Response 2 for: “Evaluation of Asian summer precipitation in different configurations of a high-resolution GCM at a range of decision-relevant spatial scales”

Mark R. Muetzelfeldt, Reinhard Schiemann, Andrew G. Turner,
Nicholas P. Klingaman, Pier Luigi Vidale, and Malcolm J. Roberts

11 November, 2021

Response from authors to Anonymous Referees

We thank the referees for their feedback and their additional points below. We have addressed each point in turn, and hope that we have fully addressed the concerns that they had. Our responses are in blue below the original point.

Anonymous Referee #2

The authors have addressed all the comments raised by the reviewers. I don’t have any further comments/suggestions for this work.

> Many thanks for your careful reading of our manuscript, and all of your suggestions to improve it.

Anonymous Referee #3

The results of the parameterized convection, hybrid simulation and explicit convection in this paper are of great significance for high-resolution Asian monsoon simulation, especially for the development of the next generation storm-scale resolution model. In addition, one of the analysis tools documented in this work is the Basin Tool, which is very effective for the application of high-resolution simulation results to water management fields. However, as far as I understand, the following concerns should be addressed:

1. One of the prominent features of the Asian summer monsoon is the interannual variation. Although only 4-year data are available, can the interannual variation of ASM be reproduced with configurations of PC and EC?

> The interannual variation is an important aspect of the EASM, and something that we would like to study further. To this end, we are conducting longer experiments (30 year) with the same models so that we can properly sample interannual variations. These simulations are computationally expensive, and running them in full for the different configurations will take some time.
>
> For the purposes of this paper, we chose not to focus on it due to the small number of simulated years we could analyse. Some justification for this was given in Sect. 2.2.1, and Figs. S1 and S2 in the Supplement. In the figures, we showed that for the observations (for which we have a 21-year timeseries), the full duration timeseries (Fig. S1) was very similar to a shorter, 4-year, timeseries (Fig. S2). From this we argued that, for the purpose of this paper in assessing the mean precipitation over Asia and Asian catchment basins, it was sufficient to use our 4-year simulations and not analyse interannual variation.

2. Has precipitation improved over the Tibetan Plateau and its surrounding complex terrain? In particular, many previous studies have shown that the precipitation in Sichuan basin is characterized by a unique diurnal cycle. However, many HighResMIP models cannot reproduce this feature.

We discuss the southern flank of the Tibetan Plateau fairly extensively due to its prominent effect on the precipitation, and the large biases in simulated precipitation that it causes (Sects. 3.2 and 3.3). In particular, we found that the simulations produced far too much precipitation over this region due to producing too much orographic precipitation. This is similar to the biases produced by coarser resolution simulations (Bush et al., 2015), but larger in magnitude. Further, the magnitude of the bias increases with increasing resolution (Fig. R1). We have added a brief description of this to Sect. 3.1: "Furthermore, this bias [the wet bias over the Himalayas] is increased at higher resolutions compared to lower resolutions (not shown), which indicates that the high-resolution simulations are producing too much orographic precipitation."

We believe that some aspects of the simulated rainfall were improved over the Sichuan Basin by the explicit convection simulation – in particular the diurnal cycle shows some signs of the phase shift seen in other studies (P. Li et al., 2018; J. Li et al., 2020) and the CMORPH observations (Sect. 4.2 and Fig. 10a–c in the paper). However, clearly some processes are not represented as the explicit convection simulation has a dry bias over the Sichuan Basin due to a reduced frequency of rainfall (Fig. 9a–c,g-i in the paper). These are both discussed already in Sects. 4.1 and 4.2 where we focus on south-eastern China.

The interaction between the simulated flow and orography is clearly important at high-resolutions. Indeed, we think this is worthy of future study – both to understand its causes and to improve model tuning to remove biases. Such process-based analysis would be a useful and worthwhile follow-on project to this (Sect. 6.4).

3. CMORPH is used as the observed products to compare with the model results. For the Asian monsoon region, can the accuracy of the comparison data, especially the characteristics of high temporal and spatial variation of precipitation in the Asian monsoon region, be well revealed in the CMORPH data? Some studies (e.g. Zhang et la., 2018, Wei et la., 2018) have shown significant errors in CMORPH compared to other satellite products.

