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Recurrence Quantification Techniques of vegetation time-series indices in semiarid grasslands

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Grassland ecosystems are extremely complex and set up intricate structures, whose characteristics and dynamic properties are greatly influenced by climate and meteorological patterns. Climate change and global warming are factors that could impact negatively in the quality and productivity of these ecosystems.

Remote sensing techniques have been demonstrated as a powerful tool for monitoring extensive areas. In this study, two semi-arid grassland plots were selected in the centre of Spain. This region is characterized by low precipitation and moderate productivity per unit. Through scientific research, spectral vegetation indices (VIs) have been developed to characterize vegetation cover. The most common VI is the Normalized Difference Vegetation Index (NDVI). However, in vegetation scarcity conditions, bare soil reflectance is increased, and the feasibility of NDVI is reduced. This study aims to perform a method to compare soil and agro-climatic variables effect on vegetation time-series indices.

The construction of the time series was based on multispectral images of MODIS TERRA (MOD09A1.006) product acquired from 2002 till 2018. Three pixels with a temporal resolution of 8 days and a spatial resolution of 500 x 500 m were chosen in each area. To estimate and analyse VIs series, Red (620-670 nm) and Near Infrared (841-876 nm) channels were extracted and filtered by the quality of pixel. All spectral bands showed statistically significant differences confirming that both areas presented different soil properties. Moreover, average annual precipitation was different in each area of study.

NDVI calculation is only based on NIR and RED bands. To improve the estimation of vegetation in semi-arid areas, several indices have been developed to minimize the soil effect. Each one of them incorporates soil influence in a different way, i.e., Soil Adjusted Vegetation Index (SAVI) adds a constant soil adjustment factor (L), whereas, MSAVI, incorporate an L variable and dependant on soil characteristics.

Recurrence plots (RP) and recurrence quantification analysis (RQA) were computed to characterize the influence of agro-climatic variables in vegetation index dynamics. Characterization was based

on various RQA measures, such as Determinism (DET), average diagonal length (LT) or entropy (ENT).

Our results showed different RPs depending on the area, VI utilized and precipitation. MSAVI patterns were further distinct, meanwhile, NDVI showed a noisy pattern. LT values in MSAVI were higher than in SAVI implying that MSAVI recurrent events are much longer than SAVI. Simultaneously, LT and DET values in ZSO, with a higher rain, were above ZEA values in MSAVI.

This indicates that incorporating more detailed information of soil and precipitation reinforce vegetation index estimation and allow to obtain a more distinct pattern of the time series. Therefore, in arid-semiarid grasslands, they should be considered.

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