CeaseFire: a website to assist fire managers in Portugal based on information derived from LSA SAF products

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Abstract

Like Mediterranean Europe, Portugal is prone to the occurrence of large and destructive wildfires that have serious impacts at the socio-economic and ecological levels. The fire season of 2017 is a tragic example with about 500 000 hectares of burned area and at least 116 deaths in the fire events.
The LSA SAF operationally disseminates a suite of wild-fire-related products, namely 1) the Fire Detection and Monitoring (FD&M) and the Fire Radiative Power (FRP) products that use information from the SEVIRI instrument on-board Meteosat satellites to provide information on time, location and fire radiative power of active fires over Africa and Europe; and 2) the Fire Risk Map (FRM) product that combines information from FD&M and FRP with vegetation maps and weather data to provide information about meteorological fire danger over Mediterranean Europe. The LSA SAF is also currently developing the Fire Burned Area (FBA) product that uses near infrared (NIR) information from AVHRR on-board Metop satellites to identify burned areas at the global level.
We present a new website designed to provide the fire user community in Portugal with relevant real-time information on fire activity and meteorological fire danger that will allow adopting the adequate measures to mitigate fire damage. The website relies on information provided by the LSA SAF and the aim is to provide users with easy, fast and friendly access to the products as well as to increase the efficiency in fire risk management by making available to the operational community better information about fire events, fire danger, fire damage and fire recovery.
The website is sponsored by The Navigator Company, a leading force in the global pulp and paper market. Since the operational start of the website, on March 2016, the number of registered users has been steadily increasing up to a total of more than 800 users from a wide community that encompasses forest managers, firemen and civil protection officers, personnel from municipalities, academic researchers and private owners.

INTRODUCTION

Mediterranean Europe is regularly affected by large and destructive wildfire events. For instance, during 1980-2015 the five Southern Member States (Portugal, Spain, France, Italy and Greece) were affected by a total of 1 751 067 fires that burned 16 121 036 ha, corresponding to an average of 48 641 fires/year and to a burned area average of 447 807 ha/year (San-Miguel-Ayanz *et al.*, 2017). A fraction of these events are large and destructive wildfires that have serious negative impacts at the social, economic ecologic and environmental levels that include property damage, dead and wounded casualties, landscape degradation and greenhouse gas emissions (Amraoui *et al.*, 2015).

With a total amount of 4 416 981 hectares in 1980-2017 (Figure 1), Portugal ranks as the major contributor to burned area among the five Southern Member States. Like in the Mediterranean basin, fire activity in Portugal results from complex interactions among climate and associated weather extremes, landscape features such as topography and land cover, and human activities including the use of fire in agricultural practices. Weather is not controllable but is predictable at the short and medium

range scales thanks to sophisticated models of the atmospheric circulation. Landscape is controllable at some extent by changing the way vegetation burns or the amount of biomass available, by introducing land management practices and fire prevention policies such as the use of prescribed fire. Human behavior is adaptable either by taking educational actions aiming at changing traditional practices or by imposing repression measures.

The climate of Portugal is characterized by rainy and mild winters followed by warm and dry summers that contribute to making the vegetation prone to the occurrence of large fire events. In turn, the occurrence of summer days with severe weather conditions characterized by high temperature, strong wind and low relative humidity play a decisive role in the ignition and spread of large fire events (DaCamara *et al.*, 2014). This is further aggravated by the increasing occurrence of drought episodes and heatwaves that played a decisive role in the extreme years of 2003, 2005 and 2017 (Figure 1).

