Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2019-448-AC3, 2019

Hydrology and Earth System Sciences
Discussions
Open Access
EGU

Interactive comment on "The effects of climatic anomalies on low flows in Switzerland" *by* Marius G. Floriancic et al.

Marius G. Floriancic et al.

floriancic@ifu.baug.ethz.ch

Received and published: 4 November 2019

We thank Anonymous Referee 4 for the feedback. Below we list our response response (in bold) to the reviewer's comment *(in italic)*.

In this paper, the authors assess to what extend precipitation and PET anomalies trigger summer low flow events in Switzerland. The assessment employs Spearman correlations between low flow magnitude and climate anomalies in P and PET aggregated over varying lead times before the peak of the low flow event. The correlations are overall weak, but still indicate that most low flows arise from the compound effects of precipitation and PET anomalies, with longer and larger anomalies related to more extreme low flow events, as one would expect. The assessment of lead times before the

Printer-friendly version

Discussion paper

peak of the event is not new (e.g. Fangmann and Haberlandt, 2019 on a monthly time scale), but indeed appropriate to assess the genesis of events.

Indeed, drivers of low flows have been studied before (as reflected by the citations, including Fangmann and Haberlandt, 2019), and the result that both PET and P are important for low flows may not be a big surprise. However, the paper provides insight into the durations, magnitudes, and timings of the anomalies that drive low flows, and how these vary across hundreds of catchments situated in diverse landscape conditions. These more detailed insights about low-flow generation reveal aspects that cannot just be derived from intuition. In addition, the aspects of low flows that we discuss are not captured by previous studies, because they study other regions, and/or they study different aspects of low flows. Therefore, we believe that the provided results (and data) may be useful for the hydrological community.

While the paper is generally easy to follow, the paper appears to suffer from weakly formulated research question and consequently from a limited scope of the study. The results remain superficial and do not provide sufficiently new insights in low flow generation in Switzerland. I therefore cannot recommend the paper for publication in its present form. I will provide detailed feedback below, which I hope to be useful for the authors for further elaborating the paper.

In the revised version we will sharpen the research questions, to make them more specific and clearer. Since the detailed comments on this issue are discussed below, we refer to our detailed responses there on how this will be done.

Weakly formulated research questions and and consequently from a limited scope of the study. The results remain superficial and do not provide sufficiently new insights

in low flow generation in Switzerland. I therefore cannot recommend the paper for publication in its present form.

Below we respond to the detailed comments that refer to this concern.

Science question
Science questions (or hypotheses) of this paper (Line 73-75) are formulated in a way that everybody would immediately agree: There is little doubt that low flows will typically occur after anomalous weather conditions, and that most extreme low flows will be associated with the most extreme weather conditions. This leads directly into a quite superficial analysis and weak conclusions. I urge the authors to sharpen the science questions and, accordingly, the study design, in order to gain more significant insights in how precipitation and evaporation together generate low flow events in Switzerland. I agree with Referee 2 that the focus of the paper should be much more on the interplay of the two meteorological drivers. And their relative importance for events with different time of occurrence within the summer/fall low flow season.

We point out that lines 73-75 do not represent our science questions. However, we will rephrase the text to make this distinction between "introductory text" and "science questions" clearer.
In the revised version we will sharpen the actual science "questions" (listed in lines 81-85). For example: "We investigate (i) to what extent low flows are driven by precipitation anomalies, PET anomalies, or their combined effects, (ii) what magnitudes of climate anomalies are leading to low flows, (iii) what durations of climate anomalies are typical for low flows, (iv) how these climate anomalies vary across the Swiss landscape, (v) how these climate anomalies vary with the severity of the low flow event."
None of the above questions is answered in previous studies for our study re-

gion. In addition, we will update all of the results and discussion paragraphs to better present the results and their implications.

Methods
The paper also suffers from weakly defined analyses. The methods section does not provide all necessary methodological details; they pop-up in a mixed results and discussion section. This makes analysis rather ad-hoc and hampers a well-structured assessment of the research question. I strongly advocate organizing the paper into clearly separated methods, results and discussion sections to foster a transparent, in-depth assessment.

Apologies for the confusion. In the revised version we will ensure all methodological aspects are already explicitly mentioned in the methods section.

In the following I review the used methods found in the results section.
In Section 3.2, the purpose of this "first correlation analysis" is not clearly defined (ref. also to the vague section title). The section assesses the correlation of 30-day-anomalies. For what purpose the time window has been chosen, and what may analysing 30 days before the event tell us has not been indicated.

The purpose of section 3.2 is to reveal what magnitude of climate anomalies are typical for low flows, how this varies between P and PET anomalies, how this varies with elevation, and whether P or PET appears to be more important. In the revised version we will introduce these purposes more clearly, both in the methods section, and the results section. We will also try to provide a more quantitative perspective on the P and PET partitioning.
The purpose of choosing a 30-day window is to reflect that low flows are generated during a prolonged period of anomalous climate. We show the results for

30 days, but emphasize that other time-windows (from 1 week to 120 days) yield broadly consistent results. We could provide such in supplementary materials. We choose 30 days as the result to present, because 30 days (as later shown) is the time window which explains most typical low flows (Section 3.4). These changes will also lead to updates in the text of manuscript that address these additional analyses and explanations.

