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**Deliverable 5.1-2 Method to produce vegetation and fuel maps using satellite imagery**

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1 Introduction

Wildfire hazard assessment is usually treated in two ways: a) a long-term element, based on the evaluation of structural factors such as fuel models, topography and general climatic patterns, or b) as a short-term element, based on the daily evaluation of meteorological parameters and of the fuel moisture content. The above mentioned approach leads to two separate families of hazard maps: a) “static” maps, assessing a “structural” hazard with generally a very good spatial accuracy, b) “dynamic” maps, assessing a “daily” hazard with generally a poor accuracy. The innovative approach is in the combination of the two systems, in the integration of a good spatial accuracy to the daily hazard assessment. As stated in the original Fire Paradox, the general objective of Module 5 “risk assessment and mapping” is to develop tools to assess and map fire risk considering space and time in its two components, hazard and vulnerability.

2 Objectives

The objective of the activity 5.1.2 is to develop a tool (software) to map fuel models and their combustibility.

3 Description of Work

The activity 5.1.2 of the WP 5.1 consists: (a) in producing stand maps using satellite imagery (Quickbird or Ikonos) on which image segmentation techniques with the necessary correction of satellite images are applied. The work will be carried out in 2 sites in South of France (Luberon-Aix area and Maures area, of around 100 km² surface each), in 2 sites in Greece (Thessaloniki area and Holomondas area of around 250 km² total surface), and in 3 sites in Argentina (Patagonia and Chacos regions) (b) in generating an automatic Digital Surface Model (DSM) from stereo imagery using softcopy photogrammetric mapping and GIS systems that operate in a desktop computing environment. The DSM, which is generated by the softcopy software using autocorrelation techniques, models the reflective surface rather than bare earth.

4 First Results

4.1. State of the art:

4.1.1. Fuel typology

The evaluation of the vegetation combustibility is one of the main problems of the fire risk characterization. Indeed, fuel models are the main entrances into the various models for calculating the physical parameters of the fire. The type of fuel is “an
identifiable association of fuel elements of distinctive species, form, size, arrangement, and continuity that will exhibit characteristic fire behaviour under defined burning conditions (Merril and Alexander 87 -Glossary of forest fire management terms NRC Canada, Comitee for Forest Fire Management, Ottawa- in Riano 2002)”. A lot of fuel typologies have been carried out in different countries since the last century: The first French typology carried out by Trabaud (1974) crossed vegetation structure, biovolume, specific composition and conditions of fire fighting. This typology came from the model carried out by the US National Forest Fire Laboratory (NFFL) given by Anderson and Brown in Rothermel (1972) and Albini (1976). Rothermel (1983) described a typology in 3 or 4 modes for the 4 fuel types (grasses, shrubs, understory litter and vegetal residues). The key of determination input is the vegetation type contributing to the fire spread. This typology has been used in Spain by Icona for the photoidentification of the different fuel types in 10 forest areas (ICONA, 1993).

An attempt to simulate past fires using the software Farsite integrating the 13 fuel types of the NFFL has been done in France (Vivien, 1999), but these are not adapted for the Mediterranean area (American species, no fuel vertical continuity, etc.). In order to improve it, the vegetation types of IFN and the Spot imagery classification have been combined to 6 of the previous fuel types. The accuracy of the simulations would be improved with the development of Mediterranean specific models.

Others fuel typologies have been carried out only at local scale or are based only on the author’s knowledge of the fire behaviour (Marchetti and Lozupone, 1985; Salas et al., 1994). There is no references for the fuel typology of Mediterranean Europe carried out in the framework of the European Programme “Prometheus” (Giakoumakis et al., 2002 ; Riano 2002); this typology is however used in the Prevention Plans for Forest Fire Risk.

Whether it is in physical complex models of the fire, or in simpler combinations, it is necessary to identify homogeneous Mediterranean vegetation types, according to their composition and their structure, in term of combustible biomass. With this aim, a fuel typology based on the forest macrostructure was carried out by sampling in the Calcareous Provence different types of forest that allowed the description of the variability of the forest structure. From measured parameters such as density, composition of different strata, estimation of the vertical continuity, biovolume, etc, a key of determination was proposed. A measurement of biomass samples allowed some simulations with Behave, with the inconvenience that the fuel was considered to be homogeneous only inside the three first meters. The output data allowed the estimation of some physical parameters of the fire (rate of spread, length of flame) for each type of fuel.

