The work of Gentile et al. investigated the causes for young water fraction (F_{yw}) variations with elevation (F_{yw} is low at high altitudes) in Alpine catchments. The study areas are 27 catchments in Switzerland and Italy. The authors proposed new criteria for catchment classification into different hydro-climatic regimes. To gain insight into the reason for F_{yw} variations with elevation, this author used a new set of hydrological variables, namely the fractional snow cover area (F_{SCA}), the fraction of quaternary deposits (F_{qd}), and the fraction of baseflow (F_{bf}). In general, the idea of this paper about what drives F_{yw} variations with elevations is novel and of interest for understanding the functioning of catchments in Alpine regions as well as for understanding flow and transport in this region and potentially in other areas. However, the methodology and results do not fully support this idea. The text was not well written. Please find my main comments and line-by-line comments below.

Dear referee #1,

We would like to thank you for the overall positive assessment and the numerous detailed comments, which will contribute to our manuscript's improvement considerably.

Please find below a point-by-point response to both your main and minor comments. We will incorporate all your constructive feedback once we receive the editor's response.

Sincerely,

The Authors

Main comments

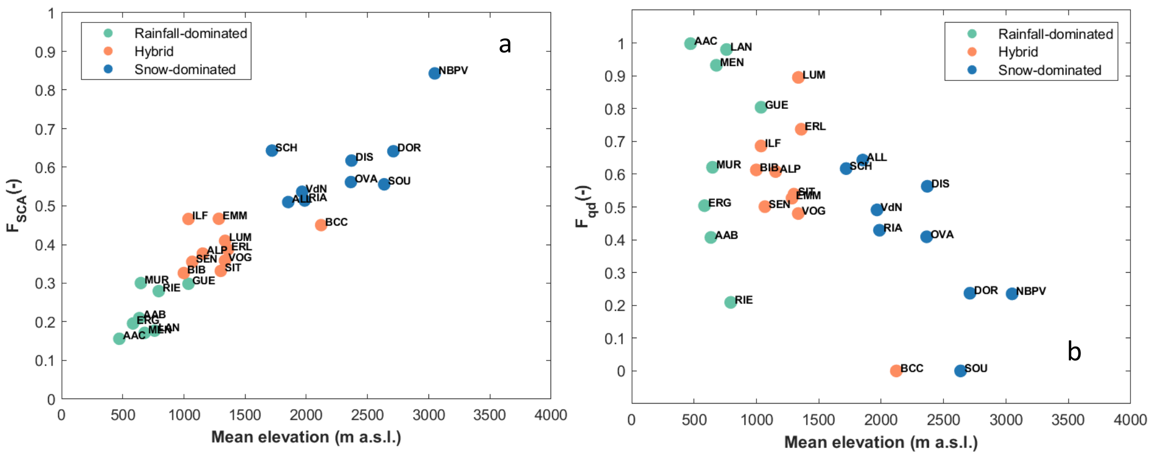
- *Why did the authors need to propose a new criterion for catchment classification? The authors used two variables: (1) streamflow ratio between different months and (2) snow cover fraction for the proposed catchment classification, but later they adjusted the threshold of these two variables to have consistent results with Staudinger et al. (2017). Why didn't they just use the method of Staudinger et al. (2017)?*

- **We propose a new criterion for the regime classification because our dataset includes catchments outside the Swiss borders (i.e., the four Italian catchments) for which the Weingartner and Aschwanden (1992) and Staudinger et al. (2017) classification scheme cannot be strictly applied since they were designed for the Swiss hydro-climatic regimes. We "manually calibrate" the thresholds of F_{SCA} and Q_{June}/Q_{DJF} for classifying catchments in "rainfall-dominated", "hybrid" and "snow-dominated" as in the work of Staudinger et al. (2017). In this way, the classification scheme is "calibrated" on the Staudinger et al. (2017) catchments and we can apply it also outside the Swiss borders. According to the referees' comments, we will consider the possibility of modifying the classification scheme to make it more straightforward to link to previous classification (e.g., using streamflow and topographical data), but it will remain transferable to other regions.**

- *The objective is to investigate what drives F_{yw} variation with elevation. The authors proposed using a new set of hydrological variables, but what are the relations between these variables with elevation? For example, what are the relations between F_{SCA}, F_{qd}, F_{bf} with elevation? With F_{SCA}, I can infer from the text, but it was not explained in the text until the last sections (Section 5.2) of the manuscript. F_{SCA} cannot be directly related to elevation, instead, it needs to be related to the catchment classification then from catchment classification to mean elevation. However, in other areas, can we still relate F_{SCA} to elevation? With the other variables (F_{qd} and F_{bf}), it is unclear to me what are their relations to elevations. In addition, F_{qd} does not seems to be a good variable because there is no significant relation between F_{yw} and F_{qd}.*

