Answer to Comments from Referee #1

We 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.

The manuscript investigates the reasons behind the link between the Atlantic Meridional Mode and the Atlantic El Nino Equatorial mode in Tropical South America. Subobjectives include determining the drivers of evaporation and establishing the sequence of physical mechanisms linking modes to anomalies.

We thank the referee for reading and reviewing the manuscript. We have revised it according to her/his suggestions to clarify the sentences and clearly convey the knowledge gaps we are solving regarding South America's evapotranspiration drivers (local controllers and Atlantic modes driving those local conditions). Each comment is answered in the text below.

We previously referred to both – climate modes, and local net radiation and soil moisture conditions – as "drivers", and this generated a misunderstanding. Both are drivers, climate modes at the beginning and the others at the end of the chain. Therefore, we propose to change the concepts of *earth system drivers* to refer to the climate modes that drive atmospheric circulation variability, which then impact local conditions, and *local controllers* of ET to refer to net surface radiation and soil moisture (which define the water- or energy-limited ET regime). This modification of concepts is implemented in several proposed changes throughout the manuscript.

Main comments:

1) I appreciate the wide use of resources and data to address the objectives and the nice figures used to do so. It is also commendable to explain the chain of atmospheric processes that explain evapotranspiration. Although I do not have major concerns with the scientific approach and its validity, the manuscript in its current state is convoluted, hard to read, and lacks a clear direction. First, the reasoning behind the need to understand the "chain" of mechanisms is not clear, nor is there a need to find all these correlations. Why are they needed in the first place? This even affects the potential reviewer's assessment regarding the scientific approach.

We are grateful to the referee for the comment. Regarding the need to unravel the knowledge gap, we indicate in the first paragraph – in line 24 – that "Among them, terrestrial evaporation is key for water, energy and carbon cycles (Wang & Dickinson, 2012). To predict ecosystem activity, it is essential to identify the evapotranspiration response to internal climate variability drivers (IPCC, 2021)". This is why the community needs to know about our research, which explains those earth system drivers of Amazon's ET and the processes involved in the chain.

The main physical mechanism in our research was presented in line 152; referee #2 identifies it in his/her comment 2 and makes a sketch which we will add to our summary figure (graphical abstract). With the term physical mechanisms or chain, we refer to the progressive physical processes or interactions that drive changes in the earth's system components. We recognize this should be in the introduction and propose a change in answer to comment 2a (to move the sentence in line 152).

We thus propose to modify the statement of the knowledge gap (line 41) by paraphrasing the sentence in line 24 close to it. We will also rewrite line 41 to address a comment about it, and thus it will change from:

"However, the physical mechanisms that teleconnect the Atlantic modes with the hydrological variability – especially with evapotranspiration – remain unclear"

To:

However, it is still not known which are the physical processes/mechanisms that teleconnect the Atlantic modes with South America's hydrological variability – i.e. its alteration of regional atmospheric circulation and thus its impact on local atmospheric and land-surface conditions – especially with evapotranspiration. Understanding these hydrometeorological processes will allow the community to better understand the response of ecological processes to hydroclimate variability (Eagleson, 2013), thus increasing the potential predictability of ecosystems' activity.

We address the comment about correlations in the comments to specific lines (line 134) and in the reviewer #2 comment 3-0. The multi-linear regression – which is explained in section 3.1 – was misinterpreted as a correlation analysis (see answer to comment 3 and specific comment to Figure 1 caption).

2a) To explain to the authors what I mean, I opted to supply an attachment with comments where I consider that the manuscript fails to explain the purpose, aim, and methods to the reader. The introduction does not correctly identify a knowledge gap; if it does, it is not based on a robust literature review that sets the state-of-the-art. When I arrived at the three objectives at the end of the introduction, I noticed that little background was given to justify them was not much related to them.

We appreciate the referee's comment that allows us to convey better how we are identifying the knowledge gap. Referee #2, in her/his general comment, argues that the manuscript "is well written and well-embedded in the current literature on this topic", and recommends publication provided the proposed changes are incorporated. We recognize the literature review was disorganized and propose to make some modifications.

We cited in line 42 "Some studies have statistically investigated ENSO's (Le & Bae, 2020; Diego G. Miralles et al., 2014; Moura et al., 2019) or Atlantic modes' teleconnections with the evaporation in South America (Martens et al., 2018)", which evidence studies using statistical techniques to identify which climates modes affect South America's ET. However, we did not find any previous study that looks at how Atlantic modes drive anomalous regional circulation and moisture, then impact the two local controllers and thus control ET; that is why we proposed sub-objective #2. More importantly, we tackle the knowledge gap between climate modes and ecological processes by showing the hydrometeorological variability processes in South America, thus increasing the capability of predicting ecosystems' activity.

Regarding subobjective #1, we also say in line 51 "Previous research has established Soil Moisture and Net Radiation as the primary evaporation drivers in the atmosphere and the land-surface (Hirschi et al., 2014; Seneviratne et al., 2010); consequently, evaporation is classified into two regimes: water- or energy-limited". However, we did not find studies that specifically explain the variability of SM and radiation in South America linked to the Atlantic modes.

