Geophysical Research
Abstracts Vol. 12,
EGU2010-926-1, 2010 EGU
General Assembly 2010

Burnt area delineation from a uni-temporal perspective based on Landsat TM & ALI satellite radiometers: results from the analysis of a fire event in Greece

G. Petropoulos (1,2), C. Kontoes (3), and I. Keramitsoglou (3)

(1) Department of Earth Sciences, University of Bristol, Queens Road, BS8 1RJ, Bristol, United Kingdom (george.petropoulos@bristol.ac.uk), (2) INFOCOSMOS, Pindou 71, 13341, Athens, Greece, http://www.infocosmos.eu, (3) Institute of Space Applications and Remote Sensing, National Observatory of Athens, Metaxa and Vas. Pavlou St, Penteli, Athens, 15236, Greece

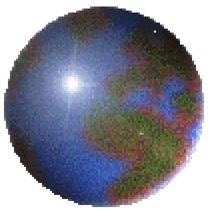
Wildland fires in the Mediterranean region are regarded as one of the most threatening sources for property, infrastructures as well as ecosystems.

In this letter, we examine the combined use of selected parametric and non-parametric classifiers (such as of Maximum Likelihood, Support Vector Machines) with satellite observations from Landsat TM and Advanced Land Imager (ALI) imagery, in obtaining maps of burnt area. As a case study it selected a major destructive fire occurred during the summer of 2009 in the Prefecture of Eastern Attika in Greece, for which both a TM and ALI image were acquired shortly after the fire suppression.

Accuracy of the examined in this study datasets and algorithms for delineating the burnt area was evaluated on the basis of the analysis of classification accuracy assessment as well as comparisons from the SAFER rapid response service operated in Greece during the year of 2009, using IKONOS satellite acquisitions.

A discussion follows the analysis of the results, focusing on the adequacy of the combined use of the satellite sensors used in this study with the properties of the algorithms in providing burnt area mapping rapidly and cost-effectively in the study region, representative of a typical Mediterranean setting.

Keywords: burnt area mapping, Landsat TM, ALI, SAFER rapid response service



Burnt area delineation from a uni-temporal perspective based on Landsat TM and ALI satellite radiometers: results from the analysis of a fire event in Greece

G. P. Petropoulos[1,2], C. Kontoes[2], I. Keramitsoglou[2]

(1) Department of Earth Sciences, University of Bristol, Queens Road, BS8 1RJ, Bristol, United Kingdom

(2). Institute for Space Applications and Remote Sensing, National Observatory of Athens, Vas. Pavlou & I. Metaxa, Lofos Nymfon, 15236, Penteli, Athens, Greece

Email: petropoulos.george@gmail.com

Background

- RS-based methods for obtaining burnt area cartography are based on the changes of the spectral signatures of the objects after the fire extinction => strong contrast of the fire-affected areas with the surrounding environment context (*e.g kokaly et al., 2007*).
  - *reduction of chlorophyll in vegetation*

  ⇨ *lowers reflectance from the visible to near-infrared*
  - *increase in charcoal and soil cover and decrease in the vegetation moisture*

  ⇨ *increase both short-wave infrared reflectance and surface temperature*

- <u>Methods differ with regards to:</u>
  - the number of images used: *uni-temporal and multi-temporal*
  - the type of processing carried out *(e.g. radiometric index, classification, sub-pixel level analysis methods)*

- Classification consists one of the most common approaches employed (e.g. *Sunar and Ozkan, 2001*).

Burned area mapping

- **Comparative studies** evaluating the performances of the combined used of different algorithms with different RS-data, even more in Mediterranean setting are limited (*e.g. Boschetti et al., 2007; Kontoes et al. 2009*).

- This despite that **nearly 90%** of all the wildland forest fires in the European Union take place in the Mediterranean countries (*Rosa et al., 2008*).

