**Hydrology and
Earth System
Sciences
Discussions**

Interactive comment on "Elevational dependence of climate change impacts on water resources in an Alpine catchment" *by* S. Fatichi et al.

Anonymous Referee #1

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— SUMMARY ———-

The paper presents the results of a hydrological model used for simulating the river network of the upper Rhone basin, Swiss Alps. The novelty of the contribution is the level of detail in which the catchment and its hydraulic infrastructure is represented. In particular, all known hydropower reservoirs, as well as water intakes for agricultural and domestic/industrial use are resolved within the modeling framework. The model performance is assessed during the reference period 1990-2010, and future simulations, based on downscaled climate scenarios, are presented until the year 2050. Although the contribution is very innovative and provides some very insightful results on the one hand, it has some obvious deficiencies on the other: Often the methods are insufficiently described, the way the glacierized surfaces are dealt with is very crude, and the

presentation of the results is sometimes speculative. The general impression of the paper is, therefore, twofold.

— GENREAL COMMENTS ———-

1) WRITING STYLE - Although certainly not badly written, the paper has a writing style that is irritating at times. Often sentences are unnecessarily "prosaic" and low in information content. In other cases (and this is especially true when the methodology is presented), artificially complex wording is used, without adding substantial information. This gives somewhat the impression that the authors try to "hide" behind some impressive wording, rather than aiming at giving a clear description of what they have actually been doing. Examples are found at page 3749 line 21-22 (why such a general sentence?), P3750 L19-20 (what is the need of the statement after the comma?), P3753 L20-21 (what is the need of introducing a concept that is then not used?) or P3758 L17-18 ("re-parametrize the multisite Neyman-Scott Rectangular Pulses and the multivariate Markovian models" sounds impressive indeed, but an explanation of what was actually done would be more appropriate...). Please refer to the "Specific comments" and "Stylistic comments" sections for more details, and suggestions for improvements.

2) LINE OF ARGUMENTATION - Sometimes, the line of argumentation exposed for justifying some particular assumption is weak – certainly too weak for making it acceptable in the current form. Examples include the reasoning exposed when justifying the choice of a uniform ice thickness for glaciers (P3753 L10-14), or the choice of not using an automatic calibration procedure when calibrating the model parameters (P3756 L22 – P3757 L14). Again, refer to the "Specific comments" for details.

3) WHAT'S ABOUT GLACIERS? - One of the conclusions of the paper is that "Ice melt contribution was identified as a crucial Process [...]" (P3772 L16-17). Why isn't there, thus, a single word on how the glaciers are modeled in the study?? The only information the reader is given is on how the initial ice thickness was computed (P3753 L1-14). But how was the glacier evolution accounted for? Currently, the reader can only

guess. My guess is that glaciers were simply downwasted non-dynamically (i.e. melted locally with the melt rate computed with the temperature-index model named at P3750 L1-2, without taking into account any ice dynamics), but this is only a guess, since no sentence state it explicitly. If this guess is correct (and the unrealistic results that are given for "ice melt" in Table 2 seem to point at that), the methodology is definitively not adequate and needs to be adapted. Also in this case, refer to the "Specific comments" for more details.

4) ADEQUATE INTRODUCTION? - Another conclusion (and this is repeated several times in the manuscript, e.g. P3756 L18-20, P3768 L1-5) is that the amount of water used for domestic, industrial and agricultural uses is negligible in the catchment. Is then the introduction, in which the importance of hydrological studies for correct water management etc. is stressed, adequate? In particular, why should it be important to work out future projections within such a complex modeling scheme if the resource that shall be managed (water) is only exploited to a negligible amount anyway? If statements such as reported at P3771 L12-14 ("broad impacts of climate change in water resources of the entire Alpine areas might have been overestimated in the past") shall be the main message of the study, an introduction pointing at the fact that the focus of previous studies was mainly on selected high-alpine basins, would be more appropriate, I believe.

5) ADVENTUROUS INTERPRETATIONS - Beside the quite spectacular claim mentioned above, the authors dare some interpretation on statistics of extreme events (minimal and maximal discharge in particular). At P3767 L5-6 for example, the statement reads that "a lack of change is the most probable projection" for "minimum discharge [. . .] and maximum 30 days discharge". If such a claim (which is potentially everything else than harmless if fed to the wrong place. . .) is made, it should definitively be based upon a serious assessment. In the paper, however, an assessment on the ability of the model in modeling extreme events is completely missing! No validation of any statistics concerning extreme events was performed for the time series modeled for the past,

and at least this would be required before making any interpretation in that direction.

