ms_borrador

AJ Perez-Luque ((???)); G. Gea-Izquierdo

2017

Contents

Intro

- The vegetation response to water deficit was assessed using remote sensing information and dendrocronologial data.

Ideas a expresar

Remote sensing

- Uso de Remote sensing para estudiar la sequía –> Leer Zhang et al. (2013) y escribir algo. Drought monitoring using remote-sensing approach was originally applied to agriculture. Several remote-sensing derived indices have been used to study the drought effects on vegetation …
- Leer también a AghaKouchak et al. (2015)

Sequías

- :red_circle: Algo de las sequías de 2005 y 2014

- Extreme sequías y ecología

Ideas a incluir

- Descripción de las sequía de 2005 y 2014

Major drought episodes in the IP were recorded in 1981, 1995, 2000 and 2005 (Vicente-Serrano et al. 2014)

La sequía es una característica del clima mediterráneo (Lionello 2012), pero en los últimos años se ha venido observando un aumento de la frecuencia y la severidad de los periodos de sequía (:red_circle: CITA; Vicente-Serrano et al. (2014) para la P. Iberica).

The 2004/2005 and 2011/2012 hydrological years are considered two of the worst drought periods recorded in the Iberian Peninsula, particularly in the southeren sector (García-Herrera et al. 2007, Trigo et al. 2013, Gouveia et al. 2015). These events were extreme in both its magnitude and spatial extent (Gouveia and Trigo 2014).

an increase in the drought severity in the Iberian Peninsula has been observed in the last decades (Vicente-Serrano et al. 2014).

frecuencia de las sequías severas (ver Dai 2011)

Algunos eventos extremos han aumentado su frecuencia en los últimos años

Althought several works have reported these two years as some of the worst drought events, we characterised the drought at several spatio-temporal scales in the study area. From a long-term perspective, we compare the accumulated monthly precipitation at a meteorological station (Granada, Base Aérea) during the hydrological years 2004-2005 and 2011-2012 with the average of accumulated monthly precipitation for the period 1950-2015.

- Extreme sequias y ecologia
- Como la dendro ayuda a evaluar las sequías (ver Gazol 2017)

Extreme climate events (as droughts, heatwaves) severely affect forests and grasslands throuhg changes in plant physiology, phenology and carbon allocation (Ummenhofer and Meehl 2017).

Droughts are most likely to have the largest and most long-lasting impacts globally due to large indirect and lagged impacts and long recovery especially for forest ecosystems (ver 18 en Ummenhofer and Meehl (2017))

Uso de NDVI como estimador de la NPP:

- The NDVI properties have allowed the use of this information for estimating the Net Primary Production (NPP) (Goward and Dye, 1987; Running et al., 2004; Hasenauer et al., 2012). Different studies have already found a strong relationship between NPP and radial growth (e.g., Granier et al., 2008; Babst et al., 2013, 2014a, 2014b; Vicente-Serrano et al., 2015), albeit with significant differences, particularly those related to species, sites and environmental conditions.

- Ver Gilaber et al. 2017 http://www.mdpi.com/2072-4292/9/3/193

Aims

`$IMPROVE$`

In this study we combined remote sensing information and dendroecological methods to evaluate the drought impacts in both greenees and growth of *Q. pyrenaica* forests in Sierra Nevada. Specifically,

The aims of this work were:

- To quantify how two extreme drought events influenced the greennes and radial growth of *Q. pyreancia* forests in their rear edge,

- to analyze the resilience of these forests to sucessive extrme drought events,

- and to explore differences in the resilience metrics between populations located in contrasting slopes within the rear edge of the distribution of this species.

References

Materials and methods

Species and study site

The Pyrenean oak (*Quercus pyrenaica* Willd.) forests extend through south-western France and the Iberian Peninsula (Franco 1990) reaching its southern limit in north of Morocco. In the Iberian Peninsula these forests live under meso-supramediterranean and mesotemperate areas and subhumid, humid and hyperhumid ombroclimate (S 2002) living on siliceous soils, or soils poor in basic ions (Serna 2014). *Q. pyrenaica* requires between 650 and 1200 mm of annual precipitation and a summer minimal precipitation between 100 and 200 mm (Martínez-Parras and Molero-Mesa 1982, García and Jiménez 2009), with summer rainfall being a key factor in the distribution of the species (Gavilán et al. 2007, Río et al. 2007).

