The EUMETSAT Satellite Application Facility on Land Surface Analysis (LSA SAF)

Validation Report

Fire Risk Map (FRM)

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DOCUMENTATION CHANGE RECORD

Issue / Revision	Date	Description:
Version I/2010	08/03/2010	Version to be presented to ORR
Version I/2010v1	09/04/2010	(i) Changes in the front page; (ii) Extension of the validation to Italy and Greece (Tables 2, 3, 7 to 12 and 16 to 21; Figures 8, 15 to 26 and 29, 30); (iii) Introduction of a section with conclusions
Version II/2011	14/05/2011	Change following the ORR meeting of April 2010: - The product name was changed throughout the document to "Fire Risk Map" with “FRM” as acronym

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1. Introduction

Remote sensing has significantly contributed to the improvement of fire risk management, because radiative signatures of vegetation may be used as pre-fire indicators (e.g. by identifying signals of vegetation stress), which merged with meteorological parameters may lead to the formulation of more accurate fire risk indices. In this respect, SEVIRI has been identified as having an especially good potential (Pereira and Govaerts, 2001).

Meteorological conditions play in fact a crucial role in the setting and spreading of wildfire and are an important factor in the resulting fire severity (Bovio and Camia, 1997). For instance, meteorological variables have been widely used to develop fire risk indices, namely the so-called Canadian Forest Fire Weather Index System (CFFWIS) (van Wagner, 1987).

The Fire Risk Map (FRM) algorithm, developed within the framework of the LSA SAF, makes an integrated use of 1) information from meteorological forecasts, 2) vegetation data from land cover maps and 3) observations of active fires and fire pixels as obtained from the Fire Detection and Monitoring (FD&M) product of the LSA SAF, in order to produce coherent maps of fire risk for Europe.

This document presents the first validation results obtained for the FRM product. Validation will be performed at two levels. First, estimated values of the Daily Severity Rating (DSR) index for Portugal, as derived from the Fire Weather Index (FWI), are compared with the corresponding values published by the Portuguese National Forest Authority (AFN). Second, a set of five classes of fire danger are derived based on values of observed FWI and active fires for the fire seasons (July-August) from 2007 to 2009 over the Iberian Peninsula; conditional probabilities of fire activity (given the class of fire danger) are then computed to assess the quality of the proposed fire rating system.

Examples of fire risk maps will be finally presented and visually compared to maps provided by JRC, in the framework of the European Forest Fire Information System (EFFIS).

2. The FRM product

The FRM product relies on the Canadian Forest Fire Danger Rating System (CFFDRS) (Stocks et al., 1989), namely in FWI.

FWI system consists of six numerical sub-indices that are relative indicators of potential fire behaviour in common boreal fuel type (Stocks et al., 1989; Alexander and Lanoville, 1989; Forestry Canada Fire Danger Group, 1992). These sub-indices are divided in two groups i) fuel moisture codes: Fine Fuel Moisture Code (FFMC), Duff

Moisture Code (DMC) and Drought Code (DC) and ii) fire behaviour indices: Initial Spread Index (ISI), Build-Up Index (BUI) and Fire Weather Index (FWI).

The FRM product computes all these indices plus the DSR and provides maps of fire risk based on past recorded values of FWI and active fires. A detailed description may be found in the ATBD for the FRM product (see Doc:SAF/LAND/IM/ ATBD_RFM/2.0.DOC)

The main advantage of FRM is that it relies on ECMWF forecasts rather than in making use of ground stations, which allows much broader and accurate meteorological information in Europe. Also, the use of active fires as obtained from FD&M allows having daily records of active fires that are essential to determine classes of fire danger.

It is worth noting that SEVIRI, despite its coarser spatial resolution when compared to MODIS, has a fine temporal resolution of 15 minutes and a 3.9 μm sensor that is very sensitive to fires, even to sub-pixel ones.

3. Validation Data

Data used to validate results were of two different kinds; 1) *in situ* observations and 2) remote sensed observations from SEVIRI.

Validation using *in situ* observations was restricted to the Iberian Peninsula because of the privileged access of the developers to fire data in Portugal and of their past experience on fires over Iberia. However the validation using remote sensed observations was extended to Italy and Greece that, together with the Iberian Peninsula, are within the most prone regions to burn in Southern Europe.

3.1. Ground data

Ground data were derived from the official dataset provided by the AFN. Relying on *in situ* information collected by the National Firemen Service, the AFN data base for Continental Portugal, covers the period from 2002-2007 for the official fire season, *i.e.*, between the 15th of May and the 15th of October. The database consists of more than 500 000 records of fire events and provides detailed information about i) location, namely district (distrito), county (concelho) and parish (freguesia), ii) duration, namely date and time of ignition and extinction, iii) extent of burnt vegetation, namely area of forests, shrublands and agricultural crops and iv) land ownership status of the affected area, namely public or private.

3.2. Remote-sensed data

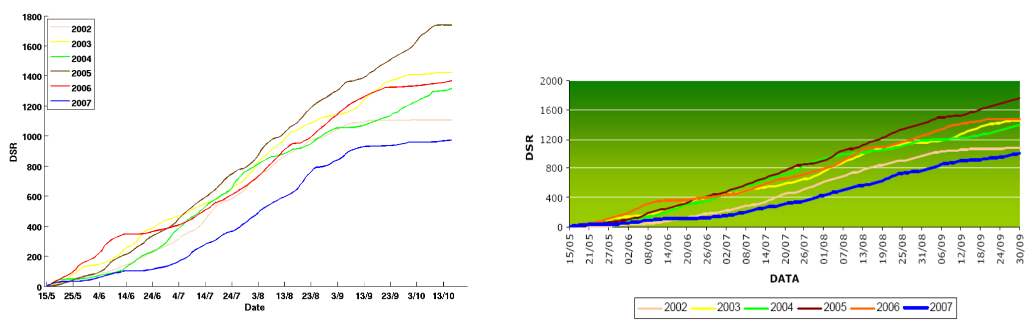
Active fire data were obtained from the FD&M product, covering the period 2007 to 2009 for the months of July and August. The FD&M product relies on FiDAlgo (Fire

Detection Algorithm), an operational procedure that allows active fire detection in near real time, based on information from Meteosat-8/SEVIRI. FiDAlgo is based on contextual algorithms that have been successfully developed for different sensors, namely NOAA-AVHRR and MODIS (see Doc: SAF/LAND/IM/ATBD_FD&M).

4. Validation Results

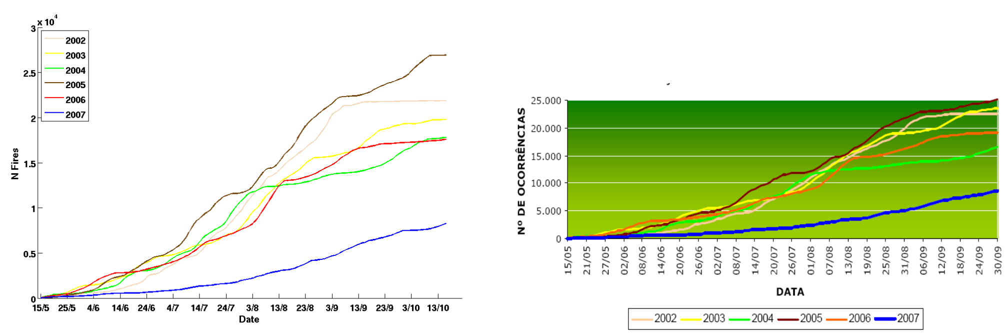
4.1. Meteorological indices of fire risk

Validation of meteorological fire indices was performed over Portugal by comparing DSR values as obtained from the FRM algorithm with the official data supplied by the National Forest Authority (AFN, 2007). Performed comparison comprised the daily cumulated DSR, the number of fire occurrences and the burnt area (Figures 1, 2 and 3, respectively).



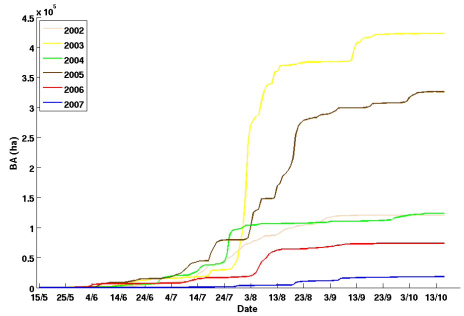
(a) (b)

Figure 1 Time series of daily cumulated DSR in Portugal for the fire season, as obtained from (a) the FRM algorithm and from (b) AFN (2007).

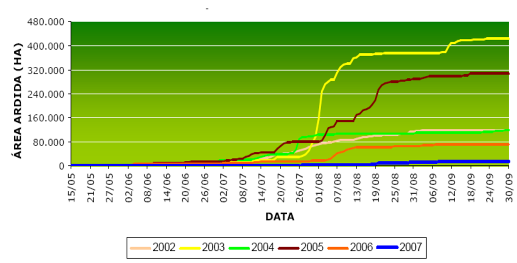


(a) (b)

Figure 2 As in Figure 1, but respecting to the number of fire occurrences.



(a)



(b)

Figure 3 As in Figure 1, but respecting to values of burnt area.

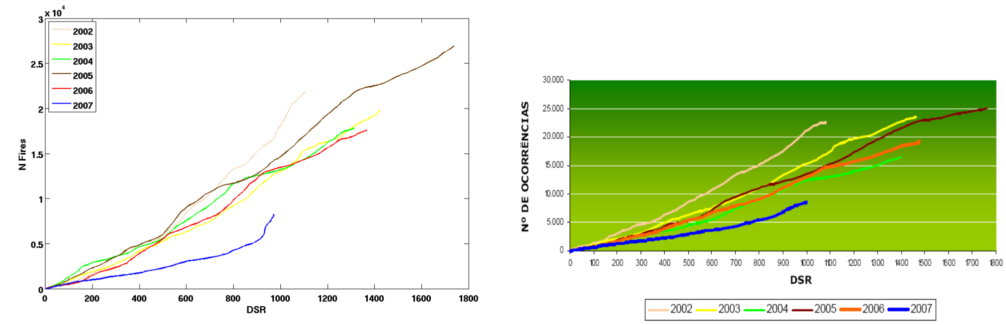
The overall agreement between DSR values from the FRM product and the official data (AFN, 2007) is well apparent in all figures and this may be further confirmed by looking at the high levels of correlation between the two time series, of the order of 0.9 (Table 1).

Table 1 Correlation of DSR as obtained by FRM and AFN for the fire season periods from 2002 to 2007, in continental Portugal.

Year	Correlation
2002	0.93
2003	0.94
2004	0.92
2005	0.94
2006	0.94
2007	0.93

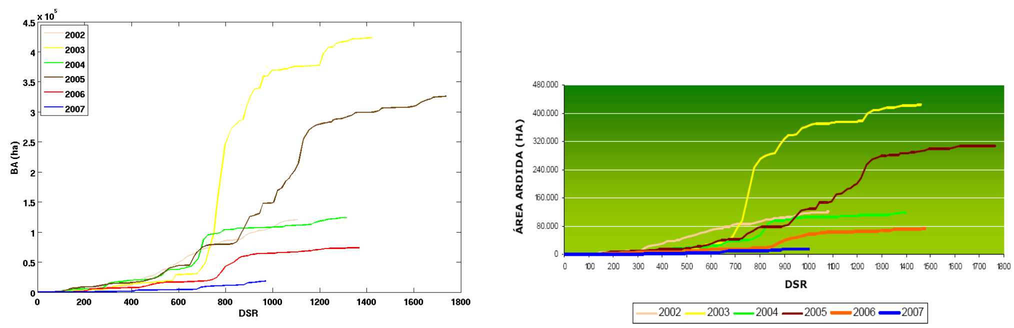
It may be noted that time series from both sources (i.e. FRM and AFN) show that, in general, cumulated DSR and number of fire occurrences present similar trends, but the same is not true in the case of burnt area. In fact, 2003 was, by far, the year presenting the most outstanding value of burnt area, but it was not the worst year in what respects to the value of DSR. This clearly suggests further investigating the role of other factors, namely those related to previous spring meteorological conditions that may affect the thermal and water stress of vegetation making it more or less prone to the onset of wildfires.

