I'm pleased to note that the authors have made a great effort to improve some sections of the manuscript following my suggestions. The scientific quality and interest of the analysis has been improved and the conceptualization of the research problem refined. I'm pleased to see that they have included an interannual analysis that complements the results that were already in the manuscript. The metrics are now better described in the data and methods section and the Figures have also been improved.

Dear Reviewer,

Thank you for carefully evaluating our manuscript again. Please find our answers to your comments in blue.

However, the narrative is still very confusing. It's not only the poor English writing that represents a barrier for an effective and enjoyable reading process. The manuscript text lacks a fluid narrative, a structured reasoning and a solid storyline. Many sections throughout the manuscript appear completely out of context. Redundant statements are often found and the reader finds himself lost trying to follow the narrative several times. There isn't a proper connection between the results and conclusions and so, in the end, it's difficult to wrap up all things and to get an overall picture of the analysis. Unfortunately, these are all aspects that were pointed out in my last review.

Based on this we decided to completely restructure and rewrite larger parts of the manuscript without changing the scientific content instead of inserting and deleting here and there.

Another major concern is related with the manuscript's size. An effort should be made to release the narrative from analysis and discussions that are not strictly necessary to fulfil the objectives. They can be either removed or moved to the supplementary material. More details about this issue are provided in my minor comments below.

We followed this suggestion and shortened the introduction by removal of some sentences.

My last major comment relates to the poor structuring of some chapters of the manuscript. For instance, the Abstract covers in a very superficial way the goals, the main results and the relevance of the paper. More details about the motivation and the importance of the analysis given the results obtained is absolutely essential.

We rewrote the abstract accordingly

The second part of the Introduction chapter is supported in isolated paragraphs with a fragile connection between them. Some sentences are extremely confusing and written with a poor scientific language.

We rewrote the introduction accordingly

The Discussion chapter presents a muddled narrative that fails to highlight the main findings of the analysis and their implications. Similarly to Introduction, it's not easy to find a connection between paragraphs. An effort must be made to reformulate all these chapters and to adopt a clear, fluid, convincing, objective and logical speech.

The discussion has been revised accordingly (see also the answers to the comments below.

The authors mentioned that the text was proofread by a native English speaker, but many writing problems are still there. Considering all this, I think the manuscript is still not ready for publication.

I've made a great effort to highlight all these problems in the following minor comments and so, I think it's fair to demand a last effort from the authors. The manuscript text must be deeply reformulated following the above describe suggestions and considering the minor issues described below. Otherwise, I will reject it for publication.

We decided to revise the manuscript because only language and structural arguments but no scientific reasons are subject of concern.

Minor Comments:

Some references to lines belong to the revised manuscript with track mode and some to the manuscript without track mode, which sometimes made it hard to understand the comments and requirements. We tried our best, when no text was cited to find the correct lines.

Line 10: Change accordingly: "(...) intensity of these events, ~~**their**~~ **its** influence is typically (…)"

The whole abstract has been rewritten.

Line 13: Consider the following suggestion: "(…) between 1991-2022 over Central Europe ~~**by means of ERA5 data**~~."

The whole abstract has been rewritten.

Lines 28-31: "This was also shown by Rousi et al. (2023) and Dirmeyer et al.(2021) for 2018, who suggest that these extreme conditions will be more likely under climate change conditions during 2020-2049 where two out of three summer seasons will experience hot and dry conditions in a +1.5°C warmer world which is already the case" The sentence is too long.

Changed to "This phenomenon was also observed by Rousi et al. (2023) and Dirmeyer et al. (2021) in relation to the extreme conditions of 2018, suggesting that such events are likely to become more frequent under climate change."

Lines 33-34: "(e.g., planetary boundary layer (PBL) height, convective available potential energy (CAPE), lifted condensation level (LCL)" a closing bracket is missing.

Changed to " (e.g., planetary boundary layer (PBL) height, convective available potential energy (CAPE), lifted condensation level (LCL)) "

Lines 53-54: Change accordingly: "(…) simulations for the ~~**period 1989-2008 for the**~~ European summer seasons **between 1989 and 2008.**

Due to rewriting of the introduction (see above) this sentence is deleted. Knist is now cited only as "Regions exhibiting Strong LA coupling coincide with those previously identified through various coupling metrics (e.g., Koster et al. (2004), Dirmeyer (2011), Guo and Dirmeyer (2013), Knist et al. (2017) and Jach et al. (2022))"

Lines 59-60: Change accordingly: "They identified a ~~coupling~~ hot spot region for the surface coupling ~~ofb~~**between** sensible and latent heat fluxes and **between** latent heat flux and 2m temperature in South Europe ~~while a .~~ **A** transition zone is present over larger parts of Central Europe".

Due to rewriting of the introduction (see above) this sentence is deleted. Knist is now cited only as "Regions exhibiting Strong LA coupling coincide with those previously identified through various coupling metrics (e.g., Koster et al. (2004), Dirmeyer (2011), Guo and Dirmeyer (2013), Knist et al. (2017) and Jach et al. (2022))"

Further the following was added: "Using water isotopes, precipitation, humidity, air temperature, and soil moisture data from 2006 to 2009, Yuan et al. (2023) identified the Central and Eastern Europe region in summer as one of 11 global hotspots for LA coupling, exhibiting varying pathways (e.g., soil moisture-precipitation, soil moisture-evapotranspiration, and soil moisture-temperature) and seasonality of LA coupling strength."

