Referee comments on HESS discussion paper (doi: 10.5194/hessd-8-365-2011)

Paper Title: Impact of climate change on the stream flow of lower Brahmaputra: trends in high and low flows based on discharge weighted ensemble modelling

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We are very pleased to the high quality detailed reviews by Anonymous Referee # 2. We believe that it has substantially contributed to the improvement of the manuscript and the quality of the paper. Our detailed response to the comment of Referee # 2 is presented below.

The paper addresses the issue of climate change impact in Lower Brahmaputra river basin (LBRB). It uses global hydrologic model PCR-GLOBWB under 12 different GCM and ensemble discharge predicted from it to study the trend in the high and low flows in LBRB. Undoubtedly Brahmaputra basin is one the hot-beds to study climate change impact as is clear from many studies and physical evident. Since climate models often have ambiguous results, there is a strong need of ensemble based forecast. Hence the paper tries to addresses a very relevant and important issue which seems to fall pretty well in the scope of the current journal.

However the approach/methodology proposed in this study needs closer insight and can be still improved (see also specific comments):

General Comments 1

Weighting factor (WF) for different GCM is calculated over entire period and same WF is applied for high and low flow. Why should WF be same over different flow regimes is not very clear from any analysis presented in the manuscript.

Response to the General comment 1:

This comment was also raised by Referee # 1 and we have extended our analysis which is explained in our response to general comment 1 of Referee # 1.

General Comments 2

It is not convincing from the manuscript why 12 GCM been chosen and whether it is an improvement over previous studies (e.g. Mirza 2002 work). In fact result in the manuscript itself shows that 3 GCM simulations are non-significant in this approach. This point should be mentioned clearly in abstract.

Response to the General comment 2:

The idea of this approach is to include all information, we have available in our analysis and then a part of the analysis is actually selecting the best GCMs. This study started with an ensemble of 12 GCMs, however based on the analysis 96% of the weights were assigned to only 4 of the GCMs. Therefore these four GCMs, due to their good performance for the Brahmaputra basin, dominate the analysis. We present this method as a method being wider applicable; one should always start with the full ensemble as we did. Based on the

performance, four GCMs are playing significant role in this study area. This finding is mentioned specifically in the abstract and discussion.

General Comments 3

Moreover the study relies heavily on one gauge station data. Is not there any other location in the basin which can be used as a cross-check point? Authors may put some words to describe the location sensitivity of the gauge station in terms of whether it's being influenced by any anthropogenic factors (e.g. artificial barriers upstream to it etc).

Response to the General comment 3

Bahadurabad is the only station in the lower Brahmaputra for which long-term and consistent observed records are available through the Bangladesh Water Development Board. The data are of high quality and used for planning purposes and major hydrological studies and flood forecasts. The station is located before the confluence with the Ganges and relatively unperturbed by anthropogenic influences.

Specific Comment 1

(1) Page 371 line 11-12: Explain why standard error of discharge observation is as sumed 25% of the observed value in a sentence or two.

Response to specific comment 1

We have added the following paragraph and reference to the manuscript:

The estimate in standard error in discharge observations is conservative, so as not to unjustifiably discard GCMs. Recent work of Di Baldassarre and Montanari (2009) showed that the overall error in river discharge observations ranges between 4.2% and 42.8%, with an average of 25.6% at the 95% confidence level.

Specific Comment 2

Page 372 line 20: "(trends) approximated as linear with time". . ...why?? Is it a good assumption? Support it through some cross reference or strong argument.

Response to specific comment 2

Referee #1 made similar remarks related to the trend analysis. We refer to the response to referee #1 and the revised text in the manuscript on the trends analysis.

Specific Comment 3

Page 373 line 12: Should mention the equation number from which mean trend and variance is calculated, like . . ..using equation 2 and 3.

Response to specific comment 3

We have corrected as suggested and we added as follows.

"…..then calculating the weighted mean trend and its variance using Eq. (2) and (3)."

Specific Comment 4

Page 373 line 19": explain in a sentence or two why in table 2 (page 382) trend in month May is negative and why it has small correlation. . . no good explanation is given. Overall this section (section 4.1) is not very clearly written, try to rewrite.

Response to specific comment 4

Now, we re-write the section 4.1 briefly describing the trend calculation. For explaining negative trend in month May, we compare our findings with the findings of CCC (2009). We added a sentence in the manuscript as follows:

".....small and the trend non-significant. This is because the monsoon may have weakened at the onset of the monsoon season and strengthened during the later months (CCC, 2009)."

Specific Comment 5

Table 2, page 382: Can you also plot the observed trend??...are they close to the GCM trends?? Perhaps Fig. 2 can help in explaining it. May consider adding a sentence to mention this.

Response to specific comment 5

Now we have compared the trend of observed and modeled data for the overlapping period of 1973-1995 and the result is very consistent. We explained this issue in detail in our response to the general comment no. 3 of the Referee # 1.

Specific Comment 6

Table 1, page 381: Why other three GCM has very low weighting factor? Then why to take it at all?? Consider to put one/two sentence to explain/address it. Suggestion: Instead of using 12 GCM can take only the top 9 GCM in rest of the analysis.

