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

The manuscript reports some interesting data relating to the structure (revealed by density and micro-CT) and air permeability of two composite ice layers sampled from a firn core co-located with the NEEM deep ice borehole, Greenland. The results indicate variable influence over permeability with only one layer decreasing permeability significantly. Even this, however, due to the scale of sampling, is calculated not to influence unduly the reconstructed age of the ice layers concerned. The paper is, on the whole, well constructed and presented. However, I do have several suggestions for improvements, both general and specific.

One general point is that these 'ice layers' appear to be composite features composed of several individual ice lenses separated by firn or icy firn. It might well be worth considering this more explicitly in the analysis – particularly since much of the internal detail of the layers is known. Could both the density and the bulk permeability values not be better derived and interpreted respectively in terms of a mixing model of ice (with a density of _850 and low permeability) and local host material (with a lower density and higher permeability)? That way the issue of explaining the different ratio of ice layer to local material at the two different depths would be formalised. Indeed, the densities could be used to determine the proportions of ice and host material present and those could be used as a basis to interpret the bulk permeability results. I suppose one of the key issues here would be the resolution of (i) the layer characterization possible from the micro CT scans and (ii) the density and permeater sample sizes relative to the individual material layers involved. Including such an analysis would enhance the paper because the results would then not solely relate to two layers at NEEM – as at present - but would have the basis of something that would be valid for all such ice layers. Some other comments are listed below, given by page and line.
This is a great idea. The density of these layers could certainly be measured at a finer scale, but unfortunately we do not have the capabilities of measuring the permeability of the individual ice lenses, because the permeameter can only measure samples with a vertical thickness of 5-12 cm. Below 5 cm, which is what would be needed to measure the permeability of the ice lenses or icy firn layers, edge effects will bias the permeability values. This would be an interesting project for the future.

Page Line Comment
1095 Title The actual subject matter of the paper is far narrower than this – indeed, the conclusions formed in the paper only apply to two icy layers in this location of the GrIS. I think that the title at least needs to acknowledge location.
We added "at NEEM, Greenland" to the title, to reflect the location of the study.

Also, are we not strictly talking about 'air' transport here and not 'gas' transport? The tests were carried out with air no?
Yes, the permeability tests were carried out with air, but it is common to refer to firn-air as 'gas'.

1096
4 Suggest insert 'reconstructed' before 'climate records'
Fixed.

Abstract The Abstract includes several references to imprecise and undefined adjectives including 'somewhat', 'likely', significantly'. I recommend replacing these with summary data wherever possible (certainly possible for key permeability values) and to quantify wherever possible. I would also restrict reference to significance to its statistical meaning, allied to its associated probability.
We removed the imprecise adjectives, and added the permeability values to the abstract.

15 I agree with this – but it is not clear where this fairly major interpretation comes from in the paper itself. I may well have missed it, but what is the argument linking the CT observation with the inference that larger melting events could 'significantly' (Ed: I'd cut that) bias ice core records. Indeed, there is not much of a statement here since (i) it is known that ice has a lower permeability than firn and therefore a thick ice layer will have more of an influence over gas transport than will a thin layer, and (ii) the whole statement is qualified by 'could' – which implies it also 'could not'. I think this last sentence needs some sorting out in detail. In fact, I think much of the Abstract does.
Yes, we're referring to the CT observations when stating that larger melting events could bias ice core records. We added another results and discussion section (section 3.4), as suggested by Reviewer #3, to discuss how the ice layer will affect ice core records, which bolsters this statement. Also, we changed the word 'could' with 'will'.

23-25 I am not an expert but I would have thought that some old gas is advected downwards with its original host snow and so what is occluded into new ice is typically a mix of decades-old and years-old gas. In contrast, this statement implies to me that newly-formed ice only includes gas from the year-old atmosphere.
You are correct. Firn air does not have a single age, and is a mixture of air with different ages (on average a spread of ~10 years). We added a sentence and referenced the work by Schwander et al. (1993) to acknowledge this age distribution.