Figures 4 and 5 present the relation between cumulated DSR and number of fire occurrences and burnt area, respectively. Again it appears that there is a better relation between number of fires and DSR than with burnt area and DSR. Nevertheless, the very good agreement between the FRM products and AFN data is again worth being pointed out.



(a) (b)

Figure 4 Scatter plot of daily cumulated DSR vs. cumulated number of fire occurrences for the fire season in Continental Portugal, for the period 2002-2007, as obtained from (a) the FRM algorithm and from (b) AFN (2007).



(a) (b)

Figure 5 As in Figure 4, but respecting to values of burnt area.

Daily time series of number of fire events and of DSR, for the years 2003, 2005 and 2007 are presented in Figure 6. In general, the number of fires tends to follow the meteorological conditions, i.e., higher values of DSR are associated to higher values of fire occurrences.

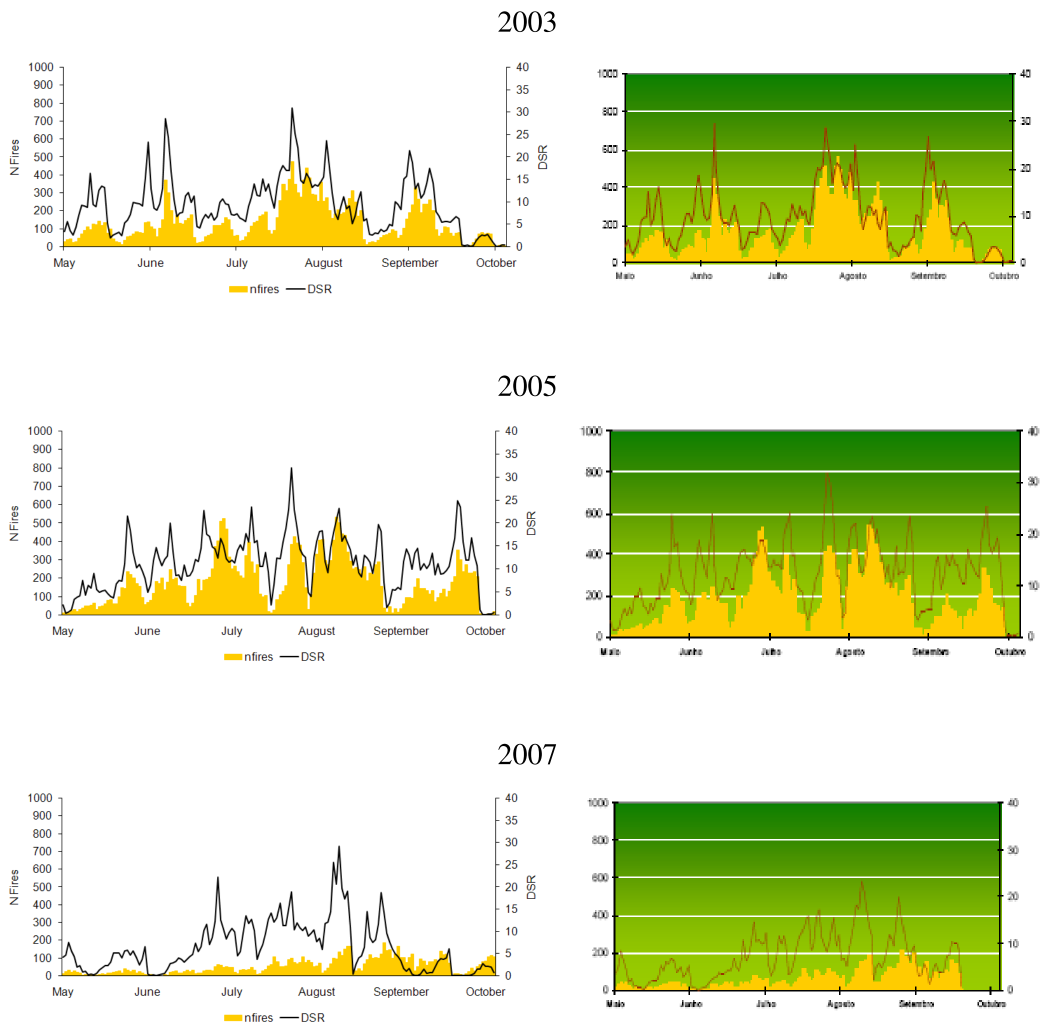


Figure 6 Time series of number of fire occurrences (yellow bars) and of DSR (lines), for the years 2003, 2005 and 2007 as obtained with the FRM algorithm (left column) and from AFN (right column).

Figure 7, presents daily time series of burnt area and of DSR, for the years 2003, 2005 and 2007. It is worth noting that high values of burnt area generally correspond to high values of DSR, but the opposite may not be true. Note that for purposes of visualization, the burnt area scale for 2007 is ten times smaller than the ones for 2003 and 2005. Again for purposes of visualization, a maximum limit of 20 000 ha, was imposed for burnt area in 2003 and 2005.

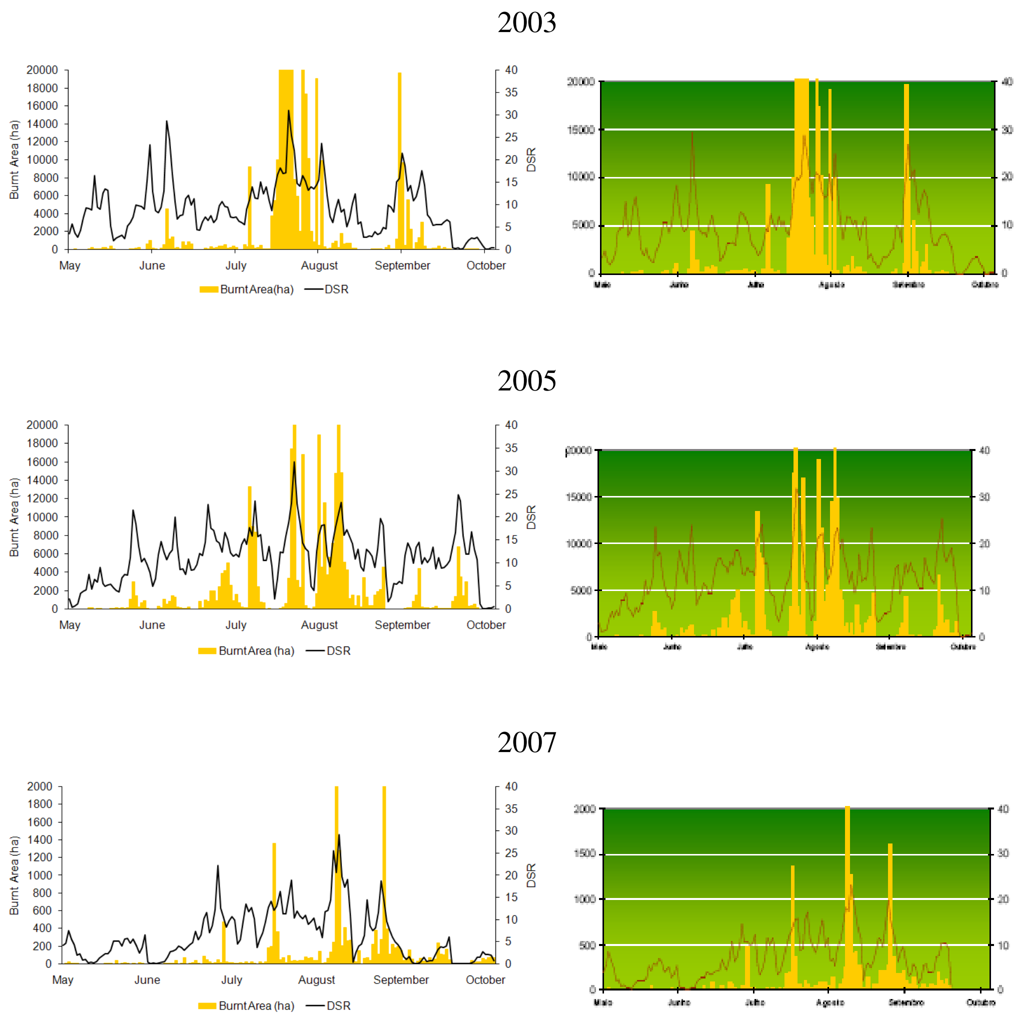


Figure 7 As in Figure 6, but respecting to burnt area and DSR.

4.2. Classes of fire danger

Results obtained in the previous section strongly suggest investigating the probability of occurrence of fire events with different levels of severity for different vegetation types, paying special attention to the dependence of probability of occurrence on meteorological conditions.

Figure 8 presents the spatial distribution of the three considered types of vegetation cover, namely forest, shrub and cultivated areas for three different Mediterranean regions, namely Iberian Peninsula (top panel), Italy (middle panel) and Greece (bottom panel). The classification of pixels as belonging to one of the three types was performed based on the Global Land Cover (GLC) 2000.

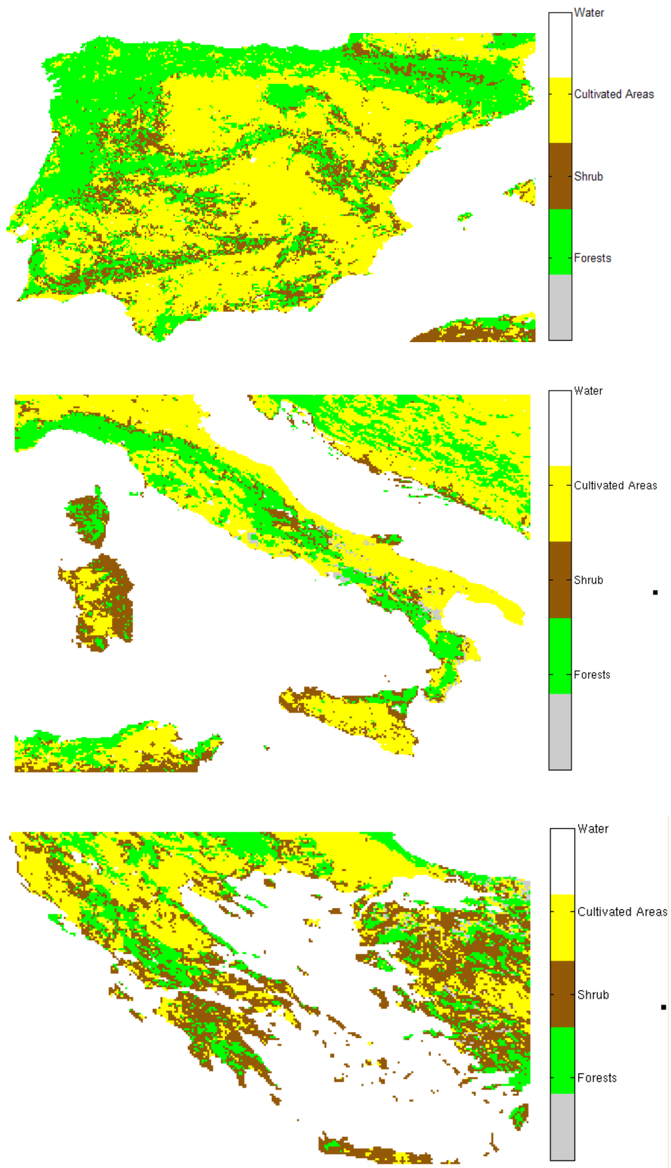


Figure 8 The three main vegetation types over the Iberian Peninsula (top panel), Italy (middle panel) and Greece (bottom panel) as obtained from GLC2000.

As shown in Table 2 (a), cultivated areas correspond to 51% of the pixels covering the Iberian Peninsula but the percentage of recorded fire pixels during the validation period of July-August 2007-2009 reduces to 27%. The largest percentage of fire pixels (52%) occur in forest pixels that cover 35% of the Iberian Peninsula and the shrubland type that reduces to 14% of the surface, is associated to 21% of fire pixels. In Italy (Table 2b) cultivated areas are also the predominant type of vegetation (65%) and, just like it was observed in Iberian Peninsula, only 35% of fire pixels were registered during the validation period. On the other hand, shrubland type only covers 2% of the surface, but is associated to 28% of the fire pixels. Forests occupy 33% of the surface and are associated to 36% of fire pixels. Finally, as shown in Table 2 (c), Greece is mainly covered by shrubland and cultivated areas (39% and 38%, respectively), but while in shrubland type occurs 56% of fire pixels, in cultivated areas only 20% of fire pixels were recorded. In forests, that cover 23% of the surface, 24% of fire pixels were observed.

