TerraMaris model evaluation paper: response to reviewers

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February 8, 2024

Response to Reviewer 1

We thank the reviewer for their positive review of the manuscript. Their specific comments will improve the paper, especially the discussion of precipitation in our two simulation suites.

Replies to specific comments

1. A wet bias over the Maritime Continent is common for atmosphere-ocean coupled models (Roberts et al., 2019), especially in DJF (Liu et al., 2023). This is a long-standing problem in simulations over the Maritime Continent: atmosphere-only models tend to underestimate mean precipitation over the MC (e.g. Neale and Slingo, 2003; Toh et al., 2018), while coupled models tend to overestimate it (e.g. Inness and Slingo, 2003; Liu et al., 2023).

   It is also common for convection-permitting models to exacerbate wet or dry biases compared to the same model run with parametrized convection; this is certainly true for the Met Office Unified Model (e.g. Muetzelfeldt et al., 2021), and in general there is no systematic improvement in mean precipitation bias for convection-permitting models over parametrized models (Prein et al., 2015). That the strongest biases in MC2 are close to the inflow boundaries is also consistent with other regional convection-permitting modelling over the MC (Jones et al., 2023) [note that they only see the strong wet bias close to the eastern boundary, but this is because their analysed period 1-11th Jan 2018 had a consistent strong easterly over that part of the domain, whereas the winds at the western boundary fluctuated much more]. This is likely due to differences in model physics between the parametrized and explicit versions of the model; for instance, if the explicit physics prefers a slightly drier atmosphere (consistent with manuscript Fig. 6b), then excess moisture advected in at the boundaries will be rapidly precipitated out.

   There is certainly an impact of higher resolution on model biases, but this link is complex (e.g. Roberts et al., 2019; Holloway et al., 2013). It is not possible to perform a clean analysis of the effects of model resolution on precipitation bias using this dataset, due to the confounding effects of very different model physics — especially parametrized versus explicit representations of convection.

   We shall add text to this effect to the discussion of Figure 4 in the manuscript.

2. All analyses of precipitation used GPM-IMERG v06B. We used the “precipitationCal” product, which is satellite observations including correction to rain gauge.

   In response to the reviewer’s comment regarding observational uncertainty, we have reproduced Figure 4 of the manuscript using the ”past” precipitation product from MSWEP (Beck et al., 2017) (see attached Figure 1). Since the rain gauge network is very sparse over the Maritime Continent, the algorithms used by both GPM-IMERG and MSWEP weight the satellite observations much more highly than in regions with dense rain gauge coverage, so differences in the datasets over the Maritime Continent should largely be due to different satellite retrieval methods. The differences between the two simulation runs, and the differences between the runs and either precipitation dataset, are much larger than the difference between the two individual datasets. In particular, the spatial patterns are very similar for both satellite datasets.

   We therefore conclude that the rain gauge-corrected satellite observational uncertainty is less important for the mean precipitation than the difference between the two models, and than the difference between the models and those observations.

   For the interannual variability, GPM has a fairly uniformly positive interannual standard deviation anomaly over ocean, and close to zero anomaly over land, relative to MSWEP (see attached Figure 2). This strengthens the conclusion that MC2 overestimates the interannual precipitation variability everywhere. For MC12, the interannual standard deviation of precipitation over ocean is generally weakly overestimated relative to MSWEP, compared to underestimated relative to GPM. For both simulations, the relative spatial uniformity of the GPM minus MSWEP anomaly causes the spatial pattern of the model biases to be broadly similar relative to both reference datasets.

In previous work, differences in diurnal cycle phase have been found to be negligible between different precipitation products over the Maritime Continent, especially at the 3 hour temporal sampling rate of many observational datasets (see e.g. Supplementary Figure 7 of Dong et al., 2023).

We shall add Figures 1 and 2 as supplementary material to the revised manuscript, along with a brief summary of the above explanatory text.

It is an excellent point that rain gauge coverage of the Maritime Continent is very poor (see e.g. Figs. 2, 3, B4, B8 of Lewis et al., 2019). This is especially true over areas with high orography, where the MC2 and MC12 biases are worst compared to GPM-IMERG and MSWEP, and of course over the ocean, where there is a general wet bias in both models. Given this fact, we feel that it is beyond the scope of this paper to perform a direct comparison with gauge data. We will instead add a sentence regarding the lack of rain gauge data in our discussion of the precipitation analysis.

3. All of our simulations were run for Boreal winter seasons (NDJF); analyses were conducted for DJF, with November discarded for spin-up. The reasoning for this is that DJF is the most active period for intraseasonal variability over the Maritime Continent (explained in line 87 of the manuscript). Therefore, while it would be an interesting research avenue, it is beyond the scope of this paper to re-run the two simulation suites for MJJASO. We will acknowledge this limitation explicitly in the “Discussion and conclusions” section of the revised manuscript.

