# Reviewer's Report

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**Title:** Quantifying sensitivity to droughts-an experimental modeling approach
**Submitted to:** Hydrological Earth Systems Science
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# 1 Paper Description and General Remarks

The authors investigated the sensitivity of 24 Swiss catchments to meteorological droughts. They constructed two drought scenarios: the first was a modest but constant progression of drying based on sorting the annual precipitation amounts; the second was a more progression of drying based on selecting months from different years to form complete years with the wettest to years with the driest months. The two scenarios are said to retain the intra-annual variability.

They deployed the conceptual semi-distributed HBV rainfall-runoff model for their experiments and report varied reactions of catchments to the meteorological droughts showing low levels of stream flow and ground water. In all the studied catchments, they found that mean elevation, slope and size were the main controls on sensitivity of catchment discharge to precipitation: catchments lying at high elevations and having steeper slopes showed less sensitivity to meteorological droughts.

Climate change is very important at the present and efforts to improve our understanding of the underlying processes and the probable effects on humanity are highly welcome, thus the relevance of the research. However, I have some remarks that are outlined below.

I could not follow the authors' arguments on many occasions. I propose they streamline their reasoning to eliminate ambiguity. The studied scenarios assume progressive future reductions in precipitation, something that is not true everywhere atleast not in central Europe (see e.g., Dai (2011)). By the way, 35 years of continuous drying seem unreasonable. It would add credibility if the results from the experiments could be compared to results performed with an observed dataset. Secondly, the different catchments should react differently to forcings but the authors do not mention the years when the various catchments were under drought. Apart from the summer drought of 2003 falling within the simulation period (the selection of which could have been motivated by data availability considerations), what else qualifies the event as *representative*?

A sustained reduction in precipitation would have an impact on temperature: there would be less water to evaporate, thereby an increase in the air temperature and thus an amplification of drought severity (see e.g. Trenberth et al. (2014)). Sheffield et al. (2012) studied the combined effect of reduced precipitation and increased temperature and decoupling the two might be an over-simplification. Much as that might be beyond the scope of the current work, I would have loved the authors to state, at least speculatively how their chosen scenarios impact the energy balance and ultimately the partitioning of soil moisture.

It is possible that the scope of the experiments was not sufficient for all the conclusions to be drawn. Specifically, I'm not convinced that the subsurface properties do not have any bearing on the groundwater storage. I also find issues with the way the authors remained silent on the changes in land cover (or land use) over the simulations period.

# 2 Specific Remarks

**P7661, L14** *...sensitivity of course results from... modification by specific catchment properties.*
It is rather counter-intuitive that hydrogeological catchment characteristics have no effect at

all on groundwater droughts. Could it be possible that the experiments conducted are not adequate for such a conclusion to be drawn.

**P7661, L15** Please write an individual instead of a individual.

**P7661, L26** Please insert a comma after Further.

**P7666, L6** Please consider rewriting the sentence as $\Delta x$ *was calculated using Eq. 2 for ... (GW+SUZ+SLZ) as shown in Fig. 1.* Numbering for line 5 seems to be misplaced.

**P7666, L10** Insert a space before IQR.

**P7669, L11** Please rephrase to *... scenario SoMo always resulted in ...*

**P7669, L27** Please change *a difference* to *the difference.* I suppose you use talking about flow rating curves and the probability of exceedence here. Since your study is on droughts (low flows), it might be confusing to some people when you speak of *days exceeding* $Q_{90}$. I suggest you briefly say something to that effect in order to mitigate the potential source of confusion.

**P7670, LL8-17** Can the results presented in Fig. 5 be reproduced when the model is allowed a reasonable *spin-up* period?

**P7670, section 3.3** The authors state that *small, high and steep catchments are less sensitive to drought than large, low-lying and flat catchments.* Could the authors offer an explanation why this is so and how the sensitivity of large, highland catchments might be? I also expected the changes in land use to be relevant to the evapotranspiration from the catchments. Could the authors say if the land use (or cover) was constant (and if so, why) over the entire period?

**P7672, L9** I think that disregarding the initial wetness destroys the autocorrelation structure of the groundwater signal (long memory effects are known to exist in some regions).

**P7687** Please make the figures bigger and print the axis labels labels close to the corresponding graphics.

The authors did not aim to construct realistic scenarios and intentionally removed the natural variability in precipitation. Since some of the results are rather surprising, it might be helpful to perform their experiments with an observed data-set. Their arguments were also hard to flow and most of them need reformulating. For these, I recommend a major revision before the manuscript is accepted for publication.

# References


Dai, A. (2011), 'Drought under global warming: a review', *Wiley interdisc. Rev. Clim. Change* **2**, 45–65.

Sheffield, J., Wood, E. F. and Roderick, M. L. (2012), 'Litle change in global drought over the past 60 years', *Nature* **491**, 435–438.

Trenberth, K. E., Dai, A., van der Schrier, G., Jones, P. D., Barichvich, J., Briffa, K. R. and Sheffield, J. (2014), 'Global warming and changes in drought', *Nature Clim. Change* **4**, 17–22.