Reference:
Schwander, J., Barnola, J. M., Andrie, C., Leuenberger, M., Ludin, A., Raynaud, D., and Stauffer, B.: The age of the air in the firn and the ice at Summit, Greenland, J. Geophys. Res., 98, 2831-2838, 1993.

1098
15 'a porous medium's'
Fixed.

18 In general Darcy's law relates to fluid permeability but the definition here refers to 'the flow rate of air'. I'd replace this with 'fluid flow rate' or make it clear in Line 15 that the statement relates to air.
We replaced 'the flow rate of air' with 'fluid flow rate' as suggested to be clearer.

1099
1 How about 'a custom-developed permeameter' or even 'bespoke'?
We replaced 'custom permeameter previously developed' with 'custom-developed permeameter' to be more succinct.

7-9 How about 'It was found that the permeability measured for different samples at a given depth varied by up to 10% due to layeral spatial heterogeneity within the cross section of the core recovered'. Is this what you mean by 'of a firn depth' (i.e., did you really measure multiple samples from the same depth?
Yes, Albert and others (2000) measured permeability of multiple samples from the same depth and compared the permeabilities measured. We modified the sentence as suggested.

20 Redundant reference to 'depth'.
Fixed.

1100
3 I'd replace 'which caused' with 'to cause'.
Fixed.

4 I'd replace 'it has been' with 'it was'.
Fixed.

8 The depth of the refrozen ice will also depend on the permeability of the host snow/firn no?
We added 'the permeability of the firn' to p.1100 l.8.

10 Can the manuscript be more specific than 'depth-age scale determined through chemistry'? Which chemical properties were measured here? How about ': : :reconstructed on the basis of seasonal variations in: : :'?
We included the specific chemistry used to find the depth-age scale and added the reference to Sigl et al., 2013.

Reference:
Sigl, M., McConnell, J. R., Layman, L., Maselli, O., McGwire, K., Pasteris, D., Dahl-Jensen, D., Steffensen, J. P., Vinther, B., Edwards, R., Mulvaney, R., Kipfstuhl, S.: A new bipolar ice core record of volcanism from WAIS Divide and NEEM and implications for climate forcing of the last 2000 years, J. Geophs. Res. Atmos., 118, 1151-1169, 2013.

19, 27 etc I recommend replacing 'average' with 'mean'.
Fixed.

25 Different 'from' The text following ': : :because: : :' is interpretation and should come later.

We are not entirely sure what changes the reviewer is suggesting here. It seems like the reviewer might be asking for an independent results and discussions sections, but we chose to combine them for ease in interpretation.

1101
5 I think this line can be deleted (and the previous few lines could be rewritten more clearly, I think by reference to measurement resolution).
We removed this sentence from this section of the manuscript, and added it into the discussion of the methods for permeability.

9-11 Interpretation.
See our response to the comment for p.1100 l.25 above.

14 Is the reference to 'seasonal snow' as opposed to 'snow' important here? If yes, then an explanation would help; if no, then I'd delete 'seasonal'.
We removed the sentence comparing to ice layers in seasonal snow for better flow of the discussion, and to remove any confusion.

16-26 I don't really follow the statement: 'If the ice layer extends laterally for great distances, such a permeable ice layer would not cause a disruption in the gas concentration profile under steady-state conditions at this depth. : : : In contrast, the permeability of ice layer 2 at 44 m depth is very similar in magnitude to the permeability of the surrounding firn, and thus would likely not cause a disruption in either steady state or time-varying concentration profiles'. I find this paragraph to be confusing, certainly in terms of my understanding of the arguments being used. It also contains too many imprecise adjectives (how far is a 'great distance' and how similar is 'very similar'?) and conditional terms ('may be expected to cause' etc.). For example, the sentence above "In contrast, the permeability of ice layer 2 at 44 m depth is very similar in magnitude to the permeability of the surrounding firn, and thus would likely not cause a disruption in either steady state or time-varying concentration profiles' could just as easily (in the absence of formal analysis or quantification) be written 'Similarly, the permeability of ice layer 2 at 44 m depth is different from that of the surrounding firn, and thus would likely also cause a disruption in either steady state or time-varying concentration profiles'. Indeed, it is materially different and therefore surely must cause some variation in permeability – the issue is how much (i.e., quantification is needed) and how that quantity influences the process outcome you are interested in (requiring further quantification or at least a formal interpretative argument). Since this is such a key section of the paper, I strongly advise it is rewritten clearly and precisely, supported with data and formal analysis and argument.
We removed imprecise adjectives, and reworked this paragraph. We also added more discussion surrounding this impact on firn-air profiles into section 3.4. However, we think a separate modeling study would be needed to precisely quantify the damping effect ice layers would have on specific gas species with time-varying concentration profiles. This would be a great project for the future.