Line 64:65: "While there was only little sensitivity over the northern part of this area, Central Europe and the British Isles showed a change in the coupling regime based on the convective triggering potential and low level humidity index (CTP-HIlow)". This needs to be better explained.

Due to rewriting of the introduction (see above) this sentence is deleted. The details of the method are not needed in the introduction.

Lines 81-82: "The analysis of Dirmeyer et al. (2021) for the 2018 European heatwave revealed enhanced soil moisture – near-surface feedback coupling under drought conditions". What is exactly a "soil moisture–near-surface" coupling?

Changed to "The analysis conducted by Dirmeyer et al. (2021) for the 2018 European heatwave revealed enhanced soil moisture-maximum temperature coupling under drought conditions"

Lines 86-89: "According to Ossó et al. (2022), Europe already faced an increase in climate extremes since 2000 and will remain a hot spot for severe droughts (Huebener et al., 2017; van der Wiel et al., 2022) impacting not only summer's crop yields (Toreti et al., 2022) but also affecting the generation of renewable energy". Out of context. This paragraph is focused on discussing the soil moisture-temperature coupling. Try to find a better way to fit this information in the Introduction.

We moved this text as part of restructuring the introduction

Lines 91-93: "Shifts in the hydrological conditions from energy- to moisture-limited conditions originating from droughts and heatwaves (Dirmeyer et al., 2021; Duan et al., 2020) or severe flooding (Lo et al., 2021) imply temporal variability in LA coupling at sub-seasonal to interannual time -scales." What are these "hydrological conditions"? An effort must be made to make use of the right concepts.

Rewritten to "The critical soil moisture threshold defines the boundary between energy-limited and water-limited regimes for evapotranspiration. Shifts from energy- to soil moisture-limited conditions due to droughts and heatwaves (Dirmeyer et al., 2021; Duan et al., 2020) or vice versa in the case of severe flooding (Lo et al., 2021) imply temporal variability in LA coupling over sub-seasonal to interannual timescales."

Lines94-96: "Additionally, the critical soil moisture thresholds (Dirmeyer et al., 95 2021; Rousi et al., 2023) suggest not only an intensification of the heat and drought conditions by LA coupling over Europe but also a strengthening of the coupling itself" I'm not getting what you're trying so say here. Please clarify.

Rewritten together with previous comments. The whole paragraph now reads:

"*Guo and Dirmeyer (2013) reported interannual variability in soil moisture-precipitation coupling, resulting from differing soil moisture availability. The critical soil moisture threshold defines the boundary between energy-limited and water-limited regimes for evapotranspiration. Shifts from energy- to soil moisture-limited conditions due to droughts and heatwaves (Dirmeyer et al., 2021; Duan et al., 2020) or vice versa in the case of severe flooding (Lo et al., 2021) imply temporal variability in LA coupling over sub-seasonal to interannual timescales. Below these critical soil moisture thresholds, intensification of heat and drought conditions occurs through LA coupling over Europe, alongside a strengthening of the coupling itself. Jach et al. (2022) identified Central Europe as a transition zone where the development of convection appears to be primarily influenced by temperature increases."*

Lines 101-102: "However, a quantification of the temporal variability in different coupling relationships and the associated impacts of the variability still lack, as LA coupling strength on other time scales than climate periods has been barely investigated over Central Europe so far. The same applies to shifts between coupling regimes due to variability in the climatic conditions." Try to be more explicit here and to use a proper scientific language.

Rewritten to "Despite significant advancements in understanding land-atmosphere (LA) coupling, a crucial aspect of this complex phenomenon remains poorly understood: the temporal variability of LA coupling strength and its associated impacts. Specifically, the investigation of LA coupling across timescales beyond climate periods has been largely neglected in Central Europe, and shifts between coupling regimes driven by variability in climatic conditions remain an ongoing research topic (Barriopedro et al., 2023). To address this knowledge gap, the current study aims to quantify the variability of LA coupling strength over Central Europe during the summer seasons from 1991 to 2022, focusing on the relationships between temperature, soil moisture, precipitation, and large-scale weather patterns. By leveraging high-resolution data from the fifth generation of the European Centre for Medium -Range Weather Forecasting (ECMWF) atmospheric reanalysis (ERA5; Hersbach et al., 2020), this study seeks to provide new insights into the dynamics of LA coupling and its implications for climate extremes, agriculture, and ecosystems in the region. Ultimately, this research aims to enhance our understanding of the complex interactions between the land surface and the atmosphere and to inform the development of more effective strategies for mitigating the impacts of climate change in Central Europe."

Lines 125: Remove the word "framework".

Done

Lines 130-131: Change accordingly: "For our analysis, we used volumetric root zone soil moisture η, defined as weighted sum of the soil moisture in the top three soil layers of ERA5 ~~**down to 1 m below the surface**~~, LH and SH, CAPE, and PBL height (PBLH).