Study objective:

- *The present study objective was to undertake in a Mediterranean setting a detailed investigation of the use of **Maximum Likelihood (ML)** and **Support Vector Machines (SVM)** classifiers for obtaining total burnt area cartography from the **Landsat TM** & **Advanced Land Imager (ALI)** satellite radiometers.*

Test site

- *As a case study it was selected a region near the capital of Greece, where a catastrophic fire occurred in August 22nd , 2009.*

Figure 1: ***Location o f the study site*** *(source: BBC news)*

Figure 2: ***Images of affected area during (left) and after (right) fire*** *(source: BBC news)*

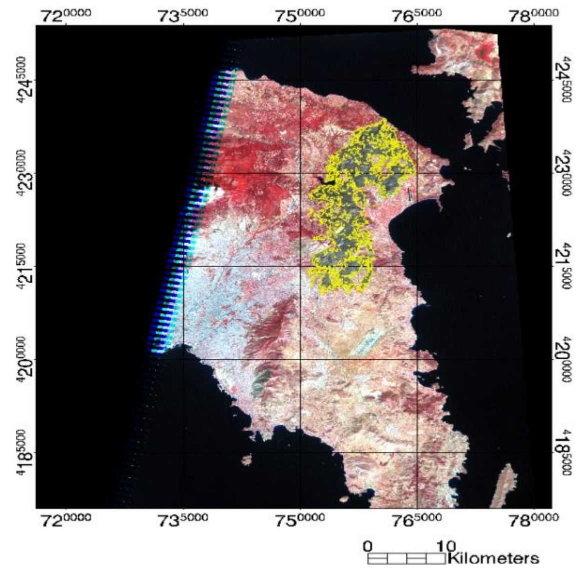
Datasets

SATELLITE DATASETS:

- *Landsat TM imagery (Sept. 3rd , 2009)*
- *ALI imagery (Aug. 30th, 2009)*

OTHER SPATIAL DATASETS:

- *CORINE Land Cover 2000 (100m spatial resolution)*
- *Burnt area estimate from SAFER (Services and Applications for Emergency Response), based on Landsat TM analysis (Kontoes et al., 2009)*



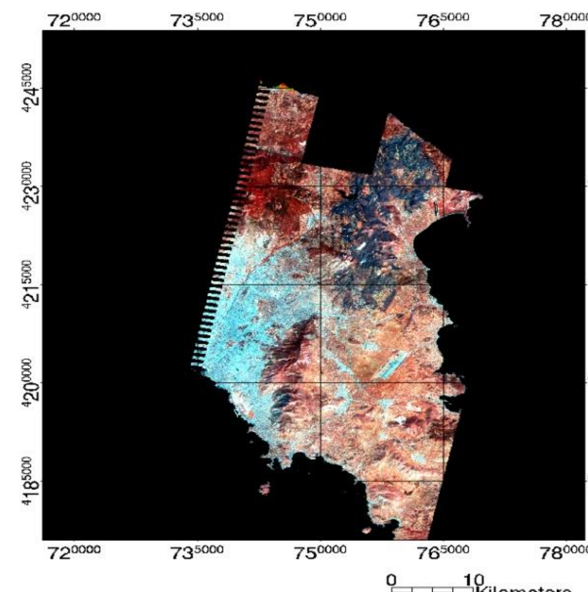


Figure 3: *TM (top) and ALI (bottom) images acquired. SAFER burnt area is also overlain in the TM image (shown in yellow, left)*

Methodology

- *The SVM & ML were applied to both the ALI & TM images, using the same set of training and validation points.*
- *These points were selected using primarily the panchromatic band from the ALI sensor (10m spatial resolution), assisted by CORINE 2000 .*
- *Spectral separability index of the points selected was computed to ensure pureness of their selection.*
- *Initially was assessed the overall classification accuracy, and then the ability of each classifier to delineate the burnt area class specifically.*