Part of our motivation for including some APHRODITE analysis was to address this point for mean precipitation. We found that, overall, our results were not too sensitive to the choice of precipitation product between CMORPH and APHRODITE (Figs. 5 in main paper and S3 in the Supplement).

In response to similar initial feedback from the HESS editors, we investigated this point. Below is our original response to them:

"Generally, CMORPH seems to produce comparable results to TRMM (Dinku, Connor, and Ceccato, 2010), especially over Asia where it performs marginally better (Liu et al., 2015; Q. Jiang et al., 2018). IMERG, being a newer product that includes more data sources than CMORPH and a similar morphing algorithm, does seem to perform better on a number of metrics. However, the differences over Asia are mainly small (Wei et al., 2018), and the metrics tend to focus on specific precipition events (e.g. Probability Of Detection, POD). Other studies have shown that CMORPH behaves worse in Asia over winter (Tang et al., 2020), but this will not affect our results. As we are using the precipitation dataset over summer for a range of years, we do not think that our comparative analysis would be substantially improved by switching to IMERG (or TRMM)."

From Wei et al. (2018) we note that "Except for in summer, TRMM 3B42 perform better than CMORPH according to RMSEs", which suggests that CMORPH should be more suitable than TRMM suitable over summer. They find that IMERG performs better over some areas, but that, for example, over the Huaihe River Basin, the improvement is slight. They also only analyse 1.5 years of data, and they do so only over three catchment basins in China, whereas we compare against CMORPH over the whole of Asia and longer time period. From Zhang et al. (2018), we first note that the study area (the Tianshan Mountains) only represents a small fraction of the area that we analysed, and thus may not be broadly applicable. Furthermore, the version of GPM IMERG they use only covers the period from 2014–2018 (their Table 1), which would not work for our analysis. Thus, while other satellite products may have some benefits over certain regions, there are practical difficulties using them and we do not think that our results would be substantially altered by using a different product.

Referee references

Zhang et al. (2018), Evaluation and Intercomparison of High-Resolution Satellite Precipitation Estimates—GPM, TRMM, and CMORPH in the Tianshan Mountain Area, Remote Sens. 10(10), 1543; https://doi.org/10.3390/rs10101543

Wei, G., Lü, H., Crow, W. T., Zhu, Y., Wang, J., and Su, J. (2018). Evaluation of satellite-based precipitation products from IMERG V04A and V03D, CMORPH and TMPA with gauged rainfall in three climatologic zones in China. Remote Sensing, 10(1). https://doi.org/10.3390/rs10010030

References

Bush, Stephanie J et al. (2015). "The effect of increased convective entrainment on Asian monsoon biases in the MetUM general circulation model". In: *Quarterly Journal of the Royal Meteorological Society* 141.686, pp. 311–326. DOI: 10.1002/qj.2371.

Dinku, Tufa, Stephen J Connor, and Pietro Ceccato (2010). "Comparison of CMORPH and TRMM-3B42 over mountainous regions of Africa and South America". In: *Satellite rainfall applications for surface hydrology*. Springer, pp. 193–204.

Jiang, Qin et al. (2018). "Accuracy evaluation of two high-resolution satellite-based rainfall products: TRMM 3B42V7 and CMORPH in Shanghai". In: *Water* 10.1, p. 40.

Li, Juan et al. (2020). "Northeastward propagation of nocturnal precipitation over the Sichuan Basin". In: *International Journal of Climatology*. DOI: https://doi.org/10.1002/joc.6886.

Li, Puxi et al. (2018). "The diurnal cycle of East Asian summer monsoon precipitation simulated by the Met Office Unified Model at convection-permitting scales". In: *Climate Dynamics*, pp. 1–21. DOI: 10.1007/s00382-018-4368-z.

Liu, Junzhi et al. (2015). "Evaluation of three satellite precipitation products TRMM 3B42, CMORPH, and PERSIANN over a subtropical watershed in China". In: *Advances in Meteorology* 2015.

Tang, Guoqiang et al. (2020). "Have satellite precipitation products improved over last two decades? A comprehensive comparison of GPM IMERG with nine satellite and reanalysis datasets". In: *Remote Sensing of Environment* 240, p. 111697.