Table 2 Total number of pixels and number of fire pixels (during July-August 2007-2009) and respective percentages for the three considered types of vegetation, for (a) Iberian Peninsula, (b) Italy and (c) Greece.

(a)

	Forest	**Shrub**	**Cultivated**
N Pixels	15685 [35]	6102 [14]	22776 [51]
N. Fire Events [%]	1151 [52]	451 [21]	606 [27]

(b)

	Forest	**Shrub**	**Cultivated**
N Pixels	7050 [33]	382 [2]	13814 [65]
N. Fire Events [%]	644 [36]	503 [28]	624 [35]

(c)

	Forest	**Shrub**	**Cultivated**
N Pixels	3957 [23]	6726 [39]	6485 [38]
N. Fire Events [%]	434 [24]	991 [56]	355 [20]

Table 3 presents, for each region and vegetation type, the distribution of fire pixels according to the corresponding number of active fires. It is well apparent that intense fire events (larger than 30/35 active fires) are quite rare events, with relative frequencies below 6%. This suggests using long-tailed distributions to characterise the statistical distribution of occurrence of active fires.

Table 3 Number of fire pixels and respective percentage according to the corresponding number of active fires (during July-August 2007-2009) for the three considered types of vegetation, for (a) Iberian Peninsula, (b) Italy and (c) Greece.

(a)

	≤ 5	]5, 15]	]15, 30*]	>30*
Forest	791	257	86	17
[%]	[69]	[22]	[7]	[2]
Shrub	335	74	30	12
[%]	[74]	[16]	[7]	[3]
Culivated	439	98	60	9
[%]	[72]	[16]	[10]	[2]

* 35 in case of forests

(b)

	≤ 5	]5, 15]	]15, 30]	>30
Forest	498	127	18	1
[%]	[77]	[20]	[3]	[0]
Shrub	367	98	34	4
[%]	[73]	[19]	[7]	[1]
Culivated	560	59	5	0
[%]	[90]	[9]	[1]	[0]

(c)

	≤ 5	]5, 15]	]15, 35]	>35
Forest	791	257	86	17
[%]	[69]	[22]	[7]	[2]
Shrub	472	252	204	63
[%]	[48]	[25]	[21]	[6]
Culivated	246	63	38	8
[%]	[69]	[18]	[11]	[2]

Truncated Weibull distributions were accordingly fitted to the sample of recorded number of active fires during the period of July-August 2007-2009, using FWI as a co-variate for the scale parameter.

Figures 9, 15 and 21 present, for Iberian Peninsula, Italy and Greece, respectively, for the case of forests, the probability distribution functions (upper panel) and the corresponding cumulative distribution functions (lower panel) for five different values of FWI. The strong dependence of both pdf and cdf curves on FWI is conspicuous, especially in what respects to the risk of having a high number of active fires. This feature is well illustrated in Figures 10, 16 and 22, where both the probability of occurrence of a given number of active fires (upper panel) and the risk of having a prescribed number of active fires strongly increase with FWI. Similar results were obtained for shrub (Figures 11 and 12, 17 and 18, 23 and 24, for Iberian Peninsula, Italy and Greece, respectivley) and cultivated areas (Figures 13 and 14, 19 and 20, 25 and 26, for Iberian Peninsula, Italy and Greece, respectively).

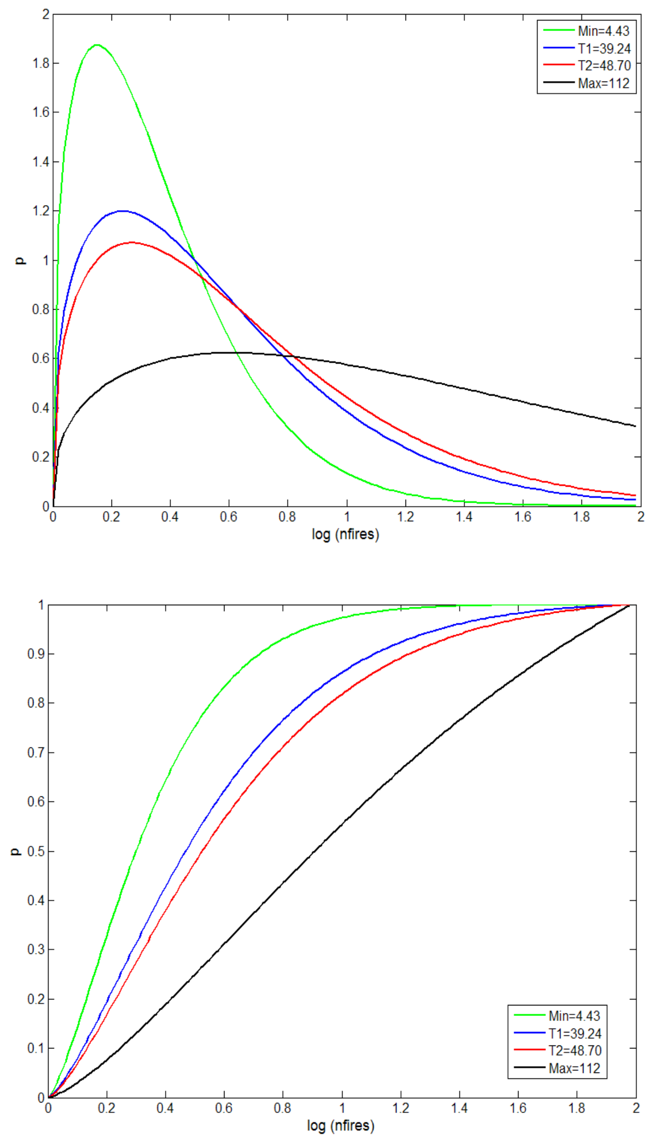


Figure 9 Density functions (upper panel) and respective cumulative density functions (lower panel) of the adjusted truncated Weibull distribution using FWI as covariate, for Iberian Peninsula and forests. The four curves respect to four different values of FWI; minimum, first and second terciles and maximum (in green, blue, red and black).

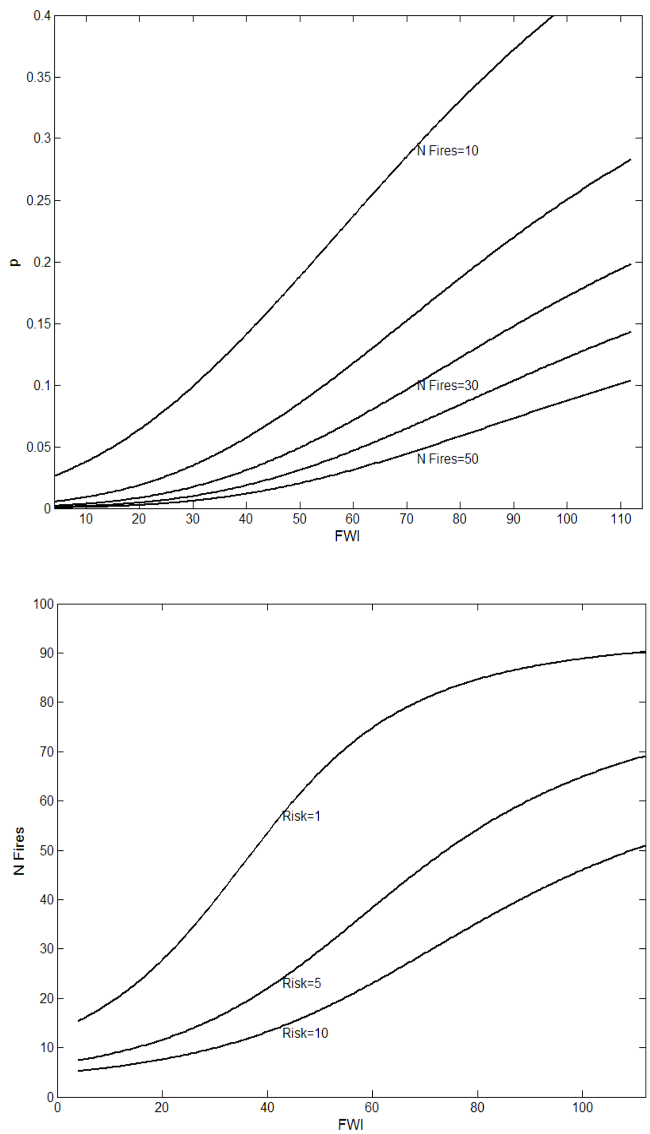
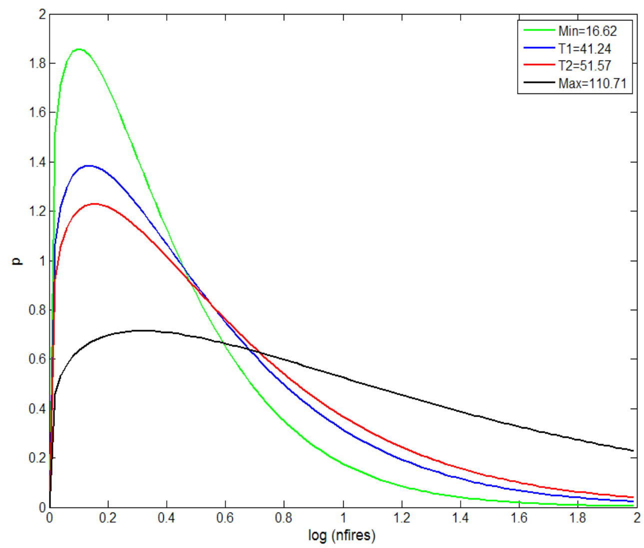


Figure 10 Dependence on FWI of (upper panel) probability of occurrence of number of active fires exceeding five selected thresholds (10, 20, 30, 40 and 50) of number of fires and of (lower panel) number of active fires for three selected thresholds (1%, 5% and 10%) of risk, for Iberian Peninsula and forests.



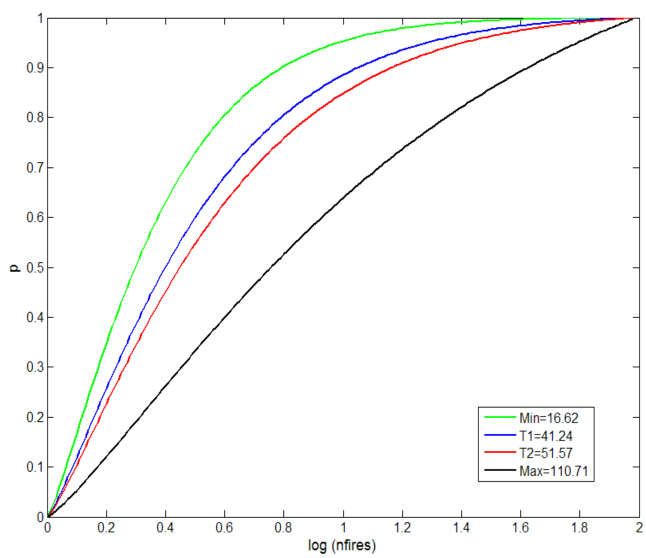


Figure 11 As in Figure 9 but respecting to the shrub type.

