Referee #1

Dear Dr. Indrani Roy,

Thank you for your careful review of our manuscript. Your comments are greatly appreciated and we think this new version of the manuscript responds to your concerns and provides an interesting contribution to the study of forecast extreme September-to-November rainfall events. Below, each comment was addressed separately in a concise manner, with the Referee's comment in *italic*, and Authors comment in **bold**. Proposed changes and additions are highlighted in red and underlined.

SOME GENERAL COMMENTS

This paper focuses on rainfall predictability over Eastern Africa for September to November by exploring ECMWF-SEAS5.1 data during 1981-2023, Using regression, spatiotemporal and composite analyses, the authors studied extreme precipitation events and atmospheric circulations. Two lead times are used for initial conditions (IC) eg., September and August, while better skill is noted for September IC in terms of annual precipitation cycle and seasonal spatial pattern. Teleconnection between rainfall and ENSO, IOD are captured well for both ICs. Certain areas of underestimation are also identified. Results have implications for improved operational forecast and I recommend a revision.

Main points:

Referee:

1. *In Table 1, there are only two years for WY in L1. Mention that significant results are obtained using only two years. Similarly for SY, there are only four years for L1. Discuss briefly whether a lesser number of year has any influence on the figure that you showed in Fig. 8 (e-h).*

Also in Fig 7, there are some years those could be identified as SY in models (2015 for both L0 and L1, 2002 for L1) or WY (1984 for L1,1996 for both L0 and L1, 2021 for L0 and 2022 for L1) but were not captured in the observation. Were those years included in Fig. 8 (e-h)? Discuss those. How does the inclusion and exclusion of those years affect the results and regions with significant signals?

In Table 1, did you check if ERA5 is also showing the same SY and WY as CHIRPS? If ERA5 is included in Fig. 7, some borderline years (eg. 1994) or other years could be different. Hence, caution should be taken in sampling the years of SY and WY part. ERA5 data are used in all analyses of mechanisms.

Authors: We sincerely thank the reviewer for these comments and suggestions, which helped us clarify our methodology. We agree with the reviewer that the sample size of the composites could significantly influence the results obtained. Since the objective of our study is to evaluate the ECMWF model's ability to

predict extreme precipitation and the associated atmospheric mechanisms, it is important to compare the model outputs with reference datasets.

Accordingly, we have redone the analyses (Figures 8–14) using only composites common to both CHIRPS and ERA5, setting the threshold at 0.5 SD. Of the seven SY years (the same as in the first version of the manuscript), six are captured by the model at both L0 and L1, while for the six WY years, five (two) are captured at L0 (L1). It is noteworthy that out of the 13 identified composites, nine were already included in the first version of the manuscript, while the four new ones (mainly WY years) consist of three La Niña years and one neutral year. The results obtained, which are very similar to those of the first version, have been added to the manuscript.

We also conducted additional analyses using composites specific to the model to examine how the inclusion or exclusion of these years affects the results and the regions showing significant signals. The outcomes are very similar, with only minor differences observed. We did not consider it necessary to include these additional analyses, as no substantial differences were found.

Referee:

2. *As Fig 9 shows there are differences between CHIRPS and ERA5, it is better to include ERA5 in Fig.7 as well as in Table 1. You included composites of SY and WY in Fig. 10 for ERA5 too, but those years are chosen using CHIRPS. However, SY and WY of CHIRPS and ERA5 could be different based on your selection criteria of the threshold. As the sampling years are very few for observation, addition or subtraction of one or two years can make a difference.*

To overcome such issues, you might consider years where both CHIRPS and ERA5 identify the same SY and WYs. Thresholds of 1 SD can also be adjusted. All the results of compositing that you presented could still be similar; however, The results and discussion will be much robust.

Authors: We have taken this comment into account, and the corresponding changes have been made in the manuscript. Please refer to the revised document.