Response to specific comment 6

See the response to the General Comment 2

Specific Comment 7

Equation 5 and 6 (page 373, line 6-7): Cannot understand why these two equations are repeated...Instead can mention equation number 2, 3 in preceding discussion section (since essentially Equation 5 & 6 is repetition of Equation 2 & 3 respectively).

Response to specific comment 7

This was an error and this has been corrected.

Specific Comment 8

Page 373, line 2-3: Author himself mention "...Obviously, in case peak flows occur around the turning of the year, or for rivers with a very strong multi-year component, e.g. due to large groundwater reservoirs, such a construction would not work". Then question will arise why should such construct be valid in lower Brahmaputra basin?? Can you dig-out some cross literature reference that shows in Brahmaputra that is not the case? It will then further strengthen the logic of employing 'transient time series construct' that they propose.

Response to specific comment 8

The approach we followed in constructing a transient time series works well for rivers which have a strong seasonality and that do not have a peak in river flow near the year boundary, because this would result in welding problems. In case of the Brahmaputra the majority of the runoff is monsoon related rain runoff from June to September and during winter months only a limited base flow is observed with limited inter-annual variation. Therefore the approach followed is suitable to generate a transient time series for the Brahmaputra River.

Specific Comment 9

Page 373, line 11: Explain little bit how trend parameter is calculated. It is not very clear from reading the section.

Specific Comment 10

Page 373, line 13: R2 notation is generally used for correlation coefficient. Is it the correct notation to use here?

Response to the specific comment (9) and (10)

We acknowledge these comments and we have changed this in the methodology section which is also explained in our response to the Referee comment 1. Please see the response of specific comment 8, 9 and 10.

Technical Corrections:

(1) In title: change 'modelling' to 'modeling'

Response to (1):

Modelling is the UK spelling and previous papers in HESS also use modelling and we have left it unchanged.

(2) Page 368 line 3: "..fore the years.." should be "for the year.."

(3) Page 369 line 9: "projectsions". . .should be "projections"

Response to (2) and (3):

This is corrected.

(4) Page 369 line 20: "PCRGLOBWB" . . .should be "PCR-GLOBWB"

Response:
The term 'PCRGLOB' will be replaced by 'PCR-GLOBWB'.

(5) Page 370 line 5 and 6: "ground- water" should be "ground-water"?

Response:
This is corrected.

(6) Page 370 line 16: Missing comma after PCMDI. ". . .for Climate Model Diagnosis and Inter comparison (PCMDI) https://esg.llnl.gov:8443/index.jsp" should be ". . .for Climate Model Diagnosis and Inter comparison (PCMDI), https://esg.llnl.gov:8443/index.jsp"

Response:
This is corrected as suggested.

(7) Page 371 line 2: "GCM-PCRGLOB-WB" should not it be "GCM-PCR-GLOBWB"?

Response:
The term "GCM-PCRGLOB-WB" is now replaced by "GCM-PCR-GLOBWB".

(8) Figure 1: Suggestion: May consider to use other color to show lower Brahmaputra basin (instead of white can use yellow or some other light color). As Country boundary is also in white, proper contrast is not coming out well.

Response:
This has been corrected.

(9) Figure 2: Suggestion: May consider to plot Jan from x=0 coordinate. Can avoid gridline and moreover color combinations are not good. . .can be improved.

Response:
Now, we have changed as suggested.

(10) Page 372 line18: ". . ..Using this approach both statistical properties (year to year variability) as well are preserved in the constructed..." should be like: ". . .Using this approach both statistical properties as well as year to year variability are preserved in the constructed. . ."

Response:
We changed the sentence like this, "Using this approach year to year variability is preserved in the constructed time-series."

(11) Fig. 4 and Fig. 5 (page 386-387): Fix y axis max to 10,000 to bring out extremes values more clearly. And also can avoid gridline here too.

Response:
In the final version of the manuscript, we avoid gridline. In the *y* axis, we now use log-scale, as Reviewer 1 suggested. We cannot take 10,000 as maximum value because we have some data that is greater than this value.

(12) Page 374 line 13: 'LBRB' introduce this short term once before using it in rest of the section.

Response:
Now in the updated version, we introduce the short term LBRB.

(13) Fig. 7 and Fig. 8: May consider adjusting the y-axis lower bound to bring out extreme value prominently.

Response:
We change figures as suggested.

(14) Page 377 line 3: "...Extreme downstream discharge"...Change it to "extreme discharge at downstream"

Response:
We change this as suggested.

References:

Di Baldassarre, G., and Montanari, A.: Uncertainty in river discharge observations: a quantitative analysis, Hydrol. Earth Syst. Sci., 13, 913–921, 2009

CCC: Characterizing long-term changes of Bangladesh climate in context of Agriculture and Irrigation, Climate Change Cell, Department of Environment, Ministry of Environment and Forest, Government of Bangladesh, 2009.

Mirza, M. M. Q.: Global warming and changes in the probability of occurrence of floods in Bangladesh and implications, Glob. Env. Change, 12, 127–138, 2002.