Answer to Comments from Referee #2

We sincerely thank the referee for her/his evaluation and comments on the manuscript that will improve the quality of the article. We address them in this document, the original referee's comment is written in blue, while the response is in black font. For those proposed manuscript modifications, we write the original sentence of the manuscript in black quotes "" and the proposed changes to the manuscript in green.

General comments:

This paper aims to describe the influence of Atlantic modes on evaporation in the Orinoco and Amazon basins and provide a description of the underlying physical pathway. The paper is well written and well-embedded in the current literature on this topic.

My main issue has to do with the chain of physical processes between the Atlantic modes and evaporation. The chain has some side branches that should be better explored. Figs 2 to 5 that present the main results are impenetrable. On the one had they show results that are not so much discussed and on the other hand the chain of physical processes is hard to follow with many variables plotted in the same panel. Another link in the physical processes is presented already in Fig1. This makes it very difficult to follow. I make some recommendations on how to improve this.

There are some more discussion points. To incorporate these points requires some work, but if discussed/implemented properly I do recommend publication of this paper.

We are very grateful to the referee for carefully reviewing and thinking about analysis to improve the quality of the paper. We also thank the reviewer for the recommendation of publication, provided the revisions are implemented. We have revised and proposed changes to the manuscript according to her/his suggestions and feel that the paper will explain the details better.

Specific issues:

1-0) Data – spatiotemporal scales: One of the attractive aspects of this paper is that it includes many data products. This fortifies the conclusions drawn as they are not hung up on a single methodology. In Section 3 the spatial extent of the AO regions are specified as well as the total timeframe (Dec1979-Nov2020) and the aggregated time resolution of the data (3 months). The information on spatial and temporal resolution and the method of aggregation of the underlying original data products is unclear or scattered over different sections and figure captions. As this is a data driven study, this requires attention. The most logical place for this is the Data section (Section 2).

We are grateful to the reviewer for noticing our intention to look for consistency in the dynamics shown by different datasets and for the comments to clarify the details of the datasets. We acknowledge that line 100 – about the timeframe and time resolution – is more suitable for the data section and move it to line 59; although it is a procedure/method that is also recorded in the computational codes we attached as a research asset (which we propose to change from GitHub to Zenodo to completely comply with FAIR principle, here cited as (Duque-Gardeazabal, Zenodo, 2025).

We propose to modify line 59 – to also tackle a comment from the referee's #1 to line 58. We will divide that paragraph and add:

This study uses – apart from ET estimates – variables that control local ET (local controllers), such as net radiation and soil moisture; but it also uses atmospheric circulation variables, such as SLP, winds, moisture transport, convergence and rainfall. We use those atmospheric variables because ocean-atmospheric modes drive the regional atmospheric circulation, which afterwards influences the local ET controllers. Sea Surface Temperature Anomalies (SSTAs) are used to identify the ocean-atmospheric modes (methods Section 3). All datasets are downloaded at monthly time scale and used between Dec-1979 and Nov-2020 (except for the satellite-based soil moisture, details in section 2.2); they are aggregated at seasonal scale and analysed for each season individually and synchronously. The aggregation method for all variables is the average of the three monthly values, except for precipitation and ET when we use the sums (Duque-Gardeazabal, Zenodo, 2025).

Spatial aspects:

1-1) Mention the spatial resolution of all the data products.

We propose then to add the following sentences.

Line 70 – division of paragraph for ERA5 and ERA5-Land. We propose to add:

"All atmospheric variables from ERA5 have a 0.25° resolution."

Line 74 – we propose to add:

"All variables from ERA5-Land have a 0.1° resolution."

Line 78 – we propose to add:

"(MSWEP)(Beck et al., 2019) and the Climate Hazard group InfraRed Precipitation with Station (CHIRPS)(Funk et al., 2015)", with a spatial resolution of 0.1° and 0.05°, respectively.

Line 81 – we propose to add:

"Three satellite-based datasets complement the three ERA5-Land variables (all of them at 0.25° resolution):"

Line 88 – we propose to add:

ERSST is at 2°, and HadSST is at 5° resolution.

1-2) How did you deal with gaps in the spatial data (e.g. in the satellite products)

Thanks for the question. The only product which has gaps is the satellite-based soil moisture (ESA CCI SM), which helped to corroborate the dynamics found in ERA5-Land. It was also the only product downloaded at daily resolution (not directly available at monthly scale); to transform/aggregate the ESA CCI SM to monthly values, we impose that each month had at least 4 values, one per week, and assume a slow dynamics of Soil Moisture within the week (Zanin et al., 2024). This unifies the temporal features of the ESA CCI SM with the other datasets and was applied grid-wise. Supplementary material Figure S2 displays the composite maps with the gaps that were not able to be filled due to the lack of data under the dense forest canopy. For the time series in panel (a,c,e,g) in proposed Figure 7, we averaged the values inside the rectangles, excluding the missing data.

We propose to add the next sentence to line 84:

ESA-CCI-SM was downloaded at daily resolution and transformed to monthly values by averaging the days within each month as long as the month had at least four values; the remaining spatial gaps were not filled and were excluded when needed. “GLEAM uses a three-layer ...”

1-3) What is the common grid resolution that all products are projected on and how did you regrid data the data going to either coarser or finer resolutions

Thanks for the question. We did not regrid or combine satellite and reanalysis data products because we were looking for consistency in the dynamics shown by them separately (as mentioned in line 65). The main products displayed in the manuscript are ERA5 and ERA5-Land due to their homogeneity in the whole time frame; dynamics in satellite products are displayed in the time series and in the supplementary material. Figure S2 shows the ESA-CCI-SM anomalies, Figure S3 shows GLEAM anomalies, and Figure S4 shows CLARA cloud cover correlations.

Line 65 – we propose to add:

“Therefore, we look for consistency in the dynamics of both sources of information; we do not regrid and do not merge any datasets because we do not perform operations between them, we just display the datasets conjointly when necessary and analyse that the dynamics unfold in both sources (Table 1).”

The only plots where satellite and reanalysis sources are displayed together are panels a) and b) in Figures 2 to 5 and 7 for separated time series. Those plots show the moisture transport, convergence and rainfall anomalies and the consistency in the dynamics of both data sources (e.g. convergence anomalies are in the same location as positive rainfall anomalies and vice versa).

Temporal aspects:

1-4) Mention the temporal resolution of all the data products.

Thanks for the suggestion. In our answer to comment 1-0, we have included a sentence at the beginning of section 2 Datasets that describes the temporal resolution of every dataset as monthly, except for the ESA-CCI-SM, which is given in answer to comment 1-2. The time resolution was mentioned in line 68 of the original submitted manuscript, but it should be clearer now with the change.

1-5) What was the method of aggregation to the 3-month products that you use in the analysis? For some variables such as ET and precipitation it can be sums or averages.

Thanks for the question. In our answer to comment 1-0, we have included a sentence that describes it.

Line 59 -

... they are aggregated at seasonal scale and analysed for each season individually and synchronously. The aggregation method for all variables is the average of the three monthly values, except for precipitation and ET when we use the sums (Duque-Gardeazabal, Zenodo, 2025).

1-6) What was the method of aggregation from the 40-years of 3-month aggregated products filtered by O-phase. In the caption of Fig2 I see that precipitation is averaged but it is not clear if it this refers to a 40-year average of 3-month precipitation sums or averages. For ET no aggregation method mentioned.

