

## **Review: “Record summer rains in 2019 led to massive loss of surface and cave ice in SE Europe”**

### **Overview of the manuscript**

This manuscript investigates the changes of ice thickness of five ice-filled caves (Scărișoara, Chionotrypa-Falakro, Chionotrypa-Olympus, Crna Ledena and Velika ledena jama v Paradani), as well as the area changes of two mountain glaciers (Snezhnika and Basnki Suhodol), all of them in Eastern Europe, during the hydrological year 2018-2019. The relatively large changes observed are associated to an anomaly in the weather (both summer and winter weather). The observations of ice changes are carried out based on in situ length measurements for the ice within caves, and with a drone for the two mountain glaciers. Weather parameters are obtained from the following datasets: E-OBS (Cornes et al., 2018), NCEP/NCAR (Kalnay et al., 1996) and MODIS/Terra Snow Cover Monthly L3 Global (Hall et al., 2006).

The authors have done substantial modifications of the manuscript, which has, in my opinion, improved significantly. They have also adequately addressed the majority of the questions from the first review. However, there are still a couple of aspects where the reply from the authors still raises some questions. This concerns mainly (1) the lack of error bars when presenting the results, (2) missing explanations in the methodology and (3) content of the abstract and conclusions in comparison to the actual content of the manuscript.

### **General comments:**

#### **Error bars:**

Although the revised manuscript has improved in this regard, showing some kind of errors in the observations, still none of the results shows error bars. For the rigor of the study, this should be adequately addressed and there should be some sense of uncertainties in all the numbers, i.e. volumes and areas, should be provided in the results.

#### **Methodology:**

The revised manuscript shows a descriptive figure of the type of measurements done with tape. However, the authors do not explain how the measurements are carried out in Chionotrypa Falakro and Crna

Ledenica, where the Table 1 shows the measurements as "Photogrammetry". This needs a better explanation. Also, the drone survey data is now better presented, and a Digital Elevation Model (DEM) is shown for each survey, as well as a map of elevation difference. However, it should be straight-forward to present a volume change from their comparison (as well as the uncertainties associated), in the same way as volume changes are presented for the cave ice.

### **Abstract and Conclusions:**

As pointed out in the first revision, there are some strong statements made in the abstract and conclusions that are not supported by the data and methods presented in this study, and they should not be presented in the abstract or in the conclusions, only as part of the discussion.

### **Specific comments**

- L20-21: The role of changing atmospheric circulation patterns and distribution of precipitation in glacier changes is not studied as such in this manuscript. The atmospheric conditions are presented as observations but there is no strong link or model carried between these observations and the glacier changes. For this reason, I find this sentence outside the scope of the abstract.
- L29-30: Same as in the previous comment, this work does not analyze any climate model prediction, and therefore this should not be included in the abstract.
- L57: Throughout the manuscript the authors refer to "cave glacier", "ice cave" and "cave ice". This needs consistency.
- L149: Does the metal ruler allow sub-millimeter precision? (most rulers only allow measuring to one millimeter). This is contradicted in Table 1.
- L161-162: "Photographs of the upper surface of the ice body (...) to visually estimate the ice level changes". How exactly is this measure taken and how is it possible to obtain a precision of 0.3 cm with this method? See general comment nr2.
- L214: Mass balance vs volume change: The authors explained in their first author response that the dimension of "mass balance" yields a fundamental question and they decided to continue using this term at several occasions through the manuscript. I kindly disagree with this response, and in the revised manuscript I have not found a clear clarification of this, which still makes this

concept misleading. I suggest either adding a sentence to clarify what the authors define as mass balance, or replace expressions as “positive mass balance” for “volume gain”.

- L226-230: Since the volume change is reported for the cave ice, why not reporting the volume change for the two glacierets too? This is straightforward to calculate from the map of elevation difference from the subtraction of the two DEMs.
- L343: Please provide a more updated reference for the accelerated warming of the Arctic.
- L353: This is still a very strong statement in the conclusions that is not supported by your material and methods. Therefore, it only should be mentioned in the discussion.
- L360-361: The Rossby waves have only been mentioned twice before in this manuscript and I also think this should not be a conclusion of your study. It needs to go to discussion.

## Figures

- Fig. 5: As pointed out in the first round of comments, this figure showing changes in snow is heavily influenced by the seasonal differences of each picture. The authors argued that the pictures were taken at the end of the melting season, but this is not the case by looking at the date of acquisition. The snow field can change dramatically between July and October. This needs to be properly addressed or otherwise this figure should not be presented. Also, the “green” outline does not match with the “yellow” color in the legend. There seems to be a “green” line in the middle of the snow patch in the 2019 image.
- Fig. 7: For the soundness of the UAV work, it would be needed to show the comparison between the two DEMs in the entire overlapping area, and not just in the glacier itself. The color scale could also be improved: due to the high level of detail and accuracy in the DEMs, the scale bar could have more discrete steps in order to discern smaller changes in elevation.

## Tables

- Fig. 5: Table 1: The uncertainties given here do not correspond to the values shown in the text. “Photogrammetry”. Can you provide additional information on how the photogrammetric measurements are done in Chionotrypa Falakro and Crna Ledenica?