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The Cryosphere Discussions

Interactive comment on "Isotope hydrological studies on the perennial ice deposit of Saarhalle, Mammuthöhle, Dachstein Mts, Austria" *by* Z. Kern et al.

Anonymous Referee #1

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General comments

Considering the up till now very sparse investigations of the glaciological characteristics of cave ice and its potential relevance as climate archive, the manuscript provides novel and useful data to help understanding cave ice formation. Also, the main questions primary asked of any climate archive - 1) the age (structure) of the ice and 2) what information (e.g. in form of delO-18) is recorded within the ice matrix - are discussed. This paper has the potential to be a significant contribution to cave ice and climate research studies. However, the current presentation of the overall well-conducted study must be substantially improved on several accounts. The manuscript would gain in

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understanding by an altogether more cautious and critical approach. The complexity of ice caves and their problems as climate archive are not sufficiently displayed. Especially lacking are more background information on the Mammut cave system and its weather conditions itself. This missing information makes it difficult to determine, how the findings of this Ms can be extrapolated or compared to other cave systems. The presentation of the data is incomplete (a plot of isotope vs depth should be included) and its interpretation seems at times patchy and incoherent. Below, I elaborate on the abovementioned aspects and several other details that need to be addressed during revisions.

Specific comments

1 Introduction

p.1450, l.1 to p. 1451, l.2:

The introduction gives the impression that cave ice provides a well structured, low accumulation climate archive directly comparable to cold, mountain glaciers and has been neglected for unknown reasons up till now. The introduction should contain more information about the potential and problems of cave ice investigations in terms of gaining insight into past climate changes.

p. 1451, l.3-14:

In order to get a better picture of the location some additional information on describing the cave system are necessary. Also, information about the water sources and sinks responsible for the ice formation are needed, even if only speculated or simply observed over time. Examples for missing information on the setting are:

l.3-8:

At which altitude are the entrances and exits? How much rock covers the cave system? Especially above the drilling position Saarhalle?

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l.9-14:

Where in the system is the Saarhalle located? How far removed from an entrance/exit? What is the average temperature and humidity in the Saarhalle? What geometry does the ice block have (e.g. reference picture in Hausmann and Behm, same issue)? Is there any sign of ice sliding or flowing? Why (not)? Are there visible calcite layers? Is there evidence of drip water infiltration into the Saarhalle? What feeds the ice formation: drip water or water vapour? What diminishes the ice? Melting or sublimation?

p.1451, l.16-18:

The first “main scope” should be removed as it certainly is not a main point in the paper and is dismissed later on with one sentence. The attempt to link GPR signals with calcite layers should be discussed, but not at this point.

2 Materials and methods

2.5 Isotopes in precipitation

p. 1454, l.1-8:

It should be explained, why the respective station was used for data comparison. For example why choose Golling and Feuerkogel for comparison with the stable isotope composition? And why are tritium data from Salzburg necessary? Furthermore there are inconsistencies: Salzburg is mentioned also for stable isotope comparison, but entirely left out of the discussion later on. At the same time tritium data from Salzburg are used (Fig. 2) but not mentioned here

3 Results and Discussion

3.1 Tritium

p.1454 f.:

I would reconstruct the Tritium chapter: => ice with less than 8.5 TU can only origin

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either before 1960 or after 1980 (based on data from Vienna and Feuerkogel) => considering the observed loss of ice in the last 10 years, two scenarios are envisioned: 1) low ice accumulation 1 cm/yr => earliest date 1905. 2) high accumulation of minimum 15 cm/yr required for all tritium samples to be not older than 1981. => Conclusion: while the first assumption is much more likely, the second can not be dismissed? Or are there any information about ice grow rates in the Saarhalle?

