Global Monitoring of the Environment and Security: a comparison of the Burned Scar Mapping services of the RISK-EOS project

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ABSTRACT: The RISK-EOS project of the European Space Agency started in 2003 under the framework of the Global Monitoring for Environment and Security (GMES) initiative, with the objective to establish a network of European service providers for the provision of geo-information services in support to the risk management of meteorological hazards. The Fire component of RISK-EOS project features as the main element, the Burn Scar Mapping (BSM) service, which provides seasonal mapping of forests and semi-natural burned areas at high spatial resolution (minimum mapping unit of 1 to 5 ha). The RISK-EOS BSM service builds on the achievements of ITALSCAR, a demonstration project for the yearly mapping of burned areas in Italy, using LANDSAT TM. The major objectives of the BSM service are to provide post-crisis information on the vegetated areas affected by wildfires to assess the damages and provide a baseline for recovery and restoration planning. A good knowledge of the land use/cover changes helps the forestry authorities and the fireguards to better assess the risk of fire ignition and fire spread in order to better allocate efforts for fire prevention and suppression. The BSM service has been provided by different providers in Portugal (Critical Software and ADISA), Spain (TELESPAZIO and INSA), France (TELESPAZIO and Infoterra France), Italy (TELESPAZIO) and Greece (NOA ISARS) and has been harmonised across countries. This paper briefly describes the methodologies applied by each service chain and compares the classification results on a specific burn scar which occurred in Portugal during the 2007 fire season.

1 Summary

In the scope of the RISK-EOS project, some Burn Scar Mapping (BSM) services have been delivered in five different countries in Southern Europe: Portugal, Spain, France, Italy and Greece, using four different service chains: Telespazio, Infoterra France, ADISA and NOA.

2 BSM service chains methodologies

The following chapters present the main characteristics of the RISK-EOS BSM service chains.

2.1 Telespazio Service Chain

The BSM chain applied by TPZ can be summarized as follows:

- Pre-processing with geometric and radiometric correction, and cloud mask generation;
- Core Processing for the automatic generation of preliminary BSM polygons with:
  - Highlightness of the spectral characteristics of burned areas using vegetation indexes (NDII, BAI and GEMI) and the hue component of the IHS transformation (bands 7-4-3);
  - Identification of the burned *core pixel* based on a multi-threshold analysis between the pre and post-fire images, and inter-annual and intra-annual comparisons;
  - Automatic delineation of the burned area perimeter, starting with the identification of pixels correlated to the core pixels of the burned area. This process is based on the application of two parallel algorithms: regions growing and watershed classification.
- Post-processing for final refinement of the burned area perimeter with photo interpretation and support of ground truth data when available.

2.2 Infoterra France Service Chain

The BSM chain applied ITF is based on the following steps:

- Pre-processing with atmospheric and radiometric corrections;
- Identification of cloud masks;
- Extraction of the biophysical parameters (GLCV - Green cover fraction; CSH - Canopy shade factor; SB- Soil brightness; DCL - Cloud reflectance);
- Development of a decision tree with the biophysical parameters in order to identify seed pixels;
- Application of a region growing algorithm in order to have a fist version of BSM product;
- Post-processing of the first version of BSM by visual interpretation and manual edition.

2.3 ADISA Service Chain

The BSM chain applied by ADISA is a multi-temporal approach based on differences between a pre and a post-fire dataset using a classification tree algorithm:

- Pre-processing in order to get geometrically and atmospherically corrected images;
- Masking out clouds and cloud shadows (automatic process followed by on-screen edition);
- Use of the spectral Landsat TM bands and normalized difference band combinations (spectral indices: NDVI, GNDVI and VI7);
- Development of a supervised burned area classification tree;
- Application of the set of rules to the input variables;
- Map filtering to reduce noise and remove small unburned patches inside burned areas;
- Vector edition and application of a pre-defined minimum mapping unit threshold.