— SPECIFIC COMMENTS ———-

Title: Why is the focus on the "elevational dependence" of climate change? This is certainly not the main finding or the main novelty in the paper. If you really feel "comfortable" with the claims mentioned in the general comments "4" and "5", they are definitively better suited for a "headline-making" title. Alternatively I would definitively stress the fact that the study addresses the hydraulic structures in the catchment with an unprecedented detail.

P3744 L22-23: Remove the sentence about biodiversity. This was not addressed whatsoever in the paper!

P3747 L9-11: Point at the section in which you describe your method or give a hint on what you will be doing.

P3747 L26-28: The fact that in the future, hydropower dams will be operated according to the exact same scheme observed in the past doesn't seems likely at all! State at this stage that you are aware of this fact (you say it later).

P3748 L1-2: Well, this is in contradiction to what you stated one line earlier! What do you mean? Reformulate the sentence.

P3748 L10 (and throughout the manuscript): Call the period 1991-2010 (sometimes you use 1991, sometimes 1990, sometimes even 1992. Be consistent!) "reference period" and not "control scenario period" (why "scenario"? You are using observed data, aren't you?).

P3749 L25-26: Check your wording – the "monthly correction factor" is probably for distinguishing the annual cycle, and not for distinguishing the land use. . .

P3750 L25: How is the "efficiency" of a "diversion" (you never defined "diversion" properly) defined? Give an explanation.

P3750 L25-28: But you know the position of the in- and out-flows, you said. So why you don't assume a constant average flow velocity in this pipes, and calculate a time lag according to the distance? It is certainly a crude estimate, but certainly better than "1h time lag no matter the length"!

P3751 L3-7: This description is definitively insufficient! How are these "specified withdrawal functions" defined? In which way are they "based on the number of inhabitants" and how do they "follow pre-defined seasonality and intrannual variability of water consumption"? How much is the "fixed fraction of losses" that is subtracted?

P3751 L17+23: You never defined a "computational element" (probably you mean "each grid-cell the catchment is discretized in").

P3751 L18: Why do you mention shortwave incoming solar radiation again? It just sounded like you wouldn't need it. . .

P3751 L21: What is an "elaborated product"?

P3751 L25: Replace "at the stations" with "at the nearest station" (that's what you do, right?)

P3752 L1-2: How often does this happen? Give the number of days. And to which 7-hour period of the day you assign the precipitation?

P3752 L3-6: Remove this sentence. It is not clear what you want to say and the reader is left with more questions than answers.

P3752 L6-7: Remove this sentence or explain what it is based upon.

P3752 L7-9: The assumption of a constant temperature lapse rate is certainly not appropriate for the study region you are addressing. Especially in winter and spring, inversions in the valley systems are very common. This may not be a big deal in midwinter, but certainly have an effect on snow melt during spring. Although not a "clean" solution, imposing an annual cycle on the lapse rate may alleviate the problem.

P3752 L12-14: A single value for the daily cloud transmissivity for the entire catchment? This is certainly not realistic! Again, this may strongly influence your results concerning snow and ice melt. At least discuss that problem if you cannot come up with some idea for getting a handle on it!

P3752 L20: State where the "additional maps for lakes and glaciers" where "available" from.

P3752 L24-27: Why would the terrain underneath a glacier be different than what is found on its forefield? And what does happen to the soil type when the glacier has retreaded? Does it changes?

P3753 L1-14: (A) There is no word on how glacier evolution is accounted for! What scheme is used for updating the glacier surface? As stated in "General comment 3" I believe that you simply downwasted the glaciers non-dinamically. This is certainly not appropriate and severely compromises your results (not in the reference period of course (so don't argue with the good performance metrics for highly glacierized basins!) but in the future scenarios!). For a simple way of accounting for glacier evolution, check out Huss et al., HESS, 2010. (B) More information is required on how you deal with snow as well. When is the model generating snowfall (according to a temperature threshold I guess)? Is this snow redistributed (no, I guess)? How is the snow melted (according to the "enhanced temperature-index model" I guess)? What do you do with snow that accumulates at high elevations, where no melt occurs according the melt model (no idea)? Are you piling up snow uncontrolled (hopefully not) or is there a solution for preventing that (I very much wonder which solution it is)? (C) A by far less important question: Any thought about permafrost? (D) For the formulation, replace Lines 6-10 with "For each glacier, ice thickness h_ice (m) was assumed to be uniform, and calculated from the glacier area A (km^2) as h_ice=33*A^0.36 (Bahr et al, 1997).". This is more than sufficient.