Thanks for the question. The anomalies of the variables are calculated form the seasonal (3-month) time series for each season individually. The aggregation method for precipitation and ET was the sums as answered in comments 1-0 and 1-5.

1-7) The derived data products (e.g. MDiv, …) are based on non-linear relations. In which order did you do determine the 3-month aggregates? Did you determine MDiv based on 3-month aggregate fields of moisture or did you determine MDiv based on hourly data and aggregate those?

We very much appreciate the question. The ECMWF-Copernicus-CDS web portal directly provides monthly datasets that come from the accumulation of the hourly values, with every variable aggregated after its individual calculation. Vertically integrated Moisture Divergence (MDiv) is also directly provided by the web portal in the single-levels category; hence, the variable is simulated at hourly resolution by the ECMWF, aggregated to monthly scale by the ECMWF, downloaded and afterwards aggregated to seasonal scale by us. This can be consulted at the Copernicus Climate Data Store web portal https://cds.climate.copernicus.eu.

In the case of the net surface radiation, we derived it from the energy balance equation using the surface net solar radiation and surface net thermal radiation at a monthly time scale (both directly downloaded from the ECMWF-Copernicus-CDS). This should not be a problem since this calculation is a simple subtraction (linear). Afterwards, we aggregated the net surface radiation to the seasonal intervals. For some variables, it was necessary to multiply for the number of days in the month. The latter is specified in our codes uploaded to GitHub and that we propose to transfer to Zenodo (Duque-Gardeazabal, Zenodo, 2025).

1-8) What about night-time data? For the relation between radiation and ET it matters whether you include night-time data or not.

Thanks for the question. Even though at night-time there is positive ET, its value is far less than during the day. If one excludes the night-time from calculations – i.e. just considers daytime – one will still retain the biggest share of ET. We include both day and night ET in the only dataset which could separate them, ERA5-Land (which is aggregated to monthly resolution by the ECMWF). All other ET datasets at daily resolution consider the night-time because they use daily mean input values to calculate the ET, and their formulations are targeted for daily totals (Martens et al., 2017).

1-9) I think a Table with an overview of the data products and their original spatial- and temporal resolutions would be a good addition followed by a description on how you bring these data together.

We thank the reviewer for the suggestion. We will include the table and the required description is included in answer to comment 1-3.

Line 65 -

... we do not regrid and do not merge any datasets because we do not perform operations between them, we just display the datasets conjointly when necessary and analyse that the dynamics unfold in both sources (Table 1).

Variable	Reanalysis (ERA5 and ERA5-Land)		Satellite		
	Spatial	Temporal	Dataset	Spatial	Temporal
Sea Level Pressure	0.25°	Monthly	-	-	-
Winds at 850 hPa	0.25°	Monthly	-	-	-
Vertically Integrated Water Vapor Flux (VIMF)	0.25°	Monthly	-	-	-

Vertically Integrated Moisture Divergence (MDiv)	0.25°	Monthly	-	-	-
Precipitation	-	-	MSWEP v2.8 (Beck et al., 2019)	0.1°	Monthly
	-	-	CHIRPS v2.0 (Funk et al., 2015)	0.05°	Monthly
Net surface thermal radiation	0.1°	Monthly	EUMETSAT CLARA-A3 cloud area fraction	0.25°	Monthly
Net surface solar radiation	0.1°	Monthly			
Soil Moisture (volumetric water content 1st soil layer)	0.1°	Monthly	ESA-CCI-SM v08.1	0.25°	Daily (aggregated to Monthly using the mean)
Total evaporation	0.1°	Monthly	GLEAM v3.8a	0.25°	Monthly
	Sea Surface Temperature Anomalies				
Sea Surface Temperature Anomalies	ERSST v5			2°	Monthly
	HadSST v4.0.1			5°	Monthly

2 - 0) Atlantic mode to ET chain: In the introduction you state that links between the Atlantic mode and the hydrometeorology in the Amazon has been mainly studied from a statistical perspective and that one of the innovations of this paper is that you will explore the underlying physical mechanisms. In the methodology section you don't explain how you will do this, but at the start of section 4.2 you outline an Atlantic mode to ET chain that I interpret as a chain, your chain, of underlying physical mechanisms. Is that correct?

We thank the reviewer for the question. Yes, we use the concept of a chain to refer to the progressive physical processes/mechanisms that link the ocean-atmospheric dynamics of the Atlantic modes with the ET over the continent (i.e. atmospheric circulation anomalies affecting local ET controllers).

Following referee #2 suggestion, we will include the detailed description of the chain at the beginning of the Section 3 methods (line 92), by moving and complementing the sentences in line 151.

Climate modes and their atmospheric circulation anomalies are expected to impact evapotranspiration through a chain of progressive physical processes. The processes start with: atmospheric moisture transport anomalies (VIMF); which changes moisture flux divergence (MDiv), affecting cloud formation; which simultaneously influences precipitation and radiation availability; precipitation then affects Soil Moisture; and afterwards, the two local controllers impact evapotranspiration. However, the impacts of the chain are also mediated by the climatological cycle of the ET regime (water- or energy-limited). Consequently, our research starts by determining the ET regime and the local controllers' annual cycle (section 3.1), then shows – with composites – how the chain unfolds with its final impacts on ET (section 3.2), and finally studies if there are conjoint effects of the Atlantic modes and ENSO (section 3.3). Moisture recycling is discussed in section 5.

Referee #1 made a comment (to line 94) where we realized about a misunderstanding with what we call drivers. We previously referred to both – climate modes, and local net radiation and soil moisture conditions – as "drivers", and this might confuse the reader. Even though both are drivers, climate modes are at the beginning, and the others are at the end of the chain. Therefore, we propose to change and use the concepts of *drivers* to refer to the climate modes that drive atmospheric circulation variability which impact local conditions, and *local controllers* of ET to refer to net radiation and soil moisture (which control water- or energy-limited regime).

We implement this change in several parts of the text, but we want to highlight one answer to referee #1 –comment 2a– where we propose to add to line 45:

Nevertheless, it is still not known how the Atlantic modes drive regional atmospheric circulation, which then alter local continental atmospheric conditions and afterwards affect net surface radiation and soil moisture, the two key local controllers of ET. We refer to the latter as the physical mechanisms of the teleconnection, which consist of a chain of progressive physical processes.

The previous paragraph will tell the reader about the chain in the introduction section of the manuscript, as requested by Referee #1.

2-1) You outline the chain as:

atmospheric moisture transport anomalies → (moisture flux divergence, clouds and radiation + precipitation and Soil Moisture) → evapotranspiration.

Arrows indicate that variables change/impact the following variable(s). Variables between brackets are changing simultaneously.

If exposing the physical mechanisms is indeed the main goal, this chain should be better defined in the methods section and followed through in the presentation of the results.

To start, I see the chain not so much in a straight line but more of a branched chain:

- Atlantic-mode chain (external moisture)
- atmospheric moisture transport anomalies → moisture flux divergence → clouds → (radiation + precipitation).
- Precipitation → Soil Moisture.
- Soil Moisture + Radiation → evapotranspiration
- Moisture recycling chain (local moisture)
- evapotranspiration → clouds → transport → rain
- evapotranspiration → Soil Moisture (negative feedback)

We are sincerely grateful to the reviewer for outlining our words with a sketch, which we will add to our summary figure (answer referee #1 comment 2a). We agree with the reviewer that there is a branched chain that includes moisture recycling; this will be addressed in the next comment 2-2. We propose making small changes on how we display the chain – considering the referee comments – and we show them in the answer to comment 2-3.

