

Dear Reviewer,

thank you very much for your comments that helped to improve our manuscript.

Please see below for a detailed reply to your comments:

- This part can be better organized. For example, you mentioned that “Pattern identification and quantification of these variations remains difficult”, you mean the variations in SWS? if so, why not just analyze the measured SWS? Why you believe “these patterns can be revealed by applying wavelet analysis”? What inspired you to conduct such an analysis? Please clarify.
 - Yes, good question, measured values can be compared as well. But patterns can give more generalized results/ information on the differences between two sites. And we assumed that we could see a transition of the patterns from those at the original to those at the new site. Also, the benefit of WCA is the possibility to analyse temporal correlations of SWS at every point in time of the time series instead of simply looking at correlations coefficients that are averaged across the time series (e.g. Pearson). Particularly, wavelet analysis decomposes a time series into several components each accounting for a certain frequency band by comparing the signal with a set of wavelet functions of known frequency. Additionally, when analysing patterns between two time series is to find possible correlations in these often nonstationary datasets (Ritter et al., 2009) to identify differences and similarities. Wavelet coherency analysis (WCA) can reveal such similarity between two signals that might have been overlooked by traditional correlation analysis (Grinsted et al., 2004). For example, if two time series contain similar frequencies but are only shifted in time against each other Pearson correlation indicates only little similarity between the signals in contrast to WCA (Bravo et al., 2019).”
 - We will clarify this in the revised manuscript by editing the beginning of the abstract and later in the introduction (see comment 3):
 - *“Pattern identification and quantification of these variations in SWS remains difficult due to the non-linear behaviour of SWS changes over time. Wavelet analysis (WA) provides a tool to efficiently visualize and quantify these patterns by transferring the time series from time to frequency-domain. We applied WA to ...”*
- Also, you concluded in Abstract that “wet and dry years exerted influence on SWS changes by leading to faster or slower response times of SWS changes to precipitation in respect to normal years.” But why? does that caused by extreme precipitation events? why you believe “Long-term observations (>30 years) might reveal similar time shifts for a drier climate” ?
 - We found that wet and dry years interrupt the annual pattern observed in the wavelet spectra for both sites. This might be caused by extreme events as you already indicated. The disruptions of this annual cycle will also affect temporal variations in the correlation between the drier and the wetter site. We will add this explanation in the abstract.
 - We found a decrease in phase shift between ETa and SWS at the wetter and warmer site that was not observed for the drier and colder site. Assuming that the climate at the colder and drier site will also change due to climate change, we expect that the time shifts at the drier site will also be affected. This can only be assessed, if we analyze longer time series. However, this is a speculation that might be misinterpreted so we decided that we will remove this statement from the revised manuscript.

- I found that the logic in some paragraphs is hard to follow, there are too much plain concepts and descriptions. For example, the paragraph talking about the methods of deriving reoccurring patterns in time series of SWS, all of these methods were fairly detailed in other researches using time series analysis. I believe the advantages of wavelet coherency analysis and the reason for taking the method in this study should be better highlighted.
 - That is a good suggestion. We will shorten the paragraph with the other methods and will highlight the advantages of WCA more, e.g. like this:
 - *“To analyse these dynamics and derive reoccurring patterns in time series of SWS, a variety of methods including principal component analysis (PCA), empirical orthogonal functions (EOF), wavelet transform, unsupervised learning like self-organizing maps (SOM), empirical mode decomposition (EMD) have been applied (Vereecken et al., 2016). However, these approaches do not allow to localize these patterns in time as it could be done with a wavelet analysis. Especially, it is not possible to determine whether annual or daily cycles within a signal are occurring over the entire period or if these patterns are interrupted in time. Wavelet analysis provides such a tool by decomposing a time series into several components each accounting for a certain frequency band by comparing the signal with a set of wavelet functions of known frequency. [...]. Additionally, when analysing patterns between two time series is to find possible correlations in these often nonstationary datasets (Ritter et al., 2009) to identify differences and similarities. Wavelet coherency analysis (WCA) can reveal such similarity between two signals that might have been overlooked by traditional correlation analysis (Grinsted et al., 2004). For example, if two time series contain similar frequencies but are only shifted in time against each other Pearson correlation indicates only little similarity between the signals in contrast to WCA (Bravo et al., 2019).”*
- In line 77, you mentioned “the effect of a change in climatic conditions on SWS has scarcely been reported to date.” But in lines 57-65, several papers were cited, please explain more.
 - We meant the effect on soil water storage **patterns** has scarcely been reported to date. The mentioned studies reported distinct effects of climate extremes on soil water storage in single years. However, our aim is to identify long-term patterns that support the hypothesis that there are overall changes in SWS induced by a change of climatic conditions. We will clarify this in the revised manuscript.
 - *“The effect of a change in climatic conditions on temporal patterns in SWS time series has scarcely been reported to date. Identification of such patterns might help to derive the impact that climate change has on SWS as an important component of the ecosystem water balance.”*
- Line 113, capitalize the first letter.
 - We will correct the typo.
- Lines 128-129. The authors mentioned: “When analyzing the effect of climate variability on SWS it is plausible to compare time series of similar soils under different climatic conditions”, why similar soils? In my opinion, soil is also part of results in a given climatic condition, so what is the practical meaning of this experiment? Needing further explain.
 - You are totally right that soil formation is also a result of different climatic conditions. However, we assume that the soil changes are slower than the changes in the water balance components, especially with regard to human-induced climate change, which is much faster than climate variability. Our aim

