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).**"

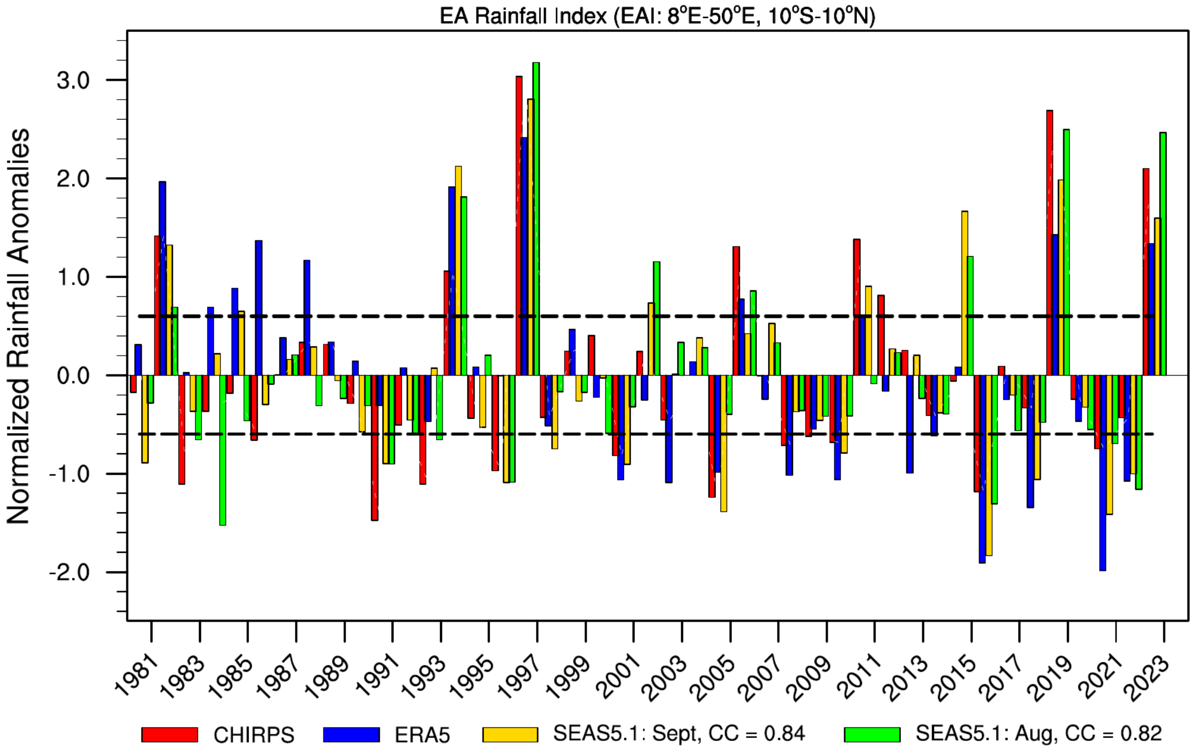

Fig 7: Indices of standardised EA rainfall anomalies over the period 1981-2023 during SON, for CHIRPS (red), ERA5 (blue), model at L0 (gold) and L1 (green). Dashed black line denotes ± 1 standard deviation of seasonal anomalies. The CC value between observed and predicted EA rainfall is shown in the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

Referee:

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

Authors: 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 revised manuscript.

"~~Over the eastern equatorial Atlantic ocean, warming (cooling) SST anomalies feature during SY (WY) composites (Dezfuli and Nicholson 2013; Dezfuli 2017).~~ **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.**"

Minor points:

Referee: *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 ($q\nabla\cdot V$) is similar (and with the same strengths) to that of moisture flux convergence ($\nabla\cdot(qV)$), in contrast to that of moisture advection ($V\cdot\nabla q$). 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.

