Response to Reviewers

We would like to thank the editor and reviewers for their time taken to review and improve our manuscript. Please see below for line-by-line response to the comments.

Reviewer #1

This manuscript investigates the mechanisms controlling the transition into the equatorial Congo Basin's biannual rainy seasons. It leverages satellite observations, water vapor isotopic data, and reanalysis to diagnose how moisture transport and atmospheric instability evolve in the weeks leading up to rainy season onsets. The topic is scientifically important and timely, as the processes initiating rainy seasons in this region have been poorly understood. The analysis is comprehensive and yields interesting results, notably that increased low-level Atlantic inflow and mid-tropospheric moistening appear to trigger the onset of deep convection in both spring and fall. Overall, this study provides important analyses, but several issues should be addressed to strengthen the manuscript.

Specific comments:

Comment: While the study is thorough, some findings (e.g., the importance of Atlantic moisture influx and mid-level moisture convergence for convective onset) are not entirely surprising in light of prior studies. For example, it was already recognized that near-surface divergence and mid-tropospheric moisture convergence play a role in equatorial rainfall (Nicholson 2018; Pokam et al., 2014). The manuscript would benefit from a discussion to demonstrate the unique contribution.

Nicholson, S. E. (2018). The ITCZ and the seasonal cycle over equatorial Africa. Bulletin of the American Meteorological Society, 99(2), 337-348.

Pokam, W. M., Bain, C. L., Chadwick, R. S., Graham, R., Sonwa, D. J., & Kamga, F. M. (2014). Identification of processes driving low-level westerlies in west equatorial Africa. Journal of Climate, 27(11), 4245-4262.

Response: Thank you for this helpful discussion. We agree that near-surface divergence and mid-tropospheric moisture convergence play a role in equatorial rainfall and have already been established; this is discussed in our text in Lines 36-38:

Lines 40-41: "*Instead, near-surface moisture diverges away from the equatorial Congo basin, while mid-tropospheric moisture convergence appears to be central for rainfall formation (Nicholson, 2022).*"

However, most studies focus on the mechanisms controlling rainfall during representative months of the dry or rainy seasons, and in addition, the mechanisms tend to be discussed in separate papers, which are cited throughout the introduction. The strength of this manuscript is that it puts together a holistic analysis of the mechanisms that control the rainy season onset, which has not specifically been discussed before. We have clarified this in the introduction in lines 26-32:

Lines 27-35: *"Most studies examining process controls on seasonal rainfall have focused on specific months during the dry or rainy seasons (Nicholson, 2018; 2022; Cook and Vizy, 2022; Pokam Mba et al., 2022). As such, the processes that control the transition to the rainy season onsets are virtually unknown. To fundamentally understand observed rainfall variability (Jiang et al., 2019; Zhou et al., 2014; Hua et al., 2016; 2018) within the equatorial region (defined as the area between 2°S-2°N, within the Congo Basin watershed), which experiences two rainy seasons, in boreal spring and fall, respectively (Fig. 1; Pokam Mba et al., 2022; Nicholson, 2022), necessitates a full understanding of the mechanisms controlling its seasonal rainfall. In addition, understanding the mechanisms controlling the transition periods to the rainy seasons can aid identification of errors in climate models for seasonal rainy season onset forecasting, which is important climate information for agricultural production (Zampieri et al., 2023; Tchinda et al., 2022)."*

Zampieri, M., Toreti, A., Meroni, M., Bojovic, D., Octenjak, S., Marcos-Matamoros, R., ... & Hoteit, I. (2023). Seasonal forecasts of the rainy season onset over Africa: Preliminary results from the FOCUS-Africa project. *Climate Services*, *32*, 100417. https://doi.org/10.1016/j.cliser.2023.100417

Tchinda, A. F., Tanessong, R. S., Mamadou, O., & Orou, J. B. C. (2022). Assessing precipitation seasonal forecasts in Central Africa using North American Multimodel Ensemble (NMME) Assessing precipitation seasonal forecasts in Central Africa using North American Multimodel Ensemble (NMME). *Theoretical and Applied Climatology*, *147*(3), 1309-1325. https://doi.org/10.1007/s00704-021-03915-3

Comment: The study's reliance on reanalysis and satellite datasets may raise concerns about data uncertainty. The equatorial Congo is data-sparse, and different reanalyses can diverge in their depiction of rainfall and moisture transport. The authors may acknowledge the uncertainties inherent in their data and methods, such as how sensitive are the moisture convergence patterns to the choice of reanalysis or to errors in satellite precipitation?

Response: We acknowledge the uncertainty in the datasets chosen to analyze the rainy season transition periods, and have added a discussion and supplementary figure to this similar to that found in Worden and Fu (2025):

Lines 81-87: "*Reanalysis datasets differ in terms of magnitude of seasonal rainfall and atmospheric circulation characteristics but generally agree on major features and seasonal evolution over Central Africa (Hua et al. 2019; Kenfack et al. 2023; Nicholson & Klotter 2021). The European Centre for Medium-Range Weather Forecasts 5th generation reanalysis, ERA (Hersbach et al. 2020) is commonly adopted as a primary reanalysis for Congo Basin studies (Cook & Vizy 2022; Kenfack et al. 2024; Longandjo & Rouault 2020) and other African regions (Cook & Vizy 2022; Vizy & Cook 2019). Its relatively high resolution helps capture topographic structure relevant to regional climate (Vizy & Cook 2019), and its precipitation is broadly consistent with recommended observational products for the basin (Nicholson et al. 2019; Cook & Vizy 2022)."*

Comment: The manuscript examines many interacting processes, such as Atlantic inflow, the Congo Basin Cell, shifting heat lows, the Congo Air Boundary, AEJ-N/S jets, orographic uplift, etc. Is it possible to clearly distinguish the primary drivers of the rainy season onset from secondary or contextual factors? For instance, if low-level westerly inflow and subsequent mid-level moistening are the essential triggers, those should be highlighted as the key results.

Response: Thank you for this suggestion. This is also in line with a suggestion from Reviewer #2. We have created multiple linear regression models for the transition to the spring and fall rainy seasons to identify the key driving factors, as well as a table explaining their changes, based on the suggestion of the second reviewer. Please see below for the table, and please see the response to Reviewer #2 on pages 13-16 for a more detailed explanation.

Spring Early Transition Phase	**Spring Late Transition Phase**
$P_{sprRSO} = 0.45MF_{mid-level} - 0.27CIN + 0.16MF_{low-level} + 0.014Shear - 0.005MSE_{low-level} - 0.002CAPE + 3.51$ $R^2 = 0.58$	
$MF_{low-level}$ ($q.DIV$ averaged between 925-875 hPa): **Convergence decreasing.** Moisture transport from Atlantic Ocean, through equatorial Congo, towards West African Heat Low.	$MF_{low-level}$: **Convergence decreasing.** Moisture transport from Atlantic Ocean, through equatorial Congo, towards West African Heat Low.

