RC1:

The manuscript entitled "Trends in long-term hydrological data from European karst areas: insights for groundwater recharge evaluation" presents an analysis of daily karst spring discharges across Europe and aims to identify connections between daily climate variables and karst discharge. I find this topic very interesting, and HESS is a suitable journal for this type of study. However, the manuscript has several weaknesses, and in my opinion, several major and minor revisions are necessary before considering this manuscript for publication.

RESPONSE: The authors would like to thank the reviewer for the positive feedback on our work and the insightful comments which we address in the following.

To avoid confusion, it would be helpful to clearly differentiate between recharge, actual recharge (mentioned in line 32), and absolute GW recharge (line 80). What are the differences between these terms?

RESPONSE: Groundwater recharge is used to describe the process. The terms actual recharge and potential recharge are used to distinguish between recharge estimates based on saturated-zone and unsaturated-zone methods, respectively. We will keep the term actual recharge. 'Absolute groundwater recharge' (L80) was initially used to refer to recharge values given in absolute terms, as opposed to percentage-based recharge. However, since no other recharge-related numerical values from the cited publication were included, we will remove the term 'absolute' and use only groundwater recharge.

In line 87: The phrasing of this question is unclear. What do you mean by "significant change"? What does "overall spring discharge" refer to? Are you discussing low and high flow conditions of what specifically?

RESPONSE: Significant change means an increase or decrease according to the Mann-Kendall test. This is further explained in L174 where it states: 'To overcome the sensitivity of the confidence level of the Mann-Kendall test, two different statistical significance levels were set, the first one with p-values of 5 %, and the second one with p-values of 10 %.' Overall spring discharge' refers to the changes in measured spring discharge over the two periods. However, we agree that we can simplify the terminology and refer to it as spring discharge. Low and high flow conditions are further defined as '0.1 and 0.9 percentile of spring discharge' (L246).

In line 88: To which karst storage properties are you referring? How can a property be sensitive to climate change?

RESPONSE: We agree with the reviewer that this is a misleading phrasing and suggest a change to: 'Is it possible to identify karst units with certain properties related to storage which are particularly sensitive to climate change? '

In its current form, the introduction does not clearly convey the study's objectives. Please restructure the introduction to improve readability and ensure it includes all the necessary information to understand the objectives. Additionally, it is important to cite studies that have conducted similar research, so that you can clearly highlight the novel aspects of your study and conclusions.

RESPONSE: We will revise the introduction. Regarding your additional point, the introduction includes an overview of the available literature. To our knowledge, there is a lack of regional studies focusing on discharge changes connected to hydroclimatic drivers, and we are not aware of any such analysis in a continental context. These are the reasons we consider this research novel.

Line 125: Why is it important to mention that some of the investigated areas lie along climate zone boundaries? This detail seems disconnected from the rest of the paragraph. Why is this not reflected in Table 1?

RESPONSE: We do not think that this is disconnected from the rest of the paragraph, where we discuss the location of the springs and introduce the different climate zones. This is important to mention because climate zones are not stable over time, and, as we later explain, regions along climate zone boundaries are 'prone to changes in river discharge (Berghuijs et al., 2014) and groundwater level variability (Nygren et al., 2020; Nygren et al., 2021). ' The climate zone, as defined in the Table caption, represents the location according to the Köppen-Geiger classification (1986-2010). In this classification, sharp boundaries exist between the different climate zones.

Line 145: You mention that you used the R package BFI. Why did you choose this method over others? How does this package separate quick from slow flow components? How does the package calculate the BFI? How much do the results and conclusions of your study change if the value of alpha is different?

RESPONSE: The BFI package calculates the BFI according to the principles described by Line and Hollick (1979). We will briefly summarize the process: the method is based on a digital filter that works iteratively, applying a smoothing algorithm to reduce peaks in the hydrograph (quick flow component). The filter coefficient α influences the degree of smoothing and sets a threshold to separate high-frequency (quick) flows from low-frequency (slow, baseflow) components. Once the time series is split into quick flow and baseflow components, the BFI is calculated as the ratio between baseflow and total discharge. In general, lower values indicate a system dominated by quick flow, where streamflow is more responsive to precipitation events.

