Dear Reviewer,

We appreciate your careful evaluation of our manuscript, and particularly value your suggestions for improvements to the figures. We agree that this manuscript acts as a call to action – there is more work to be done, and we hope this data compilation motivates that work! Here, we *provide a response to each of your comments* and describe anticipated changes to the manuscript.

Comments

> Since the figures are essential for the conclusions derived, they should be improved by enlarging them and making the colour bars showing layering and fabric observations as well as scattering information wider. It might be reasonable to use the height of a page in landscape mode as height of a subpanel shown in figures 3 and 4.

We agree with your assessment that the figures are particularly important in this work, and both you and our other reviewer rightfully point out that we need to de-densify both figures 3 and 4. We intend to modify both figures significantly, with modifications described below.

Figure 3: Line scan data from figure 3 has been removed and pulled into a new figure. The Schmidt plots have been removed entirely. The depth axis of each radargram has been adjusted to be the 850 meters above bedrock and 50 meters below bedrock for each radargram. The width of the radargram has been doubled. The symbology of the thin and thick sections has been flipped such that the thin sections are represented by the thin crosses, and the thick sections are represented by thick crosses.

Figure 4: The figure has been rotated into landscape and split into two subfigures such that each radargram extends to cover the majority of the height of the page. The depth axis of each radargram has been adjusted to be 1000 m above bedrock and 100 m below bedrock. For cores where the ice thickness is less than 1000 m, the depth axis starts at the surface and extends to 1100 m.

> L 33: Amend "All radio-wave scattering originates from electrical contrasts." All radio-wave scattering originates from electrical contrasts in conductivity and permittivity

Content changed to: "All radio-wave scattering in ice originates from dielectric contrasts."

> L 53: Please provide reference for your statement „… with transitions in c-axis fabric leading to an (up to) 1% contrast in the polarization-dependent bulk permittivity."

Reviewer 1 also asked about this sentence. We have included a reference, but provide our response to reviewer 1 here for your evaluation as well:

Because the strength of the fabric controls the bulk permittivity, you can have (a) an isotropic crystal fabric with no dielectric contrasts induced by individual crystal anisotropy, (b) you can have a perfect vertical C-axis maximum that transitions to a perfect horizontal C-axis maximum which would induce a ~1.3% contrast in dielectric permittivity (the same difference that exists between the C-parallel and C-perpendicular axes for individual crystals), or you can have (c) any intermediate contrast between those end members. It is for that reason that we prefer the phrasing (up to) rather than "a" in this sentence, as the magnitude of the fabric induced contrast must fall between ~0% and ~1.3%. But we have

added a citation to Matsuoka et al., 1997, where the single crystal anisotropy value measurements were originally published.

L 54: reference of inset (i)?: …(as in the upper half of fig. 2.a, respectively marked example i), …

Added reference to figure 2.a.i.

L 68: "Incoherent scattering typically occurs at rough interfaces …" please define in physical units

Apparently coherent, specular horizons can turn into diffuse scatterers as the scale of dielectric heterogeneity (or interface roughness) approaches the frequency-dependent Rayleigh Roughness Criterion. And at some frequency limit, it is likely that all layering within ice sheets will appear diffuse. Center frequencies in this study range from 7.5 MHz to 325 MHz, with most data sourced from radar systems with center frequencies between 150 and 200 MHz. Assuming dielectric permittivity of 3.18, most rough interfaces are on the scale of 28 to 21 cm, but extend from 5.6 m to 13 cm. We have added some text to point the reader toward more literature on this subject, because we agree that quantifying what it means to be a diffuse scatterer is important to consider.

L 77/78: The statement „each pixel typically represents backscattered energy from only a single subsurface target." is only correct if the transmitted signal and the sample interval are short enough to resolve the layering. This is for airborne RES system usually not true.

You've highlighted an important distinction – by saying "a single target" we did not intend to focus on the scale of the dielectric heterogeneity generating the backscattered energy, but rather the range of angles from which backscattered energy is arriving. That targets have some adjacency as you move along a radar profile for specular layering but not for diffuse scatterers. We've modified that sentence to read: "…each pixel typically represents backscattered energy from only a single direction of arrival."