"**Strong (weak) years are defined as those in which the common CHIRPS and ERA5 EAIs exceed +0.5 standard deviation (fall below –0.5 standard deviation).**"

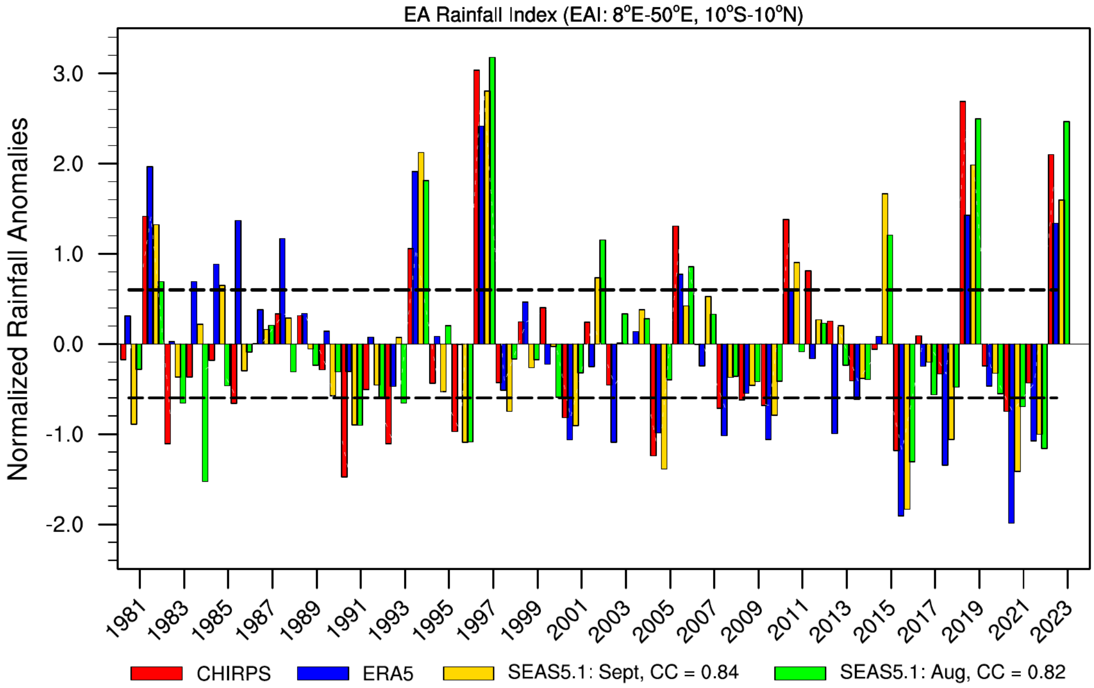

Fig 7: Indices of standardised EA rainfall anomalies over the period 1981-2023 during SON, for CHIRPS (red), ERA5 (blue), model at L0 (gold) and L1 (green). Dashed black line denotes ± 1 standard deviation of seasonal anomalies. The CC value between observed and predicted EA rainfall is shown in the legend below the map.

Table 1: Strong and weak EA rainfall years used in this study

Category	Years
Strong Years (SY)	1982*⊠, 1994*⊠, 1997*⊠, 2006⊠, 2011*, 2019*⊠, 2023*⊠
Weak Years (WY)	2001*, 2005*, 2008, 2010*, 2016*⊠, 2021*⊠

The asterisk (*) indicates the years captured by the model at L0, and the square (⊠) those captured by the model at L1.

<u>Referee</u>:

3. *Caution should be taken linking any mechanisms involving the Atlantic part. Those are not very clear in the current analyses.*

Line 532- 533: No significant influence from the Atlantic Ocean is seen for SY years in observation/reanalyses or models. For WY, some influence is present, but models overestimate observation/reanalyses. Also, for ERA5 it is nominal and for CHIRPS it is not from the 'eastern equatorial Atlantic ocean'. Mention those. In Fig.10, for WYs, the SST signals in box regions are practically missing in observation/reanalyses and L0; discuss that part. It indicates the asymmetric influence in WY compared to that from SY.

<u>Authors:</u> We thank the reviewer for this comment. We agree that anomaly values are relatively low in the Niño3.4 region during WY events compared to SY events. This analysis has been repeated using the new composite sample. Although anomaly values remain low over the western pole of the IOD during WY events, a negative dipole is still observed. This result indeed suggests a symmetric influence between SY and WY years, even though values are stronger during SY events. It is important to note that SST anomaly values are higher during the SY composites compared to WY events. This can be explained by the fact that, among the seven SY years, three correspond to record El Niño events (1982, 1997, 2023) and two to moderate events (1994 and 2006), with six of these also coinciding with positive IOD episodes. In contrast, among the six WY years, only one corresponds to a significant La Niña event (2016), with four moderate events (2005, 2008, 2010, 2021), while four are associated with moderate negative IOD episodes. The corresponding changes have been made in the manuscript; please refer to lines … of the revised document.

