**Reply to Pierre-Yves Jeannin**

## General comments:

*Nice effort! Thank you for this work and I believe this is a really interesting basis for future work.*

*The paper is well written and I made only few comments on sentences, which I could not understand very well. I also added a few questions, which arose along the reading of the paper.*

*I have however two concerns:*

*1) A strong effort is dedicated to provide parameters for catchment areas, which are mostly very uncertain. Furthermore, key-parameters controlling karst spring discharge in alpine context are not considered at all: I mean snow cover and evapotranspiration. Therefore, I don't really understand why so much was dedicated to details on uncertain catchment areas and none on snow and evapotranspiration. This should be explained somehow in chapters 6 and 7, and possibly in chapter 1 as well. It could be mentioned that further parameters should be added in the future.*

*2) The overall uncertainty of the discharge data is poorly discussed (chapter 6). Two types of uncertainties should be discussed:*

*a) uncertainty about measuring the complete discharge of one karst hydrogeological system (how much water of the hydrogeological system does flow around the gaging station?), and*

*b) What is the uncertainty on the absolute values of the provided measurements? Are provided values measured within 10, 50, 100 or more % of the real value? Is this uncertainty the some for all values or larger for low- and high-water conditions?*

*This uncertainty assessment should be more developed in chapter 6, and given as a track to follow for future improvement of the data characterization.*

*You can find more details on these two point in Jeannin, Malard & Sinreich 2026.*

*As mentioned, the gathered dataset is expected to be used for deep-learning techniques and bias on the data is a major issue for this type of analysis. I really believe that deep-learning would be strongly improved by considering the two concerns above.*

*Therefore I recommend to accept the paper with minor revisions. Revisions must include a few sentences on the two concerns mentioned above.*

Dear Pierre-Yves Jeannin,

Thank you for your positive feedback and your thoughtful review. Your comments have helped us to improve quality and clarity of the manuscript, and we believe that addressing them will really strengthen our work. We also appreciate the opportunity to discuss in more detail the two main concerns you raised.

1) We agree that much effort went into compiling a comprehensive set of static catchment attributes, despite the uncertainties associated with both expert-based catchments and catchment approximations, while important dynamic variables influencing spring discharge, particularly snow-related data and evapotranspiration, are not included in

ALPAKAS. Nevertheless, we believe that the static attributes are valuable for both comparative analyses and data-driven modelling approaches. For the latter, the intention is to provide a broad range of catchment characteristics, allowing models to independently identify the most relevant predictors. At the same time, we fully agree that snow-related data and evapotranspiration are important for understanding and modelling spring discharge across the wider Alpine region and would be valuable additions to ALPAKAS. We will therefore discuss the limitations associated with the absence of these dynamic variables and highlight their inclusion as an important direction for future extensions of the dataset in the revised manuscript.

2) Thank you for pointing out the need for a more detailed discussion of discharge uncertainties in Section 6, which we agree was not sufficiently addressed in the original manuscript. We will discuss these and other uncertainties in more detail and find the discussion in the suggested reference very useful in this regard.
    a) We agree that the current manuscript does not sufficiently address the uncertainty related to whether the monitored discharge represents the total outflow of the corresponding karst hydrogeological system, as not all discharge may be captured by the gauge. However, we would like to point out that this uncertainty is not directly related to the accuracy of discharge measurements at an individual spring, but rather to the broader question of whether the monitored spring can be deemed representative of the total discharge of the hydrogeological system it drains. Although this question goes beyond the primary scope of the ALPAKAS dataset, we acknowledge its importance for catchment delineation, hydrological interpretation, and modelling applications. We will therefore expand the discussion to address the potential influence of ungauged overflow outlets, subsurface groundwater bypasses, and additional surface runoff contributions at downstream monitoring stations, as suggested in your review.
    b) We agree that a better discussion of discharge measurement uncertainties is important for interpreting and using the dataset. The discharge data included in ALPAKAS originate from more than 20 data providers across seven countries and spans records up to 10 decades, with different measurement procedures, data processing practices, and quality standards applied. Substantial differences in measurement uncertainty can also be expected between stations operated by the same data provider, as these uncertainties strongly depend on site characteristics, measurement infrastructure, instrumentation, and applied methods. We therefore believe that a reliable quantification of uncertainty would require station-specific assessments that take these factors into account. At the same time, we fully agree that such quantitative uncertainty assessments would be very valuable, particularly if they were routinely conducted and documented by the responsible monitoring agencies as part of standard practice. This would improve the interpretation and comparability of discharge records and allow measurement uncertainties to be considered in hydrological modelling. We will therefore highlight the importance of such assessments for better quantifying discharge uncertainty in the future in the conclusion. In addition, we will expand the discussion of discharge measurement uncertainty in the revised manuscript, drawing particularly on the uncertainty estimates published in the suggested reference. We will pay special attention to how measurement uncertainty varies with hydrological conditions, especially the often substantially higher uncertainties under low-water and high-water conditions, and provide indicative