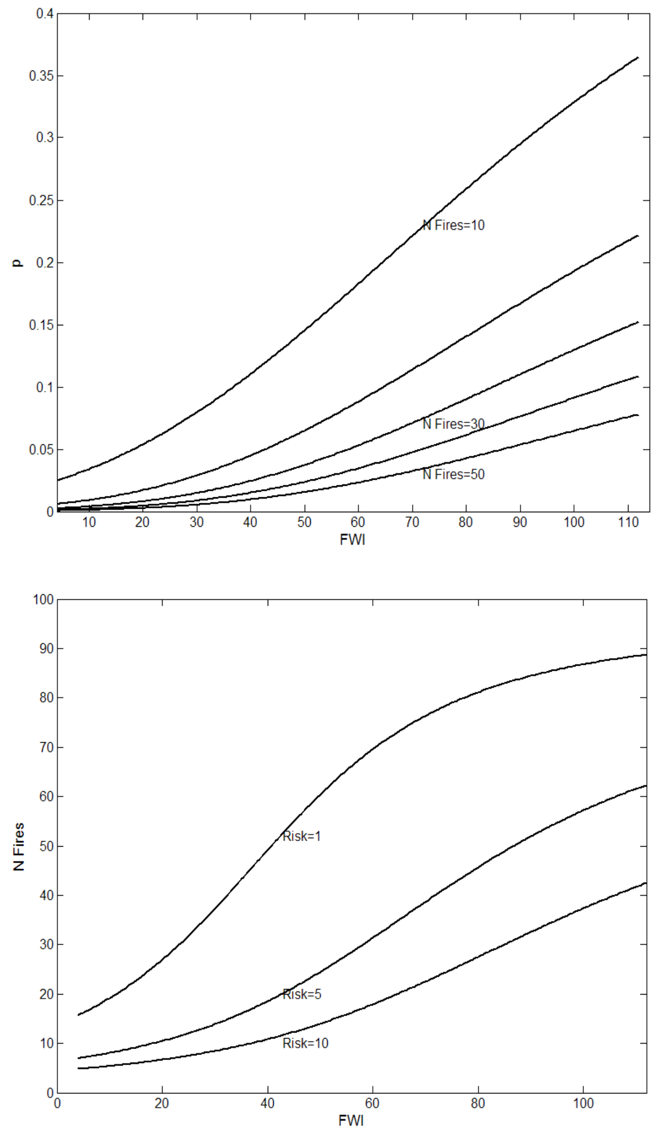


Figure 12 As in Figure 10 but respecting to the shrub type.

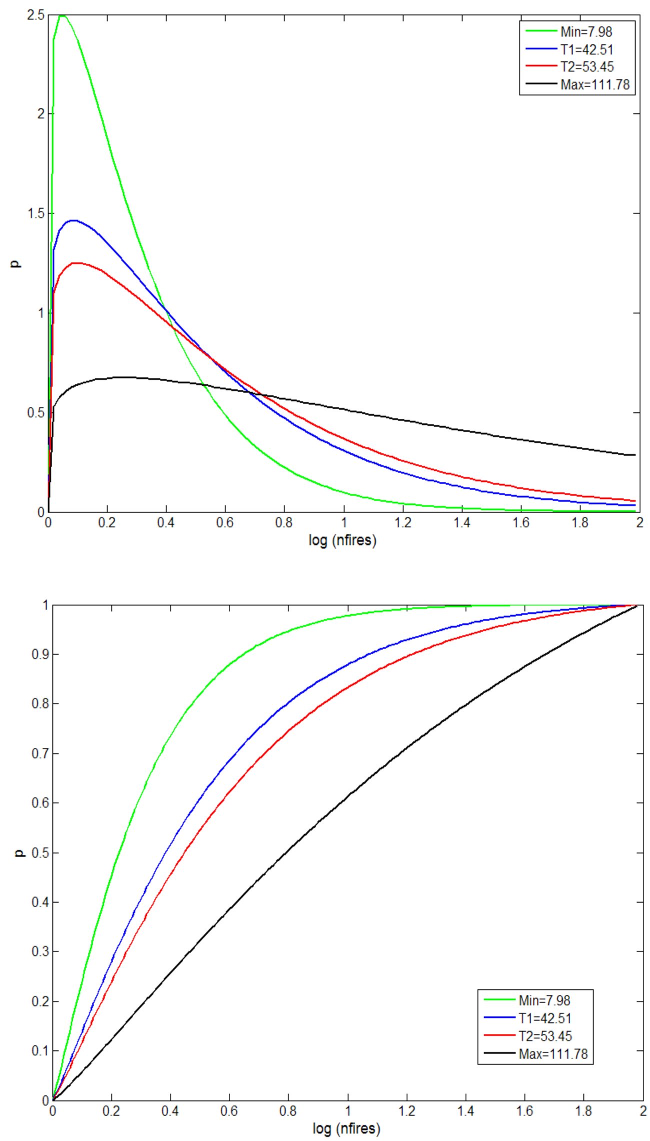
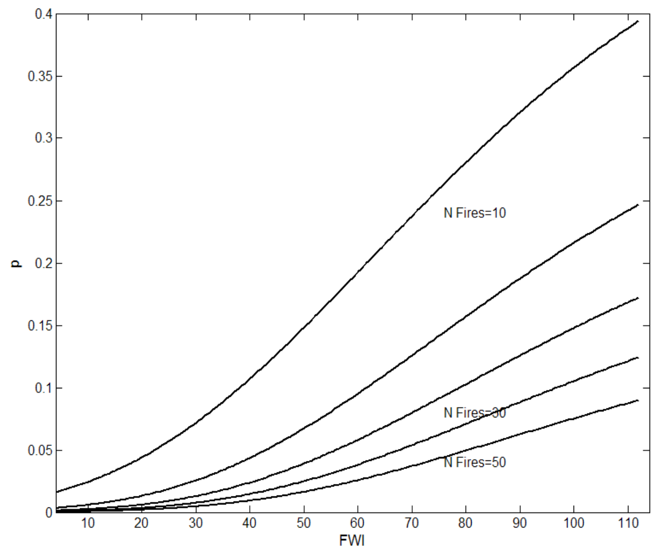


Figure 13 As in Figure 9 but respecting to cultivated areas.



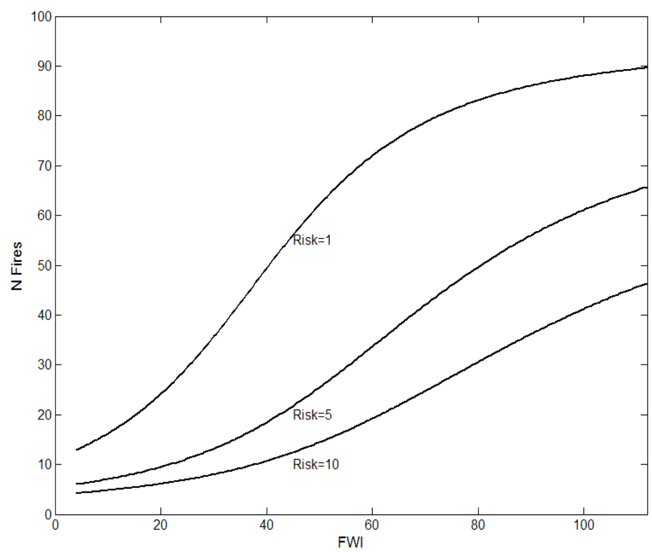


Figure 14 As in Figure 10 but respecting to cultivated areas.

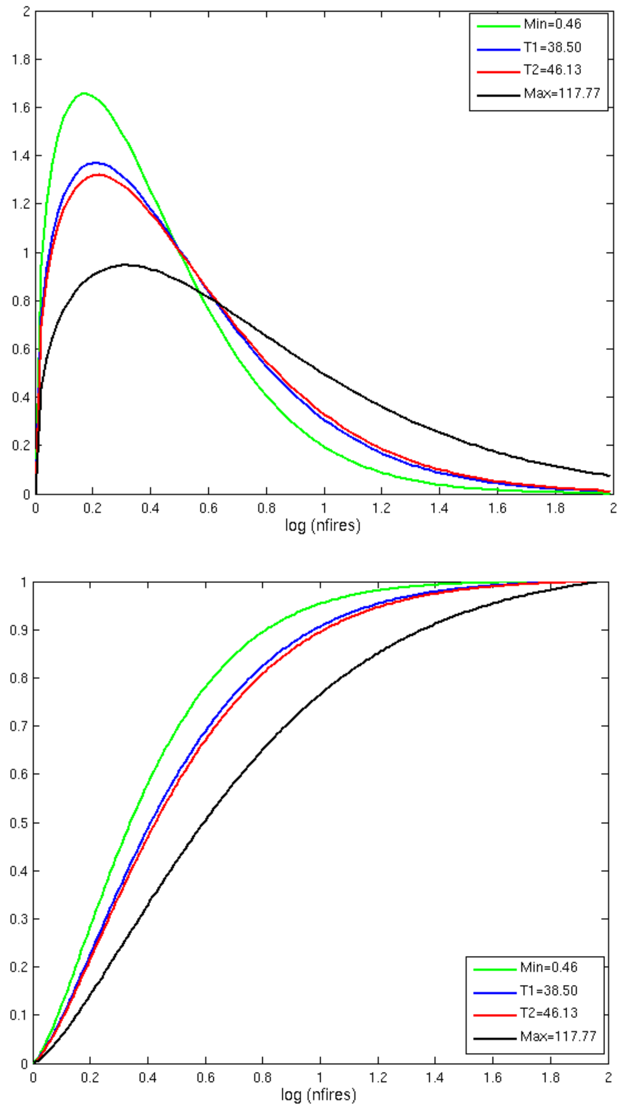


Figure 15 As in Figure 9 but respecting to Italy.

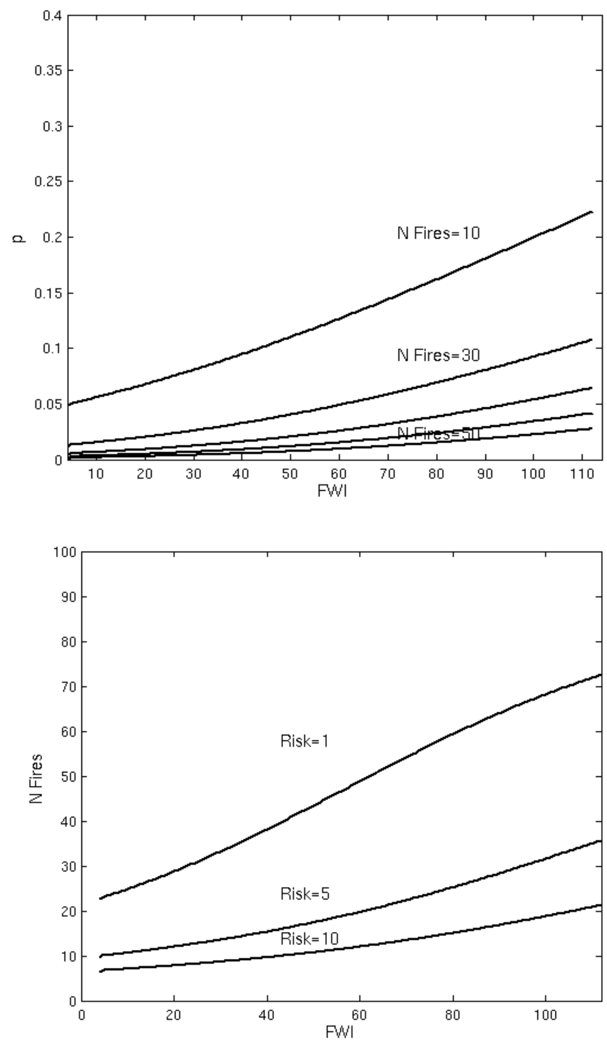


Figure 16 As in Figure 10 but respecting to Italy.

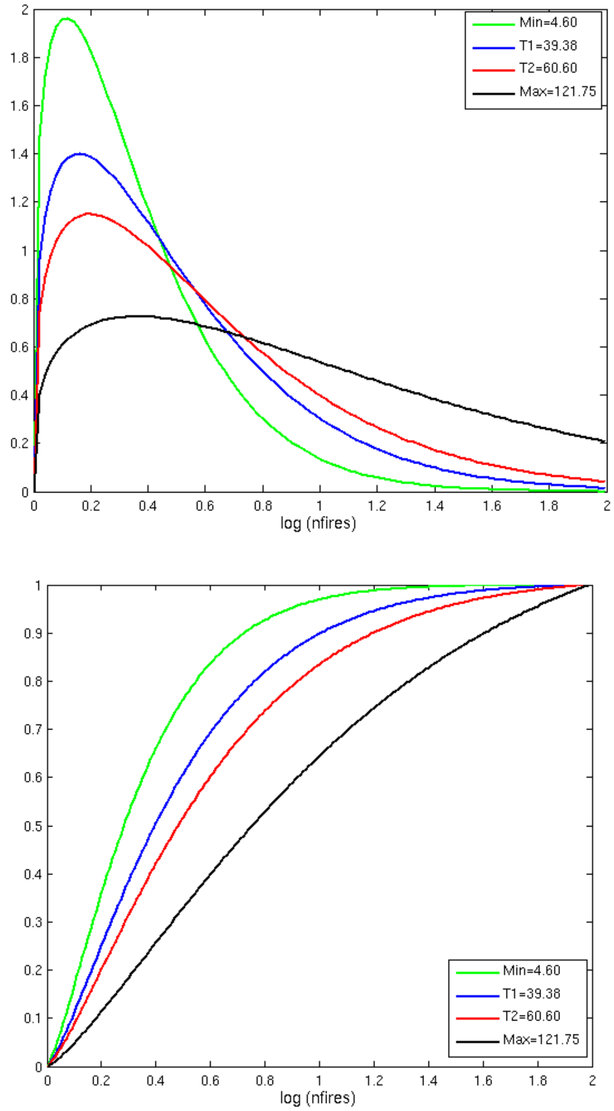


Figure 17 As in Figure 15 but respecting to shrub.

