MARSec activities in fire dection, risk assessment and damage evaluation

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Introduction

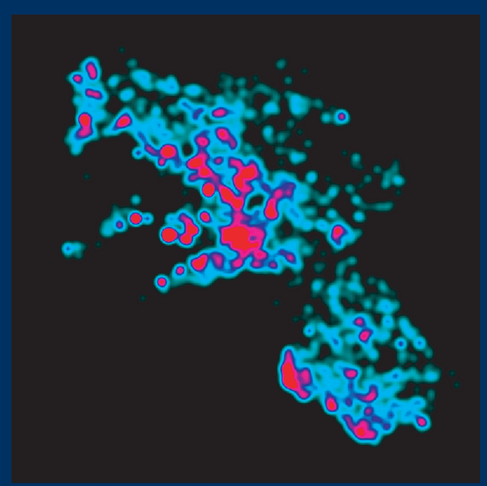
According to the Corpo Forestale dello Stato (Italian Forest Service, http://www.corpoforestale.it/), 6428 fires occurred in Italy during 2004. The fires have burned a total surface of 60176 hectares, 20866 of them were woods. Average fire extension was 9.4 hectares. A high percentage of fires (61.7%) were fraudulent, 13.3% were unpremeditated, while 23.4% where of doubt origin. Only 1% of the fires were of natural origin, and 0.6% were accidental.
University of Padova (Italy) has calculated the annual cost of fires in Italy. By taking into account the costs of regular and extra personnel, personal hardware for volunteers, helicopters and aeroplanes, post fire interventions, and loss of understorey productivity, an annual damage of € 500.000.000 has been estimated.
MARSec (Mediterranean Agency for Remote Sensing and Environmental Control), based in Benevento, Italy, has set one of its key activities in fire detection, risk assessment and damage evaluation. Direct broadcast data is used together with a deep knowledge of the landscape to monitor fire occurrence, determine the damage caused by fires, and produce timely fire risk maps.

Fire detection

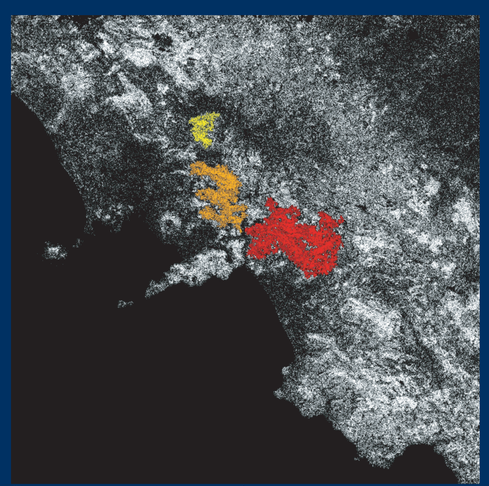
The availability of thermal bands at 4 µm and 11 µm in both MODIS and AVHRR instruments allows the detection of active fires. At the moment, we process only MODIS data broadcasted by TERRA and AQUA satellites; this allows four daily overpasses on our territory.
To detect active fires in the imaged scene, we use MOD14 algorithm. Soon after processing, HDF data is manipulated to extract retrieved information about each fire pixels. This information is properly formatted into an ASCII file that can be directly imported into a GIS. ASCII files are then automatically delivered via e-mail to interested institutions (Figure 1). We are able to send these alert e-mails within 20-25 minutes from the satellite overpass.
The Università degli Studi del Sannio (Sannio University, Benevento, Italy) will help in improving fire detection efficiency with a new algorithm (Di Bisceglie et al., 2005). Increased time coverage will be achieved by setting up the processing of AVHRR data broadcasted by NOAA-12, NOAA-15, NOAA-17, NOAA-18, allowing us to reach a total of 12 daily overpasses.

