The Next Step of Remote Sensing Services for Operational Forest Fire-Fighting within GMES

Fernando Valcarce[1], Joaquín Ramirez[2], José-Luis Casanova[3], Abel Calle[4], Angela de Santis[5]

Resumen

PREVIEW is a European VI Framework Programme project intending to setup the next generation of services for disaster management support, within the GMES initiative. For years, many activities around forest fires have been studied from remote sensing data in a quite intensive but uncoordinated manner. Nowadays, the availability of new sensors, the establishment of an European (EURORISK) consortia supported by EC and ESA and the involvement of emergency services allow the development of modern services aiming tat becoming fully operational in the mid-term horizon.

The cluster of experienced organisations within Europe is preparing the basis of this new generation of services: Windstorms, Plain floods and Flash floods, Earthquake & Volcanic risks, Landslides and Industrial accidents. All the information services are developed, tested and validated at European scale with operational users on pilot test sites distributed over 9 countries.

With respect to forest fires, the portfolio includes Information Product Services covering different phases involved in fire risk management. In early warning, we focus on the detection of hot spots using the SEVIRI sensor on board MSG (Meteosat Second Generation) through the temporal analysis of consecutive images in the MIR band(Medium Infrared Band), instead of using thresholds in MIR and TIR bands leading to false alarm detection during day-time due to the solar irradiance contribution and taking benefit from its improved temporal resolution (15 minutes). For crisis, a fire propagator tool ready to be used at the command centre is tested, providing a fire front evolution prediction for any on-line alarm received, based on the fuel cartography generated in the project framework and with daily ingestion of input data (meteorological data, vegetation stress data from MODIS sensor). In the end, for the post-crisis and recovery phase, the estimation of fire severity (level of damage on vegetation) through RTM (Radiative Transfer Models) and based exclusively on Earth Observation data is a quite innovative and cost reducing approach. All these new techniques shall be discussed in the paper.

[1] INSA, Ingeniería y Servicios Aeroespaciales, S.A. Departamento de Sistemas y Observación de la tierra, Madrid, España

[2] Tecnosylva, S.L., Zaragoza, España

[3] Departamento de Teledetección, Facultad de Física Aplicada, Universidad de Valladolid, España

[4] Departamento de Teledetección, Facultad de Física Aplicada, Universidad de Valladolid, España

[5] Departamento de Geografía, Universidad de Alcalá de Henares, España

Introduction

There is no European region that can be considered as perfectly secured from natural or man-made risks, either originating at the national or at a trans-national level. The risks may result from the direct impact of atmospheric events (windstorms, heavy precipitations, snowfalls, thunderstorms…), from their hydrological consequences (plain floods, flash floods) or from geophysical events (earthquakes, subsidence, landslides…) and in some cases be worsened or directly caused by industrial activities.

Wherever he lives, the citizen rightfully expects to get the best available information on the risks that can endanger his life and property, be warned in due time when facing a forthcoming event and be assisted with proper effectiveness during and after the unavoidable crisis.

As examples of big crisis events, the "millennium flood" on the Elbe, Danube, Vltava rivers, that hit Germany, Austria, the Czech Republic and Slovakia in August 2002, caused socio-economic damages which were evaluated to several tens of Billion €, as well as 37 fatalities and tens of thousands houses flooded. Forest fires hit each year numerous countries of the European Union, mainly affecting the Mediterranean countries such as Portugal, Spain, France, Italy and Greece. During 2005, fires in these five countries burned a total area of 589 559 hectares, which is well above the average for the last 26 years[1]. In 2005 an amount of 330.000 ha were burnt in Portugal while in 2003 the number of ha was more than 400.000.

The challenging issue is to enhance risk mitigation through better prevention and preparedness, better anticipation and more accurate assessment at various time and spatial scales of situations at risk, improved timely dissemination of meaningful and adapted early warning information, perfectly fitted to the societal needs and to the concepts of operations of rescue forces. This has to be done in a joint effort of all actors and citizens to develop risk awareness and culture.