We outlined the chain previously in line 151. We now decide to briefly mention it in the introduction (line 42) and describe it more extensively at the beginning of the methods section (line 92). See previous answer to comment 2-0.

2-2) Moisture recycling is a well-known mechanism in the Amazon region. You make an effort to separate the Atlantic-mode effect from ENSO. Can you do the same for a direct Atlantic-mode effect versus the following moisture recycling that can be seen as a secondary effect? This deserves at least a discussion. Right now you mention the term moisture-recycling briefly around line 250 without giving an idea of its impact.

We greatly appreciate the referee's comment. It is interesting and challenging to know: How much of the ET from one basin becomes moisture that influences solar radiation and precipitation in other regions?. Previous studies have focused on precipitation, indicating that between 25 to 35% of rainfall in the Amazon comes from the same basin. However, using computational tracers, Dominguez et al. (2022) discovered that this is a short lifetime phenomenon very linked to the diurnal cycle of advected moisture and convection. Apparently, local ET precipitates quicker than moisture from remote locations, especially in the east part of the Amazon (Dominguez et al., 2022). This is also supported by Staal et al. (2018), who measured the distance of transpired water before precipitating again over land, finding that for the particles transpired in the Amazon, the distance is below or around 500 km (which is short for the size of the Amazon basin). Some have determined the influence of transpiration on moisture convergence (Makarieva et al., 2023), yet the potential influence on radiation is still to be determined. Dominguez et al. (2022) also imply that "ET of Amazonian origin is less likely to contribute to downwind precipitation than originally thought".

Both the diurnal cycle and the short distance might imply that the ET influence on moisture convergence and radiation is not as big as could be thought. A quantitative estimation of the influence would require a Lagrangian analysis and specialized cloud parametrizations to detect the transpiration impact on cloud cover and radiation; that kind of analysis is out of the scope of our research.

We will still expand its discussion by dividing the paragraph in line 250. We will add to line 252 the following text:

Although moisture recycling inside the Amazon comprises between 25% and 35% of rainfall, Dominguez et al. (2022) discovered that it is a short-lifetime phenomenon very linked to the diurnal cycle of advected moisture and convection; recycled moisture precipitates quickly. Staal et al. (2018) measured the distance of transpired water before precipitating again over land, finding that for the particles transpired in the Amazon, the distance is below or around 500 km (which is short for the size of the Amazon basin). Makarieva et al. (2023) determined the influence of ET on moisture convergence, which potentially might influence radiation. It remains to be clarified to what extent moisture-recycling influences radiation availability and soil moisture at other locations in South America; the latter is out of the scope of our research.

2-3) Figs. 2 to 5 are beautifully composed and very rich in the use of data products. They try to both show the chain of processes (panels on the left-hand side) and show ppt anomaly + temporal variability of ppt and ET over the Atlantic modes and when they coincide with ENSO (panels on the left-hand side). This too much and at the same time too little, as the chain is very difficult to follow because of lack of detail. For instance, the ET anomaly is at the end of the chain and its most direct drivers are soil moisture and radiation. The soil moisture anomaly is plotted clearly in a separate panel but the radiation anomaly is given as hard to distinguish contour lines in the ET panel. This suggests that the soil moisture anomaly is more important but Fig 1 shows that most of the region is energy limited.

We are grateful to the referee for noticing our effort to convey several dynamics. Following her/his suggestion, we include now panels on the anomalies of radiation that also show their consistency with the anomalies of satellite-based cloud cover. Moreover, we include the precipitation anomalies as contours over the SM to show the step in the physical processes. Over the last panels that show the ET anomalies (and the last step in the chain), we now draw the local controllers – radiation and SM – in contours. The modified Figure should convey how the modes drive the variability of atmospheric circulation, moisture and its convergence (panels a and b); then affect cloud cover and radiation (panels c and d); which then affect precipitation and SM (panels a, b, e and f); which afterwards locally control the ET (panels g and h), as shown in the next image.

