Response to Reviewer #1's comments:

The manuscript entitled "Extent of gross underestimation of precipitation in India" by Goteti and Famiglietti, analyzes watershed-scale underestimation of precipitation over India using various precipitation datasets within a water imbalance analysis. The authors have designed the study with relevant methodology through the knowledge attained from associated literature. There are some corrections required in the manuscript, although the authors have explained the results and the methodology in detail, there are a few disconnections between sentences and minor grammar corrections required. I have raised a few questions that require clarification, also suggested some necessary modifications and additions to the manuscript.

The authors would like to thank the reviewer for the feedback and the suggestions made to improve the manuscript. The authors generally agree with the comments, and revisions were made accordingly. Please see below the specific responses to the individual comments.

Summary of major changes (based on comments from all reviewers): (1) added monthly time series information on each watershed (in addition of the annual time series, Supplement S6); (2) added a flowchart on the overall methodology; (3) the assumption on negligible inter-watershed groundwater flow (IGF) was clearly stated and discussed within the abstract, methods, discussion and conclusions sections; (4) added Appendix F showing a case study of imbalanced watersheds where IGF may not be the cause of UoP; and (5) tables on watershed characteristics were added to the manuscript (Table 1) and Supplement (Table S6).

GENERAL COMMENTS:

I would suggest the author to include the analysis for the summer monsoon season (i.e., June-July-August-September), as the summer monsoon accounts for a major portion of the annual precipitation over India.

Agree with the comment. Since the June-September time period typically has the largest contribution to rainfall and streamflow, time series graphics of these have been added for all of the stations (Supplement S6) where monthly streamflow observations were available (Peninsular India). Moreover, additional examples illustrating the monthly and annual water imbalance scenarios of $R > P_{obs}$ were included in the newly created Appendix F. These examples show that the imbalance is occurring not only at the annual scale but also at the monthly and seasonal time scale.

OTHER COMMENTS:

1. I would recommend the authors to use 'precipitation' instead of 'P', particularly in the introduction.

The word 'precipitation' was used instead of 'P' in the introduction. However, to be consistent with the rest of the manuscript, the use of 'P' for precipitation has been left unchanged in the remainder of the manuscript.

2. Line 34: "Raw data from P gauges" should be revised to "Raw data from rain gauges."

The phrase ‘Raw data from P gauges’ was revised to ‘Raw data from rain gauges’.

3. Line 43: “However, gauge-based gridded datasets can be far from ideal” Do you have any evidence to support this statement for IMD data (concerned about word ‘far’)?"

The text has been changed to “However, gauge-based gridded datasets can suffer from inadequate representation of extreme events - such as those reported by King et al. (2013) in Australia; spurious trends due to changes in the locations of reporting gauges - such as those reported by Lin and Huybers (2019) using the IMD dataset; or uncertainties introduced by the relative positioning of reporting gauges - such as those reported by Prakash et al. (2019) using the IMD dataset”.

4. Line 44: This paper, King et al. (2013), did not utilize the IMD data

Yes, King et al. (2013) did not utilize IMD data. The text has been revised to “However, gauge-based gridded datasets can suffer from inadequate representation of extreme events - such as those reported by King et al. (2013) in Australia;”

5. Line 46: What do you mean by 'other errors'? demonstrate them?"

The phrase “and other errors” was deleted since a discussion on these other errors is not directly relevant to this study.

6. Fig. 1: I would suggest plotting the rainfall estimates from the actual rain gauge stations along with the IMD gridded precipitation data. It could be possible (potentially) that the interpolation method used in constructing the IMD data introduces some biases.

It is possible that the grid resolution adopted by IMD (25 km) and the interpolation procedure used by IMD could introduce biases. However, station data is needed to investigate if biases are the result of interpolation procedures. Unfortunately, station data used by IMD is not available to the authors. Moreover, the goal of this study is not to compare IMD gridded product with station-level precipitation data – rather, the goal is to estimate gross underestimation of precipitation within IMD and other gridded precipitation data sources often used by the scientific community.

7. Fig. 1(b): I am concerned about the PBCOR data that authors have used to show the ratio of bias correction. The number of rain gauge stations used in this data (Fig. 2; Beck et al. 2020), particularly over India, is far fewer than the IMD rain gauge stations (Fig. 1; Prakash et al. 2015). So, it is possible that the observed largest ratios could be attributed to PBCOR datasets rather than IMD. I would suggest the authors to compare the PBCOR data with the IMD for both mean and extreme (e.g.; 99^{th} percentile) cases before using it for bias correction ratio calculations.

Prakash, S., Mitra, A. K., Momin, I. M., Pai, D. S., Rajagopal, E. N., & Basu, S. (2015). Comparison of TMPA-3B42 versions 6 and 7 precipitation products with gauge-based data over India for the southwest monsoon period. Journal of Hydrometeorology, 16(1), 346-362.

We understand the reviewer’s suggestion on making further comparisons between PBCOR and IMD – using metrics other than the long-term mean. The PBCOR dataset is a climatology and provides only long-term average values of annual and monthly precipitation. There is no daily data available. As

such, the suggested comparison cannot be made. We would also like to add that the PBCOR dataset by Beck et al 2020 was just one of the motivations behind this study. In this study the PBCOR dataset was used only to illustrate the extent of potential underestimation of precipitation by an independent study. As per the reviewer's suggestion, we included the paper by Prakash et al. (2015) in the discussion (Section 5.1.1, "Limitations with data").

8. Line 61: "If estimates from PBCOR are reasonable", follow comment 8

It appears that the reviewer meant to say 'follow comment 7' (instead of 'follow comment 8') since this is comment #8. As indicated in comment #7, the PBCOR dataset is a climatology and does not contain daily data. The PBCOR study estimated correction factors using a watershed imbalance analysis. We wanted to know if the correction factors from our study were consistent with PBCOR or not. Hence, PBCOR was brought into the discussion. The results of our study are completely independent of PBCOR.

9. Lines 93-95: "using procedures… watersheds of Northern India", How did you compile? Please explain in detail.

The following text has been added - "The catchment boundaries for the Northern Indian watersheds were derived using the HydroSHEDS suite of products, using the same procedures as the GHI dataset. Station descriptions available from CWC were validated using online maps (e.g., Google Maps). Stations were then relocated to the closest point on the river network. The watershed draining into this relocated point, and all of the upstream watersheds were recursively identified using a GIS software. Catchment areas for the delineated watersheds were validated against those reported by CWC."

10. Lines 97-100: Include discussion about uncertainties associated with the streamflow data

The uncertainties associated with streamflow measurements are briefly discussed in Section 5.1.1 ('Limitations with Data'). As per the reviewer's suggestion, additional literature on this topic has been added to the manuscript.