REFEREE 2

Authors: We are very grateful to the referee for the comments and suggestions to improve the study.

General comments:

The paper intended to analyze the relationship between agronomic and edaphic drought in a semiarid rangeland area. The use of several remote sensing indexes is the primary source of data to provide this analysis. The paper's general idea is valuable but not novel as vast literature uses this kind of tool to analyze such relationships at different scales and under different biomes. The main novelty of the paper is perhaps not fully addressed in the introduction.

The causal mechanisms behind the soil and vegetation drought expression are not fully addressed, probably because of the limitation of the pixel resolution that restricts the specific vegetation identifications and the lack of soil hydraulic properties or soil moisture spatial information. No ground data is used, severely limiting the robustness of the remote sensing analysis. Maybe the general idea and the title of the manuscript should be more related to comparing the dynamics of physically different remote sensing drought indexes to detect agricultural drought, which is more related to objective 2. If so, the study's outreach is limited but valuable, maybe for a letter paper.

Authors: We have eliminated the term edaphic drought in all the paper (including the title) and only keep agricultural or vegetation drought defined in the introduction.

The aim of this study is not to introduce a new concept (edaphic drought) but to show relationships between vegetation and soil moisture based on accepted remote sensing indices such as NDVI and W. In addition to this we try to show there is a relationship depending on seasons between vegetation and soil moisture anomaly indices and this can be used to increase the probability to predict an anomaly in vegetation indices (agricultural drought).

In addition, the documents presented several grammar, format, and presentation flaws that made it difficult to follow some essential ideas.

Authors: We have reviewed all the sections to improve the paper.

All these reasons support the decision to reject this paper in its current form. However, I put some specific comments to enhance the document for a possible resubmission.

Authors: Thank you very much for your comments. We hope that the present version of this manuscript will reach the scientific level for this special issue.

Abstract: The justification of the problem is not well accomplished; why does the 30% precipitation variability represent a challenge?

Authors: High precipitation variability provokes vegetation water stress. The aim of this study is to find relationships between moisture (water) stress and vegetation stress throughout remote sensing anomaly indices. Beside it, we have changed that phrase for the following:

"**Abstract.** The dynamic of rangelands results from complex interactions between vegetation, soil, climate, and human activity. In arid and semiarid areas, temporal variation of precipitation significantly influences this ecosystem."

What is the relation between degradation and rainfall variability?

Authors: The lack of water in certain periods and between different years causes a limitation to the vegetation cover and in addition, when storms occur, great erosion is generated in the poorly protected soil.

Introduction:

References are too old; I suggest keeping only references for the last 10 years. At least, it was a singular paper. The manuscript requires an extensive English revision before being resubmitted, and it is hard to follow the ideas in this current form. I suggest including a more comprehensive explanation and justification of how agronomic and edaphic drought relations can be propagated. The literature remains poor; please add more relevant and actual papers on the subject. Also, an explanation of what details about the OPTRAM index should be included. Why could this index detect something different from the NDVI?

Authors: We have eliminated some references and included some new ones. We have eliminated the concept "edaphic drought" because it is not the objective of this study. We have also included a detailed explanation of OPTRAM methodology to build the W index.

It is unclear and not correctly justified why using an arid rangeland could be singular to study these relationships.

Authors: In this study we deal with semiarid rangelands but in future research we will deal with other kind of rangelands (arid, humid, etc). On the other hand, semiarid and arid rangelands are more susceptible to changes in their precipitation and humidity regimes, especially given their commonly degraded status.

The definition of edaphic drought is missing.

Authors: We have eliminated the concept "edaphic drought" because it is not the objective of this study.

Methods:

The rationale for choosing the different remote sensing indexes is completely missing. You can use a diagram to support the text to better explain your procedure's logic.

Authors: We have modified the abstract and the Introduction to clarify this point.

Scientific names should be put in italics.

Authors: We have put scientific names in italics.

A description of root depths and the hydraulic properties of soils should be convenient.

Authors: In the section "Area of Study" we have included a brief description of the soil types in the studies areas.

The climate description is poor; please use an international reference based on the Koeppen classification.

Authors: In the section "Area of Study" we have included a brief climate description in the studies areas.

