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Atmospheric Chemistry and Physics Discussions

Interactive comment on "How well do different tracers constrain the firn diffusivity profile?" *by* C. M. Trudinger et al.

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We thank Jeff for providing helpful suggestions and comments.

Specific Remarks

Page 17779, line 24: We look only for solutions with monotonically decreasing diffusivity with depth. The reviewer asks how realistic this assumption is. A major departure from this assumption is the case of a melt layer creating a local minimum in diffusivity, as the reviewer mentions. We treat melt layers as a special case, as described in section 1.9 of the Supplementary Material, and now mentioned in the main text. More generally there may be many smaller variations throughout the whole firn that lead to effective diffusivity not being monotonic, such as due to seasonal and interannual vari-

ations in density. However, our model currently assumes that the ice properties are constant with time (i.e. stationary relative to the surface and not moving with the ice). Any local variations in diffusivity would be expected to move with the ice, like a melt layer does, and might be expect to alter mixing in different and not-yet-understood ways at different depths (for example, Hörlond et al (2012) discusses the complex variability of density through the firn column, and that high density layers at the firn-ice transition do not originate from high density layers at the surface). In theory, modelling variations in the ice properties is well suited to our moving coordinate system, however the problem is that we don't believe that there is sufficient information to constrain such a complicated time-varying diffusivity profile. We therefore try to capture the mean characteristics of tracer transport within the ice sheet with our one-dimensional model and time-invariant ice properties that vary monotonically with depth, with the special case of a melt layer being our only deviation from this. See also our response to Reviewer 1 comment 5 for computational reasons for the monotonic assumption.

We use monotonic open porosity versus density, and monotonic density versus depth, to ensure that if diffusivity is monotonic with open porosity will also be monotonic with depth. This is now made explicit in the text.

The diffusivity-porosity relation is tuned separately for each site. We have removed the part of the sentence that referred to different sites and probably caused this confusion.

The response to the first comment is also relevant to the reviewer's comment on plate-like vs spherical grains. In the present study, we have not allowed time variations in the ice properties that would be required to model this type of variability. This could be considered in future studies, if there is enough information to specify such variations.

As recommended by the reviewer, we now provide a much more thorough description of effective diffusivity.

Minor South Pole temperature - done

ACPD

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References: Hörhold, M.W., Laepple, T., Freitag, J., Bigler, M., Fischer, H., and Kipfstuhl, S.: On the impact of impurities on the densification of polar firn, Earth Planet. Sci. Lett., 325, 93–99, 2012.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 17773, 2012.

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Interactive Comment