P3753 L10-14: Remove these sentences – the way of argumentation is very weak:

Although it is true that available estimates of the ice thickness distribution of many glaciers have important uncertainty, they are certainly not as bad that they would justify a replacement with estimates derived by using volume-area scaling and the assumption of a uniform ice thickness. Check out the work by Gabbi et al., HESS, 2012 for how future runoff projections can be biased when assuming "uniform glacier thickness".

P3753 L20-21: Why do you need to introduce the concept of "efficiency" (if you think that this is really necessary, explain what it is!), if you set it then to a value which corresponds to neglecting it? I suggest removing the sentence.

P3753 L23-24: This is very confusing since it contradicts what you stated at L19-20. Where is the "capacity" (by the way, what is your exact definition of it?) coming from at the end?

P3753 L25-27: What do you mean? Have you only checked if the coordinates you had were consistent with the position of your river network? In this case you did not "introduced" the "diversions/conduits", right? Or did you added the "diversions/conduits" manually one by one?

P3755 L9-13: I think the method is smart, because of its simplicity. However, show a plot for the 7 volume-level curves that are available, so that the reader can have an idea on how "similar" these curves are actually (and display quantiles of the curves, as you did in most of your figures). Moreover, the non-adequacy of the fundamental assumption (i.e. same "target levels for the future") should be stressed more. Of course it would be difficult to make a better job by maintaining the same degree of simplicity, but the assumption of unaltered hydropower operations is certainly not realistic.

P3755 L21-22: Does this number (i.e. "0.7 mm hˆ-1") applies to all "districts" (define what a "district" is)? Didn't you say that you accounted for the "highest monthly withdrawn discharge" (P3753 L19-20)?

P3755 L27: Where is the number "160 x 10ˆ6 mˆ3 yrˆ-1" coming from? Is it a model

result?

P3756 L1-2: I don't understand the logics of this argument: Why don't you choose a different value for the "maximum capacity of the water supply infrastructure was" (P3755 L21) in order to match the two numbers? I would imagine that "0.7 mm hˆ-1 * (1-0.6)" would yield a better agreement if you overestimate the amount by 60% (P3755 L27).

P3756 L11-13: Well, probably exactly the opposite applies!

P3756 L15-16: More information is required. What are these "daily and seasonal fluctuations" that are "imposed using modulation coefficients"? What are "modulation coefficients"? Consider showing a plot for these "modulations".

P3756 L 17-20: Here, and already at L3-4, the questions arises why in the introduction you stressed so much the importance of your study in the context of water management. Here you are basically saying that water is available almost unlimitedly. . .

P3756 L 21-28: This sounds like a contradiction again: You just stated that "water used for irrigation" (L3-4) and "domestic/industrial water consumption" (L17-20) are in the order of a few % only, and now you argue that automatic calibration wouldn't be suitable because of "strong anthropogenic disturbances". Where is the problem?

P3757 L1-14: This line of argumentation is incredibly weak, and sounds, at this stage, like a unnecessarily complex formulated excuse: It wouldn't be hard defining a physically motivated range in which parameters are allowed to vary once a procedure for automatic calibration is set up, would it?

P3757 L20-23: Although the two methods certainly doesn't need to be described in detail, some more information is definitively required in order to have an idea what these methods are! What is the particularity of this "spatiotemporal Neyman-Scott Rectangular Pulses model"? Why "spatiotemporal"? Why "rectangular pulses"? Where can the "RAINSIM package" be found? What is it thought for? And why is the "Markovian

model" "multivariate"? Which "variates" does it includes? Why would it be better than other approaches?

P3757 L26: Remove the two citations: The "delta change approach" is certainly nothing introduced by Fatichi et al. or Anandhi et al.!

P3758 L5-7: To my understanding one of the main ideas behind the "delta change" approach is to be bias-independent (because only changes are considered). Why would, thus, a bias correction be of any benefit? And give some hint on how the chosen bias-correction method works.

