

I'm pleased to see that the authors have made a great effort to improve the manuscript in several aspects. The structure of the analysis is now more solid, objective and concise. The reader can now follow the entire narrative without getting lost with unnecessary, repetitive and confusing considerations and results. The manuscript finally follows a solid and robust storyline. The overall quality of the writing has also been improved, although there are still some minor issues that need to be worked on (please see my minor comments). I suggest the authors to do a thorough review of the text, as there are still several typos and many sections that need to be written more clearly.

Dear Reviewer,

Thank you for appreciating our revisions. Please find our answers to your comments in blue.

My final comment goes for the last two chapters (Discussion and Summary). I suggest merging the two sections into one. Some results discussed in the "Summary" chapter are not even mentioned in the "Discussion" and vice-versa. The ideas and the reasoning are much better organised in the "Summary" than in the "Discussion" chapter. I suggest putting together the considerations made in the two chapters and to basically wrap up the analysis following the formula used in the "Summary", adding some other observations that were included in the Discussion. As you will see in my following comments, many parts of the "Discussion" are still unclear. I think the key message here is to simplify, to be more objective and to find a more effective way of sharing the main outcomes of the analysis and to pass the message for the reader.

#### Minor Comments:

**Line 51:** "Soil moisture is essential (...)"

Corrected

**Line 52:** Please change accordingly: "According to Osso et al. (2002) Europe has **been experiencing** an increase (...)"

Corrected

**Line 61-62:** I would remove the following sentence. It sounds a bit vague... "Regions exhibiting strong LA coupling coincide with those previously identified through various coupling metrics (...)"

Deleted.

**Line 72-76:** I suggest to break this text section into two smaller sentences. "The analysis conducted (...) in Europe since 1979 (Becker et al., 2022)".

The sentence was split into two parts. The two sentences now read:

"The analysis conducted by Dirmeyer et al. (2021) for the 2018 European heatwave revealed enhanced soil moisture-maximum temperature coupling under drought conditions, where exceptionally low soil moisture limited evapotranspiration and consequently amplified heatwave conditions due to reduced evaporative cooling (Santanello et al., 2018). This led to one of the most severe heatwaves recorded in Europe since 1979 (Becker et al., 2022)."

**Lines 119-124:** This sentence is too long. Please try to split it into two.

The long sentence is now split into two parts:

“Although a study of Beck et al. (2021) revealed that ERA5-Land (Muñoz-Sabater et al., 2021) outperformed ERA5 with respect to in-situ soil moisture measurements in the Carpathians and Southeast France during 2015-2019, data sets developed solely for land surface studies like ERA5-land and the Global Land Evaporation Amsterdam Model (GLEAM; Miralles et al., 2011) lack atmospheric boundary layer variables required for studying LA coupling. Therefore, ERA5-Land and GLEAM were not considered in this study to avoid mixing different models for the investigation of the coupling chain.”

**Line 125:** Change accordingly: On average, LH in ERA5 tends to be overestimated by about 9Wm-2.

Changed.

**Line 126:** These correlations were obtained in respect to which dataset? Also, a reference needs to be included here.

The sentence now reads:

“ERA5 soil moisture shows reasonable correlations of up to 0.7 with in situ-measurements from the International Soil Moisture Network (Dorigo et al., 2021) over Europe, but may be overestimated on wet days and underestimated on sub-daily precipitation rates.”

**Line 128-129:** Please change accordingly: in ~~various studies~~ previous works.

Corrected

**Line 134:** There’s an extra comma before the word “Additionally”

The comma is deleted.

**Line 141:** Change accordingly: “The LCL deficit (m) is defined as **the** height difference (...)”.

Corrected.

**Line 153:** Change accordingly: “(...) ~~describes~~ corresponds to the (...)”.

Corrected.

**Lines 177-179:** No need to describe so extensively what figure 1 shows. The figure caption already contains all this information.

These lines were deleted.

**Lines 181-182:** Please rewrite this sentence: “Previously, there was a stronger interannual variability with mostly more than 50% of the grid cells with positive soil moisture anomalies”. It reads weird.

The sentence is reformulated. It now reads:

“Before 2015, there was a stronger interannual variability where often more than 50% of the grid cells have positive soil moisture anomalies.”

**Lines 182-183:** Change accordingly: “ Since 2015, positive temperature anomalies have been

observed over more than 75% of the grid cells. Before 2015, only the years of 1994, 2003, 2006 and 2012 were characterized by having more than 50% of the grid cells covered by positive temperature anomalies.

