sail and its sail height (S)..."

S 3.1.1 P10, L8 "...for estimating sea ice thickness,..." -> "...for estimating sea ice thickness T,...". Possibly You could use SIT for sea ice thickness throughout the manuscript?

S 3.1.2 title could be "...mean sea ice thickness..." or "...mean ice thickness..." or even "mean SIT".

P10, Fig. 5. Make the figure larger, difficult to read in the printed version. Its width could e.g. be approximately the column width.

P11 S 3.1.2 L22: Describe the use of semivariogram in more detail. Did You make any experiments by varying the window size also?

P12 Fig. 6: Same thing as for Fig. 5, make larger.

P14 Fig. 7: Same thing as for Fig. 5, make larger.

P18 Fig. 8: Make the figure larger or make the box frames wider for better visibility. Include a legend describing the classes instead of writing it in the caption.

S 3.3, P 19 L5: The best-performing linear regression result has been given here for comparison. Have You any idea, could better results have been achieved by using a nonlinear approach with the same inputs, e.g. a multilayer perceptron neural network with the same inputs (plus an additional constant/intercept input)? Or are the dependencies really linear?

P19 L12-13: "20m x20m windows", also give the window size in pixels here.

Did You study the effect of the resolution to the result by using down-sampled data? Any idea, how would this possibly affect the estimation result? Possibly You could then get average SIT over a larger area? This could give an idea of the applicability of the method to coarser resolution data.

Figs. 9, 11,12,1314 and 15: make bigger for better readability in the printed version.

App. A: did You also vary the number of neurons at each level and how did this affect to the results? How were these parameters selected? Does there exist any "rules of thumb" for selecting the parameters (e.g. numbers of neurons) for DCNN's as there exist for Multilayer Perceptrons (as a function of the number of inputs and outputs).

App. A: Also include execution times for the training and SIT estimation in the used hardware.

And yet one interesting aspect: As a researcher of microwave and optical EO imagery (over sea ice) I am also interested in possibilities of utilizing the existing imaging devices for SIT estimation. Typical high-resolution (HR) sensors covering a wide spatial area, such as HR SAR or optical/IR sensors, measure only the 2-D sea ice surface, not the elevation directly. However, it is possible to locate ice ridges and even estimate their sail width in HR EO imagery. There is some literature (e.g. Timco & Burden, 1997) relating the ridge parameters to each. However, I have not seen any good reference relating sail width (Ws) to sail height (Hs). This kind of relationship would be very useful for better estimating ice thickness from 2-D HR EO data. Could the authors comment on this topic i.e. how (well) the morphology could be derived/estimated from the available 2-D EO data/imagery and whether this relation could be utilized in SIT estimation? Possibly a deep neural network could be used after deriving some ridge parameters from 2-D HR sea ice data form SAR/optical/IR, or even just training a DCNN with the data directly. This would naturally require a good data set with a large number of (nearly) simultaneous SIT measurements (possibly made by another validated remote sensing method, such as laser scanning).

Sincerely,

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