Satellite Hyperspectral Remote Sensing for Forest Species Mapping

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Abstract

Information of species distribution is a key forest-ecological inventory objective which has not been able to be met with the use of multispectral data. The use of hyperspectral imagery, which is a relatively recent and novel data source, is being investigated and has shown some very interesting primary results. However, because of the limited number of studies only a narrow combination of sensors and environments has been tested. The aim of this study is to determine whether satellite hyperspectral imagery (Hyperion, CHRIS) is a useful tool for forest species distribution mapping in two Mediterranean forest environments, namely Thasos Island and Taxiarchis Chalkidikis, both in Greece. Thasos Island is mostly dominated by Pinus sp. while Taxiarchis Chalkidikis presents a more complex environment with mixture of Quercus sp., Fagus moesiaca and Pinus sp. The performance of the two sensors towards species classification is going to be compared, as well as the advantages and disadvantages of summer and autumn Hyperion images. In addition to that the classification models are going to be examined for their transferability between the two study areas. If hyperspectral imagery proves to be adequate for mapping forest species, it would provide a new framework for conducting qualitative/quantitative ecological analysis on a landscape level, based on information derived from satellite remotely sensed data.

Motivation

Because…

…information of species distribution is a key forest - ecological inventory objective

and…

…multispectral imagery is not capable of providing this information.

…The use of hyperspectral imagery should be investigated for its suitability. If hyperspectral imagery proves to be adequate for mapping species distribution, it would provide a new framework for conducting qualitative/quantitative ecological analysis on a landscape level, based on information derived from satellite remotely sensed data.

Aim and Objectives

The aim is to:
determine whether satellite hyperspectral remote sensing is a useful tool for forest species distribution mapping

The objectives are to:

- explore the capabilities of two different satellite hyperspectral sensors, namely Hyperion and CHRIS, in forest species distribution mapping, in two different Mediterranean ecosystems (Thasos Island, Taxiarchis Chalkidikis)
- examine whether winter-time or autumn-time imagery is more adequate for the discrimination between forest species
- examine whether the classification models are transferable between the two study areas

Study Areas

Figure 1.

Thasos Island

The island of Thasos is Greece's most northern island (figure 1). The study area covers 100km^2, approximately ¼ of the island's surface. Elevation ranges from 100 to 1217 m; slopes range from 0 to 80 degrees. The climate of the island is cool and humid Mediterranean. Several land cover types are present on the island, namely, forests and forested lands, shrublands, bare land, barren land, fields and orchards, as well as urban areas. The major forest species are Pinus brutia and Pinus nigra, but also present at the study site are Platanus orientalis, Castanea sativa and Quercus coccifera.

Taxiarchis Chalkidikis

The Taxiarchis Chalkidikis forest (Aristotle University Forest) is located in the South and South-West side of the Cholomontas mountain and it covers 66.3km^2. Elevation ranges from 320 to 1165m, while slopes range from 0 to 70 degrees. The climate is continental Mediterranean, with mild winter and dry summer. The main indigenous species are Quercus conferta, Quercus pubescens and Fagus moesiaca. However, there has been extensive reforestation so species like Pinus nigra and Pinus brutia are also present at the scene.

Materials

Thasos Island

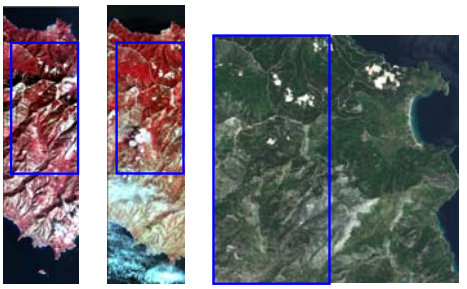
-Two Hyperion E/O1 images [autumn 2002 (a), summer 2003 (b)] (figure 2)

-A CHRIS/PROBA image [summer 2003 (c)] (figure 2)

Taxiarchis Chalkidikis

- Two Hyperion E/O1 images [summer 2008, autumn 2008 - scheduled for acquisition]

Figure 2. Site within the rectangle



(a) (b) (c)

Preprocessing

The imagery to be used in this study is susceptible to sensor introduced errors, which have to be corrected prior to atmospheric and geometric corrections. The Hyperion imagery exhibits striping pixels, smile effect (across-track wavelength shift from center wavelength) and subpixel misregistration between VNIR and SWIR bands. CHRIS imagery is susceptible to both horizontal (drop outs) and vertical (striping) noise. Various techniques will be examined for their suitability to correct those defects.

Geometric correction will be conducted using georegistered aerial photographs and a 30m DEM.

The employment of atmospheric correction will be examined for its potential to provide advanced classification results.

Methodology

In order to classify the images into different forest plant species, an object oriented approach will be used. By this method, not single pixels are classified but homogenous image objects are extracted during a first segmentation step. During segmentation, form, textures and spectral information are taken into account in order to group neighboring pixels into meaningful areas/objects. This segmentation can be done in multiple resolutions, thus allowing differentiating several levels of object categories. At a later stage these objects are assigned into classes.

The species distribution maps, which are the outcome of the images' classification, will be statistically compared with field data, in order to draw conclusions on their validity. This analysis will answer to the first two objectives which are to test the comparative performance of different-sensor-images and different-season-images.

At a later stage the classification model of each study area will be used for the classification of the other one.

Fieldwork

Visits at the study areas will provide familiarity with the ground truth, always needed when working with remotely sensed data. The main aim of these visits will be to record the species found in a dense network of control points, using a GPS device (sampling scheme is to be decided). This information will be used as an aid to the classification process, as well as means for the accuracy assessment of the species maps.

Apart from that, the possibility of building spectral libraries, with the use of a field spectroradiometer, will be considered.

Visits at the Taxiarchis Chalkidikis study area will take place at the same time as the image acquisition.

As far as the Thasos Island study area is concerned, the visits will take place at the same season as the image acquisition. The information collected will be used under the assumption that composition of forest vegetation does not change significantly in such short periods of time (5 years), unless major disturbances occur. The local Forest Department can provide information on any disturbances.

Expected results

It is expected that the methodology will produce maps with accuracy over 80%. However, variation between the different conditions/combinations under consideration is expected.

Comparing the performance of the two sensors, it is very probable that Hyperion, with much greater number of bands, will provide larger flexibility for manipulation and information extraction, thus giving more accurate results.

Between the two study areas, better results are expected in the Thasos Island site because of the simpler vegetation composition.

Regarding summer and autumn images, it is expected that in Taxiarchis Chalkidikis where the dominant species are deciduous, the difference in performance will be greater and more meaningful.

The transferability of the models is considered feasible, when it comes to species common in the two sites. However it is very probable that a calibration step will be necessary in any case

Course of Tasks