

# MONITORING WILDFIRE ACTIVITY OVER PORTUGAL USING MSG AND NOAA / METOP INFORMATION

Teresa J. Calado and Carlos C. DaCamara

CGUL, Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal  
[mtcalado@fc.ul.pt](mailto:mtcalado@fc.ul.pt); [carlos.dacamara@meteo.pt](mailto:carlos.dacamara@meteo.pt)

## ABSTRACT

The summer of 2003 was characterised by very warm and dry conditions in Europe, especially in Western Europe. In particular, it was the short-lived heatwave that occurred in the first fortnight of August that was responsible for the worst fire occurrences ever recorded in Continental Portugal.

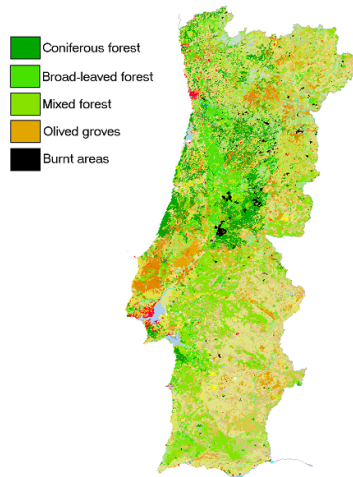
According to official data, the burnt area reached a total amount of 453,097 ha, 304,182 ha of which (i.e. 66% of the total) were recorded in the first 2 weeks of August, and 91,439 ha (i.e. 22% of the total) were recorded in August 4. It is worth emphasizing that wildfires in August were responsible for the death of 21 human beings and an estimated loss of 15.5 million euros.

The LSA SAF is now in its pre-operational phase and MSG data are currently being processed and archived at its facilities. During the current and the next years data from NOAA and Metop will also become part of the LSA SAF processing chain and new perspectives will be opened in what respects to the real time monitoring of wildfire activity. In such a context, an assessment of the added value provided by a synergic use of data from geostationary and polar orbiters is of particular interest.

Accordingly we present a first study on wildfire activity over Continental Portugal based on MSG and NOAA data for the fire season of 2003 focusing on August 3 and 4.

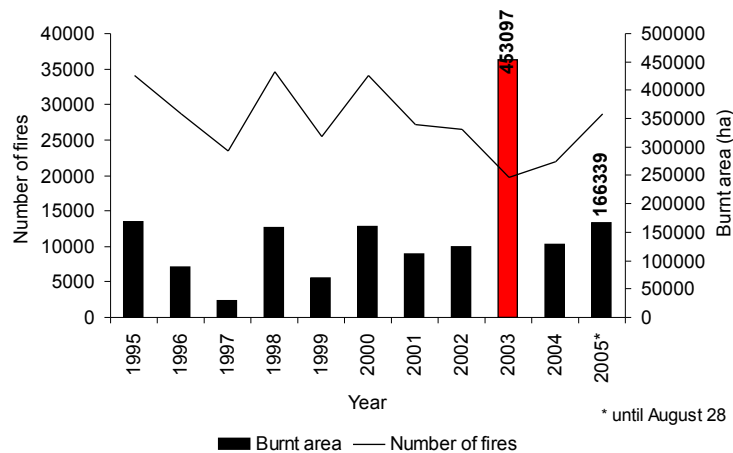
## 1. INTRODUCTION

Forest fires are a major problem over Continental Portugal, especially taking into account that forests cover approximately 34% of the surface of the country (Figure 1). The impact of wildfires on human life and property as well as on the sustainability of forests is of great concern and shows the importance of having an accurate and time knowledge of the total area burned during the fire season.



**Figure 1.** Land cover of Portugal from (source: CORINE).

According to the Portuguese Forest Service (DGF) the total burnt area in Continental Portugal during the period 1980-2005 (Figure 2) has reached 1.7 million hectare (circa 18% of the surface of the country) and it is worth noting that 2003 was by far the year presenting the highest amount of burnt area, reaching a total of 453,097 ha (304,000 ha in the first 2 weeks of August). The year of 2005 was also of great concern, even though it has not reached such a huge amount and it may be mentioned that although most of the fires in 2003 have occurred in central Portugal, the 2005 fires were mores devastating in the Northwest.