uncertainty magnitudes from previous studies while discussing their applicability and limitations in the context of ALPAKAS.

Please find our specific responses to your comments below.

**Specific comments:**

*L128-129: Slightly unclear: what is a "circular approximation"? --> please refer to Appendix A. The remaining part of the whole sentence could also be improved.*

Thank you for pointing this out. We will add a reference to Appendix A, where the derivation of the circular catchment approximations is described, and revise the remainder of the sentence to improve its clarity.

*L138: what is meant here with "catchment orientation"? What is the difference with "catchment delineation"?*

With “catchment orientation,” we referred to the placement of the circular catchment approximation relative to the spring, whereas “catchment delineation” refers to the boundaries of the expert-based catchment. We agree that this distinction was not sufficiently clear in the original formulation. We will therefore replace the term “orientation” with “placement” relative to the spring and clarify that the catchment delineation file refers specifically to the expert-based delineations.

*L144-149: An indication of the estimated uncertainty on the positioning/aggregation procedure would be useful. Here only the principle is described, indicating that efforts were made to reduce uncertainty, but it would be useful to know what is the range a remaining undertainty.*

The use of *exact_extract* minimizes aggregation errors associated with partially covered raster cells, but does not account for uncertainties in catchment boundaries or the spatial representation of the underlying data products. These remaining uncertainties are discussed in Section 6.2, which we will further expand in response to your comments, including examples from published evaluations of spatial interpolation uncertainties in catchment-scale estimates. We will clarify this and add a reference to this discussion in the revised manuscript.

*L168: How was it aggregated? Average value or measurement at closest time? Is the aggregated value given at the beginning, middle or end of the time step?*

The aggregation procedure and the corresponding timestamp convention are described in detail in Appendix B3, which we will revise in response to your comments. As this was not sufficiently clear, we will also add an explicit cross-reference in the main text.

*L179-180: Slightly unclear: you should maybe write "For data received with time steps different than one day or one hours, which needed to be aggregated,...*

Thank you for pointing out that "instantaneous data" was not sufficiently clear in this context. We will revise the sentence to clarify that it refers to instantaneous time series that require aggregation to hourly values and that flagged outliers and artefacts were removed prior to this aggregation.

*L182: What were the criteria to define "changepoints". You never clearly define the exact meaning of this word. We can guess that changepoints are time between two time periods with different data quality. Is it correct? what criteria do you use to distinguish two different data quality?*

Thank you for pointing this out. Changepoints are statistically detected shifts in the mean or variance of the discharge time series. However, these changes often indicate changes in data quality or implausible behaviour. The method is described in detail in the appendix. We agree that that this was not sufficiently clear from the manuscript and will therefore refer to the detailed procedure described in the appendix and define the term "changepoint" more explicitly in the main text.

*L200-201: Did you consider outliers as missing values or as valuable observations in this ratio?*

Flagged outliers were retained as available observations when calculating the completion ratio because it is intended to describe temporal data availability, irrespective of quality flags assigned to individual observations. We will clarify this in the revised manuscript.

