USE OF ORTHOPHOTOS AS GROUND TRUTH IN IKONOS IMAGE PROCESSING

F. Blasco[a,*], M.F. Bellan[b], V. Barbaroussi[c], and G. Miliaresis[c]

[a] CESBIO-LaDyBio, 18, avenue Edouard Belin, bpi 2801, 31041 Toulouse cedex 4, France - Francois.Blasco@cict.fr

[b] CESBIO-LaDyBio (ex LET), 18, avenue Edouard Belin, bpi 2801, 31041 Toulouse cedex 4, France - Marie-France.Bellan@cict.fr

[c] Topography Dpt, National Technical University of Athens, 9, H. Polytechniou, Athens, 15773 Greece – vbarbar@survey.ntua.gr

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ABSTRACT:

This is the first attempt to use very high spatial resolution satellite sensor data (IKONOS) on Greek landscapes. The IKONOS imagery analysed in this study covers a hilly area close to Corinth Gulf, behind an industrial harbor. The processing seeks to retrieve the main units of a Mediterranean, more or less degraded or preserved, vegetation. The validation of the results obtained through any satellite imagery processing is only possible with the help of ground data. In Greece as in many Mediterranean regions, field work may be difficult due to low accessibility. The present paper deals with the use of aerial photographs as ground data in the assistance of an IKONOS image processing. 1,280 sampling points are located on orthophotos. Their interpretation is compared to the result of a pre-classifying of IKONOS image, allowing to noticeably improving the classification.

1. INTRODUCTION

In Mediterranean countries, where human activity has happened for a long time, the vegetation cover reveals both environmental factors like geomorphology, elevation and ever bioclimatic element, and the intensity of human pressure due to grazing, cultivation, fires, etc.. These results in some complexity relied to the juxtaposition of dense vegetation in the most preserved places with more or less degraded types elsewhere. SPOT HRV data, with 10 or 20m spatial resolution, do not totally express such a variability within a broad unit ‘ Mediterranean vegetation types at low elevation ‘. The very high ground resolution of IKONOS data is a new step towards a detailed image of the vegetation cover, close to an aerial photograph but with the geometric quality, the homogeneity and periodicity proper to satellite imagery. However, whichever scale or detail may be available, ground data acquisition is always necessary to carry on, to evaluate and to improve digital processing. Especially in complex landscapes such as those commonly found in Mediterranean regions, automated classifying makes arise serious problems, even on high spatial resolution satellite imagery. However, field work is sometimes difficult to carry out, due to time consuming or hard access. This paper points out the role of air photographs in ground data acquisition for helping digital processing of very high ground resolution satellite sensor data such as IKONOS imagery. The study area is located in Greece, Corinthian Province, where an IKONOS image covers the surroundings of Agioi Theodoroi harbor. It is the first attempt of using these very high spatial resolution data on Greek landscapes. ‘ Space Imaging Europe ‘ provided for this purpose a PAN/MSI product, with 1m ground resolution and four spectral channels.

2. METHODOLOGY

2.1 Previous Works

IKONOS, first commercial high spatial resolution Earth imaging satellite, was launched on 24 September 1999 from USA. Since this date, the high quality of its products has been appreciated by many users. Through visual interpretation, interesting results were already obtained (Sotaro Tanaka and Toshiro Sugimur 2001, Imbernon 2003). Other works focus in textural analysis, especially on forest applications (Franklin et al. 2001).

In the present study, classical digital processing is applied in order to classify the vegetation types. However, in spite of a general knowledge of the vegetation cover in this part of Greece, accurate ground data are a prerequisite to retrieve important ecological information from this kind of data. Especially in Mediterranean areas, the landscape is often complex and a good satellite imagery processing is strongly dependent of a thorough field work (Merzouk et al. 1998) covering well known training areas. In Greece, some attempts were carried out with SPOT 1 (Barbaroussi 1988). Then, it was found suitable to explore the benefit of using very high spatial resolution data for a better analyses of mediterranean landscapes. Unfortunately, in such hilly regions as these found in Corinth, training sites are difficult to access and to

* Corresponding author.

locate. Field work is time consuming and costly as well. Therefore, airphotos are used as complementary or in place of field trips.

Several authors experienced the air photos usefulness for digital processing assistance, either for forests or natural landscapes (Fontès et al. 1998, Hotyat 1998). In previous studies, photo-interpretation helps in characterizing cartographic units (Codjia et Domingo 1998). Airphotos, sometimes orthophotos, are often used to locate sampling plots before visiting them in the field (Hotyat 1998). In the present study, orthophotos are used as ground data to validate training areas on satellite products.

