Responses to reviewers

Herrault et al., 2024

October 9, 2024

Title: Combined effects of topography, soil moisture and snow cover regimes on growth responses of grasslands in a low mountain range (Vosges, France)
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MS No.: egusphere-2024-1935
MS type: Research article

1 Editor

We have received two reviews of this submission and both reviewers were positive and constructive. One suggests major edits. I agree that the analysis and topic is interesting and we request major revisions. There are a few points to pay attention to in your revisions.

1. Both reviewers questioned the use of NDVI for studying growth dynamics. Please pay extra attention to their suggestions on this point.

We provided an extensive response to each reviewer about this aspect. We also added several lines in introduction about the use of NDVImax. [L. 57 - 86]

2. A personal note of mine: I could not quite follow if it was tested or discussed how the effects of topography/slopes and snow can contaminate the NDVI reflectance signal.

First, snow effects on NDVI signal were limited with the use of the 'NDSI/NDVI ¿1' principle. Second, topographic impacts on Vegetation Indices (VIs) are an old issue. A recent article published in RSE provided new results by focusing over the Tibetan plateau. Two findings should be underlined : (1) Although topography (mainly slope) had significant effects on Vis, NDVI remained the most robust index for shadow and non-shadow areas ; (2) the latter effects increased as the slope increased, mainly above 15 degrees so it means that NDVI values recorded in steep slopes are the most exposed. Due to its configuration, Vosges mountains primarily exhibit gentle slopes which naturally limits topographic effects on NDVIs.

Ma, Y., He, T., McVicar, T. R., Liang, S., Liu, T., Peng, W., ... Tian, F. (2024). Quantifying how topography impacts vegetation indices at various spatial and temporal scales. Remote Sensing of Environment, 312, 114311.

4. I personally felt that the introduction covered the breath of issues well which disagrees with the reviewers somewhat, though please ensure to remove extraneous points that are not about the main three.

Thank you for your comment. We reformulated the second part of our introduction in order to remove extraneous points and to provide more knowledge about snow-topography effects on growth response of mountain grasslands.

4. For open science purposes, please fix the data links including for GitHub as pointed out by the reviewer.

The github dedicated to the article has been opened.

2   Reviewer 1

Combined effects of topography, soil moisture and snow cover regimes on growth responses of grasslands in a low mountain range (Vosges, France) By Herrault et al.The manuscript under consideration reports the results of applying 20 years of remote sensing data on grassland growth dynamics in a mountain range in France that exposed to range of climatic conditions and grazing. The researchers found that the majority of pixels did not show significant change in color in these 20 years and therefore suggest that Vosges Mountain grasslands exhibited predominant stable productivity trends between 2000 and 2020. The major explanation suggested for this stability is compensatory effects of genetic adaptations, traits of local plant communities, plasticity in local populations. This is a good paper reporting data on an increasingly relevant topic. The researchers explain carefully and clearly about the working progress of analyzing the data including the complexity of co-linearity and the time-space scales. However, there are a few points of concern regarding the manuscript.

Comments:

1. One issue I was concerned about is the lack of the environmental conditions in the years of interest (2000-2020), did the air temperature increased in this period in the study site? Were there differences in precipitation events and the intervals between the events? For me this is important for interpreting the data. I would consider adding an environmental conditions figure (air temp, precipitation, VPD etc.). Then, the discussion can be more relevant to the specific conditions that the low mountain range grassland experienced.

We here provide climatic trends for three parameters (evapotranspiration-Fig 1, precipitation-Fig2 and temperature max in Summer-Fig3, see below). Safran grids in the study site were also given to find the location of each of them (Fig 4).

2. The second point I suggest is to make some terms clearer. First, "soil water content", this parameter appears in the title, in the discussion, and in the conclusions, but I couldn't find the explanation of how it was calculated in the methods section.