$MF_{mid-level}$ ($q.DIV$ averaged between 850-600 hPa): **Convergence increasing.** Moisture transport from Indian Ocean, through equatorial Congo, towards Atlantic Ocean.	$MF_{mid-level}$: **Convergence increasing**. Zonal Moisture transport from Indian ocean, through equatorial Congo, towards Atlantic Ocean.
CIN: **Steady**	CIN: **Decreasing**
$CAPE$: **Increasing**	$CAPE$: **Increasing**
$MSE_{low-level}$(averaged between 925-875 hPa): **Increasing**	$MSE_{low-level}$: **Increasing**
$Shear$: **Steady**	$Shear$: **Increasing**, from return branch of Congo Basin Cell
$Precipitation$: **Steady**	$Precipitation$: **Increasing**
Fall Early Transition Phase	**Fall Late Transition Phase**
$P_{fallRSO} = 0.24MF_{mid-level} + 0.13MSE_{low-level} + 0.10CAPE + 0.09MF_{low-level} - 0.06CIN - 0.014Shear + 3.49$ $R^2 = 0.43$	
$MF_{low-level}$: **Convergence increasing.** Moisture transport switch from northeast direction to southeast direction: from Atlantic Ocean, through equatorial Congo, towards Congo Air Boundary	$MF_{low-level}$: **Convergence increasing.** Moisture transport from Atlantic Ocean, through equatorial Congo, towards Congo Air Boundary.
$MF_{mid-level}$: **Convergence increasing.** Moisture transport from Southern Congo and Indian Ocean, through equatorial Congo, towards Atlantic Ocean.	$MF_{mid-level}$: **Convergence increasing**. Moisture transport from Southern Congo and Indian ocean, through equatorial Congo, towards Atlantic Ocean.
CIN: **Decreasing**	CIN: **Decreasing**
$CAPE$: **Decreasing**	$CAPE$: **Increasing**
$MSE_{low-level}$: **Decreasing**	$MSE_{low-level}$: **Increasing**
$Shear$: **Steady**	$Shear$: **Steady**, from return branch of Congo Basin Cell
$Precipitation$: **Steady**	$Precpitation$: **Increasing**

Comment: A few terms and conceptual elements would benefit from clearer definition, such as the shallow meridional overturning cell. Providing these definitions up front would make the physical interpretation clearer and help readers follow the proposed mechanism.

Response: Thank you for this suggestion. We have added a section in the Methodology to provide these definitions as the following:

Lines 204-218:

"2.2.4 Key Dynamic Features

We examine the seasonal evolution of key dynamic features that transport moisture and energy within and around the Congo Basin. They are discussed further in several review papers: Nicholson, (2022); Pokam et al. (2026).

1) *Low Level Westerlies (LLWs): These winds transport moisture from the Atlantic Ocean into Central Africa, with varying seasonal intensity (Pokam et al., 2012; 2014; Vondou et al., 2010)*
2) *Congo Basin Cell: The LLWs are the lower branch of both shallow and deep zonal circulations found over the Congo Basin. The shallow zonal circulation is called the Congo Basin Cell, with ascent over the Congo Air Boundary (see below), return at mid-levels via an easterly jet, and subsidence over the Atlantic Ocean (Longandjo and Rouault 2020)*
3) *Shallow meridional overturning cell: Here, moisture moves meridionally from the Congo Basin to the Sahel heat low, with return leading to mid-tropospheric moisture convergence over the Congo Basin (Longandjo and Rouault 2024)*
4) *African Easterly Jet North and South (AEJ-N, AEJ-S): The AEJ-N is a year-round feature with seasonal meridional migration from 5°N-17°N, while the AEJ-S is present between September-November with its core at ~8°S (Nicholson and Grist 2003; Kuete et al., 2020)*
5) *Congo Air Boundary: An extreme gradient in temperature and specific humidity that denotes the southern limit of Congo Basin, present between August to November (Howard and Washington 2019)."*

Reviewer #2

Review of "On the Mechanisms that Control the Rainy Season Transition Periods in the Equatorial Congo Basin" by Worden and Fu. [MS No., egusphere-2025-4330]

This study presents a comprehensive investigation of the mechanisms that govern the onset of spring and fall rainy seasons in the equatorial Congo Basin, with a primary focus on the roles of local evapotranspiration and regional circulations, based on satellite and reanalysis data. The authors conduct a detailed analysis of how horizontal moisture transport (regional circulations), local factors (evapotranspiration and topography), and atmospheric dynamics (e.g., CAPE and wind shears) and thermodynamics (lower-tropospheric stability) evolve across before-, early-, and late-transition stages of the rainy seasons. Particular attention is given to variations in moisture sources by examining moisture transport across the different Congo Basin boundaries. The differences of onset mechanisms between two seasons (spring vs. fall) and between two regions (equatorial vs. southern Congo Basin) are also discussed.

The paper is overall well written and organized, very easy to follow. This study provides a useful process-based framework for understanding rainy season onset, and its outcomes may also help identify the precursors of rainy season onset in the Congo Basin, critical for rainy season prediction.

However, there are some limitations or necessary clarifications related to the definition of the rainy season onset and the interpretation of the physical mechanisms. If these limitations, along with the minor issues listed below, are addressed, I believe the manuscript would be very suitable for publication in ACP.

Major comments:

Comment: In Section 2.2, the authors define the onset and end of the rainy seasons, using criteria based on the number of pentads exceeding or falling below the climatological mean (i.e., X out of Y pentads). But both X and Y seem to differ between the onset and end definitions, as well as between spring and fall seasons. It would be helpful if the authors could clarify how these numbers were selected and whether the identified rainy season onset and end pentads are sensitive to the choice of these numbers.

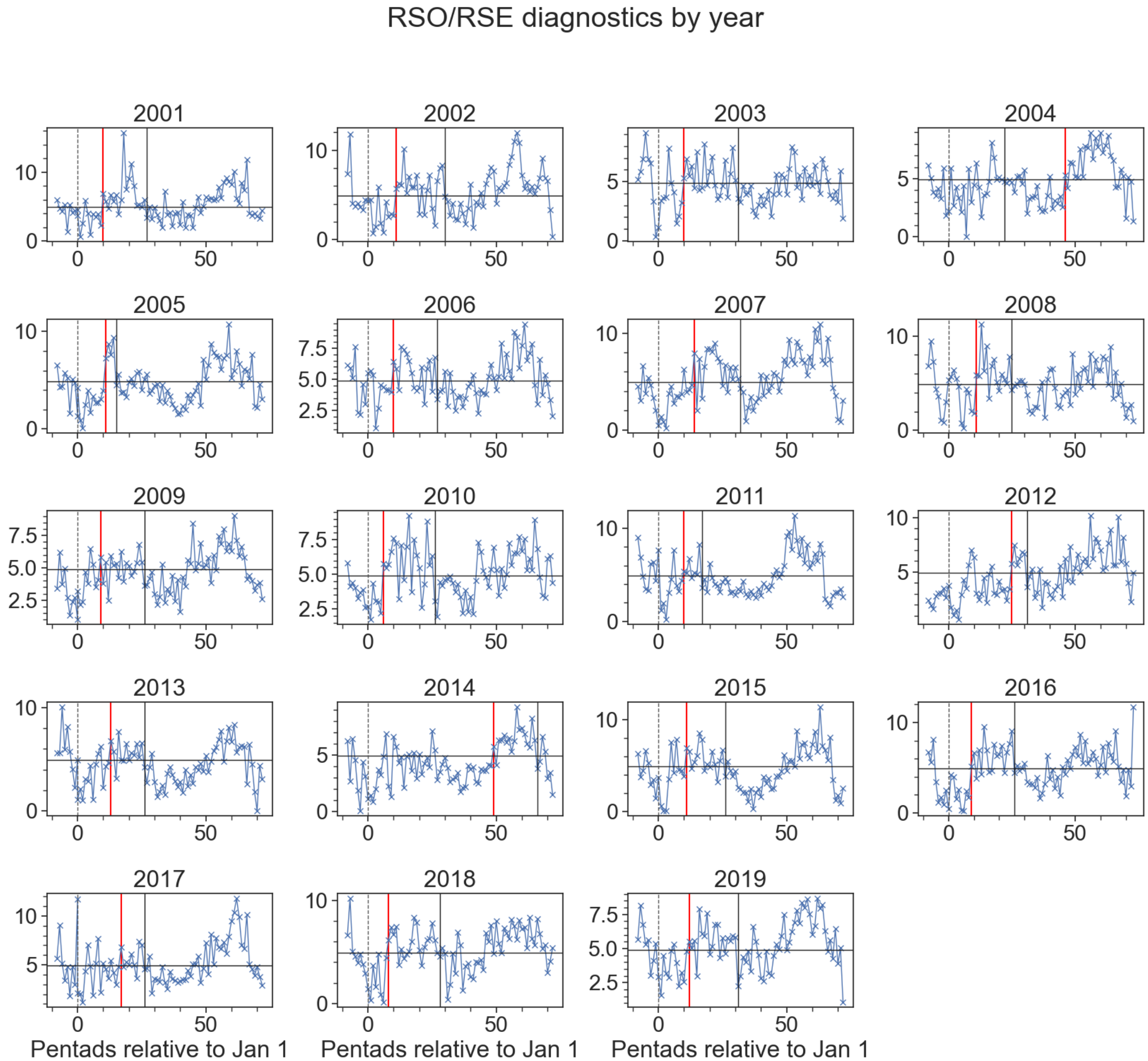
A related suggestion is to reorganize Figure 2. The authors may consider merging RSO and RSE in a single panel for each season, with year on the y-axis and pentad (also with months indicated) on the x-axis. Such a format would allow readers to more easily spot the start, end, and length of a spring/fall rainy season in each year. The authors can also easily test if this figure is sensitive to the different X and Y number choices.