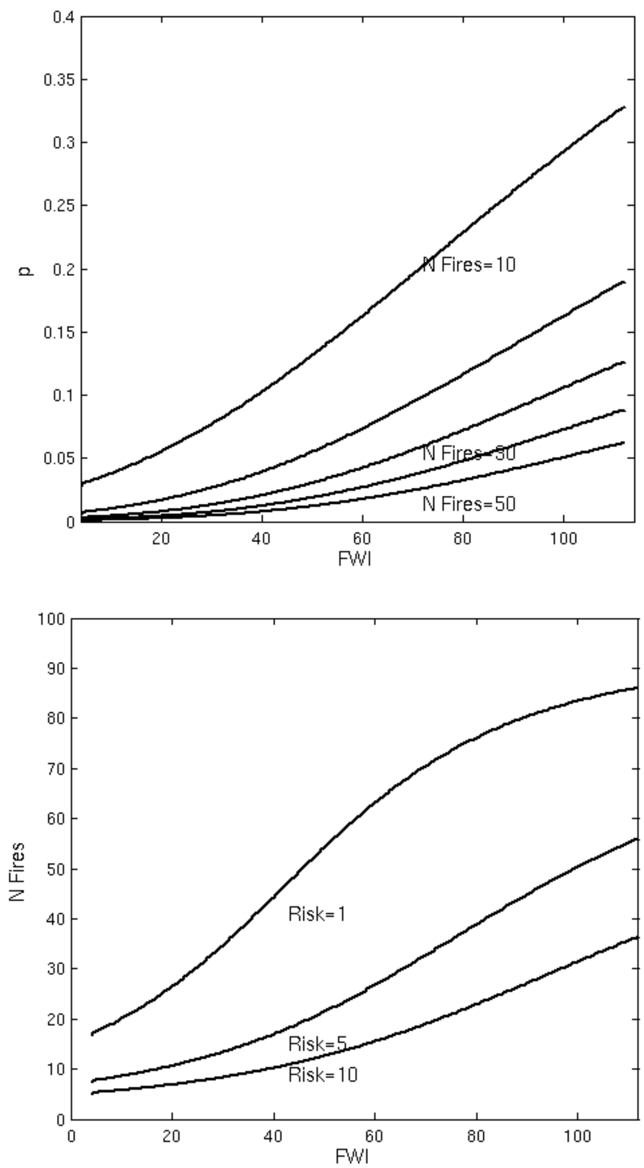
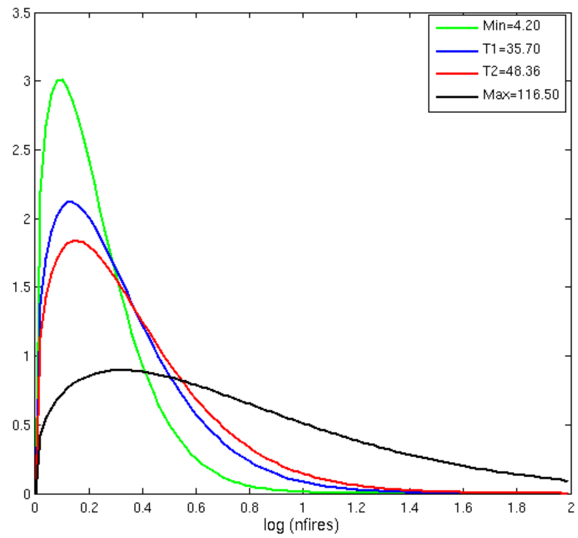


Figure 18 As in Figure 16 but respecting to shrub.



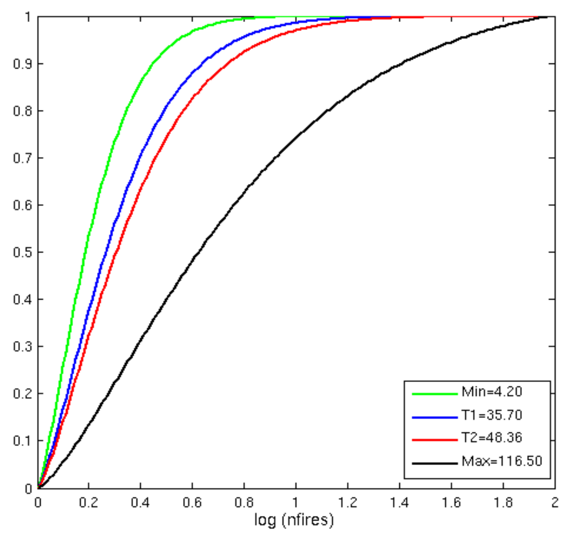


Figure 19 As in Figure 15 but respecting to cultivated areas.

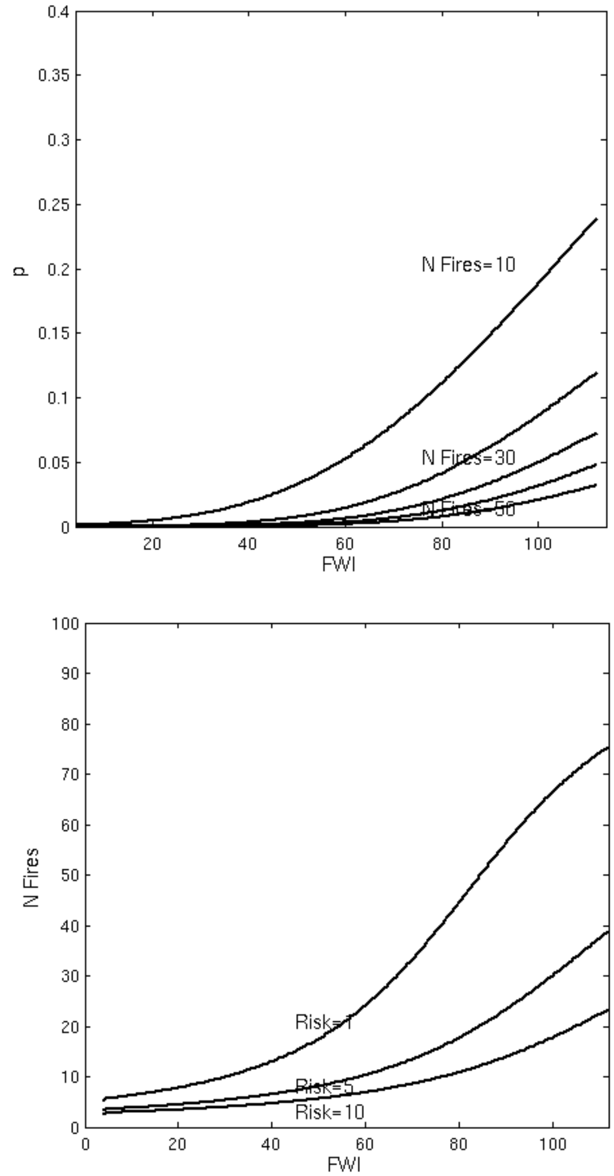


Figure 20 As in Figure 16 but respecting to cultivated areas.

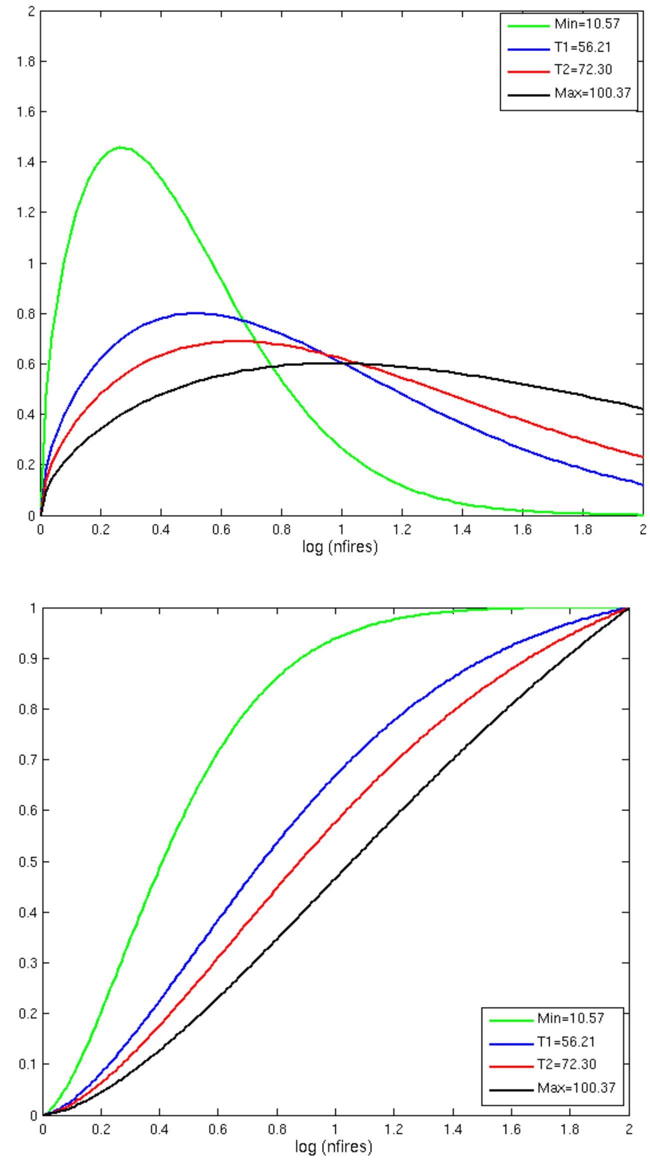
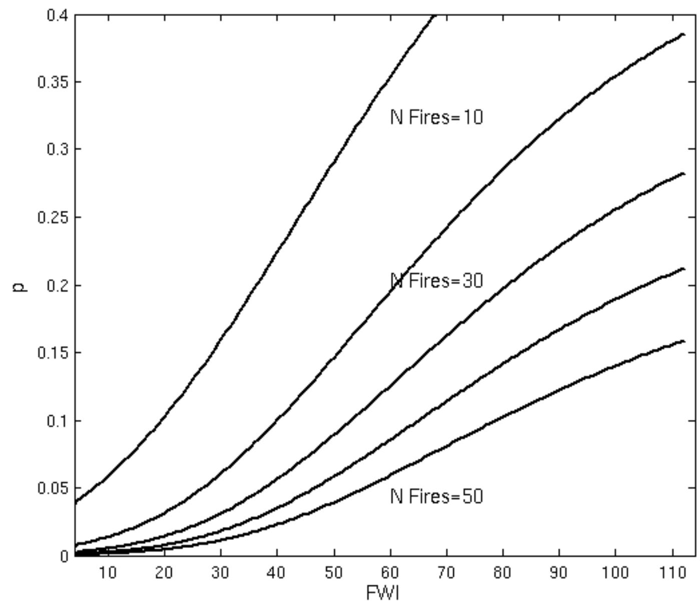


Figure 21 As in Figure 9 but respecting to Greece.