Now it says: "Los Vélez has an overall Mediterranean climate (Bsk according to Köppen classification). It has average monthly temperatures ranging from 5.4℃ to 22.7℃, and average yearly precipitations between 330 and 390 mm (Grupo de Agroenergética de la E.T.S.I. Agrónomos, 2014a)… Bajo Aragón has a Mediterranean climate (Bsk to Csa according to Köppen classification) with average monthly temperatures between 0.8℃ and 29.8℃ and annual rainfall of 648 mm."

The explanation of pixel selection is very unclear; please explain how you merge the information better.

Authors: Tragsatec company in collaboration with Entidad Nacional de Seguros Agrarios (ENESA) depending on the Agricultural Ministry of Spain selected these pixels as semiarid rangelands to be used in the context of the National Rangeland Insurance. Firstly, pixels categorized as rangeland were selected using the SIGPAC and from this previous selection, pixels with a tree coverage higher than 15% were discarded to ensure a low tree coverage, based on the MFE (Spanish Forest Map).

You must put the complete names of the MODIS products used in the study, for instance the NDVI product. How did you deal with clouds? Do you use the Quality Assessment data?

Authors: We have included the names of the MODIS products. Now it says: "The NDVI was extracted from the product MOD09GQ of the TERRA satellite and MYD09GQ of the AQUA satellite, which provide the reflectance of the red and near-infrared bands with which the index was built… Shortwave infrared reflectance (SWIR, 2105-2155 nm) was collected from MOD09Q1.006 band 7 product from AppEEARS (Team, 2020) to calculate the Shortwave Transformed Reflectance (STR)."

Do you resample the NDVI to the STR resolution or vice versa? please clarify.

Authors: Section 2.2 Data Collection says: “This product has a 500 m spatial resolution, lower than the one used for the vegetation indices, but a higher spatial resolution was not available for this reflectance band.”

Section 2.3 Estimation of Vegetation and Soil Moisture Content Indices says: “Secondly, to match the STR and NDVI spatially, every NDVI pixel was given an STR value based on their centroid proximity.”

Furthermore, we have included the following phrase to better explain this point: “Therefore, STR spatial resolution (500 m) was adapted to NDVI spatial resolution (250 m).”

A better map of the study area is necessary to understand the context better, please improve the one chosen.

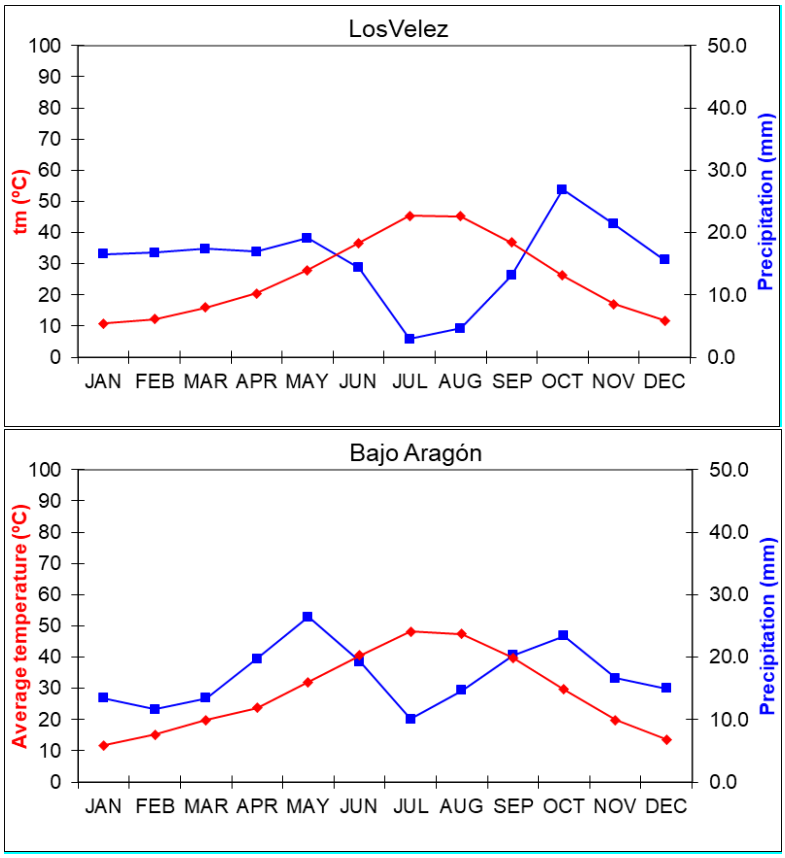
Authors: We have improved the map (Fig. 1) including different colours to identify every studied area. Now light blue corresponds to Los Vélez (A) and green corresponds to Bajo Aragón (B) in the map of Spain.