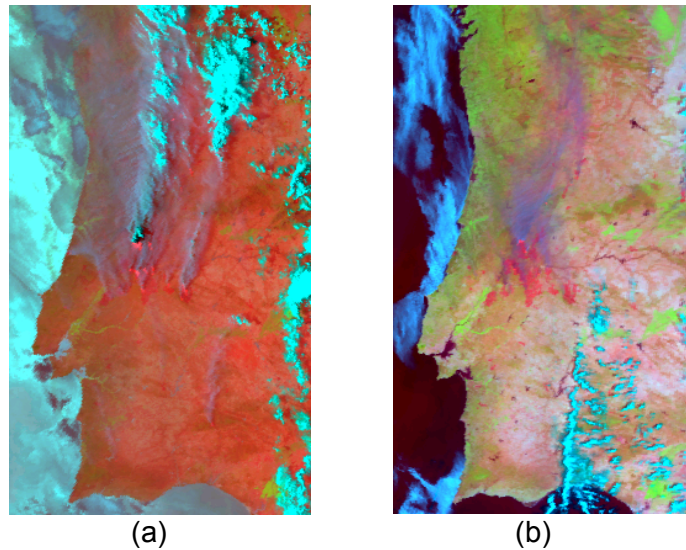


**Figure 2.** Burnt areas by wildfires in the period 1995-2005 (source: DGF, Portugal).

We present a first study aiming to show the advantages of combining the spatial and temporal resolution of NOAA and MSG satellites when monitoring burnt areas over Continental Portugal. For this purpose, a previously developed neuro-fuzzy technique (Calado and DaCamara, 2002) was applied to the near-infrared (NIR) and the thermal infrared (TIR) channels of both NOAA/AVHRR and MSG/SEVIRI.

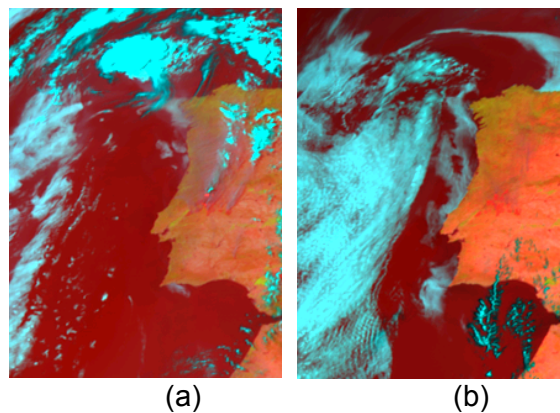
## 2. DATA

The NOAA data (Figure 3) consist of 416×246 pixel images of August 3 and 4, 2003, at 16:05 UTC and 14:37 UTC, respectively. The images were previously calibrated, geometrically corrected and georeferenced and pixels were resampled to the size of 1.1×1.1 km<sup>2</sup>. The study area was restricted to Continental Portugal and the channels used to detect burnt areas were the NIR (channel 2) and TIR (channel 5).



**Figure 3.** RGB (10.3-11.3  $\mu\text{m}$ , 0.72-1.10  $\mu\text{m}$ , 0.58-0.68  $\mu\text{m}$ ) NOAA images, respecting to August (a) 3 at 16:05 UTC and (b) 4 at 14:37 UTC 2003.

The MSG data (Figure 4) consist of 302×224 pixel images, covering August 3 and 4, 2003 on an hourly basis from 7:00 until 19:00 UTC. The channels used to detect burnt areas were the NIR and the TIR, respectively centred at 0.8  $\mu\text{m}$  and 12  $\mu\text{m}$ .