P3758 L9: Where is the "non-linearity" coming from?

P3758 L9-14: What parameters are you talking about? This is impossible to understand! And how can there be a "validation period" if you are addressing "climate PRO-JECTIONS"??

P3758 L15: Which ones are these "several [. . .] statistics"?

P3758 L16-17: HOW did you "re-parametrized" the "multisite Neyman-Scott Rectangular Pulses model"? Why "re-"? And why is the model now "multisite", and no longer "spatiotemporal" (P3757 L21). This is probably the best example for the sometimes very annoying wording :-(

P3758 L20-23: And what's about the step between decades, if individual decades are considered to be stationary on its own?

P3758 L29: What "statistical properties"?

P3759 L1: What quantity was randomly sampled? Not the "statistical property", right? That is, however, the subject of your sentence. . .

P3759 L5-8: This is not understandable. (By the way, what are "climate generated data"?)

P3759 L11-13: Does it mean that there are regions in which the precipitation for each is given by the data of one particular station only? If yes, say that clearer before and show these regions.

P3759 L24-26: And what's about data about glacier retreat and mass balance? The region you are looking at has probably the best coverage worldwide on this respect! Check out the work of the different universities working in your Country and include those data in the validation! Again, if one of the major conclusion is that components of the cryosphere play a decisive role, more attention should be given in validating the results of this compartment!

P3760 L18-21: Honestly, I'm very surprised about the so good performance of the model, especially at the shorter aggregation times and the regulated catchments. . .

P3760 L25-27: Only the amplitude? And only "similar"? Please give the same metrics of performance as you gave above.

P3761 L15-17: Although the argument is valid to some degree, you certainly cannot "get away" without considering any spatially distributed validation. At least aggregate your averaged values into elevation bands, otherwise you are throwing away most of the information!

P3761 L20: Quantify the "small delay" (e.g. how many days?).

P3761 L22-24: Where is this result coming from? Didn't you just say you compared average values only?

P3763 L2-3: This sentence leads me to the conclusion that the section is not described well: I was under the impression that you were comparing measured and simulated data both referring to the "pre-dam" period. Now, however, it sounds like you would compare "pre-dam" measurements with "post-dam" simulations in which the hydraulic infrastructure has been removed in the model. This latter option doesn't makes much sense to me. . .

P3763 L8: Why "stochastic variability"? Which other "variability" did you considered, and how do you distinguish between them?

P3763 L9: What are the numbers in parenthesis? Why is there a range? To what is the range referring to?

P3763 L16: (A) Add an explanation starting with "which causes…" after "(Table 2)". The increase in temperature alone does not explains a decrease in discharge, does it? (B) Why is the "spin-up time" mentioned only at this stage? This should happen earlier.

P3763 L20-24: Not sure, but is this something present in the original RCM runs or something introduced by your downscaling method?

P3764 L13-16. Well, these results (and in particular the unrealistic 65% decrease in glacier melt within one decade stated in Table 5!) can easily be explained with the crude way glaciers are represented in the model.

P3765 L9: You never said that the model projection show an increase in winter precipitation! And Figure 7 doesn't show it either – so, don't point at it.

P3765 L14-15: What do you mean with "unchanged"? Only in total, right? Not in the timing…

P3765 L23: Give an example for gauging stations that are not affected by glaciers.

P3766 L6: Quantify how much the "larger increase" is. And how good is the model in estimating evapotranspiration there? (By the way, how did you validated the results for the evapotranspiration at high altitudes?)

P3766 L 18-19: Explain what you mean with "both emphatize and reduce natural climate change effects" (by the way, why "natural"?).

P3766 L21-28: Honestly, how much do you believe in the upper quantiles of your modeling results? If you interpret those results, you definitively need to present a plausible validation of the model performance for the according statistics first!

P3767 L5-6: Do you really want to make this claim?

P3768 L2-5: Does this mean that your introduction was "oversold"?

P3769 L17-19: Another weak argument… The fact that the interannual variability during your control period was reproduced well may indeed be a hint that you had the correct glacierized area. However, it certainly doesn't allow you to draw any conclusion about the appropriateness of your ice thickness distribution: You could have placed 10km of ice everywhere, and your model wouldn't produce much additional melt water, since the glacier area is given, and hardly changed during that short period. Remove the sentence (and use something more realistic for your glacier modeling…).