Response: We appreciate this helpful comment and suggestion. When determining the number of pentads exceeding or falling below the climatological mean, we needed to account for the bimodal rainy season within the equator. Given shorter periods of time between the two rainy seasons, we needed to adjust the number of pentads within the moving window compared to the threshold determined for the Southern Congo rainy season onset as in Worden and Fu (2025). Furthermore, the spring rainy season is known to be weaker than the fall rainy season. Therefore, a shorter moving window and smaller number of pentads was chosen compared to the fall rainy season to be able to capture the RSO and RSO. We note that the different Y choices for the spring rainy season in the original manuscript was a typo; the threshold for the spring RSO and RSE was 4 out of 6 pentads for both.

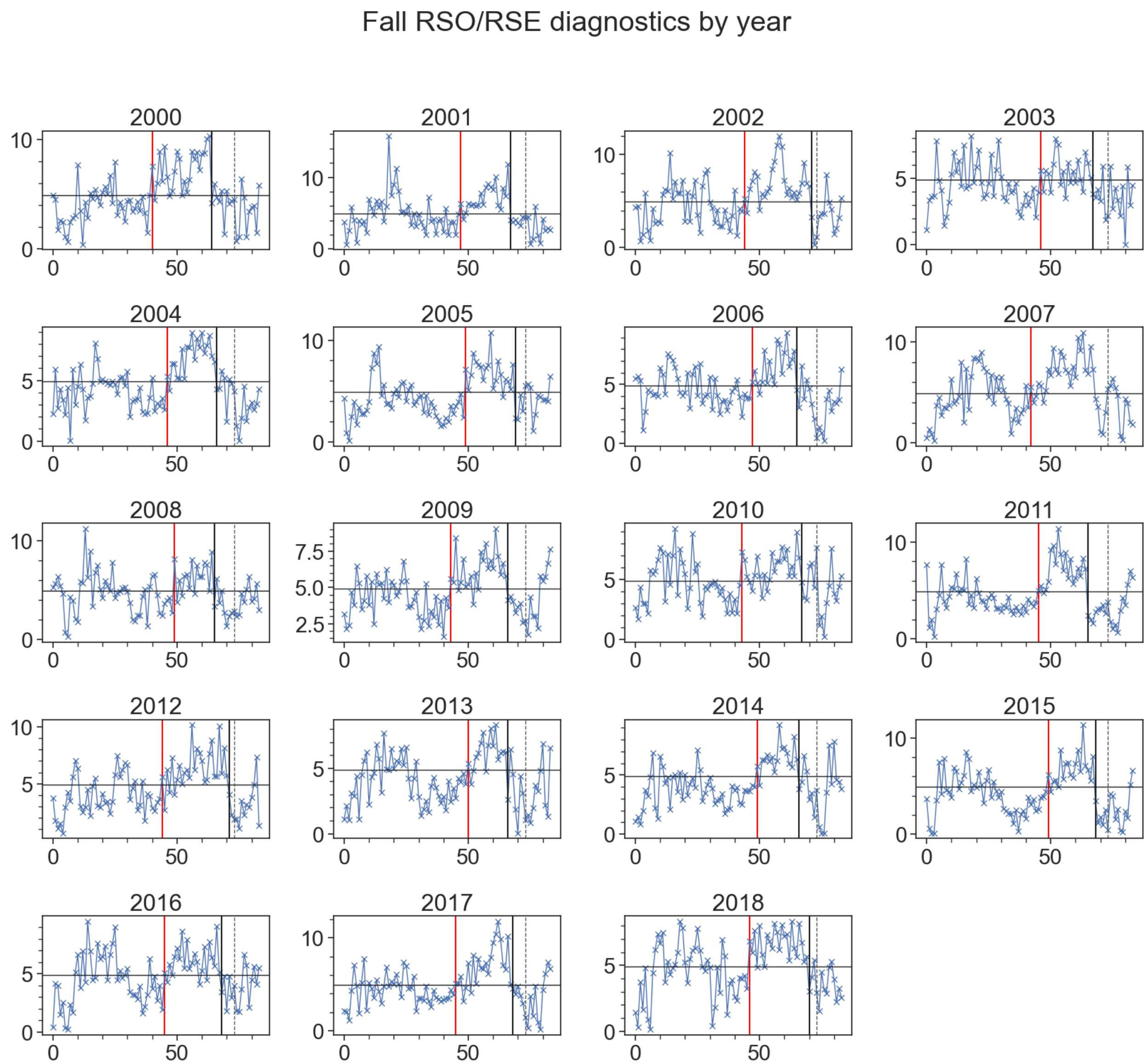
While the numbers chosen for both the number of pentads and the moving window length are somewhat arbitrary, we had visually examined the starting points for the RSO and RSE captured for each year to ensure they captured periods of high rainfall. Please see below for these figures. In addition, we experimented with changing both X and Y, with the results documented in the table below. The number of valid years is the years where both an RSO and RSE were identified, and the length of the rainy season was greater than 5 pentads. In addition, the spring RSO needed to begin before March 27th, and the spring RSE needed to be identified in between April 11-September 8. The average RSO and RSE dates reflect the average of the valid years. For the spring RSO, X=4 and Y=6 had the highest number of years and is more conservative (window of persistently high or low rainfall is shorter) than X=4 and Y=7. Therefore, we chose 4 out of 6 pentads for the spring RSO. For the fall RSO, we chose the most conservative (5 out of 8 pentads) that still identified all but one year. If we had chosen 4 out of 8 pentads, the RSO would change by one pentad. Therefore, we concluded that the sensitivity of the RSO and RSE in fall was low, and kept the original choice of combinations.

However, we have replaced Figure 2 with the formatting as suggested above. Please see the final figure in this section for the updated figure.

