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Comment on hess-2022-339

Anonymous Referee #1

Referee comment on "Machine learning based streamflow prediction in a hilly catchment for future scenarios using CMIP6 data" by Dharmaveer Singh et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2022-339-RC1>, 2022

Review of **Machine learning based streamflow prediction in a hilly catchment for future scenarios using CMIP6 data** for Hydrology and Earth System Sciences

Thanks to the authors for the efforts in the work and the manuscript. This paper investigated the performance of five machine learning models in streamflow prediction in a sub-catchment in the Sutlej River Basin and assessed the future streamflow change by driving one of the machine learning models with CMIP6 data. The results of this study can give information of future streamflow patterns for this specific region. The presentation is overall satisfactory but some arguments are not scientifically solid enough and requires detailed information. There are some major issues regarding the significance and novelty of the study that I would like the authors to clarify, which are required by the journal of Hydrology and Earth System Sciences. Meanwhile, the structure of the paper needs revision to avoid redundant information. The comments are below:

- Regarding the novelty of the paper, the paper argues that very few research have been undertaken for a mountainous catchment, which I do not agree. There are plenty of studies investigating all kinds of machine learning models on streamflow simulation across the world, which covers many mountainous areas, only except, they are not marked as mountainous areas specifically. In my opinion, investigating a mountainous area is not a solid argument for the novelty of this paper.
- Regarding the interpretation of the future streamflow patterns, as I understand, the relative change in the paper is to compare the predicted streamflow from CMIP6 data with the observed streamflow in the reference period. Since there are meteorological data in CMIP6 in the reference period, which can be used as inputs for the machine learning models and generates "reference" streamflow data series. With this reference streamflow, the bias of the CMIP6 models to the observations can be excluded. In other words, the relative change in the paper cannot distinguish itself from the bias of CMIP6

models. This will make the results less reliable when the authors argue the results can assist in strategy planning.

- The paper investigated only a small subbasin in the Sutlej River Basin (less than 10% in terms of the area), but a lot of description focuses on the whole river basin, which makes it confusing sometimes.

Line by Line comments are below:

Line 35, what is the criteria for selecting these six models?

Line 64, are these results from Dai's research also? Please add the reference in a proper way.

Line 66, what exactly is the word "similar" here referred to? As you mentioned both decreasing/increasing trends in the previous sentence.

Line 70, please list some examples of other drivers here.

Line 74, what do you mean by adverse effect here?

Line 84, "generate" should be "generates".

Line 85, "could" maybe better change to "can".

Line 137, the application of ML model should not be the novelty, as ML models are only tools. Consider address this by specifying the scientific questions.

Line 145-150, This is redundant information with Line 122-127.

Line 151, so the study area is a sub basin of the Sutlej river. Then the description of the

whole basin is way too much. Please instead focus on the description of the actual study area.

Line 154, the stations in the figure, are they meteorological stations or hydrological stations?

Line 162. Please check the numbers in the Table, or explain why the mean streamflow is much larger than the maximum flow. And there is no need to give two digits for these variables.

Line 173, the investigation is conducted for the three stations or only the outlet station? And please explain how you connect the CMIP6 data grid to the station point. Have you considered any areal weights?

Line 192, reference is absolutely needed here. It is not convincing how you select the models.

Line 208, I do not think this argument is valid here. To be applied to basins with similar geographical characteristics, the models need to be validated across multiple stations. According to the description in the method, I think there is only one station included in this study.

Line 247, there is no in the equation.

Line 241, consider to add the formula of R^2 also. As in Line 248 you are explaining R^2 together with the other two metrics.

Line 249 to Line 254, references are needed here. Are these standard categories? Also please rewrite in a more organized way.

Line 300, it is also important to consider ensembles, we need to be careful with the "best" model. So maybe be conservative with the conclusions here.

Line 305, about the reference period, are you comparing to the observed streamflow? Since there is reference period in CMIP6 also where you can run your model with these data and generated a reference streamflow series. Which method you are using here? And

I think this is important to specify in the method.

Line 321/642, the results here is very confusing as mean ensemble has a much larger relative change than any of the model individually. Could you explain the reason or show annual data series here?

Line 336, since the magnitude in the change is very different, actually it's not precise to say they are similar tendencies.

Line 352 to 375, a huge paragraph here is describing only the numbers, it will be better to put them in a more organized way and add refined information.

Line 376, please add explanation of pre-monsoon/monsoon/post-monsoon months.

Line 419, here the conclusion is different with the information in Figure 8. There, the change in May is sometimes increase.

Line 422/658, considering using different line types.

General Comments

Manuscript Title: Machine learning based streamflow prediction in a hilly catchment for future scenarios 2 using CMIP6 data

Manuscript No.: hess-2022-339

The Himalayan river system is most susceptible to the climate change and as for as India is concerned, its vast population depends on the waters of the Himalayan rivers for irrigation, hydropower generation, domestic and other uses. Any change in the water availability (increase or decrease) will definitely impact the downstream population and the ecosystem as a whole. Looking into the fragility of the Himalayan ecosystem, an assessing of the impacts of the climate change on the streamflow using the latest ML techniques such as including the Gaussian Linear Regression Model (GLM), Gaussian 30 Generalized Additive Model (GAM), Multivariate Adaptive Regression Splines (MARS), 31 Artificial Neural Network (ANN), and Random Forest (RF) is the techno-socio need of the hour, particularly in the Himalayas. Six CMIP6 models, two SSP scenarios and four rainfall scenarios (this is really interesting-the lagging concept) for future stream flow predictions at different temporal scale is really interesting and will be immensely helpful to the stakeholders of the region.

This assessment made in this study will be useful in developing water resources development and management plans in the downstream of the basin. The techniques, calibration, validation and length of the records is beyond the question and suffice for such a study. The techniques are perfect and the results are well discussed. I was just flowing through the text and the different sections of the paper. The paper is well written, smooth and the readers will find it amicably understandable. The language is perfect.

Therefore, looking into the applicability and technical enrichments of the manuscript, I will recommend for publication of this manuscript in this journal with minor corrections as given here.

Specific Comments

1. The criteria for selection of the GCMs may please be explained at the suitable place in the manuscript.
2. The conclusion part may be written in bullet form for enhanced understanding.

3. A separate section of the future scope of the research will further enrich the need and advancement of such studies.

Some Typos and minor:

238 : These were coefficient of determination (R^2). The eqn for R^2 is missing in the text. ?

248:refers to the standard deviation of observed values. Please correct the STDEVobs?

261: please write the unit of MAE?

457: Thus, the outcomes of the overall study indicate that the RF