P3771 L3-4: Why "lower hydraulic head"? Water intakes have usually a fixed height, and the difference in water pressure should be negligible…

P3771 L12-13: This sentence is too general. The studies you mentioned earlier focus mostly on headwater catchments, and certainly don't do claims for the "entire Alpine Areas".

P3771 L21-24: Remove this sentence: Why would rivers at lower elevation not "support biodiversity of aquatic environments" (and by the way, what's the definition of "biodiversity of aquatic environment"?)?

P3772 L16-18: I'm repeating myself, but if that is your conclusion, shouldn't you focus more on the according processes?

— STYLISTIC COMMENTS ————-

P3744 L2-3: Remove this sentence – it is too general.

P3744 L5: A) At this stage it is unclear what "pristine" means. Avoid the wording. B) "choosed" or "addressed" instead of "used"

P3744 L17: "reduction" of what?

P3744 L25: Add "and" between "hourly" and "daily"?

P3745 L3: Add "and" after "services,".

P3745 L7: "Swiss Alps" instead of "Alpine region of Switzerland".

P3745 L9: Add "Europe" after "central".

P3745 L10: Begin a new sentence with "Moreover…" since "which […] their" is difficult to understand (what is "their" referring to?).

P3745 L13: "authorities", not "managers".

P3745 L17: Add "here" after "The".

P3745 L19: Remove "large" after "European"

P3745 L21: Replace ")(" with ",".

P3745 L22: "case" instead of "ground"

P3745 L28: Add "the basin" before "particularly". P3745 L29: Remove "it".

P3746 L6: Add "and" after "on".

P3746 L8: "an increase in" instead of "enhancing of"

P3746 L9: "These changes" instead of "Therefore, changes"

P3746 L12-14: "Even" what? Begin the sentence with "This is true even for…"

P3746 L18: "fill this information gap" (or similar) istead of "provide an answer to such a request".

P3746 L20: Remove "at high elevation" and "at low elevation" – they are both not necessary.

P3746 L21: "particularly" instead of "specifically".

P3746 L24: Add "," after "catchments".

P3747 L8: Move "for an exception" after "2011".

P3747 L10: Remove "engineering" (what is the added value in terms of clarity of this word?)

P3747 L24: Remove "in detail" – it is in contradiction to what you state at L9-11.

P3748 L10: Add "to be" before "stationary".

P3748 L21-23: Replace "the underestimation of uncertainty induced by neglecting realizations from additional climate models" with "the problem".

P3748 L24: "due to" or "introduced by" instead of "imposed by".

P3749 L8 (and throughout the manuscript): Check your use of "significantly", and use it only where appropriate. How did you tested the "significance" of the "enhancement"? (The question is ironic)

P3749 L20: "calculated based on" or "modulated by" instead of "mediated by".

P3749 L21-22: Remove the sentence – it is too general.

P3750 L1: Replace "an" with "the" or remove "enhanced" (there are not many "enhanced temperature-index models" in the literature…)

P3750 L5: Add "," before "and".

P3750 L16: Don't begin a new paragraph.

P3750 L18: Remove "significantly"

P3750 L19-20: Remove "and that are essential for providing simulations in the regions of major interest for the society. Specifically" - the information content of the statement is negligible.

P3750 L20-24: Replace these lines with "Lakes and reservoirs are described us-

ing all of the major technical information (e.g. spillway, turbine and outlet capacity, volume-level curves, maximum and minimum regulation levels, environmental flows), and reservoirs are simulated by using a "target-level rule" (Sect. 2.2.)".

P3751 L9: "part" (or something similar), not "corner".

P3751 L10-11: Check your wording! The upper Rhone basin (which is subject of your sentence) certainly doesn't "flows" anywhere...

P3751 L16: Add "and" after "precipitation,"

P3751 L24: "downscaled" instead of "disaggregated"

P3752 L17: Remove "resolution".

P3752 L18: "grid cells" instead of "computational elements" (the information about size should be given earlier!)

P3752 L21: What is "Rhone" in this case? The catchment? The river? The glacier?

P3754 L5-7: Replace "complex reality and it represents our best effort to consider anthropogenic alterations of the natural discharge of the upper Rhone river basin given the limited availability of public data." with "reality, which is difficult to describe better given the limited availability of public data.".

