The Cryosphere Discuss.,
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Interactive comment on "Substantial meltwater contribution to the Brahmaputra revealed by satellite gravimetry" *by* Shuang Yi et al.

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Below, 'Q' is the question/comment, 'R' is our response, and 'C' is the revision in the manuscript.

Q1:

Page 2: Line 40: (Table 1): Glacier and snowmelt contribution to the total discharge of Upper Brahmaputra river basin is 34% from Lutz et al. 2014 in Table 1. Whereas, Lutz et al. 2014 have indicated the contribution to a total runoff as 24.9% (15.9% from glacier melt and 9.0% from snowmelt: Table S3: Basin characteristics). I am not sure where 34% have come from. Please check this.

A1:

The authors kindly provided us the monthly runoff data, as shown below (y-axis in Gt, or km^3). I wrote to the authors to inquire why this discrepancy happened, and I was told that 24.9% is the result for Brahmaputra with several tributaries (the red area in fig. 2, from Fig. 1 of their paper). Therefore, the value of 34% is correct here.

[Fig. 1. Contribution of various components to streamflow in the Brahmaputra.]

[Fig. 2. Excerpt of Fig. 1 from Lutz et al. (2014)].

Q2:

Page 9, 282-286: you are comparing GRACE based estimate (in Gt/year) with other studies (m w.e. /year). Does it make sense to also provide the GRACE values in m w.e./year so that the readers can compare the results?

A2:

GRACE directly detects gravity change, so it is straightforward to give a mass change (1 Gt = 1 km^3 of water). Therefore, we can convert the mass value into equivalent water height change by dividing the glacierized area of 9.679 km^2. We have provided the long-term trend in this form in the introduction.

C2:

Our results show a long-term trend of -6.5 $\pm$ 0.8 Gt yr^{-1} (or 0.67 $\pm$ 0.08 w.e. m/yr) between August 2002 and June 2017

Q3:

Line 9: 301: 33% of GS melt contribution in Brahmaputra river. It is 34% in Page 1, Line40. Please see my first comment in the major comment section

A3:

We are sorry for the typo. It should be 33% , as you may find in the figure above.

Q4:

Page 1: Line 27: Please add Lutz et al. (2014) in the reference

A4:

It has been added.

Q5:

Page 1: Line 31: Please indicate a seasonal aspect of the snow cover here (instead of ‘snow coverage’ only)

A5:

It has been changed to “widespread seasonal snow coverage of up to 100,000 km^2” .

Q6:

Page 1: Line 37: I think the word ‘concern’ should be ‘concerns’ here

A6:

It has been changed to the plural form

Q7:

Page 2: Line 56: The last sentence seems a bit off, please elaborate on how the glaciological model suffers from calibration and validation.

A7:

We cite two recent work that adopted the latest model (Wijngaard et al., 2017; Biemans et al., 2019) and the description of the new model can explain the situation.

C7:

Recently, calibration and validation of glacier mass balance and snow area changes have begun to be incorporated into the state-of-the-art model (Wijngaard et al., 2017; Biemans et al., 2019), but the glacier observations suffer from coarse temporal resolution (two observations over a 5-year span) and the snow area changes are only partially correlated with its volume changes.

Biemans, H., Siderius, C., Lutz, A., Nepal, S., Ahmad, B., Hassan, T., von Bloh, W., Wijngaard, R., Wester, P., Shrestha, A. and Immerzeel, W.: Importance of snow and glacier meltwater for agriculture on the Indo-Gangetic Plain. Nature Sustainability, 2(7), pp.594-601, 2019.

Wijngaard, R., Lutz, A., Nepal, S., Khanal, S., Pradhananga, S., Shrestha, A. and Immerzeel, W.: Future changes in hydro-climatic extremes in the Upper Indus, Ganges, and Brahmaputra River basins. PloS one, 12(12), 2017.

Q8:

Page 9, 285: Please specify that GRACE mass balance is from this study.

A8:

It has been clarified by adding “in this study” .

Q9:

Page 10: Line 287-289: ASTER you mean (Brun et al. 2017). Please specify which publication refer to -5.5+- 2.2 Gt yr-1.

A9:

We had explained in the text that "... glacier mass change of -5.5 $\pm$ 2.2 Gt yr^{-1} by using ASTER (the area-averaged rate in NTM and Bhutan multiplied by the glacierized area of 9,679 km^2)"

The paper only provided height change, so we derived this value by multiplication of the area-averaged rate in NTM (-0.62 m/yr in 6,378 km^2) and Bhutan (-0.42 m/yr in 2,291 km^2) by the glacierized area of 9,679 km^2. The trends and areas were from Table 1 of their paper.

Q10:

Page 10: Line 308: Instead of 'Lutz's model', please indicated 'Lutz et al .2014.

A10:

It has been changed.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-211, 2019.