Regarding subobjective #3, we cite in line 38 "Although the Atlantic modes are associated with ENSO through atmospheric bridges or extratropical pathways (Compo & Sardeshmukh, 2010; García-Serrano et al., 2017; Martín-Rey et al., 2014), each of them has specific regional impacts on sea-level pressure (SLP) and hence on atmospheric circulation". These papers state that is difficult to establish which places are affected by a specific mode of variability. In the answer to the reviewer's comment about line 50 we state the reasons for excluding the influence of other climate modes different from the Atlantic and ENSO. This objective helps to discuss the results in section 5 Discussion.

We identify the sources of confusion and rewrite the knowledge gap statement in our answer to comment 1.

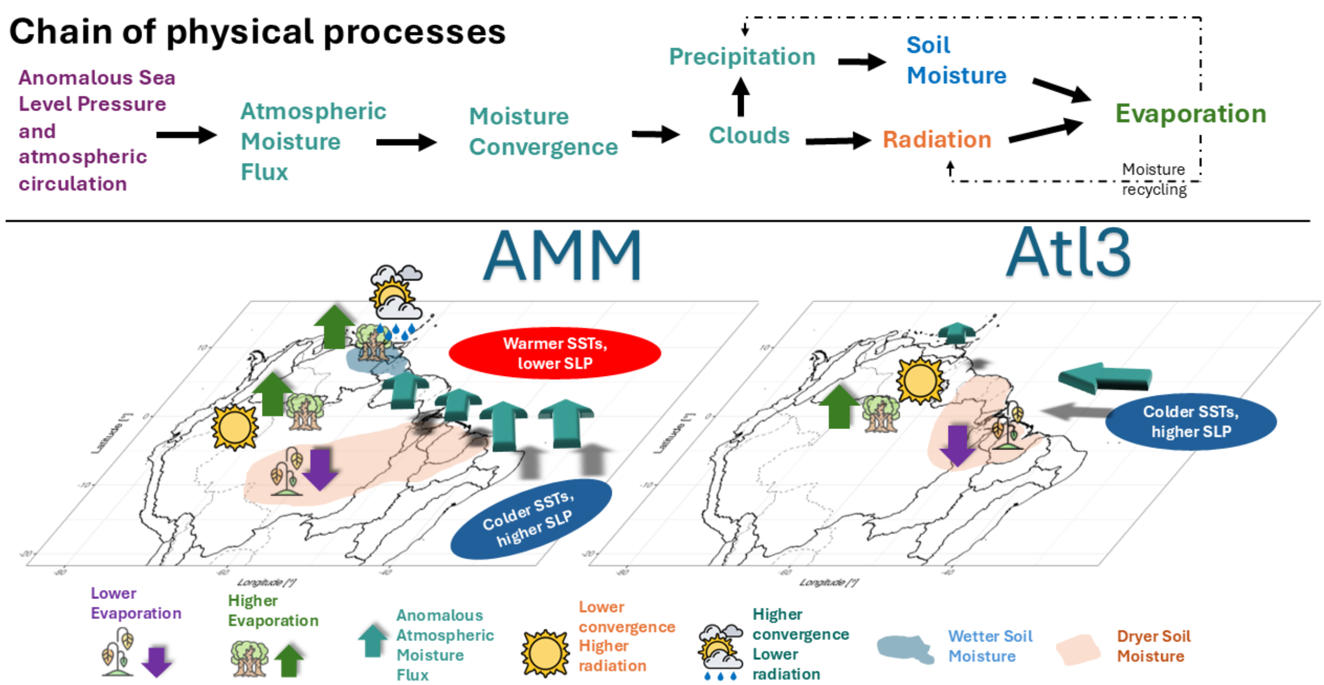
We propose to change line 42 – which is before the objectives – considering what we previously cited and the opportunity the referee gives us to reorganize and properly convey the knowledge gap. Line 51 will be moved upward to line 42, closer to the statement of the knowledge gap. Objectives will be changed to questions (see the answer to comment 2b). Line 42 will then change form:

"Some studies have statistically investigated ENSO's (Moura et al., 2019; Le and Bae, 2020; Miralles et al., 2014) or Atlantic modes' teleconnections with the evaporation in South America (Martens et al., 2018), but the physical reasons for these connections are not known"

To:

Previous research has established soil moisture and net radiation as the primary evapotranspiration local controllers (Hirschi et al., 2014; Seneviratne et al., 2010); consequently, evaporation is classified into two regimes: water- or energy-limited. Other research has looked at the influence of Amazon soil moisture memory on ET (Zanin et al., 2024), but we did not find studies linking the Atlantic modes to soil moisture. Previous studies have statistically investigated ENSO's (Le & Bae, 2020; Miralles et al., 2014; Moura et al., 2019) or Atlantic modes' teleconnections with the evaporation in South America (Martens et al., 2018). Nevertheless, it is still not known how the Atlantic modes drive regional atmospheric circulation, which then alters 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.

We will include a scheme of the chain in the modified summary image.



2b) Furthremore, the subobjectives do not relate to each other. What are the key research questions that you want to be answered? Is there a hypothesis that wants to be tested?

We thank the referee for pointing out that this is not clearly explained. The subobjectives are stated as activities; we recognize it is better to formulate them as questions.

