Anonymous Referee #3

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Reply to Anonymous Referee #3

Thank you very much for your valuable comments, which help to improve our paper significantly.

General: In general, the paper shows an interesting application of a model that runs at the hourly time step, and trying to detect possible differences in streamflow with respect to signature indices into the future. However it is a bit hard to extract the conclusions of this paper, especially due to a lack of conclusions section. There are a few things that the author should help explain or perhaps address in the revision of this paper.

The author uses a model that runs at the hourly time scale, but I wonder if, for the purposes of the signature indices that were chosen, if hourly flow that is calculated is necessary. The FDC that is constructed does use hourly flow information, but I would like to see what the difference from a FDC using daily data would be. If there is a distinct difference, it would be interesting to state what the difference is.

For our study we used the same hourly data for calculating runoff coefficients and FDCs. Using daily data for FDC would change information only about high flow: much lower values for flow exceedance probabilities < 1%. The duration of peaks of most of the rainfall-runoff events is less than 24 hours. Using daily data, these peaks would be considered in more imprecisely way when averaged over 24 or, depending on time of peak flow, over 48 hours. Using monthly data for FDCs would mean a much greater loss of information, especially for the important high flows.

I think that the selection of signature indices do tell us information about hydrologic systems, but I think that the interpretation of these indices relative to the different catchments and marching forward through time would offer extra interesting information that might help with the overall story.

In the revised version of the paper, we will focus on index interpretation relative to the different catchment an input data.

Another point that was unclear was the difference of the meteorological information that you are feeding into the model between time periods.

We will extend the description of our input data sets. In the actual text you find:

(1) Measured meteorological data from 56 DWD-stations, period 1994-2003
(2) CCLM reference data, period 1988-1997 (scenario C20_1)
(3) CCLM projection, period 2015-2024 (scenario A1B_1)

Both CCLM data sets originate from a run of version COSMO4.2-CLM3 on 5 km grid resolution within the LandCaRe 2020 project (Berg et al., 2008; Köstner et al., 2008). A bias correction has been applied for precipitation.

It would be interesting what the possible differences between these catchments would be based on the inputs in order to form hypotheses, and then to test whether your hypotheses is correct.

We will add a hypothesis section in the first part of the paper we will formulate in the following manner:

(1) We expect only small differences between measured climatic input and bias corrected CCLM reference data.
(2) Based on our signature indices, we should be able to detect the climate change signal inherent in the CCLM simulation by comparing the reference period with the near future (2015-2024).
(3) In addition, our method should allow for quantification of the hydrological impact of bias correction.
(4) Because of the large gradient in catchment properties (see table 1, this table will be added in the revised version), we expect visible differences in hydrologic behavior.

Table 1: Selected catchment properties

Catchment property		Kronweiler (65 km²)	Kellenbach (362 km²)	Gensingen (196 km²)
MAP (mm/y)		928	673	545
potET (mm/y)		535	540	614
Long term runoff rate (l/s*km²)	year	14.0	7.2	2.3
	winter	23.1	10.9	2.8
	summer	5.2	3.6	1.7
Mean runoff coefficient (93-08)	year	0.23	0.17	0.04
	winter	0.41	0.28	0.08
	summer	0.09	0.07	0.03
Field capacity of total soil column (mm)		288	356	605
Land use		43 % arable land 2.6 % built-up area 54 % forest	58 % arable land 2.5 % built-up area 39 % forest	74 % arable land, orchards, vineyards 5 % built-up area 20 % forest
Soils (FAO85)		Gleyic and humic podzols with cambisols	Gleyic podzols with few cambisols, luvisols and fluvisols at headwaters	Humic podzols and cambisols at upper reaches and luvisols, gleysols and regosols at lower reaches

Along with this point, saying that time series of climatic data should be referenced, saying to where the information was acquired. Without this information, the experiment that you ran would be hard to replicate.

We will add a reference for the data from German Weather Service (DWD):

As climatic data input we used measured data (1994-2003) interpolated from the official station network of German Weather Service (DWD). The simulated CCLM data sets originate from a run of version COSMO4.2-CLM3 on 5 km grid resolution produced within the LandCaRe 2020 project (Berg et al., 2008; Köstner et al., 2008).

The use of English in the discussion can be said a bit cleaner, but overall the use of English is ok.

The discussion section will be completely rewritten.