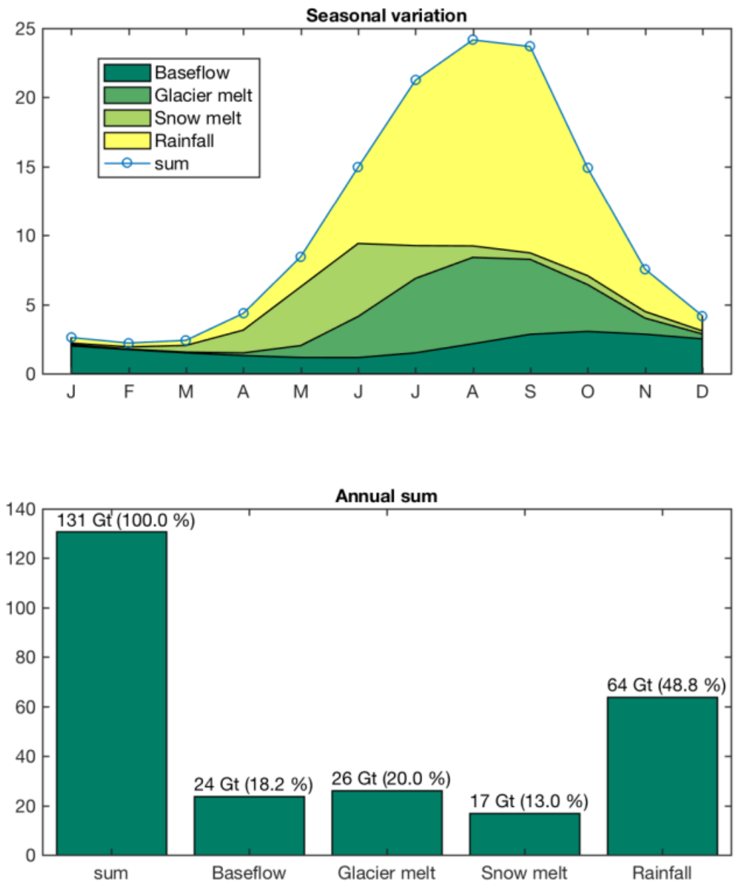

Fig. 1. Contribution of various components to streamflow in the Brahmaputra

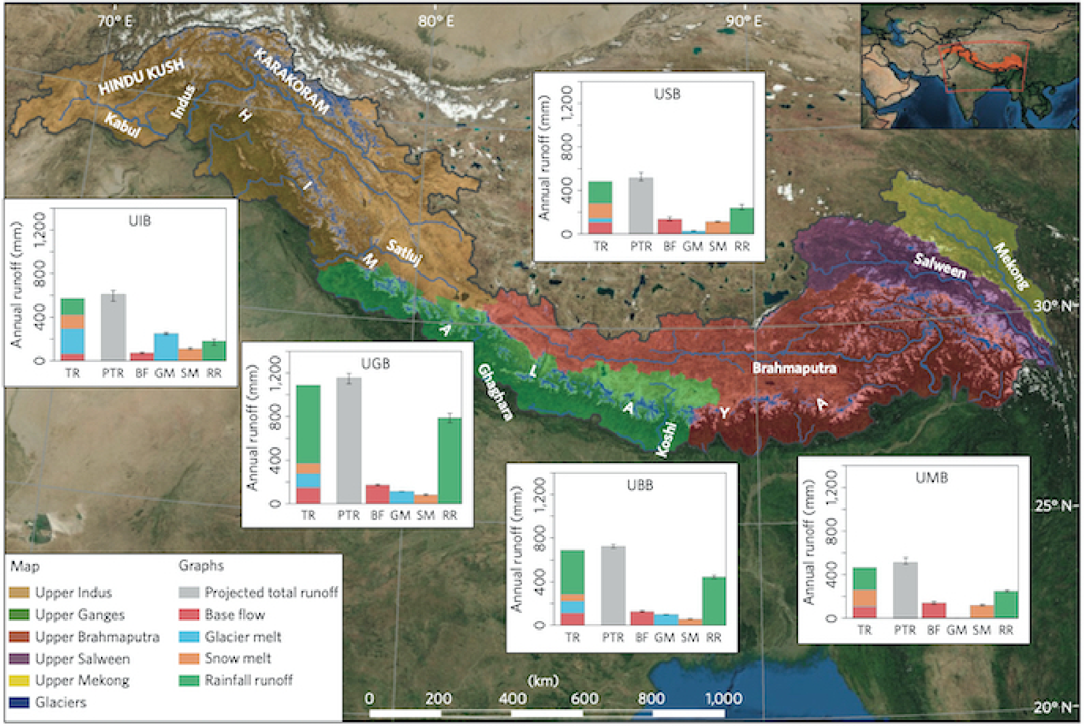

Figure 1 | The upstream basins of Indus, Ganges, Brahmaputra, Salween and Mekong. Bar plots show the average annual runoff generation (TR) for the reference period (1998–2007, REF; first column). The second column shows the mean projected annual total runoff (PTR) for the future (2041–2050 RCP4.5) when the model is forced with an ensemble of 4 GCMs. In the subsequent columns, PTR is split into four contributors (BF: baseflow, GM: glacier melt, SM: snow melt, RR: rainfall runoff). Error bars indicate the spread in model outputs for the model forced by the ensemble of 4 GCMs.

Fig. 2. Excerpt of Fig. 1 from Lutz et al. (2014)

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Discussion paper