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The Cryosphere Discussions

Interactive comment on "Experimental observation of transient δ^{18}O interaction between snow and advective airflow under various temperature gradient conditions" *by* Pirmin P. Ebner et al.

Anonymous Referee #1

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General comments: The submitted manuscript presents a really interesting laboratory investigation of the relationship between airflow, metamorphic processes, and the concentration of water stable isotopes in snow, with implication for the well-known proxy for temperature in ice core records of past climate conditions. Differing snow metamorphic properties were shown to impact the isotopic composition of snow with air being forced through it. This is a significant finding, and having the carefully-controlled laboratory experiments to support recent field observations is an important step in better understanding the controls of climate conditions on isotopic concentrations. Some of the observations made, namely that of sublimation and deposition either into the air flow-

ing through the sample or from the air onto the sample depending on the experimental conditions are really insightful and help to further explain these processes.

Specific comments: I have three comments that might require revision. The first comment is that it does seem like the Re number is high if it is 3 times that of natural conditions. It there a windspeed in natural conditions that this Re number relates to? The second comment is that some of the discussion and results sections seem more suited for the methodology or introduction sections (specific instances are detailed in the notes below, along with the technical comments I have). The third comment is that the reported density of the 3rd experiment is higher than the density of the samples in experiments 1 and 2 (which are oddly identical to 2 digits? were these taken from the same larger block of snow?). Given that the density is 10% higher for experiment 3 than the other two experiments, is there any possibility that this impacted the results at all?

Technical comments: There are a quite few mostly minor technical corrections to make to improve grammar, listed below by line number. Some are merely suggestions to improve readability.

Line 18: Suggest rewriting as "..study on the effect of airflow on snow isotopic composition"

Line 21: There should be a "the" in front of the phrase "exchange of isotopes"

Line 26: A highly resolved history of what is relevant? Not sure what authors are referring to here, think that it is a highly resolved climate history, maybe? Temperature and barometric conditions?

Line 35: Should be "the isotopic composition of high-latitude precipitation" or "the isotopic composition of precipitation in high-latitudes" not quite sure which one the authors meant.

Line 40: Suggest rewriting as "starting from the process of evaporation in the source

region, transportation of the air mass to the top of the ice sheet, and post-depositional processes..." only to make these phrases parallel.

Line 48: Suggest (very minor suggestion), replacing "nearby" with something more descriptive such as "closely spaced" or "closely located"

Line 56: Should be a comma after et al. in the citation

Line 63: don't need the dash in the phrase in between

Line 79-88: Another suggestion, but the beginning of this paragraph might make more sense further up in the introduction, before the paragraph discussing ice cores, i.e. before the paragraph starting on line 54. It seems out of place here, as the authors have just finished discussing self-diffusion in the ice matrix.

Line 85: What are the conditions for the typical half-life of a few days? I.e., normal mid-latitude conditions, or polar conditions?

Line 94: "small scale" should be hyphenated, "small-scale"

Line 95: have, should be "has", i.e. "Modeling....has assumed..." (or the authors could change it to "Models...have assumed..."

Line 107: Should be, "Here, we continuously measured..."

Line 122: Should be, "To prevent air flow between..." (delete extra "the")

Line 129: Delete "were" in front of the word "connected", i.e. should read "The experimental setup consisted of three main components....connected with insulated copper tubing..."

Line 138: Seems there is an extra word here, should be, "to limit the influence of variability" or "to limit changes in absolute vapor pressure"

Line 148: Suggest (minor suggestion) deleting the phrase "because it already had the appliance" mostly because this phrase is a little awkward, but also not really needed.

I'm not sure what the authors mean by "already had the appliance" unless they mean that it had already been applied for use in the micro-CT.

Line 163: The authors should define "opening size distribution" or describe how this is done.

Line 168: This phrase is used a few times in the manuscript, and it is slightly confusing, so I suggest rephrasing here and throughout (tried to make note of each instance), i.e. instead of "where cold air is heated up while flowing through the sample" maybe something along the lines of "where cold air entering the sample is heated while flowing..." For some reason, the phrase "heated up" is confusing. The same suggestion applies for next sentence, Line 170. I would suggest rewriting "where warm air entering the sample is cooled while flowing across the sample"

Line 177: "was" should be "were" since there are multiple temperatures being measured.

