

Interactive comment on “The impact of ice layers on gas transport through firn” by K. Keegan et al.

Anonymous Referee #4

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This paper contains some interesting data on the variation of density and permeability in parts of an ice core from the NEEM site in Greenland. In particular, the authors show that the permeability of an icy layer near the surface (at 27.3 m) is not markedly less than the permeability of some other segments between 23.5 and 28.5 m although it is less than that of the nearby firn. Another icy layer at 44.3 m has a permeability well within the range shown by nearby firn. The conclusion is that the effect of the icy layers on the diffusion of gases through the snow will not be particularly important.

The microstructure of the icy layers has been examined by X-ray micro-computed tomography. In one layer the percentage of air trapped when the ice layer froze was 6% of the overall porosity, in the other, less than 1%. This is not large enough to produce a significant bias in the firn air record. Both these results are welcome. The paper would benefit from thorough revision with particular attention to the language.

C213

Specific comments:

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

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?

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.

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.

p.1097 l.6 melting events on?

p.1097 l.9 why is “locally” here?

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?

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

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

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.

C214

- p.1098 I.15 If you need to define permeability then you also need to define diffusivity
- p.1098 I.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?
- p.1099 I.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?
- p.1099 I. 4 "fell outside of the linear flow range" ... not clear what this means.
- p.1099 I.6 What was replicated? Do you mean measurements of the permeability of the same sample at the same flow rate differ by 3%?
- p.1099 I.8 at a given firn depth?
- p.1099 I.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.
- p.1099 I.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?
- p.1099 I.23 of the order of?
- p.1100 I.3 sufficient melting to cause?
- p.1100 I.9 Only these things?
- p.1100 I.10 by chemical analysis?
- p.1100 I.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.

C215

- p.1101 I.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.
- p.1101 I.13 permeability... is OR permeabilities ... are

Interactive comment on The Cryosphere Discuss., 8, 1095, 2014.

C216