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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Elevational dependence of climate change impacts on water resources in an Alpine catchment" *by* S. Fatichi et al.

Anonymous Referee #3

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Summary of the contribution

The paper describes the modelling of the Rhone river basin under changing climate conditions, based on a distributed rainfall-runoff simulation model. The main idea is to use climate scenarios based on the A1B emission scenario, which are used to drive the rainfall-runoff model. This hydrological model integrates different hydrological processes, such as surface runoff, infiltration, snow melt and glacier melt. Moreover, the model integrates other anthropical effects, such as water diversion and storage by hydropower plants. In general, the major processes affecting the water cycle are considerred in this study at a sufficient detail level.

The major results of this contribution can be summarized as follows: 1. The greatest

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changes in water balance occur at higher elevations 2. The changes in water cycle of the main stream (Rhone river in the Rhone valley) are almost negligible because of the limited part of glacierized areas (the most influenced areas)

In general, it can be observed that these results are not surprising and not new, because they are directly linked to the assumptions of the climate scenarios. 1. A large amount of studies showed that the water cycle in glacierized regions would change with an increasing average temperature. In general, the annual quantity of water would increase and finally decrease due to the loss of glacier mass. 2. The annual influence of the glacier decreases with its relative surface in the catchment area. 3. The increase of evaporation is limited, because the general evaporation is low in high elevation regions such as the Rhone river basin upstream of lake Geneva.

As long as the climate scenarios tell us that the changes in precipitation are limited, the changes in the water balance will be limited as well !

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Comments on the general focus of the study

Choice of climate scenarios

The general sensitivity of the system (climate + river basin) cannot be sufficiently estimated by the use of a single emission scenario. Other scenarios could have been tested, with limited number of stochastic realizations. For example: - Prolongation of the reference scenario (persistance) –> what will happen if the next 50 years are similar to the last 30 years (reference period) ? In that case, the difference between the chose climate scenario and the persistance could already show (or not) any difference - Scenario with emissions having a strong influence on precipitations –> could show other types of possible realizations, maybe much more critical.

Influence of hydroelectric installations

The influence of hydroelectric installations is in general correctly modelled (with a water

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level average filling curve for large reservoirs), for the current situation. However, electricity market will change, and there is no reason to believe that the filling curves will stay similar to the current ones. In this study, it is showed that hydroelectric schemes strongly influence the hydrological regime. But it could be interesting to highlight how more it could change with other filling curves –> are they cumulative and negative effects ?

–> I suggest an additionnal analyse showing the influence of anthropogenic effects compared to climate change effects to highlight the most important ones.

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Comments on the modelling

Glacier model

I see a problem with the assumption of uniform thickness for each glacier. With this assumption, you might underestimate the celerity of ice melt during the first decades, because the thickness is normally smaller at elevations ranging from 2500m to 3000m (glacier tongue). These regions might melt very quickly. However, as the model don't take into account the glacier flow from top to bottom (mass transfer inside the glacier), you might tell that both effects compensate each other. So please tell it.

p.3747 "Simulations of natural and regulated flows also allow us to ...". See CCHydro project. I would write "for one of the first times" or someting similar.

p.3752 "This represents a much more realistic precipitation forcing ...". Please... Some clever people use precipitation forcing including altimetric precipitation gradient. Try it and compare, it may provide similar results. You are right to use the RhiresD, as it is now existing (what was not the case a few years ago). But other are not stupid. Please read (Tobin et Rinaldo al., 2012) in Journal of hydrology, they tested an interpolation method using external data (altimetric gradient) and it worked.

p. 3768 "We provided for the first time..." –> No, (Meile et al; Jordan et al.) already

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discussed these points (regarding the hydropeaking processes and flood processes). The water budget is also considerred by (Huss et al.). –> Please suppress the "first time" and focus the sentence on influence on water budget only, other effects of anthropogenic activity were already analyzed.

p. 3769 "However, the fact that interannual variability of discharge was well simulated..." I do not agree. Interannual variability depends on temperature only, as in your model the ice melt is depending on surface in (m2) of the glacier. You cannot assess the correctness of glacier mass, even by using trends over 18 years. Indeed, ice melt trend is a gradient, and you could obtain the same result with much more ice mass in your model. To check, you need to simulate longer periods up to 2100 to check when your glacier disappear. Please formulate your sentence differently –> the verification of the ice thickness must be achieved by other cross-validation (Funk et al., etc...)

p. 3771 "These results lead us to argue that broad impacts..." -> I don't agree. The studies focused on sensitive regions and the impacts are significant there. I don't think that the authors of these studies have extrapolated there results for larger basins.

Additionnal analyzis needed:

In order to fullfill the analyze, it is recommended to extend it with the following experiments:

1. Simulate the past 30 years, based on the today's initial condition of the model (particularly the glacier mass), and compare it to the climate scenarios you already presented. In that case, it will really highlight the influence of climate change in comparison with the reference scenario, which for future is not the past years, but the climatology and the actual situation.

2. Compare the reference scenario "without hydropower installations" with the future scenarios "without hydropower installations". Then you might highlight more differences due to climate change, not in water balance, but in seasonal averages discharge.

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The problem is that in you current analyze, the uncertainty due to anthropogenic influence is too high. Then you might see that anthropogenic activity has a stabilizing influence on the seasonal water regime.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 3743, 2013.