*L203-206: Do you mean that one station was used for one spring during one first time period and another station for the same spring for another time period? Or that several stations were used to obtain the complete discharge rate or one single karst spring (e.g. Milandre)? Or both?*

Thank you for the comment. Here, we mainly refer to cases where multiple stations cover different time periods for the same spring. These station records were retained as separate time series and were not combined into a single discharge record, as they are often not directly comparable due to differences in measurement location, instrumentation, or measurement methods. However, there are also cases where one station includes the discharge measured at another station together with contributions of an additional spring. For example, station SI-0038 represents the Malenščica spring, whereas recent data for the Unica spring are only available from station SI-0037, which captures the combined discharge of the Unica and Malenščica springs. We agree that this point was not sufficiently explained and will clarify it in the revised manuscript.

*L268-269: Why two values (northness and eastness), and not simply one single azimut of the main dip?*

Thanks, this is an important point. We represented aspect by its northness and eastness components because aspect is a circular variable and therefore cannot be meaningfully averaged directly in degrees. Expressing aspect through its sine and cosine components avoids the discontinuity at 0°/360° and allows spatial averaging over the catchment. Although northness and eastness can subsequently be converted into a mean aspect direction represented by a single

azimuth, retaining both components preserves additional information on the consistency of slope orientations and provides a continuous representation that is well suited for statistical analyses and machine-learning applications. We will slightly revise the corresponding description in the revised manuscript.

*L281: Indices in Table D3 are averaged over the catchment area. How is the average value calculated? Is it any weighting applied? I believe it should be better indicated in the main text, as you refer here directly to Table D3.*

Thank you for your comment. Hydrometeorological indices were calculated based on the daily time series, for which meteorological variables had already been spatially aggregated to the catchment scale using area-weighted arithmetic means based on the exact fractional overlap between raster cells and catchment polygons. This procedure is described in detail in Sect. 3. We agree that this should be made clearer at the point where the hydrometeorological indices are introduced. We will clarify this and add a cross-reference to Sect. 3 in the main text.

*Section 5.3:*

*You developed several indicators for catchment areas, meaning that you assumed some delineation for most catchment areas. Why didn't you compute specific discharge rates and provided max., mean, min. specific discharge rates?*

We appreciate this comment and would like to clarify our reasoning. We agree that specific discharge could provide additional information by normalizing discharge by catchment area. However, we decided to provide several discharge-based hydrological indicators in volumetric units (mean, min, Q10, Q90, max, sd) to avoid propagating uncertainty in catchment delineation into the derived indicators. We acknowledge that uncertainty in catchment delineation also affects indicators derived from spatial data products, as the catchment delineation determines the area over which these variables are aggregated. However, for specific discharge, catchment area enters directly as the normalization factor, such that alternative delineations would result in systematically different discharge values. As more than one catchment delineation may exist for a given site, the resulting specific discharge values would therefore depend directly on the selected delineation. Nevertheless, the station metadata (Table 1) include the areas of the expert-derived catchment (area_catch_expert) and the catchment approximation (area_catch_approx) as separate attributes, allowing users to readily calculate specific discharge rates from the provided discharge indicators. We will clarify this in the revised version of the manuscript.

*L361-362: Why twice "limestones (jointed, karstified)?"*

"Limestones (jointed, karstified)" and "chalkstones, limestones (jointed, karstified)" represent separate classes in the original IHME1500 lithological classification. We agree that the wording could be misinterpreted and will therefore separate the individual classes using semicolons instead of commas.

*Section 5.5:*

*How did you combine this information with you catchment information? Considering the scale of the map you used what is the uncertainty on the class attribution?*

The hydrogeological classes were combined with the catchment representations by calculating the areal proportion of each class within each catchment, following the approach used in the CAMELS datasets. We agree that the relatively coarse scales of IHME1500 and MEDKAM introduce uncertainty in the resulting catchment attributes, particularly for small and geologically heterogeneous catchments. Reliably quantifying these uncertainties would require comparisons with more detailed hydrogeological maps, which are not consistently available across the study area. We will clarify the aggregation procedure and associated limitations for both products at the end of Sect. 5.5. This also fits well with the existing discussion of hydrograph-derived attributes included in ALPAKAS, which are expected to be more representative of the individual karst systems. We will additionally refer to the broader uncertainty discussion in Sect. 6.2.

*Section 5.5:*

*Same remark*

We will clarify this for both IHME1500 and MEDKAM in the revised manuscript, as outlined above.