was to derive what impact the change in climate today would do to a soil. To put it bluntly, we would like to simulate the effects of climate change on soils by comparing soils that remain in the climate of their formation to the same soil relocated to a different climate. In other words, if the soil and crop rotation remain similar and only the climate differs, then deviations in SWS pattern between two soils must be attributed to climate. We will clarify this in the revised manuscript.

- *“When analysing the effect of climate variability on SWS it is plausible to compare time series of similar soils under different climatic conditions (i.e., space-for-time substitution approach, e.g., Groh et al., 2020). If deviations in soil type and crop rotation can be excluded, deviations in SWS patterns between the two places must be attributed to different climatic conditions. The hypothesis is that if there are no differences in soil water storage patterns between the two sites, climate does not affect SWS.”*
- Lines 157-158. you hypothesized that “similar to grassland soils the phase shift between ETa and SWS is smaller under drier as compared to wetter conditions”. but why? As we know the crop land has totally different hydrological characteristics from grasslands, why you believe the SWS variation patterns of them are similar?
 - You are right that cropland and grassland have different hydrological characteristics. While editing the structure of the manuscript with the comments of you and your fellow reviewers we realized that this hypothesis does not fit the overall message of the paper. At that point we would rather like to highlight the point you mentioned above “what is the practical meaning of the experiment” and connect it to the following hypothesis: *When two similar soils under similar crop rotation are subject to different climatic conditions, no deviances in SWS between the two places should be found, if climate had no effect on SWS patterns.*
- Figure 1, scales of the two enlarged maps are obviously different, and unify scales are recommended, latitude and longitude also need to be included. Besides, the text was too small and not easy to read.
 - We will add scales to the figure and the text will be enlarged.
- Explanatory text in Figure 1 was not accurate enough (only mentioned the average monthly precipitation (P) sums and average monthly temperature) and thus need to further clarified.
 - Thanks, we forgot to explain the gradient in temperature and precipitation between the two places. We will change the caption to:
 - *“Average monthly precipitation (P) sums and average monthly temperature in Selhausen (left, located in the west of Germany) and in Dedelow (right, located in the northeast of Germany) (between 1991 and 2022). Red and blue arrow indicate the gradient in temperature and precipitation. Dedelow receives on average 197 mm less precipitation than Selhausen and is on average 2.5 °C cooler than the site in western Germany.”*
- How about the influence of amount of precipitation during the vegetation period as your record in Table 2?
 - We are not entirely sure to which line this comment refers to and which variable it refers to. However, we used the information of the vegetation period to explain differences in Δ SWS time series at both sites. For example: The vegetation period precipitation amount was used to explain difference in Δ SWS time series for Dedelow (line 308-310) and when comparing both time series of Δ SWS in Dedelow and Selhausen (line 372-374).