~~"Over the eastern equatorial Atlantic ocean, warming (cooling) SST anomalies feature during SY (WY) composites (Dezfuli and Nicholson 2013; Dezfuli 2017).~~ **<u>It is important to note that SST anomaly values are stronger during the SY composites compared to those observed during WY events. This can be explained by the fact that, among the seven SY years, three correspond to El Niño record events (1982, 1997, 2023) and two to moderate events (1994 and 2006), with six of them also coinciding with positive IOD episodes. In contrast, among the six WY years, only one corresponds to a significant La Niña event (2016) with four moderate events (2005, 2008, 2010, 2021), while four are associated with moderate negative IOD episodes.</u>**"

<u>Referee</u>: *Line 569: Signal in the equatorial Atlantic for SST is not significant. Also, there is no signal there in Fig.11 (a, c, e, f).*

<u>Authors:</u> We thank the reviewer for this comment. The text has been revised accordingly and incorporated into the manuscript.

~~"These changes in SST (Fig. 10), wind and MSLP (Fig. 11) during the two rainfall events appear to be contrasted over both equatorial Atlantic and Indian oceans (strongly over the equatorial IO), and according to Pokam et al. (2012), Moihamete et al. (2022) and Nana et al. (2025), are responsible for the moisture supply over the EA during SON season.~~ **<u>These changes in SST (Fig. 10), wind and MSLP (Fig. 11) during the two rainfall events appear to be contrasted mainly over Indian ocean (strongly over the equatorial IO) compare to the equatorial Atlantic, and according to Nicholson (2015) and Nana et al. (2025), are responsible for the moisture supply over the EA during SON season.</u>**"

<u>Minor points:</u>

<u>Referee</u>: *1. Line 65: The word 'national' is used twice; omit one national.*

Authors: **Thank you for the comment. The changes have been made in the manuscript.**

Referee: *2. In the Table 1 legend, mention what SY and WY are.*

Authors: **Thank you for the comment. The changes have been made in the manuscript.**

Referee: *3. Line 297: You mentioned (45-60%) and check Fig.1 colour bar and make it clearer. Otherwise, modify the text. Also, the last marking for the colour bar is showing 55 instead of 56.*

Authors: **We thank the reviewer for drawing our attention to this point. The correct value is 45–50%. The text has been revised accordingly.**

"During SON, the highest observed precipitation fraction (Fig. 1b) occur over the eastern part of EA **(45–50 %)**, mainly over south-eastern Ethiopia, eastern Kenya and Somalia, as well as over Gabon and southern Cameroon (40–45 %)"

Referee: *4. Line 299: 'values drop below 20 % over Tanzania and northwest of Kenya'- Mention the particular Figure name and IC where it drops.*

Authors: **We thank the reviewer for the comment. This refers to the CHIRPS reference data. The reference for the corresponding figure has been added..**

"Conversely, values drop below 20 % over Tanzania and northwest of Kenya **(Fig. 1b)**."

Referee: *5. Line 335-336: correct the grammar.*

Authors: **Thank you for the comment. The changes have been made in the manuscript.**

"**Overall, the model demonstrates better skill at L0 than at L1 across the region, consistent with the conclusions of Tefera et al. (2025).**"

Referee: *6. Line 439-444: 'The model at both L0 and L1 successfully captures this Atlantic teleconnection.' Discuss more here linking those figures, as any connection from the Atlantic as you mentioned, is not seen in Fig.4.*

Authors: **Thank you for drawing our attention to this. Indeed, this paragraph refers to Figure 5 rather than Figure 4. The text has been corrected.**

"The results support the presence of IOD-like patterns over the IO and ENSO-like patterns over the equatorial Pacific, both in observation **(Fig. 5a) and model (Fig. 5b,c)**. Both observed and model exhibit significant positive (negative) regression values over WIO (EIO). The equatorial Pacific highlighted here by the N3.4 index shows strong and significant positive regression, suggesting that ENSO and IOD may exert over the region a concurrent influence on rainfall distribution. This suggests that ENSO can modulate or amplify the IOD signal when both phenomena occur simultaneously.

Another noteworthy pattern emerges over the eastern equatorial Atlantic, where strong positive and significant regression values are **observed (Fig. 5a)**."

