ANALYSIS AND VALIDATION OF A METHODOLOGY TO EVALUATE LAND COVER CHANGE IN THE MEDITERRANEAN BASIN USING MULTITEMPORAL MODIS DATA

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Key words : MODIS, land cover, decision tree classifier, accuracy assessment.

Abstract. Land cover composition and conversions are important factors that affect ecosystem condition and function. This study explored the use of 250 m multitemporal MODIS NDVI 16 day composite data to detect land cover change between 2005 and 2008 in Sardinia. We used a supervised classification procedure, based on the decision tree, to estimate land cover change and afterwards we assessed the accuracy. The methods and results detailed in this article apply only to non-agricultural areas. The main aim of this study is to propose a monitoring model to evaluate seasonal and inter-annual land cover change and utilize the information to evaluate the state of vegetation for the assessment of environmental risks. The first results show that the MODIS data are useful to evaluate the land cover change in areas with heterogeneous vegetation like Sardinia, allowing a continuous monitoring and planning of environmental management.

Introduction

The land distribution and change on the Earth land surface plays a central role in many Earth system processes. Terrestrial ecosystems affect climate through exchanges of energy, water, CO2 and other atmospheric gases. Changes in community composition and ecosystem structure alter these exchanges and, in doing so, they alter surface energy fluxes, the hydrologic cycle and biogeochemical cycles (Gutman et al., 2004).

Land cover is defined as the layer of soils and biomass, including natural vegetation, crops and human structures that cover the land surface (Dolman et al., 2003). Studying land cover change at the regional scale plays a key role in

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understanding the complex phenomena related to Global Change. Over recent years, the use of remote sensed data has been widely applied to observe environmental change. Remote sensing offers the possibility to observe, quantify and investigate the changes of the physical components of the environment both in relation to human activities and natural events.

In this study, the issue of the monitoring of land cover in Mediterranean environment was discussed using Sardinia like a test area. The main objective of this study was to evaluate the MODIS (250 m) capability of detecting land cover change in the Mediterranean areas. We used a decision tree classifier applied to MODIS images at 250m resolution.

The existing bibliography on the subject has highlighted the potential use of MODIS data in monitoring land cover change at global and regional scale.

The main reference of the research was the algorithm of the Vegetation Cover Conversion, designed to serve as a global alarm for land cover change caused by anthropogenic activities and extreme natural events. Because many land cover changes due to human activities occur at spatial scales near 250 m (Townshend & Justice, 1988), the Vegetation Cover Conversion derives from the two MODIS bands available at 250 m resolution. Normally, this product is applied in areas with homogeneous and quite extensive coverage.

In this paper, we examine for the first time the possibility of using MODIS data and this algorithm for the study of land cover change in Sardinia, although, in terms of vegetation, the area is very heterogeneous and fragmented.

The methodological approach was modified because of the landscaping variability of the area.

The single bands, red and near infrared, were used inside of the classification with decision tree instead of the NDVI (Normalized Difference Vegetation Index), normally utilized in the reference studies. Afterwards, the accuracy of the classification's results was assessed to evaluate the quality of the maps.

This paper presents the results of the analysis of remote sensing images of 2000; the results were compared with aerial photos and Landsat images for the same period.

In the final part of this paper, the capability of the NDVI temporal profile to evaluate qualitatively the land cover change was discussed, deemed from many authors as valid tool for the analysis of change detection.

1. Methodology

The multitemporal MODIS data were acquired between April 2000 and September 2008 from the Antenna Network and integrated with MODIS product (MOD13Q1) of the NASA EOS Gateway.

The remote sensing data used in this study are single bands Red_NIR and NDVI products from the MODIS sensor. The Moderate-resolution Imaging Spectroradiometer (MODIS) has a spatial resolution of 250m x 250m and radiometric resolution of 2 bands, red and near infrared. A multitemporal archive of data throughout spring, summer and autumn has been acquired.

The selected images were processed from Sinusoidal projection system to UTM (zone 32) with Datum WGS 84. It's useful to compare the final results. The classification methodology includes a supervised decision tree classifier applied on the single bands Red_NIR and the density slicing technique applied on MODIS NDVI data. The land cover classes analyzed in this work are 4: *broadleaf, needle leaf, mixed forests, barren o sparsely vegetation.*

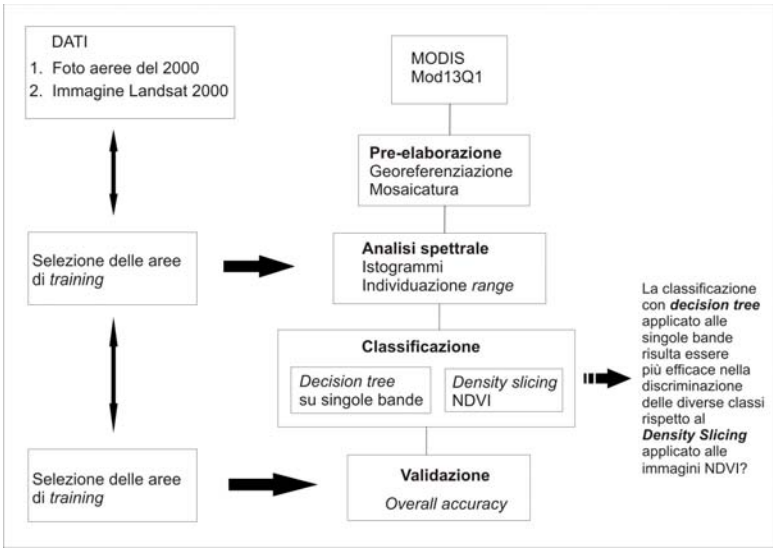

Fig. 1- Methodological scheme

A set of 50 reference pixel for each class were derived using the ground data. Reference data to support the training stage included Landsat images and aerial photography of 2000, made available respectively by Landast website and Regione Sardegna website. In this first part of the work, the agricultural areas and water bodies that have been properly excluded from the classification by creating masks based on the vector data of the Corine Land Cover 2000 database were not taken into account (fig. 1).