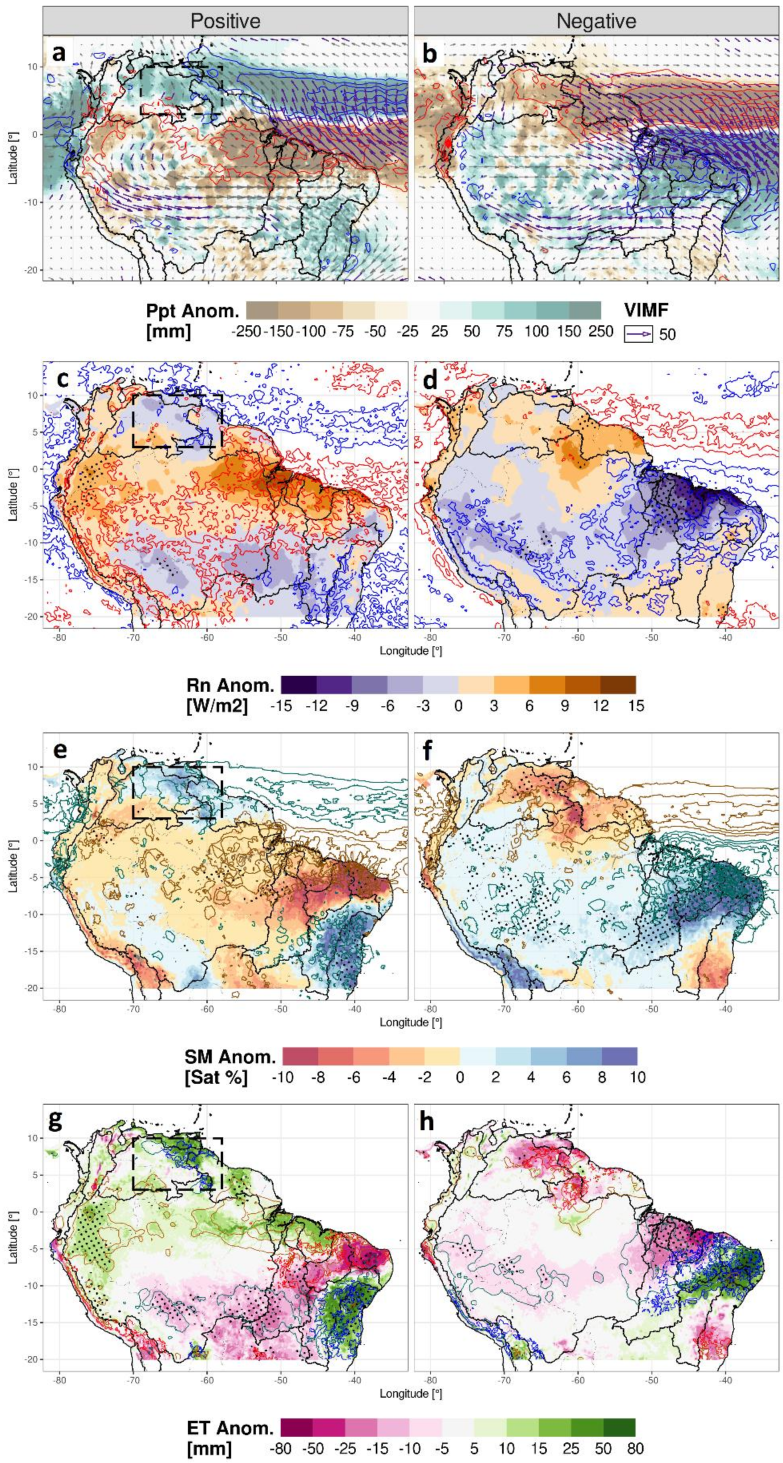


Figure 2. For Austral Autumn - MAM, composites of AMM for (a) VIMF (arrows), MDiv (contours) and MSWEP precipitation (shading) anomalies in the positive; positive MDiv anomalies are drawn in red and negative in blue repeated every 3 kg/m^2, precipitation is in mm and VIMF in kg/m/s. VIMF is depicted in purple arrows when the difference with the neutral phase is statistically significant at a 90% confidence level and in grey otherwise. (b) The same as (a) but for the negative phase. (c) Composites of ERA5-Land surface net radiation anomalies in the AMM positive phase (shadings), and satellite CLARA cloud cover anomalies (contours); positive cloud cover anomalies are in blue and negative in red repeated every 4%. (d) same as (c) but for the negative phase. (e) Composites of ERA5-Land SM saturation percentage anomalies in the AMM positive phase (shadings), and MSWEP precipitation anomalies (contours); positive precipitation anomalies are drawn in aquamarine and negative in gold repeated every 100 mm. (f) same as (e) but for the negative phase. (g) Composites of ERA5-Land evapotranspiration (shadings), net surface radiation anomalies (contours, gold for positive and aquamarine for negative), and Soil Moisture anomalies (contours, blue for positive and red for negative), in the AMM positive phase; radiation anomalies are repeated every 3 W/m^2 and SM anomalies are repeated every 5%. (h) same as (f) but for the negative phase. In every panel, black stipple dots depict regions where the difference with the neutral phase is statistically significant at a 95% confidence level for radiation in panels (c and d), SM in panels (e and f) and ET in panels (g and h).

The temporal variability panels are moved to a proposed Figure 7 (see answer to comment 2-4). We still want to display the VIMF, the MDiv and the satellite-based precipitation in the same panel since this shows the consistency between different sources of data (reanalysis and satellite); precipitation is also – as suggested by the referee – displayed over the SM (comment 2-5). We will make a more proportional layout with high-resolution images for the revised manuscript. Figures 3 to 5 will be similar to the proposed new Figure 2 but for the other seasons and climate modes.

To simplify the article, we also propose to transfer Figures 3 and 5 to the supplementary material. Consequently, we will keep just two plots of the chain in the main manuscript – Fig. 2 and 4 one for each Atlantic mode – and consolidate the difference between seasons with the following plot. The changes in the location of the AMM impacts will be summarised in the next plot in the main manuscript (new Figure 4), and sections 4.2.2 and 4.2.3 will be rewritten.

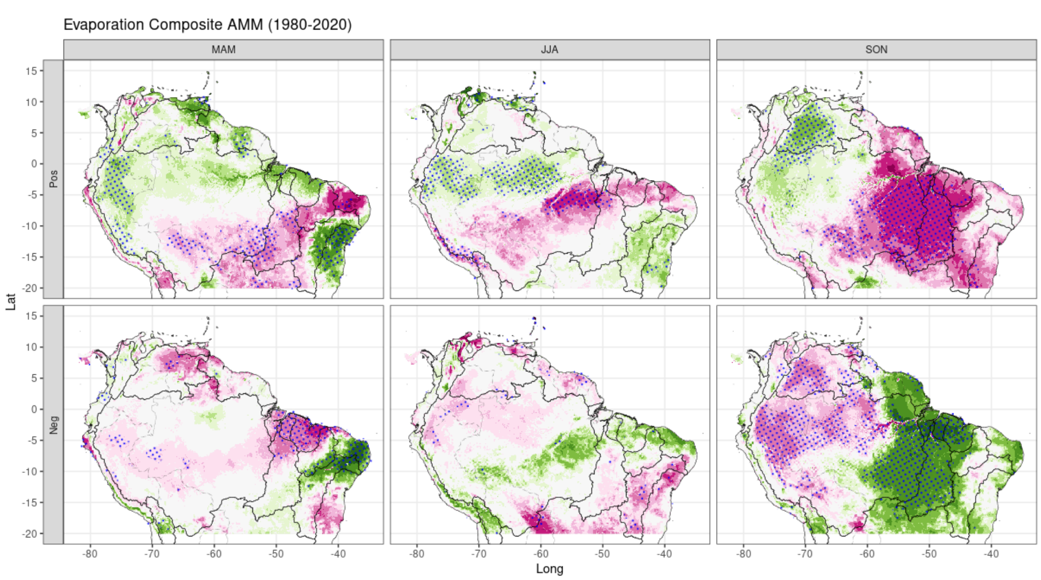


Figure 4. Anomalies of evaporation in the positive and negative AMM phases, for seasons (a,d) March-May, (b,e) June-August, (c,f) September-November. Positive phase in panels (a,b,c) and negative (d,e,f). Blue stipple dots depict regions where the difference with the neutral phase is statistically significant at a 95% confidence level.

Some suggestions to improve this:

We sincerely thank the reviewer for thinking about options to improve the manuscript.

2-4) Move all the right hand panels that are hardly discussed to a separate section or supplementary materials. Maybe in the now very short Section 4.3 as these panels show the interplay with ENSO which is discussed in 4.3?

We are sincerely grateful for the referee's advice, and hence, we have separated some of the righthand time series, simplify and joined them in a proposed Figure 7. The precipitation composite bars in the Figures have been deleted and some precipitation and SM time series have been sent to the supplementary material. This will allow us to describe and discuss specific time series of ET regarding how the modes overlap with ENSO, in section 4.3 of the results.