Changed according to your suggestion.

**Lines 186-187:** “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.”, Again, it reads weird.

We rephrased the sentence. It now reads:

“Except for 2016, the proportion of grid cells with positive dew point depression anomalies is larger than 50% as indicated by the median line inside the boxes. Before 2015, apart from 1994, the hot and dry summer 2003, 2006 and 2012, at least 50% of the grid cells show negative dew point depression anomalies.”

**Lines 188-189:** Can you please clarify this? I’m not getting what you’re trying to say here...

We reformulated this sentence and split it into two parts. It now reads:

“It is also noticeable that the anomalies have spanned the same or a larger range of values since 2015 as indicated by the upper quartile. This implies that the spatial variability and the magnitude of the anomalies is increasing.”

**Lines 191:** Change accordingly. The evaporative demand of the atmosphere increases with higher temperatures resulting in a further reduction of soil moisture and an enhanced dewpoint depression. This relation pattern has been observed in the recent summer seasons, particularly after 2015.

Changed accordingly.

**Line 193:** What do you exactly mean by “anomaly spread”? It is not clear.

We meant the range of the anomalies. Therefore “spread” was replaced by “range”.

**Lines 214-216:** I understand what you’re trying to say here, but this needs to be written in a clear way. Pls rewrite.

We reformulated this sentence. It now reads:

“The land area with potential for physical coupling ranges between 5% in the early 1990s and 33% in 2003. However, except for 2003, all summers with the largest spatial extent of the potential coupling region and the lowest median  $ACI_{LH+HCLC}$  occur in the warm and dry years of the last decade (bold-numbers in Fig. 2c).”

**Line 217:** Change accordingly: “(...) with medians showing a short variation over time (...)”.

Corrected.

**Line 218-221:** Again, I understand what you’re trying to say here, but the authors need to find another way to describe and explain these results.

The modified sentences now read:

“However, the land area with potential for coupling (positive ACILH-CAPE) varies between 0.48 and 0.8, showing variability in the spatial extent of the coupling region for this relationship. Unlike the other indices, the greatest coupling strength (represented by the median index) and the largest extent of the coupling region do not occur in the warm and dry years.”

**Line 229:** Remove: “(...) and, thus, to an agricultural drought”.

Removed.

**Line 230:** Change accordingly: “(...) it was included in our analysis considering (...)”

Corrected.

**Line 237:** Change accordingly: “(...) During **the** summer **of** 2006, the 2m temperature ~~are were~~ highest north (...)”. Please keep the same verb tense while describing the results. This applies to the entire manuscript.

Corrected.

**Figure 3 caption:** Change accordingly: “(...) The top left panel shows the mean summer 2m temperatures computed for the period between 1991 and 2020.”

Corrected.

**Line 248:** Change accordingly: “**The year of** of 2006 (...)”. This applies to the entire manuscript.

Corrected.

**Line 250:** Change accordingly: “(...) associated with ~~a~~ warm temperatures and (...)”.

Corrected.

**Lines 268-269:** Rewrite the following sentence with an appropriate scientific description of the results. “The reason is the (...) of the summer”.

This sentence had an error. It now reads:

“The reason for the less pronounced dry anomaly is the higher soil moisture availability during spring 2019 (Fig. S4f)”

**Line 359:** Change accordingly: “(...) and thus **a stronger negative** LCL deficit (...)”

Corrected.

**Line 370-371:** I got lost here: “In summer 2006, 2015, and 2017 the ACILH-HLCL is positive over large parts of Central Europe indicating that LH variations drive the evolution of HLCL”. As you mentioned previously and correctly a potential physical relation between land surface and atmosphere only occurs when ACILH-HLCL is negative, right? Could you please clarify?

Yes, that is right. In this case LH variations do *not* drive the evolution of HLCL. The text has been adjusted.

**Lines 372-373:** Please divide this sentence into two, as follows: “This implies that LH either has little variations or is high compared to other summer seasons. This leads to a HLCL decrease and, ultimately to a residual LCL deficit over Central Europe as shown in Figure 9.

Corrected.

**Line 387-394:** This text section sounds a bit out of context... It doesn't provide any useful information for the LH-CAPE coupling.

We agree. We decided to delete this text section.

