Rebuttal letter

We would like to thank the reviewers for their valuable feedback. Furthermore, we would also like to thank the editor and Co-Editor-in-Chief for providing a very thorough and detailed assessment of our manuscript.

The line references stated here are referring to the second revision of the manuscript unless stated otherwise.

Reviewer 1

Land cover and subregion classification

We are aware that compromises have to be made for aggregations at such large spatial scales. Such aggregations are common in the scientific literature, sometimes even comprising several climate zones (see e.g. van Oijen et al. 2014, Rolinski et al. 2015, Baumbach et al. 2017, all published in *Biogeosciences*). An aggregation at such a large spatial scale might not be sound for every single grid point it comprises, but it nevertheless can give insights which are valid for a large proportion of the included grid points and thus be representative.

We decided to give aggregations for subregions on the one hand side, and to complement this additionally with maps, so that spatial patterns within a certain subregion can still be identified by the reader.

The land cover classification used in our study allows distinguishing differences in ecosystem vulnerability between major plant functional types and can provide valuable insights on seasonal dissimilarities. We agree that a more detailed land cover classification scheme – which is not available for the Mediterranean Basin as a whole to our knowledge – might add further value in a future analysis.

We restricted our analysis to the climate categories Csa (“Warm temperate climate with dry and hot summer”) and Csb (“Warm temperate climate with dry and warm summer”), in order to reduce heterogeneity in the seasonal cycle of vegetation activity in our study region. The reviewer was concerned that grid points with high vegetation activity in spring and grid points with high vegetation activity in summer might be mixed up, leading to a confounding signal. However, we would like to point out that high vegetation activity in summer is rare. Less than 1% of the grid points have their maximum in July or August and two thirds of these grid points are irrigated cropland.

We will address the compromises linked to large-scale aggregations of land covers and subregions and add the following paragraphs to the manuscript:

In lines 78-80:

The study area is constrained to all grid points in the Mediterranean Basin belonging to the Köppen-Geiger classes Csa (“Warm temperate climate with dry and hot summer”) and Csb (“Warm temperate climate with dry and warm summer”) (cf. Fig. 1) to ensure a certain level of comparability within the study area.

In lines 339-345:

The ESA CCI land cover product applied in this study is a state of the art data set; a more detailed data set is currently not available for the Mediterranean Basin as a whole. The ESA CCI land cover classification allows only for the differentiation of major plant functional types and future studies might benefit from a more refined land cover classification scheme with a broader variety of land cover classes.

Furthermore, the subregions used in this study are not fully homogeneous and there is a certain variability within a given subregion. Thus, the patterns identified in this study (see Figs. 5 and 6) cannot always be inferred for an entire subregion. Therefore, the ecosystem vulnerability maps (Figs. 7 and B1) should be additionally examined for the identification of potentially deviating patterns within subregions.

Differences in the ESA CCI and ERA5 Land soil moisture data sets

The reviewer mentions deviations between the results obtained with the soil moisture data sets from ESA CCI and ERA5 Land. While the data sets often align well, they deviate for Northwestern Africa throughout the course of the year and for the Iberian Peninsula in the first half of the year. There is a section (Appendix A) in the article investigating similarities and differences of the data sets and this is discussed in lines 397-400 in the first revision of the manuscript (lines 409-412 in the second revision). This is an interesting finding in itself indicating that in certain regions at certain times of the year, the data sets are inconclusive. This information is crucial for a sound interpretation of the data and might help the data providers to address these inconsistencies.

Data standardization

Yes, there seems to be a misunderstanding regarding the standardization technique. The data are not fitted to a probability distribution as the reviewer assumes. For subtracting the mean and dividing by the standard deviation, it is not necessary to assume any underlying distribution. The SPI calculation mentioned by the reviewer is a two-step procedure where the data are fitted to a gamma distribution and then transformed to reflect a normal distribution. We carry out no such transformation. Z-score calculation simply rescales the data to a scale with mean 0 and standard deviation of 1 to be able to display various variables with different physical units. As stated before, we repeated the analysis using division by the interquartile range instead of division by standard deviation and the discrepancies in the results between both ways of calculation are negligible.

Reviewer 2

Major suggestion

We fully agree with the concern of the reviewer regarding statistical robustness. For this exact purpose, we also decided not to give statistical significances for single grid points (and restrained to showing only the magnitudes of their ecosystem vulnerability instead), but solely do so for aggregations of grid points. We agree that the value of a single grid point is not particularly robust because of the limited data available at this scale; therefore, the maps are primarily intended to provide the reader a more detailed visualisation of large-scale spatial patterns. Our major conclusions can all be inferred from the time series plots, relying on aggregations of grid points, rather than individual grid points. Also for land cover classes and subregions with a smaller number of grid points (< 100), there is often significant ecosystem vulnerability detected in the time series plots. Nevertheless, it is plausible that non-significant cases in some months of the year might be due to the relatively small amount of data available for these land cover classes and subregions.

We will address this in the manuscript text:

In lines 213-215:

Furthermore, certain land cover classes and subregions encompass a relatively small subset of grid points and thus non-significant ecosystem vulnerability might be due to data scarcity in some of these cases.

in line 227-230:

It is noteworthy that for a given grid point at a given month, only 21 observations are available. Therefore, the robustness of the magnitude of ecosystem vulnerability of individual grid points is limited and should thus be interpreted with care. The maps in Figs. 7 and B1 primarily aim to identify large-scale spatial patterns, but do not provide information on statistical significance at a grid point scale.

Minor suggestion

We updated the color scheme of Figs. 7 and B1 accordingly. They now match the color scheme shown in Figs. 3, 5, 6, A1, A2, A3, A4, A5 and A6.

References

Baumbach, L., Siegmund, J.F., Mittermeier, M., Donner, R.V., 2017. Impacts of temperature extremes on European vegetation during the growing season. ***Biogeosciences*** 14, 4891–4903.

Rolinski, S., Rammig, A., Walz, A., Bloh, W. von, van Oijen, M., Thonicke, K., 2015. A probabilistic risk assessment for the vulnerability of the European carbon cycle to weather extremes: the ecosystem perspective. ***Biogeosciences*** 12, 1813–1831.

van Oijen, M., Balkovi, J., Beer, C., Cameron, D.R., Ciais, P., Cramer, W., Kato, T., Kuhnert, M., Martin, R., Myneni, R., Rammig, A., Rolinski, S., Soussana, J.-F., Thonicke, K., van der Velde, M., Xu, L., 2014. Impact of droughts on the carbon cycle in European vegetation: a probabilistic risk analysis using six vegetation models. ***Biogeosciences*** 11, 6357–6375.