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Revealing climate and vegetation indices interactions through Cross Recurrence Techniques

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Grasslands are one of the world's major ecosystems groups many of them are now being acknowledged as having a multifunctional role in producing food and rehabilitating croplands, in environmental management and cultural heritage. Multiple studies showed pasture grasslands as a complex agroecological system, depending on multiple variables with a nonlinear dynamic greatly affected by climate fluctuations over time. Remote sensing methods proved to be one of the most effective techniques for monitoring variations over wide areas. In this line, vegetation indices (VIs) demonstrated to be an appropriate indicator of vegetation cover condition. This study aims to perform a method to visualize and quantify the complexity between semiarid grasslands and climate. With this goal, VIs and climate time series are analysed simultaneously with non-linear techniques to reveal the dynamic behaviour of both series over time and their interaction.

A semi-arid grassland area characterized by a Mediterranean climate with a continental character and low precipitation throughout the year were chosen. VIs time series were constructed from MODIS TERRA (MOD09Q1.006) product. Multispectral images composed by 8-days were acquired from 2002 till 2018 and four pixels with a spatial resolution of 250 x 250 m^2 were chosen in the selected area. Normalized Difference Vegetation Index (NDVI) and Modified Soil-Adjusted Vegetation Index (MSAVI) were calculated based on these images. Temperature and precipitation series were acquired from a near meteorological station and adapted to 8-day time step.

Cross-Recurrence plots (CRP) and recurrence quantification analysis (RQA) were performed to analyse the climate and vegetation dynamics simultaneously. To achieve this goal, several measures of complexity were computed, such as Determinism (DET), average diagonal length (LT) and entropy (ENT).

Our results showed different CRPs depending on the climate variable and the utilized VIs. Temperature and VIs CRPs showed a periodical pattern, implying the temperature seasonality over time. In contrast, precipitation and VIs CRPs showed more chaotical behaviour, due to the

occurrence of extreme events and seasonal shifts. These results are quantified by the DET and ENTR values.

Our results indicate that temperature and precipitation present a dynamical complexity that is revealed in VIs response. Both indices showed different results of complexity measures, implying that MSAVI has a higher complexity than NDVI. This fact is probably due to the addition of a variable soil adjustment factor. Consequently, MSAVI should be considered as a potential alternative to NDVI in semiarid areas.

Reference

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