*Section 6.1:*

*Thank you for discussing uncertainty, but this text is rather incomplete. You should mention here the uncertainty about the fact that the gaging station may in many cases not measure the complete discharge rate of the karst hydrogeological system, but only one outlet among several.*

*You should also mention that the uncertainty on low-water rates is often in the order of 100% or more at most stations (weirs with one single cross-section).*

*You should give an order of magnitude of the uncertainty you expect for the main part of the data: 10%, 20%?*

Thank you for these valuable suggestions. We agree that the discussion of discharge uncertainties was incomplete and will expand Section 6.1 to address these aspects in more detail, drawing on the suggested reference as well as additional studies. We propose to add the following passages to the revised manuscript to further discuss both uncertainties in discharge data and how well the monitored spring discharge represents the total outflow of the karst hydrogeological system. However, we would like to note that conducting station-specific quantitative uncertainty assessments is beyond the scope of this dataset:

*Discharge uncertainties arising from stage-discharge relationships can vary substantially between monitoring stations and across flow conditions. Focusing specifically on karst springs and rivers, Jeannin et al. (2026) analyzed 16 Swiss monitoring stations, of which eight are also included in ALPAKAS. They estimated relative uncertainties of approximately 5 % for flow conditions occurring around 60 % of the time, but substantially higher uncertainties of around 30 % during high-water conditions and at least 50 % during low-water conditions, sometimes approaching 100 %. This strong variation partly reflects the wide discharge ranges typical of karst springs, which can be difficult to measure accurately with a single-stage weir. To reduce uncertainties at extreme flows while maintaining generally low uncertainty, Jeannin et al. (2026)*

*recommend compound weirs with two or three stages. However, these estimates depend strongly on individual station characteristics and cannot be directly transferred to ALPAKAS. The importance of station-specific assessments is also illustrated by CAMELS-GB (Coxon et al., 2020), where rating-curve-related discharge uncertainty was quantified for 503 gauging stations based on an existing dataset of rating curves and stage-discharge measurements. Comparable quantitative uncertainty assessments for ALPAKAS would require detailed station-specific information on measurement methods, rating curves, and gauging infrastructure, which is not consistently available across the different data providers.*

*Beyond uncertainties in discharge measurements, karst systems often discharge through multiple outlets rather than a single spring. For example, intermittent overflow springs may become active only during major precipitation events and part of the discharge may bypass the station through subsurface flow, with relatively larger contributions during low-flow conditions (Jeannin et al, 2026). Monitoring stations located further downstream may capture a larger proportion of the total outflow of the karst system, but may also include additional contributions from surface runoff, as indicated in ALPAKAS. This uncertainty is not directly associated with the hydrograph itself but rather with how well the monitored discharge represents the total outflow of the karst system and its associated catchment.*

*L414: For which I did not find a clear definition. -> in fact it is explained in the appendix.*

We will move the appendix reference to make it clearer, where detailed information can be found.

*L415: What does "Sect. A" refer to?*

Thank you for this remark. We will correct the appendix reference by replacing “Sect. A” with “Appendix A”, consistent with the terminology used elsewhere throughout the manuscript.

*L417: Same question: is it chapter 3, Appendix 3 or anything else?*

"Sect. 3" refers to section 3 of the main manuscript, in accordance with the ESSD submission guidelines. However, we acknowledge that the previous use of "Sect. A" for the appendix label may have caused confusion and will correct the reference accordingly.

*Section 6.2:*

*Again, you should provide an indication about the expected uncertainty you assess for some general classes of the catchment you use. At least what is the lowest uncertainty you expect, the mean uncertainty and the largest one. It seems important that the reader and user of the data can know: the average uncertainty is in the order of 50% or 5%...*