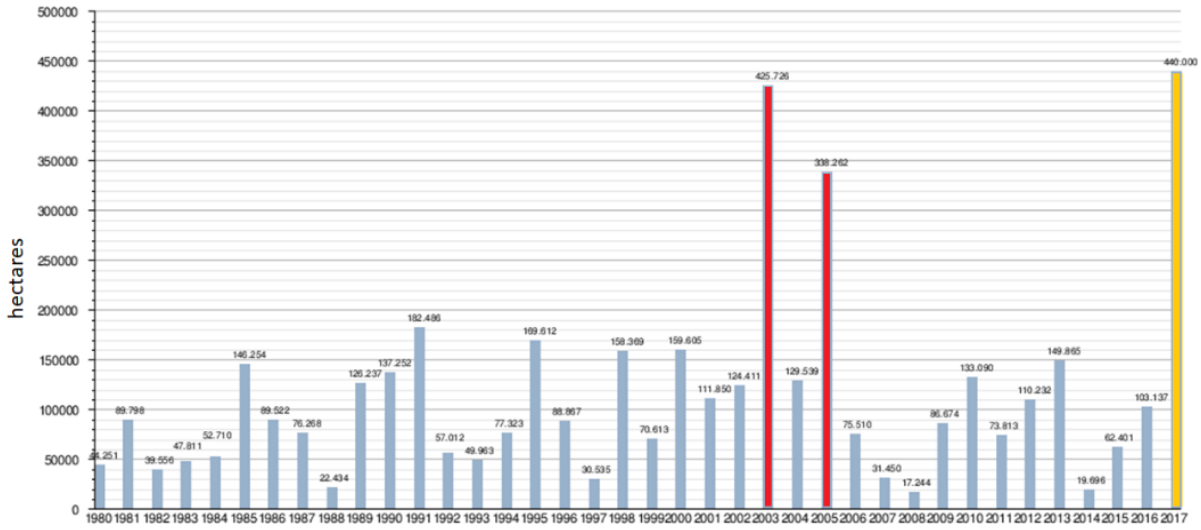

Figure 1: **Annual burned area (ha) in Portugal during the period 1980-2017 (source: ICNF, the Portuguese authority for forests).**

The occurrence of extreme fire episodes is steered by an increasing fuel availability that is mainly due to the depopulation of rural areas and associated conversion of agricultural fields into forest plantations, shrublands or woodlands (Pausas and Vallejo 1999). Inappropriate management practices also play a crucial role, in particular the inadequate used of fire that accounts for 95% of fire ignitions in the Mediterranean region (San-Miguel-Ayanz *et al.*, 2013).

Fire prevention policies require adequate and timely information about wildfire potential assessment to be used on an operational and tactical basis in decision support systems. There is therefore a growing need for the operational availability of a suite of products related to fire danger and specifically tailored to the needs of the fire community that will allow decision makers adopting the adequate measures to mitigate fire damage. We present **CeaseFire**, a new website designed to provide the user community in Portugal with relevant real-time information on fire activity and meteorological fire danger.

WEBSITE STRUCTURE

The **CeaseFire** website relies on information provided by the EUMETSAT Satellite Application Facility on Land Surface Analysis that operationally disseminates a suite of products related to fire activity and meteorological fire danger (Trigo *et al.*, 2011).

As shown in Figure 1, the **CeaseFire** webpage (http://idlcc.fc.ul.pt/ceasefire/index.php) is organized into four main areas, namely a User Area, a Danger Area, a Data Download Area and a Prescribed Fire Area.