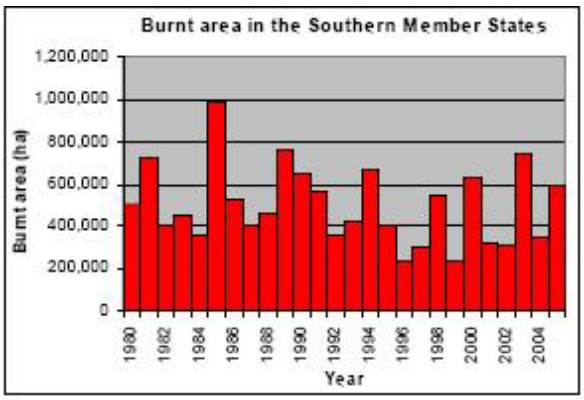

Fig 1: Burnt area in the five southern member states for the last 26 years [1]

Preview Project

PREVIEW is proposed by the EURORISK consortium which gathers major actors of the risk management in Europe: Users (Civil Protections, Planning Authorities, Environmental Agencies, Local Authorities …), Scientists (meteorology, hydrology, seismology, vulcanology…), Operators (Hydro Meteorological Services, Forecasting Offices…) and Industry (Computing, Space, geo-information service providers…).

Under the EC Sixth Framework Program, PREVIEW addresses the definition, the development and the validation in pre-operational conditions of information services to support the management in all phases (Prevention, Preparedness, Response and Recovery) of: Windstorms, Forest fires, Plain floods and Flash floods, Earthquake & Volcanic risks, Landslides and Industrial accidents.

The project is led by a Core Team of 16 partners selected from their origin community (sciences, operators, industry, end-users) from their geographical distribution in Europe and from their savoir-faire.

A second level of 40 local partners is associated to the project to bring their recognized expertise on specific methodologies and technologies and to involve the necessary actors able to adapt the developed services to local specificities.

In the end, 18 countries in Europe are actively contributing to PREVIEW.

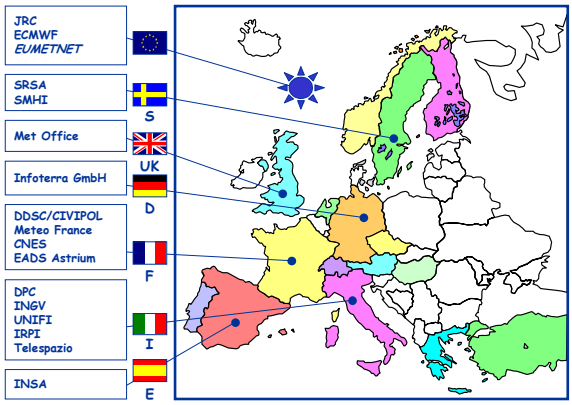

Fig 2: Core team partners around Europe

Based on the review of the operational needs and of the existing research assets, a Portfolio of Services has been defined and specified in close cooperation with end-users. Research developments are performed to transfer the most promising available results and blocks to operational use. The information services are developed, tested and validated at European scale with operational users on pilot test sites distributed over 8 countries.

The project is driven by risk management policies at European and national levels and by the needs declared by institutions and organisations involved in natural hazard risk management.

The services that shall be pre-operationally developed and validated in the 2005-2009 period are the following:

- Atmospheric risks: Windstorms (Windstorm Risk Mapping and Windstorm forecasting), Floods (Medium range plain flood forecasting, Short range plain flood forecasting and Very short range flash flood forecasting) and Forest Fires Services (Fire detection and monitoring, Fire propagator and Fire damage assessment)
- Geophysical risks: Earthquake monitoring and damage evaluation, Volcanic monitoring and damage evaluation, Monitoring of deep-seated, Slow moving landslides over large areas and Prediction of shallow rapid slop movements
- Man made risks: Accident scenarios and airborne of through water pathways transport and deposition of pollutant forecasting
- General services: Assets mapping on geo data resolution, Damages a prior estimates and risk scale and Damage fast observation (through improved services of the International charter)

PREVIEW lasts for 45 months and is organised with 2 successive cycles of 24 and 21 months respectively, each phase being defined in terms of objectives and expected information services deliveries, of results, of associated means and programmatic. A yearly review of the project with the commission is performed so as to redirect, if necessary, the content of the next cycle according to user's priorities, research results and budget envelope.

Regarding further operational deployment, Preview will elaborate representative concepts of operation and will propose organisation schemes to prepare the deployment and future operation of the services. This includes:

- Operation scenarios
- Service organisation, including building upon existing procedures and regulations
- Service partnership agreements, including an organisation scheme for service operation and maintenance
- Recommendations and implementation plan for full operations of the services from 2008

Preview fire services

The Fire Services proposed are aimed to support different phases involving the fire events: early warning (fire detection), crisis (Fire Monitoring and Fire Propagator) and post-crisis (Fire Damage Assessment).