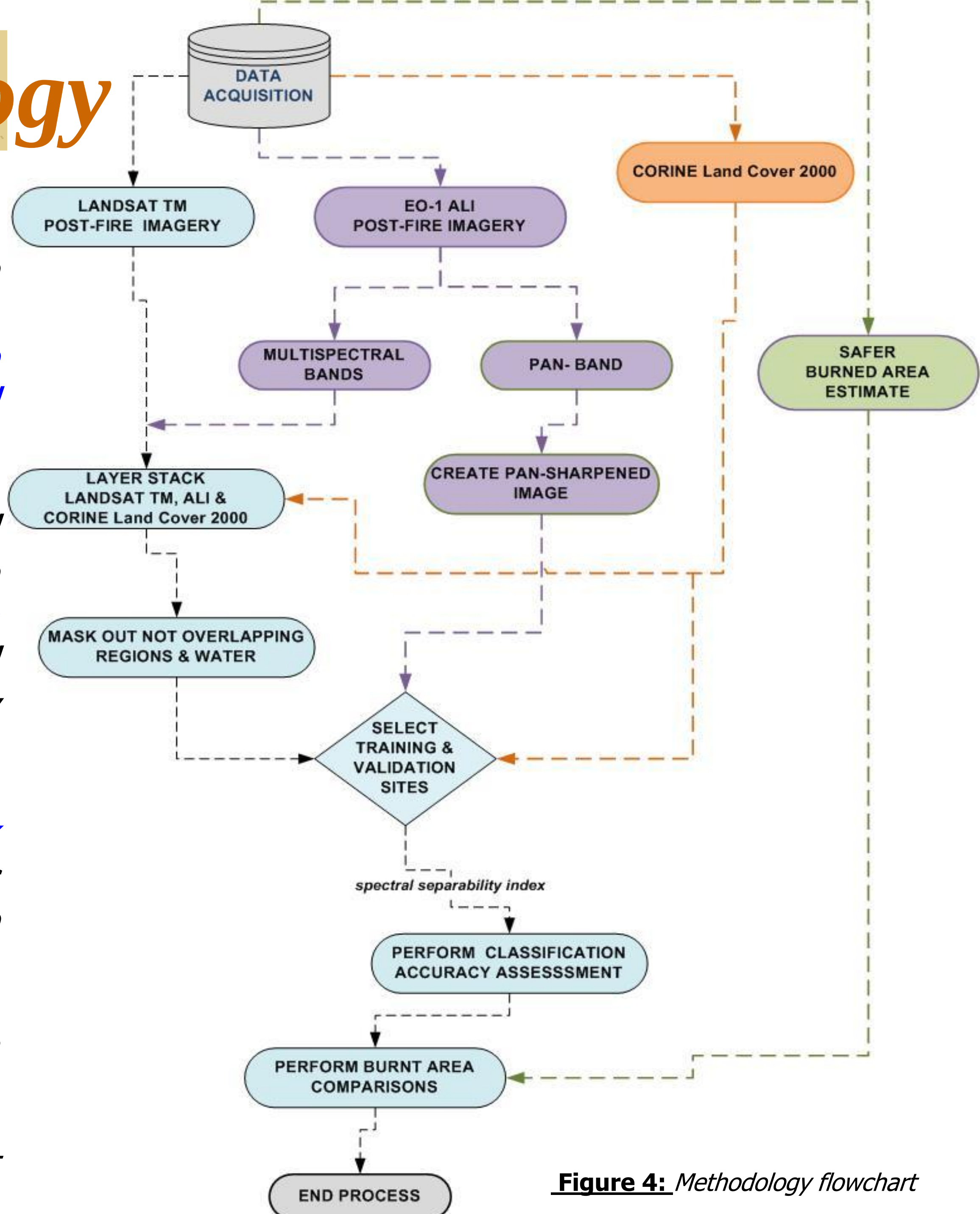


Figure 4: *Methodology flowchart*

Methodology

- ***ML** (Richards, 1999) assumes that statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class*

- ***ML** was performed by calculating the following discriminant functions for each pixel using a single probability threshold value for all classes.*

$$g_i(x) - \ln p(\omega_i) - \tfrac{1}{2} \ln |\Sigma_i| - \tfrac{1}{2}(x - m_i)^t \, \Sigma_i^{-1} \, (x - m_i)$$

Where:

i = class

x = n-dimensional data (where n is the number of bands)

$p(?_i)$ = probability that class $?_i$ occurs in the image and is assumed the same for all classes

$|\Sigma_i|$ = determinant of the covariance matrix of the data in class $?_i$

Σ_i^{-1} = its inverse matrix

m_i = mean vector

Methodology

- ***SVM** (Vapnik, 1998) is a binary classifier, provides separation of classes by fitting an optimal separating hyperplane to a set of training data that maximizes the separation between the classes. The data points closest to the hyperplane are called support vectors.*

- ***SVM** was applied using the Radial Basis Function kernel:*

Radial Basis Function: $$K(x_i, x_j) = \exp(-\gamma \|(x_i, x_j)\|^2), \gamma > 0$$

where: γ is the gamma term.

Penalty parameter was set to its maximum value, probability threshold value was set zero, γ was equal to the inverse of the number of bands.