Land surface models have different numbers and thicknesses of soil layers and different root zone depths. This impacts the potential transpiration. Therefore it is necessary to mention the total root zone depth of ERA5 data used here. We change the sentence to: "For our analysis, we used volumetric root zone soil moisture η, defined as weighted sum of the soil moisture in the top three soil layers of ERA5 (i.e. the top 1 meter), LH and SH, CAPE, and PBL height (PBLH)"

Lines 133-135: "As HLCL was not available from ERA5, we used the approach from Georgakakos and Bras (1984) and Bolton (1980) which is based on surface pressure, 2m 135 temperature, and 2m dewpoint to derive HLCL which is also applied in Dirmeyer et al.." This needs to be rewritten.

Rewritten to: "Since HLCL was not directly available from ERA5, we applied the approach proposed by Georgakakos and Bras (1984) and Bolton (1980) , which derive HLCL based on surface pressure, 2m temperature, and 2m dew point, a method also employed by Dirmeyer et al. (2014):"

Lines 145-149: Be more precise and objective. There's no need to give all these details. It only brings more confusion.

It is not clear to us if you are referring to the revised manuscript in track mode :

"To categorize the summer seasons during 1991-2022,this period into warm and wet, warm and dry, and cold summer seasons, seasonal mean anomalies of 2-m2m temperatures and precipitation from ERA5 and as well as precipitation from the ENSEMBLES daily gridded observational dataset for precipitation (E-OBS; Cornes et al., 2018) version V26.0e were calculated."

Or without track mode:

"To derive the strength of the coupling between the land surface and the atmosphere (ACI), the standard deviation of η can, e.g., be substituted by surface fluxes in Eq. 2 while LH in Eq. 2 can be substituted by PBLH or CAPE (Dirmeyer et al., 2014).

ACIs are computed 1) between LH and CAPE ($ACI_{LH\text{-}CAPE}$), and 2) between LH and HLCL ($ACI_{LH\text{-}HLCL}$): "

The second paragraph was added due to previous reviewer requests, so we think it is the prior paragraph. We rewrote it and moved it to the new subchapter 2.3: "Seasonal mean anomalies of 2m temperatures and precipitation from ERA5 as well as precipitation from the ENSEMBLES daily gridded observational dataset for precipitation (E-OBS; Cornes et al., 2018) version V26.0e were calculated to categorize the summer seasons in Central Europe between 1991 and 2022 into dry to wet and warm to cold or moderate years. "

Line 158: Change accordingly: "(…) The summer seasons **of** 2003 and 2022 are (…)" This works for all the other parts of the manuscript where this issue occurs.

Changed throughout the manuscript

Line 161-162: "A trend towards larger dewpoint depression is also observed here since 2015". Visually I'm not sure about this. Also, you must have in your hands some results to prove this. I

suggest the authors to compute the linear trends before getting these conclusions. This also applies for soil moisture and temperature.

Firstly we added chapter 2.3 and explain what is shown in figures 1 and 2:

"The investigation of interannual variability of anomalies in various variables and metrics, including their spatial distribution, involved the calculation of time series of the spatial variability of anomalies as follows. For each land grid cell, the average anomaly for the months of June to August was computed for each year. Box-whisker plots were then utilized to represent the data from all land grid cells, facilitating a comparison of the spatial variability of summer anomalies across different years." Further we rewrote the analyses of figures 1, it now reads:

"Figure 1 shows box-whisker plots of the summer mean values of soil moisture, 2m temperature and 2m dew point temperature depression from 1991 to 2022 of the land grid cells in the study area between 40°N and 60°N and between 5°W and 25°E. The anomalies refer to the mean values of the respective grid cells from 1991-2020. Since 2015, apart from 2016 and 2021, more than 75% of the grid cells in the study area show negative soil moisture anomalies (Fig. 1a), in 2021 it is more than 50%. Previously, there was a stronger interannual variability with mostly more than 50% of the grid cells with positive soil moisture anomalies. The temperature anomaly (Fig. 1b) has been positive in more than 75% of the grid cells since 2015, in some cases more than 1 K. Before that, only 1994, 2003, 2006 and 2012 show more than 50% of the grid cells with a positive anomaly; in the other years, more than 75% of the grid cells are usually cooler than the mean value. There has also been a change in the dew point temperature depression since 2015. With the exception of 2016, the proportion of positive anomalies is more than 50%, while, as with the previous temperature, apart from 1994, 2003, 2006 and 2012, at least 50% of the grid cells show negative anomalies. It is also noticeable that the anomalies in at least 50% of the grid cells have spanned the same or a larger range of values since 2015, meaning that the spatial variability of the size of the anomalies is increasing."

Further we rewrote the analyses of figures 2, it now reads:

Figure 2 shows box-whisker plots of the summer mean values of LA coupling indices from 1991 to 2022 of all land grid cells in the study area between 40°N and 60°N and between 5°W and 25°E. They represent the value range across Europe for each index and summer. Variations between the years denote both interannual variability in the number of grid cells (i.e. spatial extent) with potential for physical coupling, and differences in the strength of the coupling (higher or lower values for the index).