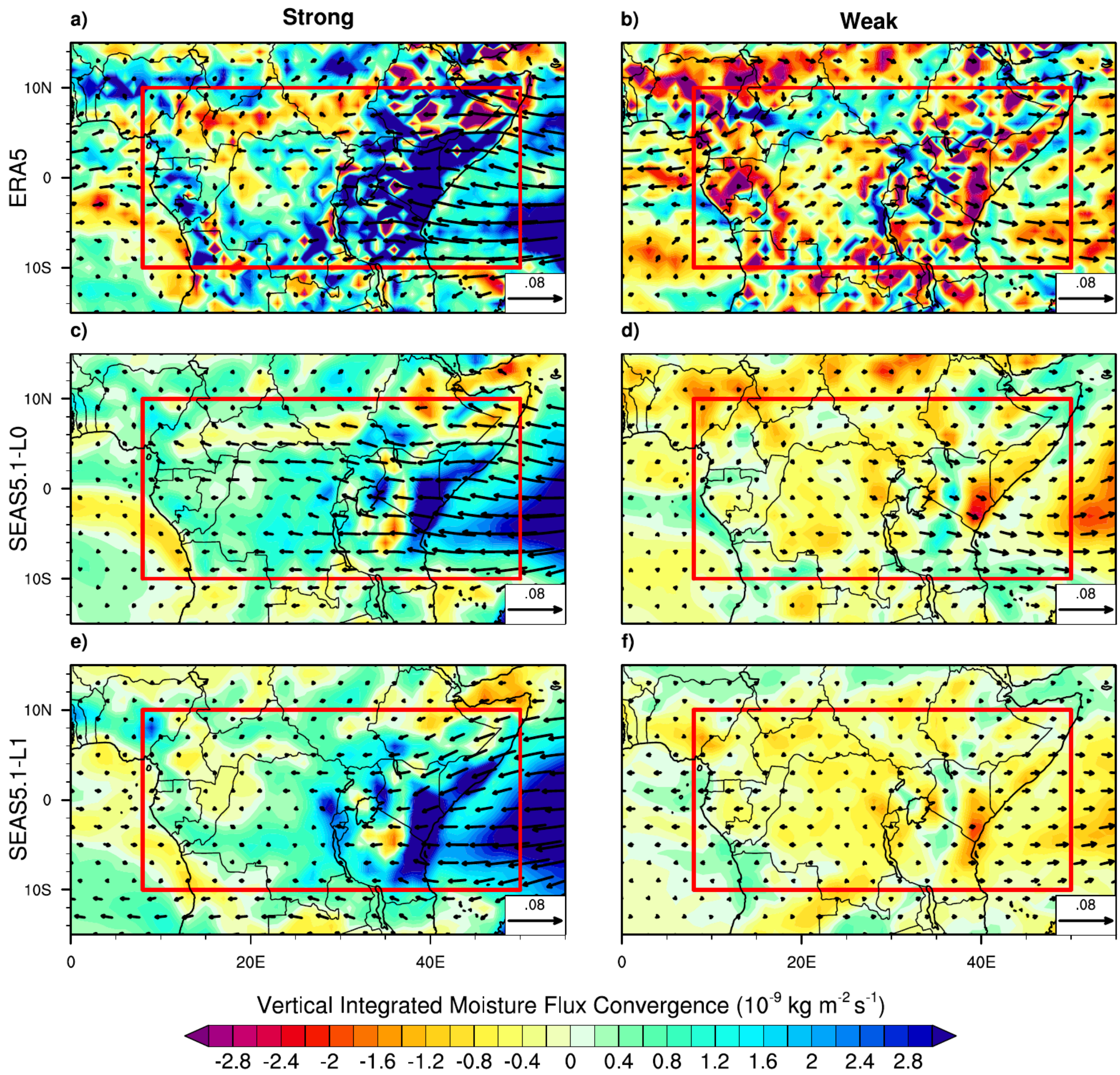

Fig 14: Same as Fig. 8, but for vertically integrated (1000-300 hPa) moisture flux (vectors, 10 -9 kg m-1 s-1) and vertically integrated moisture flux convergence (positive values) or divergence (negative values) anomalies (shading, 10-6 kg m-2 s-1). Only significant vectors and shading above the 90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

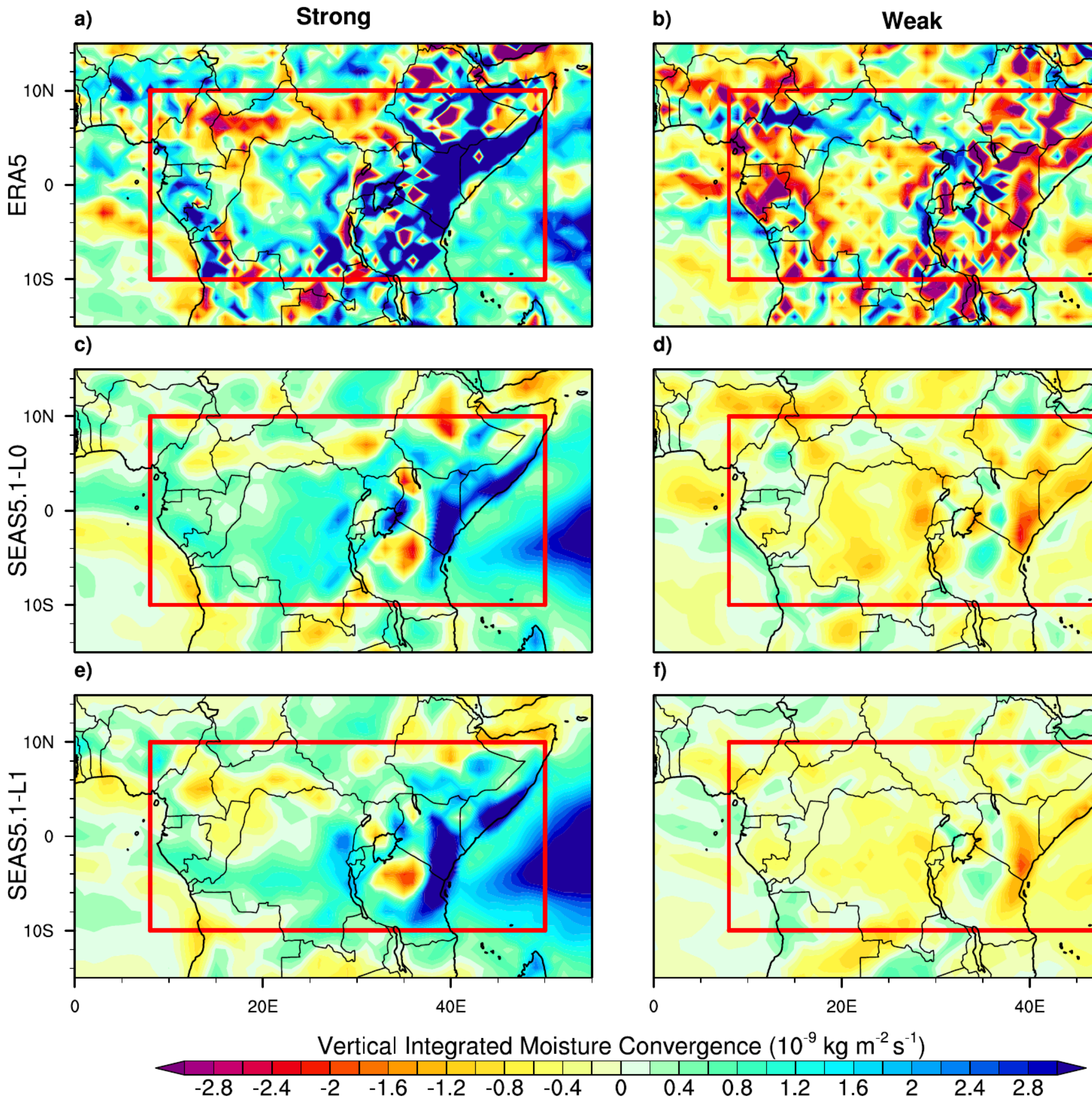

Fig S2: Same as Fig. 14, but for vertically integrated moisture convergence ([q ∇ · V])