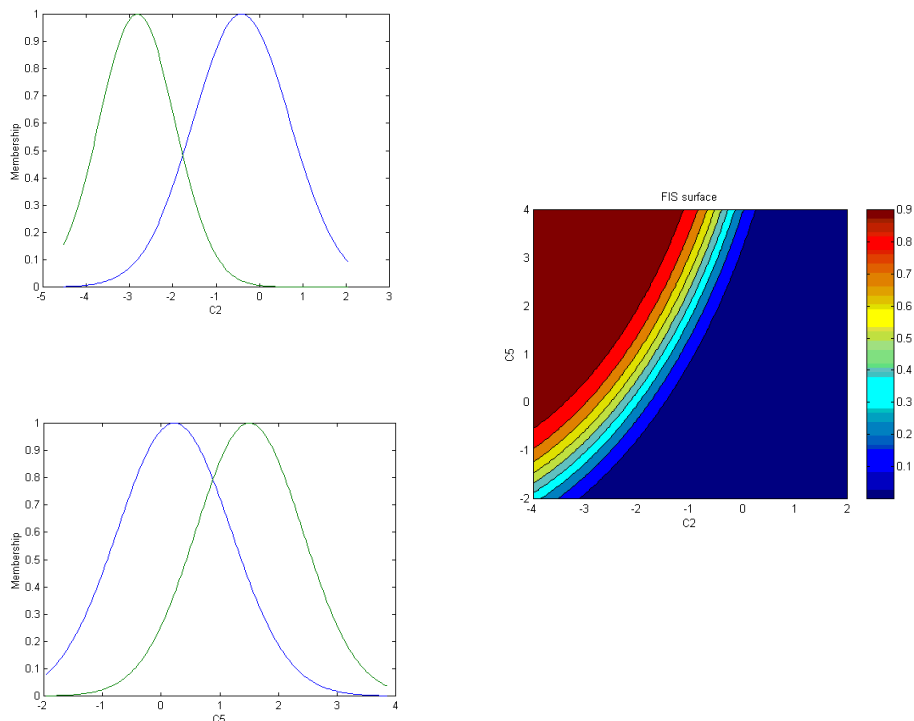
**Figure 4.** RGB (10.8  $\mu\text{m}$ , 0.8  $\mu\text{m}$ , 0.6  $\mu\text{m}$ ) MSG images, respecting to August (a) 3 at 16:00 UTC and (b) 4 at 14:00 UTC 2003.

### 3. IDENTIFICATION OF BURNT AREAS

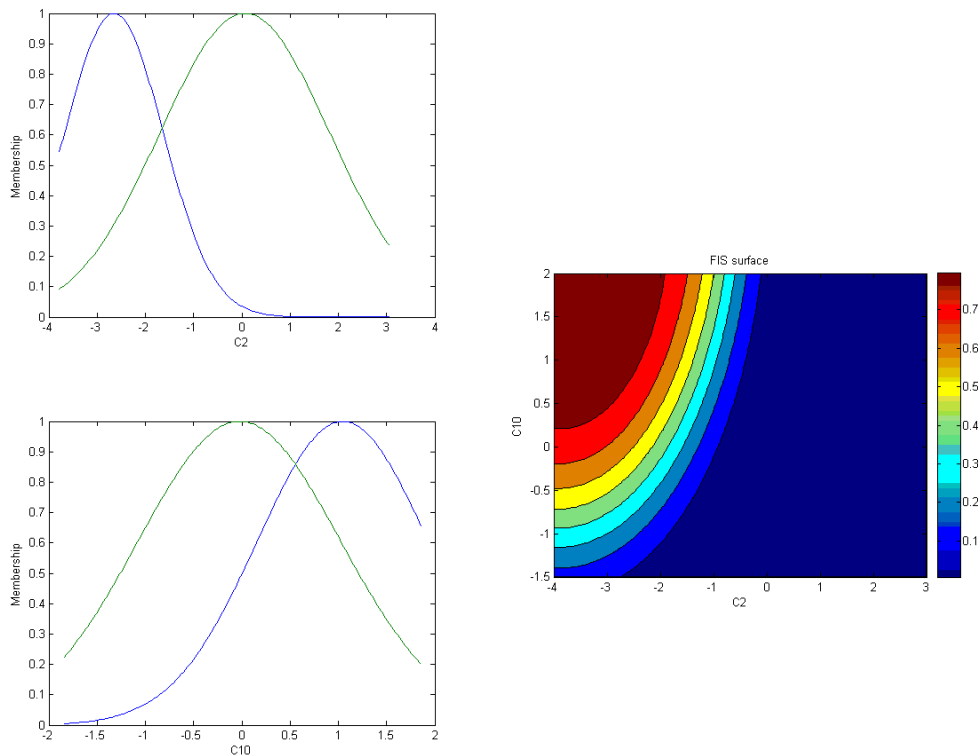
The identification of burnt areas consisted of applying a previously developed neuro-fuzzy ANFIS model (Calado and DaCamara, 2002). The method consists in building up a Fuzzy Inference System (FIS) that is able to associate given appropriate input membership functions to an output fuzzy inference surface (Jang, 1993) that translates the concept that a burnt area is characterised by a decrease in reflectance (darker regions than the surroundings) associated to an increase in temperature due to the loss of vegetation and water content.