The distributions of the TCIη-LH display strong interannual variability in terms of the expansion of the area with potential for physical coupling given as the number in each box. The fraction of land cells with positive TCIη-LH ranges between 0.54 in 2011 and 0.92 in 2022. This points to a variability in the land area with potential for coupling of up to 38%, showing substantial interannual variability in the spatial extent of the coupling region. At the same time, the median of TCIη-LH (Fig. 2a) shows higher values for the warm summer seasons (see Fig. 1b), which implies that also the strength of the coupling increases during these years. During the different summer seasons CORRSH-LH is mostly positive across Europe (Fig. 2b), which means that the LH and SH co-vary. Negative correlations, where the limitation of the LH causes an exaggeration of the SH, mostly occur in the Mediterranean. However, there are few exceptions for the very warm and dry summer seasons of 2003, 2018, 2019, and 2022 where the median of CORRSH-LH drops to less than 0.2 due to less positive correlation coefficients and a larger land area with negative correlations. The interannual variability in ACILH-HLCL (Fig. 2c) is less pronounced than that of the TCIη-LH and CORR. The land area with potential for physical coupling ranges between 5% in the early 1990s and 33% in 2003, where also the median TCI dropped below 100m. However, with exception of 2003, all summers

with the largest expansion of the potential coupling region and the lowest median ACI assemble in the warm and dry years of the last decade (bold-numbers inFig. 2c). For the ACILH-CAPE (Fig. 2d) the median index does not show strong interannual variability, but the land area fraction with positive ACILH-CAPE varies between 0.48 and 0.8. Additionally, differences in the interquartile range (height of the boxes) and length of the whiskers suggests larger spatial variability in some years. Generally, the years with the highest median index and the largest potential coupling regions does not resemble with the temperature and humidity conditions as it does for the other indices.

Line 166: Remove "which will become more likely in the near future (Huebener et al., 2017; Rousi et al., 2022)". This sounds more like a discussion of your results.

Deleted.

Lines 168-170: Why do you start the analysis of Figure 2 with panel b)? I suggest changing the order of panel a) with panel b) if you want to keep the text as it is right now.

Done

Lines 172-173: Change accordingly: "The median of TCIη-LH (Fig. 2a) shows higher values for the warm**er** summer seasons (see Fig. 1b)"

Done

Line 176: "However, during the warm and dry **years a trend** of ACILH-HLCL approaching values around or below zero is evident." The word "trend" assumes a long-term changing pattern… Here you're just saying that for specific periods the ACILH-HLCL reaches low values…

Changed to "However, during the warm and dry years (see Fig. 1b), more grid cells have small or negative $ACI_{LH\text{-}HLCL}$, i.e. their LH variability is not or only weakly coupled with the variability of the HLCL."

Figure 2 caption: "The bold-faced numbers indicate the fraction of grid cells exceeding the 75th percentile of the respective index". The numbers that are not in bold refer to what?

Changed to "The numbers indicate the fraction of land cells in the value range of the index potentially indicating a physical relationship, i.e. $TCI_{\eta\text{-}LH} > 0$, $CORR_{SH\text{-}LH}$ and $ACI_{LH\text{-}HLCL} < 0$ and $ACI_{LH\text{-}CAPE} > 0$. Bold-face numbers mark the 8 years (i.e. 25% of the examined years) with the highest share in the period."

Lines 187-188: "For the ACILH-CAPE (Fig. 2d) no clear trend for an increase or decrease can be observed which could give a hint that also the large-scale weather pattern can play a reasonable role in this case." I get what you're trying to say here but this needs to be explained more clearly.

Changed to "For the $ACI_{LH\text{-}CAPE}$ (Fig. 2d) there is also no change in the interannual variability evident, but the strength of $ACI_{LH\text{-}CAPE}$ shows a larger spatial variability expressed in a wider range of the 25^{th} to 75^{th} percentile in each year since 2003. It is worth noting that 2019 shows the largest variability

of $ACI_{LH\text{-}CAPE}$ where 78 % of the grid cells exceed the 75th percentile." The large scale circulation is discussion, so deleted here.

Lines 180-183: Change accordingly: "(…) Based on the interannual variabilities shown in Figs 1 and 2, we therefore decided to focus on summer seasons which have a median 2m temperature anomaly of more than 0.5°C **(Table 1)**. ~~**which is proven to be a realistic estimate for changes of the maximum temperatures over land in the last decade (Forster et al., 2023). All anomalies were calculated using the Climate Data Operators (CDO) version 2.0.5 (Schulzweida, 2022)."**~~

Done

Table 1: These are annual anomalies or anomalies just for the summer periods?

Summer, it is changed to "Selected summer seasons based on a positive summer temperature anomaly larger than 0.5°C with respect to the climatological summer mean of 1991-2020."

Lines 186-187: "combined with a reduced atmospheric water availability" How do the authors know this?