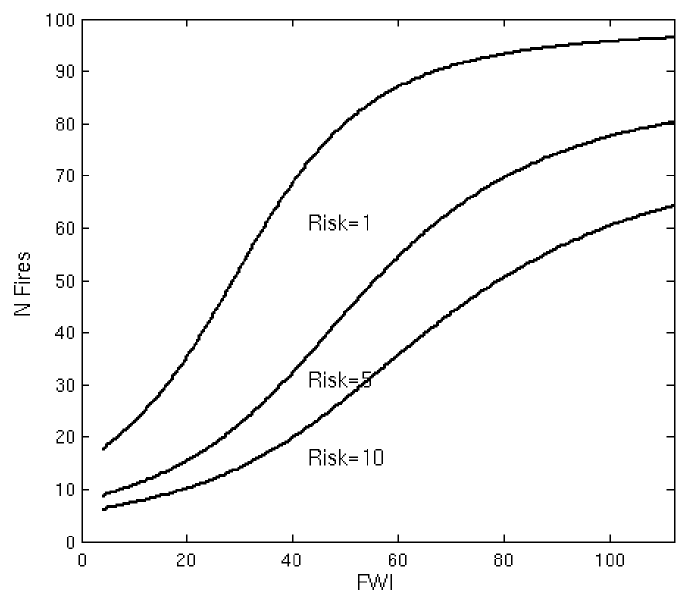


Figure 22 As in Figure 10 but respecting to Greece.

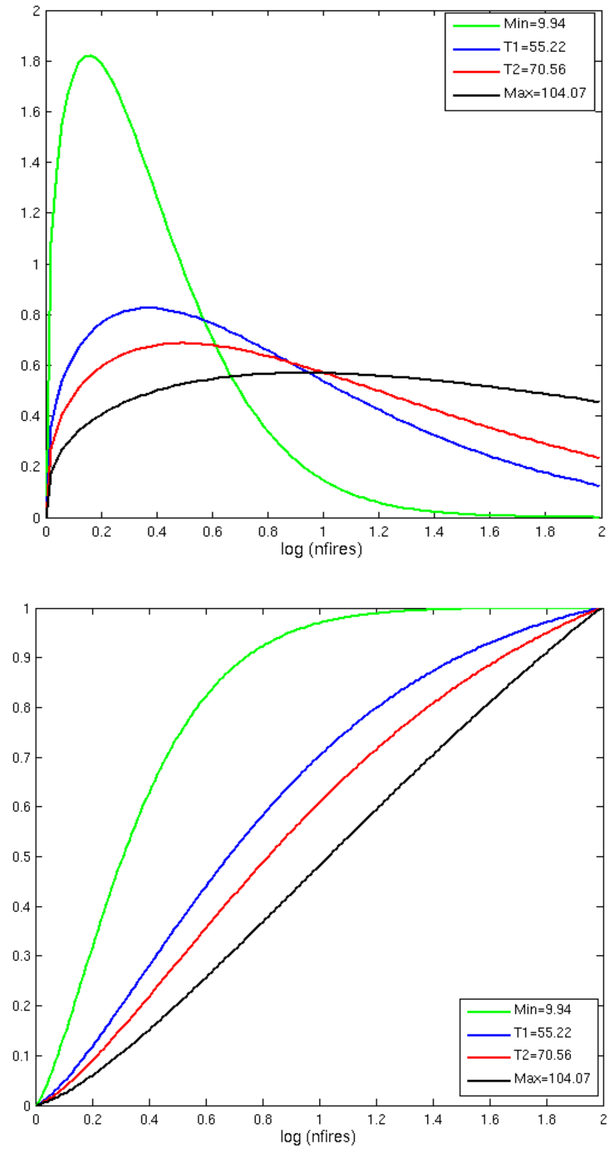
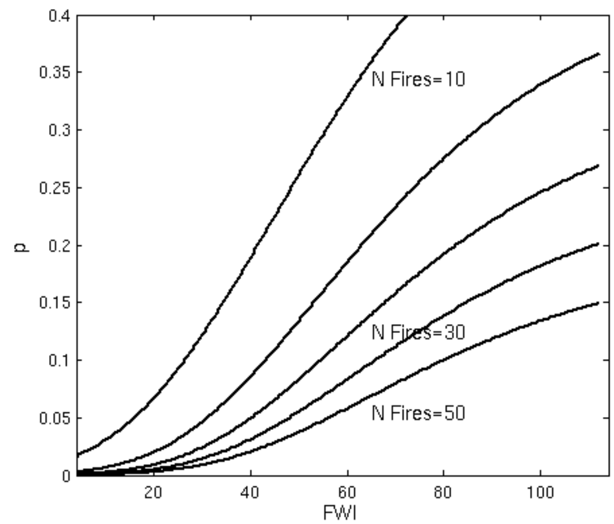


Figure 23 As in Figure 21 but respecting to shrub.



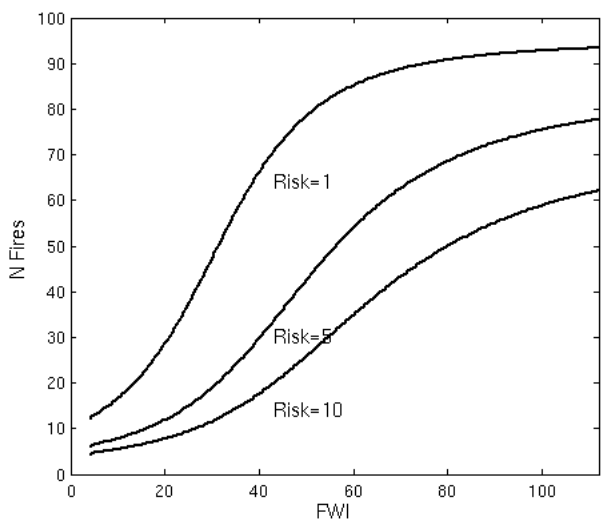


Figure 24 As in Figure 22 but respecting to shrub.

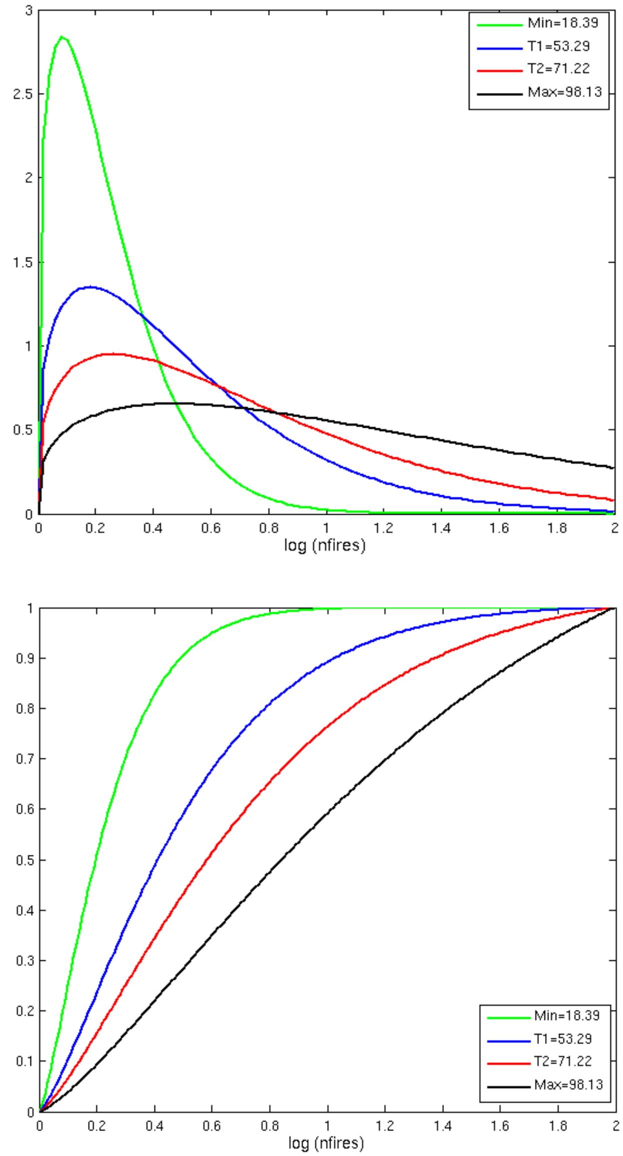


Figure 25 As in Figure 21 but respecting to cultivated areas.

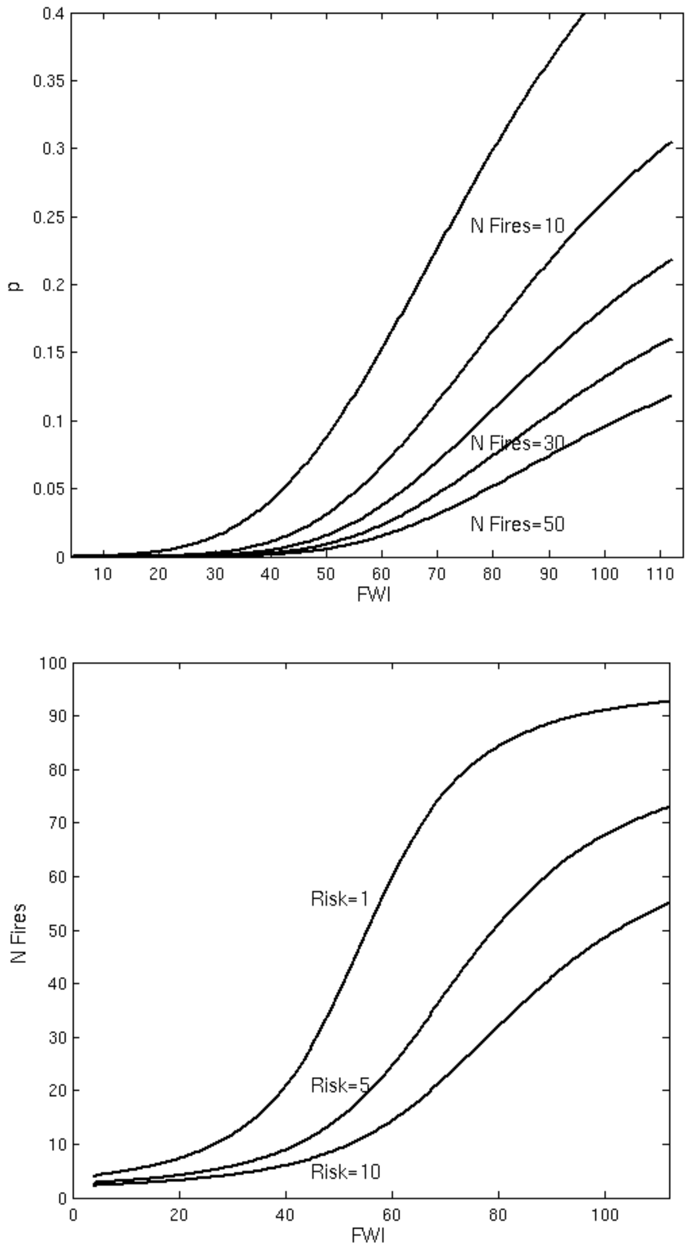


Figure 26 As in Figure 22 but respecting to cultivated areas.

Results obtained were then used to define five levels of fire risk, respectively "very low" (class 1), "low" (class 2), "moderate" (class 3), "high" (class 4) and "very high" (class 5), which depend on the threshold T, defined as having a risk of 1% for a number of active fires larger than T. The five classes, as expected, differ from region to region and are accordingly defined by T≤15,]15, 35],]35, 50],]50, 65] and T>65 active fires, for Iberian Peninsula; T≤5,]5, 10],]10, 20],]20, 35] and T>35 active fires, for Italy and T≤10,]10, 15],]15, 25],]25, 55] and T>55 active fires, for Greece.

Tables 4 to 12 present the total of observed events (and respective probability), for Iberian Peninsula, Italy and Greece, for four ranges of number of active fire that fall into each one the five different classes of fire risk, respectively for forest (Tables 4, 7 and 10), shrub (Tables 5, 8 and 11) and cultivated types (Tables 6, 9 and 12). As expected, the probability of having severe fire events (e.g. larger than 15) strongly increases when pixels are classified as belonging to classes 4 and especially 5. On the other hand there is virtually no risk of fire events when a pixel is classified as belonging to class 1 and class 2 in the case of Italy and Greece.

Table 4 Number of fire pixels of different ranges of active fires for Iberian Peninsula, for different classes of fire risk and respective conditional probabilities (in %) of having a prescribed range given a certain class, for forests.