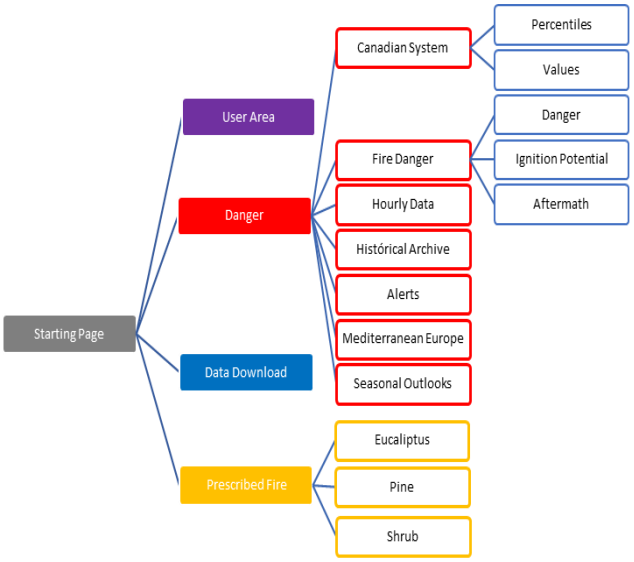

***Figure 2: The* structure of the CeaseFire website (**http://idlcc.fc.ul.pt/ceasefire/index.php**).**

User Area

The User Area is the place where the user can customize the products to its specific needs, e.g. by asking for pop-up alerts when an active fire is close to a property.

Danger Area

The Danger Area is the core of the platform. Information about meteorological danger of fire is available either in numeric form or displayed in maps. Information about active fires is also available in near real time from the LSA SAF Fire Detection and Monitoring (FD&M) and Fire Radiative Power (FRP) products (Amraoui *et al.*, 2010; Wooster *et al.*, 2015) and from the database of the Portuguese Civil Protection Authority (ANPC). Relying on information derived every 15 minutes from the SEVIRI instrument on-board Meteosat satellites, the LSA SAF FD&M and FRP products provide information about time, location and fire radiative power of active fires over Africa and Europe. Information about active fires may be added by the user to the maps of fire danger.

The Danger Area contains the following seven sections: the Canadian System section, the Fire Danger section, the Hourly Data section, the Alerts section, the Seasonal Outlook section, the Historical Archive section and the Mediterranean Europe section.

The Canadian System section provides maps of all components of the Canadian Forest Fire Weather Index (FWI) System (Stocks *et al.*, 1989) that is especially suitable as a fire rating system for Mediterranean Europe (DaCamara *et al.*, 2014). The six components of the FWI System (Figure 3), namely FFMC, DMC, DC, ISI, BUI and FWI, as well as the FWI-derived Daily Severity Rating (DSR) and Seasonal Severity Rating (SSR) are computed using 2m temperature and relative humidity, 10 m wind and daily precipitation as obtained (via the LSA SAF) from forecasts provided by the European Centre for Medium-Range Weather Forecasts (ECMWF). Maps (Figure 4, top panels) are provided either with values of the indices or with contours over a colored background showing the respective spatial distribution of percentiles as obtained from past records (1979-2017).

The Fire Danger section provides maps of five classes of fire danger (low, moderate, high, very high and extreme) as obtained from the LSA SAF Fire Risk Map (FRM) product. The classes of fire danger (Figure 4, bottom panels) are obtained from a statistical model that combines historical information from the FD&M and FRP products with vegetation maps and current meteorological conditions to provide information about meteorological fire danger (DaCamara *et al.*, 2014; Pinto *et al.*, 2018a). Maps are also available with information about the potential ignition and aftermath that were empirically derived from systematic analyses of past fire events (Fernandes *et al.*, 2018).