From Fig. 1c, we added this in the text

Lines 188-190: Change accordingly: "Although the median 2m temperature anomaly for summer 2020 was only 0.4 °C, it **was**~~**is**~~ considered in our analysis **considering that it** ~~**as this**~~ was the only summer **since 2015 witnessing a** ~~**with a moderate observed**~~ positive precipitation **anomaly according to both ERA5 and E-OBS datasets (Table 1)bias since 2015**

Changed

Line 191: Consider changing to: "3.2 Meteorological characterization of warm and dry summers".

We want to emphasize that we describe the selected summer, so now the heading reads "Meteorological characterization of the selected warm and dry summers"

Lines 192-195: Remove this text section.

Done

Line 196: I would remove the analysis of the 500hPa Geopotential. The goal of this paper is to characterize the land-atmosphere interactions and not the anomalous circulation patterns associated to droughts and heatwaves. It only makes sense to keep this if a strong connection with the land-atmosphere processes is made (which is not the case). The contribution of these results for the overall analysis is residual. If you want to keep this, I suggest moving it to supplementary material. This would also contribute to a slight and welcome reduction of the manuscript size.

It is moved to the supplement.

Line 196: It is the geopotential **height.**

Done

Figure 4 caption: "The top left panel shows the mean summer 2m temperature 1991-2020 from ERA5". Rewrite this please.

Done

Line 224-225: "with a median precipitation anomaly between -34 mm and -63 mm". This is a spatial median right? If so, It needs to be explicit.

Yes, "spatial" is added.

Lines 225-226: I would move the E_OBS anomalies to supplementary Material. It only makes sense to keep in the main body text the results obtained using ERA5 considering that the LA coupling metrics were only computed using data from this reanalysis product. It's a matter of keeping some coherence. Of course, it's always nice to have results from E_OBS but they should only be used as a complement to prove that ERA5 follows quite well observations.

E_OBS is moved to the supplement and the paragraph and also in the soil moisture paragraph is rewritten accordingly.

Line 245: Remove the word "amount".

Done

Lines 246-248: Super confusing.

Rewritten: "Interestingly, although summer 2019 was among of the warmest and driest summers, the soil moisture dry anomaly is less pronounced as in the other three hot and dry summer seasons of 2003, 2018, and 2022. The reason is the higher soil moisture content during spring 2019 (Fig. S2f), that was not used by the beginning of the summer."

Figure 7 caption: Similarly to Figure 4 caption rewrite the following sentence please: "The top left panel denotes the summer mean root zone soil moisture 1991-2020 from ERA5"

Changed, now figure 6

Line 259: "spatial patterns and the spatial extent of warm or cool as well as moist or dry anomalies" Rewrite this please

Rewritten: "While all years indicated that most of the cells experienced a significant warm anomaly, the spatial patterns and the extent of warm or cool, as well as moist or dry anomalies varied between the years"

Lines 260-261: "Firstly, 2003, 2015, 2018, 2019, and 2022 stand out the most" It reads weird

Changed to "Firstly, the years that stand out the most are 2003, 2015, 2018, 2019, and 2022."

Lines 261-262: "They are characterized by large (**warm?)** temperature anomalies, dry anomalies in soil moisture and precipitation extent over most of the land areas in our study domain". The dry anomalies in SM and precipitation are regarding the absolute values or the spatial extent? It is not

clear.

As in temperature. It now reads: "They are characterized by warm temperature anomalies and dry anomalies in soil moisture and precipitation across most of the land areas in our study domain."

Lines 270-272: "A positive TCIη-LH denotes that LH is limited by the root zone soil moisture and the soil moisture variation results in LH variation while a negative TCI η-LH indicates that the development of LH is energy limited, i.e., the incoming energy determines the LH development" Very long sentence. Break in two pls.

Done

Lines 275-276: Change accordingly: (…) **the analysis was** ~~all analyses~~ base**d** on daytime means computed for the period 06 UTC and 18 UTC of each day (Yin et al., 2023)

Done

Lines 277-278: Change accordingly: "Figure 8 shows the **mean spatial pattern of** TCI η-LH **observed for the previously selected** ~~**of all**~~ warm **and dry** summer seasons. ~~**shown in Table 1 which became the dominant situation over Europe since 2015**~~**.**

Done

Lines 282-284: The authors need to explain this better.

It now reads "In the wettest regions during both years, the index changes its sign. The now neutral to negative values indicate that there is enough soil moisture available (see Fig. 7). This implies that in these areas and during these years, the variations in latent heat (LH) flux are not directly linked to changes in soil moisture (refer to Fig. 6 and Fig. 7)." In the previous paragraph it was already said, why only positive TCLI indicate that the soil moisture is below the critical soil moisture threshold. Otherwise the regime is energy limited. So this here is not repeated.

Lines 300-301: "This is related to the anomalously warm and dry conditions in the atmosphere and a soil moisture deficit during these" **(…???).**

"years" was added

Lines 301-303: "The SH increases due to a reduction of the evaporative cooling effect at the surface, and the consequent increase in the temperature gradient between land surface and atmosphere". Please structure your reasoning better.

Now reads: "The soil moisture deficit limits LH and due to the resulting reduction of evaporative cooling SH is further increased. Consequently, the temperature gradient between land surface and atmosphere increases."

