Review for „ Assessment of Continuous Flow Analysis (CFA) for High-Precision Profiles of Water Isotopes in Snow Cores“ by Remi Dallmayr et al.

General comments:

The authors present an exciting development from the established CFA ice core analysis technique. Routinely deployed to measure stable water isotopes in ice cores, CFA is an indispensable method in ice core science. The here explored possibility of modifying a CFA system to analyze snow cores could facilitate fast, effective and high-resolution generation of recent climate data from snow covered areas and is as such very desirable and of interest to the community. As a supplement, a study result of isotopic diffusion during storage of snow cores is quantified which supports the current understanding of isotope diffusion in firn, as demonstrated by a model comparison.
The authors present an extensive and meticulously generated dataset that is being used to characterize the presented snow-CFA system that combines state-of-the-art system parts from different institutions into an unprecedented measurement instrument. Details and specifications given in the manuscript allow other laboratories to copy the design which is in the interest of open-access science. Diffusion lengths are calculated for individual and combined segments of the CFA system and thus allow to discern and rank the different smoothing-imposing system parts.
The manuscript is presented in an easy-to-follow and concise manner, yet some interesting and relevant details should be explained in more depth which are outlined below. In agreement with a statement in the introduction, the paper concludes that wicking (or percolation) is the main difficulty to overcome when analyzing snow cores with CFA, yet the authors could elaborate further on which system settings are recommended and which limitations remain in terms of density of snow, annual accumulation thresholds etc.

Please elaborate on the following topics:

- Snow property influences: Both water isotope diffusion during storage and percolation are influenced by snow properties such as density and grain size which should be discussed in both sections. Please also add a statement about the density of the snow cores analyzed in this study.
- Melt rate: How was the optimal melt rate chosen and how does this influence the results? Isotope CFA systems are often run in parallel with other instruments and thus the overall CFA melt rate is constrained by more than the water isotope line alone, but if high-resolution water isotope records from snow were the primary goal, which melt rate should be chosen, and what are the constraints? Please also add the statistics of the melt rates of your experiments to the text, both intra and inter snow core variability. Currently, only the mean melt rates are given in the figure captions and are thus hard to find.
- In line 159 the authors declare that they will compare two different diffusion length calculations (normal CDF and two lognormal CDFS) but these results are not presented, although they would be of interest to the reader as the asymmetry in the impulse response is obvious from Figure 5b.
- It would be interesting to see a deconvoluted CFA record in comparison to the discrete samples of 2019 as this would be the final post-processing step for a snow CFA campaign when producing data for climate analysis. Arguably, the reverse was done to find the percolation mixing length contribution, but these

data are not visualized and the statistics (RMS, l. 267) on the agreement with the convoluted discrete samples and the CFA data are not given. As such the reader has no sense for the agreement between discrete and post-processed CFA data. A visualization of such a final data product would help the reader understand the importance of the system characterization and demonstrate the utility of the Snow CFA line.

Specific comments:

L. 21: The sentence "With our obtained mixing lengths…" is difficult to understand. Please rephrase.

L. 46: "percolation" is often used in snow science to describe the vertical, gravity-driven water flow in a snowpack. To avoid confusion, please consider exchanging the term "percolation" with "wicking" (as done in (Jones et al., 2017)) or including a short terminology explanation.

L. 46: The authors mention here that percolation is the reason why snow cores have not been measured routinely with CFA. The results presented in this paper support this statement. However, it is not made clear whether the author's conclude that their presented method has overcome this hurdle or which limitations remain with the system presented in this manuscript. I suggest the authors include a "best-practices" or "limitations" section in the discussion.

L. 54: In the introduction it would be helpful to include a short paragraph on the characteristic "mixing of the system" or "smoothing" that all water CFA systems suffer from and that is the drawback of CFA analysis of ice cores. In the current version the "mixing of the system" is first mentioned in L.54 but it is not explained until Section 2.2, (L. 136). Since the "diffusion length" is the focus of the analyses in this manuscript it would help to explain these terms already in the introduction.

L. 59: Is this set-up significantly different from other CFA systems that are being used in ice core analysis laboratories? Explain the differences or cite studies where this set-up has been used previously.