Thank you for your comment. We added the following sentences in the text: "It represents the soil moisture level over a specific period in the two first meters of soil compared to its maximum water-holding capacity. Within the SAFRAN model, SWI is calculated based on meteorological inputs like precipitation, evapotranspiration, temperature, and wind. It is ranging from 0 (completely dry soil) to 1 (fully saturated soil)"
Second, "growing season", growing season can be varied widely in different locations on Earth and therefore it is better to define the specific dates of growing season and how did they determine.
In our study, growing season refers to the period defined between the days of Start of Season and the day of End of Season. It varies for each pixel and for each year. However, we can approximately define this period between April and September. We added the latter information between brackets.
Lastly, the term "no-significant greening", what was the specific threshold that was used to define the category of "non-significant greening"?
The threshold that we have used is a significance at 5% level.
3. The last major point is the direct connection that the authors make between color reflectance-based indices (NDVI) to plant growth response. Plant growth response can be confusing in this context because usually it is the increase between the previous day biomass to the next day. I suggest adding a sentence or two in the introduction about how NDVI represents plant growth, does it represent higher productivity? Increase in the total pixel biomass? increase in a specific plant species biomass? Generally, to avoid the direct connection between NDVI to plant growth without explaining what NDVI directly represents.
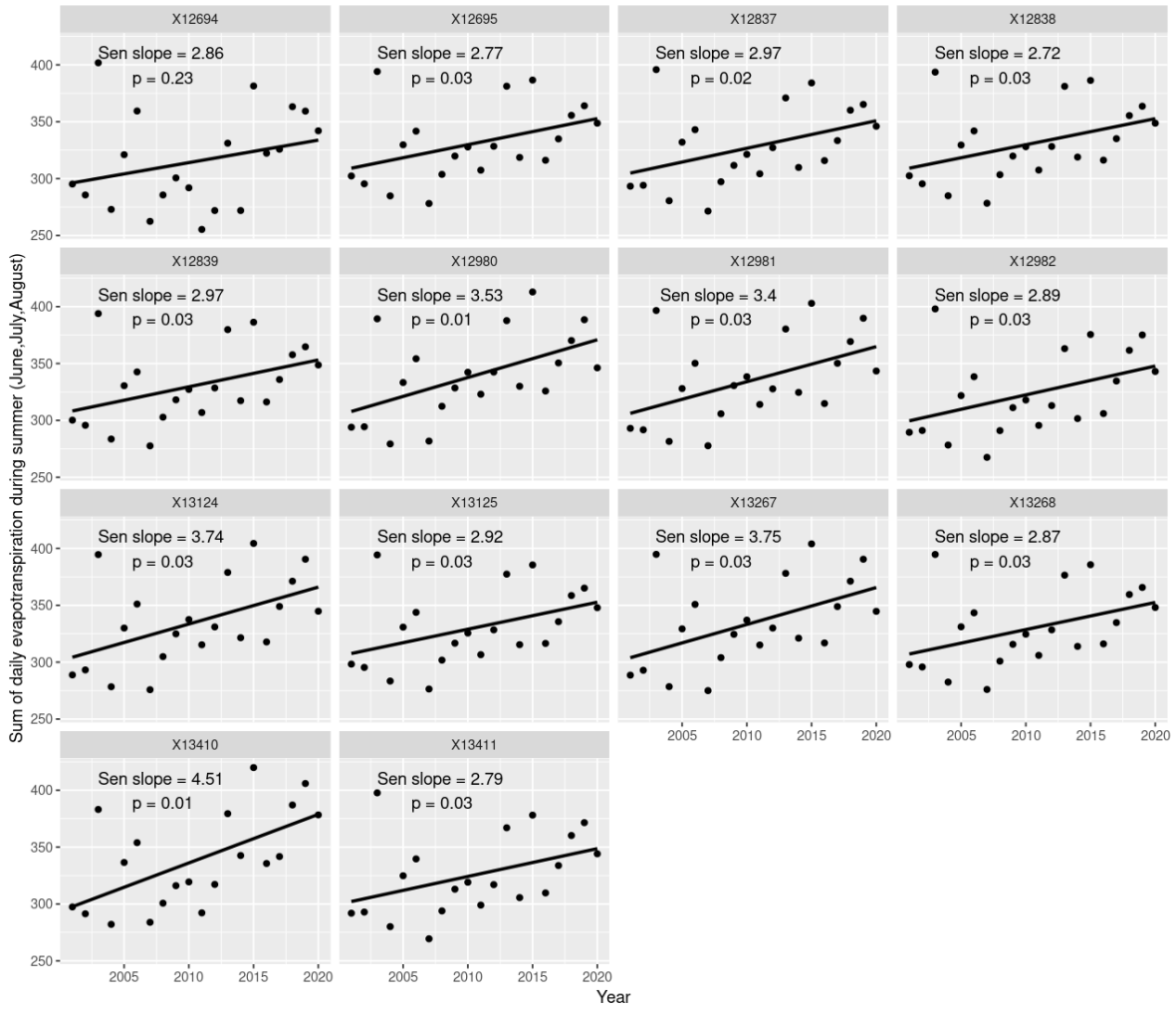
Figure 1: Trends of Evapotranspiration during Summer over the period 2000-2020
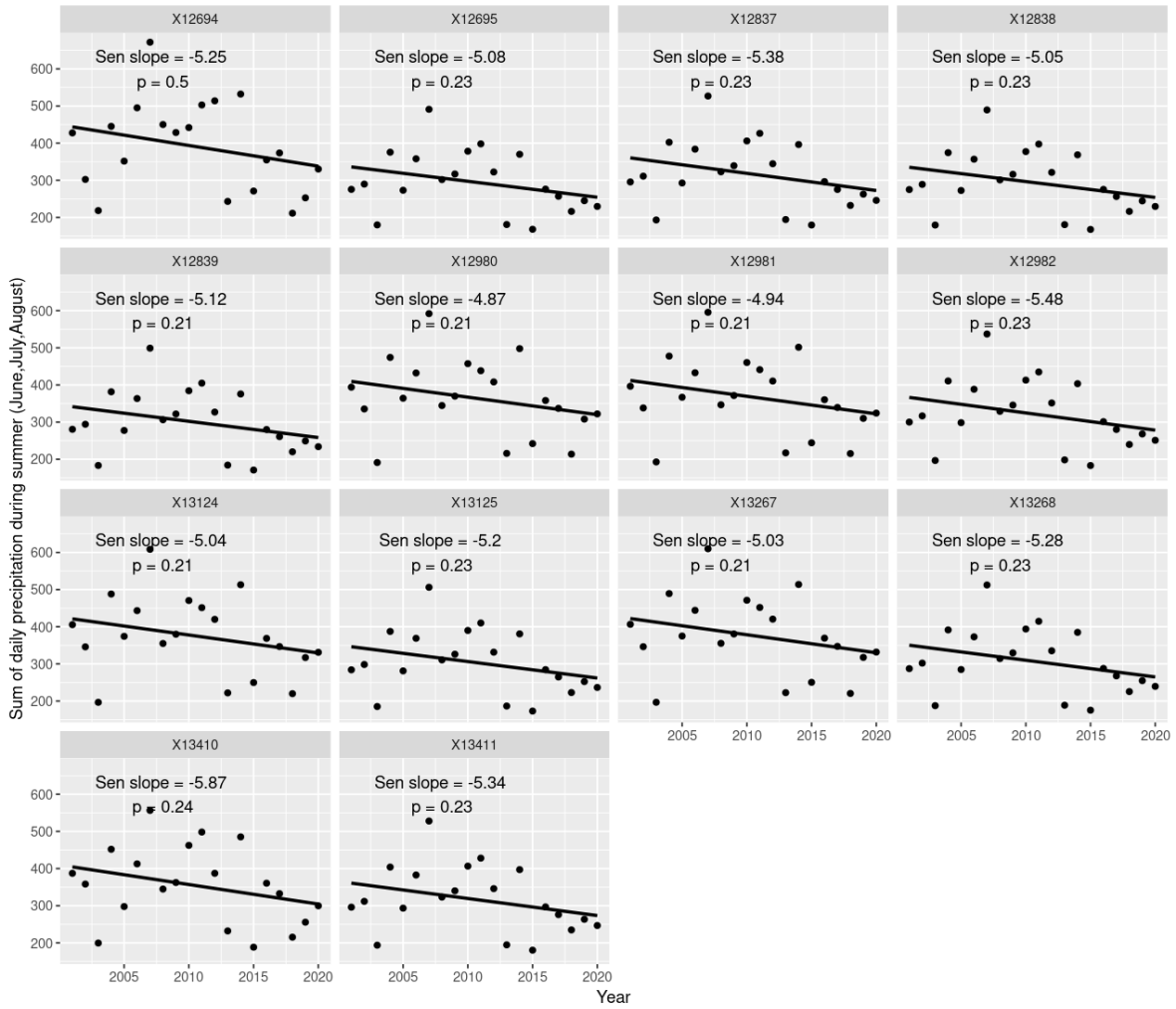
Figure 2: Trends of Precipitation during Summer over the period 2000-2020
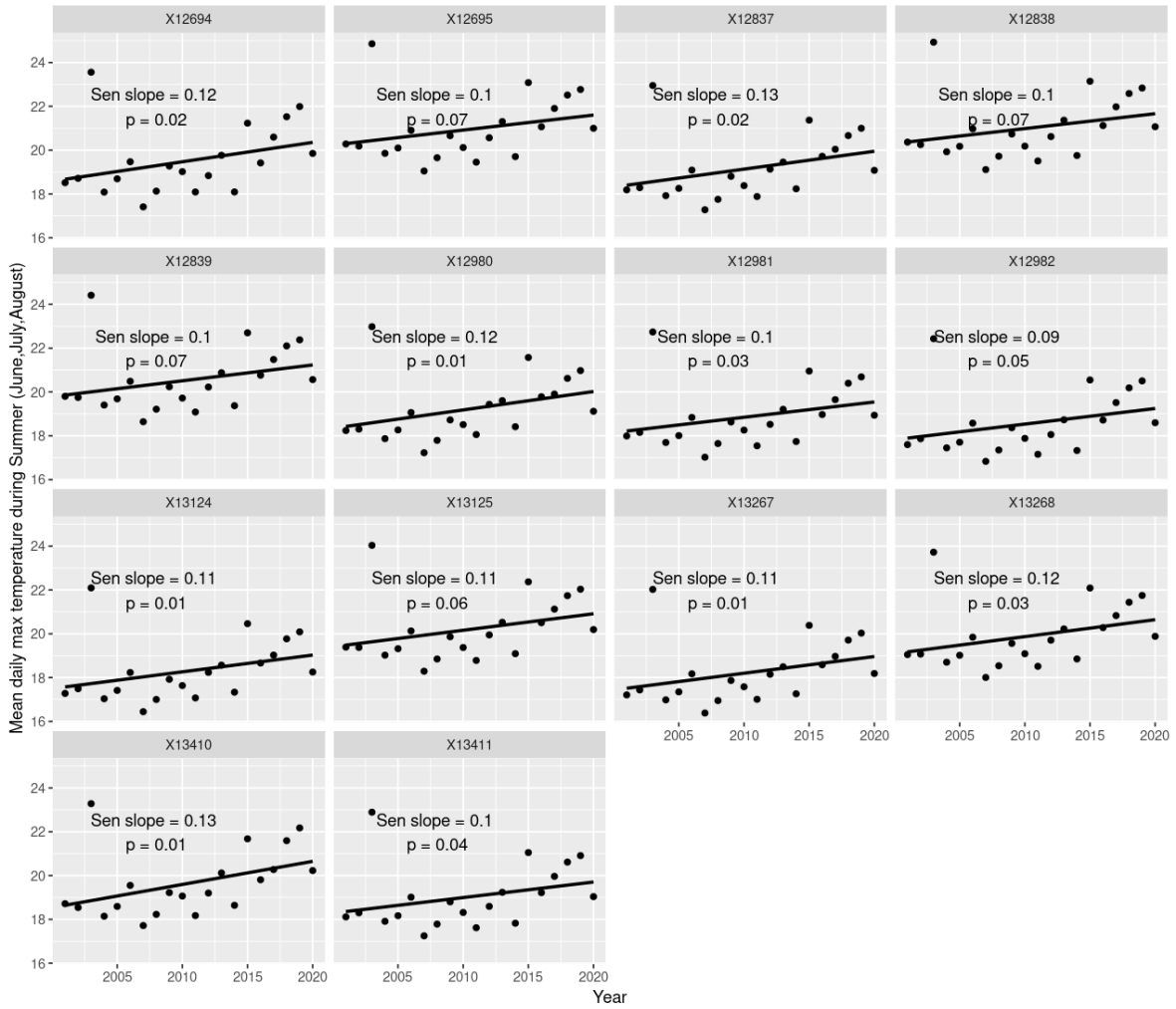
Figure 3: Trends of Temperature-max during Summer over the period 2000-2020
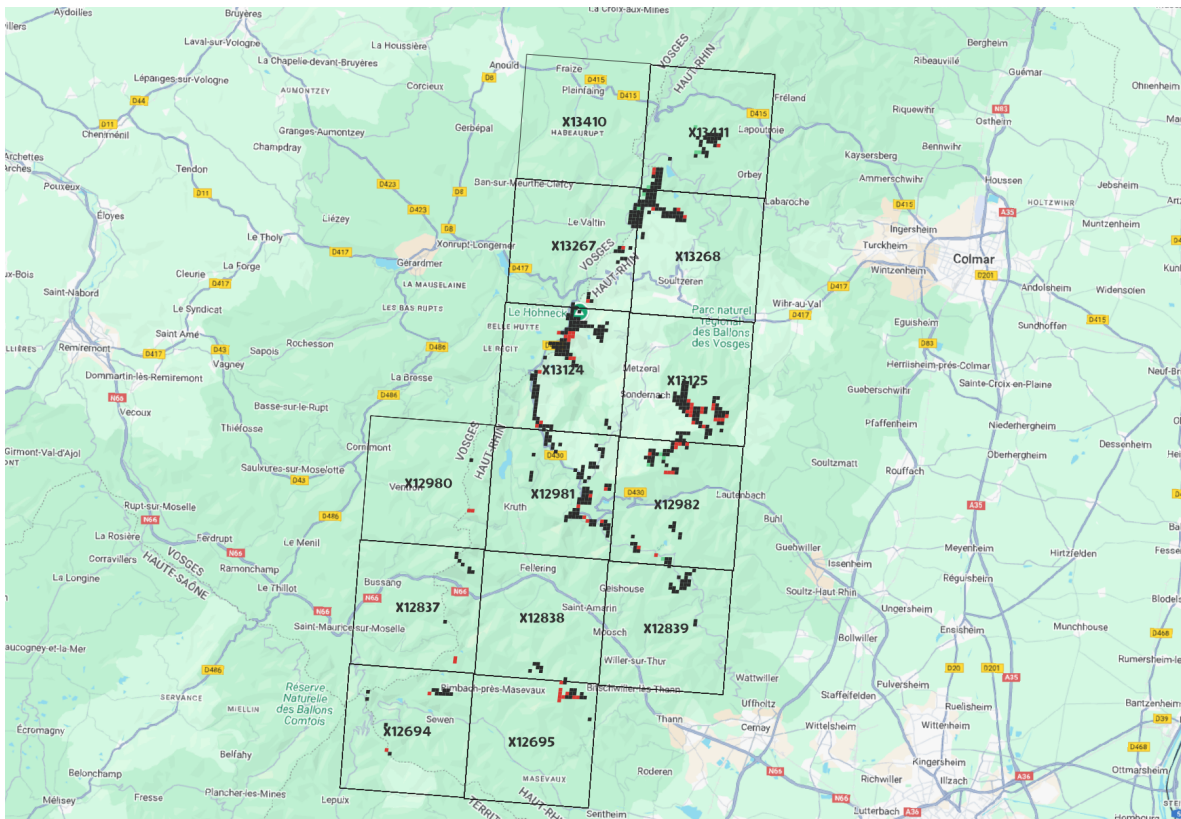
Figure 4: SAFRAN grids in the study sites