Spring			
	Average RSO Date	**Average RSE Date**	**Number of Valid Years**
3/6 pentads	2/10-2/14	5/11-5/15	9
4/6 pentads	**2/25-3/2**	**5/21-5/25**	**13**
5/6 pentads	2/5-2/9	5/21-5/25	3
3/7 pentads	2/10-2/15	5/06-5/10	8
4/7 pentads	2/20-2/25	5/11-5/15	11
5/7 pentads	2/25-3/2	5/21-5/25	8
Fall			
	Average RSO Date	**Average RSE Date**	**Number of Years**
4/7 pentads	8/19-8/23	12/2-12/6	19
5/7 pentads	8/19-8/23	12/2-12/6	15
6/7 pentads	8/24-8/28	12/7-12/11	7
4/8 pentads	8/14-8/18	12/2-12/6	19
5/8 pentads	**8/19-8/23**	**12/2-12/6**	**18**
6/8 pentads	8/24-8/28	12/2-12/6	14



Determination of the Spring RSO and RSO. Red line determines the RSO, and black line determines the RSE. The RSO is defined as the first pentad where rainfall is consistently above the mean after, and consistently below the mean prior. The RSE is defined as the first pentad where rainfall is consistently below the mean after, and consistently above the mean prior. Years where an RSO or RSE is not identified, or when the distance between the RSO or RSE is less than 5 pentads (25 days)



Determination of the Spring RSO and RSO. Red line determines the RSO, and black line determines the RSE. The RSO is defined as the first pentad where rainfall is consistently above the mean after, and consistently below the mean prior. The RSE is defined as the first pentad where rainfall is consistently below the mean after, and consistently above the mean prior. Years where an RSO or RSE is not identified, or when the distance between the RSO and RSE is less than 5 pentads (25 days)

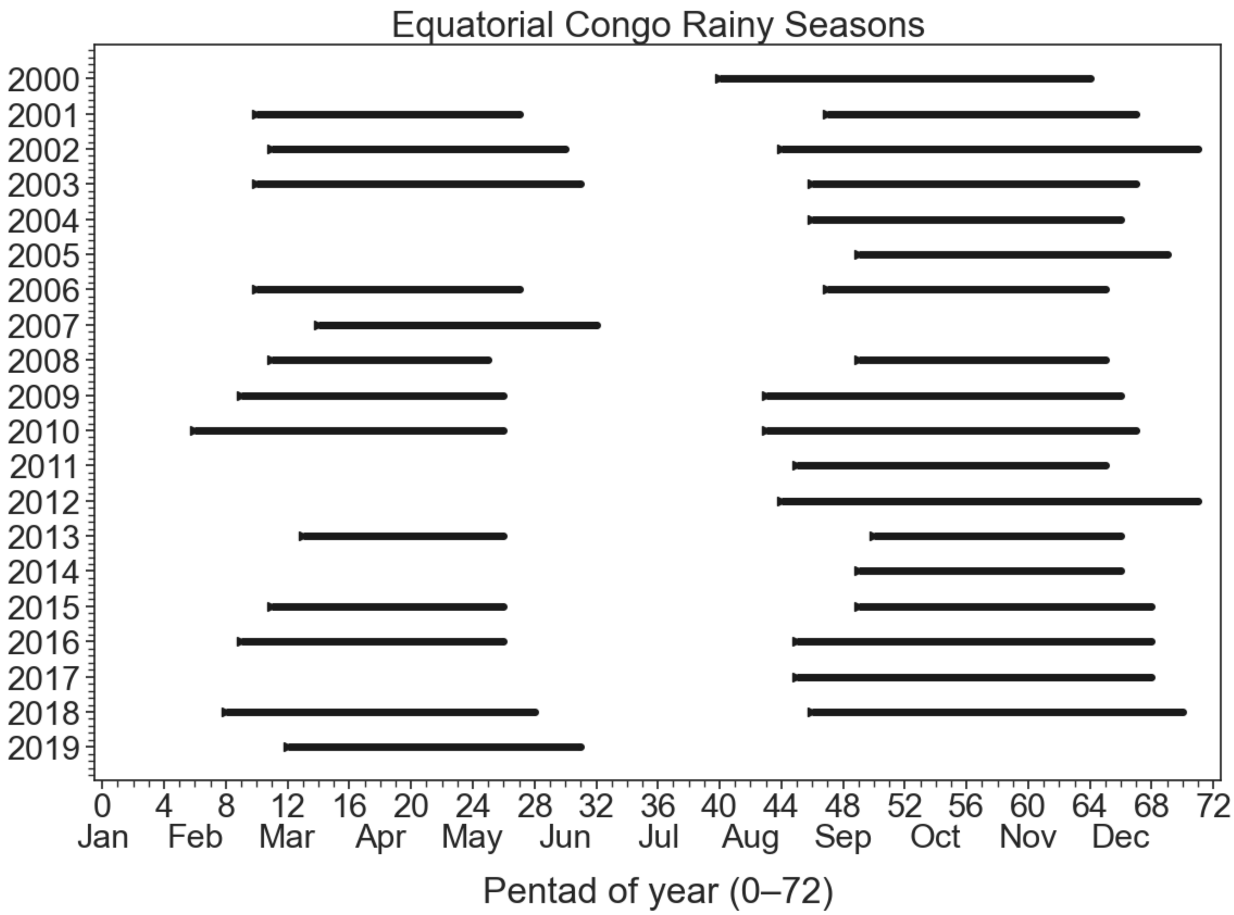


Figure 2: Rainy season onset (RSO) and rainy season end (RSE) for the spring and fall rainy seasons for each year in the equatorial Congo.

Comment: The moisture flux convergence ($\nabla \cdot$MF) can be decomposed into the moisture convergence term ($q\nabla V$) and the moisture advection term ($V\nabla q$). In Figure 4, the authors presented only the convergence term, without analyzing or discussing the advection component, which represents the effect of winds transporting moisture across humidity gradients. Please clarify why only the convergence term is shown or whether the advection term is negligible or secondary. A brief quantitative comparison would strengthen the interpretation of the moisture budget.

Response: Thank you for bringing this key point up. We originally did not include the advection term because Cook and Vizy (2022) show that the vertically-integrated convergence dominates over that of advection during selected months of the rainy and dry seasons. However, we double-checked that this is the case for the transition period and confirmed that convergence dominates. This is shown in four new Supplementary Figures. We can see that the advection does not change significantly across different pressure levels during the transition periods to the spring and fall rainy seasons. Please see below for the discussion added to the manuscript that clarifies this point, along with the new Supplementary Figures:

Lines 179-180: "*We do not examine the evolution of moisture advection term as it is small compared to that of the moisture convergence term (Cook and Vizy 2022; Figures S1-S4)."*

Spring Transition Period

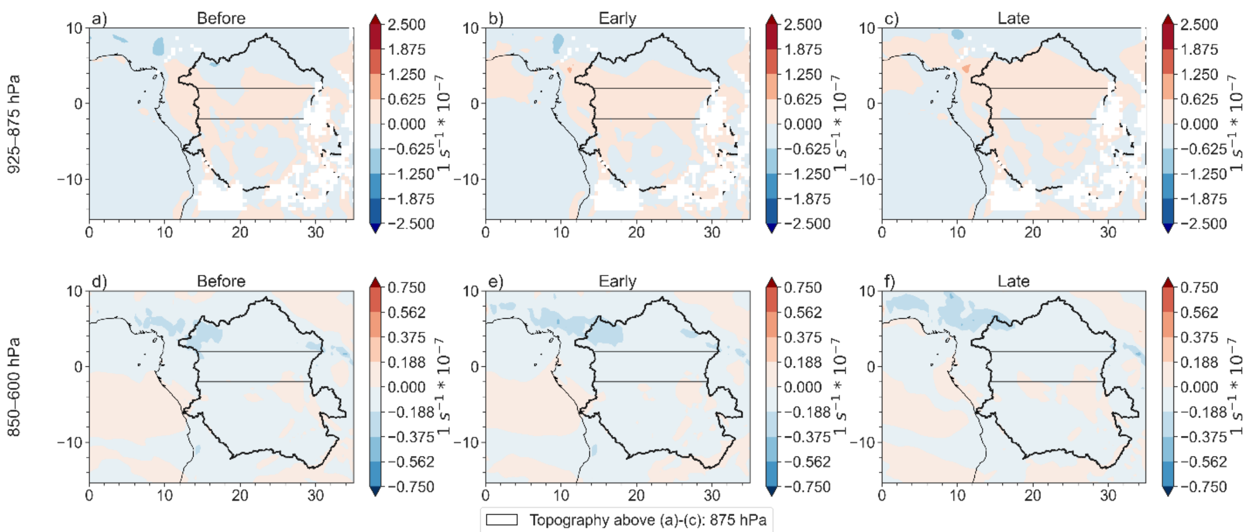


Figure S1: Moisture advection term ($v \times \nabla q$; blue) for (a)-(c) average of 925-875 hPa; (d)-f) average of 850-600 hPa.