- **Thank you for this comment: this is a good point. We will add, for each variable (F_{SCA}, F_{qd} and F_{bf}), a figure that shows the relation with mean catchments elevation. The three figures are reported here below, and we will include them in the revised manuscript.**

a) **The F_{SCA} increases with the mean catchment elevation in our data set, revealing a positive, statistically significant correlation. This suggests the increasing snow cover persistence at high altitudes.**
b) **F_{qd} decreases with the mean catchment elevation in our data set, revealing a negative, statistically significant correlation. This negative correlation reflects the fact that F_{qd} decreases when the mean slope increases (Arnoux et al., 2021) (mean slope increases with mean elevation for the catchments analyzed in this study, as shown in Fig. 4a of the manuscript). We have decided to use F_{qd} because Arnoux et al. (2021) demonstrated a strong positive correlation between F_{qd} and Winter Flow Index (WFI) highlighting the role of unconsolidated deposits in storing groundwater (in terms of age, old water). The missing information about the portion of fractured bedrocks, the thickness of quaternary deposits and the bedrock topography will demand future attention for a complete picture of the role of geology (potentially resulting in a statistically significant correlation with F_{yw}).**
c) **F_{bf} reveals an opposite behavior with respect to F_{yw}: it decreases until 1500 m and it increases at higher elevations.**



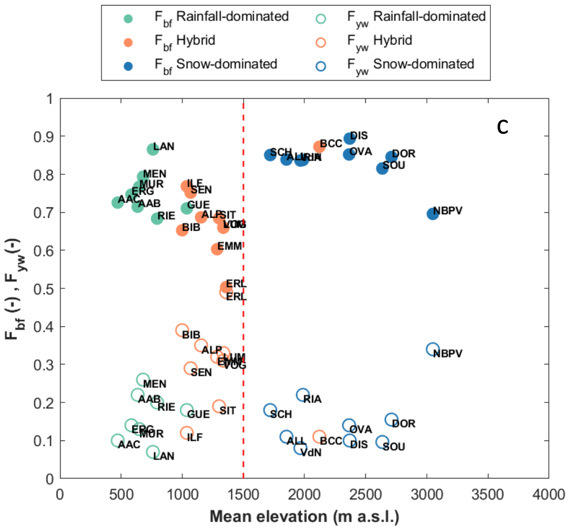


Figure 1 a) F_{SCA}, b) F_{qd}, c) F_{bf} and F_{yw} against mean catchment elevation

- *The manuscript needs to be restructured and revised. There is a lack of clarification in the text. More description of the study area characteristics is needed. Much of the information provided in Study Sites, and Material and Methods is not relevant (e.g., shape file, detailed source of data, etc.). Instead, citing the sources of the various data (both from individuals and organizations) can be moved to either the Authors' Contributions or Acknowledgements, or in the supporting information Sections or to a table rather than describe them within the text of the article, making it very difficult to read such detailed information. If possible, I would also suggest the authors publish their data in an open repository.*

- **Thank you for these suggestions. We will revise the “Study sites” and “Material and Methods” sections accordingly. We will move all the data sources in the “Data availability” section and remove irrelevant information. We will describe the study sites in a more concise manner using a Table and some descriptive figures: e.g., mean slope against mean elevation, mean annual precipitation and mean annual discharge against mean elevation, variations of mean monthly flow with elevation. These changes should make the text more fluent.**

Minor comments

Title: “F_{yw}” could be changed to “young water fraction” for general readers.

Thank you for suggesting this. We will change “F_{yw}” in the title.

L14: “The young water fraction (F_{yw}),..., is increasingly used in hydrological studies, replacing the widely used Mean Transit Time, which is subject to aggregation error.” This sentence provides misleading information. I think F_{yw} cannot replace Mean Transit Times (MTT) since the two characterize different aspects of the transit times, e.g., F_{yw} contains information about the younger part of the TT distribution (how much water in outflow is younger than 0.2 years) while MTT contains *information about the whole TT domain. "Aggregation error" could be changed to "aggregation bias".*

Thanks. Our statement was indeed not precise. We wanted to say that, before the work of Kirchner (2016 a,b), the Mean Transit Time (MTT), obtained with convolution, was used in catchment intercomparison studies. After that key paper, it is generally replaced with F_{yw} that, of course, does not provide the same information as MTT. To avoid misunderstanding, we will change the sentence simply by writing: "The young water fraction (F_{yw}), defined as the fraction of catchment outflow with transit times of less than about 2-3 months, is increasingly used in hydrological studies. The use of this new metric in catchments inter-comparison studies is helpful to understand and conceptualize the relevant processes controlling catchments' hydrological function."

