Land-cover and management modulation of ecosystem resistance to drought stress

Xiao, C., Zaehle, S., Yang, H., Wigneron, J.-P., and Bastos, A. *Earth Syst. Dynam. Discuss*

Response to Reviewer #2

R2C1: Xiao et al. make use of several satellite-based products to investigate the ecosystem's resistance to drought stress under different contexts, e.g., forest/cropland, natural/human management. This is an interesting and quite important topic in a warmer world with more droughts.

We thank the reviewer for the evaluation of our manuscript and for helping to clarify the methods. We have now improved and clarified the methods, following the comments by the reviewer. Please find our point-by-point reply below.

R2C2: However, I do see some technical flaws that should be improved. First, I'm not convinced by the definition of ecosystem resistance to drought. Why did the authors choose the annual maximum L-VOD/kNDVI/EVI to derive the drought response of the ecosystem? The "time window" when maximum ecosystem productivity occurs is likely in a favorable environmental condition, for instance, very wet, high radiation, and irrigation. I do not think it is a suitable "time window" to "see" drought impacts.

We thank the reviewer for pointing out the 'time window' to detect drought impacts. First, we would like to point out that we are focusing on biomass and not productivity. In our study, we focused on the inter-annual variations in vegetation state and its responses to drought stress, which can be assessed by annual maximum L-VOD data. In that sense, the maximum value of biomass is more likely to reflect the growing-season integrated productivity, rather than temporary spikes in productivity induced by favorable climate conditions. On the other hand, we agree that such spikes would be reflected in EVI and kNDVI if we were to consider their annual maximum values. To avoid such effects, we used annual mean EVI and kNDVI instead. See more details in our response to R1C4 (i).

There is, however, a more fundamental reason why we chose to work with maximum L-VOD.

The rationale behind the choice of annual maximum L-VOD is that L-VOD is theoretically a closer proxy for vegetation water content (VWC) than aboveground biomass (BM) (Ulaby & Long, 2014). VWC scales with the aboveground vegetation biomass:

$$VOD \sim VWC$$

$$VWC = RWC \times BM$$

where RWC is the relative water content defined as the amount of vegetation water per unit wet biomass (Konings et al., 2019). Therefore, L-VOD is also influenced by short-term variations in RWC and sub-annual L-VOD does not necessarily reflect biomass variations. This is especially problematic during drought periods because part of the reduction of L-VOD results from the short-term reduction in RWC in response to the soil water deficit.

To limit the influence of such short-term variations linked to RWC variability, we used the yearly maximum L-VOD from the reconstructed monthly L-VOD data. The yearly maximum L-VOD, corresponding to the maximum vegetation water content and which is generally associated with wet conditions, is more likely to be decoupled from RWC variations as RWC in the wet season is about constant from year to year (Qin et al., 2021). So the yearly maximum L-VOD is more likely to reflect the changes in aboveground biomass compared to the yearly mean L-VOD.
By doing so, we cannot analyze the immediate effect of drought on biomass, but this is not our objective, as our purpose is to study the concurrent effects of droughts on biomass at annual scales.

R2C3: Second, in equation (2), "φ" can represent vegetation memory, which has previously been proposed to be associated with long-term resilience to any type of perturbation. Drought is indeed one of the most important and frequent perturbations. How do we know "φ" do not already include most drought response information? Do you ever compare the general pattern (not the size due to unit difference) of "α" and "φ"?

We agree with the reviewer that the φ term is closely associated with the vegetation memory and long-term resilience to perturbations (De Keersmaecker et al., 2016) and might reflect intrinsic ecosystem feedbacks such as biomass accumulation or loss (Barron-Gafford et al. 2014). It also reflects the effects of other environmental and climate drivers or nonlinear responses not explicitly considered in our model (Liu et al., 2019). Drought might have legacy effects, which means that droughts that happened in the previous year can continue to influence tree growth (Anderegg et al. 2015). Such effects are partly considered in the φ term. However, in our definition of drought resistance, we focused on the concurrent drought effects, but not effects from drought events occurring in the previous year. Following the reviewer's suggestion, we compared the spatial pattern of α and φ (Fig. R8). The spatial patterns are not similar and spatial correlations are close to 0 from L-VOD (0.008), EVI (-0.008), and kNDVI (0.011), so drought resistance is unlikely to be influenced by vegetation memory term.

We have tested whether including the φ term would affect the α, β coefficients and contribute to increased adjusted R^2, see more details in our responses to R1C4 (iii).

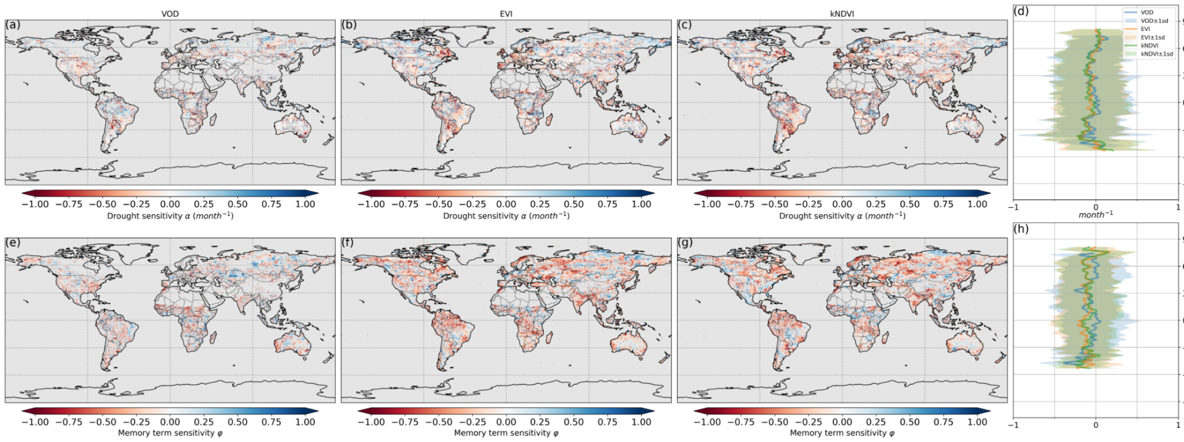

Figure R8. Spatial distribution of ecosystem resistance to drought duration α (a, b, c) and the vegetation memory sensitivity φ (e, f, g) in the linear autoregressive model with memory term from L-VOD, EVI and kNDVI. The averages for different latitudes and their standard deviations are shown on the right (d, h).

R2C4: Third, *N* is the centered number of drought months in each year. A bit confused, what does "centered" mean?

We meant that the number of drought months in each year has been subtracted from their average for 2010-2020, which is shown in the equation: $X_{year} - \overline{X}$. This does not influence the results in our linear regression except for the model intercept. Therefore we have removed this operation from our analysis.
We have modified the description in Line 204:

N is the number of drought months in each year in 2010-2020.

R2C5: Fourth, you say "To calculate the ecosystem resistance to heat and drought" in Line 182, but you utilize the yearly mean 2m temperature as the proxy of "heat".

We agree with the review that the yearly mean 2m temperature should not be considered as the proxy for heat. We have modified our definition of resistance and rephrased it to 'temperature sensitivity'. We included this term to account for the fact that vegetation growth is also strongly controlled by temperature. See more details in our reply to R1C4 (ii).

R2C6: In summary, this is an important and interesting paper. I suggest the authors refine the method. I'm happy to review this paper again.

We thank the reviewer for the constructive comments on our methods and we have improved the above points in our revised manuscript.

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