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Interactive comment on "Impact of physical properties and accumulation rate on pore close-off in layered firn" *by* S. A. Gregory et al.

Anonymous Referee #1

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This manuscript describes measurements of the physical properties of firn samples from two Antarctic sites with very different local temperatures and accumulation rates. Micro computed tomography was combined with measurements of bulk density and permeability. The analysis is concentrated on the lock-in zone of firn with the aim to better understand the role of firn microstructure on the pore close-off process. Results indicate that the grain size and the accumulation rate are more important factors for the lock in and pore close-off depths than the firn density. I have read this article with interest and consider it a valuable addition to the current understanding of the close off process of deep firn, which is of great importance in determining the gas age / ice age difference.

The article has a clear structure and is well written. The quality and readability of

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the figures, however, can be improved in my opinion. The axis labels and legends of Figures 1 and 5 are especially hard to read and the y-scales in Figure 6 seem to be too compressed.

Specific comments

P 2534, line 26 "bubbles of an ice core" should be "bubbles in the ice"

P 2535, line 16 "layers of firn impede" should be "layer of firn impedes"

P 2537, line 24 I think the words "to verify" or something similar are missing here: "and to verify the validity of"

P 2538, lines 14-15 The error mentioned here only refers to the precision (standard deviation), but not to the accuracy.

P 2540, lines 19-24 I am not familiar with the SMI and could not access the publication by Hildebrand et al. (1997), but I am a bit puzzled by this definition. According to this equation the SMI has units of meters, which means it is not an index but a length scale. Elsewhere, I found the following definition of the SMI:

$$SMI = 6\frac{\frac{dS}{dr}V}{S^2} \qquad (1)$$

which is a dimensionless quantity. I suspect that the quantities in equation (2) in the manuscript are measured in voxels rather than in m^2 or m^3 and that S' is not the artificially increased surface area but the difference between the increased surface area and the original area. With dr equal to 1 this matches with the definition above. Could the authors clarify this?

P 2543, line 26 "the same" should be "similar"

P 2543, lines 26-28 Fig. 4a shows a trend in SMI from values around 2 at 56 m depth to values around 2.7 at 75 m depth. With SMI values of 3 corresponding to cylindrical shape and 4 to spherical shape (P 2540, line18) the statement: "The pore structure

is primarily cylindrical at 55 m with increasing SMI, evolving to spheres towards the firn-ice transition." seems to be incorrect. A similar statement is found at P 2544, line 7.

P 2545, line 1 I don't see how from Fig. 5 it is "visually evident" that the less tortuous matrix causes the firn to be more permeable.

P 2546, line 12 "At depth" is a very unspecific term. Maybe rephrase this to something like: "Just above and in the LIZ"

P 2548, lines 14-17 and lines 22-24 The authors repeat themselves here with two very similar statements.

P 2550, lines 4-6 The comparison between measured porosities and permeability's with the predicted power law relation is not very clear from figure 10 (especially for the Megadunes data). It might be more illustrative to plot k as a function of $n_{op}^{3.4}$ and verify a linear relationship between these. This could be instead of the current figure 10b. Alternatively, one could make a fit to the measured data assuming a relation of the type $k = an_{op}^{b}$ and compare the values of the parameters to those of Freitag et al. (2002).
I would also strongly encourage the authors to plot error bars in these and other scatter plots.

P 2550, line 9 "200-700 %" should be "200-1900 %". Or is there a reason for excluding this point?

P 2551, lines 18-19. Could you quantify "high" and "low" accumulation sites?

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