L33-34: The sentence "..Fbf, considered…complement of F_{yw}" does not clearly show the relation you found between F_{yw} and the baseflow fraction. Please be clearer about what you mean by explicitly saying that F_{bf} is a good proxy for F_{yw} as the higher F_{yw} is, the lower F_{bf}.

Thank you for this recommendation. We will explicitly say that F_{bf} is a good proxy of F_{yw}.

L44: "the streamflow is older than the annual snowmelt" is not clear to me, what is the age of streamflow and the age of snowmelt water in this case?

We will clarify this sentence: "However, early work in the Swiss Alps showed that high celerity is caused by a massive meltwater infiltration that pushes out groundwater reserves: streamflow following snowmelt is older than meltwater infiltrated in the current year (Martinec, 1975)."

L46: why "even"? I would expect exactly that during the absence of rainfall and snowmelt the streamflow is mainly sustained by groundwater.

We wanted to underline that the hydrograph separation results show that the hydrograph is generally mainly composed of old water at the peak flow. Of course, during no-rain and no-snowmelt periods we expect that streamflow is mainly sustained by groundwater and this is also confirmed by our results. We will change "even" with "especially" to be clearer.

L46-50: The two sentences here do not seem to be connected, one about residence time and the next one about transit times.

Of course, the transit time distribution and the residence time distribution are two separate concepts. Nevertheless, the streamwater age is influenced by the storage age depending on how much the storage contributes to the stream. However, we will separate the two sentences to avoid confusion.

L53: "Kirchner (2016a, b) proposed a new metric to quantify water age at the catchment scale". I think you are mentioning the F_{yw}, I don't think this is "the water age at the catchment scale" but the amount of water with age < 0.2 years. How can we know the "water age at the catchment scale "only based on the amount of water in outflow (discharge) that is < 0.2 years? For example, if F_{yw} = 0.2, what is the "water age at the catchment scale"

We wanted to say that MTTs, obtained with the classic convolution approach, are no longer used since they are subject to the aggregation bias. However, we can say something reliable about water age using a new metric: the young water fraction, that is calculated at the

catchment scale. Of course, F_{yw} is not giving the same information of MTT. We will rephrase the sentence: "Kirchner (2016a, b) proposed a new metric to quantify the share of catchment outflow with transit times lower than 0.2 years: the young water fraction (F_{yw})"

L55-58: please revised the sentence structure

We will revise the sentence structure: "It can be conveniently inferred from the dampening effect that a catchment has on the seasonal cycle of stable water isotopes in precipitation, i.e. by estimating the amplitude ratio of the seasonal cycle of stable water isotopes in streamflow to that of precipitation (Kirchner, 2016a). The F_{yw} concept is increasingly used in hydrological studies because it has the advantage of being free from the aggregation errors inherent to Mean Transit Time (MTT) obtained through the convolution approach (Kirchner, 2016a)"

L58-59: please see my comments on line 14

We will adapt following our answer to line 14.

L70: "In line with these findings" can be removed because Lutz et al. (2008) did not state that F_{yw} above 1500 m decreases

Yes, you are right. Lutz et al. (2018) did not state that F_{yw} decreases above 1500 m a.s.l., but they said "In agreement with the results from the global study of European catchments, there is a slight tendency toward smaller F_{yw} values for the subcatchments in the mountainous region". Therefore, to be more precise, we will substitute "In line with these findings" with "Moreover".

L82-83: "…more efficient groundwater recharge, consequently reducing or increasing the young streamflow…" It is not clear to me, should it be "reducing" only instead of "reducing or increasing"?

Ceperley et al. (2020) said: "our highest elevation study site (NBPV) deviates from this trend by yielding a higher F_{yw}, it is too early to draw the conclusion that low F_{yw} could be due to seasonal versus intermittent snow cover dynamics alone." So, we remain vague in the introduction saying "reducing or increasing". From our results presented at the end of the manuscript, we can say that seasonal snow cover favors the groundwater storage emptying during winter and the groundwater storage recharge (because of meltwater infiltration) during summer, thus reducing the young streamflow reaching the stream.
We will put "reducing" partially anticipating the results.

L88: "…remarkable fraction of groundwater…" it is a bit vague, could you please be more precise?