Wei, Guanghua et al. (2018). "Comprehensive evaluation of GPM-IMERG, CMORPH, and TMPA precipitation products with gauged rainfall over mainland China". In: *Advances in Meteorology* 2018.

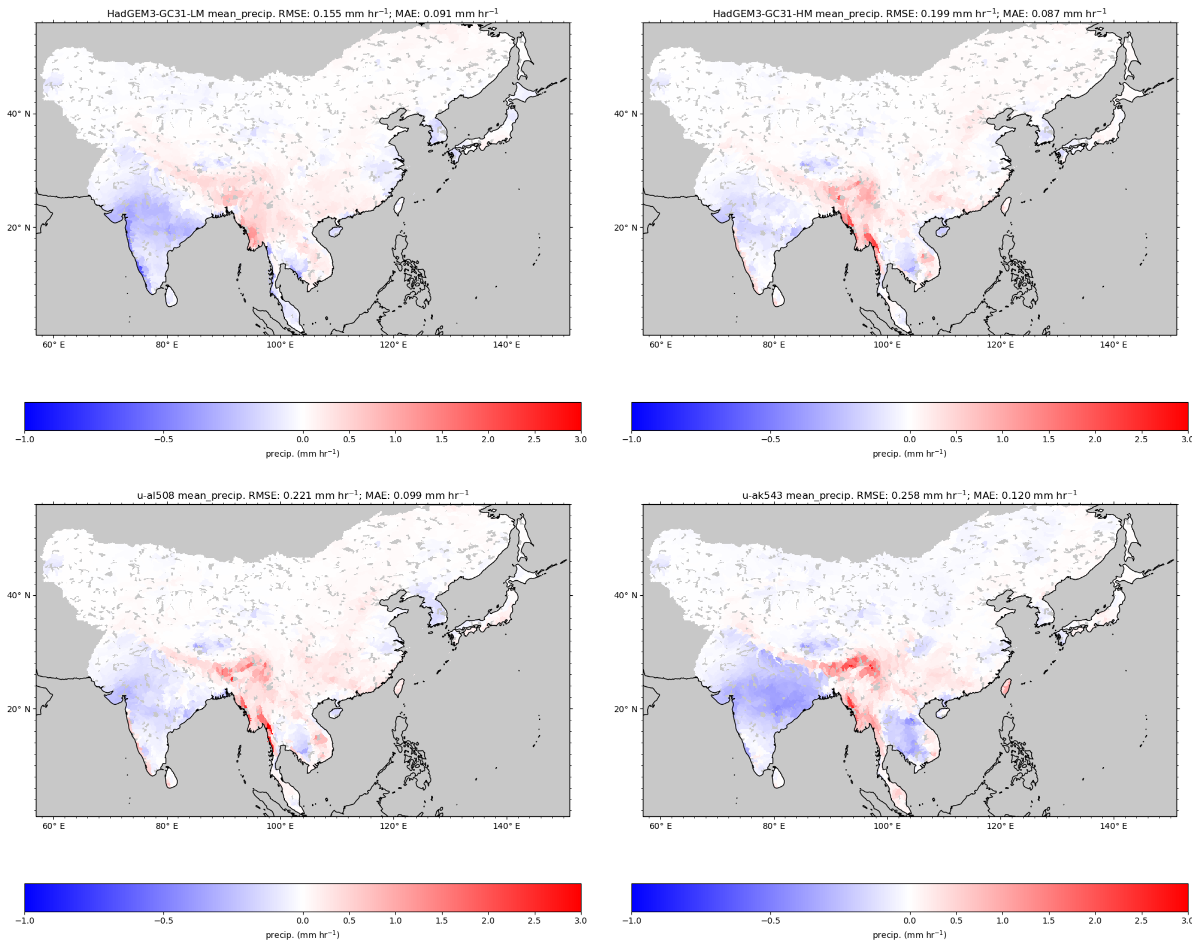

Figure R1: Mean precipitation bias of precipitation over small catchment basins against CMORPH. Top left shows N96-PC, top right shows N512-PC, bottom left shows N1280-PC, and bottom right shows N1280-EC.