

Hydrol. Earth Syst. Sci. Discuss., referee comment RC2  
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## **Comment on hess-2022-110**

Anonymous Referee #2

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Referee comment on "Towards a hydrogeomorphological understanding of proglacial catchments: an assessment of groundwater storage and release in an Alpine catchment" by Tom Müller et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2022-110-RC2>, 2022

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### GENERAL COMMENTS

The manuscript presents two interrelated but separate pieces of work in one large package: (1) literature review of proglacial landforms and (2) case study of storage assessments in an Alpine catchment. As such, the manuscript has an unusually large volume, approximately double the size of standard journal papers. The literature review is informative, but it does not offer much new insights. Therefore, I suggest that Section 1 (Introduction) be reduced to 10-15% of the current volume. That will still leave a much larger volume of texts compared to standard research papers, meaning that the rest of the manuscript will have to be condensed substantially to make it more concise and useful to the intended readership. The case-study part of the manuscript presents unique and interesting information, which will be of great interest to the reader of this journal. However, it has some fundamental issues that need to be addressed before the manuscript can be considered for publication. Overall, the case study needs to re-examine some of the assumptions that are central to the results. I will elaborate more in my specific comments below. Particularly important issues are indicated in my comments on Line 420, 660, 696, 698, and 718. I would recommend that the manuscript be rejected at this time, and the authors be encouraged to submit a completely new manuscript written concisely and clearly, presenting reanalysis of the data addressing the fundamental issues.

### SPECIFIC COMMENTS

Figure 1. What do beige areas between bedrocks represent? Are they same as beige areas inside the lateral moraine? Please clarify that in the figure legends.

Line 271. Please include the latitude and longitude of the study site. This will allow interested readers to look up the sites easily on Google Earth and other programs.

Line 288. Please indicate the weather station in Figure 2.

Line 291. Please indicate the elevation of the weather stations and their direction (e.g., northwest) with respect to the glacier snout.

Line 305. If these devices are fully screened, they are not piezometers. Please use proper terminology, such as water-table monitoring wells.

Line 312. Please present more detailed information on the ERT methodology, for example, electrode spacing, configuration, and data inversion methods.

Line 313. How was the presence of buried ice blocks identified?

Line 396. How was B determined based on ERT results? Considering the quality of ERT data and spatial heterogeneity, the determination may not be straight forward. Please explain this more carefully.

Line 402-406. Please present this information in the section of field methods (see my comment on Line 312). In general, the manuscript suffers from a lack of organization, meaning that methods are not presented in where the reader expects them to be.

Line 416. This terminology ( $S_{max}$ ) is misleading and inappropriate. What it represents is not the maximum amount of water that can be stored in the unit. It is the storage corresponding to the initial flow ( $Q_0$ ) at the beginning of recession analysis period. I suggest it to be changed to  $S_0$  instead.

Line 420 and Figure 2. I do not think that the classification approach solely based on slopes adequately captures the spatial extents and distribution of the landforms for the purpose of this study. For example, a quick examination of satellite images on Google Earth indicates that much of '22-42 deg (talus slopes)' on the north side of the instrumented area are likely bedrock slopes covered by a thin layer of soil and vegetation. They are clearly not talus slopes and hence, will have completely different hydrological storage functions. This applies to other landforms as well, putting the entire exercise of data analysis on a shaky foundation. I strongly recommend that the authors use an approach combining digital elevation models and satellite images to come up with more appropriate landform classification, and reanalyse the data set.

Line 437. 'Fitted by matching the snowline limit'. How was it done? Please explain the methodology. It may not be a straightforward task in a mountain environment with frequent cloud covers obscuring satellite images.

Line 438. If the elevation of the weather station is lower than the average elevation of the catchment, the data may substantially underestimate winter precipitation. How was this issue addressed? Please explain.

Line 441. First estimate. What does this exactly mean? Please explain it more precisely and specifically.

Line 443-444. Only a small fraction was allowed to recharge. Was this observed? Or assumed? Please clarify. If it is an assumption, please present a clear justification.

Line 447. Simple model. I feel that the model may be too simple for the purpose of determining aquifer storages with sufficient rigor. Please improve the presentation of scientific rigor in various parts of Section 3.

Line 452-454. This needs to be described in the method section, where the water balance equation is introduced (Line 431). Please see my comment on Line 402.

Line 454. Figure 4. Should this be Figure 3?

Line 455-456. Which gauging station was this recorded at? GS3? Please include this information in the figure caption as well.

Line 456-457. The increases of flow during the recession period (Figure 3) do not look like 'very small' noises. What causes the increase of flow? Please explain.

Line 479. Please see my comment on Line 416.

Line 506. This is an unusually large value for rain. Please examine the possibility of contamination by sampling devices or sample handling. Rain sample values are expected to be similar to snow sample values.

Line 539. This statement contradicts with the caption of Figure 8, which states that the lateral gradients are directed towards the main river. Which is the correct observation?

Figure 8. Please include the unit for river discharge and specify the vertical axis for discharge. Is the 'glacier outlet' discharge measured at GS1? Please clarify.

Line 545. Water contribution from the hillslopes. This is a losing stream. How is it possible for it to be gaining groundwater from hillslopes? Please clarify.

Line 582-583. Please show the actual ERT data to demonstrate the results. The ERT data will be useful for demonstrating bedrock delineation as well (please see my comment on Line 396).

Line 585-587. Decagon 5TM device. This information should be presented in the method section.

Line 590. Please be mindful of the number of significant digits.

Line 617-624. Figure 9 shows the water storage per unit area for each landform, irrespective of the area coverage of landforms within the catchment. Outwash plain may have a large storage (mm), but it may contribute relatively little to total catchment storage. This need to be explained clearly in this paragraph.

Line 660. These landforms cover the entire catchment, not just the proglacial zone. Given that glacier outflow is sustained during winter months (Figure 8), the storage capacity of these landforms in the entire catchment during winter months needs to be evaluated. I see this as a fundamental issue in this study.

Line 696-697. Can you quantify the total storage provided by these landforms in the entire catchment (see my comment on Line 660)? How does it compare to the total amount (mm) of winter flow measured at GS3? This information will provide an important 'reality check' for the perceptual model.

Line 698. This value (40 mm) is solely based on mathematical reservoir models, which in turn are based on several assumptions, which may or may not have the physical basis validated by field data. While this approach is useful, its limitation needs to be clearly acknowledged.

Line 718-719. Please consider the areal extent of the landforms in the catchment-scale storage calculation (please see my comment on Line 660).

Line 732. Having seen the results from an objective set of eyes, I do not believe that they 'indicate clearly' that winter baseflow is governed by non-superficial reservoirs. Please re-evaluate the assumptions and calculation methods, and re-examine this statement.

Figurer 11. This is a confusing diagram. Fluxes (snowmelt, rain, etc.) are mixed up with storage volumes. Please use a different scheme to represent the perceptual model.