P3754 L8: Add "," after "diversions".

P3754 L11: Add "hydropower" after "largest"

P3754 L11-14: Reword into "One of the reservoir, Arnensee, is not physically located in the Rhone catchment but was included in the simulations since water from the Rhone tributaries is pumped back and forth from it".

P3754 L15: Reword "that represents 20% of the total annual upper Rhone flow" with "corresponding to 20% of the annual discharge of the considered basin".

P3754 L16: Remove "fundamental"

P3754 L20-25: Avoid the wording "volume-level curves" 4 times in 6 lines. P3754 L21: (A) Name the 7 reservoirs instead of only saying "including Mattmarksee...". (B) What do you mean with "broader Alpine region"? That they are not inside the catchment??

P3754 L22-29: Reword into "These curves were normalized using the maximum and minimum regulation levels, and averaged to obtain a reference volume-level curve. Application to other reservoirs implicitly assumes similar bathymetry. In the model, dams were operated according to a "target-level policy". This means that for each reservoir and each day of the year, a target level was assigned (EXPLAIN HOW!), and the water released in the case the simulated reservoir level exceeded the target level. Water release rate was chosen to be lower or equal (WHEN IS IT "LOWER"? WHEN "EQUAL"?) to the [...]"

P3755 L2: What is the "environmental flow"? Probably you mean the flow outside the catchment of the reservoir?

P3755 L5-7: Remove this sentence. You said that before.

P3755 L19: (A) Remove "of the actual irrigated area". (B) "14" instead of "fourteen". (C) What are "irrigation districts"?

P3755 L23: Remove " in reality rather"

P3755 L24: Remove "called Suonen"

P3755 L25: Move "," after "model"

P3756 L3: "corresponds to" instead of "is indeed less"

P3756 L6 (and elsewhere): be consistent with the given units! (Here "0.3 mˆ3 (person * day)ˆ-1" instead of "300 L (person*day)ˆ-1")

P3756 L7: "use", not "uses"

P 3756 L10: "apart" instead of "distant"

P 3756 L11: "." After "identified".

P3757 L18-20: (A) Replace ". The downscaling methodology" with ", which". (B) Add "to be" after "assumed".

P3759 L5: Replace "multisite Neyman-Scott Rectangular Pulses and the multivariate Markovian" with "according".

P3759 L9-10: Did you say that earlier? Or why "since"?

P3759 L17 (and may cases after this point): Do you mean "validation" or something similar instead of "confirmation"?

P3759 L20: "from" instead of "as elaboration of"

P3760 L3: "Merics such as" instead of "Validation metrics in terms of".

P3760 L17: "dramatically"? Change the wording.

P3761 L5-6: Reword "we were able to reproduce well the discharge interannual variability for a 18 yr period" into " the interannual variability of discharge is well represented".

P3761 L7-12: Reword into "The simulated and observed mean discharge are in good agreement for all the examined stations (Table 1), further supporting the plausibility of the hydrological simulations, since it is very unlikely that the streamflow in 15 different stations has been simulated correctly "by chance"."

P3761 L25: "Validated", not "tested".

P3761 L26: Replace "multi-annual estimates of these quantities" with "consistent estimates".

P3762 L4-5: Remove the sentence. Begin the section with "For six of the considered stations, observations of discharge...".

P3762 L15: Remove "significant"

P3762 L27: ". This is most probably due to..."

P3763 L11-13: Rephrase to "Averaged over the catchment, the simulations directly driven by the GCM ECHAM5 predicte a decrease of about 100mm yr^{-1}"

P3764 L5: Remove "to drive the stochastic downscaling"

P3764 L11-13: Rephrase to "Reduction in ice melt has a particular influence on the runoff of August and September (Fig. 5). Glacierized area and volume are ..."

P3765 L4: Remove "downscaling"

P3765 L10: Remove "season"

P3765 L14: "pronounced" instead of "remarkable"

P3766 L9: Reword to ", which has the lowest elevation".

P3766 L11: "annual discharge", not "discharge mm yr^{-1}".

P3766 L12: Remove "for the stochastic downscaling driven by RegCM3". Why would this be true only for this particular RCM?

P3766 L14: What are "river reaches"?

P3767 L12: Remove "Rhone".

P3767 L28: "differences" between what and what?