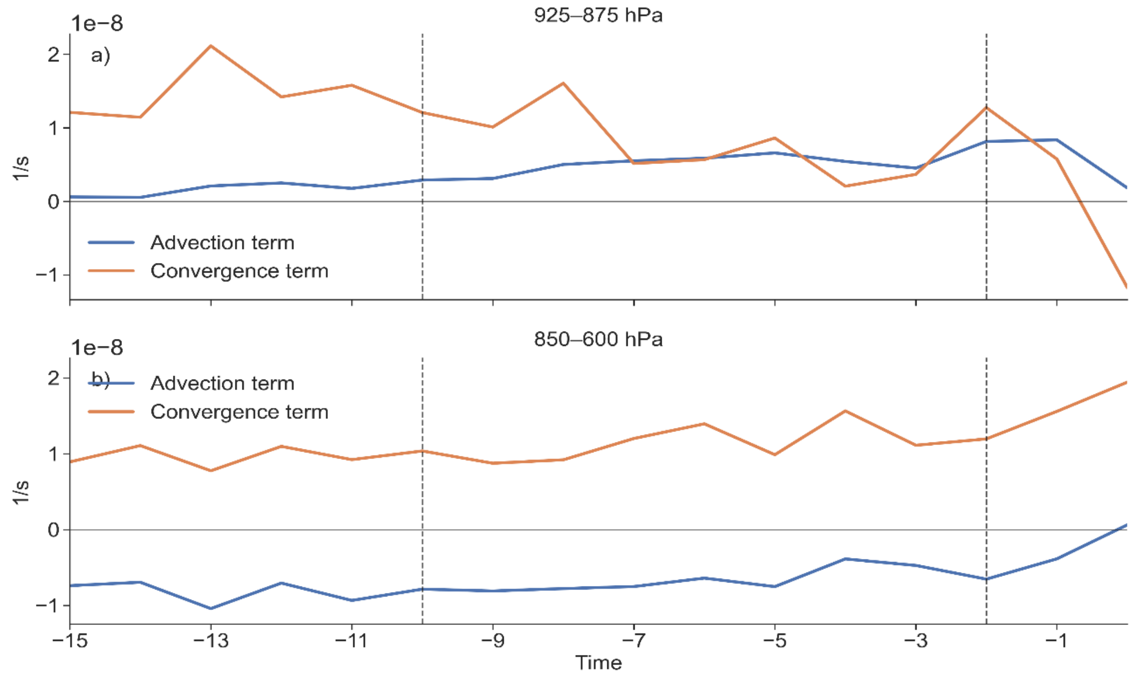


Figure S2: Moisture advection term ($v \times \nabla q$; blue) and moisture convergence term ($q \times \nabla v$; orange) for a) average of 925-875 hPa; and b) average of 850-600 hPa over the equatorial Congo.

Fall Transition Period:

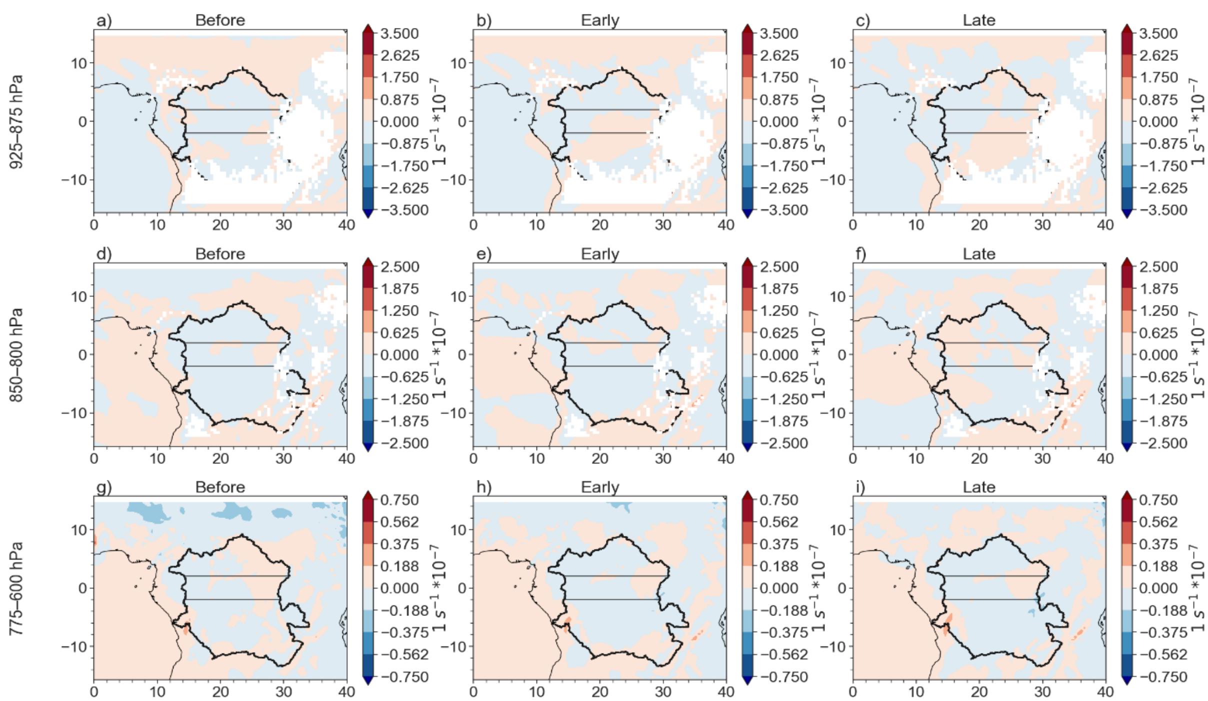


Figure S3: Moisture advection term ($v \times \nabla q$; blue) for (a)-(c) average of 925-875 hPa; (d)-f) average of 850-800 hPa; and (g)-i) average of 775-600 hPa.

