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Geoscientific Model Development Discussions

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Interactive comment

Interactive comment on "Connecting spatial and temporal scales of tropical precipitation in observations and the MetUM-GA6" *by* Gill M. Martin et al.

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Response to comments by Anonymous Referee 1.

Specific comments

- While it is mentioned in your introduction that the representation of rainfall on short timescales is important to longer timescales (because of the biases they incite; Kendon et al. 2014), there is limited discussion of this topic thereafter. I think your hypothesis

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attributing the mean-state precipitation biases to issues with intraseasonal variability and sub-daily variability is one of the main takeaways of the paper; therefore, it would be good to include (perhaps in the discussion section) a paragraph highlighting the impact of these biases on the larger scales (e.g., a wet bias in the West Pacific may inhibit MJO propagation).

We agree that this hypothesis is key to our study and was, indeed, the original motivation for the work. While discussion of the impact of mean state biases themselves is outside of the scope of this paper, we have added a few sentences to the Introduction and Discussion sections with additional examples of studies which highlight their impact and the importance of reducing them.

- You noted that many have observed that model biases develop fairly early on in climate simulations. Was this the case with your experiment? Did you observe any sort of spin-up time for the precipitation intermittency? Any note on the lead-dependence of the models' representation of precipitation would be a nice addition.

This is a good suggestion. We find that the intermittency is immediate in our model runs, with no spin-up time at all. We have added this comment to the first point of the Discussion and Conclusions. Further, we note that Klingaman et al. (2016) found similar behaviour in two-day forecasts with an earlier version of the MetUM.

- In section 4.2, you only allude to intraseasonal variability (or the lack thereof) via proxy; that is, we know that if longer and longer temporal averages pull the precipitation spectra to smaller and smaller values, there must be variability on those longer timescales. A power spectral analysis of the observations vs the model, or anything directly showing this intraseasonal variance discrepancy between CMORPH and MetUM, would help drive this point home.

We thank the Reviewer for this comment and we agree that it would be helpful to illustrate this point in a different way. In the new Figure 11, we have used the temporal autocorrelation method from ASoP1 applied to the daily rainfall averaged to the N48 grid over the four regions used in Figure 9 (now Figure 10). This clearly demonstrates the higher day to day persistence of rainfall in the models than the observations over the ocean. The results over the land regions are rather different. In fact, we have corrected the text around discussion of Figure 10d (South China) because the histograms actually suggest too little sub-daily variability (the spectrum of daily averages is similar to that of the 3-hourly averages). The autocorrelations for the "WA" region (new Figure 11b) show noticeable differences between the day to day variability in TRMM and CMORPH, with the day to day variability in TRMM (at this spatial resolution) actually being smaller (higher autocorrelations) than in either the models or CMORPH. Discrepancies in the variability between the two satellite-derived datasets at the 3-hourly timescale were noted in Section 3.2 too (though in the opposite direction). Clearly, the two estimates of actual rainfall amounts have differing characteristics, which must be related both to their different satellite data sources and derivations. It is apparent from the new Figure 11 that, in general, the model tends to over-estimate the persistence of rainfall on this spatial scale in the oceanic regions, but, for the tropical land regions studied, particularly West Africa, we cannot make a definitive statement about the validity of the characteristics of daily rainfall variations in the models compared with satellite-based estimates.

We have added this new Figure and surrounding discussion to Section 4.2.

Technical corrections

- P4, L17-20: You use different grammar each time you introduce one of your three subdomains (see the "hereafter" bits)

What we mean here is that data for only those regions were available to us (rather than that we choose which regions to use, as we do for the other simulations). However, we agree that the sentences do not read clearly, so we have changed the sentence to:

For the highest-resolution (N1024) simulations, we use data only over the two limited domains that were available to us (due to storage and computational limits), one in the western Pacific Ocean...

- Include a figure highlighting your subdomains and how they are divided up for section 3.5.

This is now Figure 1.

- P5, L28-32: Add a figure or reference to illustrate/support your explanation of how the all-or-nothing nature of the convective parameterization is the cause of the precipitation intermittency.

We have added this as a "personal communication" from Dr Alison Stirling, who leads our convection parameterization research group. She and her colleagues are currently writing a paper on convective closure which explains this process, but it is not yet ready for submission.

- P6, L30: "of this is what" to "thereof"

Done.

- P7, L2: Did you look at the model output to see if this was the case? Are the differences in precipitation intermittency observable in the raw model output?

Yes we can see this if we plot rainfall time series at a grid-point: time series of time-step data from N1024p have the usual on-off nature, while those from N1024e show continuous (and large) rainfall amounts for 20-30 time steps at a time (1.5-2.5 hours) interspersed by periods of 20 hours of no rainfall. The diagnostic package was designed to characterise and illustrate this behaviour after we (and others) had spent many years looking at time series from individual grid-points!

- P8, L27: "(Fig. 6)" to "(Fig. 6f)"

Done.

- P10, L7-9: These first two sentences of the paragraph should be earlier in the paper, as this is not the first time the data was averaged to N48 and 3-hourly to compare to CMORPH and TRMM (you did this in Figure 5 as well).

Agreed. In fact, we have simply altered these sentences to:

> When the precipitation data are all averaged to the N48 grid and 3 h time scale (in a similar manner to Section 3.4), Figure 8c-f shows that the models all tend to underestimate the 3-hourly rainfall amounts compared with TRMM and CMORPH, and that increasing the horizontal resolution does not improve the comparison on this timescale for tropical rainfall over the ocean.

- P10, L24-25: "indicates variability at the longer timescale" is awkward. Perhaps "is due to variability at longer timescales"

We have changed this to "indicates that there is variability at the longer timescale".

Other changes

We have updated Figure 2 (new Figure 3) to remove the blank column labelled "XXX" following the reviews of the ASoP1 methods paper by Klingaman et al. (2016). Also following reviews of that paper, and in response to a comment made by Referee 2, we have added a new section 3.6, and associated Table 3, describing summary metrics (from ASoP1) which quantify the differences in spatial and temporal coherence between the datasets.

We have also changed the colours of some of the figures in response to a comment made by Referee 2.

A tracked version of the revised manuscript is included as a supplemental file.