P3768 L1-2: Remove the first sentence. Start with "In all simulations, irrigation and water consumption..."

P3768 L7: Reword into "We provided for the first time simulations including present day..."

P3768 L24-26: Check your wording! This is not a property of the catchments! It's a property of your model!

P3769 L9-10: Add "used" after "of the", and remove "driving the stochastic downscaling" (that's clear from the context).

P3769 L11-12: (A) "ice melt", not "ice melted water", (B) remove "downscaled" and "driven by the different climate models" (again, that's clear from the context).

P3769 L12-14: Remove or reformulate this sentence. At the moment it is not understandable.

P3769 L15: Remove "the entire upper Rhone basin" (clear from the context).

P3769 L16: Remove "probably" – that's pretty obvious in my opinion...

P3769 L26: Remove "rather".

P3770 L6: Remove "fed by glacier sources".

P3770 L7: Remove "at lower elevations".

P3770 L11: Remove "out of the interannual variability".

P3770 L12: "less important" than what?

P3770 L15-16: Remove "to drive the downscaling".

P3770 L17-19: Reformulate the sentence (you never introduced the concept of "stochastic trajectory").

P3770 L22: What is an "autumn storm"? You never talked about.

P3770 L27: "affected" by what?

— COMMENTS TO FIGURES AND TABLES ————-

Table 1: Honestly I'm very surprised about the very good statistics for all stations. If they are true (sorry, but leave me at least express the doubt ;-)), that's great!

Table 2: (A) Where is the temperature drop for the decade 2021-2030 coming from?

I've never seen something like that in other climate projections, whilst you show it as consistent feature throughout the three models you consider. This requires at least a short discussion. (B) A reduction in ice melt of 65% within one decade?! That's neither realistic nor nearly in line with other published estimates! My guess is that since you are melting glacier ice "in place", your lower elevations run out of ice very quickly, basically stopping the computed ice melt. The only way for avoiding this is taking into account in some way the ice dynamics. Have a chat with your colleagues at the glaciological institute, they certainly can give you some advice.

Fig. 2: (A) Remove the kilometer-grid around your catchment (as you did in Fig.1) or (better) use the CH1908 coordinate system. (B) In the caption, replace with an identifying number" with "with the identifying numbers given in Table 1".

Fig. 3: (A) Additionally to panel "(a)", show a scatterplot of simulated against observed snow cover. (B) In panel "(c)", show the difference with respect to the observed values! At the moment, it is very difficult to see any difference between "(b)" and "(c)". And that's not because to model is so good ;-) Moreover, create a plot in which you show the mean difference versus average altitude (build a running window over a given altitude band, or something similar), and show let say four lines for the four different season (or similar; for catching some of the temporal vaiability). (C) Remove the first sentence of the caption (it refers only to panel "(b)" and "(c)".

Fig. 4: I'm not completely sure what you mean with the last sentence in the caption. Check the meaning, but probably, adding "simulated" after "and 15" would help to understand.

Fig. 5: (A) I cannot see any results that refer to "REMO". Change the order of the models. (B) Why is ice melt starting later in the period 2041-2050 (around DoY=150) than it is in the reference period (around DoY=125)? Wouldn't one expect the opposite (since snow is melting earlier)? This needs to be discussed!

Fig. 6: Define what your box-plots are showing (100%, 97.5%, 75%, 25%, 2.5%, 0%

quantiles and mean I guess?). Why are the "+" missing for some box-blots?

Fig. 7: (A) In the caption, remove "river sections corresponding to the location of the". (B) In the plots, add a number giving the glacierization (e.g. as a percentage) of the according catchment.

Fig. 8: (A) Caption, line 2: "between", not "among"; remove "scenario". (B) Caption, line 4: Remove all "subplot".

Fig. 9: (A) This plot is messy. Use the same box-plot style as you did in Fig. 6. (B) In the caption, remove al "subfigure".

Fig. 10: Increase the line thickness of the individual river branches – it is difficult to discern between individual colors. . .

Fig. 11: (A) This plot is messy again. Increase the horizontal distance between the individual box-plots. Use the same style as in Fig. 6. (B) In the caption, replace "difference for the stochastic downscaling driven by RegCM3" with "variations", and add " Results refer to the RegCM3-driven model run." before "The differences are [. . .]" (an "s" is missing after "difference").

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C739