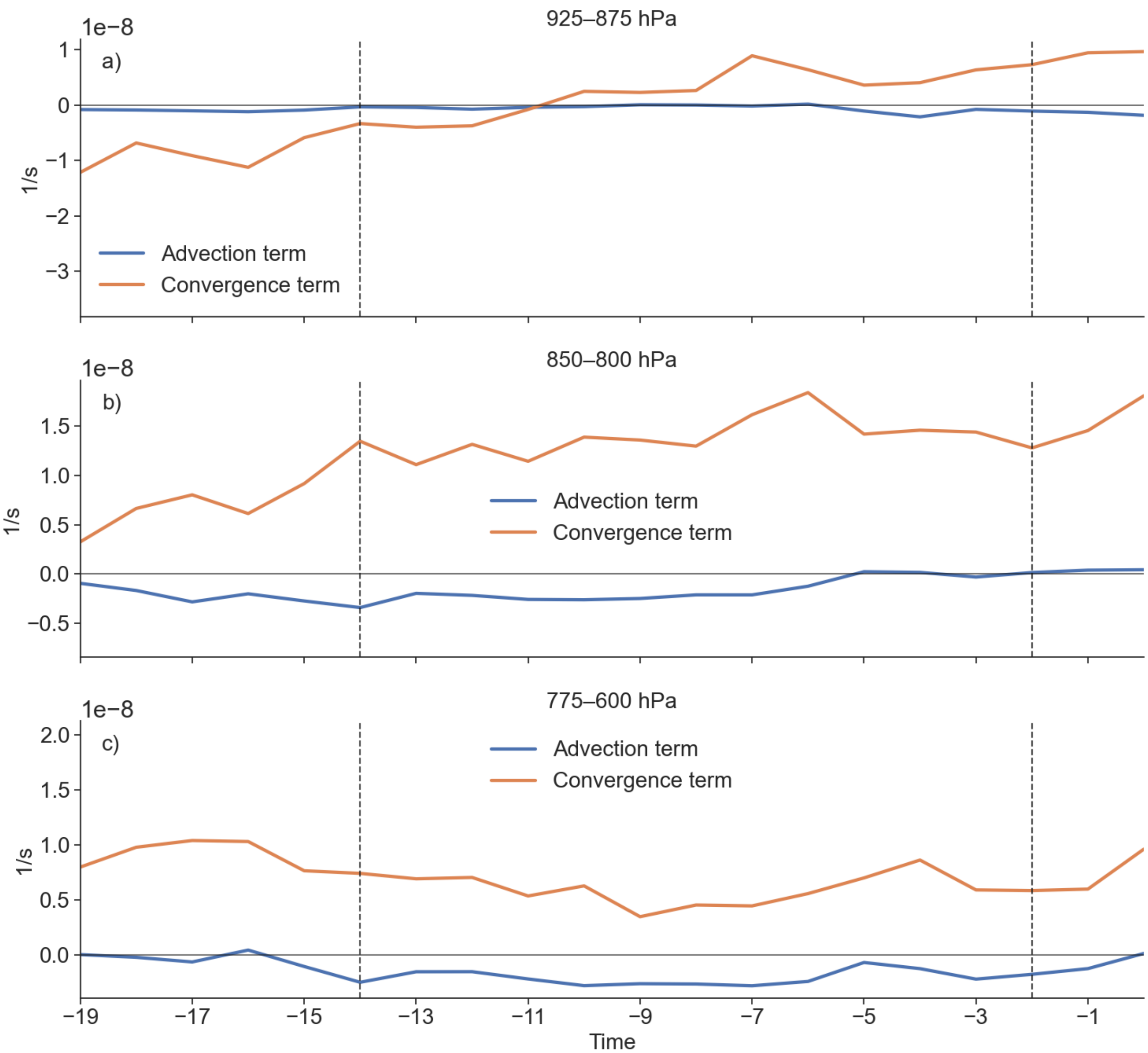


Figure S4: Moisture advection term ($v \times \nabla q$; blue) and moisture convergence term ($q \times \nabla v$; orange) for a) average of 925-875 hPa; and b) average of 850-800 hPa; and c) average of 775-600 hPa over the equatorial Congo.

Comment: It is great to see the authors have a thorough examination of the roles of multiple dynamic and thermodynamic processes in the onset of the rainy seasons. However, the relative importance of these difference process has not been quantitatively assessed. The authors may consider providing a quantitative estimate of their respective contributions. For example, a simple multilinear regression (MLR) framework could be used to relate rainfall rate changes to variations in the key physical processes across the transition period, and the explained variance associated with each process could indicate the contribution.

Response: Thank you for this suggestion. We have created a simple multilinear regression framework to relate rainfall rate changes to variations in the key physical processes across the transition period. In particular, we did the following:

We used daily instead of pentad data to increase the amount of data available for the MLR model. Then, we chose the average number of days in between the rainy season start and previous dry season end for both the spring and fall rainy season. For the spring rainy season, this was 75 days. For the fall rainy season, this was 95 days. We used ridge regression and standardized the features by removing the mean and scaling to unit variance. We used the following features:

- $MF_{mid-level}$: specific humidity times the divergence multiplied by negative one to represent moisture convergence ($-q * DIV$), averaged over 850-600 hPa for the spring RSO transition period and over

-$MF_{low-level}$: specific humidity times the divergence multiplied by negative one to represent moisture convergence ($-q * DIV$), averaged over 925-875 hPa for the spring RSO transition period and over

-$MSE_{low-level}$: Moist static energy (MSE) averaged between 925-875 hPa

-CAPE

-CIN

-Shear

We trained the model on 70% of the data and used 30% of the data to test the performance. For the spring RSO transition period, $R_{test}^2 = 0.58$. For the fall RSO transition period, $R_{test}^2 = 0.43$.

We found the following for each model:

$$P_{fallRSO} = 0.24MF_{mid-level} + 0.13MSE_{low-level} + 0.10CAPE + 0.09MF_{low-level} - 0.07CIN$$

We have created a table as suggested by the next comment and have included these results in that table. In addition, we have added the following text to the conclusion:

Spring Early Transition Phase	Spring Late Transition Phase
$P_{sprRSO} = 0.45MF_{mid-level} - 0.27CIN + 0.16MF_{low-level} + 0.014Shear - 0.005MSE_{low-level} - 0.002CAPE + 3.51$	

$R^2 = 0.58$	
$MF_{low-level}$ ($q.DIV$ averaged between 925-875 hPa): **Convergence decreasing.** Moisture transport from Atlantic Ocean, through equatorial Congo, towards West African Heat Low.	$MF_{low-level}$: **Convergence decreasing.** Moisture transport from Atlantic Ocean, through equatorial Congo, towards West African Heat Low.
$MF_{mid-level}$ ($q.DIV$ averaged between 850-600 hPa): **Convergence increasing.** Moisture transport from Indian Ocean, through equatorial Congo, towards Atlantic Ocean.	$MF_{mid-level}$: **Convergence increasing**. Zonal Moisture transport from Indian ocean, through equatorial Congo, towards Atlantic Ocean.
CIN: **Steady**	CIN: **Decreasing**
$CAPE$: **Increasing**	$CAPE$: **Increasing**
$MSE_{low-level}$(averaged between 925-875 hPa): **Increasing**	$MSE_{low-level}$: **Increasing**
$Shear$: **Steady**	$Shear$: **Increasing**, from return branch of Congo Basin Cell
$Precipitation$: **Steady**	$Precipitation$: **Increasing**
Fall Early Transition Phase	**Fall Late Transition Phase**
$P_{fallRSO} = 0.24MF_{mid-level} + 0.13MSE_{low-level} + 0.10CAPE + 0.09MF_{low-level} - 0.06CIN - 0.014Shear + 3.49$ $R^2 = 0.43$	
$MF_{low-level}$: **Convergence increasing.** Moisture transport switch from northeast direction to southeast direction: from Atlantic Ocean, through equatorial Congo, towards Congo Air Boundary	$MF_{low-level}$: **Convergence increasing.** Moisture transport from Atlantic Ocean, through equatorial Congo, towards Congo Air Boundary.
$MF_{mid-level}$: **Convergence increasing.** Moisture transport from Southern Congo and Indian Ocean, through equatorial Congo, towards Atlantic Ocean.	$MF_{mid-level}$: **Convergence increasing**. Moisture transport from Southern Congo and Indian ocean, through equatorial Congo, towards Atlantic Ocean.
CIN: **Decreasing**	CIN: **Decreasing**
$CAPE$: **Decreasing**	$CAPE$: **Increasing**
$MSE_{low-level}$: **Decreasing**	$MSE_{low-level}$: **Increasing**
$Shear$: **Steady**	$Shear$: **Steady**, from return branch of Congo Basin Cell
$Precipitation$: **Steady**	$Precpitation$: **Increasing**

Table 2: Summary of changes to key features controlling the rainy season transition periods for the spring and fall rainy seasons. A ridge regression was performed to show which features are most important to controlling precipitation during the transition period. The R^2 represents the performance of the test dataset (30% of data withheld when training the model).