L. 126: What are typical lag times between the different lines?

L. 154: Were all mixing times (in s) converted to mixing lengths (in cm) using the same melt-rate? How stable was the melt-rate of the system during the experiments considering density variability in the snow cores?

L. 166: If available, please add age and density of the analyzed snow cores.

L. 178: Were the Allan variance tests performed by injecting MQ water at the Master IV valve? Would you expect the stability to be different for MQ water injected at the MH?

Fig. 3: I suggest removing the upper row of the figure since both plots don't add much information

Fig 4: Consider moving this figure to the Appendix.

L. 204: In total, 18 calibration runs (or 15? L. 210) were performed over which time span? Was the data calibrated with one averaged calibration function or each experiment dataset calibrated individually?

L. 207: Is the diffusion length dependent on the step size, i.e. the standards used? Please add which standards were used to simulate the step.

L. 208: I would appreciate a table listing the different experiments and the corresponding naming conventions of the different σ to ease the reading.

L. 217: Please also give the results for $\delta^{18}O$, even if you focus the discussion on δD
L. 249: Can this depth assignment mismatch be a result of the system lag between the core hitting the melt head and the time the CRDS is measuring the respective sample? Or is this lag time accounted for?
L. 267: How well do the convoluted and continuous records agree? Please give RMS values.
L. 280: Please give variability of this percolation diffusion length. Discuss the dependence on melt-rate or snow properties (e.g. (Calonne et al., 2012; Yamaguchi et al., 2010; Colbeck, 1974)?
L. 285: Please add short statement on how the snow cores were stored (temperature, sealing, …)
Table 4: Please add the differences between the two measurement campaigns to the table
L. 337: The effect of density or other snow properties on the percolation strength is not discussed up to this point. Please include in discussion.
L. 339: As mentioned above, a clear conclusion and recommendation is missing whether the presented snow-CFA system is recommendable to use and, if not, what restrictions or limitations (accumulation threshold, density etc) apply.
Appendix B: Please add short introduction to the two presented figures and cite the model that is being used. I recommend highlighting AWI storage temperature and Kohnen annual mean temperature to Fig B2.

Technical corrections:

L. 21: What does "continuous analyze" mean?
L. 28: delete one "stable"
L. 29: Capitalize "East Antarctic Ice Sheet"
L. 31: change "variabilities" to "variability"
L. 52: Delete "In order"
L. 56: replace "signal, with…" with "signal, and show that…"
Fig. 1: What does "PP" stand for?
L. 80: melting
L. 143: Refer here to Fig. 5
L. 183: replace "optimal" with "minimal"
Fig. 3 and other Figures: Please add panel labels to all plots and refer to them in the captions
Table 1: Please add uncertainties of these in-house standards.
Table 2 caption: Change "means mixing length" to "mean mixing lengths", add number of measurements
L. 294: delete "the" from "the both"
L. 334: replace "Niels-Bohr Institute" with "PICE" to stay consistent
Fig A1: Please refer to this detailed schematic in caption of Fig 1 in main text.
L. 463: replace "steam" with "stream"

Bibliography:

Calonne, N., Geindreau, C., Flin, F., Morin, S., Lesaffre, B., Rolland Du Roscoat, S., and Charrier, P.: 3-D image-based numerical computations of snow permeability: links to specific surface area, density, and microstructural anisotropy, The Cryosphere, 6, 939–951, https://doi.org/10.5194/tc-6-939-2012, 2012.

Colbeck, S. C.: The capillary effects on water percolation in homogeneous snow, J. Glaciol., 13, 85–97, https://doi.org/10.3189/S002214300002339X, 1974.

Jones, T. R., White, J. W. C., Steig, E. J., Vaughn, B. H., Morris, V., Gkinis, V., Markle, B. R., and Schoenemann, S. W.: Improved methodologies for continuous-flow analysis of stable water isotopes in ice cores, Atmospheric Measurement Techniques, 10, 617–632, https://doi.org/10.5194/amt-10-617-2017, 2017.

Yamaguchi, S., Katsushima, T., Sato, A., and Kumakura, T.: Water retention curve of snow with different grain sizes, Cold Regions Science and Technology, 64, 87–93, https://doi.org/10.1016/j.coldregions.2010.05.008, 2010.