Specification of the services has been finished in March 2006. The development phase ended in March 2007 when the pre-operational validation with the users started. After that, an iterative second phase will start with the updated definition of the services based on the user feedback, new service developments and tests.

Fire damage assessment:

Burnt area mapping and burn severity discrimination are two key factors of assessing fire effects. Within the scope of Preview, the burnt area mapping (BAM) product addresses the discrimination of burned scars in short periods of time after the fire is over. This discrimination intends only to classify burned and unburned areas, from a regional and global perspective. The burnt severity (BS) product intends to discriminate in the scorched area different levels of damage. This is a critical aspect of fire effects assessment, since burn severity is closely related to regeneration patterns. For most fires, burn severity is not included in the fire reports, since it requires a great field effort. In the tables below please find the products specifications.

The service offered in the Preview project comprises two temporal scales: Short term damage assessment and Long- term damage assessment. The former is intended for quick evaluation of fire effects, and the latter for more detailed analysis. Quick assessment is required for updating strategic planning with respect to fire suppression resources, and to evaluate the functioning of fire danger indices. Long-term evaluation is expected to provide a more detailed analysis of the effects of fire on vegetation and soil, providing guidelines for planning post-fire measures.

Regarding Burnt Severity, the innovation comes from the discrimination of the field index, Composite Burn index (CBI) through the use of high resolution images (Awifs, Spot, Landsat), by means of Radiative Transfer Models and Spectral analysis [2]. Cartography for the Fires occurred in Galicia during the summer 2006 has been produced using the AWIFS sensor (60 m resolution) on board the IRS Indian satellite. The minimum fire mapped has 25 Ha and the correlation with field data (R^2) is 0.84.

For Burnt Area Mapping, the main challenge is the analysis of MERIS and AWIFS suitability for the discrimination of burnt areas. AWIFS has been used also used for the determination of Burnt Area perimeters and the amount of Ha with a result 103.728 Ha burnt. In Figure 3 we can see the severity extracted for some big fire in Pontevedra with an amount of 10.000 burnt Ha approximately. In Figure 4 we include the burnt perimeters generated for the area of Galicia.

Target Users

Regional and national fire managers, interesting of fire statistics, spatially comprehensive, fire regeneration and fire emissions (related to the burn severity).Users Organizations in PREVIEW:

- Xunta de Galicia Rural Development Council (Spain/Zamora)

- DGRF, (Portugal)

User's benefits

Forest fires assessment is critical in fire management, since post-fire measurements are decisive to reduce the effects of fire on vegetation, soil and landscape degradation. Fire evaluation is commonly done several weeks or even months after fire, and therefore fire statistics are only available several months after the end of the fire season. Considering the large costs of generating fire statistics from field observation, remote sensing provides a solid alternative to generate such information.

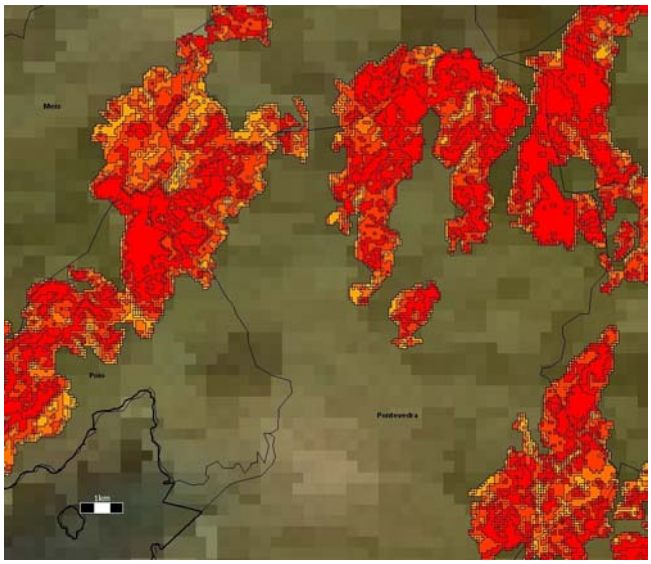

Fig 3: Burnt severity product for the fires occurred last summer in Galicia from AWIFS data