This species reaches its southernmost European limit at Sierra Nevada, a high-mountain range located in southern Spain (37°N, 3°W) with elevations of between 860 m and 3482 m a.s.l. The climate is Mediterranean, characterized by cold winters and hot summers, with pronounced summer drought (July-August). There are eight oak patches (2400 Has) identified (:red_circle: FIGURE) in this mountain range, ranging between 1100 and 2000 *m a.s.l.* and generally associated to major river valleys. Sierra Nevada is considered a glacial refugia for deciduous *Quercus* species during glaciation (Brewer et al. 2002, Olalde et al. 2002, Rodríguez-Sánchez et al. 2010) and these populations are considered as a rear edge of the habitat distribution, which is important in determining habitat responses to expected climate change (Hampe and Petit 2005).

:red_circle: `duda aqui` Varias referencias hablan de los años 2005 y 2012 como extremadamente secos. Pero habría que hacer alguna referencia y/o análisis. Tengo dudas de si hemos de analizar (e incluir) que efectivamente los años 2005 y 2012 fueron caracterizados por un extrema sequía, por lo que habría que incluyendo referencia a apéndice

- O quizá un apartado llamado Drought episodes (similar a esto https://www.nature.com/articles/srep28269)

The populations of Pyrenean oak forests at Sierra Nevada are considered relict forests (Melendo and Valle 2000, Vivero et al. 2000), undergoing intensive anthropic use in the last few decades (Camacho-Olmedo et al. 2002, Valbuena-Carabaña et al. 2010). In fact, the status of conservation of this species for southern Spain is "Vulnerable" (Vivero et al. 2000). The relict presence of this species in Sierra Nevada is related both to its genetic resilience as well as to its high intraspecific genetic diversity (Valbuena-Carabaña and Gil 2013). However, they are also expected to suffer the impact of climate change, due to their climate requirements (wet summers). Thus, simulations of the climate change effects on this habitat forecast a reduction in suitable habitats for Sierra Nevada (Benito et al. 2011).

:red_circle: La figura 1 puede tener un mapa de localización de SN, otro de las poblaciones de roble (clasificadas por colores: cluster; y señalando las dos poblaciones muestradas en dendro). Ver MIGRAME dataset

Datos de sequía.

- :red_circle: Meter aquí algunos datos de sequia, similar a lo planteado por Gazol

Greenness data

To characterize the vegetation greeness of *Quercus pyrenaica* we used the Enhanced Vegetation Index (EVI) derived from MOD13Q1 product obtained by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor (Didan 2015). EVI and NDVI (Normalized Difference Vegetation Index) are the most common greenness vegetation indices. We used EVI instead of NDVI (Normalized Difference Vegetation Index) because

EVI is more sensitive to changes in high-biomass areas (a serious shortcoming of NDVI); EVI reduces the influence of atmospheric conditions on vegetation index values, and EVI corrects for canopy background signals (Huete et al. 2002, Krapivin et al. (2015), Cabello et al. (2012)).

EVI product consits of 16-day maximun value composite images (23 per year) of the EVI value with a spatial resolution of 231 m x 231 m. Data were obtained using a Google Earth Engine script (:red_circle: cite gists) for the 2000 - 2016 period. We selected the pixels covering the distribution of Quercus pyrenaica forests in Sierra Nevada (n = 928 pixels). The EVI data are geometrically and atmospherically corrected and include information about the quality ass.... :red_circle:

`$NOTA$`: NDVI sirve para estimar la producción primaria neta. Existen diferentes estudio que han evaluado el efecto de la sequía sobre la producción primaria neta utilizando NDVI.

