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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Controls on the movement and composition of firn air at the West Antarctic Ice Sheet Divide" *by* M. O. Battle et al.

Anonymous Referee #2

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This paper describes and quantifies firn processes at the WAIS-D site using firn measurements of multiple species and their isotopes. It generally confirms previous understanding of the processes, which is a useful contribution, as well as adding new results showing oxygen isotope fractionation in the lock-in zone along with attempts to understand it. The discussion of lock-in zone effects, which are not well understood yet, is a worthwhile contribution building on previous work. This paper will be suitable for publication in the special firn issue of ACP after attention to the following points:

Major comments:

p18641, sec 6.2: The authors have given very little information about how they model diffusion. How did they specify and calibrate diffusivity for WAIS-D? Near the end of the paper they mention other studies at WAIS-D for which the diffusivity profile was

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determined and used in the models, but it would be worthwhile pointing to these much earlier (such as in the introduction), then in Sec 6.2 giving a couple of sentences of information on how they determined diffusivity and perhaps even showing the diffusivity profile(s) they used.

Sec 7 (and 6.2): The authors compare models with and without advection, but it is not clear that this comparison is valid (not enough detail of what model(s) were used is given). Are the models the same when both run without advection? If the models were both tuned to observations, one with and one without advection, the diffusivity will compensate to some extent for the lack of advection in the model without advection. The best way to show how much effect advection has would be to run the model with advection as normal then the same model with advection set to zero (changing nothing else). In this case, as well as looking at the CO2 and HFC-134a, the authors could look at modelled d15N that clearly shows the effect of advection at high accumulation sites and is not so dependent on the diffusivity profile. (I note that the observed slope of d15N discussed in sec 6.2 is greater than the theoretical slope whereas advection would work to reduce it.) Then if the difference between the same model run with and without advection is significant, it should be included in the model and a model that doesn't include advection shouldn't be used.

Minor comments:

p18638, line 11: The authors could also mention DSSW20K on Law Dome as having a similar accumulation rate as WAIS-D, particularly because they compare the spectral widths for WAID-D and DSSW20K later (p18652, line 11).

p18639, line 16: specify equal mass layers of what? I presume ice, but be specific as some firn models use amount of air.

p18640-41: It could be helpful to plot the different approaches to estimating the thickness of the convective zone on a figure, probably with a new figure because adding it to Fig 2 would probably make it too conjested. In particular this would allow the reader to

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visually compare the slope of the measurements with the theoretical barometric slope in sec 6.2. This is a suggestion only.

p18651, line 18: I think 'in' should be 'from'. It changes the meaning greatly.

p18651, line 27: please specify somewhere in the paper whether the model(s) include the expulsion of air

End of Sec 12: Do other gases provide a constraint on the amount of bubble formation above the lock-in zone? Could the authors calculate the CO2 concentration, as well as mean age and age distribution, for the different trapping assumptions tested for d15N. Do you have CO2 (or other species) measured in both the firn and ice at similar depths that might comtain information on this? Or can you show with the model that d15N would be more sensitive to early trapping than these tracers? Then is the statement on line 17 of p18655 true for all gases?

Typos:

p18635, line 25: research

p18643, line 11: 'were' should be 'where'

p18644, line 11: dependend

p18646, line 5: with with

p18648, line 10: do you need a permil symbol at the end of the line?

p18651, line 26: surrounding

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 18633, 2011.