4.1.2. Stand maps

To characterize and map stands, particularly in the Wildland-Urban Interface, satellite images are useful on large and spectrally homogeneous areas, something that was not possible on aerial photos. A first work was done with 2.5 and 5 metres resolution SPOT 5 images and 0.6 Quickbird images on two study sites near Aix-en-Provence, Southern France (Lampin et al., 2004), in calcareous Provence. Supervised classification using the
maximum likelihood rule was elaborated from these satellite images and results were compared according to spatial resolution images (Jappiot et al., 2006). Different components of the land cover could be identified, but textural accuracy provided by the very high resolution satellite images could not be exploited enough and complementary database had to be used. On the one hand, the similar radiometric composition of different land cover classes was an issue, as confusions were remaining between urban areas or bare grounds (20 % of errors). On the other hand, classes made up of several land covers could not be classified correctly: scrublands were classified as a mix of trees, bare ground, grass, etc. but not as a single scrubland class.

4.1.3. Fuel description

Eufirelab (D-02-01) gives a condensed state of the art on fuel modelling and description methods. It comprises an extended list of references starting at the fuel particle level and ending at the landscape level. It also includes examples of site and country-specific fuel modelling methods throughout Europe, covering such different countries or areas as Portugal or Fennoscandia. The scope of this state of the art is to give an overview on existing fuel description approaches.

4.2. Stand maps

The production of stand maps is a key element in order to recognize the fuel types and calculate the fuel load for a specific area. The traditional method for capturing geographic information (the digitization from satellite images) is time-consuming. In order to overcome this significant disadvantage of digitization, a number of image processing technologies and software have been developed which provide tools for feature extraction from satellite images.

4.2.1 Materials

Databases

For the French Mediterranean area, Quickbird images (panchromatic and multispectral images) taken on 23rd June 2006 was acquired. These images were first rectified from 0.5 resolution ortho-image and from a Digital Elevation Model of the French Geographic Institute using Rational Polynomial Coefficients associated to each image. Then, a principal component resolution merge between 0.6 panchromatic and 2.4 multispectral Quickbird images was done to retain the spectral information of the four Quickbird MS bands. The resample technique used was a cubic convolution to have the best continuity in the image.

In Greece, high resolution satellite images were used as input data: QuickBird satellite image (4 bands, cell size: 0.693 m) for Thessaloniki area and Ikonos satellite image (4 bands, cell size: 1 m) for Chalkidiki area.
**Software**

ERDAS Imagine 9.1® software developed by Leica Geosystem is useful to remote sensing process. It is particularly well-adapted to raster data. In our case, it is used to make geometric rectifications of images and to merge panchromatic with multi-spectral data.

Feature Analyst 4.1® software developed by Visual Learning System allows the classification of very high resolution satellite images combining spatial attributes with spectral information. It is tested to improve land cover classification of complex territories like WUI. So, the Feature Analyst version 4.1.0.30 software was used for the feature extraction procedure. Feature Analyst integrates machine-learning technology into the GIS database creation and maintenance workflow. The software is a suite of machine learning algorithms that “learn” to classify the object-specific geographic features specified by the user. Thus, in the beginning of the classification procedure, a training set (a number of characteristic polygons) is defined for each feature class.

**4.2.2. Automated feature extraction on Quickbird image required to map stands in the French Mediterranean region**

Every year about 2,800 forest fires affect more than 25,000 hectares of vegetation in the French Mediterranean area (Prométhée database 1973-2006). Some years have heavy consequences incurring casualties as well as death of humans, burned houses and many hectares of burned vegetation in different areas in the South of France, recently 61,424 hectares in 2003. Drastic land transformations have been observed during the last decades in the Mediterranean region and these dynamics of land cover increase forest fire risk. Agricultural fallows and orchards are slowly colonized by vegetation and forest is not exploited enough anymore, both conducting to fuel load accumulations.

Stand and WUI maps are a need in pre-fire planning, especially in South of France where it is very helpful in fire prevention management. The Fire Paradox research program let us working on remote sensing tools to characterize fuel typology and WUI. Very High Resolution images and automated feature extraction software are required to have an accurate and reliable land cover that is essential to characterize and map WUI (Lampin et al, 2006) at a large scale.
4.2.2.1. Vegetation types in South of France

- Vegetation in calcareous Provence (Figure 1)

**Forests dominated by pine**
*Pinus halepensis* forests are one of the most represented vegetation types in practically all the forested regions (more than 200,000 ha in southern France). *Pinus halepensis* is a species which can bear a strong period of sunshine and long periods of drought. The pine of Alep often dominates undergrowth of *Quercus coccifera* and of *Phyllirea angustifolia*.

