

## ***Interactive comment on “Model calculations of the age of firn air across the Antarctic continent” by K. A. Kaspers et al.***

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### General comments

This paper describes the development of parameterisations for pore close-off depth (PCOD) and the age of CO<sub>2</sub> in firn air at the PCOD in terms of meteorological conditions. The authors use relationships between the physical properties of polar firn and meteorological conditions, and a firn diffusion model, to develop these parameterisations, which they then apply to the whole Antarctic continent. Their motivation for creating the parameterisations is to allow them to be used in the field to predict the pore close-off depth and corresponding age of CO<sub>2</sub>, from knowledge of the meteorological conditions, without having to tune a firn diffusion model.

This idea of parameterising the PCOD and CO<sub>2</sub> age in terms of the meteorology is an

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interesting one, but I would like some indication of how widely applicable the equations are, and how reliable they are for other sites, to know whether they really are useful in the field.

In the study, the oldest CO<sub>2</sub> is found for conditions of deep PCOD, low temperature and relatively high atmospheric pressure and accumulation rate. It would be useful if, in addition to predicting the age of CO<sub>2</sub> at the PCOD, the authors could also predict some measure of the width of the age distribution at PCOD. The age spread can be specified as the spectral width of the age distribution (defined in Trudinger et al., 2002) or the full width at half height (e.g. Saltzman et al., 2003). This would make the study much more useful for researchers in the field. It is good to be able to obtain very old air, but knowing where to go to obtain old air with the smallest age spread would be even more useful.

Specific comments:

It seems that observed values of the meteorological variables were used for the density and tortuosity parameterisations, but modelled values for the PCOD and CO<sub>2</sub> age parameterisations. Could observed meteorology have been used for both cases to develop the parameterisations, then the modelled meteorology used to extrapolate to the entire continent? This seems to me like the better approach, but maybe there are reasons not to do this, or I have misunderstood what was done.

If the authors suggest that these parameterisations can be used in the field, they need to give a good indication of where and how they are applicable. Are the equations applicable at any site in Antarctica for which the meteorological conditions are known? Can researchers expect the parameterisations to give a reasonable approximation for the PCOD and CO<sub>2</sub> age anywhere in Antarctica? Is the fact that the parameterisations seem to be for modelled meteorological conditions on a 55 km resolution a limitation? Should observed or modelled meteorological conditions be used to calculate PCOD and CO<sub>2</sub> age? Have the authors verified their parameterisations at a site other than

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the ones used to generate these equations? Could DSS be used, as this was not used in generating the parameterisations, or DSSW20K (described by Sturrock et al., 2002), with observed values of the meteorological conditions to verify the equations?

The authors should carefully define what they mean by pore close-off depth. Some people have used the term 'pore close-off' to refer to the depth range over which the pores gradually close, rather than a particular depth, so a clear definition is important.

The authors chose to use DE08-2 but not DSS on Law Dome because the horizontal resolution of the meteorological fields was too coarse to resolve the area. Why did they choose DE08-2, is there a reason why the parameterisation would work for one site but not the other? Do the modelled meteorological conditions for the region reflect observed conditions at DE08-2?

Is Temperature in Table 1 from observations or RACMO?

The equations 8, 9 and 10 refer to constants in Table 3, but there are no values of  $\Phi_2$  or  $\Phi_3$  in this table, instead there are  $\epsilon_2$  and  $\epsilon_3$ , should these refer to the same thing? The legend for Table 3 says the constants refer to equations 7, 8 and 10, should this be equations 8, 9, and 10? To avoid this confusion, could the constants be written directly into the equations?

Assuming the  $\epsilon$  and  $\Phi$  in equations 8, 9 and 10 and Table 3 are the same, these equations give me a PCOD of 114m and  $\text{CO}_2$  age of 29 yrs for DE08-2, and PCOD of 102m and  $\text{CO}_2$  age of 59 yrs for South Pole. Have I implemented the equations correctly? If so, these values (particularly for DE08-2) do not seem right to me. Is there a way to show readers that they are implementing the equations correctly, like providing some test values, or labeling the points on Figure 4?

This study, by using a  $\text{CO}_2$  ice core record to determine  $\text{CO}_2$  ages at PCOD, is calculating the 'effective' age of  $\text{CO}_2$ , rather than the 'mean' age (see Trudinger et al., 2002). The effective age depends on the growth rate of  $\text{CO}_2$  in the atmosphere, and

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the degree to which this matters will depend on the width of the age distribution. This is a minor point, and the difference may not be large for CO<sub>2</sub>. The mean age would be older than the effective age for CO<sub>2</sub> (as the growth rate has increased with time). Alternatively, the authors should define what they mean by mean age.

There are other features that might affect the suitability of a site for collection of firn air, such as melt layers, dunes, or wind-blown snow. This might be worth mentioning.

#### Technical corrections

Page 1820 line 5: 'We constructed' does not make it clear that you used the model to calculate the depth profile. Wording could be improved.

Page 1820 line 8: Specify that it was by comparison with the input atmospheric record that you obtained the 'effective' age.

Page 1829 line 2: What does 'fewer chocks between molecules' mean?

Appendix: Accumulation for DSS is wrong (it is correct in Table 1). Some other values differ between the Appendix and Table 1. The units for accumulation are missing 'a'. Siple - should this be Siple Dome?

Fig 4: Could you be more specific in the figure caption whether the x-axis refers to ages estimated by the studies quoted? The text suggests this, but from the figure caption is not clear to me whether it is something you have calculated. Perhaps the CO<sub>2</sub> age at PCOD from the quoted studies could be added to Table 1.

Fig 7: Are we supposed to be able to compare the dots with the lines in this figure?

#### References

Saltzman, E.S., M.Aydin, W.J. De Bruyn, D.B. King, and S.A. Yvon-Lewis, Methyl bromide in preindustrial air: Measurements from an Antarctic ice core, *J. Geophys. Res.*, 109, 10.1029/2003JD004157, 2004.

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