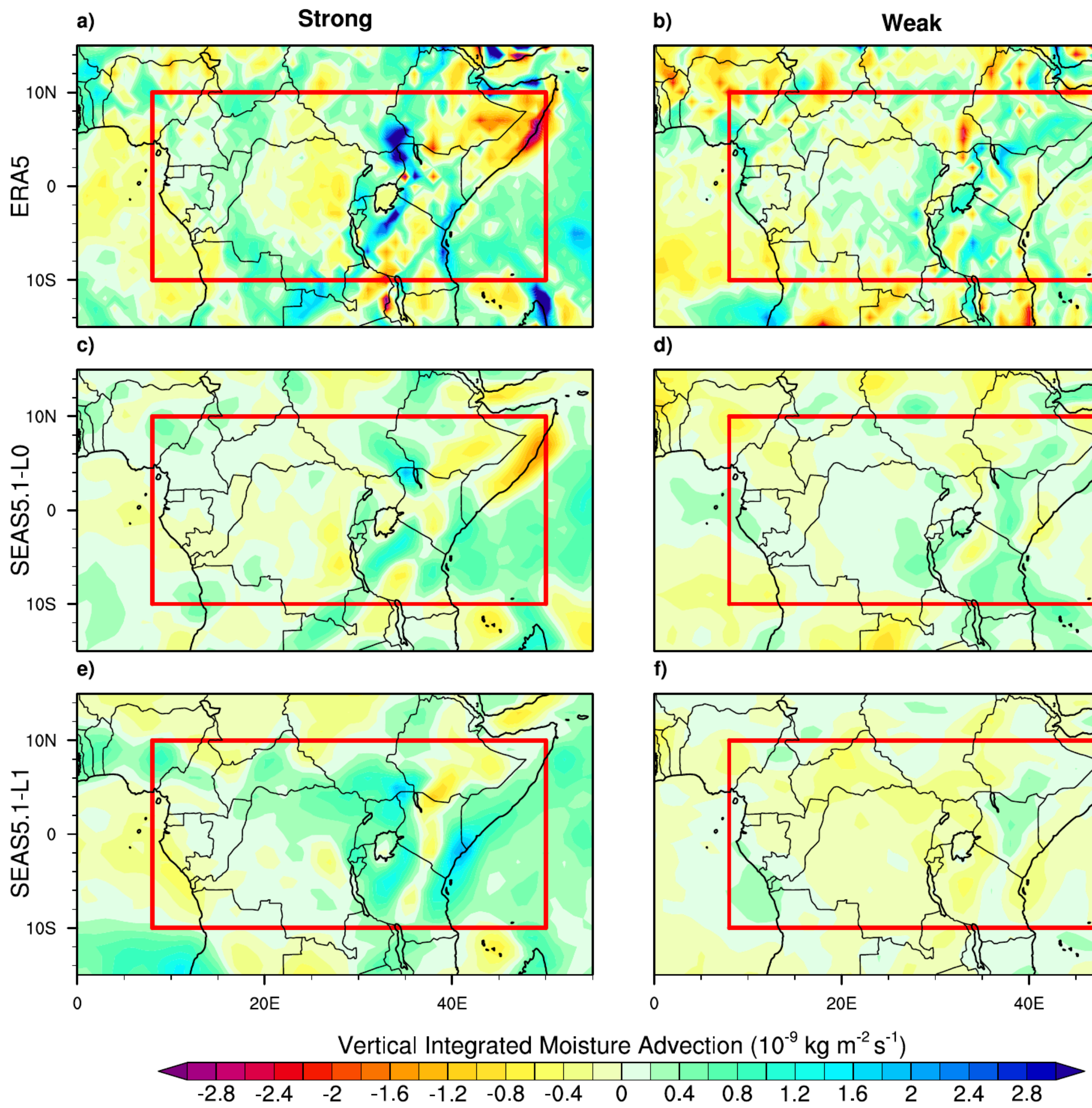

Fig S3: Same as Fig. 14, but for vertically integrated moisture advection ([V · ∇ q])

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.

Referee #2

Dear Reviewer,

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 in the updated manuscript and underlined here.

SOME GENERAL COMMENTS

Referee:

1. *The motivation of the study is not made sufficiently clear. Thus, the authors need to highlight the novelty of the study in comparison with recent ones, in particular with the study by Tefera et al. (2025) which already characterises the relationship between rainfall in OND and ENSO-IOD in observations and in C3S seasonal models and also examines some extreme years. Therefore, the authors need to clarify what gap the present study intends to fill. Is it that the previous studies did not specifically use version 5.1 of SEAS5? Is it that large-scale drivers were not addressed before for the model?*

Authors: We thank the reviewer for drawing our attention to this point. According to the following reviewer's comment, we have rewritten the introduction section and better highlighted the motivation behind the study by showing its unique nature. Please see the "Introduction" section in the revised manuscript.

