Multifractal Analyses on Normalized Difference Vegetation Index Series on Pastures

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1 Introduction

Remote sensing techniques have been rapidly improving the study of vegetation biophysical status. The interaction of weather parameters and human influence makes the study of vegetation a more challenging project. Normalized Difference Vegetation Index (NDVI) is used to monitor vegetation network dynamics, and is commonly used on grasslands and rangelands [1, 2]. Analysing NDVI time series has shown the fractal character of vegetation dynamics [3, 4]. However, only recently the multifractal analysis has been applied by Igbawua et al (2019) [5] and Ba et al (2020) [6].

The main feature of multifractals is that they are characterized by high variability over wide ranges of temporal or spatial scales that are associated with intermittent fluctuations and long-range power-law correlations. Multifractal analyses such as multifractal detrended fluctuation analysis (MFDFA) [7] allows studying multiscaling on vegetation and detecting whether it is related to long term correlations or to a broad probability density functions, further understanding their vegetation dynamics. In this publication, our goal is to characterise the selected pastures in Murcia province (Spain) to study their vegetation dynamics and multifractal character using MFDFA, Mann-Kendall test [8-9] and Hurst index[10].

2 Results

We proceeded to extract NDVI time series from 2002 to 2019 from two square plots of 2.5 km side. These plots represented two types of rangeland and vegetation types (stubbles and open woodlands). Area 1 (A1) is almost entirely covered by mixed croplands use for stubble grazing with some grasslands and scrublands. And area 2 (A2) is composed by coniferous woodland with some mixed crops on small patches. We calculated NDVI from MOD09Q1, for two different resolution 500 x 500m and 250 x 250m. We compared the NDVI series of all pixels for both resolution as well as a selection on pixels based on land uses in these areas (stubble for A1 and woodland for A2). We selected

120 and 111 pixels out of 132 in A1 and A2 respectively. Savitzky-Golay method was used to smooth both series and anomaly series (Z_{NDVI}) was calculated [11].

We can observe in both areas a trend that is maintained even when Z_{NDVI} was calculated (see fig. 1). To study these trends we used Mann-Kendall test. When using the 250 resolution for all pixels, the two areas have a significant tendency, A1 is decreasing, and A2 is increasing. Same tendencies are shown for A1 when using the selected pixel and with resolution 500. Whereas, A2 does not show a significant trend with resolution 500. Same results were obtained when Z_{NDVI} was tested. Given that the trend was still present after using Z_{NDVI} the series must have a natural tendency regardless of the effects of climatic variability. To avoid the influence of the trend on the Hurst analysis, we used multifractal detrended fluctuation analysis. This way we compared the fractal character of the different series.

H(q) is the generalized Hurst exponent (or self-similarity scaling exponent) [7]. Once that H(q) is calculated, the scaling exponents function (ζ(q)) is derived [7]. The H(q) shows in almost all cases that A1 is less antipersistent than A2 (see fig. 2). A1 is mainly used for herbaceous crops; therefore their trend will be more repetitive throughout the year. On the other hand, A2 presents a more continuous canopy growth that provides a less persistent landscape. ζ(q) functions of both areas show a multifractal character, really similar to each other (see fig. 2). When the scaling exponent is calculated using Z_{NDVI}, A1 shows a weaker multifractal character, while A2 gets a stronger curvature. The differences on the slope between the graphics with NDVI and Z_{NDVI} suggest that A1 has mildly stronger multifractal character; this is partly based on long range correlation and climatic effects. We intend to expand these analyses to more areas and types of pastures. We want to study their spatial distribution. Explore whether the abrupt changes on NDVI series have affected their multifractal character and if the different fractal characters are related to different land uses.

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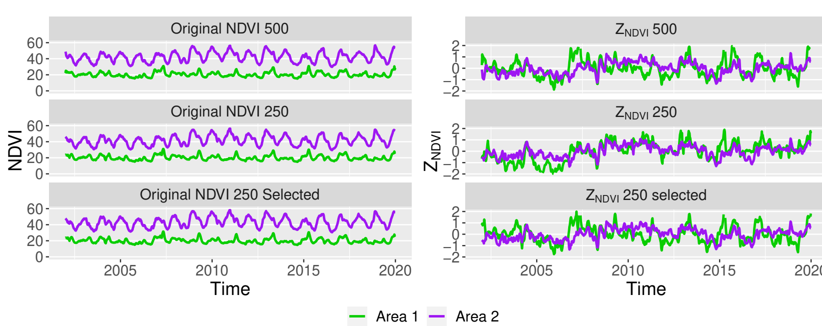

Fig. 1. Series of average NDVI and Z_{NDVI} for each area, with 500 m resolution all pixels (first row), 250 m resolution all pixels (second row), and 250 m resolution with only selected pixels (last row).

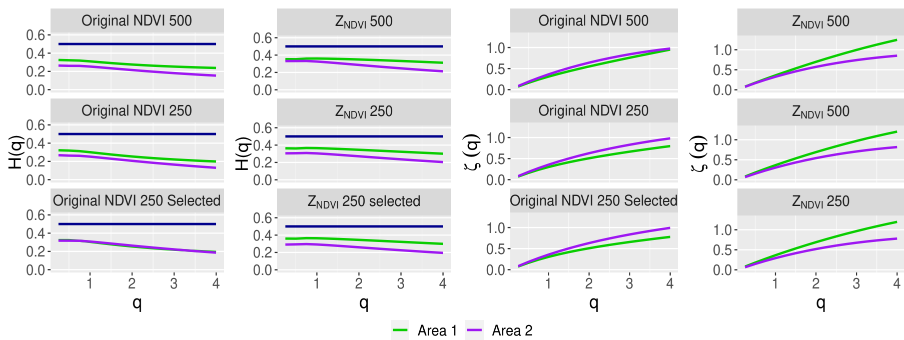

Fig. 2. Generalised Hurst exponent H(q) and ζ(q) for both areas, for NDVI and Z_{NDVI}, with 500 m resolution all pixels (first row), 250 m resolution all pixels (second row), and 250 m resolution with only selected pixels (last row). A blue line has been added for comparison, representing the Hurst exponent of Brownian motion.

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