**Forests dominated by oaks**
*Quercus ilex* (Holm oak) is the most representative oak in calcareous Provence. *Quercus ilex* woodlands and coppices include many Mediterranean shrubs such as *Cistus, Pistacia, Quercus cocciifera, Juniperus oxycedrus, Viburnum tinus* in the warm and dry situations. These woodlands and coppices can be very dense, or more heterogeneous. The herbaceous layer is generally low due to low irradiance level under closed canopies.

*Quercus pubescens* (Downy oak) forms dense forested area only locally. Its floristic composition gets closer to that of *Quercus ilex* forests. Degradation facies are composed of grasses dominated by *Graminae* (e.g. *Bromus* and *Brachypodium*).

**Mixed forests**
Mixed forests are often early succession vegetation types before Oak forests.

**Shrubland vegetation (garrigue)**
More than 100,000 ha of French Mediterranean Region are occupied by the shrubland in the department of Bouches-du-Rhône.

Shrublands are degraded woodlands dominated by small ligneous species and shrubs. Fuel bed depth is generally below 1 metre on shallow and rocky soils, but they can reach 2 metres on better sites. The garrigue is dominated by *Quercus cocciifera, Rosmarinus officinalis, Cistus albidus* and *Thymus vulgaris*. When it is afforested, *Quercus ilex* and *Pinus halepensis* are also present.

- Vegetation in acidic Provence

**Forest vegetation**
*Quercus suber* woodlands occupy the main part of the forested area, with however very important variations in dryness, according to various authors (Lavagne and Moutte, 1974 - Loisel, 1971).

The *Quercus ilex* forest occupies different areas. Three types of forest are distinguished: a coastal type which occupies the coast caps and promontories, a western Piedmont type, very often associated to *Pinus halepensis*, a type of crests in the high mountains with possible extension to the north.

In spite of this local variety, this forest is rather homogeneous as concerns its floristic composition.
Chestnut groves are mostly constituted by old-looking and abandoned orchards, which we find mainly on the fresh hillsides in the internal massif. They were often extended the area they occupied, to the detriment of the wet *Quercus suber* and *Quercus pubescens* stands. Chestnut groves present a particular flora where we find species from *Quercus pubescens* stands and also from *Fagus silvatica* stands.

All the forested stands described previously are often mixed with conifers. The maritime pine (*Pinus pinaster*), formerly dominating in *Quercus suber* stands and mattorals, was affected in the 60s by the cochineal *Matsucoccus feytaudi*. Present residual pine woodlands are made of small regeneration areas.

Aleppo pine (*Pinus halepensis*) is present on the rocky coast, as well as in the western part of the massif. There is a good correspondence between the 800 mm rainfall level and the oriental limit of the pine of Alep. *Pinus pinea* develops especially in the northern part, on light ground of sandy texture, on flat grounds, sheltered from the strong winds, in warm exposure.

**Shrubland vegetation (maquis)**

The degradation of xerophil oak groves leads to shrublands (called “maquis”) which can take several facies.

**High maquis:** dominated by high (> 3 m) individuals of *Arbutus unedo* and *Erica arborea*, relatively dense. Lavagne and Moutte (1974) distinguished a mesic variant on northern slopes and deeper soils, where *Arbutus unedo* is more plentiful and higher. The dry variant on shallow soils and southern aspect is dominated by *Erica arborea*, *Calycotome spinosa* and *Cistus* species.

**Low maquis:** they are either composed by *Erica scoparia* and *Calluna vulgaris*, which develop on sandy grounds (Aubert, 1976) and which are often associated to the maritime pine. A second facies is dominated by *Cistus*, which result from a bigger degradation, on little evolved grounds.

We can distinguish several variants following the *Cistus* species prevailing: *Cistus monspeliensis* and *Cistus salviaefolius*, *Cistus albidus* and *Calycotome spinosa*.

The ultimate stage of degradation is grassland dominated by annual species as well as grasses.
Figure 1: Fuel typology in calcareous Provence (Lampin *et al*, 2004).
4.2.2.2. Study site

The study area is located in the Meyreuil district near Aix en Provence (France, Figure 2). It covers approximately 2,000 hectares.

Figure 2: Study area on Meyreuil district in the South-Eastern France

4.2.2.3. Method

The classification is performed on the Quickbird resolution merge image using all MS bands. Feature Analyst operates like a supervised classification by pixel digitizing training sets but every class can be extracted separately. In vegetation extraction, inclusion or exclusion of shadow area in the training set are very important. Features cannot be extracted correctly with poorly drawn training examples or too few examples.

When training sets have to be learned, spatial data are integrated by Feature Analyst specifying input representation of the features. These representations define the spatial environment of the features (Table 1): narrow or wide linear features, natural features (individual tree), water mass features (lake, ocean, flooded area) and land cover features (forested area, developed area).

