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The Cryosphere
Discussions

Interactive comment on "A trace gas method of evaluating interstitial air advection and diffusion in snow" *by* Stephen A. Drake et al.

Anonymous Referee #1

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eneral comments

This paper demonstrates an interesting method to better understand the relevance of advective flow in a snowpack. This is demonstrated by several measurements. What was a bit surprising to the reviewer that the method is already described in much detail by Huwald et al., 2012. The paper demonstrates the application of the method in several field cases. The authors demonstrate that diffusion and advection of carbon monoxide is affected by wind speed. The main conclusion of the paper is that "atmospheric pressure gradients can induce subsurface advection". This is not an entirely new results. Unfortunately, the physical properties of the investigated snowpacks are not described to a degree that is state-of-art. Neither a highly resolved density profile, specific surface area measurements, measurements of spatial variability (using e.g. near-infrared photography, Tape et al. 2010) were applied. The use and progress of

this paper for interpretation of advective flows in snow is therefore very limited beyond description. The presented model, assuming isotropic and non-layered properties of the snowpack, is very simplistic.

Specific comments Title: Snow is always porous and air is a constituent, and there is no closed porosity (the major difference to firn). So "interstitial air" is redundant. A better fitting title could be: "A trace gas method of evaluating macroscopic air advection and diffusion in snow"

page 2,line 4: More recent measurements show that basic properties of the snowpack do change often in a very complex way within one layer. The traditional method to characterize a snowpack requires usually cast samples (e.g. Arakawa et al.) or other recently developed quantitative techniques.

page 2, line 15: The backfilled snowpit (dimensions?) could be a major source of disturbance for the measurements, as the density (and consequently permeability) is easily increased by about 20%. Any checks or numerical simulations of this effect?

page 2, line 20: What is "relatively high-density, spongy snow"? Which method was used (beyond interpretation of the measurements) to assure that no leakage occurred?

page 4, line 1: how was homogeneity measured? A single storm event can easily create several mm-thick denser layers.

page 5, line 15 ff: Riche and Schneebeli (2012) measured enhanced horizontal thermal conductivity in snow with little or no temperature gradient metamorphism. This would contradict the general statements about the snowpack in his paper. Clearly, anisotropy at several scales (mm to dm) is a key factor for diffusive processes.

page 7, line 28 (and other places) please define "low density snow" "high density snow" in quantitative terms.

page 9, line 19: The conclusion drawn here is not well supported. The observed pattern (especially Fig. 8)= is in my view not at all conclusive (the point x=20,y=30 could be an outlier).

Table 1: Definitions of the snowpack are insufficient for any comparison or application of the results. How was the density measured? What was the vertical spacing? What was the snow type (see International Classification) etc.

Table 2: What was the snow temperature / temperature profile? The description of the snow seems to indicate that the snow stratigraphy was rather complex (guess ...)

Searching for papers about this topic, I found the following references which seem to be relevant to the topic:

Massman, W. J., and J. M. Frank (2006), Advective transport of CO 2 in permeable media induced by atmospheric pressure fluctuations: 2. Observational evidence under snowpacks, J. Geophys. Res., 111(G3), 1–11, doi:10.1029/2006JG000164.

Ebner, P. P., M. Schneebeli, and A. Steinfeld (2015), Tomography-based monitoring of isothermal snow metamorphism under advective conditions, Cryosph., 9(4), 1363–1371, doi:10.5194/tc-9-1363-2015.

Massman, W. J. (2006), Advective transport of CO 2 in permeable media induced by atmospheric pressure fluctuations: 1. An analytical model, J. Geophys. Res., 111(G3), 1–14, doi:10.1029/2006JG000163.

Ebner, P. P., M. Schneebeli, and A. Steinfeld (2016), Metamorphism during temperature gradient with undersaturated advective airflow in a snow sample, Cryosphere, 10(2), 791–797, doi:10.5194/tc-10-791-2016.

Ebner, P. P., C. Andreoli, M. Schneebeli, and A. Steinfeld (2015), Tomography-based characterization of ice-air interface dynamics of temperature gradient snow metamorphism under advective conditions, J. Geophys. Res. Earth Surf., 120(12), 2437–2451, doi:10.1002/2015JF003648.

Other references: Tape, K. D., N. Rutter, H.-P. Marshall, R. Essery, and M. Sturm

(2010), Recording microscale variations in snowpack layering using near-infrared photography, J. Glaciol., 56(195), 75–80, doi:10.3189/002214310791190938.

Arakawa, H., K. Izumi, K. Kawashima, and T. Kawamura (2009), Study on quantitative classification of seasonal snow using specific surface area and intrinsic permeability, Cold Reg. Sci. Technol., 59(2), 163–168, doi:10.1016/j.coldregions.2009.07.004.

Calonne, N., M. Montagnat, M. Matzl, and M. Schneebeli (2017), The layered evolution of fabric and microstructure of snow at Point Barnola, Central East Antarctica, Earth Planet. Sci. Lett., 460, 293–301, doi:10.1016/j.epsl.2016.11.041.

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