Specific:

Page 3572 Line 7 – You mention the use of 3 catchment models, where I believe you mean to say 3 catchments or perhaps 3 catchment model runs. The way you currently word it makes it sound like there are 3 separate models that are applied in the paper.

You are right: We use the same model code but with catchment specific spatial parameter sets. We will change this paragraph. To avoid ambiguities concerning the word 'model': The same model code (LARSIM) has been used in all three catchments. For each catchment, a specific model configuration (subdivision into elements according to land usage, linking of elements according to stream network) has been built and a specific parameter set has been identified. For each catchment, we have three input data sets as mentioned above. Then, we applied the three input data sets for the three catchments, resulting in a total of nine discharge time series.

Page 3575 Line 17 – It is unclear to me how you go about the calibration of the model that you use for these 3 catchments. I know of the 9 signature indices that are used, but it is unclear how the results that you present are found. If they are found by manual calibration with regard to these 9 indices, then that must be stated.

The model has been manually calibrated based on R^2 and Nash & Sutcliffe Efficiency. We will include this information in the method section.

Page 3578 line 10 – You mention the use of FDCs created from hourly discharge, but I think it would be useful if you explicitly say why this FDC is different than those built from daily or monthly data (what mechanisms are being captured using hourly data that aren't captured using a coarser time step).

For our study we used the same hourly data for calculating runoff coefficients and FDCs. Using daily data for FDC would change information only about high flow: much lower values for flow exceedance probabilities < 1%. The duration of peaks of most of the rainfall-runoff events are less than 24 hours. Using daily data these peaks would be considered in more imprecisely way when averaged over 24 or, depending on time of peak flow, over 48 hours. Using monthly data for FDCs would mean a much greater loss of information, especially for the important high flows.

Page 3579 line 19 - Why were the points along the FDC chosen? Was there a reason why exceedence probabilities of 0.2 and 0.7 were chosen as opposed to 0.3 and 0.6?

As mentioned in the text, we used indices from FDC published by Yilmaz et al. (2008). Yilmaz et al. 2008 "subjectively partition the curve into three different segments ... midsegment (0.2-0.7 flow exceedance probabilities) characterized by flows from moderate size precipitation events and also related to the intermediate-term primary and secondary base flow relaxation response of the watershed". Because of a nearly straight course in this part of the logarithmic presentation of the FDC and the use of the slope as index describing the mid-segment it would be approximately the same result if we chose 0.2 and 0.7 or 0.3 and 0.6 for index.

Page 3580 line 17 – It would be helpful to list the last 4 signature indices in a similar way to the first 5 so that the structure stays the same. In other words, the last 4 signature indices should be numbered 6-9.

Text will be changed to:

"From the ECDFs of event runoff coefficients (ERCs) we derive four additional indices (Fig. 3):

6. ΔERCmean: difference of mean runoff coefficients.

$$\Delta ERCmean = \frac{1}{m_1}\sum_{j_1=1}^{m_1} ERC_{j_1} - \frac{1}{m_2}\sum_{j_2=1}^{m_2} ERC_{j2}$$

   where m_1 and m_2 are the number of events from datasets 1 and 2

7. ΔERCcv: difference of coefficients of variation, describing variability of runoff coefficients of one catchment.

$$\Delta ERCcv = \frac{\sqrt{\frac{1}{m_1-1}\sum_{j_1=1}^{m_1}(ERC_{j1} - ERCmean_1)^2}}{ERCmean_1} - \frac{\sqrt{\frac{1}{m_2-1}\sum_{j_2=1}^{m_2}(ERC_{j_2} - ERCmean_2)^2}}{ERCmean_2}$$

8. ΔERCmeanSu: difference of mean runoff coefficient in summer (May to October). Calculation like ΔERCmean for events between May and October.

9. ΔERCmeanWi: difference of mean runoff coefficient in winter (November to April). Calculation like ΔERCmean for events between November and April.

"

Page 3581 line 16 – The large bias that is seen for this catchment can also be due to a model structure that doesn't simulate the physical structure of the catchment. Bias can indeed be explained by calibration error or incorrect runoff data, but error introduced by model structure should also be included in this list.

Model structural error will be included in the list of possible errors. But in our case the observed bias results (to a large extend) from an imperfect water balance at the gauge Gensingen.

Abbreviations

We will change our abbreviations as follows:

rc → ERC (event runoff coefficient)

rcMeanSu → ERCmeanSu

rcMeanWi → ERCmeanWi

rcMean → ERCmean

rcCv → ERCcv

References

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