	Class5	Class4	Class3	Class2	Class1
<=5	189	317	188	95	2
[%]	[57]	[71]	[71]	[88]	[100]
]5, 15]	97	94	54	12	0
[%]	[29]	[21]	[21]	[11]	[0]
]15, 35]	38	27	20	1	0
[%]	[11]	[6]	[8]	[1]	[0]
>35	10	6	1	0	0
[%]	[3]	[1]	[0]	[0]	[0]

Table 5 As in Table 4 but respecting to shrub.

	Class5	Class4	Class3	Class2	Class1
<=5	128	134	61	12	0
[%]	[63]	[84]	[87]	[67]	[0]
]5, 15]	49	16	6	3	0
[%]	[24]	[10]	[9]	[17]	[0]
]15, 30]	17	8	3	2	0
[%]	[8]	[5]	[4]	[11]	[0]
>30	9	2	0	1	0
[%]	[4]	[1]	[0]	[6]	[0]

Table 6 As in Table 4 but respecting to cultivated areas.

	Class5	Class4	Class3	Class2	Class1
<=5	167	146	88	36	2
[%]	[65]	[76]	[80]	[78]	[100]
]5, 15]	50	32	9	7	0
[%]	[19]	[17]	[8]	[15]	[0]
]15, 30]	33	11	13	3	0
[%]	[13]	[6]	[12]	[7]	[0]
>30	7	2	0	0	0
[%]	[3]	[1]	[0]	[0]	[0]

Table 7 As in Table 4 but respecting to Italy.

	Class5	Class4	Class3	Class2	Class1
<=5	409	89	0	0	0
[%]	[78]	[75]	[0]	[0]	[0]
]5, 15]	106	21	0	0	0
[%]	[20]	[18]	[0]	[0]	[0]
]15, 30]	10	8	0	0	0
[%]	[2]	[7]	[0]	[0]	[0]
>30	1	0	0	0	0
[%]	[0]	[0]	[0]	[0]	[0]

Table 8 As in Table 7 but respecting to shrub.

	Class5	Class4	Class3	Class2	Class1
<=5	289	72	6	0	0
[%]	[71]	[82]	[86]	[0]	[0]
]5, 15]	86	12	0	0	0
[%]	[21]	[14]	[0]	[0]	[0]
]15, 30]	30	3	1	0	0
[%]	[7]	[3]	[14]	[0]	[0]
>30	3	1	0	0	0
[%]	[1]	[1]	[0]	[0]	[0]

Table 9 As in Table 7 but respecting to cultivated areas.

	Class5	Class4	Class3	Class2	Class1
<=5	50	94	314	101	1
[%]	[63]	[90]	[94]	[96]	[100]
]5, 15]	28	9	18	4	0
[%]	[35]	[9]	[5]	[4]	[0]
]15, 30]	2	1	2	0	0
[%]	[2]	[1]	[1]	[0]	[0]
>30	0	0	0	0	0
[%]	[0]	[0]	[0]	[0]	[0]

Table 10 As in Table 4 but respecting to Greece.

	Class5	Class4	Class3	Class2	Class1
<=5	182	9	1	0	0
[%]	[43]	[82]	[50]	[0]	[0]
]5, 15]	115	2	1	0	0
[%]	[27]	[18]	[50]	[0]	[0]
]15, 35]	92	0	0	0	0
[%]	[22]	[0]	[0]	[0]	[0]
>35	32	0	0	0	0
[%]	[8]	[0]	[0]	[0]	[0]

Table 11 As in Table 10 but respecting to shrub.

	Class5	Class4	Class3	Class2	Class1
<=5	437	34	1	0	0
[%]	[46]	[75]	[33]	[0]	[0]
]5, 15]	244	8	0	0	0
[%]	[26]	[18]	[0]	[0]	[0]
]15, 35]	169	3	2	0	0
[%]	[21]	[7]	[67]	[0]	[0]
>35	93	0	0	0	0
[%]	[7]	[0]	[0]	[0]	[0]

Table 12 As in Table 10 but respecting to cultivated areas.

	Class5	Class4	Class3	Class2	Class1
<=5	120	58	44	14	10
[%]	[58]	[76]	[92]	[100]	[91]
]5, 15]	43	15	4	0	1
[%]	[21]	[20]	[8]	[0]	[9]
]15, 35]	35	3	0	0	0
[%]	[17]	[4]	[0]	[0]	[0]
>35	8	0	0	0	0
[%]	[4]	[0]	[0]	[0]	[0]

The usefulness of the developed rating system of fire danger may be assessed by looking at Tables 13 to 21 that display the conditional probabilities of having a prescribed class of fire danger given a certain range of active fires, for each of the chosen European regions.

For instance, in the case of forests (Table 13), in Iberian Peninsula, and for the most severe events (active fires larger than 35) 100% of observed events belong to classes 3, 4 and 5, 94% of them to classes 4 and 5 and 59% to class 5. In the case of shrub (Table 14), 92% of observed severe events (active fires larger than 30) belong to classes 4 and 5 and 75% to class 5. Finally, in the case of cultivated areas (Table 15) all severe events (active fires larger than 30) belong to classes 4 and 5 and 78% to class 5. On the other hand, virtually no events of any size occur in class 1.

In what respects to Italy, forests (Table 16) present no events of any size belonging to classes 1, 2 and 3. In the case of shrub (Table 17), 100% of observed severe events (active fires larger than 30) occur in classes 4 and 5 and in the case of cultivated areas (Table 18), the magnitude of observed active fires is quite small, with all occurrences but five being smaller than 15 active fires.

Finally, in what respects to Greece no fire events occur in classes 1 and 2 of forests (Table 19) and shrub (Table 20). Moreover, for all of the three considered types of vegetation, nearly 100% of active fires larger than 15 occur in class 5.

Table 13 Number of fire pixels of different classes of fire risk for different ranges of active fires and respective conditional probabilities (in %) of having a prescribed class given a certain range of number of fires, for forests in Iberian Peninsula.

	Class5	Class4	Class3	Class2	Class1
<=5	189	317	188	95	2
[%]	[24]	[40]	[24]	[12]	[0]
]5, 15]	97	94	54	12	0
[%]	[38]	[37]	[21]	[5]	[0]
]15, 35]	38	27	20	1	0
[%]	[44]	[31]	[23]	[1]	[0]
>35	10	6	1	0	0
[%]	[59]	[35]	[6]	[0]	[0]

Table 14 As in Table 13, but respecting to shrub.

	Class5	Class4	Class3	Class2	Class1
<=5	128	134	61	12	0
[%]	[38]	[40]	[18]	[4]	[0]
]5, 15]	49	16	6	3	0
[%]	[66]	[22]	[8]	[4]	[0]
]15, 30]	17	8	3	21	0
[%]	[57]	[27]	[10]	[7]	[0]
>30	9	2	0	1	0
[%]	[75]	[17]	[0]	[8]	[0]

Table 15 As in Table 13, but respecting to cultivated areas.

	Class5	Class4	Class3	Class2	Class1
<=5	167	146	88	36	2
[%]	[38]	[33]	[20]	[80]	[0]
]5, 15]	50	32	9	7	0
[%]	[51]	[33]	[9]	[7]	[0]
]15, 30]	33	11	13	3	0
[%]	[55]	[18]	[22]	[5]	[0]
>30	7	2	0	0	0
[%]	[78]	[22]	[0]	[0]	[0]

Table 16 As in Table 13 but respecting to Italy.

	Class5	Class4	Class3	Class2	Class1
<=5	409	89	0	0	0
[%]	[82]	[18]	[0]	[0]	[0]
]5, 15]	106	21	0	0	0
[%]	[83]	[17]	[0]	[0]	[0]
]15, 30]	10	8	0	0	0
[%]	[56]	[44]	[0]	[0]	[0]
>30	1	0	0	0	0
[%]	[100]	[0]	[0]	[0]	[0]

Table 17 As in Table 16, but respecting to shrub.

	Class5	Class4	Class3	Class2	Class1
<=5	289	72	6	0	0
[%]	[79]	[20]	[2]	[0]	[0]
]5, 15]	86	12	0	0	0
[%]	[88]	[12]	[0]	[0]	[0]
]15, 30]	30	3	1	0	0
[%]	[88]	[9]	[3]	[0]	[0]
>30	3	1	0	0	0
[%]	[75]	[25]	[0]	[0]	[0]

Table 18 As in Table 16, but respecting to cultivated areas.

	Class5	Class4	Class3	Class2	Class1
<=5	50	94	314	101	1
[%]	[9]	[17]	[56]	[18]	[0]
]5, 15]	28	9	18	4	0
[%]	[47]	[15]	[31]	[7]	[0]
]15, 30]	2	1	2	0	0
[%]	[40]	[20]	[40]	[0]	[0]
>30	0	0	0	0	0
[%]	[0]	[0]	[0]	[0]	[0]

Table 19 As in Table 13 but respecting to Greece.

	Class5	Class4	Class3	Class2	Class1
<=5	182	9	1	0	0
[%]	[95]	[5]	[0]	[0]	[0]
]5, 15]	115	2	1	0	0
[%]	[97]	[2]	[1]	[0]	[0]
]15, 35]	92	0	0	0	0
[%]	[100]	[0]	[0]	[0]	[0]
>35	32	0	0	0	0
[%]	[100]	[0]	[0]	[0]	[0]

Table 20 As in Table 19, but respecting to shrub.

	Class5	Class4	Class3	Class2	Class1
<=5	437	34	1	0	0
[%]	[93]	[27]	[0]	[0]	[0]
]5, 15]	244	8	0	0	0
[%]	[97]	[3]	[0]	[0]	[0]
]15, 35]	199	3	2	0	0
[%]	[98]	[1]	[1]	[0]	[0]
>35	63	0	0	0	0
[%]	[100]	[0]	[0]	[0]	[0]

Table 21 As in Table 19, but respecting to cultivated areas.

	Class5	Class4	Class3	Class2	Class1
<=5	120	58	44	14	10
[%]	[49]	[23]	[18]	[6]	[4]
]5, 15]	43	15	4	0	1
[%]	[68]	[24]	[6]	[0]	[2]
]15, 35]	35	3	0	0	0
[%]	[92]	[8]	[0]	[0]	[0]
>35	8	0	0	0	0
[%]	[100]	[0]	[0]	[0]	[0]

4.3. Comparison with similar products

Figures 27 and 28 show two examples of fire risk maps for Iberian Peninsula, for July 22 and 23 and for August 30 and 31 2009, respectively. For comparison purposes, the corresponding maps produced by EFFIS are also shown. Pixels in green, yellow, orange, red and brown indicate pixels of very low, low, moderate, high and very high risk of fire, respectively. Pixels in black correspond to fire pixels as identified by the FD&M algorithm. Figures 29 and 30 present examples, respectively for Italy (July 24 and 25, 2007) and for Greece (August 25 and 26, 2007).

The similarity between the two classifications is well apparent. Despite the fact that, in some areas, the FRM algorithm tends to produce lower values of risk (one class lower) when compared to EFFIS results, the overall agreement is worth being noted. This is especially relevant, since the procedure adopted (in the FRM product) allow attributing a quantified risk to each of the defined classes.

In what respects to fire pixels, almost all pixels fall in classes of high and very high risk, although, in some cases one observe fire pixels coincident with the class of moderate risk, e.g. on August 30 in Iberian Peninsula.

