Assessment of the relationship between pre-fire fuel estimates and Fire Radiative Power in Portugal

Catarina Alonso[1], Célia M. Gouveia[1,2] and Patrícia Páscoa[1]

[1] Instituto Português do Mar e da Atmosfera (IPMA), Lisbon - Portugal
[2] Instituto Dom Luíz (IDL), Universidade de Lisboa, Lisbon – Portugal

1. Motivation

Forest fires are recurrent in Portugal, either due to climate conditions, to land use change, or to a combination of both. Wet and mild winters, together with dry and warm summers, favor the growth of vegetation and its subsequent low moisture content, increasing fuel availability. The exceptionality of the fire episodes of 2017 and 2018 , that were named as megafires, highlighted the need for a deep analysis of the main actors of fire risk over Portugal. The assessment and management of fuel loads is essential to understand and minimize fire risk. The structural risk depends on the type of available fuel and on the age of vegetation. Therefore, reducing fuel loads is often required to mitigate fire severity.

2. Data and Methods

- **Meteosat FRP-PIXEL** product is delivered in near real-time by the EUMETSAT Land Surface Analysis Satellite Applications Facility (LSA SAF), since 2004 with 15-min temporal resolution. FRP-PIXEL is disseminated for the full spatio-temporal resolution of SEVIRI (Spinning Enhanced Visible and Infrared Imager) imager onboard Meteosat with 3 km spatial sampling distance at at sub-satellite point (decreasing away from the west African sub-satellite point)[1].
- **Dry Matter Productivity (DMP)**, disseminated by Copernicus Global Land Service (CGLS) since 1999 at 1km spatial resolution and temporal resolution of 10-days (hereafter called decades) [2]. DMP represents the overall growth rate or dry biomass increase of the vegetation , expressed in kg/ha/day and is directly related to ecosystem Net Primary Productivity (NPP).

Active fire observations of fire radiative power (FRP) have been shown to be correlated to rates of biomass combustion. Since the FRP-PIXEL product has a 15-min temporal resolution, this allowed to calculate the beginning, end and duration of the fire event (**Figure 1**).

FRE (Fire Radiative Energy) is defined as the emitted radiant energy released during biomass combustion episodes and is computed using the accumulated FRP for the duration of the fire event (**Figure 2**).

3. Results

15th October 2017

On October 15th of 2017 there were several fire events that broke out in mainland Portugal **(Figure 1)**. The fire events were spread over the Northern Portugal. October 15th of 2017 was marked by strong and persistent southerly winds caused by the close passage of hurricane Ophelia moving northward. The very strong winds associated with Ophelia and the dry vegetation due to the extreme and prolonged drought situation were the main ingredients for the tragic events of October 15th [3].

The fire events occurred between 11h-21h, most of them had duration between 1h-3h, but there were some regions where the duration of fire events was longer than 8h leading to high FRE values over the burned areas **(Figure 2).**

However, it must be stressed that the high clouds and smoke associated with fire events may limit the detection of hot spots and therefore the FRP and the FRE retrieved by satellite.

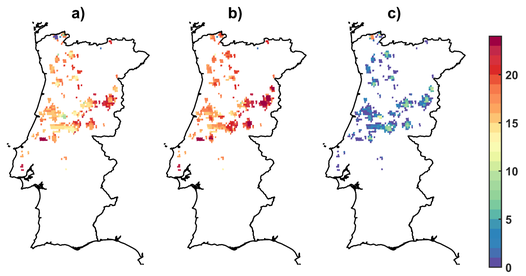

*Figure 1. a) Beginning, b) ending and c) duration, in hours, of the fire event in **15th of October 2017** over mainland Portugal, derived from fire Radiative Power (FRP) obtained through the SEVIRI-MSG instrument.*

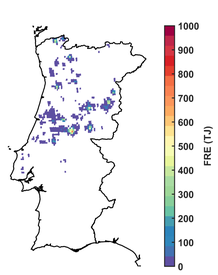

*Figure 2. Daily Fire Radiative Energy (FRE) in **15th of October 2017**.*

4. Results

The year of 2017

The 2017 fire season in Portugal was marked by two tragic events leading to a toll of 116 fatalities with a record total burned area and serious impacts at social, economic, and ecological levels. The first of the two events started on June 17th (**Figure 3**) and the second on October 15th (**Figure 1 and 2**). During the enlarged fire season of 2017, starting in June and ending in October, a record total burned area of about 500 000 hectares was achieved.

The largest fires in central Portugal started on June 17th, a day characterized by anomalous high temperatures and low relative humidity, associated to very unstable atmospheric conditions that favored the formation of convective cells and thunderstorms [3]. These fires took place for a few consecutive days, some regions namely on June 20th was burning from the previous day until the next day, with a total fire event duration greater than 24h (**Figure 3a**).

Both events, June and October, are evident on the daily averaged duration of fire event obtained for 2017, using FRP from LSA-SAF (time resolution of 15 min). The average duration for these two periods are between 5 and 10 hours/day. The summer months (July, August and September) also present several days with fire events longer than 5 hours/day. A second period of low duration fires is observed in April 2017 (Figure 5b). Figure 5a show the area in which FRE values are greater than 1PJ between June 20th and 30th (**Figure 4a**).

Figure 4b) shows the accumulated Dry Matter Productivity (DMP) recorded in the end of June 2017.