Thank you for comment. Several sentences were added and reformulated in introduction to clarify this aspect.

Minor comments:

Line 5-6: rewrite this sentence "We found a majority of no significant trends indicating several environmental and ecological compensatory effects to warming in the Vosges Mountains". It is not clear what did the authors found.

We modified the sentence in the abstract. "We found a majority of grasslands indicating no significant trends which possibly reveal several environmental and ecological compensatory effects to warming in the Vosges Mountains."

Line 44- remove question mark

Mark has been removed

Line 101- remove question mark

Mark has been removed

Line 101- "(almost) semi-continental"- should be better defined. We removed "almost"

Line 113- all species names should be italic

Species names were written in italic

Line 144 during the year or during the growing season? In the line above the authors write growing season.

We replaced the year by «the growing season»

Line 147- change "ff" to "of"

Thank you, we modified in the text.

Line 148- "exceeds"? the value was higher than the NDVI amplitude maximum? Or lower? If lower need to change "exceeds"

We talk about the time point that exceeds 70% of the amplitude maximum of the NDVI curve.

Line 207- change the semi title to be more specific, maybe "growth response" instead of "phenometric".

We modified it in the text

3   Reviewer 2

We would like to thank reviewer 2 for his comments and advices, which enabled us to considerably improve the article.

On one hand, we would like primarily respond to the point about the choice of the NDVImax to monitor productivity and not Time-integrated NDVI.

NDVImax is a performance indicator since it reflects the ability of plants to reach a certain level of photosynthesis at a key period in their growth cycle (here in summer). This is the indicator used classically in similar studies published recently in high-impact journals (Nature, Global Change Biology, Remote Sensing of Environment, see a non exhaustive list below). Although this indicator only captures one facet of plant behavior (its intensity), it has the advantage of being independent of the duration of greening (start day - peak day), making it a more robust indicator directly comparable over several decades and large areas. It also enables us to compare our results directly with those of other studies, particularly those obtained in High Mountain ecosystems or arctic regions, which is an added value when it comes to discussing our results and scaling them up. To clarify this point, we have included some elements in the introduction.