To be more precise, we will specify the average percentages of groundwater according to the cited works: "Several catchments located in the Rocky Mountains and Andes mountain ranges show that , on average, about 47% of groundwater annually sustains the streamflow (Saberi et al., 2019; Somers et al., 2019; Carroll et al., 2018; Harrington et al., 2018; Cowie et al., 2017; Baraer et al., 2015; Gordon et al., 2015; Frisbee et al., 2011; Liu et al., 2004; Clow et al., 2003; Baraer et al., 2009). Similar result is also found in the Himalayas (49%) and Alps (48%) mountain ranges (Chen et al., 2018; Engel et al., 2016; Käser and Hunkeler, 2016; Williams et al., 2016; Wilson et al., 2016; Andermann et al., 2012)"

L91-92: "…a dynamic storage contribution to streamflow…" Please clarify this term.

We will rephrase this sentence: “There is however still a lack of understanding regarding the mechanisms that lead to a rapid mobilization of old water during storm events and a variable chemical signature depending on the flow regime (Kirchner, 2003). One key to understanding these mechanisms is the concept of dynamic storage, i.e., the storage that controls the streamflow dynamics.”

L99: Why don’t the authors use a new set of hydrological variables (F_{SCA}, F_{qd}, F_{bf}, WFI) in combination with traditional variables to gain new insights into the F_{yw} along elevation gradients?

We do not know what is meant by "traditional" variables. However, we decided to use variables that were not previously considered for explaining F_{yw} elevation gradients. This is also because Jasechko et al. (2016) wrote: "Although topographic gradient provides the strongest correlation with young streamflow fractions in our data set, the fraction of unexplained variance is large, suggesting that other variables also play a significant role. We observe no significant correlation between the young streamflow fraction and catchment size, annual precipitation, bedrock porosity, population density, or the fraction of catchment area comprised of pasture land or open water". We will clarify this in the revised version.

L104: “…into three hydro-climatic regimes proposing a new criterion of classification…” Why? I think a brief explanation is needed.

Please see our answer to your first main comment. We will add a brief explanation.

Sections 2 and 3.1: Both sections about the data (e.g., Section 2: existing data, additional dataset, complete data, and Section 3: discharge data and catchment boundary), why do the authors need two different sections? The data description section (entire section 2) needs to be restructured and revised to make it more concise and clearer. I think this can be done using a table. In the text, the authors could summarize and report key information, so the reader does not have to search through the many sources you have cited. The authors can here focus more on catchment attributes, such as climate (e.g., average annual precipitation and discharge), land use cover, geology, and discharge.

Thank you. The structure suggested can improve the paper readability. We will restructure Section 2 according to your comments. We will condense existing data, additional dataset and complete data sections in a single section. Moreover, we will move all the data sources reported in Section 3 to the “Data availability” section. We will improve the study site description summarizing the main topographic and hydro-climatic quantities in a table and some figures (please see our answer to your third main comment). Furthermore, we will summarize the description of this information in a paragraph that will be more fluid for the reader that will find all the relevant information about the study sites in a single section.

“Furthermore, 21 out of the 22 … (Staudinger et al., 2017)”. This part is not relevant in my opinion.

You are right. We will remove this part.

“Two high-elevation catchments … Arnoux et al., 2021)”. This part is not relevant in my opinion.

You are right. We will remove this part.

L147: In my opinion, the "Complete Dataset" subsection is not necessary. It is sufficient to illustrate the existing data in subsection 2.1 and conclude the section with 2.2.

Good idea. We will do as you suggest.

L156-160: Like von Freyberg (2018) … are reported in Table 1. If subsection 2.3 is deleted, move it to 2.2 as the final sentence.

Yes. We will do as you suggest.

Figure 1: the background cannot be easily seen; I think you could replace with a DEM map. In addition, I cannot differentiate between Quaternary deposits and hybrid catchments visually.

We will change Fig.1 according to your suggestions. We will use a DEM map as background, and we will change the quaternary deposits and catchments colors to make them clearly distinguishable. A first attempt of the new Fig.1 is reported here below:

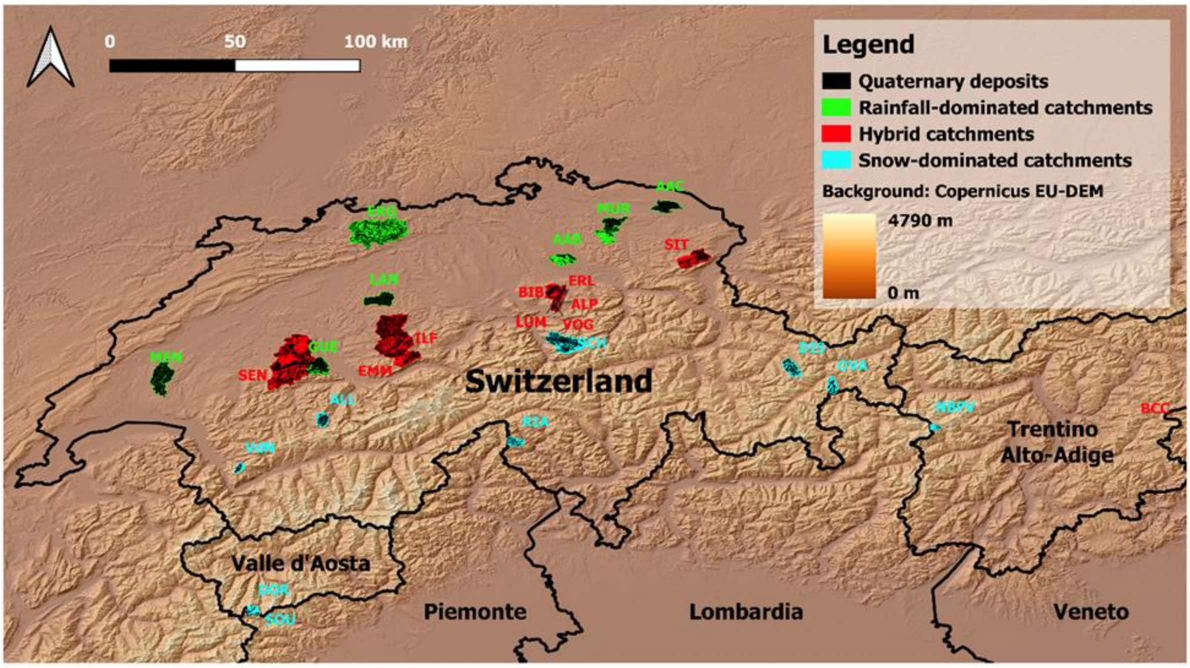


Figure 2 First attempt for the new Fig. 1

Table 1: I am curious to see the relation between average elevations and average slopes for the 27 catchments, is there a positive correlation? (also for average elevation with annual precipitation)

We will insert these two figures in the "Study sites" section and we will comment on them. Average slope ranges from 4° to 34° and our study sites reveal an increase of steepness with elevation showing a positive correlation. Precipitation increases with elevation until 1500 m a.s.l. and it decreases for higher elevations highlighting a change of precipitation regime as described by previous studies (Santos et al., 2018)."

Section 3.1: Here, I would expect more description of the discharge dynamics (e.g., giving an order of magnitude to these data by telling what is the annual discharge, whether the runoff is seasonal, etc). I would suggest moving the description of how discharge was measured and derived to the *appendix. The source of data could be combined into the same table suggested for section 2 (or move to the appendix or data availability section).*

Thank you for these suggestions. As said before, we will move all the info about the data sources to the "Data availability" section and we will describe in detail discharge dynamics in the "Study sites" section.

Line 190: I suggest mentioning the study period for the isotope data and F_{yw} *for the different study catchments since it is different.*

Thank you for this recommendation. The table reported in the "Study sites" section could be a good place for inserting this info.

Figure 2: In summer there is a higher average monthly flow from snow-dominated catchments than from rain-dominated ones (due to increased snowmelt, I suppose), and in winter it is the other way around. Please explain this better in the text because it is not clear. In addition, it is not easy to differentiate between the three boxplots, I would suggest having three separated boxplot figures with the same y axis limit. This figure should be described in the text (there is no description of this figure, it was only cited in line 243)

We will subdivide the figure in three subplots and we will explain it better in the text. Specifically, snow-dominated catchments reveal a higher average monthly flow during summer than during winter due to the increased snowmelt. This difference is less marked for hybrid catchments due to a quite homogeneous distribution of flow over the summer and winter seasons: this is because the contribution of both rainfalls and snowmelt events are relevant for streamflow generation processes of these catchments. Finally, rainfall-dominated catchments show a higher average monthly flow during winter than during summer because of the almost total absence of summer (i.e., delayed) snowmelt.

L197: no comma after "where"

Thank you.

L221: As I understood from the text (before and after this line), there is indeed a "formal" classification method

Yes, there is a formal classification method proposed by Weingartner and Aschwanden (1992), but it was designed for Switzerland. The regimes defined by Weingartner and Aschwanden (1992) were grouped by Staudinger et al. (2017) in three categories: rainfall-dominated, hybrid and snow-dominated.

Section 3.3: After reading the entire manuscript up to section 3.3. I am not clear why the authors need to classify streamflow into three regimes and why the classifier should be based on snow-related characteristics (e.g., snow cover area).