These data are geometrically and atmospherically corrected, and include an index of data quality (reliability, which range from 0 – good quality data – to 4 – raw data or absent for different reasons) based on the environmental conditions in which the data was recorded

We first used the Quality Assesment (QA band) information of this product to filter out those values affected by high content of aerosols, clouds, shadows, snow or water; and then a quality assessment was carried out to filter the ... (Reyes-Díez et al. 2015)

:red_circle: reescribir esto de la calidad. Ver Samanta et al 2012 y como describe el proceso de calidad

After the filter out process, we built the annual EVI profile for each pixel and then computed the EVI's annual mean values and the EVI anomaly for each pixel for the period 2000 - 2015. (:red_circle: Hemos seleccionado EVI medio, además de por los consejos que me ha dicho Domingo, porque he comprobado que existe una correlación entre el evi medio y el evi estacional, sobre todo el de verano. Ver esto: https://github.com/ajpelu/qpyr_modis_resilience/blob/master/analysis/prepare_modis_qa.md. Además presenta alta correlaciones significativas con el EVI de verano: 0.88; de primavera: 0.76 y anual: 0.81)

> Procedimiento de Filtrado de datos (ver https://github.com/ajpelu/qpyr_modis_resilience/blob/master/analysis/prepare_modis_qa.md)

- Información contenida en banda QA.
  - Nos quedamos con pixeles marcados como Good Data (57.89 %)
  - Filter out los marcados como Snow/Ice y/o Cloudy (2.57 + 7.08 = 9.65 %)
  - Pixeles marcados como Marginal Data (32.33 %) (ver siguiente paso)
- Explorar distribución temporal y analizar banda QA Detailed y llevar a cabo un filtrado siguiendo las especificaciones de Reyes-Díez et al. (2015).
  - Vemos los composites marcados con Aerosoles, Adjacent cluods, y Shadow.

  - According to Reyes-Díez et al. (2015) we must consider the shadow in the mountain, but we can discard the filter of adjacent clouds. On the other hand, the use of EVI mean is highly stable under the use of any filter (Reyes-Díez et al. 2015)
- Finalmente nos hemos quedado con las siguientes cifras. De un total de 360064 images composites for the study zone were downloaded (928 x 20 x 1 + 928 x 23 x 16 = 360064), tras el filtrado, nos quedamos con 286825 (79.65 %)

To explore the effect of drought events on greenness we calculated the EVI standardized anomaly (EVI~sa) pixel-by-pixel, since it minimizes biases in the evaluation of anomalies, providing more information about the magnitude of the anomalies (Samanta et al. 2012, Gao et al. (2016)). For each pixel we averaged all the EVI valid values within a year (:red_filter: see quality filter), and then the standardized anomaly was computed as:

$$\mathrm{EVI}_{\mathrm{sa},i} = \frac{\mathrm{EVI}_{\mathrm{mean},i} - \mathrm{EVI}_{\mathrm{mean,ref}}}{\sigma_{\mathrm{ref}}}$$

where $\mathrm{EVI}_{\mathrm{sa},i}$ is the EVI standardized anomaly for the year i; $\mathrm{EVI}_{\mathrm{mean},i}$ the annual mean value of EVI for the year i; $\mathrm{EVI}_{\mathrm{mean,ref}}$ the average of the annual EVI values for the period of reference (all except i year), and σ_{ref} the standard deviation for the reference period.

Field sampling and dendrochronological methods

Tree sampling

Samplig was carried during autumn of 2016. Trees were sampled at two locations located in contrasting slopes of Sierra Nevada: San Juan (SJ; northern site) and Cáñar (CA; southern site) (Table 1). Both sites were oak monospecific and representatives of two of the three the population's cluster identified for the specie in this mountain range (:red_circle: mejorar; citar Pérz-Luque et al..). In each site between 15 and 20 dominant trees were randomly selected. Two cores of 5 mm of diameter were taken per tree at 1.3 m using an increment borer. Diameter at breat height (DBH) and total height were recorded for each tree. Increment cores were air dried, glued onto wooden mounts and sanded. Annual radial growth (ring width, RW) were measured with a LINTAB measuring device (:red_circle: Rinntech 2003) coupled to a stereomicroscope, with an accuracy of 0.01 mm. Individual ring series were visually and statistically cross-dated with TSAP software (:red_circle: Frank Rinn, Heidelberg, Germany), using the statistics Gleichläufigkeit (GLK), t-value and the crossdating index (CDI). Validation of the croos-dating was done using COFECHA software (Holmes 1983).

Dendrochronological methods

... dendro For each focal tree we measured diameter at breast height (DBH) and total height. A total of xx trees were sampled. ...