2.2 Study Area

It lies on the coast of Saronic Gulf, 20km East of Korinth city, on about 37°55'N and 23°07'E (Fig.1). From the geomorphologic point of view, this 5km x 5km area is located on the southern slopes of Yerania Hill (1351m). The studied zone covers the lower part of these slopes, below 500 m elevation. Soils are mainly clayey with some outcrops of sandstones. In the southern centre part of the scene, the most conspicuous components are Agioi Theodoroi harbour on alluvial deposits, on a small river mouth, and an important refinery. This region fringing Saronic Gulf belongs to the ' thermo-Mediterranean zone ' (Ozenda 1975). It is one of the driest parts of Greece, characterized by poor rainfall (less than 400mm/year), with the main rainy season in autumn and winter (October-December) and a severe dryness in summer. In summer, mean monthly temperature is between 21° and 26°C with maxima around 32°. In winter, mean monthly temperature is between 10° and 12°C and minima are not lower than 7° near the coast. Landward, temperatures noticeably decrease with increasing elevation. The warmer fringe of this country does not extend beyond 200m elevation.

The characteristic vegetation cover growing from the sea-side up to 200m should be a low broadleaved evergreen forest (Debazac et Mavrommatis 1971, Barbero et Quézel 1976) typically comprising <u>Pistacia lentiscus, Olea europea, Ceratonia siliqua, Juniperus phoenicea, Myrtus communis ; Pinus halepensis</u> is also present. Today, this original forest type has practically disappeared, replaced by human settlements and crops, roads, plants (refinery). Only an important open pine forest (<u>Pinus halepensis</u>) still remains, greatly threatened by human activities.

Above 200m, the typical spontaneous vegetation type is a low (6-8m) broadleaved evergreen forest with <u>Quercus coccifera</u> and <u>Phyllirea media</u>. Some remnants of this forest type are still preserved on steep slopes, cool bottom valleys and to the upper part of the scene. However, due to ancient human pressure, it often gives way to a bush, 2 or 3m high, characterized by the shrubs <u>Arbutus unedo, A. andrachne</u> and <u>Erica arborea</u>.

But the largest area, behind the urbanized coastal fringe, is covered by ' phrygana ', which is the ultimate degradation stage of forest, due to overgrazing and fires. Whereas in Greece, these practises have given way to three kinds of degradation stages : ' garrigue ' mainly corresponding to a quantitative impoverishment of <u>Pistacia lentiscus</u> and <u>Quercus coccifera</u> formations ; bush and moor with predominant Ericaceae ; phrygana when other shrubs are predominant. These phryganas are poor shrubby vegetation types, more or less low and scarce, with various facies. The main dwarf scrubs constituting phryganas are deserted by cattle. The commonest facies in the study area, deriving from bush, is characterized by several species of <u>Cistus</u> (<u>C. monspeliensis, C. villosus, C. salviaefolius</u>). Other common facies are those with <u>Phlomis fruticosa</u> on rocky soil, or with <u>Poterium spinosum</u> and <u>Coridothymus capitatus</u> on stony soils (Debazac. et al. 1971).

2.3 Data

An IKONOS imagery was acquired from 'Space Imaging Europe' (Fig.1). The characteristics of this CARTERRA Geo Product are given below :Area- around 25km^2 (5km x 5km), Location- Agioi Theodoroi , Ground resolution- 1m, Image size- 6648 columns, 6296 rows, Data type- Pan-sharpened multispectral, Four channels- blue (0.45-0.52µm), green (0.52-0.60µm), red (0.63-0.69µm), near-infrared (0.76-0.90), Processing level- Standard geometrically corrected, Datum- WGS 84, Map projection- UTM 34, Date- 14 July 2000. The processing software is IDRISI 32.

Aerial photographs on 1/15 000 scale and topographic maps on 1/5000 scale were acquired from the ' Hellenic Military Geographical Service '. Aerial photographs (15 June 1998) have been geometrically corrected in order to produce orthophotos.

2.4 Method

Based on general knowledge of plant formations in this region, a preliminary image FCC interpretation allows to select 12 items or classes and delineate corresponding training areas: 1.Pine forest, 2.Mixed forest, 3.Broad-leaved forest, 4.Broad-leaved forest under smoke, 5.Phrygana, 6.Phrygana under smoke, 7.Fire scars, 8.Crops, 9.Bare cultivated soils, 10.Roads, 11.Settlements, plant, 12.Sea. These classes are provisional and should be defined again when getting airphotos. For each class, at least one training polygon is selected and delineated on the imagery. Then, an automatic classification is produced using the maximum likelihood algorithm (Fig. 3). At this stage, a first estimation regarding the size and location of each class is available. This first classification will be modified and improved after the study of airphotos and ground truth data.

