

REVIEWER #1

(The reviewer's comments are reproduced in italics, followed by our responses. Line numbers refer to the preprint.)

General:

Two 30-year simulations representing 1990-2019 with observed greenhouse gases and 2020-2049 using the SSP3-7.0 greenhouse gas forcing are analyzed. The model is a coupled GCM with 9-km resolution in the atmosphere. At this resolution, some explicit convection occurs but parameterized convection is still needed – the authors described the convective parameterization as “weakly active”. The reference to “kilometre-scale” modeling in the title is misleading, since this term is used to refer to convective-permitting modeling at resolutions under 4 km.

The precipitation analysis is especially interesting, with the decomposition into “AEW days” and “non-AEW days”. The PV analysis is also really nice – perhaps you would compare with Hsieh and Cook (2008) who discuss how PV gradient reversals interact with the jet and the waves.

The paper is well-written and informative, and the analysis is substantial. A very nice contribution.

We sincerely thank the reviewer for carefully reviewing our manuscript, and their comments have helped us immensely to improve the manuscript. Thank you for pointing us to Hsieh and Cook (2008), which we had overlooked and which is directly relevant to Sect. 4.3. In the revised manuscript, we will cite this study when introducing the reversal of the meridional PV gradient (lines 511–517). When discussing Fig. 12, we will compare our results with their analysis of how PV gradient reversals interact with the AEJ and the waves. In particular, we will discuss how the projected strengthening of the reversal near 10°N (Fig. 12a), which in our simulations arises mainly from increased static stability rather than from changes in relative vorticity (Fig. 12b–c), relates to the mechanisms they describe. We will also refer to Hsieh and Cook (2008) in the Discussion (lines 573–578).

Major:

1. Please change “kilometre-scale” in the title to, perhaps, “higher-resolution”.

We agree that at 9 km the simulations are not convection-permitting in the strict sense, and that a reader may misunderstand the term “kilometre-scale” as a cloud-resolving, explicit-convection configuration. Our use of the term followed the nextGEMS project convention (e.g. Segura et al., 2025), where “km-scale” is used for the whole class of global storm-resolving configurations, but we accept that this convention is not universal and that precision serves the reader better. We will therefore replace “kilometre-scale” with the actual grid spacing of 9 km. Rather than “higher-resolution”, which is a relative term, we will state the grid spacing explicitly. The revised title will be: “Projected changes in African Easterly Waves and rainfall events in West Africa with global coupled simulations at 9 km resolution”. We will also

add a sentence to Sect. 2.2 (after line 114), making explicit that the reduced cloud-base mass flux means convection is partly explicit and partly parameterised, so that the reader is not left with the impression that convection is fully resolved.

2. ***You mention (line 379) that there is amplified warming of the Sahara but do not reference the literature on this topic. This would be a nice point of comparison with observed trends, especially since the related intensification of geopotential height and moisture gradients across the Sahel caused by this amplified warming of the Sahara Desert are central to the changes in the energetics.***

We agree that this is a missed opportunity, both for placing the projection in the context of observed trends and for tying the thermodynamic change more explicitly to the energetics results. So the following references will be added to the results and discussion: Cook and Vizzy (2015), Vizzy and Cook (2017), Evan et al. (2015), Lavaysse et al. (2016), Zhou (2016).

3. ***Discussion of any changes that may be different in the two AEW tracks (the lower period Southern track vs. the longer-period Northern track) would be interesting.***