Referee: *7. Line 475: Fift?*

Authors: Thank you for the comment. The changes have been made in the manuscript.

"Six (**Five**) of observed SY (WY) are captured by the model at L0, whereas six (two) are captured at L1."

Referee: *8. Fig. 7 caption: Top of figure- put 'Model' instead 'Mdl'*

Authors: Thank you for the comment. The figure has been redone. Please see Figure 7 of comment 2.

Referee: *9. Results for 2nd and 3rd columns will be better if ERA5 composite years are chosen in Fig.12. Modify the discussion accordingly. Based on the current analyses, any influence from the Atlantic is not clear.*

Authors: We thank the reviewer for drawing our attention to this analysis. Based on composites common to ERA5 and CHIRPS, we used the same sample of SY years and some overlapping years in the WY sample as in the first version of the manuscript, which only included CHIRPS composites. Consequently, the results and conclusions of certain analyses remain unchanged. Using ERA5 as a reference, an anomalous westerly (easterly) flow is observed over the western region during SY (WY), primarily in the mid-troposphere (700 hPa). However, we agree with the reviewer that this flow over the Atlantic Ocean is weaker than over the Indian Ocean. The corresponding text for this figure has been revised.

"**In the lower troposphere (1000–850 hPa), easterly moisture transport prevailed over the EA region, whereas a westerly circulation appeared only in the mid-troposphere (850–600 hPa), with a weaker intensity compared to that originating from the IO**."

Referee: *10. In Fig.14, the bottom two rows, no signal from Atlantic in models!*

Authors: We thank the reviewer for drawing our attention to this analysis. As shown in Figure 12, the model is unable to simulate the westerly (easterly) flow over the Atlantic Ocean during SY (WY) composites at L0, in contrast to L1, where these flows are represented, albeit underestimated by the model. The corresponding text has been revised.

"**Although underestimated, the observed pattern is well predicted by the model at L0 (Fig. 14c-d) and L1 (Fig. 14e-f). However, the model fails to simulate the westerly (easterly) flow over the Atlantic Ocean during the SY (WY) composites at L0, in contrast to L1 where these flows are represented, although underestimated by the model**."

Referee: *11. Line 676-678: Moisture flux convergence is not present in Western EA in models! It is true for L0 as well as L1.*

Authors: We thank the reviewer for drawing our attention to this analysis. We have adjusted the color scale to better highlight low values. While there are indeed moisture flux convergence values in the models (L0 and L1) over western EA, they are lower compared to those in ERA5. We have redone this figure with the modified color scale, which now allows the moisture flux convergence values over western EA to be clearly observed in the models at both L0 and L1. Please refer to Figure 14 in the revised manuscript.

"**Although underestimated, the observed pattern is well predicted by the model at L0 (Fig. 14c-d) and L1 (Fig. 14e-f). However, the model fails to simulate the westerly (easterly) flow over the Atlantic Ocean during the SY (WY) composites at L0, in contrast to L1 where these flows are represented, although underestimated by the model.** Furthermore, examination of Figures S2 and S3 confirms that moisture convergence is the main component of moisture flux convergence, since, the spatial pattern of moisture convergence (q∇·V) is similar (and with the same strengths) to that of moisture flux convergence (∇·(qV)), in contrast to that of moisture advection (V·∇q). This finding is in line with previous research by Longandjo and Rouault (2023) and Kolstad et al. (2024), who show that moisture convergence prevails in moisture flux convergence over western EA and eastern EA, respectively. The model captures this moisture convergence very well as the main component of moisture flux convergence (Kolstad et al., 2024) at L0 (Figs. S2c,d and Figs. S3c,d) and L1 (Figs. S2e,f and Figs. S3e,f)."

Referee: *12. Line 679-681: Physical mechanisms in eastern EA may be reasonable, but not for western EA based on the equatorial Atlantic.*

Authors: We agree with the reviewer that the physical mechanisms driving precipitation in the models originate primarily from the Indian Ocean. The corresponding text has been revised.

"**In summary, precipitation in the September and August IC predictions is reasonably represented, mainly driven by dynamic processes from the IO, supporting the use of SEAS5.1 outputs for eastern EA rainfall.**"

Referee: *13. Line 517-518: Check and discuss more. Is it clear for ERA5?*

Authors: We thank the reviewer for drawing our attention to this analysis. Indeed, the probability of observing heavy precipitation (>1 mm/day) is consistently higher (lower) during SY (WY) composites compared to the climatology, and this pattern is observed across all four datasets.