Lines 499-502: "*At the mid-levels, MF convergence strengthens (most important feature for predicting precipitation; Table 2): more moisture transport enters the region across the northern boundary than leaves the basin across the southern boundary."*

Lines 502-503: "*Atmospheric moisture increases, causing decreases in CIN (second-most important feature for predicting precipitation; Table 2) and lowering of the LFC."*

Lines 520-523: ***"****This, along with increases in mid-level meridional MF convergence (moisture transport entering the basin is greater than moisture transport leaving the basin above 850 hPa) supports mid-level MF convergence (most important feature for predicting precipitation; Table 2) and moistens the mid-troposphere, lowering CIN and the LFC."*

Comment: The authors provide a clear summary of how different dynamic and thermodynamic processes changes during the early and late transition period of rainy season onset. To facilitate comparison among seasons, processes, and transition phases, the authors may consider adding a summary table that synthesizes the changes in key physical processes during each phases. This would help readers quickly identify the important precursors and better understand how different processes contribute to the onset.

Response: Thank you for this suggestion. We have added this table to the conclusion. Please see the response to the previous comment for the table and added text.

Minor comments:

Comment: Line 13 (L13): Please also indicate the East African Rift in Figure 15 if possible.

Response: Added.

Comment: L33: Please make the tick labels in Figure 1b slightly smaller.

Response: Changed.

Comment: L65: Suggest changing "likely reflect" to "are likely related to"

Response: Changed.

Comment: L85: Please clarify what “6 per mile” means? It seems like count number.

Response: Here, 6 per mil (6‰) means 6 parts per thousand relative to the reference value. We have updated this in the text:

Lines 94-96: *“The accuracy of these data is ~6 per mil (6 parts per thousand relative to the reference value) with a precision of 20 per mil (Worden et al., 2012) for the vertical range used in this analysis (~900-420 hPa, or about 1-6 km above sea level).”*

Comment: L123: The duration between spring RSO and fall RSE seems to be 58 (64 minus 6). The order of spring RSO and fall RSE is important.

Response: We agree and believe that the durations between the spring RSO and fall RSE are more clear with the updated figure (in a previous response, page 10) and text:

Lines 121-134: “*Figure 2 shows the RSOs and RSEs for the spring and fall rainy seasons between the years 2000-2020. We excluded the year 2000 when calculating the spring RSO because we needed to consider the ends of the prior years in our RSO calculations. Similarly, we excluded the year 2020 when calculating the fall RSE because we needed to consider the start of the next years in our RSE calculations. We additionally excluded from our following analyses any years during which a RSO or RSE was unable to be identified, or if the length of a rainy season was less than 5 pentads. The spring RSO ranges from the 6th to 14th pentad (with Days 1-5 defined as Pentad “0”), corresponding to early-February to mid-March. On average, the spring RSO occurs on 20 February-24 February. The spring RSE ranges from the 25th-32nd pentads, corresponding to mid-May to mid-June. On average, the spring RSE occurs on 21 May-25 May. The fall RSO ranges from the 40th-50th pentads, corresponding to mid-July to early-September. On average, the fall RSO occurs on 18 August-23 August. The fall RSE ranges from the 64th-71st pentads, corresponding to mid-November to late-December. On average, the fall RSE occurs on 2 December-6 December. We show 15 pentads prior to the spring RSO and 19 pentads prior to the fall RSO as these periods capture the key changes in processes that drive the dry to rainy season transition as in Li and Fu (2004) and Wright et al. (2017).”*

Comment: L156: Suggest removing “be able to”.

Response: Removed.

Comment: L160: Suggest revising “the first component of the moisture convergence term ($-q \times \nabla V\%^{\rightharpoonup}$)” to “the first component of the moisture flux convergence (named the moisture convergence term, $-q\nabla V\%^{\rightharpoonup}$)”

Response: Revised.

Comment: L235: Please add the description and colormap for the color shading.

Response: Added to the captions of both Figure 5 and 11 the following:

“Blue shades represent a density map of the TES δD observations.”

Comment: L268: The increase in boundary layer moisture cannot be clearly spotted from Figure 8. I’d suggest adding the third column showing the difference between the panels (b) and panel (a) to highlight the changes.

Response: Thank you for this suggestion. We experimented with adding a third column but decided on changing the colormap to more clearly show increases in boundary layer moisture instead. Please see the updated plots for both Figure 8 and Figure 14.

Comment: L295: Suggest adding the pressure level (e.g., 925-875 hPa) to the left side of each row to improve readability.

Response: Added to both moisture transport and convergence maps.

Comment: L367: “As” to “At”

Response: Fixed.

Comment: L369: “20oC” to “20oE”

Response: Fixed.

Comment: L383: Remove the extra “comma”

Response: Fixed.

Additional Edits

In addition to the edits made in response to the reviewers, after some discussion we have updated the methodology behind Fig. 3c and Fig. 9c.

Please see Lines 156-176:

"*Finally, we examine changes in moisture in the equatorial Congo with the following. We use vertically integrated moisture flux* $MF = \int_{p_s}^{p_{TOA}} q \cdot \vec{V} dp\, /g$*, where q is the specific humidity, and* $\vec{V}$ ***=(u,v)****, is the horizontal wind, with* u *the zonal, and* v *the meridional wind components, respectively.* P_s *denotes the surface pressure and* P_{TOA} *denotes the pressure of the top of the atmosphere. In particular, we calculate the net zonal and meridional* MF *as follows: We take the zonal vertically integrated* $MF_{zonal} = \int_{p_s}^{p_{TOA}} q \cdot u dp/g$ *across the western and eastern boundaries of the equatorial Congo basin, and the meridional vertically integrated* $MF_{meridional} = \int_{p_s}^{p_{TOA}} q \cdot v dp/g$ *across its northern and southern boundaries. For simplicity, we choose the northern boundary along* $2°N$ *and between* $14 - 30°E$*, and the southern boundary along* $2°S$ *and between* $14 - 30°E$*. The western boundary is along* $14°\ E$ *and between* $2°S - 2°N$ *and the eastern boundary is along* $30°\ E$ *and between* $2°S - 2°N$*. To be able to compare to vertically integrated MF convergence, we calculate the length between the western/eastern boundaries and the northern/southern boundaries, respectively, and integrate average* MF_{zonal} *and* $MF_{meridional}$ *across these boundaries as in Satyamurty et al. (2013):*

$$Q_E = \int MF_{zonal,E} dy$$

$$Q_W = \int MF_{zonal,W} dy \qquad \textit{Eq. 7}$$

$$Q_N = \int MF_{meridional,N} dx$$

$$Q_S = \int MF_{meridional,S} dx$$

Where $MF_{zonal,E}$ *is* MF_{zonal} *integrated along the eastern boundary,* $MF_{zonal,E}$ *is* MF_{zonal} *integrated along the western boundary,* $MF_{meridional,N}$ *is* $MF_{meridional}$ *integrated along the northern boundary, and* $MF_{meridional,S}$ *is* $MF_{meridional}$ *integrated along the southern boundary.* y *is the length of the northern/southern boundaries, and* x *is the length of the western/eastern boundaries. To calculate the net zonal vertically integrated MF, we* *calculate* $Q_{zonal} = Q_{W-}Q_E$. *To calculate the net meridional vertically integrated MF, we calculate* $Q_{meridional} = Q_S - Q_N$ *. This ensures that positive values of* Q_{zonal} *and* $Q_{meridional}$ *means net convergence, and negative means net divergence."*