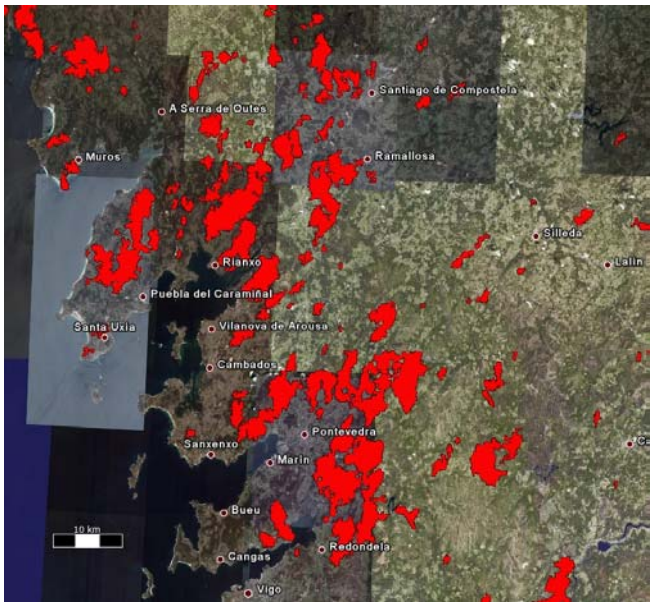

Fig 4: Burnt perimeters for the fires occurred in Galicia for the summer over Google Earth background (courtesy of Google)

Fig 5: Burnt perimeters for the fires occurred in Galicia for the summer 2006 Google Earth Background (Courtesy of Google)

Fire propagator

The aim of the service is the development of a high performance fire propagator providing the fire front predicted shape, implementing the existing models of wildfire behaviour and with these objectives:

- Easy to feed model engine, as transparent to the user as possible
- Direct integration of the products developed in this work (Fuel type, Fuel load, Canopy Cover) and other GIS meteorological and EO data
- Results showed over VHR imagery in 3D, with the forest fire fighting resources and any other information to result a really operational Decision Support System
- Become a useful platform to support training for Forest Fire technicians without high level GIS skills
- No need of understanding neither fire propagation models nor time consuming format conversions.

This service is focused on changing the current lack of use in European Forest Fires services of this kind of tools, but in the prevention phase, and in a few cases only (EUFIRELAB has recently pointed the actual situation) [5]. The main reasons for this actual scenario are:

- Fires in Euro-Mediterranean countries are very fast, and a lot at the same time (30 fires in province per day is not uncommon), with a few chances to spend resources in data providing and results analysis
- Actual tools are difficult to feed, and used data is not fitting the needs of the users (no integration with VHR imagery, no

vegetation from EO data used, difficult to get meteorological variables needed, etc.)

- High skill users are needed to get the best results from tools, and are difficult to evaluate because of low use of 3D capabilities in actual systems

Scenarios of use of the propagators

The operational phase has two different scenarios:

- The fire fighting command centres (FFCC), usually at NUTS 3 level (provincial, department, etc.)
- the fight against fires in the field

Fire propagators used in Euro-Mediterranean area should be short-range models, because of the number and size or fire events. The use of a propagator should be focused after the detection phase, at the Fire Fighting Command Centre, where the cycle of work is detailed below.

At the initial evaluation phase, every alarm is analyzed with the help of the propagator, and in several cases it should be done more than 40 times per day.

Only big fires, with duration of more than 36 hours, get the fire behaviour analysis equipment in the field helping the fight with these capabilities. Right after this tool is well accepted in the Forest Fire Control Centre, it will be the time to use it in the field, where portable capabilities and easiness to run for the operational use are the main characteristics required. At that time, accurate and high detailed meteorological predictions are needed so that kind of tools could offer operational results.

The final objective is that when any fire alarm is received at the FFCC, the propagator automatically runs over it to support short time decisions. Yearly, a FFCC like the target area (Zamora, Spain) may have more than 1500 fires, sometimes more than 30 per day. All of them should have the support of a technical evaluation of danger done by a propagator, which needs no intervention to give results; it should run automatically once the alarm is located. In any other case, it will not be used, as it occurs now.