Finally, it is possible to degrade the image when all the information provided by VHR is too detailed or useless, to mask area, to remove clusters having a minimum size and to detect feature in all direction or not (interesting for object with an associated shadow).
Table 1. Extraction characteristics according to land cover

<table>
<thead>
<tr>
<th>Feature selector</th>
<th>Pattern Name</th>
<th>Width</th>
<th>Land cover type</th>
<th>Aggregate area</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow linear feature (&lt;10m)</td>
<td></td>
<td>11</td>
<td>Road</td>
<td>50 pixels</td>
<td>Yes</td>
</tr>
<tr>
<td>Land Cover Feature</td>
<td></td>
<td>7</td>
<td>House</td>
<td>200 pixels</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Coniferous tree, hardwood, tree planting</td>
<td>1000 pixels</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Mixed tree, shrubland</td>
<td>500 pixels</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>Field</td>
<td>2000 pixels</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Garden, shrub-cleared area</td>
<td>200 pixels</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>Watered grass, dry grass, bare ground</td>
<td>100 pixels</td>
<td>No</td>
</tr>
</tbody>
</table>

4.2.2.4. Results

Figure 3 presents the results obtained on a 100 hectares area. Thirteen classes have been identified: bare ground corresponds to rocks and man-made surfaces like paving; coniferous trees, hardwoods and mixed trees correspond to dense vegetation (percentage of cover more than 60%); scrubland corresponds to wildland, low vegetation with sparse trees (percentage of cover less than 60%); garden and shrub-cleared area correspond to vegetation where trees are well spaced and ground is clean.
Figure 3: Classification obtained with Feature Analyst® on the Meyreuil area

<table>
<thead>
<tr>
<th>Land cover</th>
<th>Omission error</th>
<th>Commission error</th>
<th>Well Classed</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare ground</td>
<td>1%</td>
<td>1%</td>
<td>99%</td>
<td></td>
</tr>
<tr>
<td>Garden–shrub-cleared area</td>
<td>9%</td>
<td>24%</td>
<td>76%</td>
<td>Some confusions with scrubland</td>
</tr>
<tr>
<td>Coniferous tree</td>
<td>0%</td>
<td>2%</td>
<td>98%</td>
<td>Some confusions with planting trees or mixed trees</td>
</tr>
<tr>
<td>Hardwood</td>
<td>0%</td>
<td>8%</td>
<td>92%</td>
<td>Some confusions with mixed trees</td>
</tr>
<tr>
<td>Mixed tree</td>
<td>11%</td>
<td>6%</td>
<td>94%</td>
<td>Some confusion with shrubland</td>
</tr>
<tr>
<td>Shrubland</td>
<td>7%</td>
<td>3%</td>
<td>97%</td>
<td></td>
</tr>
</tbody>
</table>

Classification with Feature Analyst® allows the detection of several objects in heterogeneous context. This detection is very important to characterize and map stands, especially for different structures of vegetation. Objects having the same reflectance but a different texture (forest, scrubland) can be detected easily (more than 90% of pixels are well classed; table 2). Brush cleaning area can be observed if there is enough...
distance between trees to see the ground and if the ground is clear (otherwise it can be confused with shrubland).

However, the classification could be improved on vegetation detection especially as different densities of trees inside forest or scrubland classes, specific arrangement of trees like tree lines, etc.

4.2.3. Production of stand maps for Thessaloniki and Chalkidiki areas.

4.2.3.1. Methods

In the case of Thessaloniki, the following feature classes have been specified (Figure 4):
- a) Settlements
- b) Buildings
- c) Roads
- d) Urban vegetation
- e) Crops
- f) Grasslands/shrublands
- g) Maquis (Quercus coccifera)
- h) Broad leaved trees
- i) Pine (Pinus brutia)

Figure 4: Defining training sets for Thessaloniki area

Three bands (red, green and blue) were used as reflectance plus band 2 (green) as texture. Features were extracted in the following order: First the settlements, then, buildings, roads, urban vegetation and crops. In the remaining area of the images, a
multi-class feature extraction of the 4 remaining classes (grasslands / shrublands, maquis, broad leaved trees and pine) was performed.