Referee: *14. Line 620: What is AEJ and define it.*

Authors: We thank the reviewer for bringing this to our attention. The text has been revised accordingly.

"**An important atmospheric feature over western East Africa is the African Easterly Jet (AEJ), defined as the maximum easterly winds in the mid-troposphere (700–600 hPa; Nicholson and Grist 2003). During the September–November rainfall season, the AEJ shows a southern branch (AEJ-S) with its core near 10°S, and a northern branch (AEJ-N), which occurs year-round with its core near 10°N (Kuete et al., 2022). The following analysis highlights the characteristics of these features during extreme September–November rainfall episodes**."

Referee: *15. Line 728-729: 'This study demonstrates that the novel ECMWF-SEAS5 version 5.1 (SEAS5.1) outperforms its predecessors (ECMWF-SEAS5 version 5)'. You did not compare any results here with the previous model version, ECMWF-SEAS5 version 5 and hence the statement is not justified. Modify accordingly.*

Authors: We agree with the reviewer, and the text has been revised accordingly.

"**The model also demonstrates its ability to reproduce maximum composite rainfall anomalies over eastern EA, particularly across Kenya, southern Ethiopia, and Somalia, although it tends to underestimate their magnitude.**"

Referee: *16. Fig S3: completely blank for d and f, and mention that. Also, no signal in the western EA.*

Authors: We thank the reviewer for drawing our attention to this analysis. We have adjusted the color scale to better highlight the low values; please refer to Figure S3 in the revised manuscript. The low values shown in this figure are consistent with recent studies and confirm that, among the two components of moisture flux convergence (moisture convergence and moisture advection), only moisture convergence (Fig. S2) exhibits a pattern similar to that of the total moisture flux convergence (Fig. 14). Moisture advection (Fig. S3), on the other hand, shows much lower values compared to the other two. It is important to note that the same color scale has been applied across the three analyses to allow direct comparison.