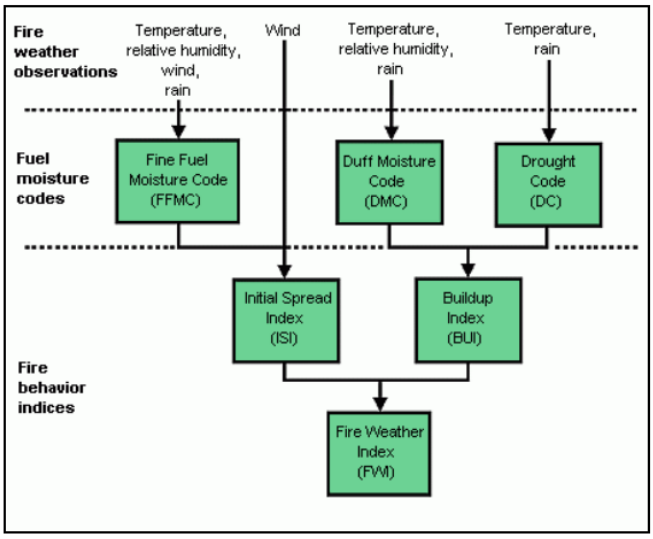

***Figure 3: The* structure of the FWI system (source: http://cwfis.cfs.nrcan.gc.ca/background/summary/fwi).**

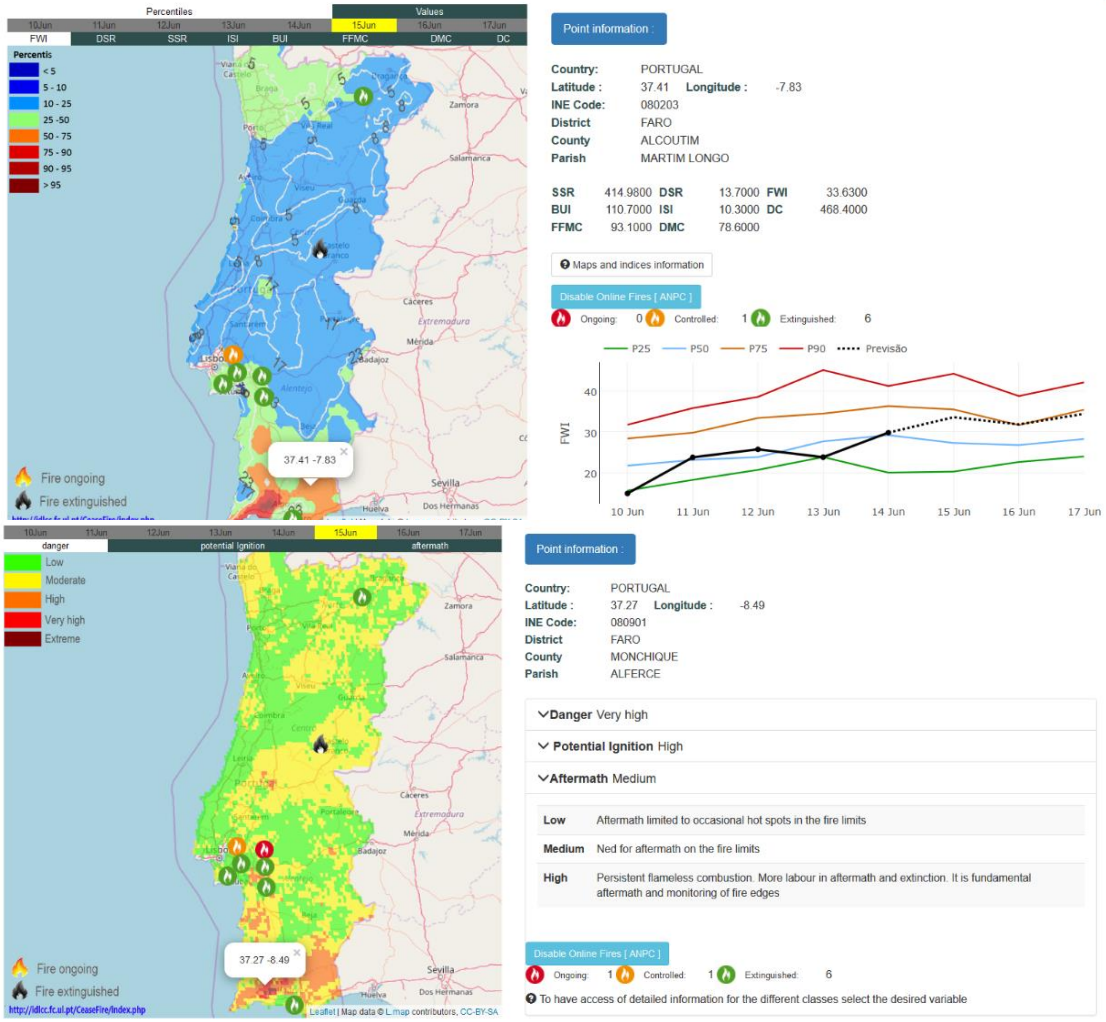

***Figure 4:* An example for 15 June 2018 of the contents of the Canadian System (top panels) and Fire Danger (bottom panels) sections of the Danger Area. Left panels: maps with contours of FWI over the climatological background (top panel) and of classes of fire danger (bottom panel). Right panels: information at a chosen location about fire danger (top panel) and about class of fire danger, potential ignition and aftermath (bottom panel). Active fires from LSA SAF products (flames) and ANPC (flames inside circles) are also displayed in the maps.**

The Hourly Data section provides static and animated maps of hourly forecasts of meteorological parameters as obtained from the WRF mesoscale model (Skamarock *et al.*, 2008). Hourly forecasts of FWI are also provided using the meteorological conditions of each hour for the FWI system components with no memory and a linear combination of the conditions from the two previous days for the components that change slower in time (Pinto *et al.*, 2018b). The result (Figure 5) is an hourly FWI that presents a smooth transition between days and keeps the hourly FWI at 12h UTC identical to the standard daily FWI.

