Referee #1:

Thank you very much for your thorough review. We very much appreciate your valuable suggestions.

The article analyses climate change impacts on runoff regimes in 93 rivers in Switzerland. The study is based on the results of a large Swiss research project, which provided consistent downscaled local climate projections under three emission pathways. The changes are presented with respect to seasonal and yearly changes in the mean discharge and with respect to the timing (seasonal shifts). Next, a time of emergence is presented, which is the time when a significant change of the seasonal and yearly means is detected. Additionally, changes of the runoff regimes are related to increasing global mean temperatures.

Evaluation of review criteria (details are provided by annotations in the PDF manuscript):

1. Does the paper address relevant scientific questions within the scope of HESS? Yes. The focus is on regimes in Switzerland, but methods and results are certainly of interest for other (alpine) countries.

2. Does the paper present novel concepts, ideas, tools, or data? Yes.

3. Are substantial conclusions reached? Yes.

4. Are the scientific methods and assumptions valid and clearly outlined? Yes.

5. Are the results sufficient to support the interpretations and conclusions? Yes.

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? Due to the huge amount of data involved, not easily. But all datasets are publicly accessible.

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution? Yes.

8. Does the title clearly reflect the contents of the paper? Yes.

9. Does the abstract provide a concise and complete summary? It is rather long and not easy to read (too many numbers).

Reply: *Thank you for this comment. We will shorten the abstract and reduce the numbers stated in the abstract.*

10. Is the overall presentation well structured and clear? In general, yes. Subsections of section Methods should be reordered to be consistent with section Results.

Reply: *Thank you for this suggestion. We will reorder the subsections in the methods part (3.3 and 3.4).*

11. Is the language fluent and precise? In my opinion, many paragraphs seem to be too closely translated from German, which makes the text difficult to read. One specific concern: the frequently used expression “signal of change” apparently refers to the sign of changes only (up or down), not to the magnitude of change – while in my opinion the term “signal” includes both, sign and magnitude.

Reply: *We will change the phrase “signal of change” to “sign of change” or “direction of change” to make clear that it does not refer to the magnitude of change. We will submit the revised version to an English editor.*

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? N.a.

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? See PDF annotations

Reply: *Thank you for your time reviewing the paper in detail. We appreciate your suggestions in the PDF. We directly replied to your suggestions in the document and only discuss comments which need some more explanations in the following:*

L50: this selection seems to be a bit biased. There are also publications by other groups, e.g. in Vienna.

Reply: *The following references will be added:*

Blöschl, G., Schöner, W., Kroiß, H., Blaschke, A. P., Böhm, R., Haslinger, K., ... & Viglione, A. (2011). Anpassungsstrategien an den Klimawandel für Österreichs Wasserwirtschaft–Ziele und Schlussfolgerungen der Studie für Bund und Länder. Österreichische Wasser-und Abfallwirtschaft, 63(1-2), 1-10.

Goler, R. A., Frey, S., Formayer, H., & Holzmann, H. (2016). Influence of climate change on river discharge in Austria. Meteorologische Zeitschrift, 25(5), 621-626.

l136: This paragraph contains some assumptions whose effects need to be discussed: why use the last - and not the central - year of a 30-y window? what is the effect of the 95% significance? why 66% of the models? also, there is an inconsistency between the section title "seasonal changes" and the text where you mention seasonal and yearly means.

Reply: *We adopted the thresholds from Mahlstein et al. (2012). They defined the year of emergence as the last year of the first 30-year window, where significant changes are detected (95% significance) for each of the simulations. The time of emergence is shown when 66% and 90% of the models show significant changes. This corresponds to "likely" and "very likely" in IPCC terminology. We will make this clear in this paragraph and adapt the title of the section.*

Mahlstein, I., Portmann, R. W., Daniel, J. S., Solomon, S., & Knutti, R. (2012). Perceptible changes in regional precipitation in a future climate. Geophysical Research Letters, 39(5).

l144: "Since the time of emergence may not be constant in time" - What does this mean?

Reply: *The concept of time of emergence is based on a statistical test between two distributions of seasonal means (reference vs future). However, changes in runoff may not be linear over time. Even though changes in seasonal runoff are tested as significant in one period, they may not be significant in all periods afterwards (e.g., due to non-linear effects of enhanced snow melt, decreasing snow cover, increasing glacier melt and decreasing glaciation. This is the reason why we included Figure 7 showing the temporal evolution of the p-value over time. In order to make this point clearer, we will include an explanation in the methods section as well as in the discussion section.*

l200: I see almost identical runoffs in October and only small changes from J to M.