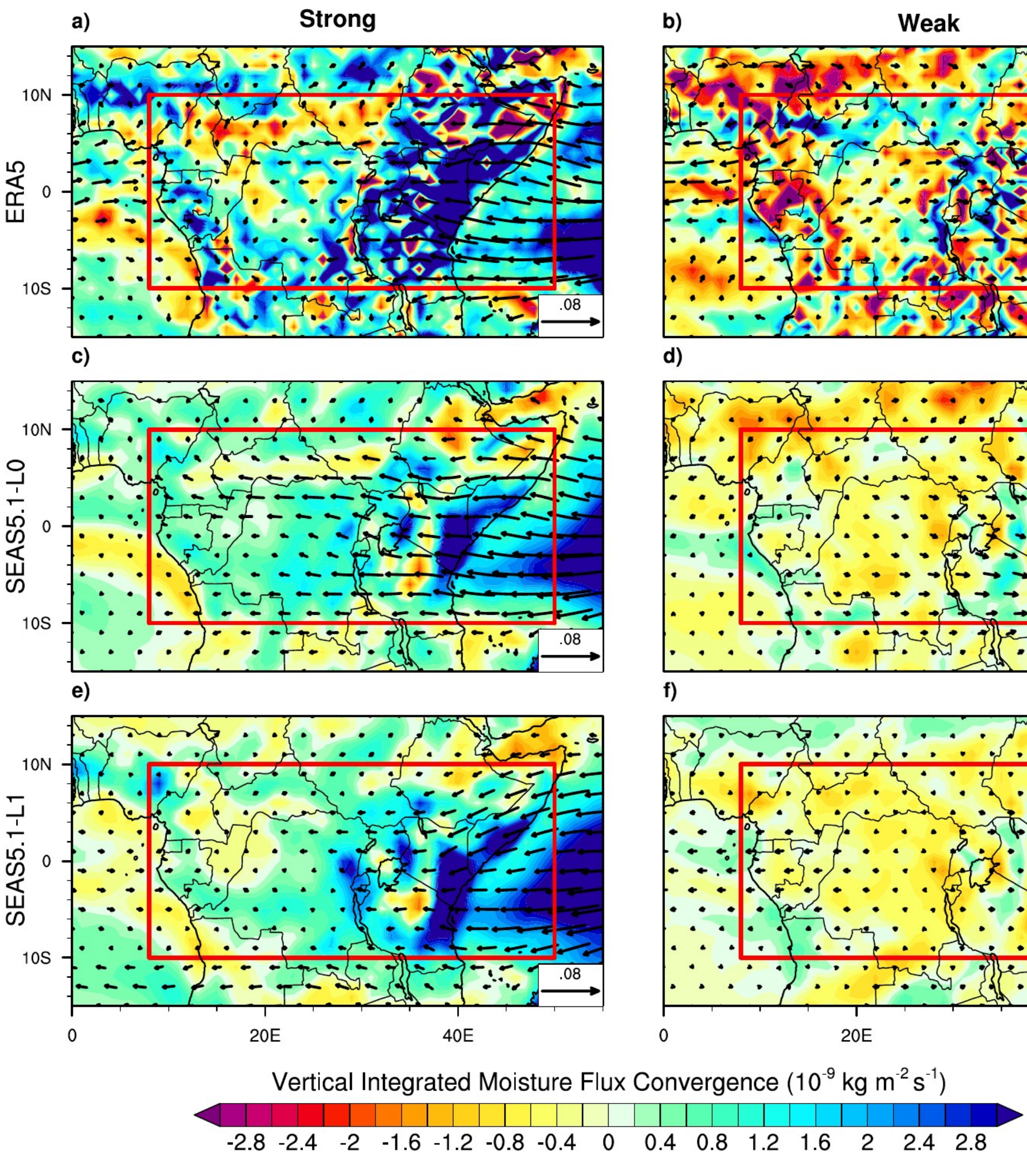

Fig 14: Same as Fig. 8, but for vertically integrated (1000-300 hPa) moisture flux (vectors, 10^{-9} kg m^{-1} s^{-1}) and vertically integrated moisture flux convergence (positive values) or divergence (negative values) anomalies (shading, 10^{-6} kg m^{-2} s^{-1}). Only significant vectors and shading above the 90 % level are shown. The red box indicates the EA region.

