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Climate of the Past Discussions

Interactive comment on "Glacial-interglacial dynamics of Antarctic firn columns: comparison between simulations and ice core air-δ^{15}N measurements" *by* E. Capron et al.

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Comments to specific items of text are referened as Pxxx Lyyy for Page xxx Line yyy

1 General Comments

Capron et al. present a detailed study on the evolution of Antarctic firn columns over the last deglaciation, focusing on air-ice age differences using measured and simulated δ15N profiles. The paper analyses and discusses several previously published hypoth-

esis on causes of the mis-match between measured and simulated glacial-interglacial δ15N. The paper is well written and structured and generally presents sufficient supporting evidence. I recommend minor alterations and corrections detailed below.

2 Specific Comments

I don't think you present enough evidence to support the last paragraph of the abstract, namely that firn densification dynamics may be driven mostly by accumulation rate changes. Specifically, you have shown for the TALDICE core that the measured δ15N is intermediate between simulations that allow only for the influence of surface temperature or accumulation rate. Furthermore, Figure 8 clearly shows the dependence of simulated δ15N on both surface temperature and accumulation rate. Therefore, clearly surface temperature is also very significant. I think the first sentence of last paragraph of the abstract needs to be altered to something more like "We conclude that accumulation rate changes may play a more significant role on firn densification dynamics during deglaciation than current firn models simulate"

Introduction: It could be made clearer (possibly just after P6055 L5) that there are two competing mechanisms influencing the fractionation of Nitrogen (in the absence of rapid temperature changes) represented by the barometric equation. 1) The firn temperature directly impacts fractionation and 2) any factor that changes the diffusive column height, which will include factors such as firn temperature (again), accumulation rate, initial snow density and firn permeability.

P6056 L25-29 These two sentences need expanding. In particular, need to justify the statement that firn models still should predict LID correctly even though they don't simulate permeability. In addition need to clarify what is meant by the statement "only δ15N should be affected" affected by what, the model shortcomings discussed in the previous sentence, or the changes in permeability discussed two sentences ago.

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P6059 L19-24 Suggest adding some text to explain that porosity is not directly modelled, but calculated from the modelled firn density, so that the selection of a closed porosity corresponds directly to the selection of a firn density for bubble close off.

P6061 Equation 4. This equation appears to be incorrect, and "ΔD" should be "$\Delta\delta$D"

Give units for both α and β, throughout the manuscript including Table 2.

There is a lack of consistency in the units used for accumulation. Throughout the text "ice eq.yr^{-1}" has been used yet Figures 1 and 8 use "we.yr^{-1}" which is presumably "water equivalent per year".

P6064 L14-17 The statement concerning the sensitivity of BI scenario A to variations in accumulation or temperature needs clarifying. In particular, scenario A is not more sensitive than scenario B to both temperature and accumulation variations. In fact compared to scenario B, scenario A will produce stronger response in δ15N for a given temperature variation but a weaker response due to accumulation variations.

My preference when giving multiple citations is to list them in chronological order. Suggest changing the ordering of citations to reflect this, for example P6064 L23-24 would change the order to Kawamura, 2000; Caillon et al., 2001; Dreyfus et al., 2010).

To help lead the readers through Section 5, suggest changing P6067 L1 from "First, Hypothesis C" to "First, in Sect. 5.1, Hypothesis C".

Should make it clear throughout the manuscript when you are given numerical values for Δdepth if this is ice equivalent metres or actual metres (will obviously be the same for deep layers).

There is no real evidence to support the statement on P6070 "The deglacial increase in Antarctic accumulation rates is underestimated, especially at the end of the deglaciation" The "arguments supporting this view below" are

- That β may vary considerably over time at a given site

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- Good agreement between layer thickness bases accumulation estimates and thermodynamically based accumulation estimates at EDML
- Accumulation variations uncorrelated with water isotope changes at EDC

Together these do not provide sufficient support for above statement.

3 Technical corrections

P6053 L17 change “large convective zone as the explanation” to “large convective zone within the firn as the explanation”

P6053 L20 change “snow” to “ice”

P6053 L21 delete the word “only”

P6054 L6 delete “i.e.”

P6054 L8 change “leads to trapped air at” to “leads to air becoming trapped at”

P6055 L1 change “Colum” to “Column”

P6055 L20 more usual to list ranges from smallest to largest, so suggest changing “152 to 2.4” to “2.4 to 152”

P6057 L8 change “one or other approach” to “various approaches”

P6058 L13 move “recently drilled” to before “BI”

P6058 L19 replace “m/z” with appropriate words. Both “m” and “z” have already been used in equation 1 with a different meaning to that used in this sentence.