Results: classification accuracy

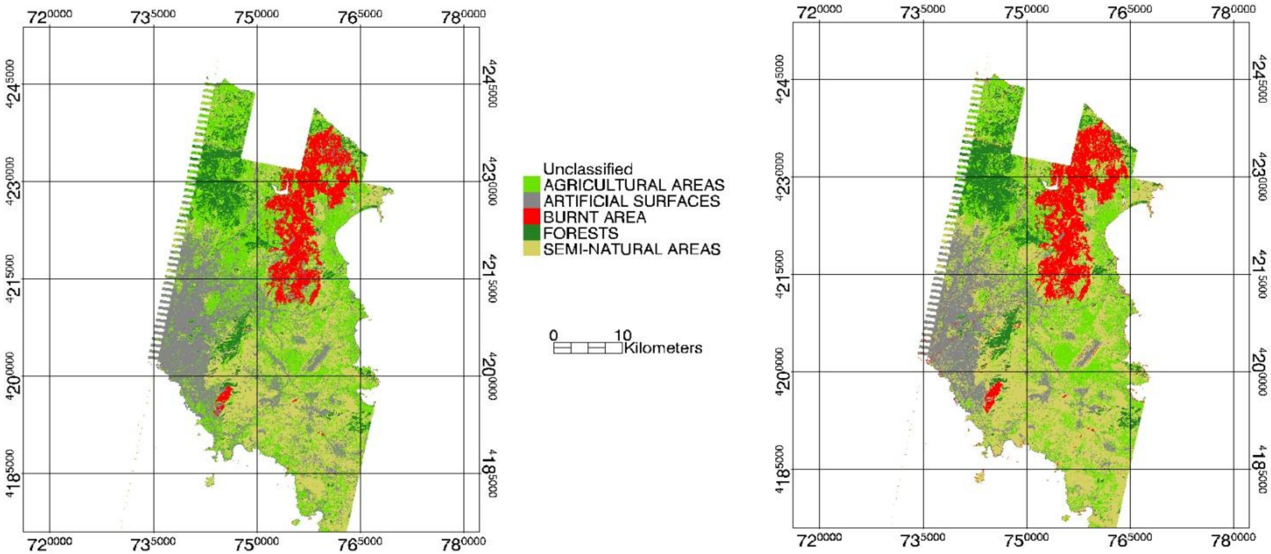


Figure 5 Landsat TM classification using ML (left) and SVM (right) classifiers

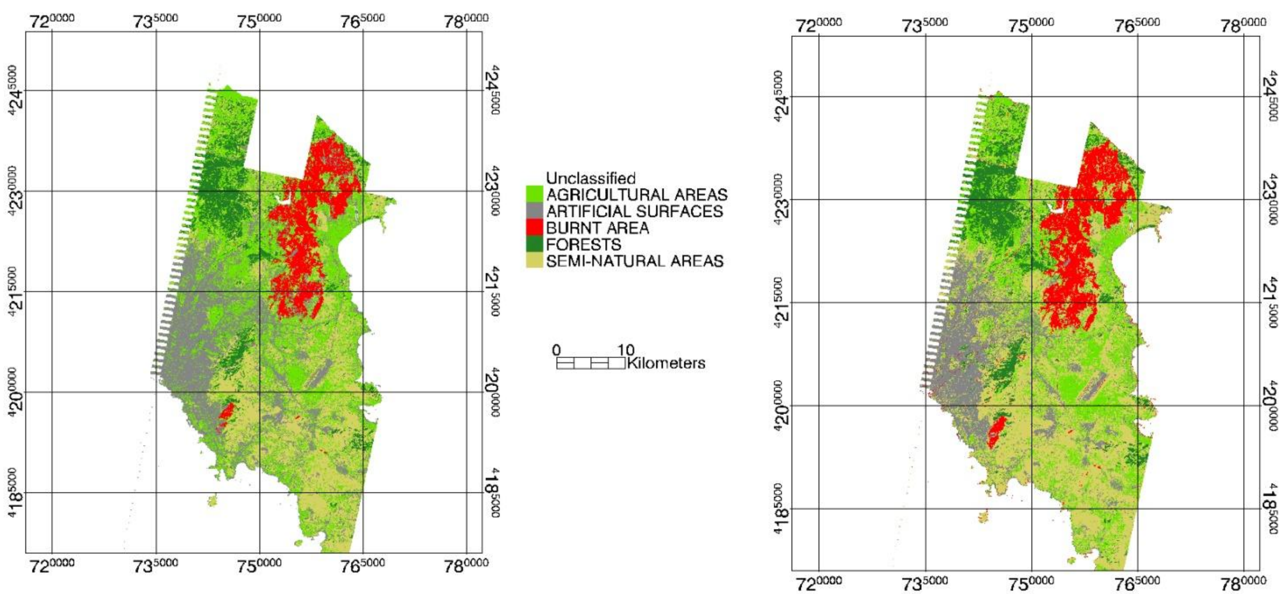
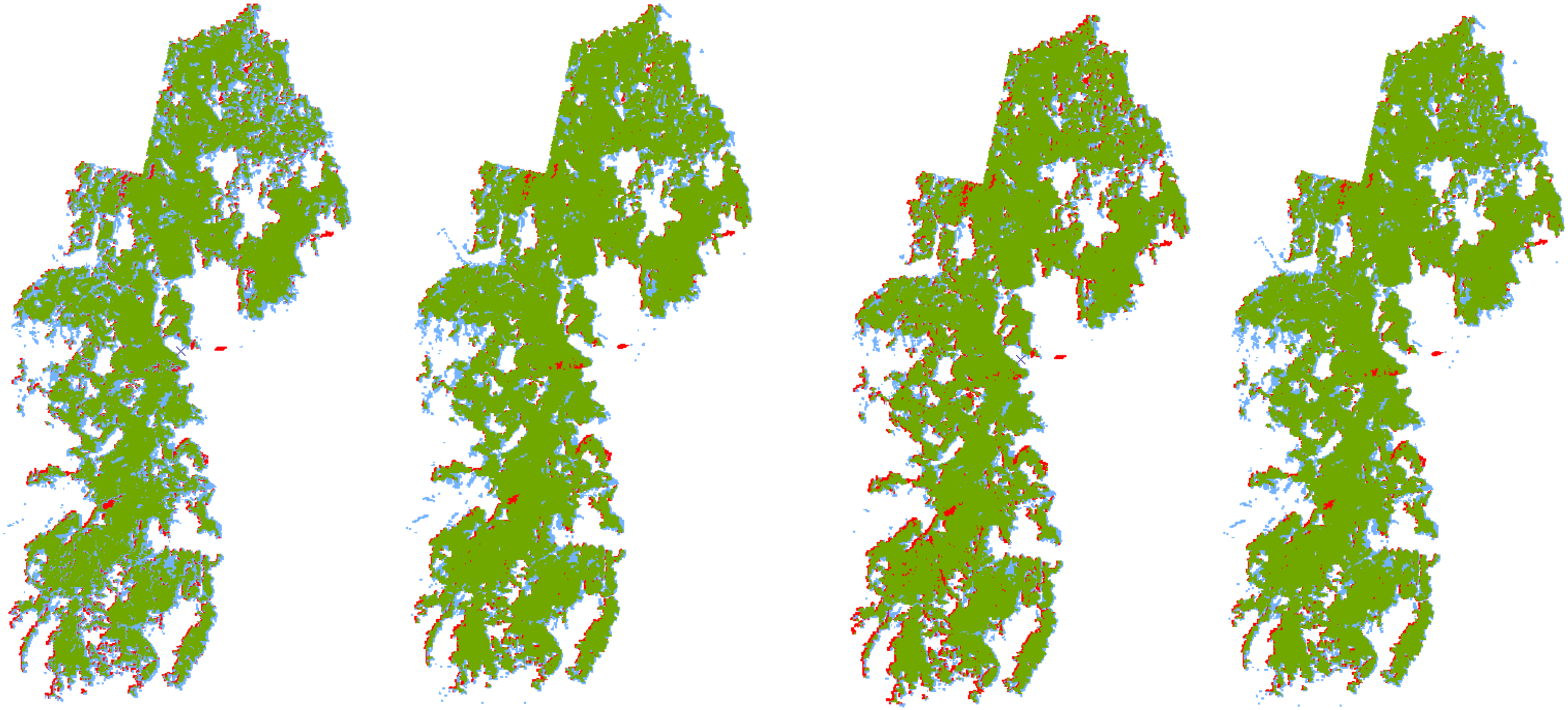


Figure 6: ALI classification using ML (left) and SVM (right) classifiers

Table 1: *Summary of classification accuracy assessment*

Classification method applied	Overall accuracy (%)	Kappa coefficient
TM ML	90.32	0.880
TM SVM	93.54	0.920
ALI ML	90.78	0.885
ALI SVM	93.55	0.920

