

Review Comments

Title: Benefits of Coherent Large Beamwidth Processing of Radio-Echo Sounding Data

Journal: The Cryosphere

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General Comments:

In this manuscript, the authors present a novel radar focusing method that improves image quality based on the scattering properties of the ice surface, englacial reflectors, and ice bottom. This method can be used to improve the signal to noise ratio of englacial reflectors, can aid in the elimination of surface clutter and surface multiples, and can be used to diagnose the roughness characteristics of the surface and subsurface reflectors. The authors present the algorithm in sufficient detail to reproduce the results of their analysis, but the discussion of the *scientific* impact of the algorithm is limited -- at present, this work is more appropriate for IEEE. To publish this work in The Cryosphere, the authors should include either (a) substantial discussion of the scientific utility of the new algorithm, or (b) more rigorous interpretation of their test data.

Specific Comments:

The aims and scope of The Cryosphere sets standards for originality and impact of the published works. These are areas of weakness for the manuscript at present. Direction of arrival analysis is already well established in the literature (Al-Ibadi et al., 2017; Jezek et al., 2009; Wang et al., 2016). The authors do present a novel numerical scheme for inferring direction of arrival in the along-track direction. But their primary analysis is to show that englacial layers are more specular than the bed, and that deep layers are more conformal with the bed than shallow ones, two observations already discussed widely in the literature.

There are few issues with the information presented, which makes this manuscript challenging to review. The authors cite (but do not pursue) two possible scientific applications of their method – (1) to characterize bed roughness or subglacial hydrology (Schroeder et al., 2013) and (2) to better estimate layer slopes (Macgregor et al., 2015) and potentially relate those slopes to ice dynamics. To make this manuscript more appropriate in The Cryosphere, the authors could provide more substance in a number of ways: discuss the ice dynamic understanding derived from resolving steep englacial layers (Hindmarsh et al., 2006; Holschuh et al., 2017), spatially constrain the roughness characteristics in their test data and relate those to the underlying geology or ice flow behavior (Schroeder et al., 2014), or work toward a better understand the waveform characteristics of englacial reflectors (Drews et al., 2012) or diffuse scatterers (Jordan et al., 2017). Right now, the manuscript simply defines an algorithm and applies it – there is essentially no interpretation of results. While the summary and conclusions might be interesting to radioglaciologists who regularly process radar data, they are unlikely to be interesting to radar-data end users or a general Cryosphere audience.

Technical Corrections:

<u>Line #</u>	<u>Comment</u>
Pg1, L10	“The use of synthetic aperture radar (SAR) allows to improve...” – allows is missing an object. Allows who/what to improve?
Pg1, L13	“Several algorithms were offered for ...” – offered by whom? Offered for what? Odd phrasing.
Pg2, L3	“MacGregor et al. (2015) introduce two new methods for estimating the slope of internal layers, among them the Doppler centroid method, which uses the fact, that internal layers’ returns ...” – remove comma after fact.
Pg2, L22 – P3, L4	Section 2 is written with an electrical engineering audience in mind – clearer definitions are needed to make this accessible in The Cryosphere. This includes your coordinate system (maybe include “azimuth” and “range” in figure 2?), pulse compression, motion compensation and range cell migration corrections.
P4, Eq 2	Your variable definitions and nomenclature in this section is confusing. Figure 1 defines the height above the surface as R_0 and the depth below surface as d , but then your height above the surface is h in eq 2? h is actually never defined.
Pg11. L10	“... and fit it into a piecewise linear regression ...” -- this is not clear enough to be reproduced, but seems critical to your image refinement technique.

Review References:

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