We thank the reviewer for this suggestion, which we agree adds an interesting dimension to the results. Our analysis is restricted to the 3–5-day band, and we deliberately did not extend it to the 6–9-day waves, which are predominantly a northern-track phenomenon (Diedhiou et al., 1999; Chen, 2006), to keep the manuscript to a manageable length: the validation, energetics and precipitation decomposition would all have to be repeated for the second band. We now state this scope explicitly in Sect. 3.1 and in the Discussion. However, the 3–5-day band is not exclusively a southern-track band. Waves of this period are found on both flanks of the AEJ (Thorncroft and Hoskins, 1994; Pytharoulis and Thorncroft, 1999), and this is visible in our figures: the 3–5-day filtered meridional-wind variance (Fig. 2a–b) peaks near 20°N over the Atlantic, i.e. on the northern flank, and the composite wave structures in Fig. 3 extend well into the Sahara. What is southern-track-specific in our method is the base point (1°W, 11.5°N) used for the composites and the AEW-day classification; the EKE and energetics fields (Figs. 7 and 8) cover both flanks. The track contrast the reviewer asks about is therefore already contained in the results. In the revised manuscript we will add a sentence to Sect. 3.1 clarifying that the 3–5-day band captures waves on both flanks of the AEJ, that the base point targets the southern track, and that the 6–9-day band is not analysed and add a note in the Discussion that a dedicated analysis of the northern track, including the 6–9-day band, is left for future work.

Fig. R1 shows the projected change in 6–9-day EKE at 700 hPa, computed in the same way as Fig. 7 of the manuscript. The 6–9-day waves, which are more representative of the northern track, respond differently from the 3–5-day waves. The most prominent signal is a dipole over the eastern tropical Atlantic. The 6–9-day EKE decreases significantly off the coasts of Senegal and Mauritania, reaching about $-0.5 \text{ m}^2 \text{ s}^{-2}$ near 20°N, 25°W, with weaker reductions extending over the westernmost Sahel. Farther northwest, it increases significantly, by up to about $0.5 \text{ m}^2 \text{ s}^{-2}$ near 25°N, 35°W. Elsewhere over the Sahel the changes are weak (mostly within $\pm 0.2 \text{ m}^2$

s⁻²) and patchy, with nothing comparable to the 3–5-day increase over West Africa in Fig. 7, while over the Sahara they consist of alternating positive and negative cells of small spatial scale. In our simulations, therefore, the 6–9-day waves do not intensify over land; instead, their activity appears to be displaced northwestward over the eastern Atlantic.