The first subobjective pretends to identify in which season a specific location is behaving in a water- or energy-limited regime (Seneviratne et al., 2010). This is necessary because the Atlantic modes will induce atmospheric circulation anomalies, not directly an ET anomaly or local controllers anomaly. A hypothesis in our study is that climate modes change the radiation availability; the hypothesis comes from the previous studies about rainfall anomalies induced by the climate modes because of related cloud cover changes. This was implicitly stated in line 44: "Some research has addressed the interannual changes in moisture transport, convergence, cloudiness and associated rainfall in the region (Cai et al., 2020; Hoyos et al., 2019; Ruiz-Vásquez et al., 2024)". To keep the introduction concise, we had decided not to explicitly state this hypothesis, but we now recognize that it is needed to add the radiation component to the sentence (see specific answer to comment about line 44).

The second subobjective intends to corroborate the previous implicit hypothesis. We need to establish what is the chain of events imposed by the Atlantic modes, that starts with the modes altering the atmospheric circulation and then impacting the local atmospheric conditions. Afterwards, those local atmospheric conditions affect the land-surface controllers – such as the surface net radiation and soil moisture – which is tackled in the 1st subobjective.

The third subobjective connects to the 2nd because of the debate on the pantropical climate interactions, which we stated in line 38 (Cai et al., 2019; Compo & Sardeshmukh, 2010; Martín-Rey et al., 2014; García-Serrano et al., 2017). With the partial correlation analysis, we intend to know where the modes control the variability of ET by retrieving the signal from the other modes, whose physical mechanism was addressed in the 2nd subobjective. As the influence of ENSO on South America's ET was already statistically established (Moura et al., 2019; Le & Bae, 2020; Miralles et al., 2014), we evaluated the effects of the Atlantic modes retrieving the ENSO signal.

We thus propose to change the subobjective/activities – in line 54 – to questions, from:

"1. determining where and when evaporation is dominated by a water- or energy-limited regime

2. establishing the chain of events that link the Atlantic modes to anomalies in atmospheric and land-surface drivers and thus in evaporation, and

3. discovering which regions are affected by the Atlantic modes, by ENSO, and where the impacts of the modes overlap"

To:

"We aim to answer the following questions:

1. where and in which season is the evapotranspiration dominated by a water- or energy-limited regime (dominated by which land-surface local controller, i.e. soil moisture or radiation)?

2. How do the Atlantic modes drive anomalous atmospheric circulation and influence the variability in local atmospheric conditions, and how do they then affect the local controllers and thus affect evapotranspiration? (chain of events)

3. Where do the dynamics and thus the impacts of the Atlantic modes overlap with those of ENSO in time and space?"

2c) How is the manuscript advancing the current literature? It is unclear why "the teleconnection of the Atlantic modes of variability with the soil moisture and evaporation of the region remains unclear" in the literature.

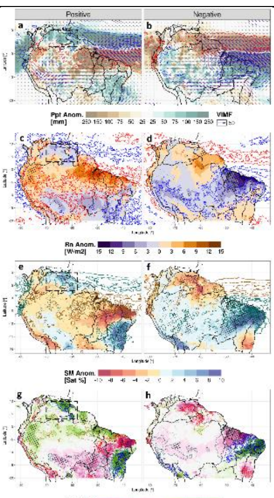
We thank the reviewer for the question. Our research discovered that interannual changes in winds and moisture advection drive changes in the local controllers of ET (SM and Radiation) and, thus, in ET. Variability exerted by the Atlantic modes. Therefore, our study also helps to explain the variability of latent heat flux in the Amazon and to improve the predictability of ecological processes and ecosystem behaviour since ET is closely related to the process of photosynthesis. We discover that ENSO's convection inhibition is not the only driver of ET, but the anomalies of moisture advection exerted by the Atlantic modes also play a role and they affect different areas compared to ENSO. The changes in Atlantic regional atmospheric circulation and moisture were never linked before to the variability of radiation, soil moisture or evaporation in South America. This was shown in figures 2 to 5 and stated in line 300 in the conclusions. Reviewer #2 recognizes the new knowledge gap in the general comment.

In our answer to the first comment, we proposed to rewrite the statement of the research gap to clarify it.

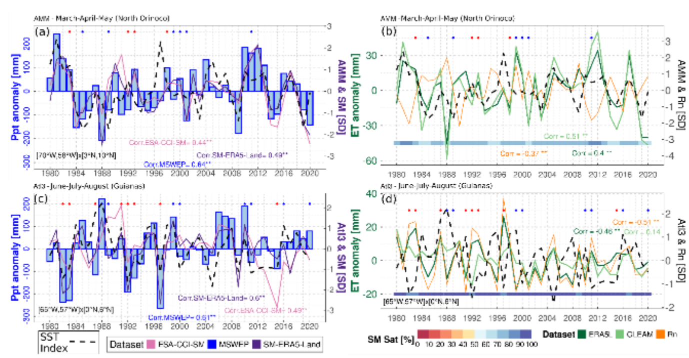
3) The number of acronyms used and the lack of explanation of the reasoning for conducting the methods also make it hard to judge or even read the results. I recommend the results be divided into several additional sections that may independently address each objective. This is especially necessary for section 4.2., which is too repetitive and complex to understand. The figures are also complex; they have too much information and acronyms. I recommend opening these figures and analyzing each of the panels separately.