We agree that quantitative uncertainty estimates would help users better assess the reliability of the provided catchment-scale variables. However, ALPAKAS includes a wide range of variables derived from different observational, reanalysis, and model-based products, with uncertainties varying substantially between variables, products, spatial and temporal scales, and individual catchments. We therefore believe that providing general minimum, average, and maximum

uncertainty estimates across these variables would hardly be sufficiently reliable, while a detailed quantitative assessment is beyond the scope of this dataset. Nevertheless, we agree that the discussion could give a better indication of uncertainty magnitudes. We will therefore expand Section 6.2 by including quantitative examples from published evaluations of reanalysis products in Alpine catchments (Wood et al., 2025). We also highlight that spatially and temporally resolved uncertainty estimates are directly available for some observation-based meteorological products, such as E-OBS (Cornes et al., 2018) and SLOCLIM (Škrk et al., 2020), but not consistently across all products included in ALPAKAS. Finally, we will clarify the limitations of transferring these estimates to ALPAKAS and emphasize that more comprehensive uncertainty quantification would require product- and catchment-specific evaluations and suitable reference data, which we identify as an important direction for future work.

*General comment:*

*Thank you for this huge effort, which is really valuable.*

*To my opinion, the question of uncertainty should be strengthened in future work, and this is something you could/should mention in your conclusion.*

*Ideally an uncertainty indicator should be attached to any single data value. I know that we are far from this ideal aim. Starting with some classes (e.g. <10%, 10-20%, 20-50%, 50-100%, >100%) would already be a huge advance.*

We really appreciate your feedback and agree that more systematic quantification of discharge uncertainty would be highly valuable. We believe that the responsible monitoring agencies could play an important role in assessing and documenting site-specific uncertainties, providing a better basis for assigning flow-dependent uncertainty classes to individual discharge observations as a first step. We will highlight this as an important direction for future work in the revised conclusion.

*L470-473: Not very clear: Is the catchment area assumed to be a circle with its lower border at the spring? Or is the catchment assumed to be a "piece of cake" with its edge at the spring? It would be useful for the reader to have a slightly more clear idea, without having to read Thinius et al. 2026).*

*In fact the answer is given indirectly in figure A1.--> please cite the figure here!*

We will add the reference to make the shape of the catchment approximation clear.

*L478-479: Not clear*

We intended to point out that, for 46 stations in our dataset, positive tracer detections at the spring were reported, but no corresponding expert-based catchment delineation could be included in ALPAKAS. We considered it important to mention this because readers familiar with karst hydrology may expect tracer-test investigations to be accompanied by, or provide a basis for, catchment delineations and may therefore wonder why no expert-based delineation is available for some springs with tracer-test evidence. This does not necessarily mean that such delineations do not exist; some may not have been identified during our literature review, while others may not

have been available for inclusion due to data-access or licensing restrictions. We agree that the original wording did not convey this point clearly and will revise the text accordingly.

*Appendix A:*

*Why did you select the circular approximation and not a "piece of cake" or even simply a triangle? The approximation would very probably be much better.*

Thank you for this critical remark. We selected a circular approximation because we aimed to use the simplest geometric representation that can be fully defined from the catchment size derived from the water balance, while allowing its placement relative to the spring to be specified separately. More complex shapes, such as a circular segment or a triangle, would require additional geometric parameters and assumptions that cannot be constrained consistently across all springs alone from the catchment size.

We acknowledge that a more flexible shape could provide a better approximation for individual catchments. However, karst catchments can have highly irregular and variable geometries, making it difficult to identify a single generic shape that would systematically outperform a circle. For example, the Source de Verneau shown in the figure could clearly be represented more closely by a circular segment. Nevertheless, our objective was not to reproduce the detailed geometry of individual catchments, but to provide a simple and consistently applicable approximation for estimating catchment-scale variables where expert-based delineations are unavailable.

*Appendix B1:*

*Your title says "data cleaning" but according to the text you kept the data, and only flagged the expected low-quality data. It this right. Maybe you should change the title?*

Thanks for this observation. We agree that "data cleaning" may imply that flagged data were removed or modified. We will therefore change the name of the subsection to "Manual data quality review" and adapt Figure B1 accordingly.

*L542-543: What does it mean? how is it "time-weighted"? If it is related to the beginning of the aggregation interval?*

We agree that the meaning of "time-weighted" was not very clear. The weighting refers to the duration of the intervals between consecutive observations and is not related to the time stamp convention used for the aggregated values. We will clarify this in the revised manuscript and also specify the applied maximum gap length, as suggested for the daily aggregation.