The predefined values for the filter coefficient have only a minor impact on the results and conclusions of this study. The base-flow index is used only for a simplified classification of the springs, and the exact location is of secondary importance. Normally, karst spring classification based on spring discharge is done by analyzing single events (e.g., Bailly-Comte et al., 2023), but the temporal and spatial extent of the analysis presented in our paper does not allow for such an in-depth analysis.

Could you explain in Section 2.3 the meaning of a positive and negative Sen Slope? How are these slopes calculated?

RESPONSE: We will add a short description about the meaning of Sen´s slope and one sentence to explain the meaning of Sen´s slopes.

Line 160: Why do you analyze the information from only one cell? Is it possible that karst capture areas are larger in extent than 0.1 degrees (about 10 kilometers)? If so, what are the implications of this for your study?

RESPONSE: Unlike river catchments, it is difficult to delineate karst catchments (see, for example, Geyer et al., 2013). Catchment limits may change depending on the characteristics of the karst system, local topography, and hydrogeological connectivity. Large karst aquifers often span several kilometers and may not align with surface topography, meaning that a single 0.1° cell may not fully capture the entire recharge area. We are aware that this might impact the results for large systems (i.e., those larger than a single cell area) and will mention this in the text.

Line 177: With your data, you could evaluate how close or far your discharge distributions are from normal. I would recommend calculating this instead of simply assuming that your data is not normal.

RESPONSE: The Mann-Kendall test does not require the distribution to be normal, so we think that the normal condition does not need to be tested in the context of the paper.

Line 183: You initially mentioned that 6 springs exhibit significant changes. Then, explained that 3 of them exhibit negative and 2 positive variation. What kind of variation does the remaining spring exhibit—positive or negative?

RESPONSE: Thank you for pointing this out. We will change the text.

Why do you include figure 2a if you never mention it in the text?

RESPONSE: We will mention it in the text.

Line 222: How can you justify this assumption? To me, it is critical that you disregard the effects of temperature variability when you are trying to quantify the impact of climate variables on karst spring discharge.

RESPONSE: We do not ignore the effect of temperature variability. We state that we do not consider temperature in the following analysis because Fig. 2f clearly shows an overall increase in temperature across mainland Europe, which does not account for the observed increase in spring discharge over the same period (Fig. 2b). The main part of the paper focuses on trend analysis, which differs from variability. There are distinct differences between these two terms, such as timescales (long-term vs. short-term), patterns (directional vs. fluctuations around a mean), and implications (potential shifts in climate/environmental conditions vs. natural cycles/extremes). Nonetheless, we included an analysis of seasonal temperature trends in Section 4.2 and, for example, conclude that 'it can be summarized that long-term changes in the Jura Mountains are mainly related to increases in temperature, influencing snow contribution in the cold seasons and increasing evapotranspiration during the warm seasons' (L365).

The label for Figure 4 refers to subplots a and b, but only one figure with an inset is presented. Following Section 3.3 is complicated; it is unclear which figure corresponds to the 20-year period and which to the 40-year period

RESPONSE: The large figure corresponds to the 20-year period and the inset to the 40-year period. We will add labels to the figures.

You begin the discussion section by arguing that precipitation trends are rare and hardly explain variability in karst discharge. However, I think the temporal scale should be considered. Daily precipitation trends might be rare, but hourly precipitation trends could be common and significant. Could you elaborate on this?

RESPONSE: Yes, we acknowledge that we state there are hardly any significant trends in precipitation for both periods, as shown in Fig. 2c and 2d. We also agree that the temporal scale must be considered; hourly precipitation trends may be common, and significant for discharge patterns in the areas investigated, although we do not see a direct connection to the long-term trend analysis presented here. We also noted this in the discussion. For example, 'but due to the fact that trends in spring discharge might not only be influenced by long-term changes in hydroclimatic conditions but also short-term (e.g., seasonal) changes in processes related to groundwater recharge and storage' (L300), and 'This strongly indicates changes in the partitioning between concentrated and diffuse recharge, suggesting changes in precipitation patterns' (L342).