Target Users

- Forest fighting services at regional and provincial levels (command centre), all over Europe
- Regional and Departamental/Provincial services in charge of forest fires prevention and crisis

Users Organizations in PREVIEW:

- Junta de Castilla y Leon, Enviromental Council (Spain/Zamora)
- DDSC (French Civil protection)

User's benefits

- During the prevention phase, better training can be provided with the easy to use and to interpret tool. Also is useful to localize areas with risk of difficult operations
- During the crisis phase, user will be able to have real time simulations without the need of feeding the tool. Its easiness will be a clue factor of its high level of acceptance between potential users
- The immediate evaluation of alarms thanks to the 3D visualization tool over VHR imagery
- Minimum skill necessary to get immediate results, which is very important for a big amount of possible users

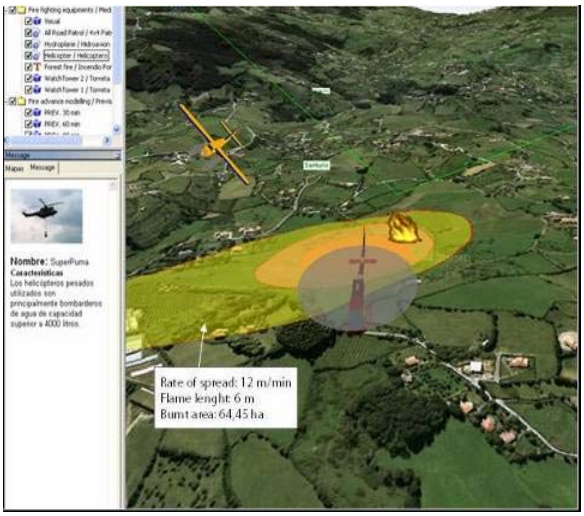

Figure 7: 3D propagator results integrated in a Decision Support System with VHR imagery

Fire monitoring

The fire monitoring service aims to provide a near-real time monitoring of on-going fires, at large scale and with large coverage. It shall be carried out in near real time, by means of Meteosat Second Generation (MSG) SEVIRI and TERRA/AQUA MODIS sensors. The information that is extracted from every fire is:

- Hot spot location
- Fire temperature
- Fire released power
- Reliability
- Number of pixels affected
- Fire line
- Flaming area

The fire is located with a standard precision of 3 km when images came from SEVIRI, and 250 m when images came from MODIS.

The main innovation is the use of the MSG images which have a frequency of one every 15 minutes. That means that a powerful computing system is needed in order to obtain these parameters as soon as possible, typically two or three minutes after the image capture, and provide the information to the fire fighters

The use of thresholds in bands 3.9 mm and 10.8 mm usually requires thresholds adapted to daytime or night-times conditions to be established, since during the day, the solar contribution in the MIR spectral region MIR leads to an increase in brightness temperature. Moreover, this contribution is highly variable due to the different surface illumination geometries. The methodology followed for the present study is based on the multi-temporal analysis of the Brightness Temperature in the MIR band setting specific thresholds. We considered it appropriate to establish a threshold of 4K as the temperature increase value to detect the outbreak of a fire without incurring in false alarms. We should mention that there are two very well defined daily periods: from sunrise to midday, in which the temperature increases and where the estimation of 4K is appropriate, and the second between midday and sunset, for which a value of 2–4K would prove sufficient, being a negative gradient. Detection is easier at night [6].

The fire monitoring is based on the use of two thermal spectral bands situated in the region of 3.9 and 10.8 μm respectively. A contextual analysis is carried out on them through a spatial matrix of NxN pixels, establishing the required statistical parameters, mean value and standard deviation. Once the existence of fire in a pixel is determined, Dozier's method is be applied in order to find out the area that is burning and its temperature [7].

Target Users

- Forest fighting services at national, regional and provincial levels, all over Europe.
- Regional and Departamental/Provincial services in charge of forest fires Crisis

Users Organizations in PREVIEW:

- Junta de Castilla y Leon, Enviromental Council (Spain/Zamora)
- DGRF (Portugal)

Users benefit:

These parameters will inform the regional authorities and to the fire fighter patrols about the destructive power of the fire, in order to estimate in advance the necessary means and effort to extinguish the fire. Also, in case of a good knowledge of the fuel characteristics, it could be possible to determine the flame height and other characteristics of fire.