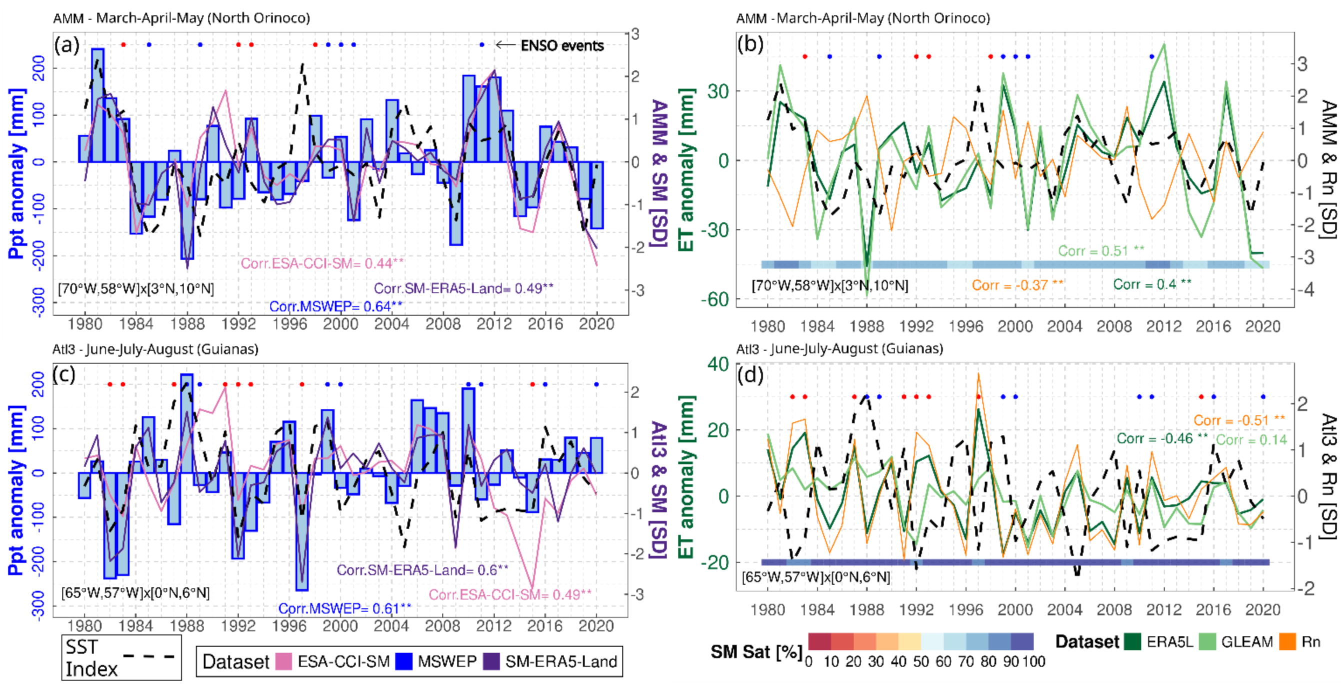


Figure 7. (a) Area-average precipitation (bars) and SM standardised anomalies time series (lines) for the same boxes in Figure 2; the Atlantic index time series is in black dashed lines in standard deviation (right axis), and top points show ENSO active periods (positive phase in red and negative in blue). (b) Area-average evapotranspiration time series (greens), ERA5-Land net surface radiation (orange), standardise Atlantic index (black dashed) and ERA5-Land absolute SM in saturation percentage at the bottom of the panel with coloured rectangles. For all panels, Pearson correlations are calculated between the variable – either precipitation, SM, Rn or ET – with the respective Atlantic index, 95% confidence level is indicated with **. Boxed region: North Orinoco. (c and d) same as (a and b) but for the boxes in Figure 4; Boxed region: Northeast Amazon and Guianas.

We propose to modify the paragraph in line 228, in section 4.3, from:

“Both ENSO and the Atlantic modes are connected through tropical and extra-tropical mechanisms, but each of them has effects on South America’s hydroclimate. The partial correlation shows a conjoint effect of ENSO and AMM over the evaporation of northeast Brazil in austral autumn and in JJA (Fig. 6a,b,e,f), yet ENSO also impacts the eastern Amazon and the AMM the Orinoco (see Sect. 5 Discussion). Whereas in SON, the AMM and ENSO tend to impact different regions (ENSO being strong over the Guianas and the AMM over the west and southeast). The Atl3 does not show strong correlations and the ENSO pattern for JJA is very similar to the Atl3 negative phase composites (Fig. 6b and h), indicating some overlapping dynamics with ENSO probably related to the increased divergence and radiation. The impact of ENSO in DJF causes a reduction of convergence and rainfall and increases radiation (Fig. 6d).”

To:

Both ENSO and the Atlantic modes are connected through tropical and extra-tropical mechanisms, but each of them has effects on South America’s hydroclimate. Figures 6 and 7, respectively, separate the effects of each mode in the spatial and temporal dimensions.

ENSO and AMM have impacts on ET at similar but also over different locations depending on the analysed season. The partial correlation shows both modes’ influence on ET over northeast Brazil in MAM and in JJA (Fig. 6a,b,e,f), yet ENSO mainly impacts the eastern Amazon and the AMM the Orinoco. ENSO usually affect east and central Amazon with droughts during El Niño events –mostly during its peak season DJF – and with heavy rainfall and floods in La Niña events. This is clear from Figure 6d and from the rainfall time series for the central Amazon drought in 1983, 1992, 1997 and 2015 and positive rainfall anomalies during La Niña 1987, 1999 and 2010 (Fig. 7c). Figure 7 (a) and (b) show for North Orinoco in 1983 El Niño did not reduce the rainfall in that region and ET still increased due to the extra moisture advection of the positive AMM. Conversely, in 1985 La Niña should have brought more rainfall, but the AMM caused a southward moisture advection that reduced precipitation, SM and thus ET (Fig. 7b). A similar dynamic unfolded for the Central Amazon in JJA-2010 when above-average rain did not arrive – even though it was expected during a La Niña event – and ET had slightly above-average values (Fig. 6b and S4); the cause was the positive AMM event (see Sect. 5 Discussion). For season SON (Fig 6. c and g), the AMM and ENSO tend to impact different regions, ENSO being strong over the Guianas and the AMM over the west and southeast. For instance, over western Orinoco and Amazon, the 1986 negative AMM brought more moisture and rainfall when El Niño event was expected to cause a drought that never unfolded (Fig. S4); the above-average convergence and lower-than-normal radiation decreased the ET (Fig. S4).

The Atl3 does not show strong correlations with ET, and the ENSO pattern for JJA is very similar to the Atl3 negative phase composites (Fig. 6b and Fig. 4h), indicating some overlapping dynamics between the two modes. The latter is probably more associated with the atmospheric dynamics of ENSO which causes increased divergence and radiation, and reduction in precipitation during El Niño events which have unfolded simultaneously with the Atl3 negative phase (Fig. 6h). Figure 7c and d show this dynamic in 1983, 1992 and 1997 for the Northeast Amazon and Guianas, but not in 1987 when a positive Atl3 cooccurred with El Niño. The Atl3 positive events did not show a clear effect in 1987 and 1999 when precipitation (Fig. 7c) and radiation (Fig. 7d) anomalies were not of the same sign for the two events; ENSO dynamics were stronger for those two years. The impact of ENSO in DJF causes a reduction of convergence and rainfall and increases radiation (Cai et al., 2020), therefore causing positive ET anomalies in the central Amazon rainy season and negative over the Guianas that experience its dry season (Fig. 6d).

2-5) Expand the left hand panels: VIMF and MDiv can be combined, but ppt, SM, Radiation and ET should have their own panels. Contours of driving variables could be added on top of a plotted variables, e.g. contours of rain on SM or contours of SM and Radiation on ET.

We thank the reviewer for the suggestion. Even though contours can represent the driving variable in each step of the chain (i.e. Cloud Cover with net surface radiation or precipitation with SM), having more than one type of contour in the panels of ET makes the plot difficult to interpret. The request for the case of ET – where SM and Rn are the two local controllers – implies that we need to draw the contours very thin so that the ET in shadings can be seen properly. The accompanying plots are in answer to comment 2-3 with their respective caption.