Section 3.4 Duration of climatic anomalies – The analysis of durations of anomalies before the peak of the event is largely depending on very short interruptions of the climate anomaly that have no effect on streamflows. Some pooling would be necessary to filter out disturbances in this type of analysis. The second analysis based on various time windows is more robust, and the most insightful analysis of the study.

We acknowledge that short (irrelevant) interruptions may affect the determined length of a climate anomaly. To address this we do multiple things. First, we use a 10 day moving average of time series to filter out short duration interruptions. Second, for the revised version, we plan to calculate these results also using other time windows to test their sensitivity. Third, these limitations and the sensitivity of the results will be discussed in the revised version.

Section 3.5 The role of winter precipitation is not a pertinent research question, it is well-known that in an Alpine environment it is rather snow-storage than accumulated precipitation that shapes summer low flow with respect to timing and magnitude. Analysing winter precipitation (instead of snow storage and snow melt) has not the potential to lead new insights in the low flow generation process in Switzerland.

As pointed out by previous reviews, winter precipitation is not always a robust proxy for winter snowpacks. We will change our discussion of the role of winter

precipitation for summer low flows accordingly. We would like to emphasize that it remains largely unquantified how winter conditions (either snow specifically, or both snow and winter rain) affect low flows across the Alps. This is clearly important information as we all agree that in many Alpine landscapes winter conditions can shape summer low flows. In addition, in the revision, we will quantify the effect of solid vs liquid precipitation (e.g. by using a temperature threshold) and discuss if this better explains the low flow behaviors.

Specific comments:
L 41: It is not either climate, or catchment, but the combined effect of meteorological drivers and catchment functioning that determines streamflow.

We obviously agree that both climate and the catchment itself shape low flows (as we tried to convey in the original text). We will see how we can rephrase this to avoid confusion.

L68: Contradiction to "the effects of evapotranspiration on low-flow occurrence and magnitude have received relatively little study" (two paragraphs above).

In the revised version we will rephrase this to make clear what aspects of ET have not received much attention, rather than to make the generic statement we currently have.

L72 Sentence does not make much sense.

In this sentence we aim to explain why focusing on climate anomalies makes sense. We will consider how to rephrase to avoid confusion.

L73 ff: Please revise hypothesis (better formulate them as science question(s) and objectives of the study. Avoid duplication of the overall aim into one objective (currently objective a).

As stated earlier, this is not the hypothesis we test in the paper. We now realize that this confusion can arise (probably because we used the word "hypothesize" in this sentence). We will reformulate this statement to reduce the chance of this confusion.

L114: One sentence methodology, apart from the definition of the anomaly measures, is definitely too short.

In the revised paper we will add some text that explains the rationale of this analysis.

Section 3.1: This is prior knowledge and should go into the introduction

We agree that some of the aspects in Section 3.1 can already be stated in the introduction. We, however, like to still repeat some of these aspects to put the Swiss results into context of other studies. We also emphasize that the presented results in section 3.1 (e.g. the 1200m split) are not part of existing literature and should therefore not be presented in the introduction.

L222: Statement is not true. What the cited papers say is that large parts of Europe were affected by the drought events of 2003 and 2015. But papers also show how different timing and magnitude of events were across Europe.

We now realize that we oversimplified the spatial coherence reported in previous studies. We change the interpretation of our results accordingly, by not stating that Switzerland is necessarily in contrast with other regions of Europe. However, we would like to point out that the spatial gradients in low flow timing in Switzerland appear stronger than in some other parts of Europe. We will reformulate to clarify this in the revised manuscript.

L226: ditto

See response to previous point.

L239: Citation needed. What do you mean by erratic?

By "erratic", we mean that daily precipitation is more irregular in time (compared to PET). We now use the word "irregular" to be clearer. We are unsure where a citation is needed in line 239?

L285: No, snowpack is not the same as precipitation sum, snowmelt is precipitation redistributed over time.

We forgot to add an additional line of logic in our statement that connects winter precipitation as a (weak) proxy for snow for our study region. We will add this to avoid confusion. In addition, we will be careful with stating implications of the results as we earlier discussed that winter P and snow are not identical.

L300 ff: "if SWE is important, we expect to see stronger correlations between winter precipitation and summer low flows at higher elevations – see my previous comment (L222). The following analyses are wrongly motivated and results overinterpreted.

We will revise the text to reflect that winter P and snow (pack/fall) are not identical.

L327: Remove sentence, as the paper does not represent a novel methodological Framework

We agree that no real framework is provided, and will change this statement accordingly.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2019-448, 2019.