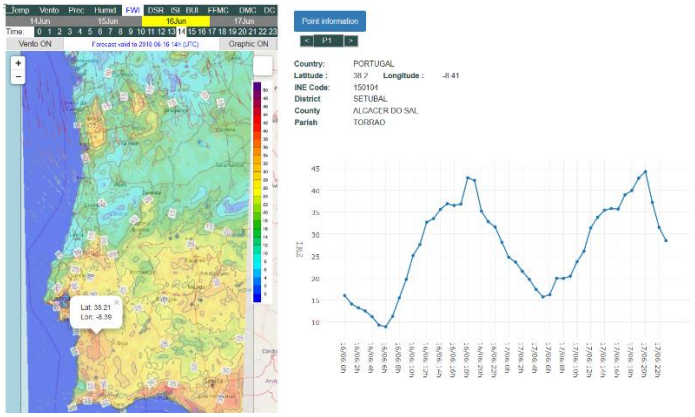

Figure 5: **An example for 16 June 2018 of the contents of the Hourly Data section of the Danger Area. Hourly forecasts of FWI (left panel) and respective daily cycles at a chosen location (right panel).**

The Alerts section provides four levels of alerts at the municipality level (*concelho*) which were defined according to the specific requirements of The Navigator Company, the sponsor of the website. The user can also define the area of interest, the ranges of meteorological variables, indices and classes, and the number of levels and their meaning.

The Seasonal Outlook section provides indications of likelihood of the severity (in terms of expected total burned area) of the fire season, defined as the months of July and August, for seven different regions of Portugal (Figure 6, left panel). This information is derived from a statistical model based on long-term indicators of fire activity (Nunes *et al.*, 2014). Seasonal outlooks of severity of the fire season (Figure 6, right panel) are computed starting on April 1 of each year and updated on a daily basis.