On the other hand, we are aware that duration of greening and the productivity accumulated during this period is a key indicator for understanding the response of mountain grasslands in terms of growth strategy. This is what we have done in addressing our third question, involving both peak productivity and the time needed to reach this peak (Time To Peak, TTP). The possibility of using Time Integrated NDVI was tested, but it was very strongly correlated with TTP, providing no additional information. These two latter indicators (TTP and PkV) were then regressed against Snow Habitat Indices and Topograghy indexes which allows for understanding snow-vegetation interactions along the different facets of plant performance (Intensity + Duration).

Choler, P., Bayle, A., Carlson, B. Z., Randin, C., Filippa, G., & Cremonese, E. (2021). The tempo of greening in the European Alps: Spatial variations on a common theme. Global Change Biology, 27(21), 5614-5628.

Filippa, G., Cremonese, E., Galvagno, M., Bayle, A., Choler, P., Bassignana, M., ... & Dibari, C. (2022). On the distribution and productivity of mountain grasslands in the Gran Paradiso National Park, NW Italy: A remote sensing approach. International Journal of Applied Earth Observation and Geoinformation, 108, 102718.

Carlson, B. Z., Corona, M. C., Dentant, C., Bonet, R., Thuiller, W., & Choler, P. (2017). Observed long-term greening of alpine vegetation—a case study in the French Alps. Environmental Research Letters, 12(11), 114006.

Berner, L. T., Massey, R., Jantz, P., Forbes, B. C., Macias-Fauria, M., Myers-Smith, I., & Goetz, S. J (2020). Summer warming explains widespread but not uniform greening in the Arctic tundra biome. Nature Communications, 11(1), 4621

Point-to-point comments:

"Climate Change" I do not think that it needs to be capital letters here.

We changed climate change to climate warming in our article.

In general, the introduction is very long and lacks structuring and flow. More importantly, the reader is not very well prepared for the concerned research questions, except the first one. For example, topographic effects are not very well hypothesized as well as different effects behind snow cover dynamics. Much more emphasis was put on the land-use changes, however we do not see the relevance of this emphasis to the research questions. I think the introduction needs to be re-written to better

highlight the motivation in tackling these research questions and the hypotheses behind.

Thank you for your comment. We are aware that snow and topographic effects were under-discussed in our introduction. So, we reinforced these aspects in our introduction. We also removed sentences or words as much as possible in order to reduce the introduction.

L35-55: this part is very long and hard to follow. Authors should consider significant shortening. If the purpose of this part is to emphasize contrasting hypotheses, authors might want to consider creating a table with expected responses and matching mechanisms, for example.

The bullet list aims at describing specificities of low mountain ranges compare to the high mountains ones. We noticed this is something missing in the literature. Each one of these bullets (relationships with agriculture, species composition and variability of the snow cover) are likely to have effects on productivity and phenology signals of mountain grasslands. References were cited to demonstrate these effects. We would like to keep this bullet list in the introduction.

L48: Adaptation to what? Also it is not clear how functional traits relate here especially in the context of given example. Do you mean "specific leaf area"?

Thank you for your comment. We modified the sentence. «Surface Leaf Area» was also replaced by «Specific Leaf Area».

L66: The connection with the first part of the introduction and phenology is very loose. Authors might even consider mentioning productivity and phenology relationship earlier.

Thank you for your comment. The paragraph that you mentionned aims at justifying the importance of considering drivers in scientific studies to understand spatial heterogeneities of productivity and phenological patterns. We proposed to make one only paragraph to record this aspect while integrating additional information about topographic and snow effects.

L74: This paragraph is also very long and loosely connected to the previous one. Instead of explaining MODIS, its products, and indices, I suggest that authors consider emphasizing more the reasons behind looking at these products and not the products per se. Products can be mentioned at the methods section.

Thank you for your comment. We shortened and modified the paragraph while bringing additional information about the interest of using NDVImax to monitor productivity over multiple decades.

L94: So far, the emphasis was on climate change but now the questions are based on "warming". Climate change also involves drought, especially in the mountains. This question falsely sets expectations that the authors will be able to disentangle warming from drought effects.

We talk about climate warming. We have used "climate warming" everywhere in our article.

Methods:

I highly appreciate the detail given for the methods (except the study area section). The study sounds reproducible, however I would like to see the code to assure this. However, the github link does not open.

The github link has been opened.