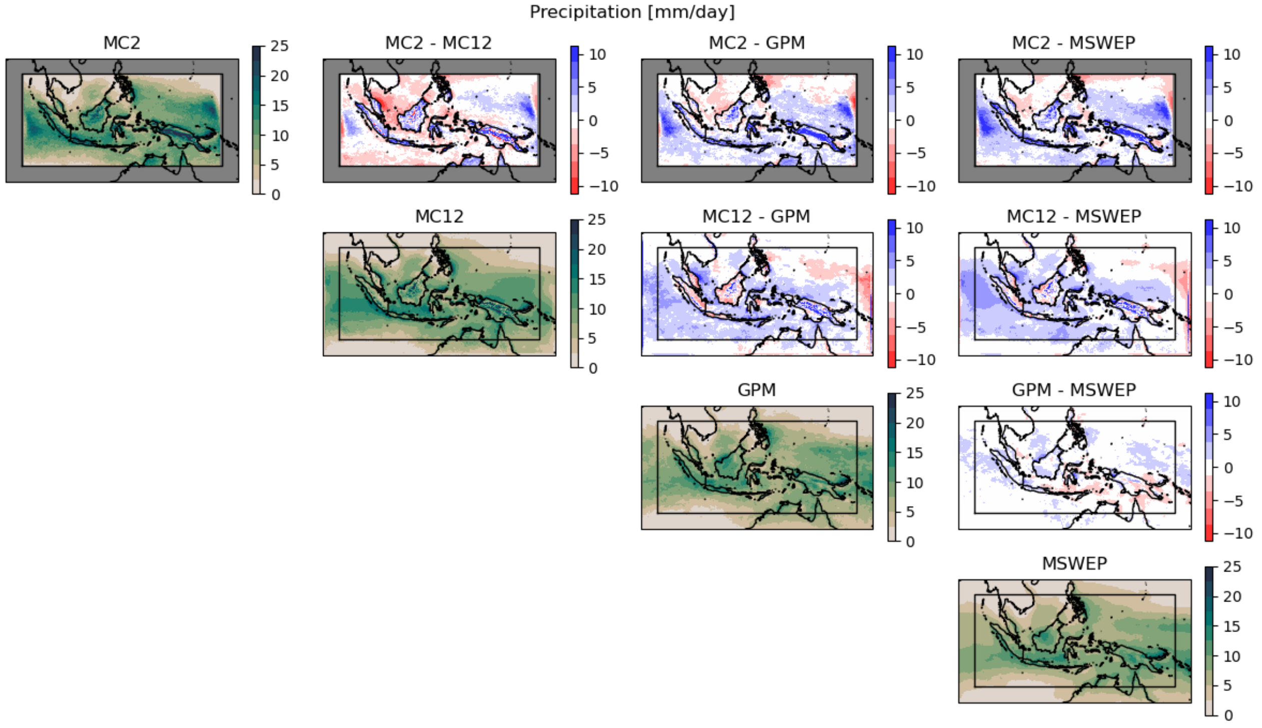

Figure 1: Mean precipitation and biases (mm day^{-1}). Subplots along the diagonal indicate MC2, MC12, GPM-IMERG, and MSWEP respectively. Upper off diagonal subplots show difference plots between each of the datasets.

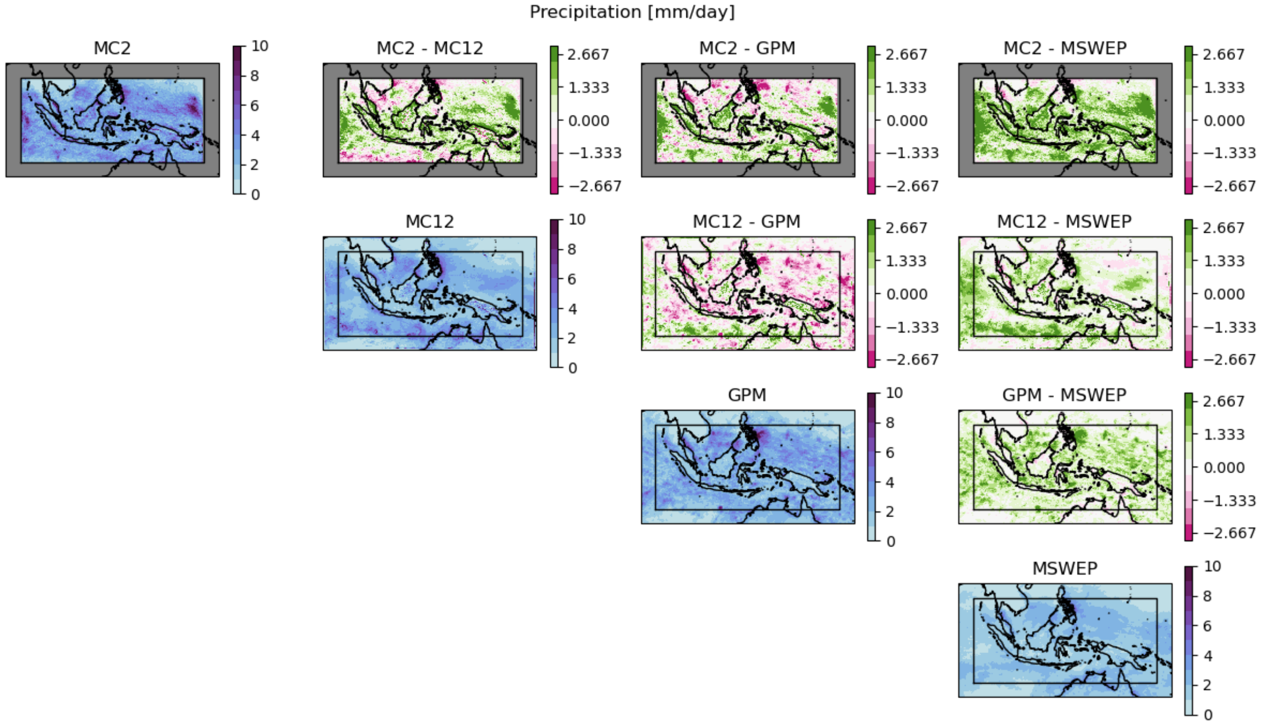

Figure 2: Interannual standard deviation of precipitation and biases (mm day^{-1}). Subplots along the diagonal indicate MC2, MC12, GPM-IMERG, and MSWEP respectively. Upper off diagonal subplots show difference plots between each of the datasets.

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