We thank the referee for the suggestions. Section 3 Methods is subdivided into three subsections to answer each one of the three questions/activities, and these methods sections correspond to each of the three subsections of Section 4 Results.

We have opened up Figures 2 to 5 as suggested; the details are given in the answer to reviewer #2 comment 2-3 and 2-4. In summary, the time series are moved to section 4.3 to a new Figure 7 and further discussed regarding the overlapping effects with ENSO.



Modified Figure 2



Proposed new Figure 7

For subobjective #1, the local ET controllers, we used the multiple linear regression slope which is explained in section 3.1. Line 96 says the reasoning for this analysis "The regression analysis can suggest whether the evaporation anomalies are associated with water availability or a radiation anomaly (evaporation regime)".

However, in section 4.1, Figure 1, the key ET controllers, the referee comment confuses our multi-linear regression with a correlation analysis, the top panels are the coefficient of determination (see the answer to comment about line 134).

For subobjective #2 and section 4.2, we created repetitive figures because each season has a particular impacted region. This is very important because the seasonal changes in the evaporation regime cause the Atlantic Meridional Mode to affect different regions depending on the season. We state this in the conclusions in line 309. The repetitive figures will be simplified, see answer to comment 4. The reasoning for the composite analysis is stated in line 99: "This study uses composite analysis to exemplify the state of the atmosphere and the land surface at the active phase of the Atlantic modes".

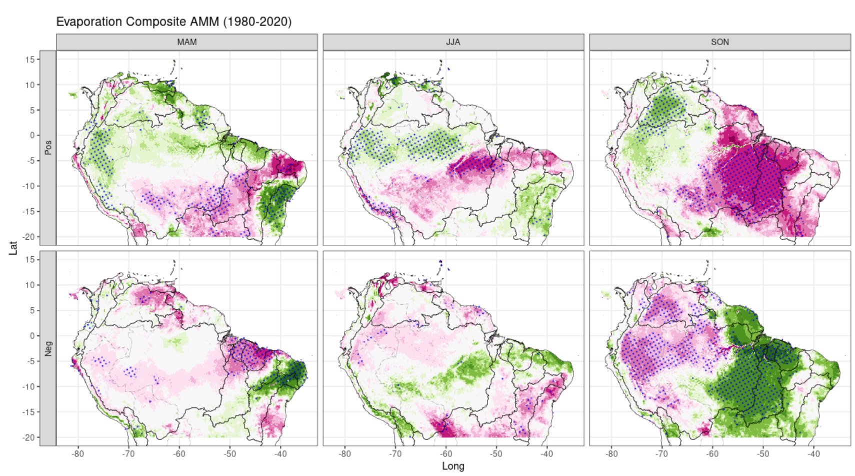
For subobjective #3, section 3.3 explains that we intend to know where the modes drive the variability of ET by retrieving the signal or the confounding effect from the other climate modes. Regarding other possible climate modes, we answer below in the comment to line 50.

We still address and propose changes to all specific comments that might cause misunderstandings with the figures and their interpretation (see answers to specific comments below). We proposed to change subobjective to questions in answer to comment 2b.

4) Finally, I believe that most readers of HESS do not have sufficient knowledge to understand the paper. Many evident and necessary definitions of terms for the study are missing, making it difficult for the paper to understand. Conclusions should also be directly and explicitly related to your objectives of questions.

We thank the referee for indicating those terms that are not clear or are difficult to understand. However, we do not agree with the claim that the readers of HESS do not have sufficient knowledge to understand the paper; we recognize that some definitions need to be extended and propose changes in this and the answer to reviewer #2. The need to understand the chain is modified in answer to comments 1 and 2c, and the explanation of the physical mechanisms – the chain – is modified in comment 2a.

To simplify the article, we 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, and sections 4.2.2 and 4.2.3 will be rewritten.



Regarding the conclusions, we summarize the physical processes/mechanisms associated with the climate modes in lines 301 about the chain, 304 about the processes of the Atl3 and 307 about the processes of the AMM, correspondingly with the identified research gap and the 2nd sub-objective. The 1st sub-objective/question is answered in line 317 where the role of SM and radiation are highlighted. The 3rd subobjective is answered with line 305 where the conjoint effect of ENSO with the Atl3 is summarized.

We propose to add the following lines to the conclusions Section to make more explicitly the answer to the 1st subobjective (drawn from results in Fig. 1). We will add to line 303:

However, the chain of processes is modulated by the annual cycle of the ET regimen which is not completely energy-driven throughout the tropical region and throughout the annual cycle. The chain can be applicable to other tropical regions in the world.

We also propose to add the following lines to the conclusions Section to make more explicitly the answer to the 3rd subobjective (drawn from results in Fig. 6 and 7). We will add to line 313:

AMM and ENSO conjointly affect the breadbasket region of Northeast Brazil and the central Amazon but the AMM affects more the western Amazon and Orinoco.

We also propose to modify line 323 to emphasize the usefulness of our results, changing from:

“The analysed phenomena have implications for gross primary production, the carbon cycle and can be used for predicting the response of ecosystems’ activity.”

To:

The analysed phenomena have implications for gross primary production, the carbon and energy cycle, and can potentially be used for predicting the response of ecological processes and ecosystems’ activity.