Line 185: Is the 0.7 % amount an average for the 3 experiments? It looks like it just pertains to Experiment 1, and the other experiments had lower increases, so maybe this could say, "A slight increase with a maximum of 0.7% of d18O in the water vapor produced by the humidifier was observed in experiment (1), with lower increases during experiments (2) and (3).

Line 193: the word "was" should be deleted (since "decreased" is the verb in the sentence).

Line 196: "memory effects" should be defined or explained. I think that the authors are referring to the having some water vapor in the lines that is either outside air, or the air that was left in the lines before the experiment started that needs to be purged. I also wonder if it is worth reporting these values, or if it could be better explained as part of the methodology, and not include the first 30 min of data in the plots.

Line 200: The authors use the phrase "was observed" twice in this sentence (and

throughout). I suggest changing the second "was observed" to something else, i.e. "as manifest by" so that it is not a repetitive

Line 212: This sentence uses "was observed" twice again. Suggest rewriting to something along the lines of, " As in the isothermal experiment (1), we observed a relaxing exponential decrease of d18Oa in the outlet flow through the measurement period..." (also, the way it is written is not quite grammatically correct, it should be, "Again, we observed..." but since that is a little vague, and not clear what "again" is referring to, I suggest elaborating a bit)

Line 217: again, the term "memory effects" should be defined at some point, probably at first mention of this idea.

Line 220: The phrase "decreased up to..." is a little confusing, suggest writing as "decrease in value from 4.66 to 7.66%..."

Line 221: There should be a "the" in front of the phrase "isotopic composition"

Line 239: As before, the phrase "decreased up to" is confusing. I think it could even just be "decreased 4.46 - 15.09%"

Line 251-257: This section of the paragraph seems out of place, like it belongs in the methods section. Also, it does seem like the Re number is high if it is 3 times that of natural conditions. It there a windspeed in natural conditions that this Re number relates to?

Line 262-268: This section of the paragraph seems like it would be better suited to the introduction than this section of the paper.

Line 273: This sentence is not grammatically correct as written, specifically, "will lead to influence the interpretation" is not correct. Suggest rewriting as, "will lead to improvement of the interpretation..."

Line 277: These citations should be written as "Persson et al., 2011 and Fujita and

Abe, 2006) to be consistent with the rest of the manuscript.

Line 290: I'm not sure what the authors mean by "changing the "target" toward which the snow is equilibrating." This sentence needs to be clarified and corrected.

Line 295: There is a missing phrase here, I think it should be something like, "Relatively short time exposed to vapor-snow exchange..." as it is written is a little confusing, and maybe grammatically incorrect (unless the first bit is meant as one long phrase).

Line 296: suggest adding the word "exposure" (or similar word) after "long -time" to clarify.

Line 305: This sentence is awkward, not necessarily incorrect. I suggest rewriting to "Despite a relatively small change in the difference..."

Line 311: suggest "is altered" instead of "gets altered"

Line 313: suggest adding the phrase "of the ice crystals" after "interior" just to clarify

Line 319: suggest changing "experiment" to "experiments" since there are 3 experiments discussed

Line 320: suggest instead of "an expected low altering" maybe "an expected minimal alteration" or "an expected minimal change"

Line 325: suggest deleting "(above)" and maybe replacing with, "...,as defined above,..."

Line 325: there is a missing "of" in front of the word "the"

Line 326: suggest rewriting these two sentences starting with "It is quite hard..." and ending with "the snow between experiment (1) and (2)" to something along the lines of, "There is a small, but notable, difference in the total d18O of the vapor..."

Line 338: suggest specifying the mechanism of redistribution of ice referred to, i.e. "this redistribution of ice caused by temperature gradient" (I think that is what the authors

are referring to, anyway.)

Line 359: instead of "there are complex interplays.." suggest changing to "causes a complex interplay"

Line 362: instead of "thus the change in the d18O of air" suggest, "and causes the change in the d18O of air"

Line 364: "there are deposition" should be "there is deposition"

Line 364: This observation of the sublimation and deposition either into the air flowing through the sample or from the air onto the sample depending on the experimental conditions is really cool.