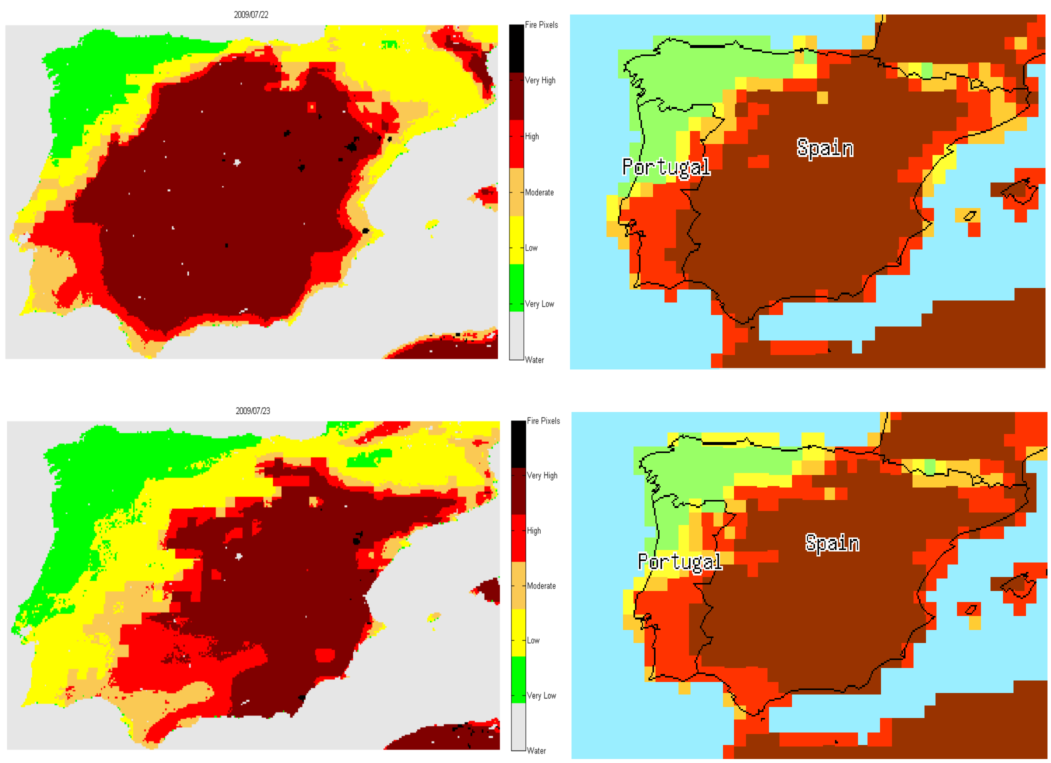


Figure 27 Example, for July 22 (upper panels) and 23 2009, of maps of classes of fire risk for the sub-area of the MSG EUR window (left panels) and corresponding maps produced by EFFIS (right panels). Green, yellow, orange, red and brown correspond to very low, low, moderate, high and very high risk of fire. Pixels in black correspond to fire pixels as obtained by FD&M.

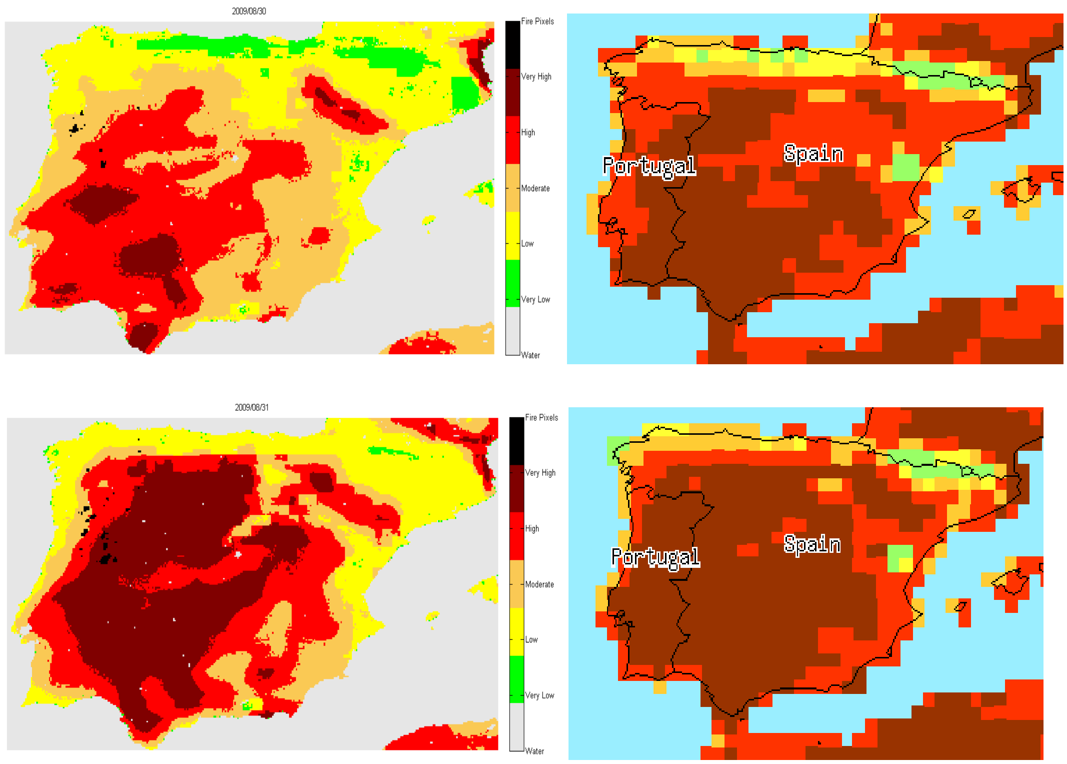


Figure 28 As in Figure 27, but respecting to August 30 (top panels) and 31 (bottom panels).

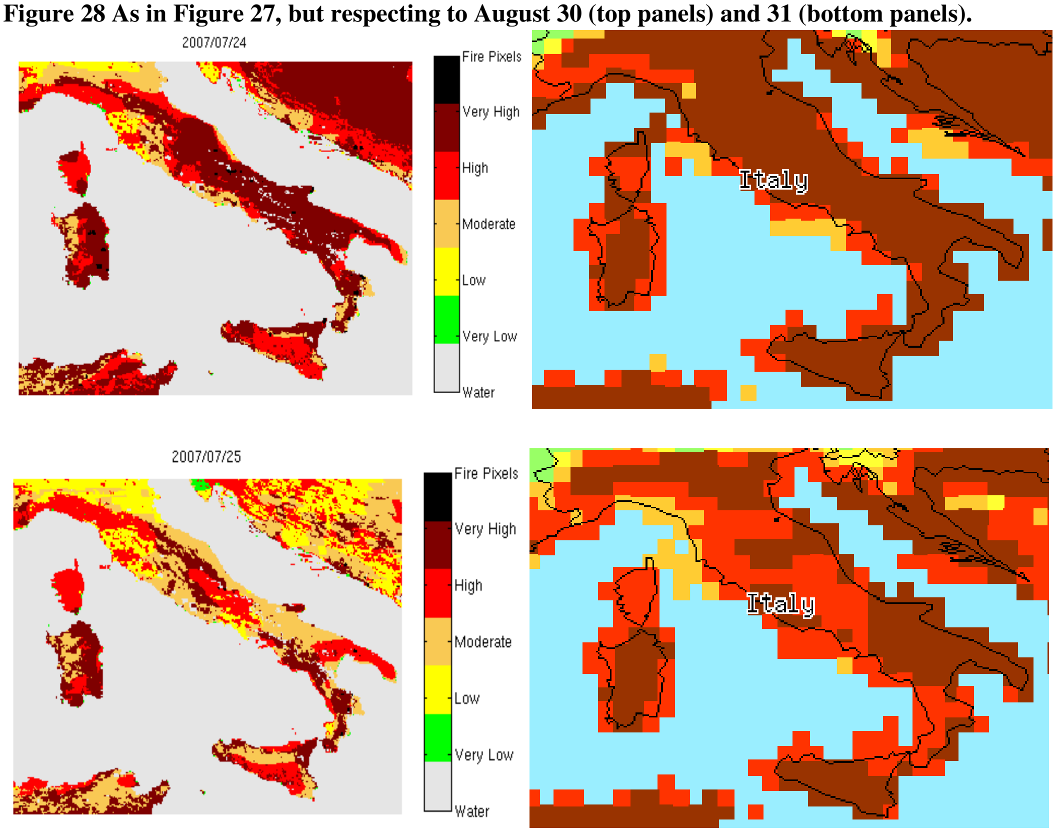


Figure 29 As in Figure 27, but respecting to Italy on July 24 (top panels) and 25 (bottom panels) 2007.

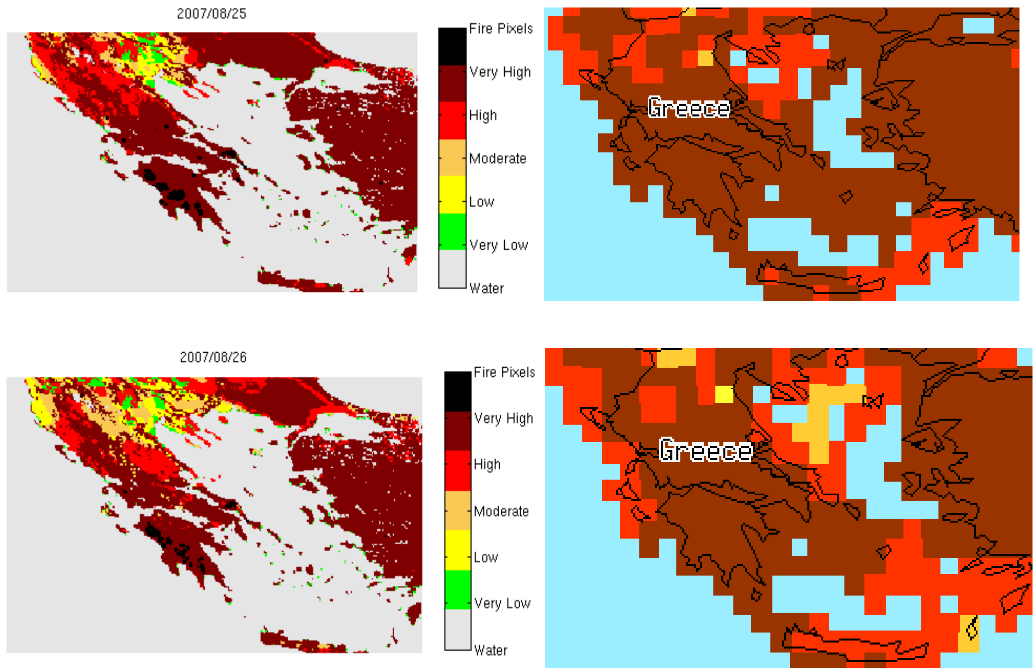


Figure 30 As in Figure 27, but respecting to Greece, on August 25 (top panels) and 26 (bottom panels) 2007.

5. Conclusions

Validation was performed on products generated in the framework of the Fire Risk Map (FRM), namely daily fields of indices of meteorological risk of fire and derived daily maps of classes of risk of fire. The validation exercise covered the months of July and August from 2007 to 2009 over the Iberian Peninsula, Italy and Greece.

Time series of daily values of DSR were compared against a similar product as obtained from the official report published by the Portuguese National Forest Authority (AFN). Results obtained indicate a close agreement (Table 1) between time series of cumulated daily values of DSR (Figure 1), fire occurrences (Figure 2) and burnt areas (Figure 3). A close agreement was also found in what respects to the relations between cumulated values of DSR and cumulated number of fires (Figure 4) as well as between cumulated values of DSR and cumulated burnt areas (Figure 5). Time series of daily values of DSR together with daily values of fire occurrences (Figure 6) and together with daily values of burnt areas (Figure 7) also showed a very similar behaviour when obtained from AFN and FRM.

Daily values of FWI were then used to define a set of 5 classes of fire risk for three types of vegetation cover, namely forest, shrub and cultivated areas. The definition of the classes of risk was based on truncated Weibull distribution that use FWI as a meteorological covariate in the scale parameter. Obtained classes were spatially consistent with classes of risk disseminated by EFFIS from JRC (Figures 27 to 30).

Finally, it is worth emphasizing that the large majority of fire pixels and those associated to a high number of active fires fall into the classes of high and very high risk. In fact, the obtained values of conditional probability of occurrence of fire pixels given a class of risk (Tables 13 to 21) follow the requirements specified in PRD, namely that:

- The class of lowest risk should indicate a virtual absence of active fire pixels;
- The classes of intermediate risk should indicate the virtual absence of highly active fires (larger than 30/35 fire pixels) and a relative frequency lower than 1/3 of moderate fires (between ~10 to ~30 fire pixels);
- The class of highest risk should indicate a relative frequency higher than 2/3 for large fires (higher than 30/35 fire pixels).

Besides showing that the FRM product requirements are met, this last aspect is also relevant since it illustrates the main advantage of the developed system of rating fire danger, which consists in having quantitative values of risk for each class, giving the user community the possibility in incorporating quantitative information in their own warning systems.

6. References

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