2.1 Study area: This part can be significantly shortened.

Thank you for your comment. We removed one sentence but we strongly believe that remaining information are needed to understand the context of this low mountain range.

L113: Species names should be written in italic and the first letter of the genus name in capital.

Species names have been written in italic.

It is not clear why 900m was selected as a threshold.

Thank you for your comment. 900M asl corresponds to the altitude where first mountain grasslands are tree free. To ensure that each pixel was above the tree line, we also removed pixels from the analysis pixels containing more than 10% of trees. We clarified this point in the text.

L142: Usage of the maximum NDVI was never discussed or justified especially over the usage of time-integrated NDVI (ie. area under the NDVI curve) as a proxy of productivity. I think that for the research questions and phenology-productivity relationship time-integrated NDVI seem more suitable to me. Why did the authors choose using maxNDVI?

See our comment in introduction. Hereafter scatterplots between PkV, TTP and Time integrated NDVI (during the green-up period) for each MODIS pixel in our study sites between 2000 and 2020.
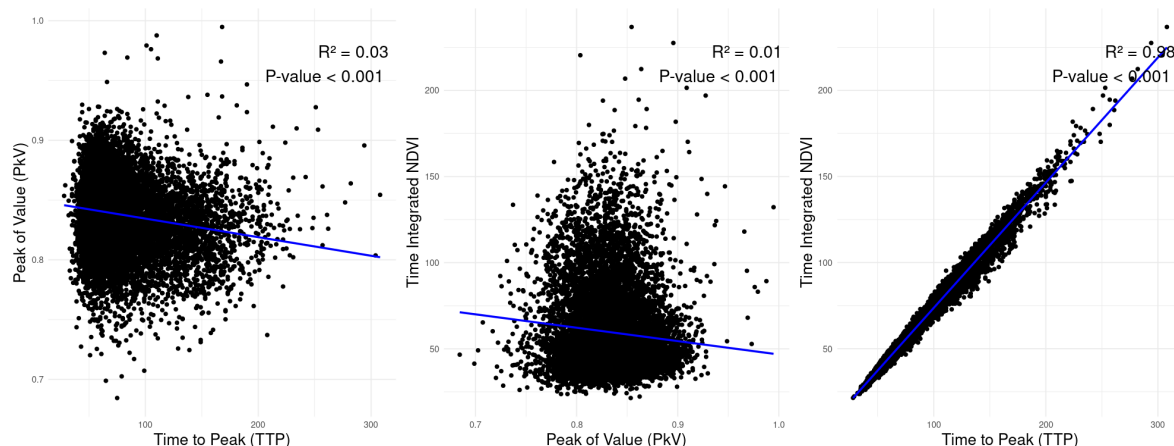
Figure 5: Scatterplots of phenological indices

Figure 2: In this figure, I would also add an illustration of the NDVI curve and show the indices calculated.

Thank you for your comment. We don't think such figure is necessary. The description of the variables is clear enough with text information.

L180: Is this threshold determined for this study only? Can you show the distribution on the appendix?

Thank you for your comment. Yes, this threshold has been determined for this study only and corresponds to the upper limit of the 3rd quantile. The histogram showing the distribution of SWI values observed from May 1st to August 1st between 2000 and 2020 is plotted below.

L188: Interpretation of the browning will be hard (I prefer browning than "negative greening"). The browning can be simply due to advanced phenology. (ie. plants grow more in the early season and thus, the growth does not produce the usual peak) The fact that the max greening is less would not mean that there is an overall browning trend to me. That is why in fact I strongly suggest the usage of the time-integrated NDVI.

Thank you for your comment. We replaced negative greening by "browning". However, browning and greening are the well-suited words to describe negative or positive trends of NDVImax (see the list
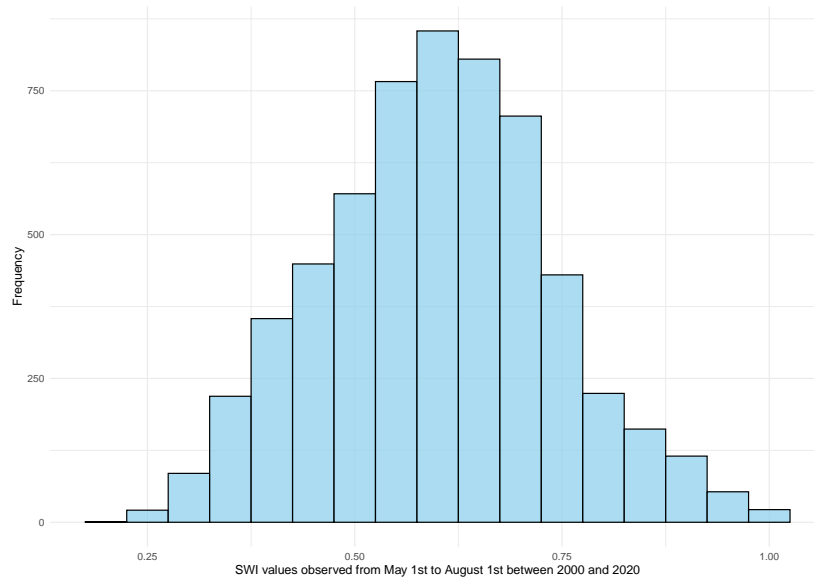
Figure 6: Histogram of SWI values from May 1st to August 1st between 2000 and 2020

