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.

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)?

- 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}.

- 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.

Minor comments

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

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".

L33-34: The sentence "..F_{bf}, 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}.

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?

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

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

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"

L55-58: please revised the sentence structure

L58-59: please see my comments on line 14

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

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"?

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

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

L99: Why don't the authors use a new set of hydrological variables (Fsca, Fqd, Fbf, WFI) in combination with traditional variables to gain new insights into the Fyw along elevation gradients?

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

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.

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

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

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.

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.

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.

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)

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).

Line 190: I suggest mentioning the study period for the isotope data and Fyw for the different study catchments since it is different.

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)

L197: no comma after "where"

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

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).

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

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

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?

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

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

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

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.

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, Fyw, streamflow...) and indices (e.g., Fqd, WFI, Fbf) 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.

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

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.

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)?

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?

L353: "snow-regime" should be explained here

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

"Section 4.3: New explanatory variables for the Fyw elevation gradients" I would expect all subsections in section 4.3 will use variables that are related to elevation to explain the relation between Fyw 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 (fSCA) and Fyw) and elevation (Please also see my main comments)

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

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

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

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

L393: "lowering" could be changed to "decreasing of Fyw with increasing FSCA"

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

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.

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.

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

L483: *higher up* sounds odd. Simply say upstream.

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.

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?

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

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

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.

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)

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