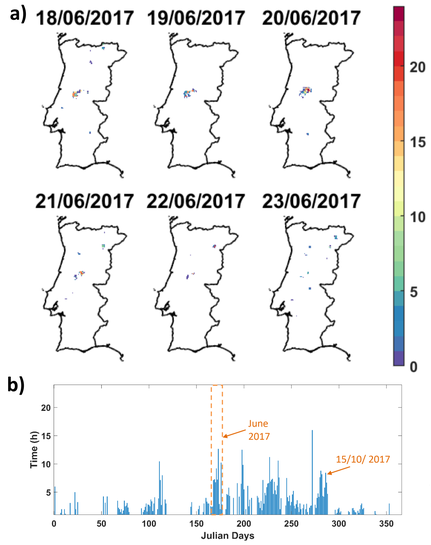

Figure 3. a) Duration in hours of the fire event in June 2017 and b) duration in hours of fire events in 2017.

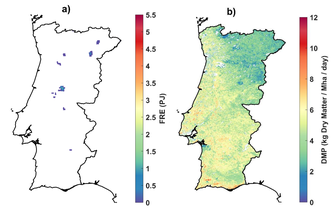

Figure 4. a) FRE values accumulated between June 21th and 30th of 2017 and b) DMP values accumulated in 2017 until June 30th .

5. Results

The year of 2018

In 2018 another tragic fire event hit mainland Portugal, the so-called Monchique fire, with a result in about 27 000 hectares of burned area, 41 people injured and millions of euros in economic losses. The fire occurred within a context of very high temperatures and intense and highly variable winds in terrain with difficult access and high accumulation of biomass. [4]

The fire of Monchique started on August 3rd about noon and was not fully dominated until August 9th. During the active fire days, several regions were constantly burning (consecutive fire duration over 24 hours), with the most severe situation being on August 6th (**Figure 5a**). Compared to other fire events in the year 2018, this event reached very high durations with daily fire duration above 15h (**Figure 5b**). These high duration values meant that the FRE reached high values, above 5 PJ between 1 and 10 August (**Figure 5a**). High accumulated biomass is verified through the high values of DMP in region of Monchique (**Figure 6b)**.

The comparison of the three mentioned events show the higher/lower (and negative) anomalous values of accumulated biomass were recorded in the case of June 2017/August 2018 fire episode. On the other hand the higher values of FRE were observed for October 2017 fire event (**Figure 7**).

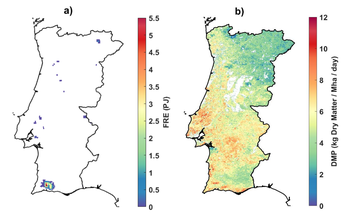

Figure 6. As in Figure 4, but respecting the August 2018 Monchique Fire.

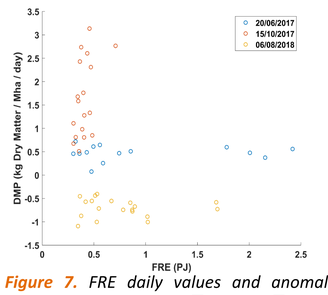

Figure 7. FRE daily values and anomaly of accumulated DMP, i.e. $(\sum DMP - \sum DMP_{clim})$ until the decade before the day of FRP value.

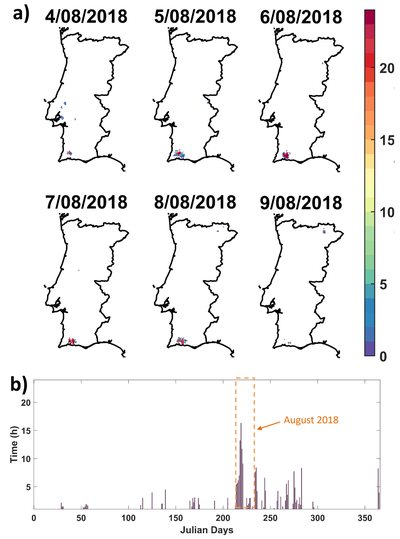

Figure 5. As in Figure 3, but respecting the fire events in 2018.

6. Conclusions

Using Meteosat FRP-PIXEL is an asset, since it gives information from 15 to 15 minutes, compared to other products that only give the daily value. FRP-PIXEL allow to define the begin, the ending and the duration together with the computation of the total energy released on the fire episode.

Reviewing the three different fire events (**Figure 7**), it can be concluded that:

- In June 20th of 2017 due to high fire duration, the FRE in these day as high values too, furthermore when the accumulated DMP anomaly values are positive.
- In October 15th of 2017, in spite of high accumulated DMP anomaly values , the duration of the fire events was not high enough to occur events with FRE as high as in the two other events.
- In August 6th of 2018, despite highly FRE values and the high accumulative DMP values (**Figure 6b**), accumulated DMP anomaly values are negative.

REFERENCES
[1] Wooster et al.,2015, LSA SAF Meteosat FRP products-Part 1: Algorithms, product contents, and analysis. Atmospheric Chemistry and Physics, 15(22), 13217-13239.
[2] Lacaze et al., 2015, Operational 333m Biophysical Products of the Copernicus Global Land Service for agriculture monitorng . Inter. Arc. Photo., Rem.Sen. Spa.Inf. Sci, XL-7/W3.
[3] Pinto, Miguel M et al., 2018, The extreme weather conditions behind the destructive fires of June and October 2017 in Portugal, presented at Coimbra
[4] DaCamara, C. C et al., 2019, Near-and-Middle-Infrared Monitoring of Burned Areas from Space. In Satellite Information Classification and Interpretation, IntechOpen.

Acknowledgements: *This study was performed within the framework of the LSA-SAF, co-funded by EUMETSAT This work was partially supported by national funds through FCT (Fundação para a Ciência e a Tecnologia, Portugal) under projects FIRECAST (PCIF/GRF/0204/2017) and IMPECAF (PTDC/CTA-CLI/28902/2017).*