"Equatorial Africa (EA) exhibits a complex annual rainfall cycle shaped by the seasonal migration of the Intertropical Convergence Zone (ITCZ), local convection, and moisture transport from the Atlantic and Indian Oceans. Among the different seasons, September to November (SON) is particularly important, as it marks one of the peak rainfall periods for many EA countries and is frequently associated with severe hydrometeorological hazards such as floods and landslides (Moihamette et al., 2024; Gudoshava et al., 2022a; Kenfack et al., 2025; Nana et al., 2025). Understanding and predicting SON rainfall variability is therefore critical for risk preparedness and climate-sensitive planning across the region. The SON rainfall system in EA is influenced by a combination of local, regional, and large-scale drivers. Local factors include mesoscale convective systems and interactions between topography and atmospheric flow (Pokam et al., 2013). Regional circulation patterns, particularly over the eastern equatorial Atlantic and western Indian Ocean, further modulate moisture availability (Kuete et al., 2019; Longandjo and Rouault, 2020). At larger scales, Sea Surface Temperature (SST) variability in the Pacific, Indian, and Atlantic oceans plays a central role in shaping interannual rainfall anomalies (Pokam et al., 2014; Nicholson, 2015). In particular, El Niño Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), and Atlantic SST anomalies have been shown to influence SON precipitation extremes across EA (Preethi et al., 2015; Roy et al., 2024; Palmer et al., 2023; Nana et al., 2025). Years characterised by the co-occurrence of a positive IOD and strong El Niño such as 1997 and 2023 have produced widespread heavy rainfall over several EA regions (Okoola et al., 2008; Nana et al., 2025). These links underscore the importance of accurately capturing SST-driven teleconnections and associated atmospheric circulation patterns when forecasting SON rainfall.

Despite advances in global numerical weather prediction systems, forecasting SON precipitation over EA remains a persistent challenge. Sparse observational networks, limited understanding of regional climate dynamics, and model-specific errors contribute to substantial uncertainties in seasonal forecasts (Tanessong et al., 2017). While several studies have evaluated the skill of general circulation models over EA (e.g., Feudjio et al., 2022; Nana et al., 2024; Tanessong et al., 2024), important gaps remain particularly regarding the model's ability to reproduce SON extreme rainfall events and their associated large-scale drivers. Most existing evaluations focus on earlier SEAS5 versions or on mechanisms relevant to other seasons (e.g., MAM or JJAS), thus providing an incomplete picture of SON dynamics. These studies found that EA rainfall variability is mainly associated with several factors, including easterly and westerly waves, tropical cyclones, the Madden-Julian Oscillation (MJO) and sea surface temperature (SST) in the Atlantic, Indian and Pacific oceans. For example, Nana et al. (2024) demonstrated that the ability of seasonal forecast models to predict rainfall anomalies occurring over western EA during extreme South Atlantic Ocean Dipole (SAOD) events depends on their skill in forecasting the relationship between rainfall and SAOD, which decreases with increasing lead time. Their results showed that the ECMWF seasonal forecast system 5 (SEAS5) model best captures this relationship and the associated rainfall anomalies, a finding also supported by Gebrechorkos et al. (2022). Similarly, Mwangi et al. (2014) evaluated SEAS5 products against data from ten East African stations and found significant forecasting skill for both rainy seasons, with better performance in October–December (OND) compared to March–May (MAM). The ability of the SEAS5 model to simulate the drivers of extreme rainfall during MAM 2018–2020 over eastern EA has been analyzed by Gudoshava et al. (2024). The findings of this study indicate that the heavy rainfall events of March–May 2018 and 2020 coincided with an active MJO (Phases 1–4) or a tropical cyclone east of Madagascar. In contrast, the low rainfall observed during the same period in 2019 was linked to tropical cyclones west of Madagascar. Their study also concluded that underestimation of these extreme rainfall intensities was linked to inaccurate MJO forecasts and errors in tropical cyclone location and intensity. For the June–September (JJAS) season, the findings of Ehsan et al. (2022) establish that the spatial and temporal patterns of observed EA rainfall variability, as well as the key climatic features that drive EA precipitation excesses and deficits, are successfully captured by the SEAS5 model, when initialized in May and April. Recent analyses have begun to examine the role of large-scale climate modes in shaping extreme SON rainfall, but few studies have assessed how well seasonal forecast systems capture both the rainfall anomalies and the underlying physical mechanisms. For example, Tefera et al. (2025) showed that SEAS5 is able to capture hydroclimatic extremes linked to coupled IOD-ENSO modes during the first two lead times, but their assessment did not consider the most recent ECMWF system nor did it explicitly evaluate the associated atmospheric circulation patterns during SON. This gap limits our understanding of the forecast system's ability to represent the processes driving extreme rainfall variability during this crucial season.