*L544-545: Why the beginning? If so, it means that the time stamp is systematically too early compared to the data it is supposed to reflect. However, I acknowledge that the potential bias is low (lower than one hour).*

Thanks for your remark. The time stamp at the beginning of the aggregation interval was used as labelling convention for hourly aggregates, as defined at the beginning of Sect. 4. This does not imply that the aggregated value represents the conditions specifically at that time. This convention is also used in other hourly hydrological datasets, such as LamaH-CE. The same

convention was applied when computing the hourly meteorological aggregates from ERA5-Land, as documented in the preprocessing code, thereby ensuring that the forcing data matches the discharge values. We therefore propose retaining this convention, while acknowledging that an alternative time stamp conventions would also be possible.

*L547: Does it mean that some daily values could result from no hourly values within the corresponding day? Are values with hourly gaps flagged? If hourly gaps is larger than 24 hours, will you have a daily gap?*

Thank you for pointing out the possible confusion with our formulation. Missing hourly values were linearly interpolated only between consecutive observations separated by no more than 24 hours, i.e. a maximum of 23 values can be interpolated. Under this criterion, each calculated daily value necessarily contained at least one observed value and could therefore not be based exclusively on interpolated values. Gaps between consecutive observations exceeding 24 hours were not interpolated and could consequently result in missing daily values. We will clarify the sentence.

*L548: What does it mean?*

By "nominally daily time series", we referred to time series containing one instantaneous observation per day, typically recorded at a fixed time of day, rather than a value representing the entire day. We will clarify this in the revised manuscript.

*L549-550: Not clear to me.*

Thanks, we will clarify the sentence.

*TableD3: How is it averaged over the catchment area?*

We appreciate your comment. Meteorological variables were spatially aggregated to the catchment scale using area-weighted arithmetic means, with raster cells weighted according to their exact fractional overlap with the catchment polygons. We will clarify this procedure in Sect. 4.2 and additionally in the caption of Table D3.

**Reply to Klaus Hinsby**

## General comments:

*Congratulations on completing this huge work, and thank you for providing access to and presenting this valuable dataset, which I highly recommend publishing as is, with only a few suggestions to consider:*

1) *It seems that all the countries covered in the ALPAKAS study have springs listed in the MIKAS-project of IAH: https://mikasproject.org/, which I know that at least one of the authors of the paper has contributed to. I suggest referring to the MIKAS project (e.g., in the hydrogeology section) and either presenting a table or a map listing which MIKAS springs are included among the ALPAKAS springs; this way, readers can link to the MIKAS project to get more detailed information on and impressions of selected springs.*

2) *In addition, I suggest mapping the investigated springs onto the IHME 1500 hydrogeological map as background and present it in a figure in the hydrogeology section.*

3) *The possibility of including the spring locations and providing FAIR data access to the compiled data via the map viewer of the European Geological Data Infrastructure (EGDI) should be explored. In this way, the spring data can be plotted on relevant (hydro)geological maps (Like IHME 1500) and compared to groundwater levels, recharge and quality data across Europe, available via the upcoming European Groundwater Monitoring Database etc. – this would enhance the value of the data for more integrated analysis of the evolution of groundwater quantity and quality together with other EGDI data and groundwater quantitative and chemical status assessments according to EU water policies.*

4) *Please write a small section on the availability of quality data from the springs; even if none or only little data exist, it is of interest to know if such data is available. I realise this is not the objective of the paper, but it would be helpful to know whether, e.g., monitoring of electrical conductivity or any pollutant data, are available somewhere. If quality data exist, information about where to access such data would be helpful for researchers investigating spring impacts on ecosystems or drinking water etc., e.g. in an appendix.*

Dear Klaus Hinsby,

Thank you for your helpful comments and suggestions. We will address the points you raised as follows:

1) We will add the Boolean attribute 'MIKAS_listed' to the ALPAKAS metadata file in the updated dataset and code repository, indicating whether the spring is listed among the globally important karst springs of the MIKAS project. We will also update the corresponding attribute description in Table D1 of the manuscript and refer to the MIKAS project in the main text.