Results: burnt area comparisons



ML (Landsat TM) SVM (Landsat TM) ML (ALI) SVM (ALI)

<u>Figure 7:</u> Burnt area overlaps between sensor considered each times (blue) , SAFER (red), and the burnt area identified by both the latter two datasets (green)

Results: burnt area comparisons

Table 2: *Summary of total burnt area comparisons*

ESTIMATED BURNT AREA FOR THE COMMON REGION BETWEEN TM & ALI SENSORS	
Classification method applied	*Burnt area estimate (km²)*
TM ML	110.44
TM SVM	115.79
ALI ML	104.15
ALI SVM	115.79
SAFER BURNT AREA ESTIMATE FOR THE SAME REGION:	***126.29***
COMPARISONS FOR THE TOTAL BURNT AREA (COVERED ONLY IN THE TM IMAGE)	
Classification method applied	*Burnt area estimate (km²)*
TM ML	113.65
TM SVM	119.37
SAFER TOTAL BURNT AREA ESTIMATE:	***130.46***

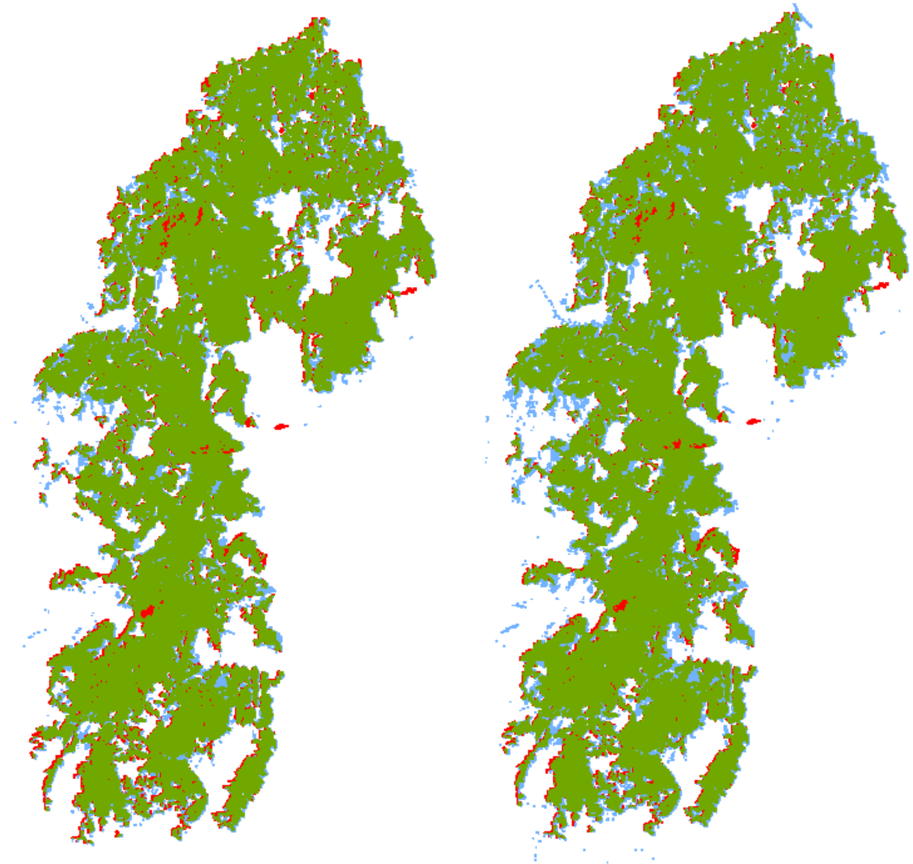


***Figure 8:* Burnt area overlaps between Landsat TM (blue), SAFER (red), and the covered area by both the latter two datasets (green)**

Conclusions

- *Overall classification accuracy for **both TM & ALI** was higher with the SVM in comparison to the ML classifier.*

- *Also for **both TM & ALI,** total burnt area estimate from SVM was in closer agreement with the SAFER**.***

- *Results comparable to other studies particularly for SVM (e.g. Zammit et a., 2006; Cao et al., 2009)*

- *Differences in results obtained are attributed mainly to:*
  - *signal-to-noise ratio and DN dynamic range differences between TM & ALI sensors, relative to the algorithms characteristics on treatment of land cover heterogeneity , burning responses of different vegetation types and terrain complexity.*

…Thank you for your attention!