Ground data are given by scanned panchromatic orthophotographs. The 12 classes used for the above classification of IKONOS imagery are interpreted in selected points derived from a systematic sampling. So, 1286 points were located on the airphotos (Fig. 2). One of the classes 1 to 12 (excluding 4 and 6, i.e. smoke) was affected to the ground data sampling points, avoiding to consider borders of landcover units. So, the random sampling has been locally slightly modified in order to avoid the 'edge effect'. This means that when a border was in the middle of the small sampling square/circle we sampled few pixels further. Then, each class on the classified image is compared to the airphotos, in order to detect mixed pixels or spectral signature confusions. Finally, a confusion matrix was computed. The correspondence between interpreted orthophotos and maximum likelihood classification has been performed for each sampling point. The percentage of coincidence between 'ground data' and classified IKONOS image can be measured either as the number of coinciding points derived from the sum of the confusion matrix principal diagonal versus total number of points (1286) or with Kappa coefficient.Taking into account the results obtained through photo-interpretation results, the legend is improved, new training zones are defined (with their area in proportion with the occurrence of the class), then a new classification is performed (Fig. 4).

2.5 Discussion of Results

The 1286 plots were interpreted on the orthophotos, using the 12 items of the classified IKONOS imagery. There was a problem of interpreting 'Broad-leaved forest under smoke' (class 4) versus 'Broad-leaved forest'(class 3) and 'Phrygana under smoke'(class 6) versus Phrygana (class 5) since the air-photographs were acquired before the forest fire while the IKONOS imagery was acquired after the fire. We decided not to use the classes 4 and 6 (classes 4 & 3 were merged under the label 3, and classes 6 & 5 were merged and labelled 5).Another classical problem was related to the refinery area, which is a restricted zone. The Hellenic Military Geographical Service erased this area from airphotos. Pixels belonging to each class on IKONOS image were compared with the air photos in order to detect mixed pixels or spectral signature confusions. The number of well classified points versus the total number of points is 752 out of 1286, giving an agreement of 59%. Kappa coefficient is K = 0.471.

The training areas have been revised, taking into account the general remarks on confusions between some classes (see previous paragraph) as well as orthophotos interpretation on the sample points. The revised legend is the following : 1.Pine Forest (Pinus halepensis), 2.Dense Forest (Q.coccifera/Phyllirea media), 3.Broadleaved Forest/Bush (Arbutus, Erica), 4.Broadleaved Forest/Bush (Arbutus/Erica) under smoke, 5.Phrygana, 6.Phrygana under smoke, 7.Firescars, 8.Crops,orchards, 9.Bare soils (croplands, tracks, rocks), 10.Highway, plant, buildings, 11.Water, 12.Shadow The result were shown on the classified image.It has to be noticed that classes 10 and 11 (' Highway ' and ' Plant, buildings ') were finally merged; class 6 (' Phrygana under smoke ') is often classified as ' Phrygana ' (class 5), as the light smoke plume does not strongly influence the Phrygana spectral response ; class 12 (' Water ') is unclassified because a mask had been previously applied on sea ; some confusions remain with shadows (class 13). Finally, the number of well classified pixels versus total number of pixels is 263 982 out of 329 900, giving an accuracy of 80.02% ; overall Kappa coefficient is K=0.6609. Considering that classes ' Water ' and ' Unclassified ' may be merged due to the mask, the agreement becomes 88.12%.

3. CONCLUSION

The groundtruthing reliability depends on the correct location of the sampling points. Provide orthophotos on a convenient scale are available, time and cost can be saved by using these data in place of field work. In the given example, the classification accuracy was noticiably improved (59% to 88%) by this method. The resulting classified image of this 5km x 5km area gives a realistic view of the vegetation conditions in the Greek mediterranean coast. In the surroundings of an important port served by a highway all along the coast, there are many settlements with accompanying croplands. The pine forest on the lower slopes is widely moth-eaten by new settlements. Behind, the bush with Arbutus and Ericaceae members has been degraded and replaced by a low discontinuous phrygana. The impact of fire is conspicuous on this scene. In the upper zone only, on the Yerania slopes, the bush is still present, as well as the Quercus coccifera forest, above 200m elevation.