Motivated by these limitations, the present study evaluates the performance of the latest ECMWF seasonal forecasting system, SEAS5.1 (Johnson et al., 2019), in simulating SON extreme rainfall events over EA using forecasts initialized in August and September. SEAS5.1 was selected due to its demonstrated skill in representing key global climate teleconnections such as ENSO and the IOD (Nana et al., 2024; Tefera et al., 2025), which exert strong influence on SON precipitation. In addition to providing an updated assessment of model skill, our study explicitly examines the large-scale physical mechanisms SST anomalies, moisture transport, zonal and Walker circulations that accompany extreme rainfall events. This dual approach offers a more comprehensive and physically grounded evaluation than previous studies, thereby contributing toward improved understanding and prediction of SON rainfall extremes in EA. Extreme rainfall events are among the most impactful climate hazards over EA, often leading to severe flooding, infrastructure damage, and socio-economic losses, yet their predictability at seasonal timescales remains limited. Understanding whether a state-of-the-art seasonal forecast system can realistically represent the large-scale drivers of these extremes is therefore essential. The remainder of the paper is structured as follows. Section 2 describes the SEAS5.1 model, the observational and reanalysis datasets, and the methodology. Section 3 presents the skill assessment of SEAS5.1. Section 4 focuses on rainfall composites and associated SST patterns during extreme SON years, and Section 5 analyzes the corresponding atmospheric circulation features. Section 6 concludes the study.**"**

Referee:

2. *The current structure of the Introduction makes it somewhat difficult to follow, and a more streamlined presentation would improve readability. I suggest the following:*

- *Start with a very brief description of the seasonal cycle of rainfall in EA and what drives this seasonal variability. This provides useful context for readers who may be unfamiliar with the region and justifies the focus on the SON season.*
- *Keep the description of mechanisms limited to SON, which is the season examined in this study. Although the current introduction summarises a wide range of relevant literature, reviewing mechanisms across all seasons may distract from the primary objective.*
- *In line with my previous point 1, emphasise the gaps that remain in the existing literature and explain how the objectives of this study will help address them. It is fundamental to make very clear why this study is necessary, and this is not clear in the current version of the manuscript.*

Authors: We thank the reviewer for drawing our attention to this point. Please see the "Introduction" section in the previous comment.

Referee:

3. *This study uses seasonal forecast data at lead month 0 (lead-0). I am unsure that this is standard practice in the analysis of large scale drivers or teleconnections. At lead-0, forecast skill will exhibit a substantial influence from atmospheric initial conditions and short-range predictability, while for lead-1, lead-2... the role of the ocean as a predictor becomes more important. For instance, Fig. 2 shows that lead-0 forecasts exhibit higher ACC than lead-1. However, it is unclear whether this increase in skill is due to better representation of teleconnections and large-scale drivers at lead 0, or whether it primarily reflects the influence of atmospheric initial conditions. Hence some results should be interpreted with caution. Moreover, SEAS5 forecasts initialised in September are not available at Copernicus CDS until 6 September (10 September for the rest of the seasonal models available at CDS), i.e. when part of the month has already passed, thereby limiting practical applications for climate services. For these reasons, I think that lead-0 seasonal forecasts are probably not the most suitable choice for the purposes of this study, unless the authors provide convincing arguments for their use.*

Authors: We thank the reviewer for this important comment. In this study, *Lead-0* refers to forecasts initialized in September. This means that the forecasts for October and November correspond to *Lead-1* and *Lead-2*, respectively. Similarly, the August initial conditions (referred to as *Lead-1* in this study) indicate that forecasts were initialized in August; therefore, the forecasts for September, October, and November correspond to *Lead-1*, *Lead-2*, and *Lead-3*, respectively. With this definition, the initial conditions have a relatively limited influence on the model outputs across the different analyses, especially when compared to the dominant predictive role of oceanic conditions. Regarding the official release date of the forecasts (the 6th of each month), we agree with the reviewer. However, our focus is on the hindcast initial conditions, which are set on the 1st day of each month in the SEAS5.1 system. Therefore, our analysis is based strictly on these hindcast initialisation dates.

Referee:

4. *Section 4, on the large-scale drives, currently reads as if it were a standalone study. Integrating it a bit with the preceding discussion would improve the cohesiveness of the manuscript. How do the* *differences between model and observations on the physical mechanisms relate to the forecast skill and the ability to reproduce observed precipitation patterns in SW and WY?*

Authors: We thank the reviewer for this important comment. The changes have been made in the manuscript.

"Previous studies highlighted the fact that spatial pattern of extreme rainfall over EA is strongly influenced by SST anomalies in the surrounding ocean basins (Palmer et al., 2023; Roy et al., 2024; Nana et al., 2023,2025). Examining the associated SST composites therefore provides essential insight into the drivers of these rainfall extremes, and highlights the importance of accurately representing oceanic conditions in seasonal prediction models (Nana et al., 2024).“

Referee:

5. *Regarding the statistical significance of the results: the authors should be aware of the correction of p-values due to multiple testing. Each time an hypothesis test is carried out, there is a small albeit non-negligible probability of erroneously rejecting the null hypothesis. If just one test is carried out, this is not an issue. However, an enormous amount of tests are carried out when evaluating significance over a latitude-longitude grid, and consequently a number of erroneous rejections will arise and statistical significance is often overstated. Please see Wilks (2016) for a description of the problem and how to take into account test multiplicity.*

The authors should either:

- *Take into account the multiple testing problem and correct the p-values in order to limit the false discovery rate.*
- *Keep the evaluation of statistical significance as-is in the current manuscript, but acknowledge in the Methods section that the correction of p-values due to multiple testing was not addressed. Figure captions should be adjusted as well, e.g. "the stippling occurs where X is locally significant at the 95% confidence level through a Student's t test" (i.e. emphasise that significance was evaluated just locally). The discussion should accordingly reduce the emphasis placed on significant results.*

Wilks (2016): https://doi.org/10.1175/BAMS-D-15-00267.1

Authors: We thank the reviewer for this important comment. The changes have been made in the manuscript. Please see the last sentences of section 2.2 and figure captions.