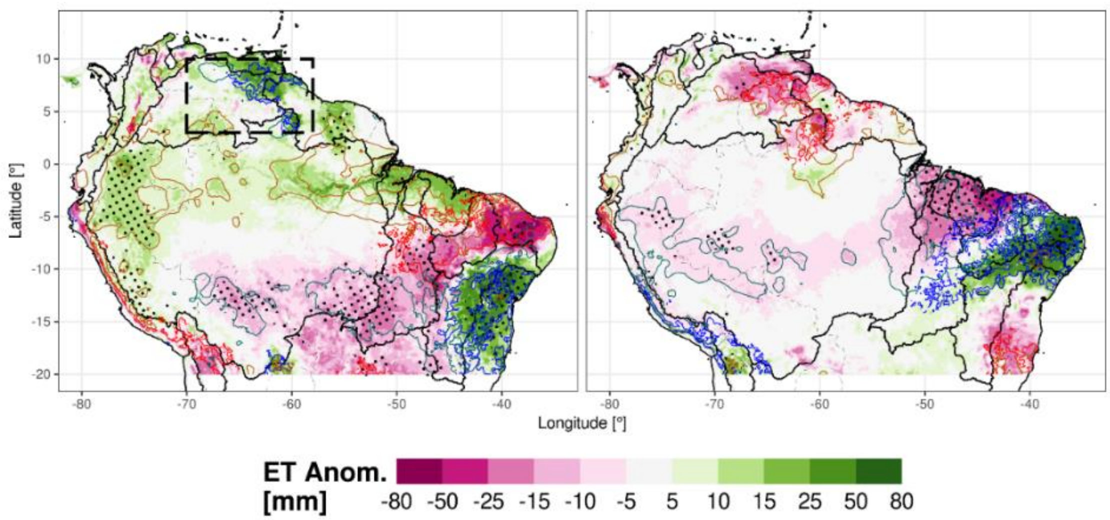


Figure 2. (g) Composites of ERA5-Land evapotranspiration (shadings), net surface radiation anomalies (contours, gold for positive and aquamarine for negative), and Soil Moisture anomalies (contours, blue for positive and red for negative), in the AMM positive phase; radiation anomalies are repeated every 3 W/m^2 and SM anomalies are repeated every 5%.

We proposed the new panels for the radiation – with the cloud cover in contour as a driver – and for the soil moisture (with precipitation in contour as a driver) in the answer to comments 2-3.

2-6) In addition: Black dots are explained for SM but not ET. I assume it means the same thing? Do you need it? It is hardly discussed.

We thank the reviewer for the comment. Even though statistical significance is not discussed much it indicates that the dynamics found in the analysis are more probable than random chance since it has repeated on several occasions. The description of their calculation is explained in line 116.

We have modified the caption of the figure to indicate in each panel the meaning of the black dots (see answer to comment 2-3). The specific text added is:

In every panel, black stipple dots depict regions where the difference with the neutral phase is statistically significant at a 95% confidence level for radiation in panels (c and d), SM in panels (e and f) and ET in panels (g and h).

2-7) Net radiation, now plotted with contours, has relatively small (3 W/m2) anomalies. Is that because the night is included that contributes very little to the anomaly?

We thank the referee for the question. Yes, we consider the nighttime when the net surface radiation is smaller than during the day. However, we want to highlight that the contours are repeated every 3 W/m^2, and in some plots, there are even four levels of contours, meaning that the radiation anomaly reaches even 12 W/m^2 (which should be more visible in the new Figure 2).

We propose to add the word "repeated" to the caption. So it would change from:

"(g) Composites of ERA5-Land evapotranspiration (shadings) and net surface radiation anomalies (contours) in the AMM positive phase; positive radiation anomalies are in red and negative in blue every 3 W/m^2."

To:

(g) Composites of ERA5-Land evapotranspiration (shadings), net surface radiation anomalies (contours, gold for positive and aquamarine for negative), and Soil Moisture anomalies (contours, blue for positive and red for negative), in the AMM positive phase; radiation anomalies are repeated every 3 W/m^2 and SM anomalies are repeated every 5%.

2-8) Does it make sense to add a correlation between the ET anomaly and the radiation and soil moisture anomalies in line with Fig 1 to see which one is dominant in explaining the differences for each Atlantic mode? This could replace Fig1. Alternatively consider adding the ET regimes (Radiation or SM driven) marked in Fig1 to the ET anomaly panels of Figs2 to 5

We thank the reviewer for the question and the suggestion, the other question about Figure 1 and its answer is in comment 3-0. Multiple correlation analysis and multi-linear regression have very similar applications, yet in the regression the assumption of causality is stronger as it specifies independent variables and a dependent variable (in our case, Soil Moisture and radiation impact over ET). The latter was the reason for not using correlations for subobjective #1.

We see the reviewer's point of view that it is uncomfortable to look first at Figure 1 and then at the individual Figures from 2 to 5 to understand the dynamics of the end of the chain. However, we intended to first contextualize the reader with a description of Figure 1 and then describe the results of the chain. That is also why we decided to start Section 4.1 Results with the ET regimes in Figure 1 and show the chain in Section 4.2 from Figures 2 to 5; the classification of the ET regime is the 1st sub-objective. For instance, in the text in line 165, in section 4.2, we stated:

"The Orinoco behaves as water-limited (Fig. 1e) as this is the transition from dry to wet season, then the increase in rainfall and SM causes above-average evaporation (Fig. 2g)"

which links the results of both figures. This is repeated in the description of the results in section 4.2 for Figures 3, 4 and 5 (we propose to transfer Fig 3 and 5 to Supp. Mat., see answer to comment 2-3).

We consider the suggested alternative of displaying the ET regime over the ET anomalies, yet we believe it has the disadvantage of making the Figure even more dense. Plotting the regime with a hatch would not allow to draw the anomalies of the two local controllers – SM and radiation – in the same panels with ET (as shown in answer to comment 2-5). SM and radiation anomalies are located over the anomalies of ET and allow the reader to visualize the last step in the chain. We propose to leave Figure 1 separate from the others with a change (see answer to comment 3-0).

2-9) Variable names are missing in the Colorbar titles of panels a+b (precipitation) and g+h (ET). It is given for panels d+e (SM)

We thank the reviewer for noticing this. We have complemented all the labels in all the colour bar legends; see answer to comment 2-3.

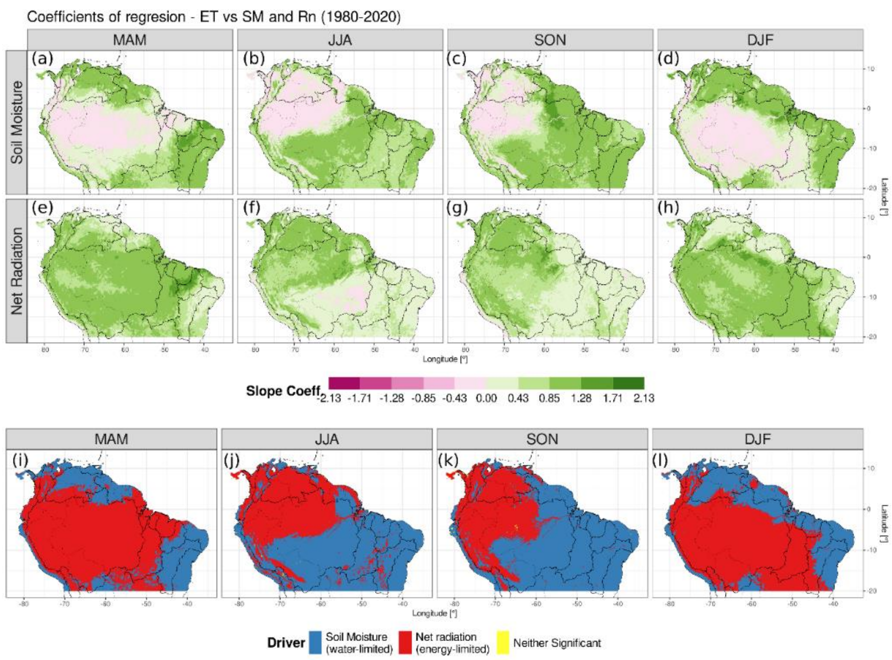
3 - 0) Figure 1: If I understand well to the top panels give the maximum correlation of either SM or net radiation (Rnet). In the panels at the bottom the variable of maximum correlation is given. The "neither significant" seems to indicate pixels where the correlation with SM and Rnet are not sufficiently different to declare a winner. At the same time there are winners that have very low correlations with r2-classes going down to almost 0. Doesn't it make more sense to define "neither significant" as pixels where r2 is below a certain threshold (maybe 0.5 or 0.6)?