of references given in introduction). We already provided arguments about this point. Accumulated productivity over the green-up phase between two years can be similar but the peak of productivity very different indicating that plant performance was greatly altered. As Time-integrated NDVI depends on greening duration, it is not suited for multi-decadal trends. However, we are aware that greening duration is crucial for describing growth cycle and this is what we did through the calculation of the indicator ≪Time to Peak≫ when studying snow-vegetation interactions.

Results:

Figure 3 is great! One small improvement could be indicating the percentages (or directly giving the percentages) of pixels for herbs vs shrubs comparison.

The percentages are given in the text. We added the number of pixel for browning and greening depending on the class.

Figure 4: Colors are not needed. Instead of at the bottom/top indications, I suggest using letters (A/B). Thank you for your comment.
We mentionned letters A/B instead of ≪bottom-top≫. The caption was also converted in graylevels.

Figure 5: Perhaps add on the y-axis "Probability of browning" and order the variables same as in the Fig.4
We replaced by "Probability of browning"

On the figures, sometimes abbreviations and sometimes full variable names were given. I suggest harmonizing them by giving the full names at all times.

We harmonized the figure 7. For sake of clarity, we wish to keep short names of variables for the other figures.

L221: Where does the information on herbs vs. shrubs come from? Moreover, herbs vs. shrub comparison was not very highlighted in the introduction. What were the hypotheses behind?

Information on herbs and shrubs stem from the CIGAL Land Cover database mentionned in the section 2. We do not have hypotheses behind these two categories but we believe it is an information

which may help understanding how and which grasslands are impacted by climate change. Indeed, grasslands dominated by herbs communities were more prevalent in the lower range of our study site ($> 1200m$) while shrubs communities are predominant above 1100m, at a subalpine level.

L230: Important predictor of what? Browning? This needs to be clearer in the text.
Important predictors of browning. We modified the sentence in the text.

Discussion:
The discussion can be shortened.Overall, I am not convinced if the trends that we see are driven by the earlier start of the season. That is why, I would like the authors to first clarify that point before I provide an extended review on the discussion on the predictors of the trends. I have the intuition that if authors use time-integrated NDVI the results might change.

Once again, we already provided arguments about this topic. We firstly discussed the trends calculated from NDVImax and then we focused both NDVImax and Time to Peak in order to study strategies of plant growth regarding snow and terrain complexity.

L265: Again, I think this is related to changes in earlier season/greening start.

Yes, it is the topic of the question 3.

L275: When methodological improvement suggested like here, reader immediately expects to be applied instead of the chosen method.

Thank you for your comment. Non-linear trends are beyond the scope of this study since it would involve many other aspects such as looking for tipping points or including new predictors to analyze trends categories. We believe that it was important to mention it to open perspectives (and we are working about it but it might be the topic of one full article.

L277: Are they all looking at the same NDVI index? Ie. MaxNDVI?

Yes, we still talk about NDVImax at this moment.

L293: "do not" instead of "don't"

We modified in the text.
There are many results. I suggest that the reader would greatly benefit from a figure where the results are summarized like the one on the following article:(Figure 6)
Wang, H., Liu, H., Cao, G., Ma, Z., Li, Y., Zhang, F., Zhao, X., Zhao, X., Jiang, L., Sanders, N.J., Classen, A.T. and He, J.-S. (2020), Alpine grassland plants grow earlier and faster but biomass remains unchanged over 35 years of climate change. Ecol Lett, 23: 701-710. https://doi.org/10.1111/ele.13474
Citation: https://doi.org/10.5194/egusphere-2024-1935-RC2
Thank you for your comment. We do not think such figure is necessary in the scope of our paper.