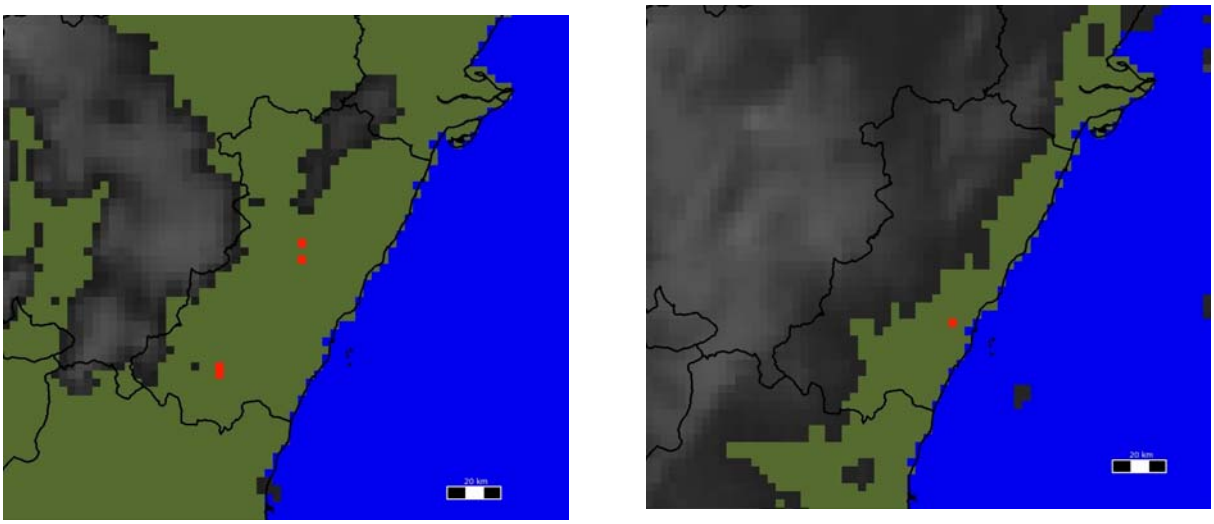

Figure 8: Hot Spot Raster product for Fires occurred in Spain derived from Seviri and including cloud masking

Conclusions

Preview proposes the development of new or enhanced information services for risk management at European scale (use of new sensors such as MSG/SEVIRI and extensive research on others like MERIS, AWIFS in an operational manner)

As a GMES directive, PREVIEW is a user driven project, where users are fully involved in its development. A large user federation has been achieved, where the major end-users are the European Civil Protection authorities, being key actors in the following processes:

- Definition and performance of the services
- Test campaigns and assessments of the services
- European scalability
- Promotion and dissemination

Regarding fires, the set of 3 dedicated services proposed try to provide an integral solution for the fire risk management cycle covering several phases involved: early warning (Fire Detection), crisis (Fire Monitoring and Fire Propagator) and post-crisis (Fire Damage Assessment) which are based on key users requirements.

The services have already been technically validated giving satisfactory results taking into account the limitation of Earth Observation data regarding spatial and temporal resolution and availability. By the moment a functional validation phase is

being carried out with users involvement in order to determine their validity in supporting fires operation and analysis. First results shall be delivered by May 2007.

After that, a second iterative phase will take place taking into account the lessons learnt from users and from technical partners, with a re-engineering, development and validation phase (summer 2007 and 2008), leading to an end of the project by December 2008.

Reference documents

[1] European Comission, Joint Research Center, Forest fires in Europe 2005

[2] Chuvieco, E., Riaño, D., Danson, F. M., Martin, P. (2006). "Use of a radiative transfer model to simulate the post-fire spectral response to burn severity." Journal of Geophysical Research

[3] Arroyo, L.A., Healey, S., Cohen, W., Cocero, D. And Manzanera, J.A., 2005. Using object-oriented classification and high resolution imagery to map fuels types in the Mediterranean region. In DE LA RIVA J., PÉREZ-CABELLO F. and CHUVIECO E. eds. 2005. Proceedings of the 5th International Workshop on Remote Sensing and GIS Applications to Forest Fire Management: Fire Effects Assessment. EARSeL (FF-SIG)-JRC, Zaragoza.

[4] EUFIRELAB, 2005a. Methods for Wildland Fuel Description and Modelling:A State of the Art. http://eufirelab.org/

[5] EUFIRELAB, 2005b. Wildland Fire Danger and Hazards:a State of the Art. http://eufirelab.org/

[6] A. Calle, J. L. Casanova, and A. Romo. Fire detection and monitoring using MSG Spinning Enhanced Visibleand Infrared Imager (SEVIRI), JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 111, G04S06, doi:10.1029/2005JG000116, 2006 data

[7] Dozier, J. (1981), A method for satellite identification of surface temperature fields of subpixel resolution, Rem. Sens. of Env., 11, 221-229

[8] PREVIEW Risk web site: http://www.preview-risk.com