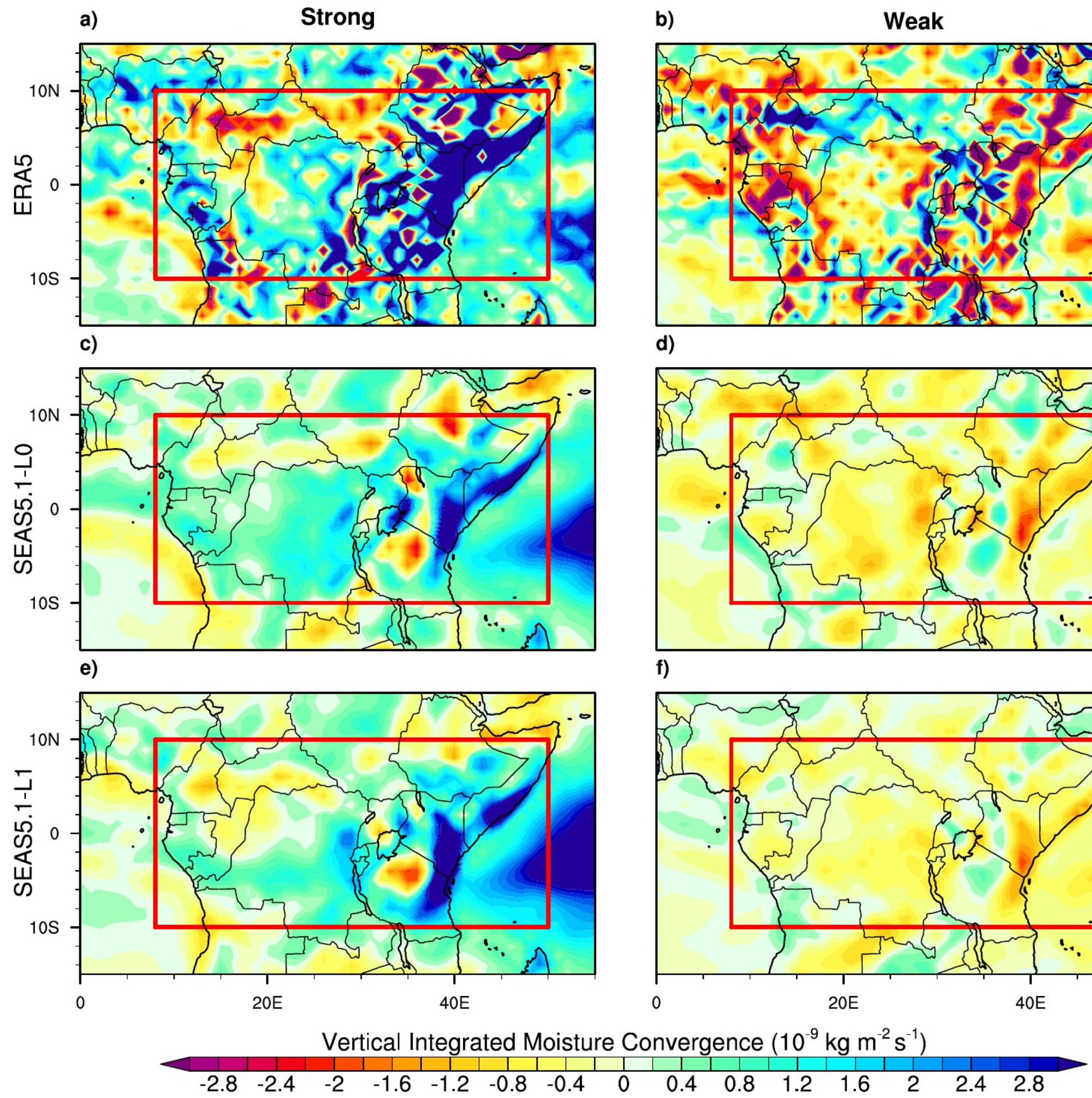

Fig S2: Same as Fig. 14, but for vertically integrated moisture convergence $([q\nabla \cdot V])$