Specific comments:

Line 19 – Convoluted sentence

Thank you. We propose to rewrite the sentence from:

“Other variability sources stem from other ocean basins, Madden-Julian Oscillations or local features like topography or land-atmosphere interactions”

To:

Other sources of seasonal variability stem from other ocean basins (e.g. the Atlantic), and at other temporal scales from Madden-Julian Oscillation or local features like topography or land-atmosphere interactions.

Line 21 – Convoluted sentence, you use the word "anomalies" three times in the same sentence

We thank the referee which indicates the specific difficulty with the sentence. We propose to rewrite it, changing it from:

“The modes cause their impact through atmospheric circulation anomalies; those anomalies enforce hydrological variability, which is evidenced by anomalies of precipitation, soil moisture (SM), temperature, evapotranspiration and streamflow”

To:

The modes cause their impact through atmospheric circulation anomalies and hence drive local atmospheric conditions; those interannual deviations from the climatology enforce hydrological variability, which is evidenced by variations of precipitation, soil moisture (SM), temperature, evapotranspiration and streamflow.

Line 23 – Is this the same as evapotranspiration?

Yes, transpiration is also a type of evaporation, and open water is considered part of the continents, terrestrial evaporation consists of whatever evaporative flux over the continents. Evapotranspiration consists of soil water, open-water evaporation and transpiration, so then terrestrial evaporation is also a synonym of evapotranspiration. D. G. Miralles et al. (2020) argue that using evaporation is a more accurate term and that the fact of using one concept or the other should not matter.

Line 26 – planning or considering them

Thanks. This is a typo. We also take the opportunity to rewrite it:

and their consideration in long-term planning is critical for achieving sustainable development.

Line 30 – what do you mean by this? Is this supposed to be the knowledge gap?

We thank the referee for indicating where clarifications are needed. The sentence refers to studies about precipitation variability, in which physical phenomena cause interannual changes at several temporal scales (thus, it is still not completely understood). However, as our research focuses on interannual evapotranspiration variability and at seasonal scale, we decided to suppress the second part of the sentence that talks about precipitation and cloud cover.

We added an explanation of what physical mechanisms mean in answer to comment 1. Physical processes comprise climate phenomena; they are quantifications of physical properties rather than statistical variables.

Line 38 – what do you mean with these two terms? (atmospheric bridges or extratropical pathways)

The cited literature in the sentence describes how ENSO alters the Walker cell and then generates atmospheric subsidence over East South America and the Atlantic. The latter is what they and us refer to as the atmospheric bridge; the anomalous subsidence weakens the Atlantic Hadley cell, the trade winds towards the equator and then partially forces the coupled Atlantic ocean-atmospheric modes (the AMM and the Atl3). The extratropical pathway is the excitation of the Pacific North American pattern, a series of anomalous high and low pressure systems that connect the tropical Pacific, Alaska, east North America and the Tropical North Atlantic; the pressure systems then influence the atmospheric conditions over the Atlantic, which influence the ocean, and partially force the phase of the Atlantic modes.

Line 41 – Not clear what you mean with "the physical mechanisms". This is important as it appears that this is your knowledge gap of the study.

Effectively this is the sentence and paragraph where we identify the knowledge gap. We thank the referee for pointing out that this is not clear; this has been answered in comment 1, where we have also modified the sentence. The definition of physical mechanisms is also addressed in comment 1 and it will be added to the introduction (answer to comment 2a).

Nevertheless, it is still not known how the Atlantic modes drive regional atmospheric circulation, which then alters 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.

Line 44a – again, give an example of what a physical reason would be? It is not clear where you are going with this.

Thank you. This has been answered in comment 1, comment 2a and comment 41.

Line 44b – The studies have addressed what really? (Some research has addressed the interannual changes in moisture transport, convergence, cloudiness and associated rainfall in the region)

We see that this sentence can be complemented. The sentence supports the knowledge gap regarding the cloudiness, it will now also explicitly indicate the control climate modes exert in the variability of radiation.

We changed it from:

"Some research has addressed the interannual changes in moisture transport, convergence, cloudiness and associated rainfall in the region (Hoyos et al., 2019; Cai et al., 2020; Ruiz-Vásquez et al., 2024)"

To:

Some research has addressed the causes of interannual rainfall variability by analysing the interannual changes in moisture transport, convergence, and cloudiness exerted by Atlantic modes and ENSO in the region (Hoyos et al., 2019; Cai et al., 2020; Ruiz-Vásquez et al., 2024); those changes in moisture transport and cloudiness might affect radiation availability.

Line 48 – This again is too vague. The authors do not specify what really is poorly understood. They also do not say what are these physical mechanisms that they want to address. They also do not mention the importance of addressing these gaps.

We thank the referee for pointing out this is not complete. The cited studies concluded that there are still regions – e.g. Orinoco – where the causes of seasonal rainfall variability are not explained by the atmospheric circulation under the influence of the analysed climate modes (e.g. the TNA, which is brought up in line 47). As we mentioned in answer to comment 2a, the altered atmospheric circulation and moisture transport will also affect the variability of radiation – the physical process – and is now explicitly written in the modified line 42.

