

Authors response to:

Referee #3

Referee comments:

In this paper, the authors compare the results of two physically based hydrological models, for the current situation and for changes in meteorological forcing and land use. I think the authors made a relevant comparison with multiple variables (models, climate scenarios and land use scenarios). The analyses for this comparison are thorough and broad.

I think that especially considering different models is very relevant. From a hydrological modelling point of view, however, I miss some relevant information in the paper, as well as a discussion on the suitability of both models for this catchment. On the other hand, some of the presented information seems redundant or less relevant to me.

In the Specific comments below I will point out which information I miss and which I think is redundant. Further, from a hydrological point of view, there are no losses. Although I understand that water availability in the rivers is the main concern of the authors, I would not use the words yield or loss.

Finally, I do not fully agree with the other referees that the paper is written in clear English. I think that the paper would become more clear if the authors have another look at the length, word order and structure of certain sentences and the length of most of the paragraphs (see Specific comments for some examples).

Authors:

We thank the referee for the extensive revision of the manuscript and her frank opinion about it, and will try to correct the main drawbacks that she highlights, as well as all the specific corrections suggested.

Specific comments:

All of the comments below are suggestions, it is up to the authors to use them or not.

Referee: 11983, 4: *I would change models comparison to model comparison*

Authors: We have changed it as suggested

R: 11984, 25: *I would use mountain areas or mountain ranges, or in some cases upstream areas.*

A: In this case we keep “mountains” as it is a generic word, and the meaning does not change too much

R: 11985, 9-12: *This sentence is very long.*

A: The sentence has been reduced

R: 11986, 6: *Now it seems that hydrological models do not require observed data.*

A: We have deleted the discussion about observed data, to avoid misunderstandings.

R: 11986, 12: *I do not agree that physically based models are required when spatial heterogeneities are investigated. Conceptual models applied in a distributed way can be very useful as well (see for example: Uhlenbrook et al., 2004; Winsemius et al., 2008; Gao et al., 2013). It might be good to also point out the disadvantages of physically based models. Especially the large data requirements: physically based models require much more input data than conceptual models. For example, in the response to anonymous referee #2 the authors state that three important variables to determine the evaporation were not available and, therefore, generated by the model itself. How does this influence the results and are physically based models still more useful than conceptual models in case of limited data availability?*

A: We appreciate the referee's insight at this regard and we have changed the paragraph. However, we were not intending to compare physical and conceptual models, and much less to put down conceptual models. Therefore we won't go too much deeper in the discussion of advantages/disadvantages of the different kind of models. The corrected paragraph looks like this:

A comprehensive understanding of the processes that govern the water balance in mountains is crucial to ensure suitable management of water resources in downstream areas. For this, hydrological models are very useful tools as they allow predicting the possible response of hydrological parameters to changes in input conditions. The “process-based” hydrological models allow reproducing, through empirical equations, the physical processes of the watersheds, and they yield hydrological variables including runoff, evapotranspiration, groundwater recharge, or snowpack water content, in a distributed fashion and at different spatial and temporal scales. These models constitute valuable tools for water management and decision making in the context of environmental change (Borah and Bera, 2004), although they require large amounts of data and pre-processing, which needs to be considered when attempting hydrological simulation.

R: 11987, 17: Or because the authors want to model the inflow in the reservoir and not the reservoir itself?

A: This is implicitly said in the sentence

R: 11987, 21: How approximate?

A: This was answered already to referee#2

R: 11988, first paragraph: Is this paragraph relevant for the study?

A: It is indeed not relevant, and we have removed it from the manuscript.

R: 11988, 19: 'to make the comparison of results possible'

A: This was already corrected in a response to referee#2

R: 11989, 21: The authors might consider adding a table here, with for each process the variable name, the abbreviation used in RHESSys and the abbreviation used in SWAT. This prevents the

list of variable explanations after each equation. In addition, the differences between the models can be observed more easily.

A: A table (new Table 1) has been added as suggested, and explanations of each variable after equations have been removed.

R: 11989, 25: *Why is there only snow melt when the snow pack is mature?*

A: That sentence was not well contextualized and we have removed it to avoid misunderstandings.

R: 11990, 6: *Is the daily temperature of the snow pack known?*

A: It is indeed modeled within the snow-melt SWAT module

R: 11990, 9-11: *This information is known by hydrological modellers.*

A: It has been removed from the manuscript.

R: 11991, 6-7: *Information in this subordinate clause is known by hydrological modellers.*

A: The sentence was as well removed.

R: 11991, 16: *Are these daily temperatures?*

A: Yes. This information has been included

R: 11993, 12-16: *This sentence is not relevant.*

A: The sentence has been removed

R: 11994, 9: *Why are literature values used as reference? Is there no data about LAI available?*

A: No, there are no LAI values available for the study area.

R: 11994, 11-25: *This is a description of the model, not of the calibration procedure.*

A: The referee is right, however we consider more suitable to place this information in the calibration section, as the adjustment of LAI parameters was a key procedure within the calibration process.