Damage evaluation

We have verified the potential of MODIS data to evaluate the damage after a fire event has occurred. Normalized Burn Ratio (Key and Benson, 2000), E1 (Eva and Lambin, 1998) and K1 (Piccolini, 1998) have been calculated using MODIS data acquired during the summer months of 2004. These have been tested against ground data measured in Campania Region by the Italian Forest Service. Our results show that these indexes together with MODIS data are not able to correctly evaluate the extension of the burned areas. The main limitation is in the resolution of MODIS, which is characterized by pixels that are large as compared to typical burned area extension. In the observed period (July 16 to August 31) only 2% of the fires had a surface larger than one pixel of 500*500 m2., which were only 25% of the total burned surface.
Besides traditional optical remote sensing technologies, we are testing SAR capabilities. SAR sensors can acquire high quality data under any weather condition as the microwaves penetrate clouds as well as haze during active burning. In addition, microwaves can also penetrate pioneer vegetation allowing a detailed recognition of the burned area even few days after burning (Siegert et al., 1999; Ruecker et al., 2000; Siegert & Nakayama, 2000). The spatial resolution of the SAR sensors range from about 25m of ERS satellites, to 6m of RADARSAT-1 Fine Beam mode (http://www.esa.it/; http://www.rsi.ca/). MARSec station is starting the Certification Procedure in order to receive SAR data from RADARSAT-1 so we hope soon we will be able to propose a conjoint analysis of MODIS, NOAA-AVHRR and RADARSAT-1 Synthetic Aperture Radar high resolution data. Our target is: high temporal resolution (but low spatial resolution) from MODIS and NOAA-AVHRR (up to 6 daylight passes a day) associated to high spatial resolution (but low temporal resolution) from RADARSAT-1 (up to 6 m).



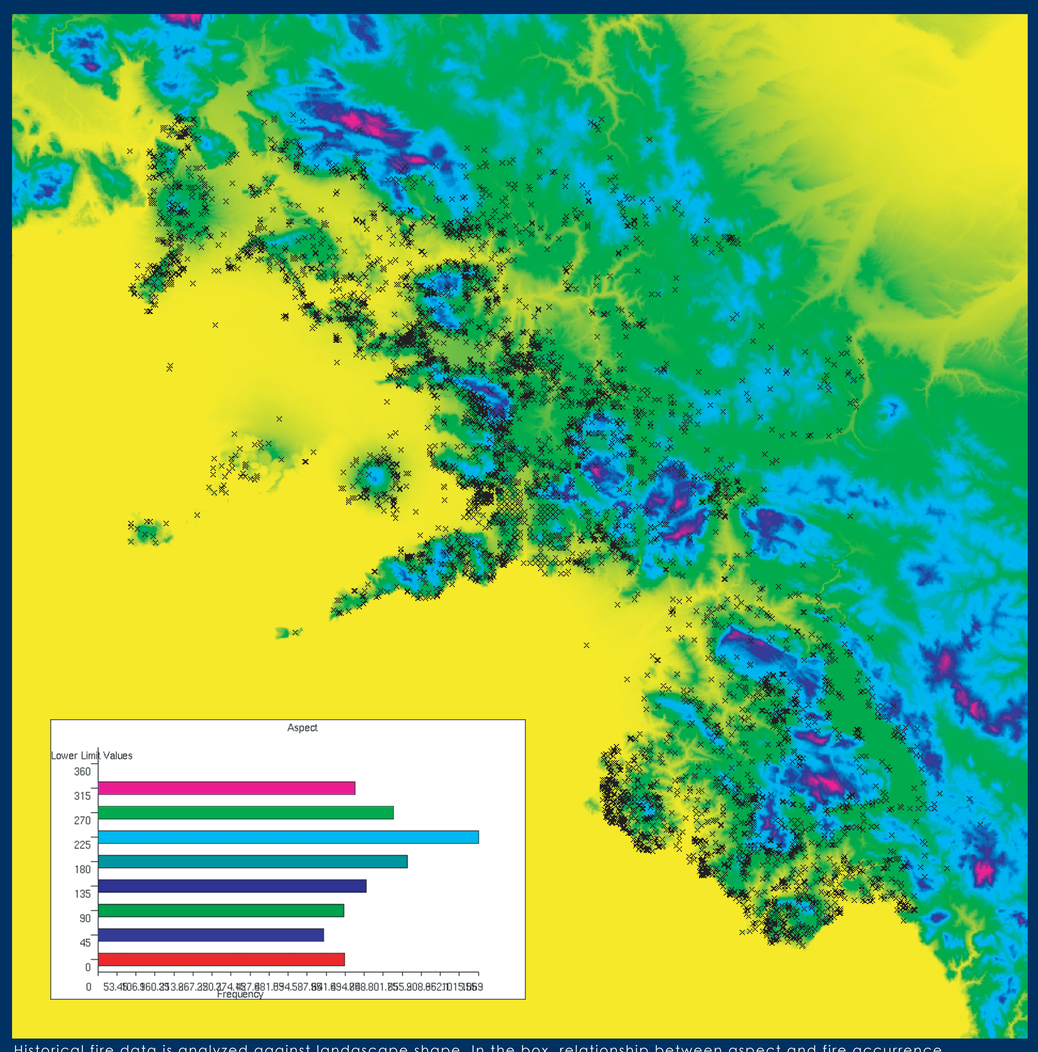
Long term fire risk map. Historical punctual data has been spatially interpolated to produce this fire occurrence density map.



