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Interactive comment on "Gas enclosure in polar firn follows universal law" *by* Christoph Florian Schaller et al.

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It is interesting to see further work on applying the percolation model from lattice statistics for the analysis of bubble trapping in firn.

This paper probably needs to take more account of a defining characteristic of such transitions: the existence of fluctuations on all length scales. It was the observation of large fluctuations in closed porosity by Schwander and Stauffer (1984) that suggested to Enting (1985) that percolation may be a useful description of firn closure. The simulations given by Enting (1993) show, for various numbers of bubble sites, the degree of sample to sample variation that occurs. The value of the Schaller et al paper would be greatly enhanced if the results reported the number of pore sites in the various samples.

Given the large critical fluctuations, it is not surprising that the low order summations by Martinerie (1990) (see also Martinerie et al., 1990) underestimate the cut bubble correction.

The large critical fluctuations have two consequences for finite size (indeed relatively small) systems. The first is that systems of the size of actual ice samples can be simulated directly without the need to extrapolate the results to infinite size (see for example Enting, 1993). Thus simulations of the cut bubble correction should be readily achievable. The second is that the behavior of finite size systems differs from that of infinite systems by corrections termed “finite size scaling". This raises the question of whether the results shown in figure 2 could be better fitted by a finite size correction to the infinite power law behaviour (characterised by $\beta \approx 0.454$), rather than equation (1).

One of the open questions in firn closure concerns the behavior of the gas diffusivity near closure. Modelling has often assumed that this goes to zero before full closure (Trudinger et al., 2013). Percolation modeling would suggest that diffusivity behaves like conductivity of random resistor networks and go to zero at closure with a critical exponent of about 2. The extent to which the early cutoff could be reinterpreted as very slow power law decay to zero remains to be explored.

The Schaller et al paper models the system in terms of the interstices of a BCC lattice, as was done in earlier work (Enting, 1986, 1993) following a suggestion by Stauffer et al. (1985). Another open question is whether any of the universal (i.e. lattice independent) amplitude ratios, expected in percolation transitions, can provide useful constraints on properties of firn closure, relating easily measured properties to less accessible aspects.

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