R: 11995, 5: *How many and which parameters were calibrated during each phase and which value was selected for each parameter (maybe present the calibration results in a table)?*

A: This is a rather sensitive issue, and we ourselves were hesitating whether presenting these results or not. We decided to not present them, as the calibrated parameters in SWAT and RHESSys were different, and therefore there is no point for comparison here. On the other hand, is it really relevant to show the values of the calibrated parameters? Maybe if we were modeling different catchments with the same model it would be useful to compare the calibrated parameters in each catchment, but in this particular case we did not see it significant.

R: 11995, 5: *Was the calibration based on daily or monthly data, if it was based on daily data, why does fig. 2 show monthly data?*

A: The models are run in a daily basis and the parameters are calibrated as well in a daily basis. However, the calibration algorithms were set on a monthly basis, and thus results are displayed on a monthly basis.

R: 11995, 17-23: *The information in this sentence is known by hydrological modellers.*

A: The information has been removed.

R: 11995, 28-2: *This sentence is redundant.*

A: The sentence has been removed.

R: 11996, 9-10: *Are these NSE values for daily or monthly data?*

A: They refer to monthly data. This information has been included.

R: 11996, 19: *'keeping the calibrated parameters constant'*

A: The sentence has been changed as suggested

R: 11997, 9: *Include a reference to the construction of a Taylor diagram.*

A: The reference has been included

R: 11999, 2: *From the graph, it seems that REHSSys has a decrease of 11%.*

A: The figure has been corrected to 11%

R: 11999, 17: *Why is it a pessimistic scenario? 'most extreme scenario' is more objective.*

A: We change it as suggested

R: 11999, 18: *When is a shift dramatic?*

A: word has been replaced by “intense”

R: 11999, 21: *I would replace always by 'for these scenarios'.*

A: We replaced “always” by “generally”

R: 11999, 25: *Change 'water losses' into 'decrease in runoff'.*

A: Replaced as suggested

R: 12000, 22-25: This elaboration does not seem to match with figure 5.

A: There were a couple of errors, and they have been corrected

R: 12001, 1: *Why are these scenarios not described in the method section?*

A: We don't think it is necessary to include them in the methods, as they don't need much explanation to be understood.

R: 12001,3-8: *This sentence is too long.*

A: It was actually missing a dot, and it's been corrected.

R: 12002, 27: *The comment between brackets is redundant.*

A: Is has been removed.

R: 12003, 29: *The text between brackets is redundant.*

A: It has been removed

R: 12004, 7: *Why is this experiment not described in the method section?*

A: We don't consider necessary to explain in methods section as there is not much technical concepts to describe.

R: 12004, 7: *From a modelling perspective this is an experiment, so I would not change it into 'set of runs' or run.*

A: We then leave it as “experiment”

R: 12008, 9: *This sentence is not correct.*

A: The sentence has been corrected

R: 12009, 11-13: *I think that it is important to know the behaviour and uncertainties of your own model (not necessary hydrological modelling), before using it to make predictions.*

A: “hydrological modelling” has been replaced by “the models used”.

R: 12009, 19: *It is maybe better to quantify the decrease instead of calling it dramatic.*

A: dramatic has been replaced by “significant”

R: 12021: *I find the axis labels confusing, maybe change to 'change in river discharge'. What is the time span of the change (20 yrs or per year)?*

A: The y axis has been corrected

R: 12022: *I find the legend of this graph confusing.*

A: This graph condenses a lot of information and we made the legend the most intuitive possible. The explanation in the caption helps to understand the legend.

R: 12024: *I find again the axis labels and the units of the axes confusing.*

•12024: *relative difference in respect to which discharge?*

•12024: *Something went wrong with the lines forming the axes.*

•12024, line 2 of caption: *change 'figures' into 'numbers' for clarity*

A: The errors have been corrected. Relative difference refers to difference between SWAT and RHESSys in a relative fashion (percent).

R: 12025: *The axis labels are again confusing: eg. mean snow pack cannot be negative.*

A: We have added “change in mean SWE”

R: 12025, b+c: *A flux has a L/T dimension, so mm/day or mm/year.*

A: The temporal dimension has been added.

R: 12025, c: *The REHSSys graph has yearly ET as label instead of yearly runoff.*

A: Corrected

R: 12026, b: *I would keep the scale the same and leave out the negative part of the scale.*

A: We leave it as it is, as the caption makes it clear the difference.

R: *Technical comments:*

- 11984, 15: *used*
- 11984, 26: *they produce more than*
- 11986, 1: *For this,*
- 11988, 18: *conceptualization*
- 11995, 18: *10% and 15%*
- 11996, 24: *These comprise*
- 12003, 26: *(6 %)*

A: Except “conceptualization” and “these comprise” (ensembles project is singular, therefore “this comprises) all have been corrected