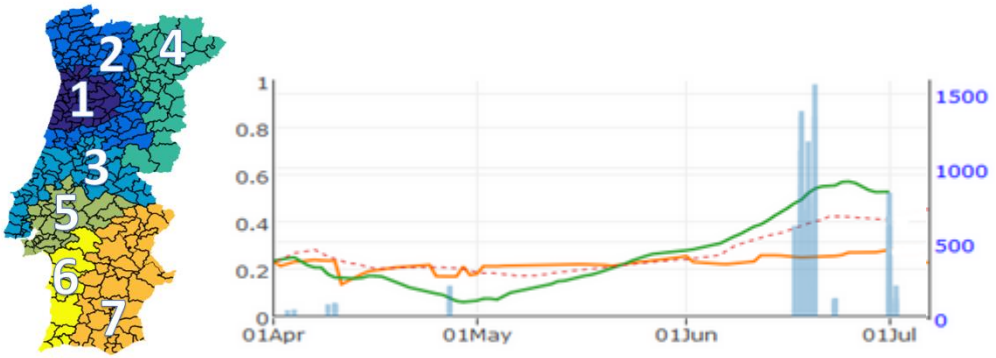

Figure 6: **An example for 2017 of the contents of the Seasonal Outlook section of the Danger Area for region 3 (as shown in the left panel). Time series (right panel) for 2017 (green line), for the severe year of 2005 (red dotted line) and reference threshold (orange line) and daily energy (in GJ) released by active fires detected from MSG (blue columns).**

The Historical Archive section contains daily maps of all indices of fire danger for Portugal since July 15, 2015.

Finally, the Mediterranean Europe section provides regional maps of forecasts of meteorological fire danger (Figure 7) for the current day and the next two days as derived from the LSA SAF fire products.

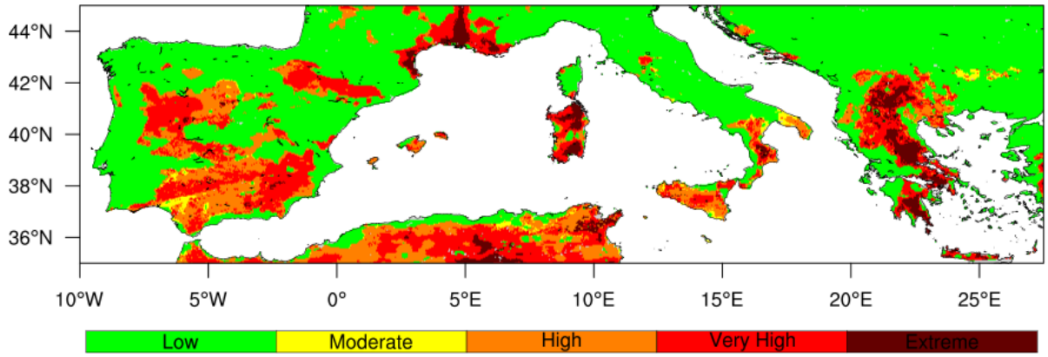

Figure 7: **An example for 23 July 2018 of the contents of the Mediterranean Europe section of the Danger Area. Map with five classes of fire danger for a day when a deadly fire struck Greece.**

Prescribed Fire Area

The Prescribed Fires Area contains information about underburning planning for areas of eucalyptus, pine and shrub using generic prescriptions based on indices from the FWI System (Fernandes, 2018).

Data Download Area

The Data Download Area is where authorized users select stored information in the site to be retrieved.

PRODUCTS IN DEVELOPMENT

Burned Area Mapping

Maps of burned areas are currently being tested using information from the LSA SAF Burned Area (FBA) product that uses near infrared (NIR) information from the AVHRR instrument on-board Metop satellites to identify burned areas at the global level. Using a 30-day sliding windows the second lowest value of NIR is computed at each pixel as well as the NIR difference between the second lowest values of NIR during the last and the first 15 days. VIIRS and MODIS hotspots are then used to select candidate pixels and the respective values of NIR post-fire and NIR differences are retrieved for each pixel. A One-Class Support Vector Model (Pereira *et al.*, 2017) is then trained to find approximately 70% of the filtered candidates and pixels inside the decision boundary (Figure 8, left panel) are assumed to be pixels with high probability of being burned. These pixels are then used as seed points in a contextual aggregation algorithm (Libonati *et al.*, 2015). A comparison of results obtained with the MODIS (MCD64A1) operational product is shown in Figure 8 (central and right panels).