Lines 306-307: "In 2017, the spring season showed a positive soil moisture anomaly over Germany, East Europe and the British Isles which is reflected in the strong correlation over these regions. What are the supplementary figures and the manuscript figure showing this?

The figures are added: "In 2017, the spring season showed a positive soil moisture anomaly over Germany, East Europe and the British Isles (Fig. S4) which is reflected in the strong positive correlations between LH and SH during the summer over these regions (Fig. 7d)."

Line 315: Remove the following: "building a bridge toward convective processes".

Done

Line 318-324: Read carefully this section. I think there's an incorrect use of the acronyms LCL and HLCL.

They are used correctly.

Line 327: "(…) Simultaneously, the LCL deficit is negative (Fig. 12) leading (…). Should be Fig. 11 right?"

Yes, done

Lines 331-332: "This is the area in the study domain facing considerable interannual variability, which is reflected in sign changes, among other things". Explain this better. What are the "among other things"?

We deleted ", among other things".

Line 336: (…) negative values in the ACILH-HLCL (Fig 11a, e, f, i)". Should be Figure 10 right?

Yes, done

Line 341: This is also shown by the negative values of the TLCIη-LH-HLCL. What is the TLCIη-LH-HLCL? I would suggest to remove this from the paper. Your results and already self-explanatory and the manuscript is super extensive.

We followed your suggestion and deleted the correseponding text regarding the TLCI. Also, the two supplementary figures were deleted.

Line 342-348: "Please note that the SH is always positively correlated with the PBLH over land and doesn't experience strong interannual variability (not shown). This implies that a strong increase in the SH due to the LH limitation causes strong PBL heating and growth. This in turn pushes both the PBLH and the HLCL upward. Due to the combination of strengthened PBL heating and decreased PBL moistening the HLCL rises further, which leads to an intensification of the LCL deficit and thus inhibiting deep moist convection (Santanello et al., 2011). The areas with the strongest changes in the signal converge with the regions experiencing the strongest warm and dry anomalies (compare Fig. 3j, Fig. 5j, and Fig. 7j)." Remove this. It only brings more confusion.

Done

Lines 357-370: Please rewrite all this section. In fact, I would suggest a deep reformulation of all this

chapter. The reader finds himself lost frequently and it's super hard to follow a logic narrative or a solid storyline. The authors really need to structure better their ideas and made a real effort to expose them in a more effective and organized way. There's a total confusion of Figures, metrics that are not defined and you're continuously switching the region or the period under discussion. This is not the right way to interpretate the analysis. Also, and as I suggest previously, there's a lot of supplementary material that honestly, I think it's unnecessary and it only brings more complexity.

Changed to "Over Germany, France, and Benelux, the $ACI_{LH\text{-}HLCL}$ shows low or negative values during the extreme warm and dry summer seasons of 2003, 2018, and 2022 (Fig. 8a, e, i).This indicates that the very dry soil during these summers (Fig. 5) caused low LH which in turn initiated a considerable increase of the HLCL (Fig. S5) and thus a higher LCL deficit as shown in Figure 9.

In summer 2006, 2015, and 2017 the $ACI_{LH\text{-}HLCL}$ is positive over large parts of Central Europe indicating that LH variations drive the evolution of HLCL. During summer 2021, the positive soil moisture anomaly (Fig. 5) is connected to weak or negative coupling between η and LH (Fig. 6). This implies that LH either has little variations or is high compared to other summer seasons and thus lowering HLCL (not shown, e.g., Wei et al., 2021) which is also reflected in a mostly neutral LCL deficit over Central Europe as shown in Figure 9.

As the $TCI_{\eta\text{-}LH}$ is mostly positive over these regions during these summers, while the $ACI_{LH\text{-}CAPE}$ is neutral to slightly positive, this indicates that soil moisture variation impacts LH variations but with weak feedback to the atmosphere. "

Line 373: Change accordingly: "This index aims ~~at~~ **to assessing** the(…)"

Done

Lines 381-383: Please remove the following sentence: "CAPE depends on the atmospheric humidity which is, among others, related to LH while LH is related to the atmospheric temperature, humidity, soil moisture and LAI."

Done

Lines 387-388: "Together with a temperature gradient of up to 30 °C or more in the Mediterranean between 850 hPa and 500 hPa (not shown), this leads to stronger atmospheric instability and thus reduced coupling to LH." However, you mention that these regions are defined by large evaporation rates… Thus, a correlation with LH should be visible, right?

Changed to "Together with a temperature gradient of up to 30 °C or more in the Mediterranean between 850 hPa and 500 hPa (not shown), this can leads to a strong atmospheric instability in ERA5 and thus to an overestimation of CAPE in the Mediterranean (Taszarek et al., 2018)."

Lines 394-395: "Over Germany and France, mostly only weak coupling is seen with stronger signals during 2003 and 2019". Poor English

Changed to "Over Germany and France, coupling is generally weak, although stronger signals were observed in 2003 and 2019."