We built chronologies for each site (two)

Site chronologies were built by averaging all tree BAI measurement of the same site. To explore similarity within locality, each site chronology was smoothed using centred moving averages with different window sizes, and then Pearson's correlation coefficient between the two chronologies of the same locality (higher and lower elevation) were calculated. Significance was tested using 1000 boostrap replicates and with 95 % confidence intervals built using the R packgae `boot` (Canty and Ripley 2016)

Resilience

To evaluate the effects of the disturbance events on greeennes and tree growth we used four resilience indices proposed by Lloret et al. (2011): resilience (*Rs*), resistance (*Rt*), recovery (*Rc*) and relative resilience (*RRs*).

The resistance index (*Rt*) quantifies the severity of the impact of the disturbance in the year it occurred. It is estimated as the ratio between the performance during and befor the disturbance:

Resistance (*Rt*) = Drought / Predrought

The Recovery index (*Rc*) is the ability to recover from disturbance relative to its severity, and it is estimated as the ratio between performance after and during disturbance:

Recovery (*Rc*) = Postdrought / Drought

The Resilience index (*Rs*) is the capacity to reach pre-disturbance performance levels, and it is estimated as the ratio between the performance after and before disturbance:

Resilience (*Rs*) = Postdrought / Predrought

The Relative Resilience (*RRs*) is the resilience weighted by the severity of the disturbance, and it is estimated as:

Relative Resilience (RRs) = (Postdrought - Drought) / Predrought

We computed the values of these indices for tree growth and greenness during each drought event. We considered 2005 and 2012 as singles drought events. The predrought and postdrought values of each target variable (i.e.: tree growth or EVI) we computed as the mean value during a period of three years before and after the disturbance events respectively. A period of three years was chosen because we found similar results comparing periods of two, three and four years (:red_circle: incluir tabla de coeficientes y/o gráfica?? como suplement, see Gazol 2017)

Statistical analysis

- Explore anomalies EVI
- Explore long and short term trends in RW :red_circle: ver correo Guillermo
- ANOVA analysis EVI events and populations

We tested for significant differences between drought events (2005 and 2012) and oak population (northern and southern slopes) for each of the resilience indices. Robust two-way ANOVAs were used beacuse original and log-transformed data both did not match the assumptions of normality and homogeneity of variance (Wilcox 2012). Robust measures of central tendency (M-estimator based on Huber's Psi) were used since they were close to mean value in all cases (Wilcox 2012). When running the robust ANOVA test, data were boostrapped 3000 times and trimmed automatically to control the potential influence of outliers (Field et al. 2012, Wilcox (2012)). Post-hoc differences were assessed pairwise using a similar boostrap test. All the robust ANOVA and post-hoc tests were carried out using the WRS2 (Mair et al. 2017) and rcompanion (Mangiafico 2017) R packages. The level of significance was set at 0.05 and adjusted for multiple comparisons.

References

AghaKouchak, A., A. Farahmand, F. S. Melton, J. Teixeira, M. C. Anderson, B. D. Wardlow, and C. R. Hain. 2015. Remote sensing of drought: Progress, challenges and opportunities. Reviews of Geophysics 53:452–480.

Cabello, J., D. Alcaraz-Segura, R. Ferrero, A. Castro, and E. Liras. 2012. The role of vegetation and lithology in the spatial and inter-annual response of {evi} to climate in drylands of southeastern spain. Journal of Arid Environments 79:76–83.

Canty, A., and B. D. Ripley. 2016. Boot: Bootstrap r (s-plus) functions.

Didan, K. 2015. MOD13Q1 MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006. NASA EOSDIS Land Processes DAAC.

Field, A., J. Miles, and Z. Field. 2012. Discovering statistics using r. Page 1426. SAGE.

Franco, A. 1990. Quercus l. Pages 15–36 *in* A. Castroviejo, M. Laínz, G. López-González, P. Montserrat, F. Muñoz-Garmendia, J. Paiva, and L. Villar, editors. Flora ibérica. Real Jardín Botánico, CSIC, Madrid.

Gao, Q., W. Zhu, M. W. Schwartz, H. Ganjurjav, Y. Wan, X. Qin, X. Ma, M. A. Williamson, and Y. Li. 2016. Climatic change controls productivity variation in global grasslands. Scientific Reports:26958.

