Dear Reviewer,

Thanks for your comments on our paper. Detailed comments and responses are as follows.

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[0] This study used a random forest machine learning algorithm to downscale the GPM satellite precipitation measurements and calibrated them with gauge observations and the aforementioned high-resolution variables. The study is interesting and the authors presented some interesting results, while the context is hard to follow and the writing needs significant improvement. The tense of the article is very confused. The present tense and past tense are confused throughout the article, and there are also many grammatical mistakes. There are too many mistakes to point out here. It is suggested that the paper should be revised by someone who is good at English.

[Reply]

Our paper will be polished by someone who is good at English.

Major comments:

[1] You have the daily measured precipitation data, and you can also get daily GPM precipitation data. Why don't you analyze the downscaling model on the daily scale? In fact, there have been many daily downscaling models based on Random Forest. In general, the novelty of the article is not enough.

[Reply]

It is rather challenging to downscale daily precipitation data, since the relationship

between precipitation and land surface characteristics at the daily scale are more complex than at the monthly scale. Moreover, many land surface variables at the daily scale cannot be obtained. For example, we only obtained MODIS 16-day Normalized Difference Vegetation Index product (MOD13Q1) and MODIS 8-day Land Surface Temperature product (MOD10A2).

In this study, the objectives are to (i) develop an easy-to-use spatial RF (SRF) by taking into account the spatial autocorrelation between neighboring gauge measurements, and (ii) to propose a downscaling-calibration method based on SRF for producing high resolution and high accuracy precipitation data at the monthly scale. In our future work, efforts will be focused on the daily precipitation downscaling and calibration.

[2] The author did not give a clear explanation why the environment variables could be used in RF model to derive the correlations. The relationships between these variables and precipitation should be explained in detail, not just by listing the reference papers that use these variables. The correlations between each environmental variables (NDVI, LST, DEM etc.) with precipitation and their contribution to the prediction of the precipitation should be fully discussed.

[Reply]

Vegetation types have a significant impact on fluxes of sensible and latent heat into the atmosphere, obviously influencing the humidity of the lower atmosphere and further affecting moist convection (Spracklen et al., 2012). Therefore, the response of vegetation to precipitation has been widely investigated (Immerzeel et al., 2009; Wu

et al., 2019).

Precipitation can influence land surface temperature (LTS) both in the daytime and at night; rain leads to cool temperatures, and droughts often couple with heat waves (Jing et al., 2016; Trenberth and Shea, 2005).

Topography could affect the regional atmospheric circulation and the spatial pattern of precipitation through its thermal and dynamic forcing mechanisms (Jia et al., 2011; Jing et al., 2016). With the increase of elevations, the relative humidity of the air masses increases through expansion and cooling of the rising air masses, which causes precipitation (Jing et al., 2016).

The above information will be added to the revised paper.

[3] The IMERG data were fused into precipitation products from the satellite observations and gauge data. As the gauge data had been applied in the IMERG data generation (Level3), how could you reconcile the errors in SRF with the gauge data at ground used in your study?

[Reply]

The gauge data used in the Global Precipitation Climatology Centre (GPCC) rain gauge data were removed from our dataset in the study.

[4] Evaluation of the model was performed by considering rain gauge data as observations at ground. However, it assumed that the rain gauge measurements were representative values at their respective grid-cells. Although this was widely used in other literatures, the authors should discuss this issue to support their decision.

[Reply]

Each IMERG pixel represents the areal average precipitation within it, whereas rain gauge measurements are point-based. Therefore, this scale difference between point-based measurements of rain gauges and pixel-based values of the IMERG can cause errors during validation and calibration processes. One effective solution is to downscale precipitation data from coarse to fine. Here, IMERG was downscaled from 10 km to 1 km. Thus, the scale mismatch can be greatly reduced. Moreover, for each testing point, we extracted its value from the grid cells based on the bilinear interpolation on the neighbor cells to further reduce scale mismatch issue.

The above information will be added to the revised paper.

[5] This paper analyzed the accuracy of various precipitation data sets on a monthly, seasonal, and annual. There is no need to spend a lot of space in the paper to analyze the differences between seasonal and annual results, which makes the paper look more like a technical report without scientific insights. You should compare with previous literature that states if the results are in agreement or not with other studies in the field in your Discussion part. However, the present part of the discussion is rather empty, and it mainly analyzes the research results of others, and lacks the systematic analysis and discussion of the proposed method in this paper.

[Reply]

The results on the seasonal and annual scales will be removed from the revised paper.

In the discussion, the performance of the proposed method will be compared with those of the classical methods.

[6] Minor comments:

Line 158-160: “Overall, the high spatial and temporal variability of precipitation with the complex topography makes the study site ideally suitable for the evaluation of satellite-based precipitation estimates.” Can you give the reasons or some references as evidences?

[Reply]

Overall, the high spatial and temporal variability of precipitation makes the study site ideal for evaluating satellite-based precipitation estimates (Karbalaye Ghorbanpour et al., 2021; Zhang et al., 2021).

The references will be added in the revised paper.

[7] Section 5.1. Please indicate the optimized hyper parameters (i.e., number of trees, depth of the tree, and number of features) for the Random Forest model.

[Reply]

This information will be added in Section 3.1 in the revised paper. It is as follows:

The general framework of RF is shown in Fig. 4, where three parameters should be optimized, i.e., number of trees, depth of the tree, and number of features.

[8] Line 269-271: “the spherical model was used since it shows better results than the others in the experiments.” You should give the analysis results (data, charts, etc.) to prove the reason for choosing the spherical model.

[Reply]

The fitting results will be added in the revised paper.

[9] Line 315-316ï¼ “Our monthly-based estimation method was compared with the

annual-based SRF fraction disaggregation method (termed as SRFdis)" Please explain SRFdis in detail.

[Reply]

For SRFdis, the relationship between the precipitation and the land surface variables were constructed at the annual scale, and then the annual precipitation at 1 km for each typical year was estimated based on the constructed model. Finally, monthly fractions derived from IMERG were used to disaggregate 1 km annual precipitation to 1 km monthly precipitation.

The above information will be added to the revised paper.

[10] As can be seen from Figure 5 and Table 2, the proposed method and Bi SRF have very similar performance in most accuracy index, such as CC. However, the bilinear interpolation downscaling method is obviously easier to operate than SRF downscaling method. Is it necessary to use a more complex downscaling method to improve the CC value of 0.003?

[Reply]

As shown in Figure 5, the RMSE and MAE differences between the proposed method and Bi-SRF are 0.56 mm and 0.30 mm, respectively. We are sure that the proposed method outperforms Bi-SRF. The user can select the best one according to its requirement.

[11] line 404ï¼ Change "our method" to "the proposed method"

[Reply]

'the proposed method' will replace 'our method' in the revised paper.

[12] Line 432ï¼ Why do you say that "This is because this year has the largest precipitation (Fig. 2)." Can you explain why this is the reason for the worst results in 2018?

[Reply]

Extreme precipitation is often caused by complex environmental factors, which could result in complex predictors-precipitation relationships. Thus, the downscaling and calibration models tend to cause large estimation errors.

The above information will be added to the revised paper.

[13] Line 488: "Table 1"? Table 1 is the detailed information of the datasets used in the study.

[Reply]

It should be 'Table 2'.

[14] Line 499-500ï¼ What are the reasons that the day-night land surface temperature difference was used in this study?

[Reply]

Precipitation can influence land surface temperature (LTS) both in the daytime and at night. The day-night land surface temperature difference might be helpful to capture the complex LTS-precipitation relationship.

References

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