Lines 395-405: Rewrite all this section please. There's a total mixture of concepts, physical relations, etc. In fact, it sounds a bit out of context… An effort should be made to better connect this information with the link between LH and CAPE.

We reorganised and rewrote the section as follows: "3.4.2 Coupling LH-CAPE

This section explores the results of $ACI_{LH\text{-}CAPE}$ for the warm summer seasons. This index aims to assess the relationship between surface moistening of the PBL represented by LH and the energy in the atmosphere, which is potentially available for the development of deep moist convection (CAPE). CAPE represents the deviation of the atmospheric virtual temperature profile from the moist adiabat between the level of free convection and the equilibrium level. This buoyant energy is typically stored a couple of hundred meters above the ground. It depends on both atmospheric humidity and the temperature gradient, which in turn are subject to surface influences through the surface heat fluxes. Through PBL moistening, an increase in LH can lead to an increase of CAPE which indicates the potential for convective developments and thus precipitation. In case evapotranspiration and therefore LH is not limited by soil moisture, the incoming radiation is allowing for potential evapotranspiration and surface LH and SH are partitioned accordingly. In case evapotranspiration is not limited by incoming radiation but by available soil moisture, evapotranspiration is below the potential rate leading to higher Bowen ratios and a further increase in temperature. This enhances evapotranspiration and therefore a gradual decrease in soil moisture towards wilting point. According to Benson and Dirmeyer (2021) this ultimately leads to the situation that LH almost vanishes and the incoming radiation mainly transforms into sensible heat which can exacerbate heatwaves and droughts.

A common feature is the negative $ACI_{LH\text{-}CAPE}$ along the coast of the Mediterranean. As the sea surface temperatures in this region can reach up to 26°C (García-Monteiro et al., 2022), this leads to high evaporation over the sea and thus high precipitable water values. Together with a temperature gradient of up to 30 °C or more in the Mediterranean between 850 hPa and 500 hPa (not shown), this can lead to a strong atmospheric instability in ERA5 and thus to an overestimation of CAPE in the Mediterranean (Taszarek et al., 2018).

Coupling hot spots are observed over East and Southeast Europe with $ACI_{LH\text{-}CAPE}$ values of more than 250 J kg^{-1} in summer 2006, 2019, 2020, and 2021 (Fig. 10). They are related to higher values of LH over these regions (not shown) due to neutral or positive root zone soil moisture anomalies (Fig. 5). These coupling hot spots were also observed in a climate sensitivity study of Jach et al. (2022). Over Germany and France, coupling is generally weak, although stronger signals were observed in 2003 and 2019. The low values of $ACI_{LH\text{-}CAPE}$ over the British Isles and South Scandinavia suggest that these regions are more frequently impacted by large scale synoptic systems with a more stable atmosphere rather than localized precipitation events (Jach et al., 2020). This is also reflected by the positive LCL deficit shown in Figure 9."

Line 408: remove the following sentence: "We now discuss the key findings".

Done

Line 409-415: Please rewrite all this paragraph. Again, try to expose your arguments more clearly and in a logical way.

Rewritten to

"Our objectives were to evaluate interannual variability of coupling strength over Central Europe (summer 1991-2022), and to further investigate the warmest nine summer seasons in the context of the prevailing temperature and humidity anomalies.

The results reveal that interannual variability occurs in different coupling relationships throughout the summer seasons from 1991 to 2022. This variability is particularly evident in indices associated with the hydrological cycle, such as the terrestrial coupling index ($TCI_{\eta\text{-}LH}$), the correlation between

surface sensible heat flux and surface latent heat flux ($CORR_{SH-LH}$), and the atmospheric coupling index between LH and the lifted condensation level ($ACI_{LH-HLCL}$). These indices show a connection with temperature and moisture anomalies on the interannual scale, which is consistent with previous studies (Jach et al., 2022; Guo and Dirmeyer, 2013).”

Line 417 and 421: No trend was discussed or presented in Fig.2 Please use another word to describe your point of view. This follows one of my previous comments.

Changed to “However, the last decade shows the largest spatial extent and highest coupling strengths due to more the warm and dry summers (Fig. 2a). “

Lines 25-426: “atmospheric stratification which is not only impacted by the surface conditions but also by the large-scale weather pattern and atmospheric stratification”. Rewrite this pls.

The paragraph including the commented sentence reads now as follows: “The $ACI_{LH-CAPE}$ shows coupling hot-spots over Southeast and East Europe as well as over the Baltic states which coincides with the hotspot observed in Jach et al. (2022) who studied surface fluxes influences on the potential for deep convection triggering. However, the interannual variability of $ACI_{LH-CAPE}$ shows little connection with the temperature and humidity conditions. CAPE results from a complex interplay of atmospheric stratification, synoptic circulation and moistening and heating by the land surface. The results suggest that rather the atmospheric factors drive the interannual variability.”

Line 424-426: Rephrase it.

Same as previous, done

Line 435-437: These precipitation deficits could only be **partially** explained by changes in the soil moisture-evaporation regimes and soil moisture-precipitation coupling. Only a small fraction of precipitation results from local moisture recycling processes. The other fraction is explained by moisture convergence and transport of water vapour from remote regions. Also, this is something observed over a long-term period of for some specific years/summers? Please clarify this.