2) We considered adding a map showing the spring locations overlaid on IHME1500 but believe that, given its relatively coarse scale and generalized hydrogeological information, it would provide limited additional value for our study focused on karst systems. To better characterize

individual karst systems, we derived hydrological indices directly from the preprocessed hydrographs and present their spatial distribution in Figure 4. The spring locations are also shown alongside the distribution of karst aquifers based on MEDKAM (Figure 1) and the structural tectonic units of the Alpine region (Figure 2). However, following your suggestion in comment 3, we are exploring the integration of the ALPAKAS spring locations into the EGDI platform, which would allow users to visualize them alongside other relevant (hydro)geological information, including IHME1500.

3) We agree that integrating the ALPAKAS spring locations into the EGDI platform would improve data accessibility and make it easier to visualize and compare the data with other (hydro)geological spatial information. We have therefore contacted the EGDI team and requested to include the ALPAKAS spring locations as a point layer to the platform. As the integration process may take some time, we will continue working towards this contribution beyond the current manuscript revision.

4) Thank you for this valuable suggestion. We agree that the availability of complementary water-quality data and their potential future integration into ALPAKAS should be discussed, particularly given its extensible design and the increasing inclusion of water-quality observations in other large-sample hydrological datasets (e.g., CAMELS-Chem, CAMELS-CH-Chem, QUADICA v2, and Caravan-Qual). We will therefore add a new appendix section (Appendix C) and refer to it in the main text. In this section, we will briefly outline the availability of water temperature and electrical conductivity time series, which can be obtained from various monitoring networks that also provided discharge data for ALPAKAS. Incorporating such observations could be a first step towards extending ALPAKAS with water-quality data in the future. We will also note that other chemical parameters, such as nutrients and pollutants, are less consistently available and typically measured through periodic sampling. We will refer to complementary datasets containing water-quality observations from karst springs and springs in the Alpine region. Finally, we will highlight the potential value of such data for better understanding hydrological and hydrochemical processes and assessing the vulnerability of karst systems.

**Reply to Ruben Carl Kubina (community comment)**

## General comments:

*Thank you for the excellent dataset and for your work.*

*I have a few comments regarding the dataset and the preprint.*

1. *The attribute `ALPAKAS_ID` is spelled differently in the files `ALPAKAS_station_meta.csv` and `catchment_approx.geojson`.*
2. *The attribute `catch_expert_shp` is set to "false" for every spring, even though you provide the delineations of 151 expert delineated catchments.*
3. *In the attribute `area_catch_expert` there are many zeros that should likely be replaced with "NA".*
4. *I found one discharge time series of a daily station in the hourly stations folder (FR-0001) with wrong labels of `temp_res`. For this measuring station, the hourly and daily values should be identical, but they differ from one another. Perhaps you could double-check whether the hourly monitoring stations actually have an hourly resolution.*
5. *In appendix A, you could describe in more detail which variables were used for the water balance to estimate the recharge area. In your code you use the total precipitation, the total evaporation, surface runoff, snow depth water equivalent, and the soil water. However, it is not clear to me whether all of the variables are actually used for the provided approximate catchments*

Dear Ruben Carl Kubina,

Thank you for your detailed comments on the dataset and code. We find them very valuable and appreciate your contribution. We will address the points you raised as follows:

1. Thank you for pointing this out. We will correct this in the GEOJSON files to consistently use "ALPAKAS_ID".
2. We will correct this metadata in the dataset.
3. Thank you for highlighting this issue. It affects catchment delineations that could not be published due to licensing restrictions but for which we provide catchment attributes. We will correct this so that the actual catchment areas are displayed instead of zero values for those sites.
4. Thank you for making us aware of this error. This time series is actually only available at daily resolution. The observations were incorrectly assigned a time of 00:00 and subsequently aggregated using time-weighted averaging, resulting in daily values that differed from the original observations. We will correct this by providing the original daily observations and updated static hydrological attributes in a revised dataset version on Zenodo. We will also update the corresponding metadata in the data and code repositories. In addition, we will correct the number of hourly time series to 182 in the revised manuscript.

5. We agree that this could be made clearer and will specify in the appendix of the revised manuscript that the water balance estimate accounts for precipitation, evapotranspiration, and changes in soil water and snow storage. Please note that surface runoff is not included and is therefore disabled in the corresponding code. We will make this more explicit in the code.