- Section 2.2, as you said in line 195, “the average monthly temperatures and precipitation were obtained from automated weather stations”, and in line 218, “Missing data were gap-filled on aggregated hourly basis within the post-processing scheme”, considering the 1-min resolution collection in lysimeters, how did you ensure the accuracy of precipitation data post-processed? Are there any uncertainties from this processing?
 - The long-term weather observations (1991-2022) were obtained from a close by station at Selhausen and Dedelow, as the lysimeter were established in 2010. Regarding the second question: The precipitation data were obtained from weight changes of the lysimeter and parallel observations from other lysimeters, and in a first step, linear regression models were used to fill in the time series first on a 10-minute and then on an hourly time scale. The last missing values were filled in with hourly precipitation data from the lysimeter weather station. A linear regression model was also used here. A detailed comparison between precipitation data from Lysimeter and standard rain gauges can be found in the following publication (Schnepper et al. 2023).
- Equation 1, P was from automated weather stations, Qnet from lysimeters, but where did ETa come from? You didn't give explicit data source.
 - P and Eta was calculated from the lysimeters, as proposed by e.g., Schrader et al. 2013 or Schneider et al. 2021,. We did not use externe rain gauges for obtaining hourly P values. As previously mentioned, P values from standard rain gauges underestimate the amount of P partially largely (see more details in Schnepper et al. 2023). We will clarify this in the revised manuscript.
- Figure 2, legend “dd” and “sel”, while “DD” and “SE” in Figure 8, it is better to be consistent.
 - We will change the legend in figure 8.
- In line 294, “They related these fluctuations to seasonal variations due to water consumption by plants (transpiration) and soil evaporation.” Is that the same reason for the changes reported in your study?
 - Yes, we assume that these seasonal variations can be attributed to transpiration. We will add this explanation in the revised manuscript.
- Line 332, “the periodicities at the daily scale were significant throughout the vegetation period at both sites”, in the current drawing forms, the daily scale periodicities were not obvious to obtain.
 - The significance of the periodicities at the daily scale is indicated by the black lines at the 24-h-scale. Since at smaller scales the white rim indicating significant areas in the wavelet plots is rather omnipresent, the software indicates the average significant periodicities by black lines. This is however not mentioned in the description of Figure 3 and we will add this in the revised manuscript.
- Line 339, “In contrast to Dedelow, a small peak around a period of approximately 16500 hours was found in Selhausen”, similar to comment 8, not obviously.
 - This was a typo. We refer here to Figure 4b, the close-up of Figure 4a. There the peak around 16500 hours in Selhausen should be fairly visible. We will correct that in the revised manuscript.
- As you said in line 486, “the end of the vegetation period for crops is determined by the harvest and not by the actual drop in temperatures”, while calculations were executed according to Ernst and Loeper (1976) with hourly temperature data in Figure 8, please clarify.
 - With the analysis by Ernst & Loeper we tried to analyse, if there is an effect of the vegetation period length that might explain the deviations in SWS changes

between the places. E.g., if the vegetation period started earlier every year at one place but not the other site than this might explain the differences found. However, the differences for the sites were only obvious for the end of the vegetation period, which is in our case not relevant, since we analyse cropland. Thus, the difference in the end of the vegetation period cannot be used to explain the found differences SWS patterns between Dedelow and Selhausen.

We will clarify this in the revised manuscript.

- Most importantly, the study areas in your paper were located in Selhausen (51°52'7''N, 6°26'58''E) and Dedelow (53°23'2''N, 13°47'11''E), is the climatic discrepancy between them significant enough to call them “different climatic conditions” as section 3.1 and your title ?
 - Yes, one might argue, if this difference might already be called “different climatic conditions”. We have certainly not relocated our lysimeters to two different climate zones. However, by analysis of precipitation data and temperature data as given in Figure 1 there is a distinct climatic gradient between the two places, that might represent climatic changes expected due to climate change (at least for the temperature). In addition we will also include other important variable to clarify the different climatic conditions at both site: By relocating the lysimeters from Dedelow to Selhausen the soils were subjected to a higher annual average air temperature (+2.5°C) and rainfall (197 mm a⁻¹). We will add the difference in global radiation, wind speed and ET₀.
- The tables need to be better organized.
 - We will reorganize the tables so that table headers are better separated from the table body.
- Discussion is not sufficient in section 3.2. The reason for time shifts is lacking, and the implication of these results needs be illustrated better.
 - We have described probable reasons for the time shifts in section 3.2: For SWS we attribute these time shifts to carry-over effects of extreme years and to the impact of extreme years. In the precipitation spectrum the time shifts indicate deviations found to the different longitude of both locations and the pattern that is expected because of the European West wind drift. When we consider ET_a, the earlier onset of the vegetation period might be the reason for the observed time shift. These results imply that climatic conditions indeed have a distinct effect on SWS patterns, that are especially found in extreme years. As the climate is about to become more extreme, e.g. as suggested by Rahmstorf et al. (2023) by the weakening of the gulf stream in northern Europe, these patterns might persist over the years. Temporal changes in SWS increase over winter time and decrease over summer time will affect crop production or the infiltration capacity of soils during extreme events. Crops might need to be planted earlier but also harvested earlier due to an earlier water deficit in summer, as it is already suggested by German agencies (. We will improve the discussion section to make this important finding more clear in the section and also provide more clearly the implications of the results in the Conclusion section.
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References:

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