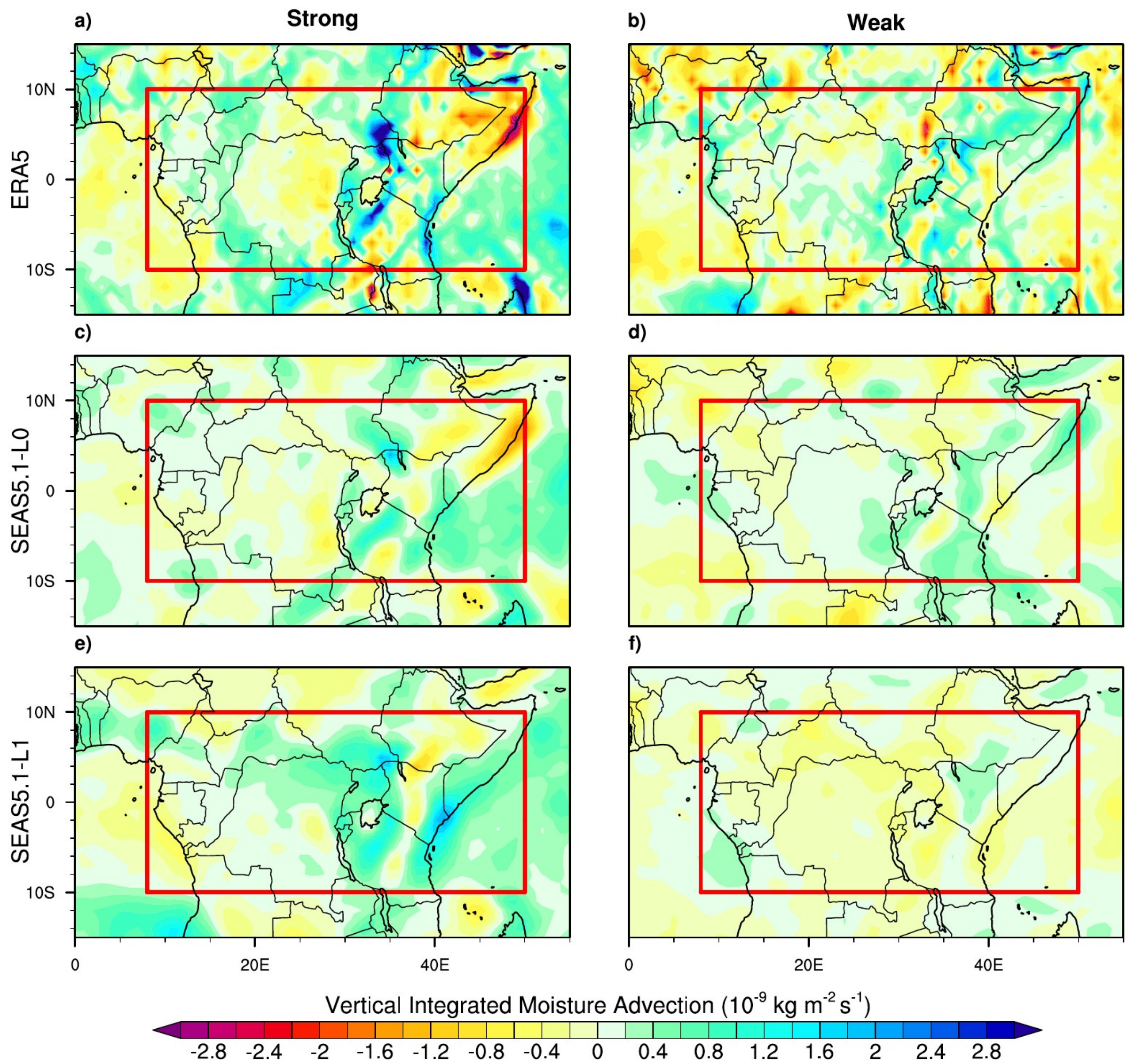

Fig S3: Same as Fig. 14, but for vertically integrated moisture advection $([V \cdot \nabla q])$

Referee: *17. 3rd bullet point in the conclusion is not clear.*

Authors: We thank the reviewer for bringing this to our attention. The text of the conclusion has been revised accordingly.

"**Summary and Conclusion: By analyzing hindcasts and forecasts from the latest operational seasonal forecasting system based on dynamical climate models, the European Centre for Medium-Range Weather Forecasts seasonal prediction system 5, version 5.1 (ECMWF-SEAS5.1), this study highlights the influence of atmospheric drivers in forecasting extreme precipitation events over equatorial Africa (EA) during the September–October–November (SON) season for the period 1981–2023. While some anomalous rainfall patterns over eastern and western EA have been linked to moisture transport from the Indian and Atlantic oceans respectively, further investigation is needed to evaluate the model's ability to simulate Madden–Julian Oscillation (MJO) activity during these extreme events.**

The results indicate that the spatiotemporal and interannual variability of EA rainfall is generally well represented by ECMWF-SEAS5.1 in both lead times during SON. However, the model exhibits limited skill in predicting rainfall over the Congo Basin, where hindcast data points are more dispersed at L0 than at L1, and both prediction and confidence intervals deviate more strongly from the regression line at L0. Predictability skill is higher for shorter lead times (September IC), particularly over Kenya, southern Somalia, and northern Tanzania. Moreover, ECMWF-SEAS5.1 successfully reproduces large-scale teleconnections between tropical sea surface temperatures over the Atlantic, Indian, and Pacific oceans and precipitation over EA, with forecasts initialized in September (Lead-0) showing stronger teleconnection skill than those initialized in August (Lead-1). For September ICs, the model captures 85.71% of strong rainfall years and 83.3% of weak years, while for August ICs, it captures 85.71% of strong years and 33.3% of weak years.

The model also demonstrates its ability to reproduce maximum composite rainfall anomalies over eastern EA, particularly across Kenya, southern Ethiopia, and Somalia, although it tends to underestimate their magnitude. Both the Indian Ocean Dipole (IOD) and ENSO modes are realistically simulated during extreme events and for both lead times, along with their associated atmospheric circulation. Furthermore, ECMWF-SEAS5.1 accurately simulates moisture flux convergence and its components (moisture convergence and moisture advection), with relatively stronger performance for September IC compared to August. Overall, the system shows strong and statistically significant skill in reproducing atmospheric features linked to extreme rainfall events over EA, with higher performance in the eastern sector compared to the western part. Given that skillful seasonal forecasting of equatorial rainfall has critical socio-economic implications including reservoir management, groundwater recharge, irrigation planning, and agricultural productivity these findings provide valuable guidance for policymakers in the region to strengthen adaptation strategies and risk mitigation efforts.”

Referee: *18. Summary and conclusion: write in the form of paragraphs throughout and omit using bullet points.*

Authors: We thank the reviewer for bringing this to our attention. The text has been revised accordingly. Please see “Summary and Conclusion” in the previous comment.