We thank the referee for the comment. There is a misunderstanding in the referee's interpretation; Figure 1 top panels (panels a to d) are not correlations, they are coefficients of determination of a multi-linear regression. The latter is written in the Figure caption "(a-d) Adjusted coefficients of determination for the multiple regression ..." and the method is described in section 3.1 Methods line 95 (which corresponds to section 4.1 results where Figure 1 is located). The coefficient of determination is a metric of the performance of the multiple regression and does not refer to the individual independent variables. We included the metric in the Figure to show that it is enough to just consider SM and radiation for explaining the local variability of ET (climate modes are the earth system drivers of ET).

The bottom panels (panels e to h) show the variable with the maximum coefficient of the multi-linear regression, as indicated in the caption "(e-h) variable with the highest significant coefficient.". This coefficient is the same slope described in the Methods section 3.1 line 95. The significance comes from the t-student test p-value in the regression for each independent variable; we used a 95% confidence interval. Hence, when the p-value for one of the independent variables/predictors is below 0.05 ($p<=0.05$), it means that the variable is a meaningful addition to the multi-linear regression, and it does not depend on the coefficient of determination (R^2). This is another advantage of regressions over correlations; we do not need to specify a threshold. We see that we forgot to specify the p-value we used for identifying if the coefficients of the dependent variables were significant and hence we will add it.

Consequently, the significance of the predictors cannot be defined with a threshold of the R^2. However, a very low R^2 would tend to produce high p-values over all predictors (not significant variable) because already indicates that the chosen independent variables cannot explain the dependent variable.

Since the coefficient of determination can create a misunderstanding, we propose to change it for the plots with the values of the multi-linear slope coefficients; the R^2 will be sent to the supplementary material. The new Figure 1 will be:



Therefore, we propose to change the caption from:

"(a-d) Adjusted coefficients of determination for the multiple regression of SM and Rn standardised anomalies targeting those of ET and (e-h) variable with the highest significant coefficient"

To:

"(a-d) multiple linear regression slope coefficient for Soil Moisture, (e-h) slope coefficient for the Net Radiation and (i-l) variable with the highest significant multiple linear slope coefficient ($p<= 0.05$)"

We also propose to add the equation of the multi-linear regression to the methods Section 3.1 (line 97):

The multiple linear regression is then expressed as:

$$ET_{ij} = a * SM_{ij} + b * Rn_{ij} + C$$

Where *ET* is the total evaporation, *SM* is the volumetric soil water content in the first layer, *Rn* is the surface net radiation, *i* refers to a specific longitude and *j* to a specific latitude. *a* and *b* are then the regression slope coefficients and *C* the intersect.

4 - 0) Tower data: You use model data and satellite remote sensing products that are models themselves (e.g GLEAM) or rely heavily on empirical calibrations procedures (e.g. Soil Moisture). Did you consider to do this analysis for in-situ tower data? There are now many, long-term tower sites in the Amazon, which can be filtered based on the same Atlantic mode index and evaluated for the rain-radiation-soil moisture-ET chain. It would make the message stronger.

We appreciate the comment and question. Yes, we looked for the data but found that the time span was short (most of them after 2000s), for having enough repetitions of the inter-annual climate variability modes. For example, the Atl3 had just two positive events and three negative during JJA after 2000s (look at Figure S6 in our supplementary material). Moreover, there were few ENSO events, making it difficult to separate the effects of this mode from the Atlantic modes. Consequently, even a correlation analysis would probably indicate not statistically significant correlations due to the few degrees of freedom. Baker et al. (HESS, 2021) managed to use one tower with 19 years of data (1999-2017) and highlighted that the records in the other towers were only available for a few years (mainly between 1999 and 2006). Moreover, Jung et al. (2019) produced the FLUXCOM product which is available after 2001, imposing the same problem.

The performance of ERA5-Land and GLEAM ET have been evaluated by several research (Muñoz-Sabater et al., 2021; Xie et al., 2024). Xie et al. (2024) specifically evaluated several products against eddy-covariance towers – with some of them in the east part of the Amazon – and found a correlation with ERA5-Land of around 0.7 and with GLEAM of 0.6 for the Evergreen Broadleaf Forest (which is the land cover category assigned for the Amazon towers). Furthermore, some have reported problems with the energy balance closure across tower sites (Jung et al., 2019; Mauder et al., 2020).

Therefore, we excluded the data from our analysis and mentioned in the conclusions – line 330 of the original manuscript – that a longer time series could confirm the dynamics exposed in our research. Moreover, in Section 4 discussion in line 258, we cite some studies that evaluated the performance of ERA5-Land and GLEAM against eddy covariance towers.

We still propose to add this description to section 2 Data, in line 66 in a new paragraph:

Some eddy-covariance towers are located in the Amazon and other places in South America and their measurements are –in general– after 2000. Baker et al. (2021) managed to use records from one tower with 19 years (1999-2017) but highlighted that in the other towers the data was only available for a few years (mainly between 1999 and 2006). Other global products based on FLUXNET towers, such as FLUXCOM (Jung et al., 2019), also have data after 2001, which constrains the possibility of registering several events to analyse the effect of the climate modes (few degrees of freedom). The performance of GLEAM and ERA5-Land ET have been evaluated against eddy-covariance towers and have found correlations of around 0.6 and 0.7 for the Evergreen Broadleaf Forest, respectively (Muñoz-Sabater et al., 2021; Xie et al., 2024). Therefore, we choose not to analyse this source of data.

Minor issues – comments specific lines:

Line 26: remove “planning” and replace “achiving” with “achieving

Thanks. Changed.

Line 30: replace “…physical mechanism is...” with “…underlying physical mechanisms are …”.

Thanks. Changed.

Line 37: replace “besides” with “as well as”

Thanks. Changed.

Line 50: previously you also mentioned TNA as relevant Atlantic mode. Motivate why you will not include that one in this study

We appreciate the referee’s comment. We do include the TNA dynamics within the Atlantic Meridional Mode (AMM). Many define the TNA as the spatial averaged SSTA in the region [70°W-15°W]x[5°N-110 25°N]. Many authors have just studied the TNA without considering the southern part of the tropical Atlantic (Arias et al., 2020).