The importance of the altered atmospheric circulation in addressing the knowledge gap is to explain the variability of radiation and its effect on ET. The importance of addressing the ET variability is answered in comment 1, and also mentioned in line 23 of the original manuscript.

We propose to modify the sentence from:

"Atmospheric circulation variability produced by the Atlantic SST modes is poorly understood, especially over the north (Orinoco basin)."

To:

Atmospheric circulation variability produced by the Atlantic SST modes is poorly understood between September and November since is not known how altered moisture transport changes convergence, cloudiness and radiation, especially over the north (Orinoco basin).

Line 50 - But why only these, you had mention several modes, so why only AMM and Atl3. And also, what do you mean that their link is with evaporation? I think that here the use of English int he introduction really hampers the understanding of the manuscript an its goals.

We thank the referee for pointing out this is not clear and will improve the manuscript based on it.

The reason why we just analysed those two is what we discovered with the literature review and the principal component analysis described in section 3.2. Previous works have already analysed ENSO's influence over the ET in the Amazon (Moura et al., 2019; Le & Bae, 2020; Miralles et al., 2014), which we described in line 42. In the discussion section, we also mentioned other modes such as the Atlantic Multidecadal Oscillation (line 273), but debated that this is a mode produced by the aerosol forcing in the northern hemisphere (Hua et al., 2019; He et al., 2023), and state that the AMM and the AMO are associated (line 274). We tried to keep the introduction concise, but we recognize that is better to also include some information about it.

With the principal component analysis of the SSTs, we also discarded modes in the Indian Ocean and decided not to mention them (line 109 "not shown"). Moreover, the ocean-atmospheric modes that are not in the neighbouring Pacific and Atlantic oceans and therefore do not change the atmospheric circulation around South America (Cai et al., 2019; Cai et al., 2020 – also in the manuscript). The cited articles are reviews of the pantropical climate interactions and the effects of ENSO over South America, and explain which modes and which do not have effects on the atmospheric circulation around South America.

We propose to add the following sentences after line 40 in a separate paragraph:

The Atlantic Multidecadal Oscillation (AMO) is a climate mode that recently has been attributed to aerosol forcing, and that has an influence on the AMM (He et al., 2023). Previous research claimed that AMO has impacts on South America's rainfall (Knight et al., 2006), but the atmospheric circulation that should be responsible for driving rainfall and cloud cover is related to the AMM (Rodriguez & McPhaden, 2014). The Indian Ocean Dipole mode is another mode whose dynamics are associated with the ENSO's pantropical dynamics (Cai et al., 2019), and do not change South America's regional atmospheric circulation. These modes can be excluded.

Line 51 - Sorry but these does not make much sense. Several concepts are put together in a way that is not coherent and convoluted. Please revise these objectives so that make sense and they follow the main thread that you were trying to portray in the introduction.

We thank the referee for pointing out this is not clear, we will improve the manuscript based on it. We proposed to rearrange the sentences in this paragraph in our answers to comments 1, 2a, 2b and 2c. They modify the paragraph of the identification of the knowledge gap, the transformation of the subobjectives to questions, describe what is a physical mechanism.

Line 58 – I am missing here an overall summary of the methods and the data. Why do you need this data? Why have you chosen these products?

We thank the referee for the comment, we will modify the first paragraph which is already an introduction to the data section but can be complemented.

Line 60 provides evidence as to why we cannot just use satellite data, and in line 62, we argue why we can also not just use reanalysis data. In line 64 we state that both sources are needed to have confidence in the phenomena that we are analysing (i.e. reduce the uncertainties each one of them might have and find consistency). We propose some additions to those sentences.

The products that we use are widely known and chosen because of the methodologies that created them and their performance. The cited literature has evaluated them and evidence they are reliable for certain dynamics (Beck et al., 2021; Gebrechorkos et al., 2024; Valencia et al., 2023; Xie et al., 2024), and therefore many studies used them; we describe possible limitations in line 327. The specific variables are brought up in subsections 2.1 and 2.2., and we will also add their names in the proposed complement to the paragraph.

We propose to add the following statements as a summary of Section 2 Data:

Line 59 – division of paragraph, we 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).

Line 60 – beginning of a new paragraph: Satellite and reanalysis data sources have strengths and limitations. Satellite data can provide some of the needed data mainly over land and moisture transport is not available from this source. Reanalysis data are considered physically-based interpolations of observations and provide atmospheric variables that satellite data does not directly acquire. "Satellite-based datasets have strengths ..."

Line 59 – But what variables are you focusing on?

We thank the referee. In the previous answer – line 58 – we propose to separate the paragraph in two and add sentences describing which variables we will use, even though they are mentioned in subsections 2.1 and 2.2. We will also add a table (see answer to comment 1-9 from reviewer #1).

Line 63 – of reanalysis or satellite-based methods. (?)

Yes. The subject of the previous sentence is "both data sources", in the paragraph which topic is satellite-based and a reanalysis datasets. The pronoun "their" refers to "both data sources".

Line 69 – Why do you choose thee variables? For what purpose?

The mentioned variables are those related to atmospheric circulation and then influence the local atmospheric conditions (i.e. the ET local controllers, already said in line 51). The purpose is to analyse the chain of events that link the atmospheric circulation anomalies – under the Atlantic modes –with local atmospheric conditions and the land-surface controllers (which is the second subobjective as we said in line 55).