Reply: *We agree that mean runoff changes in October are small. The absolute changes between January to March are also small but the relative changes in these months are large. We will make this clearer by pointing out the difference between absolute changes and relative changes.*

l256: "is not necessarily persistent over time". What does this mean? Obviously, to detect "emergence" with the described method, assumes a monotonous trend, which in some watersheds is not occurring.

Reply: *We refer to the answer for line 144 above. This will be discussed/explained in more detail.*

l296: what do you mean? Availabilty for which purposes?

Reply: *We refer here to the contribution of winter runoff to the yearly volume. The sentence will be changed to "In nival and pluvial catchments the contribution of winter runoff to the yearly volume increases."*

l308: is that true for all watersheds? In austrai, there is a sginificant positive trend in autumn precipitation north of the Alps main ridge.

Reply: *In most of the catchments, mean autumn precipitation is decreasing or not changing significantly. However, there are few catchments in the very east of Switzerland which show increasing precipitation. A pattern of increasing autumn precipitation north of the Alps like in Austria is not found. We will adapt this sentence to acknowledge the precipitation increase in few catchments.*

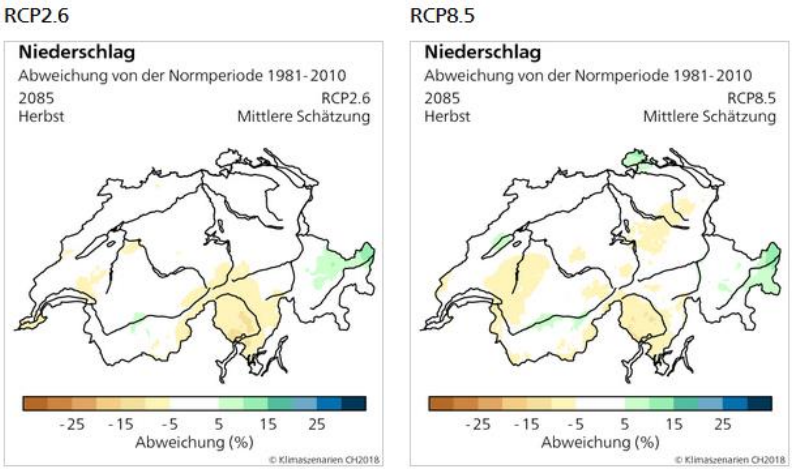

Figure from the NCCS Webatlas showing the changes in mean autumn precipitation for Switzerland under RCP2.6 (left) and RCP8.5 (right).
Source:https://www.nccs.admin.ch/nccs/de/home/materialien-und-daten/daten/ch2018-webatlas.html

l315: misleading expression. winter and spring have an increase (Fig 4). Did you mean: on average for a year ?

Reply: *We apologize for this misleading expression. We refer to the decrease in the yearly mean runoff. This sentence will be changed to make this clear.*

l316: a bit fuzzy: can you give examples?

Reply: *We will provide examples. For example, increasing winter mean runoff may be beneficial for energy production while decreasing summer runoff may lead to a deficit for irrigation in agricultural regions.*

l350: Either skip this paragraph - or make a statement on the severity of these uncertainties and why your work is still useful!

Reply: *This paragraph will be extended, and the different sources of uncertainty will be discussed in more detail.*

l367: Fig 4 tells a differnt story!

Reply: *This sentence refers to figure 6 showing the time of emergence where the significance of changes is tested. We will change this sentence to avoid confusion and directly refer to Figure 6.*

Figure 5: Difficult to read overlapping shadings. Could it support easier comparison if you use the same runoff axis scale in all graphs? Or what about using Pardé coefficients instead of mm/d?

Reply: *Thank you for your thoughts and suggestions. We fully agree on the difficulty of distinguishing between the shadings. Figures for each RCP will be provided in the supplement. Since the representative catchments cover a large variety of different runoff regimes, the y-axis scale of the plots also varies strongly from 0-12mm/d for the Rosegbach (glaciated, pronounced peak) to 0-4 mm/d for the Venoge (pluvial, less pronounced peak). Using a constant y-axis (0-12 mm/day) would reduce the readability of the regime curves and changes would be hard to see. Therefore, we suggest keeping different y-axes to account for the different regimes. However, we will test whether the use of Pardé coefficients improves readability of the graphs.*

14. Are the number and quality of references appropriate? Yes.

15. Is the amount and quality of supplementary material appropriate? Yes.

Please also note the supplement to this comment: https://hess.copernicus.org/preprints/hess-2020-516/hess-2020-516-RC1-supplement.pdf