Please see our answer to your first main comment. Moreover, we think that a classification that uses snow-related characteristics is suitable since what drives the regime changes is the increasingly important role of snow.

L240: should it be "it is expressed in mm per unit area and time step"?

We will rephrase the sentence: "Considering the data set investigated by Staudinger et al. (2017) as a starting point, we compare the monthly streamflow (flow is relative to catchment area: i.e., it is expressed in mm per time step)..."

L251: "…more than weekly…" do you mean biweekly?

We will rephrase: "Temporally, this relatively recent satellite has increased the visitation frequency to a sub-weekly temporal resolution…"

Eq: (5) the denominator ($N_{tot} - N_{clouds}$): This could result in an overestimation of f_{SCA}. What is the maximum fraction of cloud cover in these images?

We follow the approach of Hoffmeister et al. (2022) and Di Marco et al. (2020) that define f_{SCA} as $N_{snow}/(N_{tot}-N_{clouds})$. They did not comment on the effect (i.e., underestimation or overestimation) of the mathematical expression of f_{SCA} on their results. If the two detection algorithms (snow detection and cloud detection) would work with a 100% accuracy, values greater than 1 cannot be encountered. In fact, the maximum cloud cover fraction can also be very close to 1 in some dates (e.g., > 90% as encountered in our data set), but if the snow detection algorithm works well N_{snow} will be at most "complementary" to N_{clouds} (i.e., $N_{snow} + N_{clouds} = N_{tot}$) and f_{SCA} will be at most 1. Sometimes these algorithms can result in a misclassification and f_{SCA} values > 1 can be encountered: i.e., $N_{snow} > (N_{tot}-N_{clouds})$. Our approach was to set $f_{SCA} = 1$ if $f_{SCA} > 1$. The authors will deepen if this approach can overestimate the f_{SCA} and, if so, we will think about the application of an alternative approach.

L276-279: The error in f_{SCA} is still there with the "moving window" approach, it is just smoothed. Anyways, at the end, you calculated the average f_{SCA} over the whole period so applying "moving average on a window" does not have any effect?

Of course, the average of the series after the application of the moving average (that is what we call F_{SCA}) is not the same as the average over the original series.

L282-289: "Some authors have revealed … F_{yw} in Alpine catchments". This is more suitable for Introduction than Methodology. In addition, what is "key possibility"? Does it mean "high possibility"

Thank you for this comment: it is a good idea; we will move this part to the Introduction. With "key possibility" we wanted to express "the importance" of quaternary deposits (moraines, alluvium, and talus) in storing groundwater. We will change this expression.

L292: … 23 Swiss catchments … Is F_{qd} calculated only for 23 sub-catchments, while WFI and F_{bf} for all 27? Why? How does it affect the interpretation of the results? Be clearer about which indices are available for each study site.

We have written: "Operatively, for the 23 Swiss catchments of our dataset, we calculate the portion of the catchment area occupied by quaternary deposits using the Geological Atlas of Switzerland…" The number "23" refers to catchments located in Switzerland because, for these catchments, we have used the GeoCover dataset for estimating the area covered by quaternary deposits; for the remaining four Italian catchments we have used regional geological dataset. F_{qd} ,WFI and F_{bf} are calculated for all the 27 catchments.

L299-301: For the DOR and SOU … provided by Dr. Giulia Zuecco. This part is not relevant here, should be moved to the data section.

Thank you for this recommendation. We will move this part to the data section.

L315-318: "For VdN, NBPV and BCC catchments we consider the time windows … we consider discharge measurements in the period November 2017 - January 2022". I think you should indicate at the beginning the different study periods, because it is confusing to read a lot of data (e.g., stable isotopes of water, F_{yw}, streamflow...) and indices (e.g., F_{qd}, WFI, F_{bf}) for your methodology and find out that your study areas were analyzed in different periods. You should say this explicitly each time you mention a new data item or index or create a table in which you explain it.

Thank you for this recommendation. We will insert this info in the Table reported in the "Study sites" section.

Section 4.1. I think this can be moved to the data section or supporting information, as this is only for 2 catchments.

Thank you for this suggestion. We will move this part to the Supplementary Material.

L334-335: "these have the same names as the ones proposed by Staudinger et al. (2017 but the classification is not based on the same criteria" why? I think should be explained earlier in the methodology section.

Please see our answer to your first main comment. We will explain this point earlier in the methodology section.

L336-337: "In order to achieve a classification as consistent as possible with that of Staudinger et al. (2017), but based on these two variables, we propose the thresholds presented in Table 2:" I cannot understand why. If the authors want to have consistent results with Staudinger et al. (2017), why did not they use the method proposed by Staudinger et al. (2017)?