We propose to clarify it by adding the paragraph described in answer to comment about line 58. The comment will be written in line 59.

“... it also uses atmospheric circulation variables such as SLP, winds, moisture transport, convergence and rainfall because they drive the local ET controllers.”

Line 93 – This title does not agree with the content of the paragraph. I also think that a brief summary of your methods is needed here. I still do not know where are you heading with this manuscript.

As we mentioned in our subobjectives, we first intend to find the location and the time of the water- or energy-limited evaporation (line 54). Afterwards, in the second subobjective we find the influence of climate modes driving the physical processes. The title and the paragraph indicate we want to find the seasonal annual cycle of local land-surface controllers and not yet the climate variability drivers.

We propose to modify the title from:

“Local and seasonal changes of ET drivers”

To:

Determining the location and annual cycle of local ET controllers

Line 94 – I thought that the modes were the drivers of evaporation. So there are other drivers besides the modes?

We thank the referee for pointing out the misunderstanding we are generating in the manuscript. Local land-surface conditions are the direct drivers of ET and the ocean-atmospheric modes are the drivers of the local conditions; we now see that calling both of them “drivers” generates confusion (even though both are drivers or controllers of the beginning and end of the chain). Therefore, we change now to use the concept of climate modes *drivers* for the atmospheric circulation variability impacting local conditions, and *local controllers* of ET to refer to net radiation and soil moisture. As mentioned in answer to the general comment.

Each methods’ subsection corresponds to one subobjective. First subobjective is to determine the location where and specific local controller dominates, and second, is to determine the ocean-atmospheric phenomena and its influence on the physical processes driving the local controllers.

Line 97 – What do you mean here? (evaporation regime)

The sentence in lines 96 and 97 clearly states the relation between evaporation and water and radiation, the controllers. As we also state in line 53, supporting it with citations (Seneviratne et al., 2010; Hirschi et al., 2014), evaporation is classified into two regimes: water- and energy-limited.

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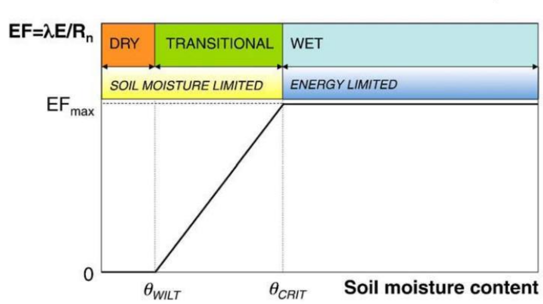

Fig. 5. Definition of soil moisture regimes and corresponding evapotranspiration regimes according to framework described in Section 4.1. *EF* denotes the evaporative fraction, and EF_{max} its maximal value.

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Line 99a – What do you mean with composite analysis?

Composite analysis is a statistical technique widely used in climate sciences to identify and characterize typical conditions or patterns associated with specific events or phenomena (Wilks, 2011). It involves combining multiple instances of a particular event (specific time steps) to create an average or representative picture of the conditions during those events. In line 112, we described how we defined those particular events.

Line 99b – Can you define the active phase for the normal reader?

As described in line 112, "The positive and negative phases are identified when their indices are above or below ±1 standard deviation, respectively, and otherwise are defined as neutral phase (threshold for mode's activation)". "their indices" refers to the climate modes indices based on Sea Surface Temperature Anomalies (SSTAs). This definition comes from the definition of ENSO phases, El Niño and La Niña, when El Niño characterises by high positive SSTAs and La Niña by low negative SSTAs.

Line 108 – "?" (Not shown)

The sentence describes the intermediate step of an exploratory correlation analysis that indicated us which ocean-atmospheric modes have an impact on hydrological variables (the whole paragraph talks about identification of the modes). Those intermediate results, with also the literature review, allowed us to focus on the Atlantic modes and discard ENSO and other modes for the analysis (IOD, AMO, PDO, etc). As those results are not significant for explaining the physical processes of the phenomena, we decided not to show them (see answer to comment about line 50).

Line 132 – Where do I see this in Figure 1?

Thanks for the question. The ITCZ is a narrow band of tropical ascent of moist air, clouds and heavy rainfall (Schneider et al., 2014). Figure 1 e-h show how the net radiation – same energy-limited regime – migrates with the annual cycle from south to north and comes back, as also specified in lines 132 and 133. The fact that energy-limited evaporation unfolds when there is enough availability of soil moisture is evidence of saturated soils (Seneviratne et al., 2010), which happens at high precipitation rates (feature of the ITCZ), but also energy-limited ET unfolds with reductions of net radiation or high cloud cover (also a feature of the ITCZ). The latter are typical conditions of tropical equatorial areas and the migration of the ITCZ. The maps in Figure 1 also display the latitude to clarify that the analysed region is on the equator.

We still propose to add the next sentence to line 133:

, since the heavy rainfall of the ITCZ saturates the soils and influences the locations of energy-limited regime.

Line 134 – what p-value did you use for the test? What test specifically? More details on the correlation analysis are needed.