García-Herrera, R., E. Hernández, D. Barriopedro, D. Paredes, R. M. Trigo, I. F. Trigo, and M. A. Mendes. 2007. The Outstanding 2004/05 Drought in the Iberian Peninsula: Associated Atmospheric Circulation. Journal of Hydrometeorology 8:483–498.

Gouveia, C. M., and R. M. Trigo. 2014. The 2005 and 2012 major drought events in Iberia: monitoring vegetation dynamics and crop yields using satellite data. Page 15179 *in* EGU general assembly conference abstracts.

Gouveia, C. M., P. Ramos, A. Russo, and R. M. Trigo. 2015. Drought trends in the Iberian Peninsula over the last 112 years. Page 12680 *in* EGU general assembly conference abstracts.

Holmes, R. L. 1983. Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin 43:69–78.

Huete, A., K. Didan, T. Miura, E. Rodriguez, X. Gao, and L. Ferreira. 2002. Overview of the radiometric and biophysical performance of the {modis} vegetation indices. Remote Sensing of Environment 83:195–213.

Krapivin, V. F., C. A. Varotsos, and V. Y. Soldatov. 2015. Remote-sensing technologies and data processing algorithms. Pages 119–219 *in* New ecoinformatics tools in environmental science: Applications and decision-making. Springer International Publishing.

Lionello, P., editor. 2012. Page 502. Elsevier, Oxford.

Lloret, F., E. G. Keeling, and A. Sala. 2011. Components of tree resilience: Effects of successive low-growth episodes in old ponderosa pine forests. Oikos 120:1909–1920.

Mair, P., F. Schoenbrodt, and R. Wilcox. 2017. WRS2: Wilcox robust estimation and testing.

Mangiafico, S. 2017. Rcompanion: Functions to support extension education program evaluation.

Reyes-Díez, A., D. Alcaraz-Segura, and J. Cabello-Piñar. 2015. Implicaciones del filtrado de calidad del índice de vegetación evi para el seguimiento funcional de ecosistemas. Revista de Teledeteccion 2015:11–29.

S, R.-M. 2002. Vascular plant communities of spain and portugal. addenda to the syntaxonomical checklist of 2001. part ii. Itinera Geobotanica 15:5–922.

Samanta, A., S. Ganguly, E. Vermote, R. R. Nemani, and R. B. Myneni. 2012. Interpretation of variations in modis-measured greenness levels of amazon forests during 2000 to 2009. Environmental Research Letters 7:024018.

Serna, B. V. de la. 2014. Comprehensive study of "quercus pyrenaica" willd. forests at iberian peninsula: Indicator species, bioclimatic, and syntaxonomical characteristics. PhD thesis, Complutense University of Madrid, Madrid.

Trigo, R. M., J. A. Añel, D. Barriopedro, R. García-Herrera, L. Gimeno, R. Castillo, M. R. Allen, and A. Massey. 2013. The record Winter drought of 2011-12 in the Iberian Peninsula [in "Explaining Extreme Events of 2012 from a Climate Perspective. [Peterson, T. C., M. P. Hoerling, P.A. Stott and S. Herring, Eds.] 94:S41–S45.

Ummenhofer, C. C., and G. A. Meehl. 2017. Extreme weather and climate events with ecological relevance: A review. Philosophical Transactions of the Royal Society of London B: Biological Sciences 372.

Vicente-Serrano, S. M., J. I. López-Moreno, S. Beguería, J. Lorenzo-Lacruz, A. Sanchez-Lorenzo, J. M. García-Ruiz, C. Azorín-Molina, E. Morán-Tejeda, J. Revuelto, R. Trigo, F. Coelho, and F. Espejo. 2014. Evidence of increasing drought severity caused by temperature rise in southern Europe. Environmental Research Letters 9:044001.

Wilcox, R. 2012. Introduction to robust estimation and hypothesis testing (third edition). Page 608. Third Edition. Academic Press.

Zhang, Y., C. Peng, W. Li, X. Fang, T. Zhang, Q. Zhu, H. Chen, and P. Zhao. 2013. Monitoring and estimating drought-induced impacts on forest structure, growth, function, and ecosystem services using remote-sensing data: Recent progress and future challenges. Environmental Reviews 21:103–115.