"A 5% significance level was applied throughout, with results considered locally statistically significant if $p < 0.05$. It is important to note that the correction of p-values due to multiple testing was not addressed, in accordance with Wilks, (2016).**"**

Specific comments

Referee:

1. Regarding Figure 1:

- *It is confusing to use different plot types for model lead-0 and lead-1 in Fig. 1a. Please use the same plot type for model data in order to allow a clearer model-observations comparisson.*
- *In Fig. 1a, the difference with model lead-1 is striking. In fact, I retrieved the SEAS5 data from CDS and tried to reproduce the same plot and found no lag between model lead-1 and model lead-0. There might have been an issue when selecting the lead time or plotting lead-1 data. Please check this.*
- *The authors indicate in the Methodology section that SEAS5 data from the August and September initialisations are used. However, in Fig. 1, model data throughout the year are represented. I suppose that more initialisations apart from August and September were used, but this is not specified in the manuscript. Finally, in Fig. 1c and 1d, how is the total annual precipitation computed? Is it from model or observations? Please clarify in the text.*

Authors:

- **We thank the reviewer for this comment. The suggestion has been taken into account, and the figure has been revised accordingly.**
- **The data were re-downloaded, the codes were carefully re-checked, and all calculations were repeated; however, the same results were obtained. These results are consistent with previous studies showing that the ECMWF model tends to overestimate JJA rainfall over Central Africa at Lead-0, as well as JJAS and OND rainfall over East Africa at Lead-0 and Lead-1. It should be noted that, as described in Sect. 2.1 of the manuscript, the analysis combines the first 25 ensemble members for the period 2017–2023 (and not 51 members) with the 25 members from the 1981–2016 period. Furthermore, as stated above, Lead-0 corresponds to September initialisation (i.e., Lead-0 for September, Lead-1 for October, and Lead-2 for November), whereas Lead-1 corresponds to August initialisation (i.e., Lead-1 for September, Lead-2 for October, and Lead-3 for November). This distinction explains and confirms the differences between the results obtained at Lead-0 and those at Lead-1.**
- **We thank the reviewer for highlighting this point, which was insufficiently explained in the original manuscript. Here, the term *initialisation* refers specifically to the SON seasonal forecasts. For monthly data, lead times correspond to those indicated on the data download platform. For example, for January 1981, the initialisations correspond to January 1981 and December 1980 for Lead-0 and Lead-1, respectively; for February 1981, they correspond to February 1981 and January 1981; and for December 2024, to December 2024 and November 2024 for Lead-0 and Lead-1, respectively. The method used to extract lead times is consistent with that adopted by Ehsan et al. (2021). However, for SON, Lead-0 (Lead-1) corresponds to a September (August) initialisation, as explained above. The manuscript has been revised accordingly (see Sects. 2.1 and 3.1). In addition, total annual rainfall was computed from observations in Fig. 1b and from the model at Lead-0 (Lead-1) in Fig. 1c (Fig. 1d). To improve clarity and readability, the text has been revised to provide a more detailed description of the methodology used to extract the different variables at each lead time.**

"This means that the forecasts initialized in September correspond to Lead-1 and Lead-2 for October and November, respectively. Similarly, the August initial conditions indicate that forecasts were initialized in August; therefore, the forecasts for September, October, and November correspond to Lead-1, Lead-2, and Lead-3, respectively. The method used to extract lead times is consistent with that adopted by Ehsan et al. (2021). With this definition, the initial conditions have a relatively limited influence on the model outputs across the different analyses, especially when compared to the dominant predictive role of oceanic conditions."

Ehsan, M. A., Tippett, M. K., Robertson, A. W., Almazroui, M., Ismail, M., Dinku, T., Acharya, N., Siebert, A., Ahmed, J. S., & Teshome, A. (2021). Seasonal predictability of Ethiopian Kiremt rainfall and forecast skill of ECMWF's SEAS5 model. *Climate Dynamics*, *57*(11–12), 3075–3091. https://doi.org/10.1007/s00382-021-05855-0

Referee:

2. In the discussion of Fig. 6, the authors state "The SEAS5.1 captures these relationships reasonably well at both L0 and L1, but overestimated the correlations, ...". I do not agree with this statement since it cannot be derived from the data shown in Fig. 6. When the ensemble mean is computed, part of the high-frequency internal variability is filtered out and the part of the signal that remains is mainly associated with the lower frequency forcing and boundary conditions, in this case mainly from oceanic sources of predictability (IOD and ENSO). Conversely, this filtering is not present in the observations, and thus care should be taken when discussing the differences between model and observation. Hence, the fact that correlations with SST indices are higher in SEAS5 compared to observations may well be an artefact arising from using ensemble mean data. In order to assess whether there is a true overestimation of the correlation in SEAS5 related to some model deficiency or bias, the authors could compute correlations for the individual ensemble members. Comparing the observed correlation value with the distribution of correlation values from the individual ensemble members provides a robust framework to assess whether there is a systematic overestimation in the model.

Authors: We thank the reviewer for drawing our attention to this point. We agree with the reviewer regarding the influence of ensemble averaging on the distribution of values. In this study, all analyses were first performed separately for each of the 25 ensemble members before deriving the ensemble mean, as described in the Methods section. Specifically, the ensemble mean was computed only after applying all diagnostics including correlation and regression analyses, rainfall indices, composite anomalies, moisture flux, and moisture flux divergence to each individual ensemble member, following the approach of Abid et al. (2023). The results presented in this study therefore address the reviewer's concern. For clarity, additional explanations have been included in the revised manuscript; please refer to the Methods section.