We propose a new criterion for the regime classification because our dataset comprises catchments outside the Swiss borders (i.e., the four Italian catchments) in which the Weingartner and Aschwanden (1992) and Staudinger et al. (2017) classification scheme cannot be strictly applied since they were designed for the Swiss territory. Therefore, we decided to design a new classification scheme based on F_{SCA} and Q_{June}/Q_{DJF}. We "manually calibrate" some thresholds of F_{SCA} and Q_{June}/Q_{DJF} for classifying catchments in "rainfall-dominated", "hybrid" and "snow-dominated" as in Staudinger et al. (2017). In this way we "calibrated" the classification scheme on Staudinger et al. (2017) catchments and we can apply it also outside the Swiss borders.

L345-346: "Following our classification scheme, … and 9 snow-dominated catchments". How do you compensate for the fact that the catchments data belong to different periods?

F_{SCA} is calculated for all the catchments in the same period (2017-2021). Q_{June} and Q_{DJF} are the average values of June discharge and the sum of December,January and February discharge for periods that can be different from one site to another. We suppose that by calculating the average values we are capturing the typical Q_{June} and Q_{DJF} so that the classifiers are comparable for the different sites, also if they are referred to different periods.

L353: "snow-regime" should be explained here

We have written:" This result suggests that the easy-to-calculate Q_{June}/Q_{DJF} ratio is a good predictor of the snow regime, here represented by F_{SCA}". The term snow-regime is here used to describe the snowpack persistence. In fact, we consider the snowpack persistence as represented by F_{SCA}.

L354: "for the first order estimate of the second classifier" what does it mean?

It means that, inverting the exponential relationship we have obtained (indicated in Fig.3 of the manuscript), it is possible to calculate F_{SCA} from Q_{June}/Q_{DJF}.

"Section 4.3: New explanatory variables for the F_{yw} elevation gradients" I would expect all subsections in section 4.3 will use variables that are related to elevation to explain the relation between F_{yw} with elevation. However, I cannot see what is the relation between the variables in the section title (e.g., Section 4.3.1. Fractional Snow Cover Area (f_{SCA}) and F_{yw}) and elevation (Please also see my main comments)

We will follow your suggestions and we will insert, for each variable, a figure that relates the variable with elevation.

L361-368: part of this information was already described in the introduction, can be removed here or merged into the introduction.

Thank you for this suggestion. We will merge this part in the Introduction.

L389-391: Our results ... for hybrid catchments (median F_{yw} of 0.32) ... Why are there these differences? I suggest arguing and explaining them.

We have structured the manuscript so that in the "Results" section we minimally discuss the results that are explained and argued in the "Discussion" section. In fact, the difference in median values of F_{yw} for hybrid and snow-dominated catchments can be explained considering the perceptual model reported in Section 5.2. However, we will add an explanation referring to the differences about these median values.

Figure 4a can be moved to the data section, figure caption: "the horizontal bars correspond to +/- standard deviation" of slope or elevation?

Thank you for the suggestion. We will move the figure to the data section. The horizontal bars correspond to +/- standard deviation" of slope.

L367: "Despite this" why should an increase in slope with elevation result in a correlation between Fwy and slope?

Thank you for this comment. This is probably a typo. We could expect a negative correlation between F_{yw} and slope because of the results of Jasechko et al. (2016): "...topographic gradient provides the strongest correlation with young streamflow fractions in our data set…"

L393: "lowering" could be changed to "decreasing of F_{yw} with increasing F_{SCA}"

Thank you.

L408: Why were the two catchments with F_{qd} = 0 is excluded? why do the group need to have features as close as possible to those used by Arnoux et al. (2001)

We are assuming that groundwater is stored by unconsolidated sediments and we want to understand the role of unconsolidated sediments in modulating F_{yw} elevation gradient. If we include catchments with F_{qd} = 0, we are biasing our analysis since, for these catchments, of course F_{qd} cannot have a role.

Section 5.1. I would expect here a discussion about the advantages of the new classification compared to other approaches (e.g., Staudinger et al., 2017), especially when the focus of the study is to understand what drives F_{yw} variations with elevations. The text written in this section does not seem to be relevant to this study.

Thank you for the suggestion. We will discuss the advantages of the new classification reported in the answer to your first main comment (i.e., it can be applied also outside the Swiss borders and the F_{SCA} can be estimated from Q_{June}/Q_{DJF} inverting the equation obtained in this study). We will consider moving this part to an Appendix or Supplementary Material.

L473: How does your work harmonize with previous results? I suggest expanding this point by making it clearer and highlighting the novelty of your work compared to the previous studies.