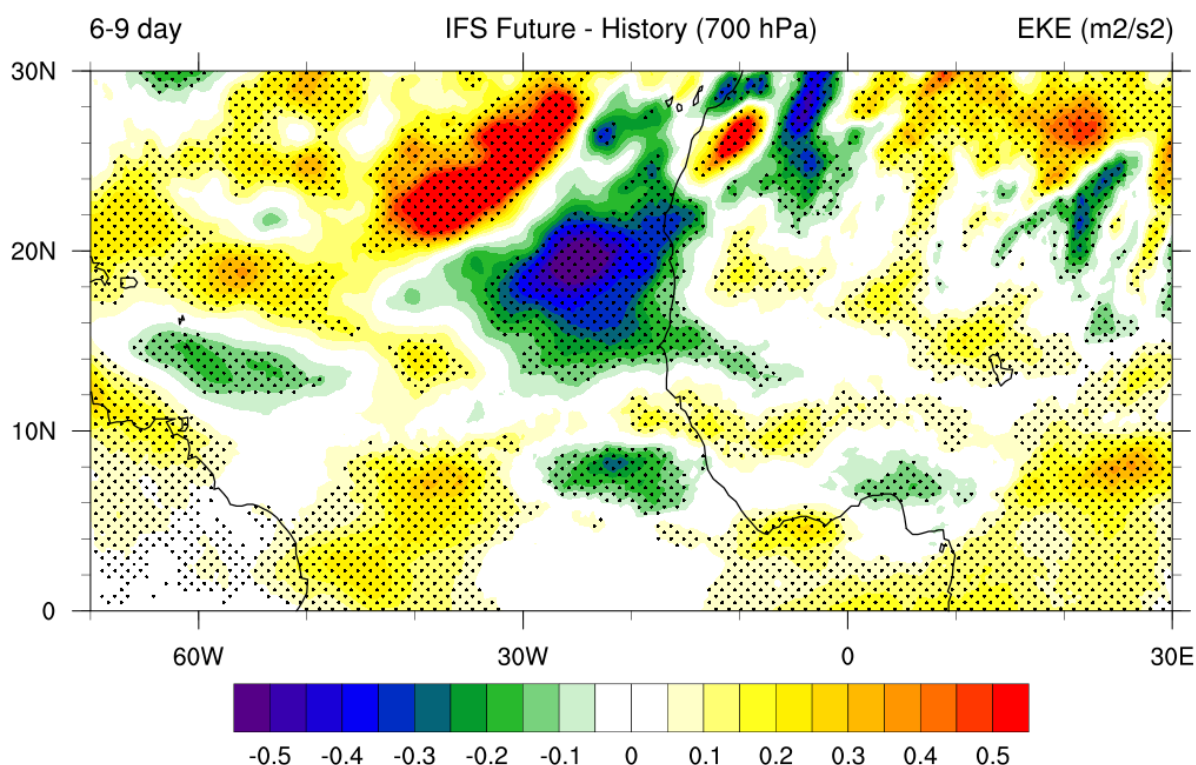


Figure R1. As Fig. 7 of the manuscript, but for 6–9-day band-pass filtered winds: difference between JJAS 6–9-day EKE at 700 hPa in the future (2020–2049) and historical (1990–2019) simulations ($\text{m}^2 \text{s}^{-2}$). Stippling marks regions where the p-value of the local null hypothesis of equal means is below 0.05.

Minor:

Abstract: *Cyclone not cyclon.*

Thank you for pointing out the typo. It will be corrected in the manuscript.

References

- Cook, K. H. and Vizi, E. K.: Detection and analysis of an amplified warming of the Sahara Desert, *J. Climate*, 28, 6560–6580, <https://doi.org/10.1175/JCLI-D-14-00230.1>, 2015.
- Cook, K. H. and Vizi, E. K.: Contemporary climate change of the African monsoon systems, *Curr. Clim. Change Rep.*, 5, 145–159, <https://doi.org/10.1007/s40641-019-00130-1>, 2019.

Diedhiou, A., Janicot, S., Viltard, A., de Felice, P., and Laurent, H.: Easterly wave regimes and associated convection over West Africa and tropical Atlantic: results from the NCEP/NCAR and ECMWF reanalyses, *Clim. Dynam.*, 15, 795–822, <https://doi.org/10.1007/s003820050316>, 1999.

Evan, A. T., Flamant, C., Lavaysse, C., Kocha, C., and Saci, A.: Water vapor–forced greenhouse warming over the Sahara Desert and the recent recovery from the Sahelian drought, *J. Climate*, 28, 108–123, <https://doi.org/10.1175/JCLI-D-14-00039.1>, 2015.

Lavaysse, C., Flamant, C., Evan, A., Janicot, S., and Gaetani, M.: Recent climatological trend of the Saharan heat low and its impact on the West African climate, *Clim. Dynam.*, 47, 3479–3498, <https://doi.org/10.1007/s00382-015-2847-z>, 2016.

Pytharoulis, I. and Thorncroft, C.: The low-level structure of African easterly waves in 1995, *Mon. Weather Rev.*, 127, 2266–2280, 1999.

Rackow, T., Pedruzo-Bagazgoitia, X., Becker, T., Milinski, S., Sandu, I., et al.: Multi-year simulations at kilometre scale with the Integrated Forecasting System coupled to FESOM2.5 and NEMOV3.4, *Geosci. Model Dev.*, 18, 33–69, <https://doi.org/10.5194/gmd-18-33-2025>, 2025.

Segura, H., Pedruzo-Bagazgoitia, X., Weiss, P., et al.: nextGEMS: entering the era of kilometer-scale Earth system modeling, *Geosci. Model Dev.*, 18, 7735–7761, <https://doi.org/10.5194/gmd-18-7735-2025>, 2025.

Thorncroft, C. D. and Hoskins, B. J.: An idealized study of African easterly waves. I: A linear view, *Q. J. Roy. Meteor. Soc.*, 120, 953–982, 1994.

Vizy, E. K. and Cook, K. H.: Seasonality of the observed amplified Sahara warming trend and implications for Sahel rainfall, *J. Climate*, 30, 3073–3094, <https://doi.org/10.1175/JCLI-D-16-0687.1>, 2017.

Zhou, L.: Desert amplification in a warming climate, *Sci. Rep.*, 6, 31065, <https://doi.org/10.1038/srep31065>, 2016.