In this case, we did not aim to discuss local moisture recycling, but rather a growing occurrence of heatwaves and droughts due to drought-induced warming. Koster et al. (2009) used precipitation-temperature correlations based on observations and global simulations as surrogates for soil moisture and evaporation to analyze this. We revised the paragraph to make this point more clear:

“From the interannual variability of the different variables shown in Figs. 1 and 2, it can be concluded that warm and dry summer seasons are associated with a differing behavior of LA coupling strength across Europe. During summer seasons with enough moisture, despite higher temperatures strong LA coupling is largely limited to the European South as seen in the summer of 2021. This matches with the finding of Guo and Dirmeyer (2013), that areas with normally wet climate can experience a shift in coupling regimes under dry conditions. On the seasonal time-scale, Lo et al. (2021) also found regime shifts due to an extreme flood in a semi-arid region. According to Rousi et al. (2022) the frequency of occurrence of heat waves is accelerating over Europe in the last 30-40 years where the large scale circulation pattern often features mid- and upper troposphere blocking situation leading to a split of the jet stream towards the Arctic and the Mediterranean. As the position of the jet stream has a decisive effect on European weather, it can also alter the near surface flow conditions in West and Central Europe (Laurila et al., 2021) while in other regions like

the Mediterranean and East Europe, soil moisture preconditioning is more important as the impact of the jet stream becomes weaker (Prodhomme et al., 2022). Dirmeyer et al. (2021) showed the causal connection between the hot and dry conditions during the 2018 extreme summer. The spring already started with a warm anomaly and slightly drier conditions over Germany (Xoplaki et al., 2023) turning into a severe drought due to a strong soil moisture depletion (Rousi et al., 2023). Dirmeyer et al. (2021) also showed that the drought conditions intensified the 2018 heatwave, because when the volumetric soil moisture content fell below a critical value, surface fluxes and temperatures became highly sensitive to the further declining soil moisture. The concept of drought-induced warming through evaporative controls was also found by Koster et al. (2009)."

Line 339-341: How can the authors get this conclusion from what is said in the previous sentences? Is this supported by any kind of climate projections?

We revised the paragraph. It discusses our finding of increased coupling strength and spatial extent of the coupling region within hot and dry years in the context of an increased frequency of heat waves as well as mechanisms for the co-occurrence of drought and heat conditions reported in literature. On this basis, the sentence was revised to: "The increased frequency of hot and dry extremes together with our findings suggests that greater coupling strength can occur more often over a larger extent of Europe in the future. Despite the warmer temperatures variations in humidity can cause variability in coupling as seen in 2021 for instance."

Line 450: "These regions are usually water-limited leading to limited evapotranspiration thus further reducing LH". In addition to the poor writing quality, I'm not seeing how a water-limited regime leads necessarily to lower LH….

Rewritten to "The available net radiation energy is divided between LH and SH according to the energy required for evapotranspiration. LH and SH are correlated as long as evapotranspiration is not limited by the available soil moisture. LH in the regions south of 44 °N (Fig. 8) is usually water-limited. Therefor a common feature of the warm and dry summer seasons is the anticorrelation of LH and SH."

Line 454-455: "Though not yet represented in the model, in reality, this results in a low LAI which is often the case in South Europe" I got lost here.

Deleted

Line 471-475: Rewrite all this please.

It now reads: "During warm and humid or moderate summer seasons, the local LA system is characterized by sufficient moisture, which leads to a decoupling in several links along the local coupling (LoCo; Santanello et al., 2018) chain. Specifically, the terrestrial coupling index $TCI_{\eta\text{-}LH}$ is negative, indicating that variations in η do not drive LH. Additionally, LH and SH co-vary, suggesting that evapotranspiration is not limited by soil moisture availability."

Lines 489-510: All this sounds out of context and extremely confusing. Most of this information doesn't add anything relevant. The authors really need to reformulate this section and to find a better way to fit this information in the context of the analysis.

We agree and deleted Lines 489-504. Lines 505-510 were rewritten and moved to the dataset description: "While ERA5 is a robust data set, it has some limitations. LH in ERA5 tend to be

overestimated on average by about 9 W m^{-2} (Muñoz-Sabater et al., 2021). ERA5 soil moisture shows reasonable correlations of up to 0.7 over Europe, but may be overestimated on wet days and underestimated on sub-daily precipitation rates. Despite its limitations, ERA5 is a reliable data set for studying LA coupling and has been successfully applied in various studies. Its hourly estimates and high horizontal resolution make it a valuable tool for understanding the complex interactions between the atmosphere and land surface."

Line 516-518: "Firstly, the interannual variability between all years of the period was examined in the context of prevailing temperature and moisture anomalies in the light of a warming climate and a projected increase in hot and dry periods until 2100". Rewrite

Changed to "Firstly, the interannual variability of these relationships was examined across all years of the period taking into account the prevailing temperature and moisture anomalies in the context of a warming climate and a projected increase in hot and dry periods until 2100 (Huebener et al., 2017)."