"All analyses were performed separately for each of the 25 ensemble members. The ensemble mean was then computed from the 25 members after applying all diagnostics to each individual member, including correlation and regression analyses, rainfall indices, composite anomalies, moisture flux, and moisture flux divergence, following the methodology of Abid et al. (2023).**"**

Abid, M. A., Kucharski, F., Molteni, F., & Almazroui, M. (2022). *Predictability of Indian Ocean Precipitation and its North Atlantic teleconnections during early Winter*. Springer Science and Business Media LLC. https://doi.org/10.21203/rs.3.rs-1730304/v1

Referee:

3. In the Methods section, it is explained that ERA5 data are used for the evaluation of the physical mechanisms. However, ERA5 precipitation data are represented in Fig. 8 and Fig. 9 and there is no mention of or discussion about ERA5 precipitation in these figures. Could you indicate what is the purpose of using ERA5 precipitation? If it is for validation with the CHIRPS database, there should be at least some sentence about it in the discussion.

Authors: We thank the reviewer for drawing our attention to this point. Indeed, ERA5 reanalysis precipitation was included in these figures in order to validate ERA5 against the CHIRPS reference dataset. The text has been revised accordingly to explicitly state this.

"The precipitation from the ERA5 reanalysis has been included in these figures in order to validate ERA5 with the CHIRPS reference.**"**

Referee:

4. In case that this study differs from the previous literature in that it uses version 5.1 of SEAS5, I think it would be convenient to briefly explain the main differences between version 5.1 and the previous version when the model is presented in the Data and Methods section.

Authors: We thank the reviewer for drawing our attention to this point. This has been added to the revised manuscript, in the Data and Methods section.

"From November 2022 onwards, the updated version SEAS5.1 is used, which differs from the original SEAS5 mainly by the adoption of a new interpolation tool and a revised 1° grid with half-degree–centered latitude/longitude points, ensuring consistency with other Copernicus Climate Change Service seasonal forecast systems. SEAS5.1 also provides an extended set of variables, including top solar incoming radiation, additional fields at the 1000 hPa pressure level, and separate surface and sub-surface runoff components. The underlying model physics remains unchanged between the two versions."

__Referee__:
5. The analysis of composites of extreme events begins rather abruptly, moving immediately into the discussion of Figs. 7 and 8. Instead, it would be convenient to add a paragraph that serves as a link between the preceding discussion and the subsequent analysis of extreme events. This paragraph would be also useful to emphasise the motivation for the study of extreme rainfall events, which is not stated in the current manuscript. What are the main objectives of the analysis of extreme events?
__Authors:__ We thank the reviewer for drawing our attention to this point. An explanatory paragraph has been added to the revised manuscript, both in the paragraph preceding Section 4 and in the final paragraph of the Introduction.
"Following the assessment of SEAS5.1 in simulating rainfall characteristics and their associated teleconnections with SST, the analysis is extended to a composite-based approach. This complementary framework allows a more detailed examination of the large-scale atmospheric and oceanic patterns associated with extreme rainfall events over EA. In particular, composites of precipitation, SST, and low-level wind fields are used to characterize the dominant circulation features and moisture transport pathways linked to these extremes. This approach provides additional physical insight into the mechanisms driving extreme rainfall beyond the skill-based evaluation of the model.

Extreme rainfall events are among the most impactful climate hazards over EA, often leading to severe flooding, infrastructure damage, and socio-economic losses, yet their predictability at seasonal timescales remains limited. Understanding whether a state-of-the-art seasonal forecast system can realistically represent the large-scale drivers of these extremes is therefore essential."

__Referee__:
6. Figs. 6 and 8 seem to suggest an asymmetry in the teleconnections to EA rainfall. For instance, in Fig. 6 it appears that if only SST < 0 values are considered, the correlations with ENSO are not significant, while for SST > 0 the positive correlations become more apparent. Fig. 8 appears to confirm this, in the sense that the weak rainfall years composite is not the exact opposite pattern to the strong one. In fact, SST anomalies over the ENSO region and Indian Ocean are weak and generally not statistically significant in the weak rainfall years composite. However, it is not until the discussion of Fig. 11 that these differences in the magnitude of the anomalies are mentioned. I think the apparent asymmetry should be discussed earlier.
__Authors:__ We thank the reviewer for drawing our attention to this point. Sentences addressing the asymmetry have been added to discuss the precipitation and SST anomaly results. Please refer to the last paragraph of Section 4 in the revised manuscript.
"The observed SST anomalies, as well as rainfall anomalies (Fig. 8) stronger during SY than during WY, are well simulated by the model at these two Lead-time."

__Referee__:
7. Lines 545-547: I do not agree that the patterns are "strong opposite" looking at Fig. 10. This is in fact the lack of symmetry in the teleconnection I was mentioning in my previous comment.
__Authors:__ We thank the reviewer for drawing our attention to this point. We agree with the reviewer regarding the asymmetry observed in Figs. 8 and 10, as mentioned previously. The text has been revised and adjusted accordingly; please see the first sentence of Section 5.

“Previously, observed and reanalysis, as well as predicted composite SST anomalies over the Atlantic, Indian, and Pacific oceans showed a strong and significant composite anomalies pattern during both strong and weak years (but more pronounced during SY than WY), which shows that EA rainfall has diverse dynamical linkages from these oceanic regions.”

Referee:
8. The results from the study by Tefera et al. (2025) can also be cited in lines 412 and 436.
Authors: We thank the reviewer for drawing our attention to this point. The study by Tefera et al. (2025) has been added to the manuscript.

Referee:
9. Line 118. I could not find in the references the study by Tanessong et al. (2025). Do you mean Tanessong et al. (2024)? The SEAS5 model is not used there.
Authors: We thank the reviewer for drawing our attention to this point. The study by Tanessong et al. (2025) is not included because it is still under review; we had initially expected it to be published earlier. The Introduction has therefore been revised, and this reference has been removed.