We do not know if the referee would consider incorporating a context map, for example of the western Mediterranean like the one we put here below. We are open to suggestions.

A climograph could be added, for example, and the land cover present in the selected area.

Authors: Climograms can be included, but they would reflect the precipitation and temperature information in another format. This information is already included on 10-days series in the work. The type of climate is already included by the Köppen classification.

We have included here the climograms. If the referee believes that should be incorporated we will.



Authors: The land cover present in the selected areas has been included in the manuscript: Now it says for Los Vélez: "In this area, 47% of the surface is dedicated to crops, 31% is forestry and 26% is scrub, pastures and meadows.".

And for Bajo Aragón: "In this area, 41% of the surface is dedicated to crops, 21% is forestry and 38% is scrub, pastures and meadows.".

Results:

The results are attractive and are the main strength of the paper, however, they are difficult to connect to the main objectives. Maybe you could enhance the idea of early detection of a hazard.

Authors: Thank you very much. The idea of early detection and prediction increment is developed in the Discussion section.

The Discussion sections reflect the poor level of analysis displayed in the document, with only three references to confront the results.

Authors: We have included this new paragraph with two new references:

"Early warning system are being developed for famine, agricultural yield, and drought. Recently remote sensing has been used in this regard and is more commonly used for rangeland monitoring. In this paper we merge remote sensing monitoring with early warning indices to inform managers and rangers (Rembold et al., 2019; Haigh et al., 2019)."

Specifics comments:

Line 11: To communicate the idea of precipitation variability, I suggest using another metric or explaining better what you mean by 30% of the coefficient of variability.

Authors: Now it says: "In arid and semiarid areas, temporal variation of precipitation significantly influences this ecosystem."

Line 13: what is water soil moisture? Please use a widely used terminology.

Authors: There is a mistake in the phrase. Now it says: "We aim to study the feasibility of using soil moisture anomalies as a warning index for vegetation or agricultural drought."

Line 17: Please explain why you selected two MODIS resolutions.

Authors: This is explained in Section 2.2 Data Collection, as shown below.

"Shortwave infrared reflectance (SWIR, 2105-2155 nm) was collected from MOD09Q1.006 band 7 product from AppEEARS (Team, 2020) to calculate the Shortwave Transformed Reflectance (STR). This product has a 500 m spatial resolution, lower than the one used for the vegetation indices, but a higher spatial resolution was not available for this reflectance band."

Line 21. What specific season?

Authors: We have changed "season" by "months". At the end of the abstract says: "The stronger relationship between vegetation and precipitation from autumn to the beginning of spring is reflected in the feasibility of Z_{WCI} to aid the prediction of Z_{VCI}. During these months, using Z_{WCI} and Z_{VCI} as warning indices are possible for both areas studied. Notably, November to the beginning of February showed an average increase of 20-30% in the predictability of vegetation anomalies knowing moisture soil anomalies 4 lags (period of 10 days) later. We found other periods of relevant increment in the predictability, such as March and April for Los Vélez, and from July to September for Bajo Aragón."

Line 34, I suggest explaining that plant growth can be related to NDVI. The Normalized Difference Vegetation Index must be described with its entire name.

Authors: We have reorganised the introduction:

Now it says Ln 44: "Remote sensing observation has been increasingly used to monitor drought-related variables and assess their effects and impacts from an ecosystem perspective (Liu & Kogan, 1996). Precipitation has been studied with several indices (Kim et al., 2009; Mahmoudi et al., 2019), such as the Standardised Precipitation Index (SPI; McKee et al., 1993), Effective Drought Index (EDI; Byun and Wilhite, 1999), or Percent Normal Precipitation Index (PNPI; Willeke et al., 1994). Among the vegetation indices, Normalised Difference Vegetation Index (NDVI) is the one most often used for monitoring environmental conditions (e.g. grassland status, land degradation, desertification, and drought) all over the world (Hassan et al., 2018). Kogan (1995) proposed a vegetation condition index (VCI) that utilised historical maximum and

minimum NDVI data to measure vegetation conditions against the historical worst situation. This VCI has been successfully used for drought monitoring (Baniya et al., 2019 and references therein)."

