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Review

Environmental assessment and land change analysis in seminatural land covers applicable to land management

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ABSTRACT

The present research is based on the hypertemporal analysis of a set of 212 images from the NDVI index from January 2003 to March 2012 provided by the medium-resolution sensor MODIS TERRA. The study area is located in the center of the Iberian Peninsula (Spain). The specific objectives of the study are to investigate the rhythms of the annual development of the NDVI of each of the classes, determine the classes that are most sensitive to climatic variability and define the interannual sequences of variation in NDVI with an associated trend analysis. The classes situated in lower-altitude areas are strongly dependent on autumn rainfall and present negative temporal tendencies, and those situated at mountaintops and on upper slopes are correlated with spring–summer temperatures and exhibit stable or positive tendencies.

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Introduction

The study makes use of a hypertemporal analysis of a set 212 images from the NDVI index provided by the moderate-resolution sensor MODIS TERRA, acquired from January 2003 to March 2012 and comprised of 23 images per year. The values of the NDVI index of these images reflect the incidence of both habitual and exceptional factors during the period of observation. Although the sample location is usually considered to be stable with apparently little temporal variability, this study hypothesizes that the different land covers are undergoing a noteworthy change process.

This study attempts to establish the susceptibility of a territory to change by means of study of the evolutionary trends occurring at the heart of spatial units, and to apply the information provided by Remote Sensing as a basis to land planning processes. The specific objectives are as follows: (1) demonstrate the validity of the method used for define land cover classes in the study area; (2) determine the phenological behavior of the classes; (3) establish the temporal tendencies and changes that occur; (4) show the relationship between the climatic variables and annual development of the NDVI.

This research is focused on the mountains of the Central System (Spain) and includes the easternmost sector of the Gredos Range and the Guadarrama and Somosierra Ranges; this region is located in the Madrid region and in the Avila, Guadalajara, Segovia, Soria and Toledo Provinces. The three mountain ranges have a maximum elevation of 2430 m (Fig. 1).

This set of mountains is representative of a continental environment situated at the southern edge of Europe's temperate zone and has a subtropical influence. It conserves a large amount of seminatural covers and presents significant and well-contrasted climatic characteristics. Spatial organization of the vegetation and land covers in this geographic area is closely related to topographic contrasts and to rock and soil types.

Study methods

Two phases of the research can be differentiated: the first phase consists of an unsupervised classification with the ISODATA technique based on the stacked images and the second phase develops the data analysis.

Design of an unsupervised classification

Correction of outliers

Although the images were corrected for distortions, atmospheric contamination and cloudiness, negative outliers were still found that coincided primarily with the dates on which snowfall covered a significant portion of the sector in the image (AEMET, 2010). Because snow-covered ground provides low NDVI values that are not a result of variations in NDVI productivity of the defined classes, it is considered convenient to correct such data.

The correction is an adaption of the *mean-value iteration filter* (MVI) proposed by Ma and Veroustraete (2006) and used by Julien and Sobrino (2010) as the iterative interpolation for data (IDR) method.

Classification of the images

To obtain the most suitable number of classes for the study, we produced a total of 90 unsupervised classified images with the *Iterative Self-Organizing Data Analysis* (ISODATA) algorithm and 50 iterations. Each unsupervised classification is obtained from the set

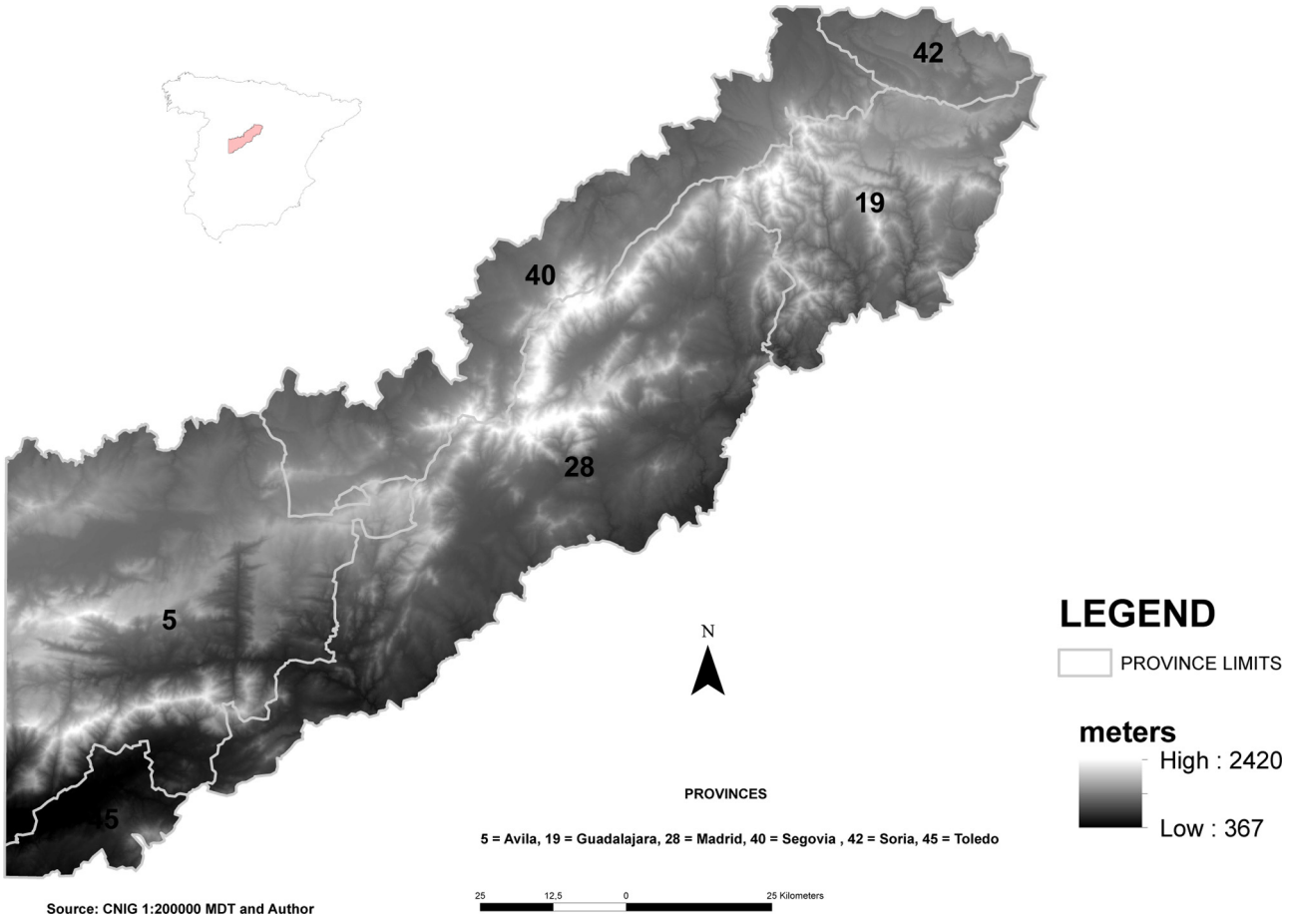

Fig. 1. Study area in the Spanish Central System.

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