Authors response to:

Interactive comment on “Sensitivity of water balance components to environmental changes in a mountainous watershed: uncertainty assessment based on models comparison”

Anonymous Referee #2
Received and published: 4 December 2013

Referee comments:

The main aim of this study is to evaluate the sensitivity of the components of the water balance to changes in climate (2021-2050 horizons time frame) and land-use in a Pyrenean watershed using two hydrological models: SWAT and RHESSys.

The paper is written in well and clear English.

The bibliography is complete, up-to-date, and of international broad.

Authors:

We appreciate the referee’s outlook and we will try to answer every point in the revision to clarify concepts.

***Referee** : Thought the use of two models is appreciated but needs further justification. In fact, one of the selection criteria is “the need of two models of differing conception and purpose”. Further, you mention “The two models differ in the basic equations governing water partitioning and runoff generation, and this can be therefore the cause of possible differences in the results obtained from the analyses” ?.*

Authors: The comparison of RHESSys and SWAT arises from a number of reasons that include similitudes and differences between the two models. On the one hand we needed two models with same inputs requirements and same outputs variables in order to make the comparison

possible. Obviously, there must be as well differences between models, otherwise we wouldn't have different models! Every model out there is developed for a particular purpose with a unique combination of processes, physical equations, spatial partitioning etc…, although most of the time they are upgraded and include new processes and outputs and these make them comparable. As our intention was to assess the sensitivity of water balance to land-use and climate changes and evaluate the uncertainty related to model's choice, we needed two models with different routines and equations for the main processes that govern climate-vegetation-hydrology relationships. This is the reason why we specify in the manuscript the equations responsible for snowmelt, evapotranspiration and runoff in each model.

We believed that the use of the two models was enough justified in the manuscript, but since the referee expresses his/her doubts, we have added new information in the next paragraph:

The selection of RHESSys and SWAT models for this study was based on different criteria that include similitudes and differences between the two models. On the one hand we needed two process-based distributed models with similar spatial partitioning, in order to compare the effects of spatially distributed processes of change (land-use, climate change) at different spatial scales and over different components of the water balance. Moreover, the models had to present the same input requirements and same output variables to make comparison possible. However, as our purpose is to assess the sensitivity of water balance to land-use and climate changes and evaluate the uncertainty related to model's choice, we needed two models with different routines and equations for the main processes that govern climate-vegetation-hydrology relationships. RHESSys and SWAT were developed for different conception and purposes, and here we specify the main differences between them.

Referee *:* In page 11997, it was mentioned that "C4I and SHMI present poorest performance". Why did you continue using them?

Authors: As this was the main topic of criticism by Referee #1, you can find a comprehensive explanation in our response to Referee #1. To summarize here, we did not use the regional climate models as inputs for the hydrological models. We only used them as a reference of plausible changes in climate variables, and then applied these changes to our observed climate series. Therefore the errors (in Figure 3) of the RCMs are not propagated into the hydrologic simulations.

***Referee** :* It is recommended to add quantitative figures either in the Abstract and the Conclusion.

Authors: We included quantitative figures in both abstract and conclusion, in relation with changes in streamflow, peak flows, evapotranspiration and snowmelt.

Specific comments

***Referee** :* In the title: correct the word 'senstitivity'

Authors: Thanks, we actually realized about this error but it was too late to correct it. The word has now been corrected.

***Referee** :* P11987 L17: Why the reservoir is excluded from the study area ? (Is it situated downstream the gauging station ?).

Authors: Yes, the reservoir is located downstream the gauge station. In fact we specify that "The lower point of the catchment (492 m) coincides with the hydrological station at the mouth of the Yesa reservoir". We change to phrase to make it clearer: **"coincides with the hydrological station located before the mouth of the Yesa reservoir".**

***Referee** :* P11987 L24-25: ".. lower values are registered" how much ?

Authors: In the highest parts, annual temperatures are usually below 5-6ºC. This data will be included in the sentence.

***Referee** :* P11991 L10-13: The application of Penman-Monteith method yielded results out of bounds. Is it linked to the method itself or to your available input data ?

Authors: It has to do more with input data, and the way that models generate/interpolate unavailable data. Data as wind speed, solar radiation and relative humidity are required for this method, and were not available in our case. The models have weather generator modules for such situation, and in this particular case, the module of SWAT does not generate reliable data, and this is the reason why Penman-Monteith in SWAT produced defective results.
This information, however, has been removed from the manuscript. As recommended by the Editor, the manuscript was too long, and some information relative to model's equations had to be shortened. We have removed this sentence (which does not provide relevant information for the purpose of the manuscript) and others of the same kind.

***Referee** :* P11993 L10-28 + Fig 1: What is the resolution/scale of the maps ?
Authors: The scale is included in the Figure (scale bar in the bottom part of the figure). And the spatial resolution of the maps is 40x40m. This information has been included in the figure's caption

***Referee** :* P11994 L26: Why did you use 351 yr (spinup) ?
Authors: In RHESSys spinup period is necessary in order to stabilize the soil's parameters. During the process the model adjusts the initial values of the parameters in order to find equilibrium of carbon and nitrogen values between vegetation and the soil. The time period required varies as a function of physical characteristics of the watershed (climate, vegetation, soils…). The process is repeated until the difference between the initial and final values of C and N during the simulation period is less than 5%. In this case, it took 351 years.

We believe that this information is too specific and it can mislead the potential reader. We have therefore removed the sentence concerning spinup, in this way we make the text lighter as suggested by the Editor.

***Referee** :* P11997 L5-6: "show fairly good statistical agreement.". How much ?
Authors: The statistical agreement is given by the Pearson's correlation, the ratio of variances and the root-mean-squared error. They are all depicted in the Taylor's Diagram of Figure 3, (radial, x and y axis), therefore we don't think it is necessary to give exact values on the text.
As this issue was as well addressed in the response to Referee #1, we wrote a new paragraph for better explaining Figure 3:

The Taylor diagram shows the model's performance with respect to observations in terms of their long-term correlation, ratio of variances, root-mean-squared error, and their percent bias. For precipitation, only DMI is capable of reproducing the statistical characteristics of the observations, whereas C4I and SMHI present poorer performance. For temperatures the three RCMs show good performance in terms of correlation, variances and RMS error with respect to observations, however, minimum temperatures simulated by models present a large bias (nearly 60%).

***Referee** :* P11998 L21: Why only here that you used 'm.a.s.l.' ?
Authors: For clarifying we have changed it to "m above sea level".

***Referee** :* P12004 L7: Replace 'experiment' by 'run'
Authors: As it was not only a "run", we have replaced experiment by "set of runs"

***Referee**:* P12010 L17-19: What do you recommend to use with models when planning/implementing water policies ?
Authors: In the final conclusion we state: "Until this type of detailed model evaluation is done for this region, caution is recommended when interpreting results from hydrological modeling and implementing water policies based solely on model results"
Based on the results of this study we cannot recommend one or the other model for implementing water policies. We observed how SWAT is more sensitive to climate changes, and RHESSys to land-cover changes, but it does not mean that one is "better" or more accurate than the other, especially since calibration procedure can play such an important role in obtained results. Both have their strengths and weaknesses. SWAT is more user's friendly and easy to implement in large watersheds, but RHESSys is more physical-based and has a more elaborated module of vegetation ecology. Therefore the main (and we believe rather valuable) conclusion that can be withdrawn from this paper is the importance of considering ranges of uncertainty in hydrological projections, especially by policy makers. Also model's users (scientists and planners) have to carefully review the characteristics of models in order to choose the most convenient for their particular case. (This last sentence has been as well added to the final conclusion in the revised manuscript)