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Figure 1. IKONOS image on Agioi Theodoroi. Colour composite RGB (Near-infrared/Red/Green), X : minimum = 23.0430° , maximum = 23.1202°, Y : minimum = 37.9044° , maximum = 37.962 ***Copyright © Space Imaging Europe 2001***

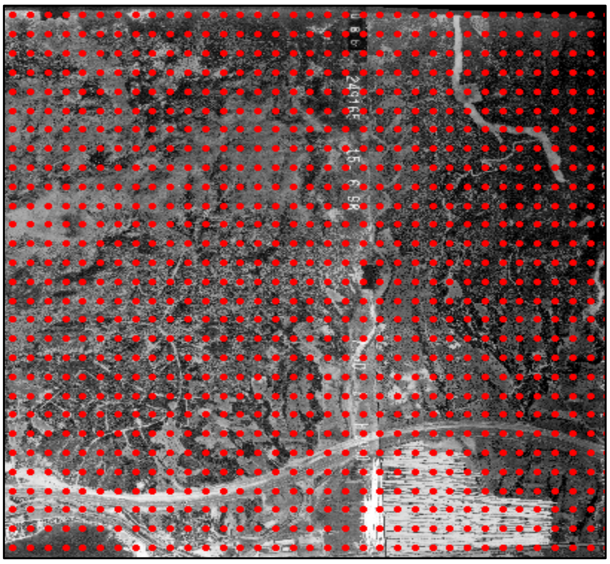

Figure 2. Systematic sampling of the orthophotos (Number of sample points : 1000).

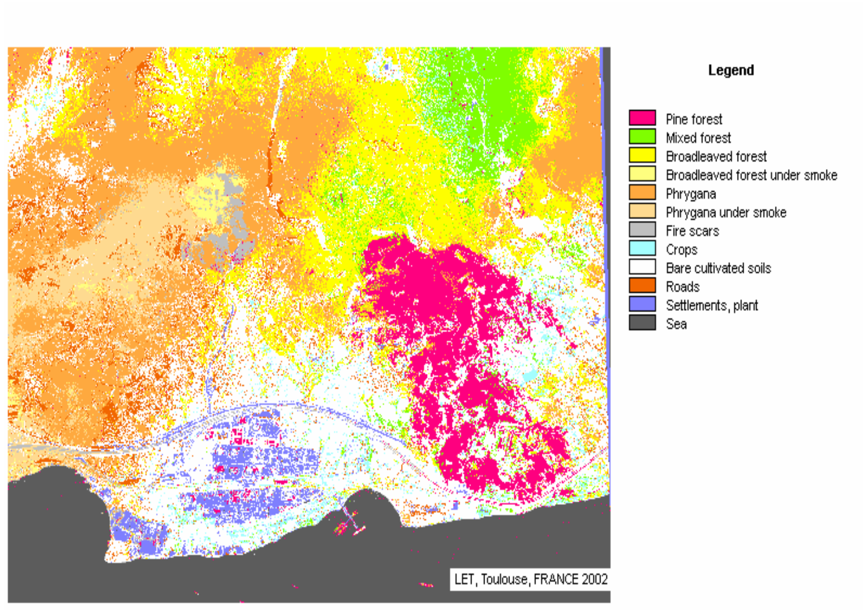

Figure 3. Pre-classifying through maximum likelihood.

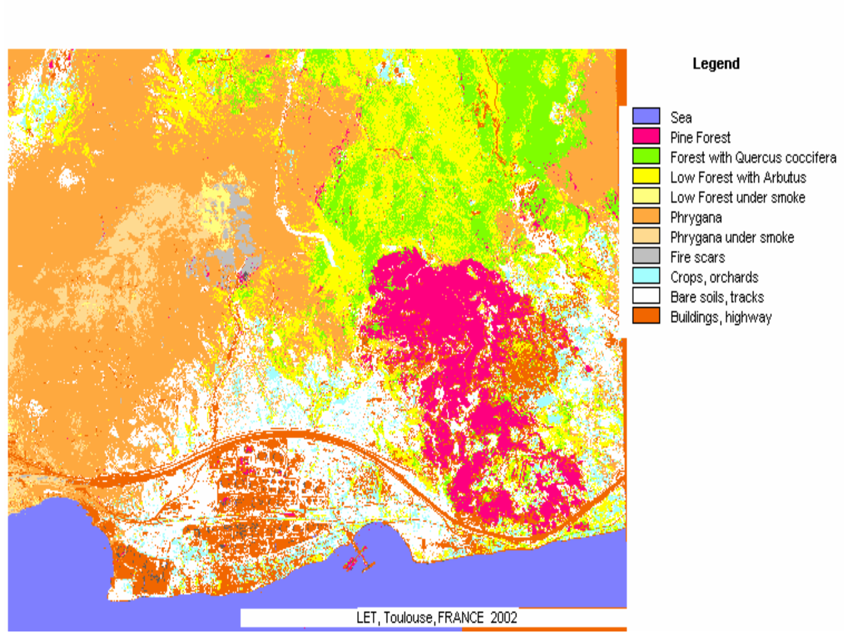

Figure 4. New classifying after ground truthing through orthophotos