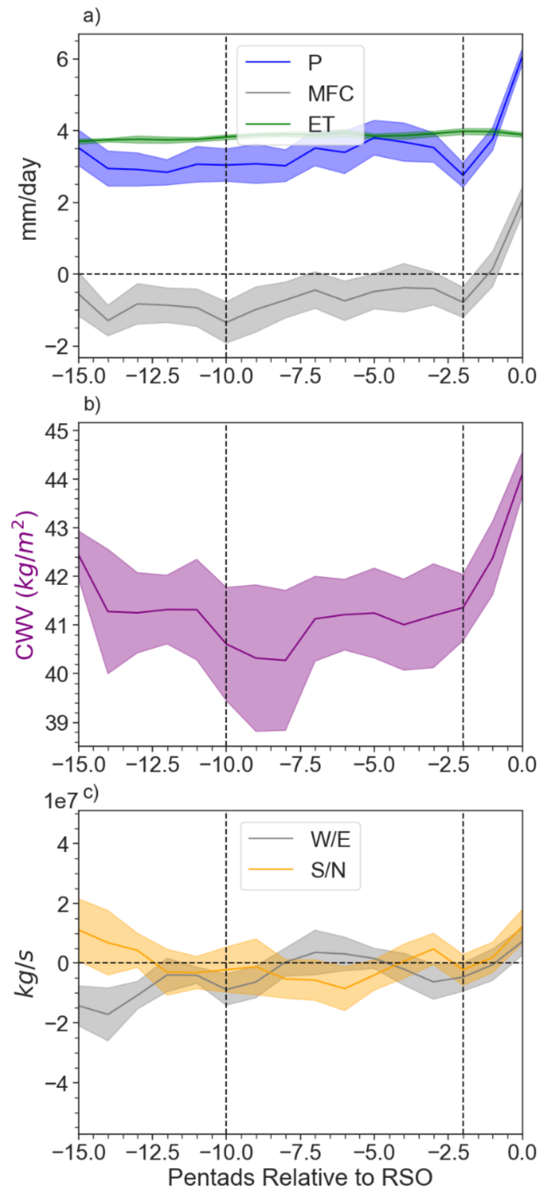


Figure 3: For the transition to the spring RSO: (a) Precipitation (P), vertically integrated MF convergence (MFC), and evapotranspiration (ET); (b) column water vapor (CWV); and (c) Net vertically integrated MF across the zonal and meridional boundaries (**Q_{zonal}**, **$Q_{meridional}$** Methods, Units: kg/s*1e7). Positive means convergence, negative means divergence. All are relative to the RSO (denoted as '0' in the graph). Time series are smoothed using a Savitsky-Golay filter (number of coefficients: 5, polynomial order 2). Shades represent the standard error of the mean of the different years.

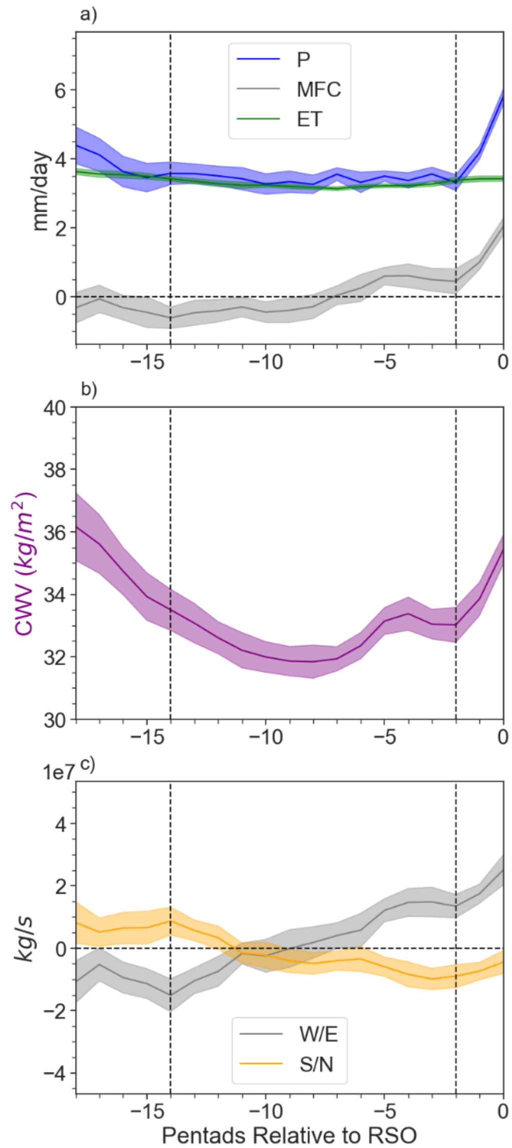


Figure 9: For the transition to the fall RSO: (a) Precipitation (P), vertically integrated MF convergence (MFC), and evapotranspiration (ET); (b) column water vapor (CWV); (c) $\mathbf{Q_{zonal}}$ and $\mathbf{Q_{meridional}}$ (Methods; Units: kg/s*1e7). Positive means convergence, negative means divergence. All are relative to the RSO (denoted as '0' in the graph). All have been smoothed using a Savitsky-Golay filter (number of coefficients: 5, polynomial order 2). Shades represent the standard error of the mean of the different years.

Finally, we found minor issues with the code used to produce Figure 5. We have updated it and our conclusions associated with this figure have not changed.

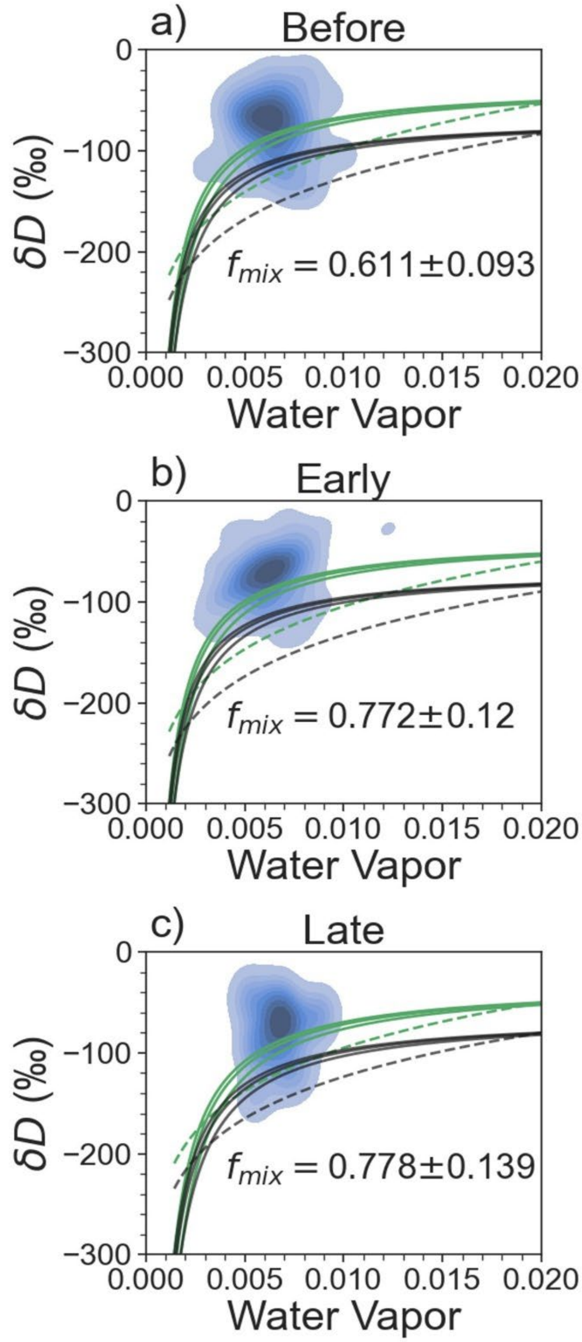


Figure 5: Fraction of observed δD above a series of mixing (solid) and Rayleigh (dashed) models. Blue shades represent a density map of the TES δD observations. Green indicates land-based water vapor models, while black indicates ocean-based water vapor models. f_{mix} is the fraction of observed δDabove the uppermost, land-based mixing model. For (a) the "before" period (15-11 pentads prior to the spring RSO); (b) the early-transition; and (c) the late-transition.