

Interactive comment on “Water Content of Greenland Ice Estimated from Ground Radar and Borehole Measurements” by Joel Brown et al.

Joel Brown et al.

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Response to: Interactive comment on “Water Content of Greenland Ice Estimated from Ground Radar and Borehole Measurements” by Joel Brown et al. A. Heilig (Referee) heilig@r-hm.de Received and published: 7 November 2016

****Author responses are in italics.****

The manuscript "Water Content of Greenland Ice Estimated from Ground Radar and Borehole Measurements" by Brown et al. presents a novel data set on EM wave velocities in temperate ice within the ablation zone of the Greenland Ice Sheet. The authors compare borehole records on temperature and total ice thickness with radar measure-

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ments. From conversion of two-way travel time (TWT) and measured depths, Brown et al. are able to calculate for velocities. Since measurements are conducted within the ablation zone, the contributing volume fractions of air and ice remain constant and are known. In consequence, it is possible to derive liquid water content. The estimated water contents for the temperate basal layer in this work exceed previous estimates applied in models. The presented results are of high interest to the scientific community and are worth publishing.

In summary, this work is relevant, well-written and adequately presented, I only ask for moderate revisions. More major points I criticize are:

The term liquid water content (lwc) is not defined in this manuscript. It is of relevance whether you describe volumetric or gravitational lwc. Since the hoisting medium is considered as ice with a density of 917 kg/m³ (which is not defined either), you only have a 10

Because the CRIM and Looyenga equations are explicit in solving for the volumetric percentage of water the, calculated liquid water content is volumetric. We have added this information to the manuscript.

The title of the manuscript is quite extensive and might lead to misinterpretations. Since you only discuss a small part within the ablation zone of an outlet glacier, I suggest to reduce the title to its geographical location.

We have changed the title to “Liquid Water Content in Ice Estimated Through a Full-Depth Ground Radar Profile and Borehole Measurements in Western Greenland”

I agree with Joseph MacGregor that Figure 4, in the current state, is not very supportive. However, the Figure already appears in a Youtube video and consequently the

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video and its location must be referenced or the Fig. removed. Otherwise, this is a plagiarism!

We have added the video, which we made, to the supplementary information. We have not cited the YouTube video as it is not a scientific source, it was uploaded for display on a personal website of one of the authors.

The chapter S3 in the supplemental information is not referenced in the manuscript. However, the information within this chapter is of high relevance and should be included into the main part.

We have moved this information to the main text since two referees suggested that the information is highly relevant.

Furthermore, I recommend to include the error analysis of the supplement into the main part as well. This section only requires little revisions but provides important information for the reader.

We agree that the error analysis is important for understanding the limitations of this study. However, we feel that including the description of how the errors were estimated to the main text, distracts from the continuity of the paper. This section is included in the Supplementary information for readers who are interested in the error estimation. We did not move this section to the main text.

Minor points that should be addressed: Figure 1a, the red dot within the GrIS overview is hardly visible in a print out. I suggest increasing this feature or at least provide bars leading to the respective locations.

We have added an arrow pointing to the location in Figure1a.

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Figure 2 the blue and yellow dashed lines are hardly recognizable. I understand that you don't want to hide radargram information by the lines but at least consider increasing the thickness of the lines or change to colors with higher contrasts.

We have experimented with many iterations of the appropriate weight and color of these lines. We find that the increasing the weight of the lines completely masks the data we are trying to highlight, the same is true for changing the color of the lines. We have not changed the color or weight of these lines.

I recommend to include Hobbs (Ice Physics) as reference in page 8 L30ff

Although Hobbs' book is informative, since (1) the majority of the book does not deal with water inclusions and (2) the book was published after the two citations included in this line, we do not cite Hobbs. We have added e.g. to this list of references to show that the list is not exhaustive.

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-208, 2016.

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