

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2021-348

Anonymous Referee #1

Referee comment on "The impact of lateral boundary forcing in the CORDEX-Africa ensemble over southern Africa" by Maria Chara Karypidou et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-348-RC1>, 2022

The impact of lateral boundary forcing in the CORDEX-Africa ensemble over southern Africa by Karypidou et al

This manuscript attempts to answer the challenging question regards the extent to which RCM simulations can reduce biases present in GCM simulations for the regional climate of southern Africa. The manuscript is well-written with clearly documented methods, a well-justified aim, and appropriate figures.

There are a few minor and major queries or difficulties I had in understanding these results, which I detail here.

Major

- Variance analysis presented in Fig.8 and 13.: These results are crucial to the stated aims of the manuscript. However, I am left wondering to what extent the physical interpretation made in this analysis is undermined by the low number of RCM members (three) along with a sensitivity to total rainfall in the following way:
 - Variance is constrained to be lower in October than January. Indeed much of southern Africa only experiences full onset of rains by November. So any intermodel variability is constrained by total rainfall. This seems reflected by Fig. 8 C and D, where GCM variance is higher in the respective region's wetter months. Similarly, in October in the future [Fig. 13] all variance is very low, reflecting the lack of rain in this month.
 - The behaviour set out in a. would be seen in a well-sampled system (e.g. 12 GCMs) but with 3 RCMs there the is a high risk that either they all look the same and there is no variance or there is one that is very different and the variance is substantial. This happens here as CCLM4 is biased dry in October with the others two biased wet.

- The behaviour in b. is strongly dependent on the behaviour of only one RCM. If that RCM comes in line with the others later in the season, as CCLM does with similar wet/dry bias patterns to the other RCMs in January, the variance is much lower. Indeed in region B and D it is surprisingly almost zero in some months.
 - Part of this query may be unpicked if the rainfall is standardized per month in order to remove problem (a). I'm not sure if this will address b and c though.
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- Based on my understanding of recent literature for the region, I disagree with the interpretations about the regional climate drivers.
 - Munday & Washington 2018 demonstrated the heat low to tropical low switch of the Angola Low. Howard & Washington showed the tropical Angola low was in fact the monthly aggregate of frequent tropical depressions crossing southern African from Mozambique and stalling in Angola. This is at odds with the interpretation provided in line 143-145, where the Angola Low is viewed separately.
 - In the Heat Low phase, the Angola Low is not directly driving rainfall. It cannot because it can only develop under subsiding clear-sky conditions. Rainfall in the early season happens when the heat low is temporarily displaced/dissolved. The leading candidate for this displacement is large-scale synoptic westerly waves. See c.
 - Work from the early 1990s by D'Abreton and picked up by others, including recently Hart et al 2018, suggested southern African rainfall is controlled by mid-latitude westerly wave dynamics (large-scale) earlier in the season. This then gives way to more local processes later in the season as the moist thermodynamic environment becomes more tropical (less subtropical) by the height of summer. Your speculation (Line 25-28) counters this, which is fine, but see d. below.
 - Speculation about land-surface coupling seems key to your argument, but at least as far as I am aware this is not well-established for early season over southern Africa. Please include references which point to this if you have them available. I am not sure if the literature, as yet, has shown that for example the soil-moisture – rainfall coupling seen in Indian and the Sahel does play a role in southern Africa. And it is an open question whether this is true in the real-world, let alone whether it is resolved in RCMs.

Minor:

- Line 97-98, (line 300 too). Excess surface heating is surely even greater in peak summer months? Furthermore, heating is insufficient for convection when surface environments are moisture limited as they are during October.
- Line 208-209: I am not quite sure how to understand this statement about smooth topography. I read this to imply that the topography should be smooth, but is not the point of RCMs to include more detailed "jaggedness" that the real world topography contains?
- Line 358,359 linked to line 388. The only truly unambiguous signal, already well-established in literature, is this early season drying for southern Africa. So these

statements about models struggling with transition (October) seem paradoxical with the clear drying signal. In the revision of the manuscript, hopefully this can be rethought and rewritten.

- Line 383 talks about observation products being kept in sight. I suspect you mean, in mind. Taking this quite literally, Kendon et al 2019 made this observation uncertainty visible by display TRMM-CMORPH bias alongside other bias or change plots (panel d in Figures 2-6). Including such a figure in your manuscript would help stay true to your line 383 statement and give the reader and indicate of magnitude of changes relative to obs. uncertainty.
- For clarity remove region letters in text and figures. Just go with SAF-All, Angola, East Coast, SAfr, or similar throughout to make for easier reading.
- Bias plots will be much clearer to interpret if in expressed % bias from climatology (with mask for negligible rainfall areas, e.g. <1mm/month) and if colours were white for low/no bias increasing to dark red (dry) or blue (wet).
- A paper you may have missed by which is relevant to some of your analysis here is Munday, C., & Washington, R. (2019). Controls on the diversity in climate model projections of early summer drying over southern Africa. *Journal of Climate*, 32(12), 3707-3725.

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