P6059 L2 change “see Table 1” to “see Table 1 and Section 3.2”

P6059 L18-19 move this sentence to the start of P6059 L13.

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P6062 L24 “scenarii” should be “scenarios” which is the correct plural of scenario which has been used elsewhere throughout this manuscript.

P6062 L26 change “large” to “larger”

P6062 L26 change “that can” to “than can”

P6065 L6 “smaller” should be “larger”

P6066 L23 change “fine” to “appropriate”

P6067 L2 change “and the changes” to “and changes”

P6067 L2 change “from EDML” to “from the EDML”

P6067 L4 delete the second “changes”

P6068 L6 delete “e.g.”

P6069 L10 change “on the upper end of the” to “larger than the”

P6069 L22 change “thinning factor in the ice flow model” to “thinning factor from an ice flow model”

P6069 L23 change “mean firn density” to “column averaged firn density”

P6069 L23-24 change “unthinned ice thickness to firn equivalent thickness” to “firn thickness to an ice equivalent thickness” as Δdepth is in ice equivalent metres.

P6070 L4 change “empirical Δdepth estimates” to “Δdepth estimates from gas CH_4 and ice ^{10}Be matching”

P6070 L9 change “also” to “similarly”

P6071 L19-L20 change “Further exploring” to “Furthermore,”

P6072 L16 change “disfavours” to “undermines”

P6074 L2 “atm” should be subscript

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Inconsistent inclusion/exclusion on doi's in references

P6075 L 3 missing doi "doi:10.1038/372663a0"

P6075 L8 missing doi "doi:10.1038/nature03975"

P6075 L11 missing doi "doi:10.1038/29447"

P6075 L14 missing doi "doi:10.1016/S0012-821X(03)00672-1"

P6075 L17 "ALDICE-1" should be "TALDICE -1", missing journal "Climate of the Past", missing doi "doi:10.5194/cp-7-1-2011"

P6075 L20 missing doi "doi:10.1126/science.1078758"

P6075 L24 missing doi "doi:10.1016/j.quascirev.2009.07.014"

P6075 L32 missing doi "doi:10.1038/nature02599"

P6076 L2 missing doi "doi:10.1038/nature05301"

P6076 L4 missing doi "doi:10.1126/science.283.5408.1712"

P6076 L11 missing doi "doi:10.1016/j.epsl.2007.06.014"

P6076 L19 missing doi "doi:10.1016/j.epsl.2006.01.002"

P6076 L26 missing doi "doi:10.1002/jqs.622"

P6076 L29 missing doi "doi:10.1029/2002JD002677"

P6077 L2 missing doi "doi:10.1126/science.1141038"

P6077 L4 this is actually a PhD Thesis from Tohoku University

P6077 L7 missing doi "doi:10.1016/j.epsl.2006.02.017"

P6077 L23 missing doi "doi:10.1016/j.quascirev.2005.06.007"

P6077 L25-26 the article title is actually "What drives the millennial and orbital varia-

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tions of δ18Oatm?". Missing doi "doi:10.1016/j.quascirev.2009.07.005"

P6078 L9 missing doi "doi:10.1038/nature06950"

P6078 L12 missing doi "doi:10.1038/nature06949"

P6078 L14 spelling "terminaison" should be "termination"

P6078 L15 missing doi "doi:10.1126/science.291.5501.112"

P6078 L20 missing doi "doi:10.1038/nature02805"

P6079 L16 missing doi "doi:10.1016/j.quascirev.2009.03.011"

P6079 L17-19 I think this reference is wrong. I believe the correct reference is "Schwander, J., Sowers, Y. Barnola, J.-M. Blunier, T., Fuchs, A. And Malzizé, B., Age scale of the air in the summit ice: Implications for glacial-interglacial temperature change, Journal of Geophysical Research, 102 (D16) 19483-19493, doi:10.1029/97JD01309 ,1997"

P6079 L32 missing doi "doi:10.1126/science.1169473"

P6080 L12 missing journal name "Journal of Geophysical Research" and doi "doi:10.1029/JD094iD04p05137"

P6080 L15 missing doi "doi:10.1029/92JD01297"

P6080 L27 missing doi "doi:10.1038/ngeo1026"

P6080 L31 think the year is wrong should be 2006. Also missing doi "10.1016/j.quascirev.2006.08.003"

P6081 Table 1 change "NaN" to "N/A" ie not applicable rather than not a number

P6083 Figure 1 caption, change "conducted during" to "obtained for"