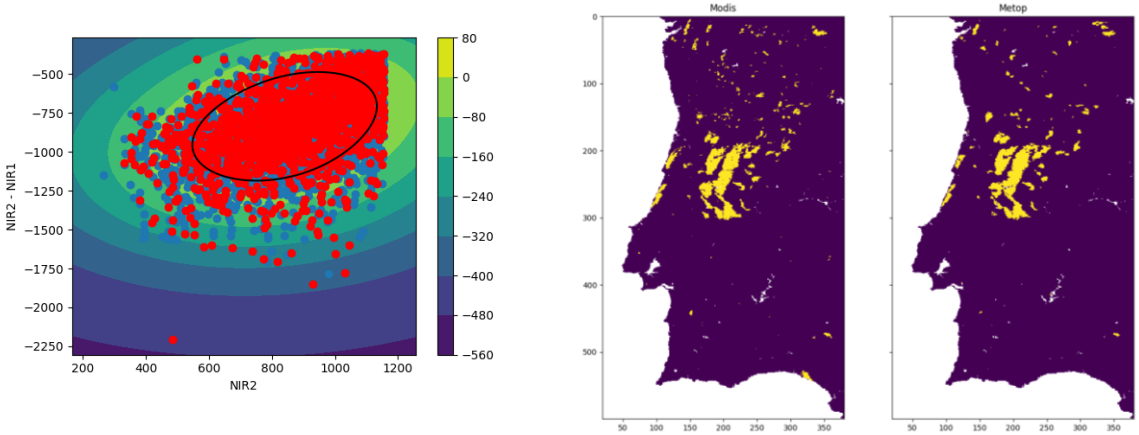

Figure 8: **An example of application of the burned area mapping procedure for August 2017. Candidate pixels (red and blue dots) and decision boundary (solid line) by the SVM (left panel) and burned areas from the MODIS (MCD64A1) product (left) and from the developed algorithm using NIR as obtained from AVHRR on-board Metop (right panel).**

Vegetation Recovery

Mapped burned areas are being used to characterize post-fire vegetation behavior as derived from recovery rates estimated by fitting a mono-parametric model of vegetation recovery to NDVI data over each burned scar (Gouveia *et al.*, 2018).

Mobile Application

A mobile application (APP) for Android has been released to restricted users with the aim of efficiently providing information to assist in making decisions on fire management and combat. Information released includes daily alerts, maps of FWI components, classes of fire danger, ignition potential and aftermath for the day and the two following days and maps of hourly FWI, as well as location of active fires in near real-time provided by ANPC and from the LSA SAF FD&M and FRP products (Figure 9).

Figure 9: **Screenshots of the developed APP: login area (left panel), active fires (central panel) and classes of fire danger (right panel).**

CONCLUDING REMARKS

CeaseFire is a new website that was designed to provide the user community in Portugal with relevant real-time information on fire activity and meteorological fire danger. The website relies on information provided by the LSA SAF and the aim is twofold; 1) to provide users with easy, fast and friendly access to the products and 2) to increase the efficiency in fire risk management by making available to the operational community better information about fire events, fire danger, fire damage and fire recovery.

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ACNOWLEDGEMENTS

Main research is in the framework of EUMETSAT Satellite Application Facility for Land Surface Analysis (LSA SAF) Project. Part of research is supported by the Brazilian Fire-Land-Atmosphere System (BrFLAS) Project financed by the Portuguese and Brazilian science foundations, FCT and FAPESP (project references FAPESP/1389/2014 and 2014/20042-2). The CeaseFire website is sponsored by The Navigator Company. Research by Miguel M. Pinto was supported by the Portuguese Science Foundation (FCT) through PhD grant PD/BD/142779/2018. Research by Sílvia A. Nunes was supported by a grant in the framework of Project “Fire Early Warning System in Mozambique” (World Bank Group Contract 7184114). Research by Renata Libonati was funded by Serrapilheira Institute (grant number Serra-1708-15159) and supported by Centro de Estudos Florestais (CEF) of the University of Lisbon, a research unit funded by FCT (UID/AGR/00239/2013).

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