1102

1-2 This is a repeat of Methods
We removed this sentence, to not be repetitive.

12 The reference to 'much older' is meaningless, to the uninitiated at least. Can this age not be approximated quantitatively from accumulation rates, density, and annual layering, all of which the manuscript has?
Yes. General suggestions from Reviewer #3 helped to shed light on how much older then air occluded in the ice layer bubbles would be. Please see our comments regarding this issue below.

18 (& 21) I find the reference to ': : : bubbles, which caused 0.2% of the porosity to be closed on average' a bit confusing because porosity already has units of %. Then we have the issue of 'closed porosity' as opposed to 'open porosity' – which can also be expressed as a fraction or %. I think this could usefully be clarified – perhaps extending the argument a little too so no steps are missed.
We added a sentence to the discussion here to explain what porosity we are talking about. Also, we added a few sentences to a new discussion section (3.4) comparing these porosities to those of mature firn layers, as suggested by Reviewer #3.

20 - 28 Some care is needed in referencing the delta values (which are ratios); e.g., I don't think there can be an 'enrichment of delta 15-N'. I believe this should be an 'enrichment of 15-N' or an 'increase in delta 15-N'. Same for 'the delta 15-N content'.
We corrected these references to the delta 15-N values.

1103
2 Why not help the reader by inserting 'with a closed porosity of _8% (above)' after 'Therefore, '?
We added "with a closed porosity of >8%" as suggested.

9 I think (if I understand the argument) it might be helpful to insert 'reconstructed' before 'ice core records' here.
Fixed.

6-11 Can this be clarified further that the argument here relates to an effect reference to measurement resolution rather than a real physical effect? If this is the case (which I think it is) then it could also be usefully spelled out in the Abstract.
We are not quite sure what the reviewer is suggesting here. We think that this might be a similar suggestion to Reviewer #1's comment for p. 1103, l. 7-11. Please see our response to that comment above.

11-25 Numerous references to 'significant(ly)' here that are not strictly true – whereas they are elsewhere in the paper. I'd consider wording carefully here and reserve 'significant' for its statistical sense.
We removed all uses of the word 'significant' for this reason.

1104-5

References Citations of in review papers should be updated or replaced or removed.
We have removed the references to papers still under review, and corrected those that have been published.

1106
Table 1 Can layer thickness be added as a column?
Yes, we added a layer thickness column to Table 1.

I'd label the third column 'Bubble concentration (%)' (% is not the unit of volume).
Fixed.

1108
Fig 2 Nice data. I assume each point marked on these plots is a composite of several individual samples. If so, then each ice layer was only one sample? If not, as I assume, then could some indicator of error or range be given as whiskers for each point on the plots?
We added error bars to the data points, indicating one standard deviation and adjusted the figure caption accordingly.

Incidentally, I don't think Times works well as a font for Figures. (Fig 3 too)
We changed the font to Arial for all figures.

1110
Fig 4 Nice data again. However, these are smaller than the ice layers referred to in the text and marked on the previous figures. Maybe they should therefore be referred to in the caption as 'sub-samples' or 'illustrative examples of : : :'.
We added 'of sub-samples' to the figure caption for Figure 4 to clarify this issue.