**Lines 429-433:** Please consider changing this text section to the following: (...) In agreement with Jach et al. (2022), the Southeast/East Europe and the Baltic states were found to be regions marked by a strong  $ACI_{LH-CAPE}$  coupling. However, when analysing the interannual variability of  $ACI_{LH-CAPE}$ , a weak connection is observed between this coupling mechanisms and temperature and humidity conditions, suggesting that such variability might be driven by other atmospheric processes.

Corrected.

**Lines 436-437:** Change accordingly: "(...) despite higher temperature, strong LA coupling is largely limited to ~~South Europe European South~~ as seen in the summer of 2021 (...)".

Corrected.

**Lines 437-438:** This reads weird: "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".

We reformulated this sentence. It now reads:

"This agrees with the results of Guo and Dirmeyer (2013), who showed that areas with normally wet climate can experience a shift in coupling regimes under dry conditions."

**Lines 446-451:** This section of the text needs to be rewritten. Authors should find a better way to link all the sentences creating a more objective a clear narrative. The ideas and the reasoning are disconnected. The English writing quality should also be improved.

We reformulated this text section. It now reads:

The spring of 2018 showed a warm temperature anomaly and slightly drier soil moisture conditions over Germany (Xoplaki et al., 2023). These turned into a severe drought due to a strong soil moisture depletion during summer (Rousi et al., 2023). Dirmeyer et al. (2021) also showed that in 2018 the drought conditions further intensified the heatwave. The reason is that when the volumetric soil moisture content fell below a critical value, surface fluxes and temperatures became highly sensitive to the further declining soil moisture. This concept of drought-induced warming through evaporative controls was also found by Koster et al. (2009).

**Lines 451-454:** Please remove the following text section. Your results show nothing for the future: "(...) The increased frequency (...) in 2021 for instance".

This section is removed.

**Lines 455-461:** Improve the English writing.

We reformulated this text section. It now reads:

"The coupling signals remain stable throughout the evaluated summer seasons over North Europe and the Mediterranean region (Seneviratne et al., 2006; Knist et al., 2017; Jach et al., 2020; Jach et al., 2022). It is worth to note that the correlation between SH and LH is mainly positive over the British Isles, indicating that evapotranspiration is limited by the incoming energy (Knist et al.,

2017). This is also the case over France, Benelux, and Germany for summer 2021 where a positive soil moisture anomaly was present during spring. Over Central and East Europe changes in the coupling regimes occur between the individual summers as indicated by switches in the sign of different indices. This area coincides with the transition zones observed in the studies of Knist et al. (2017) and Jach et al. (2022)."

**Lines 462-472:** Following my comment above, this text section is very confusing. This needs to be explained in a clear way. Try to simplify your message and to create a solid and objective narrative.

The handling editor wrote in his comment, that he does not demand major changes in the discussion section. However, we modified this text section:

"The available net radiation is partitioned 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. Our study revealed that LH is often water-limited (reddish colors in Fig. 6) which is associated with an anticorrelation of LH and SH. As enough incoming solar energy is present, this further enhances SH and thus could further intensify drought periods (positive coupling). Together with the positive TCIn-LH, the anticorrelation of SH-LH points to a strong limitation of evapotranspiration by insufficient root zone soil moisture (Fig. 5).

Moisture-limitation of the LH in the warm and dry summers leads to a shift in the energy flux partitioning towards reduced PBL moistening and amplified PBL heating because of increased SH. This shift causes a drying throughout the PBL, which is shown by an increased HLCL (Fig. S5) and an intensified negative LCL deficit (Fig. 9). Thus, the warm and dry conditions at the land surface propagate through the atmosphere leading to less favorable conditions for local convection."

**Lines 481-482:** "This led to a stronger westerly flow air which allows for more humid air masses from the Atlantic". Again, try to keep the same verb tense. To correct this problem, the entire manuscript should be carefully proofread.

Corrected. The final proofread will be performed during the publication process in NHESS.

**Lines 519-521:** "In wet years, LH does not depend on the soil moisture availability as sufficient transpiration of the leaves is possible and the HLCL is not primarily controlled by the lack of moisture at the surface". This is not correct. Under energy-limited conditions LH is controlled by the amount radiative energy. If you're referring to something different, please clarify. Be careful... this sentence might lead to a wrong interpretation. Clarify.

We reformulated this text section to avoid misunderstanding. It now reads:

"In wet years, LH is not soil moisture limited, i.e., HLCL is not primarily controlled by the lack of moisture at the surface but by the available energy from radiation."