Figure 1 is not a correlation analysis; it is a multi-linear regression, as indicated in the caption's first line when it says "regression coefficient" and in section Methods 3.1 where the multi-linear regression is described (line 95). The dependent variable is the ET, whereas the independent variables are soil moisture and radiation. The main metric of multiple regression is not the p-value, it is the adjusted coefficient of determination (R^2), which is shown in Fig1 a-d and written in its caption. The R^2 gives information on the quality of the regression. p-values in regression analysis are associated with the individual independent variables and this is shown in Fig1 e-h with yellow colour when a p-value >0.05 (as indicated in the legend). The latter indicates where neither of the independent variables is significant for explaining the dependent variable.

We propose to change the figure's top panels (see answer to comment 3 from reviewer #2), and specify the p-values of the regression coefficients. Therefore, we propose to change the third line of the caption from:

"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 linear slope coefficient ($p<= 0.05$)"

Line 135 – The explanations that come now are very insightful; however, I do not understand where are you getting all this information just by looking at the figures.

We thank the reviewer for the compliment. We are describing the annual cycle of the phenomena of the ITCZ and at the end of the sentence in line 136 we refer to the "energy-limited evaporation", which is one of the main results in Figure 1. The description goes season by season as Figures 1 e to h are displayed. To make easy to spot, we will add the label of each subplot panel to the text, that is:

Line 135 – In MAM (Fig 1e); line 137 - As the ITCZ moves northward in JJA (Fig 1f); line 140 – In SON (Fig 1g); line 142 – In DJF (Fig 1h).

Line 134 – The correlations (R2) are between what variables? Between a mode and a variable? It is not clear.

As specified in the caption, the analysis is a multi-linear regression to find the slope coefficients, not a correlation analysis; this is also explained in section Methods 3.1 multi-linear regression (line 95). The R^2 is the coefficient of determination of the multiple regression (Fig 1 a-d); in panels a to d there are some zones with red and yellow colours but almost all areas are blue and green, meaning what we state in line 133, the majority of ET variance can be explained by just considering SM and radiation.

Caption Figure 1 Line 2 – targeting those of ET? (the multiple regression of SM and Rn standardised anomalies targeting those of ET)

Thank you for the question. Targeting is used – in a linear or non-linear regression analysis context – to also refer to the dependent variable (Martens et al., 2018). First the independent variables are mentioned and afterwards the dependent. The equation for our multi-linear regression is:

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

Where SM is Soil Moisture, Rn is net radiation, and ET is total evaporation, all of them form ERA5-Land and all of them at the same location. The method is also mentioned in line 95 of the methods section. As specified in line 100, all datasets are used between Dec-1979 and Nov-2020, aggregated at seasonal scale and analysed for each season individually and synchronously.

We propose to add the equation to the description of the method in section 3.1, then we will add to line 97 the following:

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.

Caption Figure 1 Line 4 – Also, if the correlations are low (e.g.., red and yellow areas) meaning that there is now correlation, how can you say that the driver is driving SM and Rn anomalies.

Because this is a multiple regression analysis and we are displaying the coefficient of determination (R^2), not a correlation analysis. We are able to determine the driver with the slope of the regression, which is in panels (e) to (h). The colours of the R^2 bar relate to panels a-d. Regarding the red and yellow areas, as we said in line 134: "with some exceptions where wind speed or vapour pressure deficit might be important." Almost all the maps are colour green or blue, meaning R^2 is higher than 0.6, a good threshold for regression performance.

Line 146 - What information in Fig 1 or what interpretation makes you arrive to these statements? Sorry, It is not clear.

We thank the referee for indicating this is not clear. This was meant as an introductory paragraph to section 4.2, where we analyse the moisture convergence, clouds and radiation, rainfall and soil moisture. As the reader will see in the other figures, there are cases when above-average evapotranspiration unfolds during negative precipitation anomalies (Fig 2a and 2g, e.g. over northeast Brazil).

To avoid the confusion with Figure 1, we propose to move the paragraph to line 151, after the title of section 4.2.

Line 150 - Do you mean relationship? (Chain)

We thank the referee for the question. As answered to comment 1, with the chain we refer to the progressive atmospheric processes that generate interactions in the components of the earth system.

To clarify, we propose to change the section title from:

"Chain between the Atlantic modes and the evapotranspiration"

To:

"chain of progressive physical processes linking the Atlantic modes and continental evapotranspiration"

Line 151 - You mean soil moisture and radiation? (key climatic drivers of evapotranspiration)

We thank the referee for the question that highlights the confusion between the drivers and the local controllers. Yes, in this case we refer to the local controllers because at the beginning of the sentence we say that "The interannual variability of atmospheric circulation affects the key local climatic drivers of evapotranspiration". To avoid the confusion, and to be coherent with what we proposed to comment 1, we propose to replace the word "drivers" for *controllers*.

So line 151 will change from:

"The interannual variability of atmospheric circulation affects the key local climatic drivers of evapotranspiration"

To:

The interannual variability of atmospheric circulation affects the key local climatic controllers of evapotranspiration (Soil Moisture and radiation)

Line 152 - I think what you mention in this sentence should have been explained in the introduction

We thank the referee for the suggestion that will clarify an important concept we used in our manuscript. We addressed this comment in answer to major comment 2a, where we proposed to complement line 42 with the sentence:

“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 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.”

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