Referee:
10. I suggest that Fig. 9 is moved to Supplementary material, as its discussion is very short and it serves as a confirmation of the previous findings.
Authors: We thank the reviewer for drawing our attention to this point. Figure 9 has been moved to the Supplementary Material, as this result is not central to the main conclusions of our study.

Referee:
11. Line 204: Could you indicate what interpolation technique was used?
Authors: We thank the reviewer for drawing our attention to this point. To bring all data to the model grid, linear interpolation was applied. The text has been revised accordingly; please see the last sentence of Section 2.1.
“For consistency in comparison, both observed and reanalysis datasets are regridded to a 1° × 1° horizontal resolution based on linear interpolation and to seven pressure levels (1000, 925, 850, 700, 500, 400, and 300 hPa).”

Referee:
12. Although it is stated later on in the manuscript, please indicate in the Methods section that the N34 and DMI indices used are standardised indices.
Authors: The Niño-3.4 and DMI indices have already been defined in the Methods section, along with a description of how they were calculated.
“This analysis uses two SST indices: the Niño 3.4 index (N34) and the Dipole Mode Index (DMI). The N34 index, used as a proxy for the ENSO, is defined as the area-averaged SST anomaly over the region 5° S–5° N, 170°–120° W (Trenberth, 1997). The DMI (Saji et al., 1999), which represents the IOD, is calculated as the difference between the area-averaged SST anomalies in the western Indian Ocean (WIO; 10° S–10° N, 50°–70° E) and the eastern Indian Ocean (EIO; 10°S-0° N, 90°–110° E).“

Referee:
13. Line 593: I think that you mean the western part of EA, not eastern.
Authors: We thank the reviewer for drawing our attention to this point. This refers to the western part of EA, not the eastern part of EA.

Referee:
14. Line 895: This reference follows a different format compared to the rest. Please ensure consistency.

Authors: **We thank the reviewer for drawing our attention to this point. We have inserted the updated version; please refer to the "References" section of the revised manuscript.**
"Nana, H. N., Gudoshava, M., Tanessong, R. S., Tamoffo, A. T., and Vondou, D. A.: Diverse causes of extreme rainfall in November 2023 over Equatorial Africa, Weather Clim. Dynam., 6, 741–756, https://doi.org/10.5194/wcd-6-741-2025, 2025.**"**

Referee:
15. The subpanels of Fig. 6 (a, b and c) are not labeled.
Authors: **We thank the reviewer for drawing our attention to this point. The figure has been redrawn and the labels (a, b, and c) have been added.**

Referee:
16. Colourbar units are missing in Figs. 4 and 5.
Authors: **We thank the reviewer for drawing our attention to this point. The figures have been redrawn, and the units have been added.**
"mm day^{-1} °C^{-1}"

Minor language, formatting and/or consistency corrections
Referee:
1. Line 104: Replace "equatorial Africa" with EA (abbreviation already defined). Check throughout the manuscript.
Authors: **We thank the reviewer for drawing our attention to this point. The manuscript has been carefully reviewed again, and the suggested modifications have been implemented.**

Referee:
2. The current manuscript mixes British spelling (e.g. "organised" in Line 164, "standardised" in Lines 468 and 479) and American spelling (e.g. "normalizing" in Line 270, "characterized" in Line 629). Please check throughout the manuscript and ensure consistency.
Authors: **We thank the reviewer for drawing our attention to this point. The manuscript has been thoroughly reviewed again, and the necessary modifications have been made.**

Referee:
3. Line 328: "...strength of SEAS5.1 to simulated SON rainfall..." does not sound correct. Please clarify this sentence.
Authors: **We thank the reviewer for drawing our attention to this point. The sentence has been revised.**

Referee:
4. Lines 371-372: "... internal variance is dominated by the external variance". This statement may be misleading, as if the external variance was part of the internal variance. I suggest replacing it with something like "... external variance outweighs the internal variance...".
Authors: **We thank the reviewer for drawing our attention to this point. Done**

Referee:
5. Line 455: "... ENSO has an indirect effect through IOD conditions, ..." (add "effect").
Authors: **We thank the reviewer for drawing our attention to this point. "effect" has been added.**

Referee:
6. Line 469: Typo: "periode" is "period". Please check throughout the manuscript as this typo appeared several times.
Authors: **We thank the reviewer for drawing our attention to this point. The manuscript has been thoroughly reviewed again, and the necessary modifications have been made.**

Referee:
7. Lines 472-473: The sentence starting with "The criteria..." is grammatically incorrect. Please revise it.
Authors: We thank the reviewer for drawing our attention to this point. The sentence has been revised.

Referee:
8. Line 484: please correct "years capture" to "years captured" (add the d).
Authors: We thank the reviewer for drawing our attention to this point, "d" has been added.

Referee:
9. Line 489: replace "weak column" with "second column".
Authors: We thank the reviewer for drawing our attention to this point. This was an error, and the suggested correction has been applied.

Referee:
10. Line 546: a comma is missing between "Atlantic" and "Indian".
Authors: We thank the reviewer for drawing our attention to this point. Done

Referee:
11. Line 584: I suggest replacing "positive and negative" with "strong and weak".
Authors: We thank the reviewer for drawing our attention to this point. Done

Referee:
12. Line 590: replace "underestimate" with "underestimation"
Authors: We thank the reviewer for drawing our attention to this point. Done

Referee:
13. Line 620: this phrase reads better if re-structured "... over which the AEJ components (black dashed contours) at 15° E, and specific humidity (red contours) calculated between 10°E and 30°, are overlaid".
Authors: We thank the reviewer for drawing our attention to this point. Done