However, we discover in our exploratory analysis that the influence of the TSA is needed for finding statistically significant correlations of the climate modes with rainfall, ET and many other variables used in our study. The AMM could be defined as:

$$AMM = TNA - TSA$$

as specified in our manuscript in line 109 - "The AMM monthly index is defined as the subtraction of spatially averaged tropical southern Atlantic SSTA [40°W-0°W]x[25°S-5°S] from the northern domain [70°W-15°W]x[5°N-110 25°N];"

We propose to add to line 111 in the Section 3.2 Composites the next text:

The spatial definition of the AMM comprises also the TNA.

Line 68: "related"??? Do you mean "relates"?

Thanks. Yes, it was a typo. Corrected.

Line 73: You take the first soil layer, is that because the root-zone is defined in this layer?

We appreciate the referee's question. The dynamics of the lower layers are linked to the changes in the first layer. Moreover, the root-zone in ERA5-Land depends on the type of vegetation as a root percentage is defined for each soil layer (table 8.4 of the technical documentation of the IFS – Cy48r1 (ECMWF, 2023)). There are some vegetation types that do not have roots in the bottom layers, and in many types, the percentage of roots in the 1st layer is the highest. Hence,

Trees with deep roots can still access water from the deep layers when stressed, but this is a survival mechanism, and hence, they access the 1st layer most of the time. We discuss this in line 261 of the original manuscript as requested in a previous submission.

Line 79-80: Incomplete sentence "MSWEP also uses ERA5 rainfall estimates but strongly in the extra-tropics whereas …"

We do not understand this comment; in the manuscript the sentence continues with: "satellite data is given stronger weights in the tropics".

To clarify if we propose to add:

"where as the ingested satellite data in MSWEP is given stronger weights in the tropics"

Line 95: Rephrase "SM and net radiation are classified with a multi-linear regression slope,.." to "SM and net radiation are classified with the slope of their multi-linear regression against evaporation, .."

We are grateful for the proposed change that can clarify the misunderstanding.

Title section 4.2: replace "… and the evaporation" to "..and evaporation"

To also answer referee #1 comment about line 150, we have modified the title of the section from:

"Chain between the Atlantic modes and the evapotranspiration"

To:

“chain of physical processes linking the Atlantic modes and continental evapotranspiration”

References:

Arias, P. A., Martínez, J. A., Mejía, J. D., Pazos, M. J., Espinoza, J. C., & Wongchuig-Correa, S. (2020). Changes in Normalized Difference Vegetation Index in the Orinoco and Amazon River Basins: Links to Tropical Atlantic Surface Temperatures. *Journal of Climate*, *33*(19), 8537–8559. https://doi.org/10.1175/JCLI-D-19-0696.1

Baker, J. C. A., Garcia-Carreras, L., Gloor, M., Marsham, J. H., Buermann, W., Da Rocha, H. R., Nobre, A. D., De Carioca Araujo, A., & Spracklen, D. V. (2021). Evapotranspiration in the Amazon: Spatial patterns, seasonality, and recent trends in observations, reanalysis, and climate models. *Hydrology and Earth System Sciences*, *25*(4), 2279–2300. https://doi.org/10.5194/hess-25-2279-2021

Beck, H. E., Wood, E. F., Pan, M., Fisher, C. K., Miralles, D. G., van Dijk, A. I. J. M., McVicar, T. R., & Adler, R. F. (2019). MSWEP V2 Global 3-Hourly 0.1° Precipitation: Methodology and Quantitative Assessment. *Bulletin of the American Meteorological Society*, *100*(3), 473–500. https://doi.org/10.1175/BAMS-D-17-0138.1

Dominguez, F., Eiras-Barca, J., Yang, Z., Bock, D., Nieto, R., & Gimeno, L. (2022). Amazonian Moisture Recycling Revisited Using WRF With Water Vapor Tracers. *Journal of Geophysical Research: Atmospheres*, *127*(4). https://doi.org/10.1029/2021JD035259

Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., Shukla, S., Husak, G., Rowland, J., Harrison, L., Hoell, A., & Michaelsen, J. (2015). The climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes. *Scientific Data*, *2*, 150066. https://doi.org/10.1038/sdata.2015.66

Jung, M., Koirala, S., Weber, U., Ichii, K., Gans, F., Camps-Valls, G., Papale, D., Schwalm, C., Tramontana, G., & Reichstein, M. (2019). The FLUXCOM ensemble of global land-atmosphere energy fluxes. *Scientific Data*, *6*(1), 74. https://doi.org/10.1038/s41597-019-0076-8

Makarieva, A. M., Nefiodov, A. V., Nobre, A. D., Baudena, M., Bardi, U., Sheil, D., Saleska, S. R., Molina, R. D., & Rammig, A. (2023). The role of ecosystem transpiration in creating alternate moisture regimes by influencing atmospheric moisture convergence. *Global Change Biology*, *29*(9), 2536–2556. https://doi.org/10.1111/gcb.16644

Martens, B., Miralles, D. G., Lievens, H., Van Der Schalie, R., De Jeu, R. A. M., Fernández-Prieto, D., Beck, H. E., Dorigo, W. A., & Verhoest, N. E. C. (2017). GLEAM v3: Satellite-based land evaporation and root-zone soil moisture. *Geoscientific Model Development*, *10*(5), 1903–1925. https://doi.org/10.5194/gmd-10-1903-2017

Mauder, M., Foken, T., & Cuxart, J. (2020). Surface-Energy-Balance Closure over Land: A Review. *Boundary-Layer Meteorology*, *177*(2–3), 395–426. https://doi.org/10.1007/s10546-020-00529-6

Muñoz-Sabater, J., Dutra, E., Agustí-Panareda, A., Albergel, C., Arduini, G., Balsamo, G., Boussetta, S., Choulga, M., Harrigan, S., Hersbach, H., Martens, B., Miralles, D. G., Piles, M., Rodríguez-Fernández, N. J., Zsoter, E., Buontempo, C., & Thépaut, J. N. (2021). ERA5-Land: A state-of-the-art global reanalysis dataset for land applications. *Earth System Science Data*, *13*(9), 4349–4383. https://doi.org/10.5194/essd-13-4349-2021

Staal, A., Tuinenburg, O. A., Bosmans, J. H. C., Holmgren, M., van Nes, E. H., Scheffer, M., Zemp, D. C., & Dekker, S. C. (2018). Forest-rainfall cascades buffer against drought across the Amazon. *Nature Climate Change*, *8*(6), 539–543. https://doi.org/10.1038/s41558-018-0177-y

Xie, Z., Yao, Y., Tang, Q., Liu, M., Fisher, J. B., Chen, J., Zhang, X., Jia, K., Li, Y., Shang, K., Jiang, B., Yang, J., Yu, R., Zhang, X., Guo, X., Liu, L., Ning, J., Fan, J., & Zhang, L. (2024). Evaluation of seven satellite-based and two reanalysis global terrestrial evapotranspiration products. *Journal of Hydrology*, *630*, 130649. https://doi.org/10.1016/j.jhydrol.2024.130649

Zanin, P. R., Pareja-Quispe, D., & Espinoza, J. (2024). Evapotranspiration in the Amazon Basin: Couplings, hydrological memory and water feedback. *Agricultural and Forest Meteorology*, *352*(April), 110040. https://doi.org/10.1016/j.agrformet.2024.110040