Simulated vegetation cluster for the evaluation of potential fire damage

Risk assessment

Prevention activities help in reducing damages induced by fires. MARSec is now devoted to the development of a daily fire risk map that can serve in a sound management and planning of on site intervention activities.
Fire risk has the contribution of of two factors: static and dynamic. Static risk is related to all those landscape factors that do not vary with time. These include slope and aspect of the terrain, "fuel" type and density, anthropic pressure, distance from roads. Dynamic factors are variable in nature, and include local winds and vegetation hydric stress. Current work is on quantification of these factors and on their contribution to fire risk definition. Italian Forest Service data have been used to produce historical fire density map that serves as a "long term" risk map (Figure 2). In cooperation with CNR-ISAFoM (Consiglio Nazionale delle Ricerche – Istituto per i Sistemi Agricoli e Forestali del Mediterraneo, Italian National Research Council – Institute for Agricultural and Forest Systems in the Mediterranean), Ercolano (NA), Italy, the landscape is being analysed for the definition of the static factors related to landscape shape (Figure 3) and vegetation cover properties. MODIS data collected at MARSec will be used to produce a daily map of vegetation status.
In cooperation with Sannio University, percolation models are used to produce a map of "potential damage". The knowledge gathered in building a fire risk index, is used to produce transition and extinction probabilities (probability of a burning pixel to ignite the adjacent pixel, and probability of a burning pixel to become burned) (Favier, 2004). By simulating propagations within vegetation clusters (Figure 4), a priori fire damage is evaluated, to assess the potential damage in environmentally relevant areas.



Historical fire data is analyzed against landascape shape. In the box, relationship between aspect and fire accurrence.

Acknowledgments

We are grateful to Prof Massimo Menenti and Dr. Antonio P. Leone (Consiglio Nazionale delle Ricerche – Istituto per i Sistemi Agricoli e Forestali del Mediterraneo, Italian National Research Council – Institute for Agricultural and Forest Systems in the Mediterranean, Ercolano (NA), Italy) for their help in defining and quantifying fire risk factors.
We would like to thank Prof. Maurizio Di Bisceglie (Università degli Studi del Sannio, Sannio University, Benevento, Italy) and its research team for the work in fire detection with a constant false alarm rate algorithm.
We thank the Corpo Forestale dello Stato, Coordinamento Regionale Campania (Italian Forest Service, Campania Regional Command) for historical fire data in Campania Region.

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