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Interactive comment on "Characterization of L-band synthetic aperture radar (SAR) backscatter from floating and grounded lake ice in arctic Alaska" *by* M. Engram et al.

Anonymous Referee #2

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Characterization of L-band synthetic aperture radar (SAR) backscatter from floating and grounded lake ice in arctic Alaska

by M. Engram, K. W. Anthony, F. J. Meyer, and G. Grosse

General comments

This paper aims to "examine the value of single-polarized (single-pol) L-band HH backscatter from floating and grounded lake ice compared to C-band VV SAR values to determine its utility in distinguishing between grounded and floating ice." In their 2012 paper, Engram et al.* showed that L-band SAR (HH) backscatter intensity from ALOS PALSAR acquired in autumn (late October to late November) was useful tool for

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constraining estimates of regional CH4 ebullition in shallow thermokarst lakes, while C-band (VV) from ERS-2 did not show any such relationship. This was the first study of its kind that clearly demonstrated the value of space-borne L-band SAR data to explain the scattering mechanisms involved in radar-lake ice interactions in the presence of ebullition bubbles.

As many thermokarst lakes freeze to their bed (either completely or partially) in winter, the current submission builds on the publication of Engram et al. (2012) by exploring the value of L-band HH SAR data (JERS-1 and PALSAR) acquired between late March and late April (close to the time of maximum ice thickness) for differentiating floating ice from grounded ice (i.e. frozen to bed) in contrast to C-band VV (ERS-1/2). Space-borne C-band SAR has been used as the main tool for this purpose since the 1990s. In this respect, the authors have done a very good job summarizing the key literature on this subject, including earlier work with X- and L-band airborne SLAR data in the 1970s.

The paper submitted by Engram et al. is generally well written, the image analysis methodology is sound and the interpretation of the results is correct; however, it falls short of a paper deemed acceptable for publication as a "Research Article" in The Cryosphere. The two main reasons for my recommendation are: 1) L-band (the focus of the study) is shown to be of little value for differentiating between floating and grounded lake ice compared to C-band (the main band used successfully in previous studies); and 2) the lack of any coincident field observations of ice properties needed in support of the interpretation of the main findings from the analysis of L-band quad-pol and C-band data.

Regarding 1) – The finding that L-band is not very useful for differentiating between floating and grounded ice is shown but is something that one should expect, based on what we already know about radar interaction (at both C- and L-band frequencies) with lake ice that contains bubbles of various sizes. Previous work has clearly shown that both C-band (VV and HH) and X-band are very useful for differentiating floating ice from

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grounded ice, and this (C-band) has formed the basis of approaches for monitoring the evolution of lake ice from floating to grounded ice conditions. Ice cover on shallow lakes has been documented to contain a large volume of tubular bubbles, particularly in late winter/early spring (March-April) on the Arctic Coastal Plain of Alaska (e.g. Jeffries et al., 1994) and other similar coastal areas of the Arctic/sub-Arctic. Due to the limited value of L-band for discriminating between floating and grounded ice, as shown amply in the "Results" and "Discussion" sections (up until section 4.3), the authors switch the focus of the paper (particularly starting on p. 14) on the value and use of C-band data. For example, the last paragraph of 4.1 (pp. 11-12) is somewhat irrelevant to the original goal of the study (L-band, as the title of the paper suggests), as are the last two paragraphs of section 4.3 (pp. 15-16) and the first paragraph of the "Conclusions" (p.16).

Regarding 2) – The approach to studying grounded and floating ice, and identifying the scattering mechanisms at L-band (volume, double bounce, roughness) is interesting, but the lack of any field observations (bubble type, density, location of bubbles at various depths within the ice volume, rocky bottoms or not, fully frozen sediments or not) around the time of at least one of the space-borne SAR acquisitions make the interpretation of results (Discussion) very speculative. Words such as "could" and "possibly or possibility" are therefore used throughout.

Suggestion

Although I cannot recommend publication of the current version of paper in this journal, I suggest that the authors explore the possibility of extracting the key results from the polarimetric analysis (L-band) for submission to a remote sensing journal, either as a research note or a technical note. The lack of field observations is usually not seen as negatively in these shorter forms of publication.

* Engram, M., Anthony, K. W., Meyer, F. J., and Grosse, G.: Synthetic aperture radar (SAR) backscatter response from methane ebullition bubbles trapped by thermokarst

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lake ice, Can. J. Remote Sens., 38, 667–682, doi:10.5589/m12-054, 2012.

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