The ANFIS model was applied to the NIR and TIR channels (channels 2 and 5, respectively) of NOAA/AVHRR, using as learning data burnt scars from an end-of-season Landsat-TM map. In what respects to MSG/SEVIRI, we have used as input the NIR and TIR channels (2 and 10, respectively) and as learning data the output from the NOAA model, which was downscaled to the MSG scale by averaging the values of the NOAA pixels.

Figures 5 and 6 show the input membership functions, as well as the respective FIS surfaces as obtained from the ANFIS models for both NOAA and MSG. Results confirm what is to be expected over burnt areas, *i.e.*, low values of NIR and high values of TIR channels.

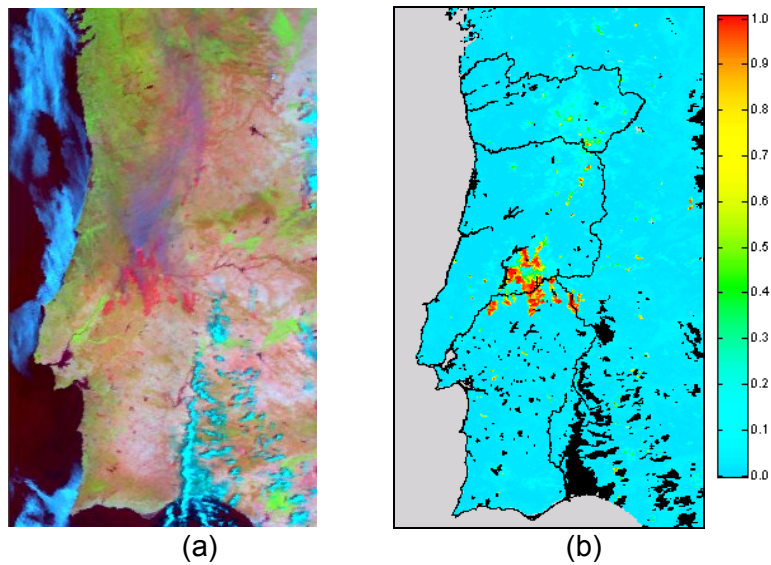


**Figure 5.** ANFIS membership functions, for channels 2 (upper left panel) and 5 (lower left panel) and FIS surface (right panel) for NOAA/AVHRR.

