

## ***Interactive comment on “Vegetation vulnerability to drought on southeastern Europe” by Patrícia Páscoa et al.***

### **Anonymous Referee #3**

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Review for "Vegetation vulnerability to drought on southeastern Europe" by P. Pascoa and co-authors

Summary: The authors present a study that investigates the co-variability of vegetation greenness (based on remotely sensed NDVI) and water availability (assessed through SPEI) over a territory that roughly encompasses the state of Romania. The authors further split up their analysis by altitude and land cover type; and also look at a severe drought episode that occurred in Romania around 2000/2001. While the results are technically sound, and in general a regional-scale analysis of vegetation responses to meteorological variability in different land cover types is interesting, I believe the study could be strongly improved by a suite of potential further in-depth analyses and discussion. The presentation of the study's results appears mainly descriptive, and

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a discussion of broader hypotheses, processes or wider implications is missing. An important weakness that needs to be addressed is that correlations are in some cases directly interpreted from a process point of view (e.g. in the Abstract, "[...] a positive effect of dryness on the vegetation activity") - which completely disregards the fact that there are likely confounding meteorological factors that are not analysed. I'll provide a few suggestions below.

Major comments:

\* Interpretation of negative correlations between SPEI and NDVI \* The authors identify a number of negative correlations between NDVI and SPEI, mostly in early spring and in higher altitudes; and mostly with the shorter time scales of SPEI (e.g. Fig. 5). These are mentioned for instance in the Abstract as one of the highlight results ("a positive effect of dryness on the vegetation activity", p. 1, l. 19/20). This kind of interpretation of a simple correlation analysis is strongly misleading (and the paper relies too much on inferences of this kind): First, correlation does not imply causation (in principle). Second, from a process point of view, it seems more likely that dry springs coincide with warm temperatures / high radiation, which appear a much more likely driver of vegetation activity at high altitude sites (and changes in meteorological drivers from spring to summer and in high altitude sites are not entirely new: See for instance: Jolly et al 2005, GRL; Wolf et al 2016, PNAS; Sippel et al 2017, ERL). This appears also likely, as not only the correlation pattern reverses, but also the relevance of time scales reverses (i.e. in summer it's long SPEI time scales, in spring vegetation responses appear to be on rather short time scales...) While the authors mention that it seems likely that temperature or radiation, and not water availability is limiting vegetation activity in spring, and in higher altitudes (p. 9, l. 279 onwards), a discussion or even further analysis of these likely confounding factors (that are correlated with SPEI!) is missing. Hence, in particular, if the true control of NDVI in spring and at high altitudes would be temperature and/or radiation, and not SPEI, is it meaningful at all to analyse and interpret SPEI/NDVI correlations only? Would it be possible to assess NDVI anoma-

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lies jointly, using both SPEI datasets and temperature/radiation datasets? (using for instance partial correlation analysis or other statistical techniques that might be able to account at least to some degree for the covariation of SPEI and temperature/radiation). Also, in light of current literature it would be interesting to analyse whether there are carry-over effects from warm/positive spring conditions towards negative summer conditions? These have been recently found in observations (Buermann et al. 2012 ERL, Wolf et al. 2016) and models (Sippel et al. 2017); and it would be really interesting to analyse whether there is a correlation between spring and summer NDVI conditions? Nonetheless, it would be very interesting to see an analysis that takes into account not only SPEI, but for instance also temperature/radiation in a partial correlation analysis (in which I would guess that the "positive effect of dryness" disappears if controlled for temperature/radiation).

\* Descriptive presentations of results \* The present text is very hard to read, as it presents numbers over numbers from the analysis, and it appears very descriptive overall. It would probably provide for a better readability if the authors would clearly state 2-3 hypotheses that they investigate, and refer back to these throughout the text. For example, on p. 3, l. 85, the authors state three objectives: "i) to map the vegetation response to drought conditions, ii) to identify the vegetation types that show the strongest response to drought severity and iii) to study the impact of a severe drought episode on the vegetation activity." The readability of the paper might improve if the authors would structure their Discussion&Conclusion Section also along three objectives/hypotheses, and refer back to them in the Discussion&Conclusion section.

\* Analysis tools and discussion \* The authors use two widely used analysis metrics, namely SPEI and NDVI. However, none of these two metrics is based directly on measurements: SPEI relies on an estimate of the evapotranspiration component; NDVI is remotely sensed vegetation "greenness". While these two metrics are widely used as proxies for dryness and vegetation activity, respectively, it still needs to be emphasized (e.g. in the methods section) that both metrics are only highly simplified proxies of

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dryness/vegetation activity; and thus that some care needs to be taken in interpretation of results due to these methodological choices. In a similar vein, it would be very interesting to see a discussion on how the results of this paper compare to analyses of direct vegetation growth measurements (e.g. FLUXNET) in response to meteorological variability. There are some papers available, some that analyse also stratified by land cover type /vegetation type: e.g. Schwalm et al. 2010 GCB; von Buttler et al. 2018 BG.

Minor comments: \_\_\_\_\_

p. 1, title: shouldn't is say "vegetation vulnerability to drought IN southeastern Europe"  
 p. 1, l. 17 "on July and August" should read "in July and August". Several more writing issues across the text. p. 4, Section 2.2 on NDVI data. Are NDVI time series deseasonalized? This would be reasonable for looking at vegetation activity anomalies. Is there any pre-processing done on NDVI values other than discarding values below 0.1. p. 5, l. 136. A threshold of -0.84 appears very subjective. Could you maybe make a plot to show where this threshold lies across the SPEI values obtained in the study?  
 p. 5, line 150: What about sensor ageing? p. 6 line 187: should read "shown IN fig. 3"  
 Fig. 4: "Significant correlation" (figure caption) and "Corr > 0" (title of figure) must be a different thing.

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