3.2 Stable water isotopes

The conclusion drawn from the stable water isotope data is not convincing. It is a priori clear that the source of the frozen water is eventually precipitation water. The almost identical parameters in the delD delO-18 regression found for the ice and for a certain precipitation site (Golling) appears to be somewhat by chance. The result suggests indeed that local kinetic effects are not important, but this finding would not indicate (as claimed by the author) that the ice has preserved or would preserve climate signals associated with precipitation. In any case the isotope depth profile needs to be displayed giving a feeling on the overall variability or any major features.

p. 1455, l.15-27:

When comparing the delD delO-18 regression Golling seems to be chosen simply because it is close and matches with the findings from the ice core. However, Golling lies significantly lower and it is therefore questionable, if the station is really suitable for comparison with the cave ice, since the precipitation infiltrating the cave origins significantly higher up. I strongly suggest here a comparison with more than one source. What about Feuerkogel or Patscherkofel? Also Springwater signals could be considered here (e.g. Scheidleder et al., 2001 (http://www.umweltbundesamt.at/fileadmin/site/publikationen/M108.pdf)?

p. 1456, l.1-20:

Discussing the overall mean values of the delO-18, again references are only made for

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one other source (which is now curiously Feuerkogel and not Golling). Also only the mean values are given, whereas there is no mention of a standard deviation or a span. A table containing major statistical data (mean, standard deviation, max, min) would help to easily compare the ice core and reference data. However, it is quite apparent from Fig. 3, that the isotope composition in the ice core is clearly less variable than for the Golling (or the Feuerkogel) station. Compared to both stations the heavier and lighter values are not found in the ice. This observation of course correlates with the shift in the mean values. Comparing summer and winter values from the reference stations with the ice data indicate a selection of summer precipitation, thus solidifying the assumption of a biased seasonality. Of course an attempt at explaining such a selection should be given. What would be an alternative explanation for the heavier values? What about fractionation during freezing?

p. 1456, l.12-20:

Point 1.: I can not follow the authors claim that water evaporates under saturated conditions from the karstic fissures. Point 2: Why should the melting snow run off and not be infiltrated into the cave?

3.3 Conductivity data

p.1457, l.1-14:

I can not follow the argumentation of linking the EC signal with drip-water and/or melt-water. What is the difference between drip water and melt water? Water infiltration into the cave is always in the form of drip water. Or is there any evidence, that water infiltrates the cave by any other way? I assume, that the authors mean to distinguish between slow infiltration, where the water is long retained in the stone overburden (later the term karstwater is used) and fast infiltration, where a strong addition of water (through heavy rain or snow melting) reduces the time in the stone. In this case, I find the term melt-water confusing. The term surface water used in the conclusions seems more appropriate. In this context, the study of precipitation and spring water in the

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Dachstein area by Scheidleder et al., 2001 should be included/referenced as another example of EC in surface water. Is the explanation of contribution from different sources the only one? What about salt-exclusion during freezing (as described by May et al.)? Are there no calcite layers at all in the ice block, or only not in the core? Is there any co-variation with the isotope signal?

p. 1457, l.15-19:

The Eisriesenwelt ice core shows several distinct layers and spots of cryo-calcite, which was not observed in the Mammut cave. This supports the assumption by May et al. that strong salt exclusions during freezing is the reason for the low EC values in the ERW core rather than a change in the water source.

4 Conculsion

The conclusions should be reevaluated following the revisions.

Minor and technical comments

p. 1452, l.19-21:

What is meant by the characteristic reflector zone? Explain or reference! Insert here the discussion about linking GPR to calcite layers (= first “main scope”).

Fig. 2: Is the Salzburg data really needed?

Fig. 3: What resolution have the reference values for Golling: annual or monthly? Why not plotting only the ice core data and including the water lines for the reference data (Golling, Feuerkogel, Springwater) in the same plot?

* Include a delO-18 vs depth plot!

* Include a table for the statistical data (mean, standard deviation, min-max) of the ice core and any reference stations! distinguish between summer and winter.

* There are several mistakes in wording and spelling (not all are mentioned below), e.g.

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exchange electrical conductivity with electrolytic conductivity

p. 1451, l.19: . . . of the water forming the Saarhalle. . .

p. 1452, l.12: . . . collected in an insulated box. . .

p. 1452, l.16: . . . was transferred to the Institute for Nuclear Research HAS for tritium concentration and electrolytic conductivity measurements.

p. 1452, l. 19: . . . characteristic reflector zone but no major clay. . .

p. 1454, l.16: . . . $\sim$ -7cm yr-1 rate (Mais and Pavuza, 2000), this fact not only. . .

Interactive comment on The Cryosphere Discuss., 4, 1449, 2010.