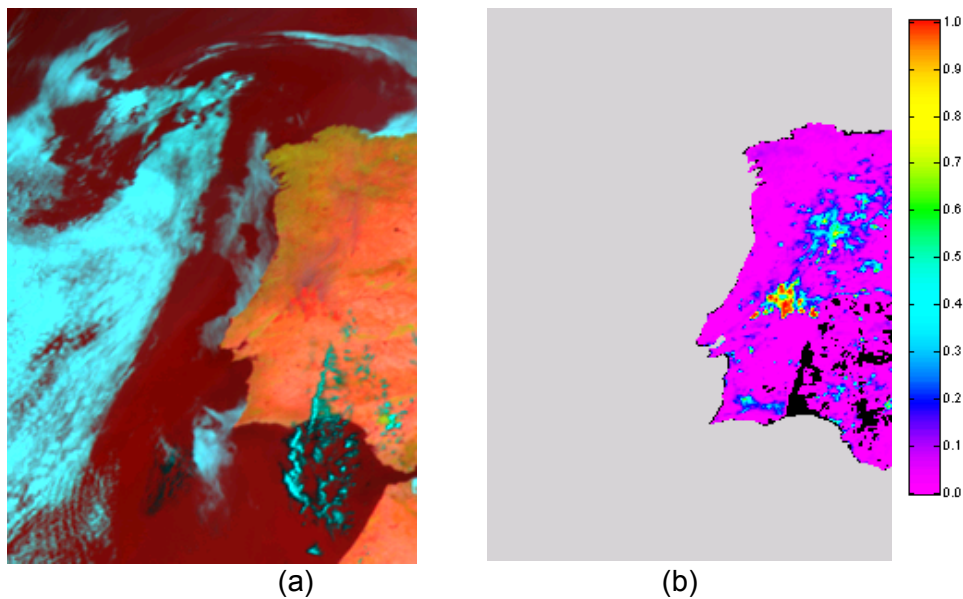


**Figure 6.** As in Figure 5 but for channels 2 and 10 of MSG/SEVIRI.

Figures 7 and 8 show an example for August 4 of membership grades obtained with NOAA/AVHRR and MSG/SEVIRI, respectively. Results show that high values of membership (red areas in the right panels) are in agreement with areas covered by burnt scars (reddier pixels in the left panels).

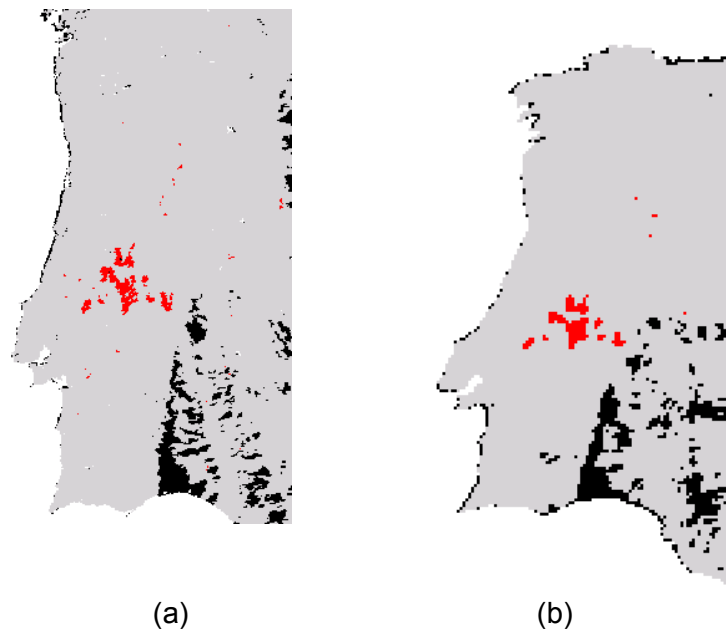


**Figure 7.** (a) RGB (4,2,1) NOAA image of August 4 and (b) corresponding membership values as obtained from ANFIS model.



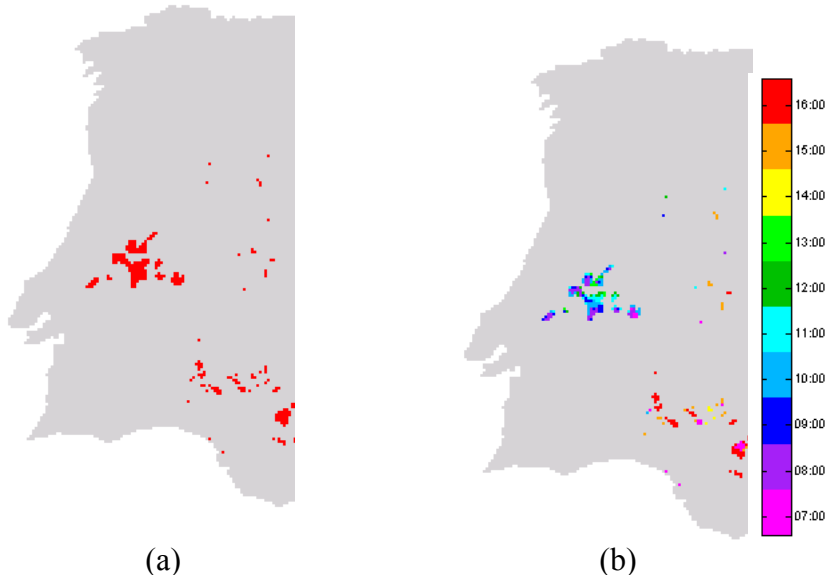
**Figure 8.** (a) RGB (9,2,1) MSG image of August 4 at 14:00 UTC and (b) corresponding membership values as obtained from ANFIS model.