In the case of Chalkidiki, the following feature classes have been specified (Figure 5):

- a) Buildings
- b) Roads
- c) Crops
- d) Grasslands/shrublands
- e) Maquis (*Quercus coccifera*)
- f) *Quercus* (*Q.pubescens/Q.frainetto*)
- g) *Quercus ilex*
- h) *Fagus sp.*
- i) Pine (*Pinus nigra*)

![Figure 5: Defining training sets for Chalkidiki area.](image)

Three bands (red, green and blue) were used as reflectance plus band 2 (green) as texture. Features were extracted in the following order: First, the buildings, then, roads, grasslands / shrublands and crops. In the remaining area of the images, a multi-class feature extraction of the 5 forest classes (maquis, *Quercus*, *Quercus ilex*, *Fagus* and pine) was performed.
4.2.3.2. Results (Figures 6 and 7)

The outputs of the procedure (shape files) included vegetation features and man-made features like buildings and roads.

Figure 6: View of stand map of Thessaloniki area

Figure 7: View of stand map of Chalkidiki area
4.3. Production of Digital Terrain Model (DTM) and Digital Surface Model (DSM) for Thessaloniki and Chalkidiki areas

The segmentation method is restrictive in the sense that it only shows the horizontal structure of the stands, not their height. It was necessary to add a new layer of information and to develop a method according to the DSM.

DTMs and DSMs are a basic component of any geographic information system. The DTM includes information about the elevation of the terrain, while the DSM includes also the height of the surface. DTMs and DSMs are usually required for the generation of orthoimages, one of the most common photogrammetric products. In our case, terrain elevation data was required in order to interpolate meteorological measurements acquired from several meteorological stations in both (Thessaloniki and Chalkidiki) areas.

4.3.1. Materials and methods

Stereo images of the area are needed as input data for the production of DTMs and DSMs. A stereo image is a pair of images of a single site, viewed from different angles. Stereo images came from Cartosat-1 satellite. Cartosat-1 carries two panchromatic cameras (Fore and Aft), which can acquire along-track stereo images of 27.5 km swath. The stereo images have a spatial resolution of 2.5 m and are acquired nearly simultaneously with a time difference of 52 seconds from the two Fore and Aft cameras at +26 and -5 degrees respectively. The cameras specifications are shown in table 3

Table 3. Cartosat-1 camera specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focal length (both cameras)</td>
<td>1945 mm</td>
</tr>
<tr>
<td>Integration time</td>
<td>0.336 ms</td>
</tr>
<tr>
<td>Quantisation</td>
<td>10 bits (1024)</td>
</tr>
<tr>
<td>Pixel size</td>
<td>7x7 µm</td>
</tr>
<tr>
<td>GIFOV Fore</td>
<td>2452 m (across track)</td>
</tr>
<tr>
<td>GIFOV Aft</td>
<td>2187 m (across track)</td>
</tr>
</tbody>
</table>

Simultaneous stereo pair acquisitions are of great advantage since the radiometric parameters of the images are identical. The stereo data of Cartosat-1 comprise of radiometrically corrected image data from both Fore and Aft cameras and the Rational Polynomial Coefficients (RPC) file. RPCs are used for image orientation. The RPC model relates image coordinates (row and column) to ground coordinates by two polynomial ratios. Additional corrections are estimated from Ground Control Points (GCPs). GCPs’ data can be obtained either from reliable topographic maps or measured with GPS.

Leica Photogrammetry Suite (LPS) version 9.2 was used for the handling of the data and extraction of DTMs/DSMs. The stereo images and the related RPC files were loaded into LPS v9.2 software and image orientation was automatically calculated using Area Based Matching algorithm. Since RPCs are estimated using only position and altitude data of the sensor, it is expected that the accuracy of the output can not be very high. It has
been shown in different studies and mainly in the summary report of the ISPRS-SRO Cartosat-1 Scientific Assessment Programme that large positional residuals have been found when original RPCs were used for image orientation. Instead, point determination based on bias corrected RPC (using Ground Control Points) leads to location accuracy around 2 metres.

Figure 8: Ground Control Points at Chalkidiki area

For each stereo pair, 31 Ground Control Points were used in order to improve the accuracy of the calculations (Figure 8). GCPs data were measured using GPS. Finally, the output was stereoscopically checked and edited from qualified personnel especially in areas where accuracy was not satisfactory.
4.3.2. Results

Accuracy of the DTMs (Figure 9) and DSMs varies (from 1 m to 6 m) according to the terrain morphology.

Figure 9: Digital Terrain Model (DTM) for Chalkidiki area
5 Conclusion

This first draft of this deliverable shows the first steps in the elaboration of a method to produce vegetation and fuel maps using satellite imagery, especially in the French South-Eastern area and in Greece. This work is in progress.
6 References


Lavagne A. and Moutte P., 1974. Carte de la végétation de la Provence et des Alpes du Sud. Feuille de St Tropez au 1/100 000è. Université de Provence, Marseille St Charles.