2.4 NOA Service Chain

The NOA processing chain is a fixed thresholding approach that relies on automatic processing of spectral indices (NBR, NDVI, multi date NDVI and ALBEDO), as well as radiometric change vector analysis:

- Satellite data radiometric normalisation, geo-referencing and mosaicking. Cloud, water and shadow mask generation;
- Calculation of radiometric change vectors and generation of change/ no-change pixel masks;
- Derivation of uni- or multi-temporal spectral indices and definition of the appropriate index thresholds (sensor and area specific);
- The thresholded spectral indices are then combined in order to achieve a first separation between burnt and unburned areas. To resolve any ambiguities, the burn scars are compared against the derived change pixel map (output of the radiometric vector change analysis);
- Removal of pixel noise using a median filter, and elimination of objects smaller than the specified minimum mapping unit (MMU);
- Generation of GIS compatible burn scar polygons and enhancement of their thematic value.

3 Comparison of the different methodological approaches

The four service chains have similar approaches, applying vegetation indexes and band combinations in a multi-temporal analysis, followed by a supervised classification performed with a decision tree. In order to share the information and experiences, a workshop was performed within the scope of RISK-EOS project. An analysis of the different service chains approaches was performed using as a reference a forest fire that occur in the centrer of Portugal during the 2007.

3.1 Common Problems

After analyzing the different approaches and results, several common issues were found:

- Difficulties in mixed land use types separation (mixing of forests and semi-natural lands with clear cuts, permanent crops, agriculture, etc.) given the coarser spatial resolution of the satellite data used (30m).
- Decision of Burnt/Not Burnt boundary (ancillary data need);
- Commission errors due to non-distinguishable spectral data;
- Availability of the proper images regarding the acquisition dates. Images should be clean of clouds and atmospheric contamination and they should be acquired at the end of the fire season;
- Differences between smoothed boundaries (generalization) and raster looking-like boundaries;
- Availability of the proper "ground truth" data for classifier training and reliable accuracy assessment.

3.2 Results

The results obtained by the different methodologies were very similar in terms of burn scar shape, with small difference appearances due to differences in the post-processing of the four service chains, such as boundary smoothness or removal of small unburned islands. Table 1 presents the main characteristics of the different BSM service chains and the results obtained during the RISK-EOS project.

Service Chain	Input Data	Validation Data	Detection Efficiency Rate
TPZ	Landsat 5 TM SPOT 4 IRS-P6	AIB Fire logs and/or GPS surveys in Italy. Promethee surface in France. Fire logs or GPS perimeters in Spain.	Between 77,25 - 90,0 % for fires ≥ 2ha
ITF	Landsat 5/7 TM SPOT 2,4, 5 F-2, K-2	GPS contours Promethee database	98% for fires > 1 ha with SPOT
ADISA	Landsat 5 TM SPOT 4 XS	GPS surveys and data acquired by cameras installed in surveillance towers	84,5 % for fires ≥ 2ha
NOA	Landsat 5 TM SPOT 4 XS F-2 P&XS	Existing burn scar drawings on 1:50.000-scale analogue maps GPS surveys of specific reference fires	Between 77 - 93 % for fires ≥ 1ha

Table 1: Main characteristics of the different BSM service chains

4 Conclusions

All service providers have used similar methodological approaches. Due to specific requests of the users, different post-processing techniques were applied and thus the final results were slightly different. The same problems were encountered by all service providers and were mainly resulting from the image acquisition dates and ground truth data applied for adjustments in the post-processing phase and validation. Due to its spectral and spatial resolutions, Landsat TM has been the sensor most widely used to map burnt areas. However, the high risk of reaching the end of its life in a short period of time causes the very high dependency on this sensor. Because of this risk, the BSM service providers have adapted their production chain and are now using SPOT, Formosat, IRS and other satellite sensor images which include near infrared and red spectral bands. However, these sensors have limitations concerning the needed spectral information and the full extended European coverage (Formosat), and do not seem to be the most suitable satellite sources for this type of service. The ESA Sentinel 2 (to be launched in 2012) with its large swath (300km), its high frequency revisit and its good spectral and spatial resolutions (13 optical channels and 10m resolution) will solve most of the identified limitations. This comparison study provided concrete evidence that the four methods offer advanced burnt area mapping in terms of cost and accuracy, compared to conventional field methods and/or aerial photo-interpretation. The accuracy results and the overall experience gained through the RISK-EOS project suggest that the satellite-based mapping methods replace the conventional methods at an accuracy level far exceeding the existing mapping standards established by Forestry Services in many Mediterranean countries.

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