

Thank you for your review. Your comments have been very helpful. My response is given below each of your italicized comments.

Specific comments:

p.1096 l.18 “Colder” possibly but not “coldest”?

We replaced “coldest” with “colder” as suggested.

p.1096 l.25 “transition” is only allowed as a verb in US English so will distract some readers – why not use “change”? And why specify “glacial” ice?

We replaced ‘transition’ with ‘change’, and removed ‘glacial’ as suggested.

p.1096 l.25 and p.2 l.13 An inanimate object can only take certain active verbs. For example, in English a thermometer can measure temperature or provide accurate measurements but it cannot assess temperature or prove hypotheses. These activities require conscious thought. In the same way, firn cannot create and ice layers cannot require.

As noted in the above comment, we removed the word ‘transition’ from p.1096 l.25. We added ‘the presence of’ to p.1097 l.13.

p.1097 l.3 “Melt rarely occurs in the dry snow regions... However, melt events do occur occasionally in the dry snow region”. Unnecessary repetition.

Fixed.

p.1097 l.6 melting events on?

We replaced the word “of” with “on” as suggested.

p.1097 l.9 why is “locally” here?

We used the word ‘locally’ to emphasize that the interconnected pore space was not interrupted throughout the entire firn layer. To limit any confusion we removed the word ‘locally’ and added the phrase ‘in that area’ to the end of the sentence.

p.1097 l.9 Not clear what the argument is here. In the context of gas transport the porosity is divided into the porosity available for transport and that which is inaccessible to the gas molecules or part of a dead end. At the lower boundary the transport porosity falls to zero. Above that boundary, variations in transport porosity are surely allowed in the models? Do you mean that it is normally assumed that porosity decreases monotonically with depth and low-porosity layers are not considered?

Yes, typically porosity decreases monotonically with depth and low-porosity layers are not included. We added ‘which decreases monotonically with depth’ to the sentence to make our initial intent clear.

p.1097 l.24 you can “address” a problem but not an ice layer

We added “the problem of” before “ice layers.”

p.1098 l.6 “qualitatively characterised” is rather awkward. What about “we recorded stratigraphy and grain size....”?

Good suggestion. We replaced “documented” with “recorded”, and also removed “qualitatively characterized the” as suggested.

p.1098 l.8 This would be the right place to define the instrumental error in density. I am not convinced that this is of order 0.0005 g cm^{-3} as implied by the densities quoted to 3 decimal places later on.

We added the instrumental error of calculating density (0.06 g cm^{-3}) here.

p.1098 l.15 If you need to define permeability then you also need to define diffusivity
We added the definition of diffusivity, as well as an empirically determined relationship between permeability and diffusivity to this section.

p.1098 l.24 “height” here is confusing . Maybe define dP/dz as the pressure gradient across the sample and then define ΔP as the pressure drop and Δz as the length of the core section?

Good suggestion. We added the sentence “Therefore, dP/dz is the pressure gradient across the sample, where dP is the pressure drop and dz is the length of the core section,” and replaced “pressure drop over the height” with “ dP/dz .”

p.1099 l.1 “custom permeameter previously developed”. By giving the reference you are telling the reader that this instrument was developed before your work. If it was developed especially for measuring snow then “snow permeameter” would do surely?
Please see our response to Reviewer #2 to address this issue. We used the suggested “custom-developed” instead of “snow,” because the instrument can measure the permeability of many porous media.

p.1099 l. 4 “fell outside of the linear flow range” ... not clear what this means.

We modified the sentence to ‘Measurements that were outside of the linear flow range, and therefore violate Darcy’s law, were not used.’ for clarity.

p.1099 l.6 What was replicated? Do you mean measurements of the permeability of the same sample at the same flow rate differ by 3%?

Yes, the permeability measurements were replicated on the same sample. We added “permeability” before measurements to be clearer.

p.1099 l.8 at a given firn depth?

Yes, that is a much clearer phrase. We replaced “of a firn depth” with “at a given firn depth.”

p.1099 l.12 I “micro-CT” is defined as the abbreviation for micro-computed tomography. Therefore use “Skyscan micro-CT scanner” or similar rather than just “Skyscan micro-CT” for the instrument.

We added the word “scanner” to the sentence, as the reviewer suggested.

p.1099 l.20 It is difficult to envisage “multiple horizons in 1-2 cm” that are different from

“layers millimetres in thickness” Obviously the difference is not a matter of thickness so what is it?

We added the phrase “are comprised of ice without grain boundaries,” to further illustrate how the ice layers are different than wind crusts.

p.1099 l.23 of the order of?

We replaced “that are on the order of millimeters in thickness” with “that are approximately 1 mm in thickness” to be clearer.

p.1100 l.3 sufficient melting to cause?

We replaced the word “sufficient” with “ample” to convey better the original meaning of the sentence.

p.1100 l.9 Only these things?

As far as we are aware, these are the major factors. If the reviewer has some specific suggestions, we will be happy to include them.

p.1100 l.10 by chemical analysis?

Reviewer #2 also commented on this issue. See our response to Reviewer #2 above.

p.1100 l.18 Why do you assume the core samples from 23.5 to 28.5 m are selected from a population in which density varies randomly? Does density not increase with depth? It looks like it from Fig.2.

We are not quite sure what the reviewer is suggesting here. In Figure 2, we are trying to show that the sample containing Ice Layer 1 is more dense than the surrounding firn samples and that the sample containing Ice Layer 2 is not more dense than the surrounding firn. To show this mathematically, we averaged the densities of the surrounding firn samples for each ice layer and compared to the density of the ice layer samples.

p.1101 l.1 You mean the permeameter cannot measure permeabilities less than $0.1 \times 10^{-10} \text{ m}^2$ - but why is this relevant? What we need to know is the instrumental error in the measurements. The standard deviation is not helpful since there is reason to suppose that the permeability decreases with depth like the density.

We moved the discussion of the detection limit of the permeameter to the methods section. We also included the instrumental error in this section.

p.1101 l.13 permeability.... is OR permeabilities ... are

We changed the wording to “permeabilities... are.”