Line 374: "in to" should be one word, "into"

Line 375-382: This is a really good discussion of the results.

Line 387: should have parentheses around "3" after "experiment" to be consistent

Line 390: suggest rewriting "By having this observation in mind," to "This observation, together..." since the phrase as written isn't grammatically correct, and is also colloquial.

Line 392: "lead" should be "leads" since it refers to "this observation," which is singular

Line 397: This sentence is not quite correct, and should be rewritten (since the hypotheses can't ask for anything). I suggest something like, "Our results and conclusions indicate that there is a need for additional validation..."

Line 399: This sentence is confusing since "scanning" defined. I think the authors mean that the entire sample should be scanned in the micro-CT, but then not sure what they mean by the phrase, "or gravimetrically." I'm confused because to determine the density of the snow gravimetrically would lead to a macro-scale measurement on the order of a few centimeters, when really, it seems like higher resolution measurements

are needed, i.e. grain-by-grain changes throughout the whole sample. I guess it would be good for the authors to define the scale at which the microstructure changes should be measured.

Line 402: "this would allow calculating more precisely the different observed exchange rates" should be "more precise calculation of the different observed exchange rates..."

Line 411: "helps" should be "help"

Line 412: I would suggest adding the phrase "under low accumulation conditions" after "better" to help tie into natural conditions that correspond to longer experimental times.

Line 412: this sentence is confusing, suggest rewriting as, " Further, because a complex interplay of sublimation and deposition was created within the humidifier as well as due to the geometrical complexity of snow..." somehow that isn't quite what was intended, but it is hard to understand what is meant by this sentence.

Line 415-418: This sentence is confusing, not really sure what to recommend. Suggest something like, "With the suggested experiment, whether or not there is measureable fractionation and if the sublimated vapor has the same d18O value as the sublimating ice can be determined."

Line 419: At the beginning of what? This experiment? Or also just after deposition?

Line 424: "an approach of the d18O value of the vapor and ice should be seen" is confusing, not sure what is meant by this.

Line 429: Suggest rewriting the sentence to, "This estimation suggests that after about 10^3 second..."

Line 431: suggest deleting the last sentence, as the entire section was about laboratory experiments that are suggested based on the results of this work

Line 438-447: These are all details about the methodology that don't really belong in the summary. I think a lot of the details should be deleted, if not this whole paragraph,

and start the summary on line 448.

Line 455: think there is a missing word or phrase between "ice matrix" and "the temporal change", i.e. maybe should be, "the ice matrix causes the temporal change...at the outflow to decrease..."

Line 457: the same comment as above for this sentence, think that it should say, "Decreasing the recrystallization rate causes the temporal curve of the outlet concentration to become steeper,..."

Line 462: Is "cloud-temperature signal" a real term, or is this precipitation? If it is a real term, it should be defined. I am not familiar with that as a commonly used way to describe the temperature in the clouds.

Line 465-467 suggest deleting this first sentence in the paragraph...I think it is much stronger to say simply, "Our results represent the first direct experimental observation..." I would suggest replacing the word "showing" with the phrase "of the" If the authors do want to leave the first sentence, it is not grammatically correct, and should be, "These are novel measurements and will therefore be important as the basis for further research and experiments."

Line 470-471: Either this sentence should be broken into two sentences after the work "process," or I would suggest deleting the first part of the sentence, and simply saying, "Our results demonstrate that recrystallization and bulk mass exchange must be incorporated into future models..." That sentence is much stronger without the first phrase, as it avoids the repetition of the word "recrystallization."

Line 734 in Fig 2 caption: "run" should be "runs"

Fig 2: I am not sure what the large, long arrow is supposed to represent that is going diagonally across the figure. I think the little arrow is the "recrystallization rate" Should be explained, or labeled. Or is the long arrow recrystallization rate? Regardless, it is confusing.

Figure 3: What are the oblongs circling the lines supposed to represent? Are they supposed to be circling the "t=end" results vs. the "t=0" results to group them together somehow? I would recommend maybe different colors or something else. The oblongs are just confusing, and there is enough separation between the 2 groups of results that there must be another way to represent the time difference.

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