Accuracy assessment is the process used to estimate the accuracy of the classification present in a map, by confronting the map with reference information that we assume as true. The final goal is the production of an error matrix, from which statistics and indices that indicate the accuracy of individual classes and of the whole map can be derived. Hence, the main objective of accuracy assessment is to derive a quantitative description of the accuracy of the classification map. The confusion matrix has been used to evaluate the accuracy for each map of each month considered. The reference data utilized are mainly the aerial photography integrated with Landsat image. A set of 20 reference pixel for each class were derived using the ground data for the validation stage. In the first part of this work we compare both the procedures and assess the accuracy.

The land cover classes resulted from the classification were utilized to build different land cover masks. Each land cover mask was used to delineate the land cover areas in the corresponding MODIS NDVI image and it was used to build qualitative NDVI temporal profile.

2. Results and discussion

An operational methodology for land cover classification using MODIS data has been developed and implemented based on a decision tree classifier. Results achieved are good enough for the decision tree approach.

Detection accuracy was assessed for April at 61,11%, for May 63,64,% for June 65,28%, for July 61,11%, for August 67,27%, for September 62,07% and for October 64,63%.

In general, broadleaf and sparse vegetation classes were discriminated well enough while mixed forests and needle leaf classes have not been having good results.

The vegetation cover in Sardinia is extremely heterogeneous; in fact it has been very difficult to characterize each land cover class. The high variability of the vegetation included many mixed pixels and, also the spatial resolution of the MODIS has an important impact in the accuracy assessment.

Therefore, the allocation of classes becomes a very difficult procedure for the presence of so many mixed pixels. This is especially true for coniferous forests that have small extensions range, indistinguishable to the scale of the satellite, with the exception of some areas that, having an important size, are the majority of training areas.

A qualitative analysis of the temporal profiles corresponding to phenological end-members was performed to provide an initial performance assessment of the procedure described above for producing high quality time series data to support subsequent change detection analysis. NDVI temporal profiles are an useful tool to

visualize immediately land cover change without specific knowledge of remote sensing.

The land cover classes derived from the decision tree classification were used as masks to define the corresponding pixel in the MODIS NDVI image. Figure 2 illustrates the four principal land cover classes for the Sardinia region during the year 2000.

In general, the NDVI trend for each class decreases from April to August and then increases towards the autumn months. This trend is characteristic of Mediterranean environments that have hot and dry summers and mild and rainy winters. The broadleaf class is higher in April than other months for the reflectance contribution of the grassland vegetation. On the other hand, in August, the sparsely vegetation has the lowest value due to the dryness.

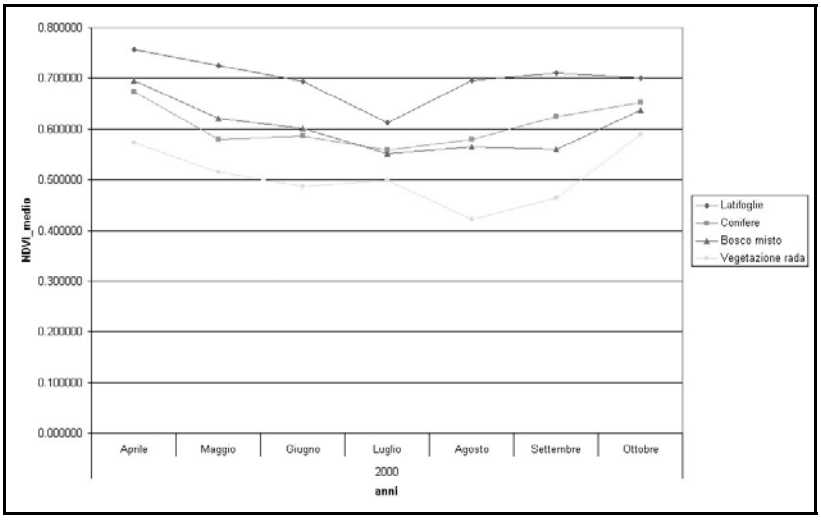

Fig. 2 - NDVI temporal profile of 2000

Summarizing, the temporal profiles are useful qualitative methods for monitoring the land cover change and for supporting change detection analysis.

Conclusions

This paper describes the capability of multitemporal MODIS data to detect the land cover change in Sardinia. The methodology based on decision tree classifier was applied for the first time in Sardinia. The methodological approach that has been validated may be considered sufficiently suitable to study land cover

change, although further improvement of the accuracy can be obtained. Moreover, the analysis should be completed with the classification of agricultural areas that greatly influence land cover change. Therefore, the results encourage the use of this methodology in fragmented areas such as the Sardinia region. This study can only give an overview of the environmental situation and the change taking place.

In conclusion, the results presented here are promising for these applications and demonstrate the possibility to utilize MODIS in the land cover monitoring in Sardinia in the future.

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