Thresholds used to defuzzify the results were of 0.8 and 0.7 for NOAA and MSG, respectively (Figure 9). These thresholds were tuned by visual inspection and their performance was assessed by means of contingency tables.



**Figure 9.** Pseudo-colour images for August 4 of defuzzified burnt scars with thresholds of (a) 0.8 for NOAA and (b) 0.7 for MSG. Black pixels identify cloud systems.

Figure 10 shows an MSG time composite for August 4 and the spatial coherence associated to the time evolution of burnt areas (right panel) is well apparent, suggesting that in spite of the coarse resolution MSG is still appropriate to detect and follow in time and space burnt scars associated to large fire events.



**Figure 10.** Pseudo-colour MSG images for August 4 of (a) burnt scars after applying a threshold of 0.7 and (b) time evolution of burnt areas.

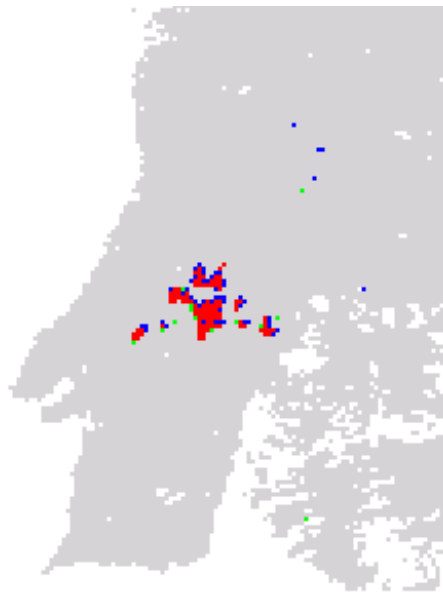
**4. VALIDATION AND CONCLUSIONS**

Validation of results was performed by means of a confusion matrix (Lillesand and Kiefer, 1994), respecting to August 4 at 14:00 UTC (Table 1) and it is worth noting that the NOAA output was taken as “the truth”. Performance was assessed by means of the Producer’s Accuracy (PA=89%), the User’s Accuracy (UA=68%) and the  $\hat{k}$  statistic ( $\hat{k}$ =76%) and obtained results show that the developed method shows coherence in the location of burnt scars, even though there is a large amount of commission errors (51) in comparison to the omission ones (13). However, as shown in Figure 11, most of the commission errors (blue pixels) are located at the borders of the burnt scars (red pixels), raising the possibility that these errors are mainly due to scale differences between the two sensors.

**Table 1.** Confusion matrix for August 4, 14:00 UTC as obtained from the ANFIS models.

	<b>NOAA ANFIS model</b>
--	-------------------------

<b>MSG ANFIS model</b>	<b>Burnt</b>	<b>Burnt</b> 106	<b>Non-burnt</b> 51
	<b>Non-burnt</b>	13	10527



**Figure 11.** Pseudo-colour image for August 4 of burnt scars identified by NOAA/AVHRR (green pixels), by MSG/SEVIRI (blue pixels) and both sensors (red pixels).

Obtained results support that the developed techniques applied to discriminate burnt scars are able to *grab* the very nature of large burnt area signatures. They also suggest that a synergistic use of information from NOAA/AVHRR and MSG/SEVIRI allows a proper spatial and temporal characterisation of burnt scars, an endeavour that may be undertaken within the framework of EUMETSAT's Satellite Application Facility on Land Surface Analysis (LSA SAF). In this respect it is worth stressing that relying on operational meteorological satellites to discriminate burnt scars has the undeniable advantage of insuring reliable and long-lasting databases.

## REFERENCES

Calado, T.J. and DaCamara, C.C., 2002. Burnt area mapping in Portugal with a neuro-fuzzy approach. *Proceedings from the EUMETSAT Meteorological Satellite Data User's Conference*, Dublin, Ireland, September 2002, 577-584.



Jang, J.-S.R., 1993: "ANFIS: Adaptive Network-based Inference System". *IEEE Transactions on Systems, Man and Cybernetics*, **23**, n° 3, 665-685.

Lillesand, T.M. and Kiefer, R.W., 1994: "Remote Sensing and Image Interpretation". John Willey & Sons, Inc. 3<sup>rd</sup> edition (1994), pp.750.