In Section 4.1, you mention that karst spring flow follows a similar pattern to that depicted by streamflow. If precipitation variability is not important, how can you justify this?

RESPONSE: We respectfully disagree with this comment. At no point in the manuscript do we state that 'precipitation variability is not important,' as we do not analyze precipitation variability. This work focuses on long-term (seasonal) trends in karst spring discharge and hydroclimatic conditions. However, our findings even led us to conclude that 'This is a strong indication of changes in the partitioning between concentrated and diffuse recharge, and therefore suggests changes in precipitation patterns' (L342), implicitly incorporating precipitation variability

Line 27: global change of what? Climate change?

RESPONSE: Global change is a commonly used expression including climate change but also human societies and the impact of their activities. We refer to literature.

Line 32: Is it possible to directly measure integrated (over space) recharge at regional scale?

RESPONSE: No, direct measurement of spatially integrated recharge at a regional scale is not feasible.

Line 51: Why GW recharge "needs" to be divided into concentrated and diffuse processes?

RESPONSE: Groundwater recharge in general does not need to be divided into concentrated and diffuse processes, but it is necessary for conceptual modelling of karst systems. This is a direct consequence of the influence of karst systems properties on groundwater flows, described extensively in literature. We refer to the literature mentioned in line 50 to 54.

Line 58: Efficient in which sense?

RESPONSE: We will delete "efficient" and replace it with "important".

Line 73: Correlated to what?

RESPONSE: We deleted "correlated to".

Line 75: Which authors?

RESPONSE: The authors of the last-mentioned publication, in this case De Vita et al., 2012.

Line 84: Multi-decadal

RESPONSE: Changed according to the comment.

Line 100: Which quantiles?

RESPONSE: 0.1 and 0.9 percentile

Line 112: How is this information combined?

RESPONSE: A detailed description of the WOKAS data set can be found in Olarinoye et al. (2020). Time series from both databases, WOKAS and Hydroportail, that met the requirements were combined into a single database, ensuring duplicates were avoided..

Lines 118-122: Check correct use of word "respectively". Do this in the rest of the document too.

RESPONSE: We will do it and make changes accordingly.

Line 118: It is written "No further pre-processing was done prior to the analysis". It is not clear what preprocessing you applied to the data. Do you refer to the data selection?

RESPONSE: We agree that the sentence is as misleading. We have not done any pre-processing and therefore delete "further" from the sentence.

Also, you mentioned that data is available for four countries. Maybe it is a good idea to write their names, given that in Table 1 you only list abbreviations.

RESPONSE: We will add an explanation of these official abbreviations following the ISO 3166-1 (alpha 2 code) to the table caption of Table 1.

Line 169: Why the spring discharge?

RESPONSE: Without further context it is not possible to understand what the reviewer wants to point out.

Line 232: How many? Could you add this information to the figure?

RESPONSE: It is not entirely clear what kind of information reviewer 1 is asking for. Every point in Figure 3 represents one of the springs resulting in 54 data points for the short period and 22 data points for the long period.

Figure 1 label: I see orange symbols.

RESPONSE: There are no orange symbols in Figure 1, the reviewer might refer to Figure 2. The colors used in the figures follow the recommendations for a better visibility for people with color vision deficiency.

References:

Bailly-Comte, V., Ladouche, B., Charlier, J.-B., Hakoun, V. and Maréchal, J.-C.: XLKarst, an Excel tool for time series analysis, spring recession curve analysis and classification of karst aquifers. Hydrogeol J, 31, 2401-2415, doi:10.1007/s10040- 023-02710-w, 2023.

Geyer, T., Birk, S., Reimann, T., Dörfliger, N., and Sauter, M.: Differentiated characterization of karst aquifers: some contributions. Carbonates Evaporites 28, 41–46 https://doi.org/10.1007/s13146-013-0150-9, 2013.