Thank you for this suggestion. We will explain better how our results harmonize with previous studies and how our work sheds light on the literature gap about the processes hidden behind low F_{yw} values in high-elevation catchments. Section 5.2 is rich of references to past works that support our perceptual model and the reviews to the present manuscript gave us further suggestions about the linkages of our study with previous findings: they will be integrated in the manuscript.

L477: "increase of precipitation and slope with elevation (Fig.12a, Fig. 4a)" I cannot see this in these figures

Precipitation is indicated by the point color (with the relative colorbar). However, we will add a plot of annual precipitation against elevation.

L483: higher up sounds odd. Simply say upstream.

Thank you.

L484-486: Therefore, it is more likely that ... possibly ephemeral, snowpack. I do not see a connection between these two statements. If you are saying that lower-order (i.e., more downstream) channels release greater amounts of old water than higher-order (i.e., more upstream) channels, why do you say that water age decreases with elevation? Please clarify this point.

This sentence refers to the discussion about the rising limb of the F_{yw} vs F_{SCA} bell-shaped relationship. In other words, for rainfall-dominated and hybrid catchments with ephemeral snowpack, water age decreases with elevation:

- **The increase of precipitation with elevation and the reduction of evaporation with elevation, due to reduced temperatures, promote wetness conditions that increase F_{yw}.**
- **Considering the Strahler's stream order, lower order channels, upstream, are more rarely activated (e.g., because of intense rainfall/snowmelt events) draining young water.**

Vice versa, higher order channels, downstream, are more often active (e.g., because of low/medium rainfall/snowmelt events) and inclined to drain more old water.

- **The limited number of snowfall days and the mid-winter melt (due to an ephemeral snowpack) reduce the snow accumulation. Such a snowpack does not protect the underlying soils from freezing thereby inhibiting infiltration and favoring rapid flow paths during mid-winter melt/rainfall events, with subsequent increase of F_{yw}.**

L493: "a persistent, deep snowpack can promote deep vertical infiltration by insulating the soil and thereby preventing freezing" do you mean this happens in winter? If in winter, there might be only snow, how can it be melted and promote deep vertical infiltration? Where is the source of water for vertical infiltration?

The persistent and deep snowpack prevents soil freezing during winter so that during snowmelt onset in spring, meltwater can infiltrate and recharge the groundwater storage. This will be made clearer.

L495: what's a temporal concentration? Make it clearer.

We have written: "The resulting effect on water partitioning between the surface and the subsurface has however to be analyzed in light of the temporal concentration of water input on the snowmelt period and remains largely unexplored to date (Rey et al., 2021)"

Temporal concentration: the time-interval in which the snowmelt enters the system as water input.

L499-501: This is for the karst area, how relevant is it for your area?

In our dataset we have two dolomitic catchments: BCC and OVA. We will specify this in the text.

L518: I suppose the fast flow paths are due to the fact that the glacier acts as an impermeable layer and thus promotes rapid overland flow? Please explain what you mean.

This comment refers to a possible explanation of the high F_{yw} for the glacier-covered catchment. The current text reads as "Such (glacier-covered) catchments could show fast flow paths and small storages as e.g. discussed in the work of Jansson et al. (2003), reviewing glacier-dominated environments. Moreover, reduced baseflow during winter can be related to increasingly high temperatures causing the glaciers retreat, thus reducing and anticipating the glacier melt fluxes that possibly recharge groundwater (Hayashi, 2020)". We will rephrase to:
"The high F_{yw} of the high elevation glacier-covered catchment can be explained considering that the glacier-melt produces high amounts of streamflow that transit the glacier-system very quickly during the summer and only limited water storage capacity in the glacier forefield (Muller et al. 2022). Accordingly, fast flow paths and small storages were described reviewing glacier-dominated systems (Jansson, 2003, Ceperley et al. 2020). Schmieder et al. (2019) also found a high F_{yw} in an Austrian glacier-covered (35%) catchment leading to the conclusion that the basin behaves like a 'Teflon basin' with fast transmitted ice melt, also if this behavior is distributed in space (i.e., part of the catchment defined "sponge" behaves differently delaying the release of water).

Figure 13: Which subfigure is for lower altitudes (< 1500m) and which one is for higher altitudes? Figure caption: the word "panels" can be removed because I thought a panel always consists of two subfigures (e.g., the lower panel contains two subfigures c,d)

Subfigures titled with "Ephemeral snowpack" refer to lower elevations, while subfigures titled with "Seasonal snowpack" are for higher elevations. We will remove the word "panels" as suggested.

L531: "unconsolidated sediments are not the only…" could be changed to "water storage in unconsolidated seidments are not the only …"

Thank you.