Line 35 Farrat et al., 1994 studied the relationship between NDVI, rainfall, and soil moisture. This is a very old reference, please provide more actual references.

Authors: We have eliminated this reference and included two more actual:

Sharma, M., Bangotra, P., Gautam, A.S. et al. Sensitivity of normalized difference vegetation index (NDVI) to land surface temperature, soil moisture and precipitation over district Gautam Buddh Nagar, UP, India. Stoch Environ Res Risk Assess 36, 1779–1789 (2022). https://doi.org/10.1007/s00477-021-02066-1, 2022.

Felegari, S., Sharifi, A., Moravej, K., Golchin, A., Tariq, A. Investigation of the relationship between ndvi index, soil moisture, and precipitation data using satellite images. In book: Sustainable Agriculture Systems and Technologies, Wiley Online Library, pp.314-325, 2022. https://doi.org/10.1002/9781119808565.ch15, 2022.

Authors: Now, in Introduction, Ln 67: "Adegoke & Carleton (2002) aimed to show the link between NDVI and water soil content with different lags. This study obtained stronger relations with soil moisture data that lagged to the vegetation indices by up to 8 weeks. This result implies that soil moisture may be a valuable predictor of warm-season satellite-derived vegetation conditions. Recently, Felegari et al. (2022) showed that plant indices such as NDVI have a delayed response to soil moisture. In most cases, soil moisture data and other meteorological characteristics strongly correlate with these indices in a short period. In a related study, Sharma et al. (2022) examined the trends in MODIS/TERRA derived NDVI and its correlation with Land Surface Temperature (LST), Soil Moisture (SM), and precipitation over Gautam Buddh Nagar (India) during the period 2005–2018. The correlation between NDVI and LST was higher than that of NDVI with SM and precipitation."

Line 37 what are the main findings of the papers you referred to?

Authors: Now, it says: ""Adegoke & Carleton (2002) aimed to show the link between NDVI and water soil content with different lags. In this study, stronger relations were obtained with soil moisture data that are lagged by up to 8 weeks with respect to the vegetation indices, implying that soil moisture may be a useful predictor of warm season satellite-derived vegetation conditions".

Line 39 and 40: is very difficult to follow the idea, strong correlation of what? The soil moisture between soil surface and lower layers?

Authors: We understand that in a daily context and extreme meteorological situations the relationship between soil moisture satellite indices and root-zone soil moisture will probably not occur. But in a decennial-monthly-seasonal context it does happen. We have included in Introduction Ln 60:

“The difference between surface soil layers and root zone soil must be noted when studying water soil content (Hirschi et al., 2014). Even though a strong correlation has been shown between these layers (Albergel et al., 2008; Babaeian et al., 2018). Different responses of NDVI to water soil content are found among distinct vegetation types, especially between humid and arid or semiarid areas. These differences are due to the disparities among these areas at root zone soils and surface soil layers (Adegoke and Carleton, 2002; Liu and Kogan, 1996; Wang et al., 2007). NDVI has been shown to have strong links with root zone soil moisture and surface soil moisture in grassland and shrubland in semiarid regions (Guan et al., 2020; Schnur et al., 2010; Wang et al., 2007).”

For example, Albergel et al (2008) states: “In general, the soil water indices derived from the surface soil moisture observations and simulations agree well with the reference root-zone soil moisture.”

Babaeian et al. (2018) states: “A close agreement was observed between the OPTRAM-SWDI and CMI drought indices for most selected sites. In conclusion, OPTRAM can estimate temporal soil moisture dynamics with reasonable accuracy for a range of climatic conditions (semi-arid to humid), soil types, and land covers, and can potentially be applied for agricultural drought monitoring.”

Line 42. Please check English grammar.

Authors: Thank you very much. We are working to improve the English grammar.

Lines 46 to 49 please use references to support the drought definitions.

Authors: The following references already appear: Allaby, 2014; American Meteorological Society, 2004, 1997; Wilhite and Buchanan-Smith, 2005. If you consider it is necessary, we can include more references. At the beginning of the introduction:

“Drought is the principal climatic hazard to arid and semiarid Mediterranean grasslands and causes physical suffering, economic losses, and environmental degradation. Droughts are often divided into four major types: meteorological, agricultural, hydrological, and socioeconomic (Allaby, 2014; American Meteorological Society, 2004, 1997; Wilhite and Buchanan-Smith, 2005).”