L 119 … „within the ~8 cm diameter ice cores." – doesn't make much difference, but isn't the diameter of m

You are right that the diameter of deep ice cores varies from site to site depending on the drill, so we expanded this to a range of ~8-13 cm, capturing all cores.

L137: (first occurrence): I suggest to replace NorthGRIP by NGRIP when referring to the ice core.

We appreciate this comment, and struggled with identifying convention in the literature for the NorthGRIP2 ice core. Because Dahl-Jensen, Svensson et al., 2005, Capron et al, 2010, and Johnsen et al., 2001 each refer to it as "NorthGRIP" our sense is that this is the convention for the literature. But if you can help us identify a clearer convention in the literature, we are open to changing this!

L 177: (first occurrence): When referring to the ice core drilled at Dome C use EDC, similar to EDML.

References to Dome C changed to EDC to be consistent with EDML.

L 331 Correct "… interfaces to not manifest …" Correct "… interfaces do not manifest …"

Content corrected.

L 492 Oatm atm should be subscript

Content changed to "O_{atm}".

L 493, 495: ky kyr

Content changed to "kyr".

References, L695-697 Wang et al 2023 not cited in main manuscript

Reference removed.

Reference list in the supplement is incomplete:
L55: reference Dansgaard 1982 is incomplete
L60: Eichler 2013: what kind of thesis; how published?

The Dansgaard reference is now complete. Eichler reference updated to include "Master's Thesis". DOI for Eichler 2013 is not available.

Fig. 2:
Captions for a-c should be below the figure
Sublabel should be before the respective text (same for other figures)
Labels of examples in 2a are difficult o read and boxes are too small
2c – it should be clearly stated that the two RES sections are not mapped on the same profile

We have updated the caption such that sublabels precede the text describing them, and to ensure there is a clear statement about the spatial relationship between profiles in 2c. Both profiles and their coordinates will be available in the supplemental information, so a reader can evaluate our own interpretation. We have also increased the box sizes in figure 2a and changed the labeling to make it easier to read.

Fig. 3:
The sub- panels of the figure should be larger
It seems to be counter-intuitive to use a bold "+" for thin section and a normal sized one for thick sections.
The depth exis should be of equal length for all panels

There were similar comments made by reviewer 1 – we have made significant changes to the figure to try and simplify and bring forward the key ideas (and make the interpretation by the reader simpler). Among other changes, we have changed the boldness applied to "+" symbols for thin and thick sections, and we have standardized the depth range across the figures, so they each show ice from 850 m above the bed to 50 m below.

> Fig. 4
> The sub- panels of the figure should be larger
> The depth axis should be of equal length for all panels

Similar to our modifications of Figure 3, we have expanded Figure 4 to make the radar data easier to interpret by the reader and standardized the depth axis.

> Fig. S2: label (c) is not readable in the figure
> the feature marked with (c), diffuse, banded scattering, looks very much like 2a i coherent scattering might not be a typical example; please choose a better one

This is an important observation, and we want to make sure we address it fully. It is the case that some of the bright reflectors within the glacial ice in Greenland (which can be seen in figure 2a) do behave qualitatively differently from the conductivity controlled layering that makes up the Holocene layering. For that reason, we've changed which layer we indicate for 2ai, which was uncritically selected in our original submission. We've improved the color-scale in figure S2 so that it conforms to the standard color ranges used elsewhere, which we hope makes clear why we interpret the layer we see in this image differently. But we also agree there is ambiguity in labeling this feature as an example of diffuse banded scattering and will adjust the text and caption accordingly.

> Fig S3: Even though it is stated that only examples of strong laterally heterogeneous incoherent scattering are indicated in the figure, the choice of marked features, respectively their distribution is odd.

You're right that the selective sampling of the arrows doesn't properly capture the full distribution of features visible in this figure. We've changed the language of the caption and the way we indicate the regions of heterogeneous incoherent scattering to try and more fully capture what we think is present in the data.

Thank you again for your thoughtful review, we believe the changes made in response to your comments have significantly improved the manuscript.

Ellen + Nick