

Daily maps of fire danger over Mediterranean Europe

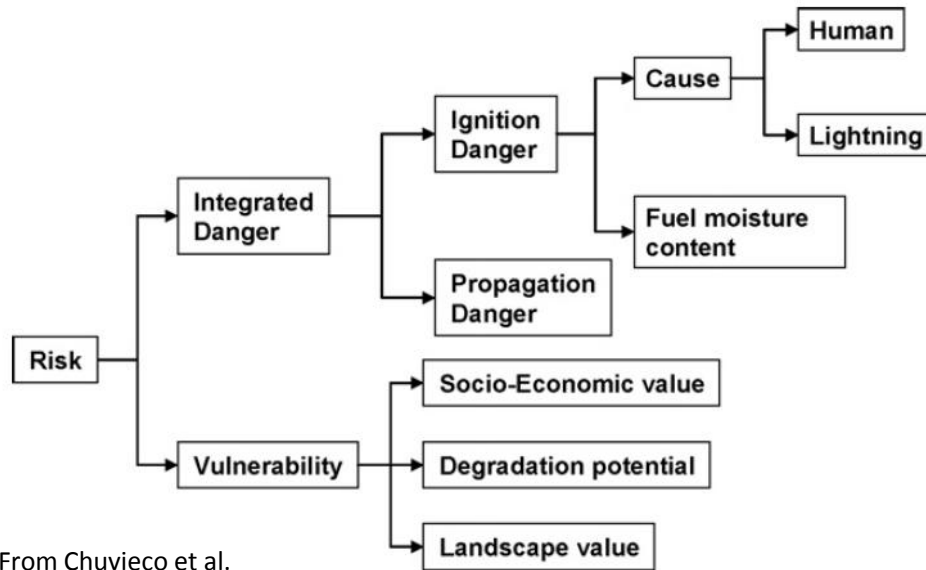
Carlos C. DaCamara⁽¹⁾, Teresa J. Calado⁽¹⁾,
Sofia L. Ermida⁽¹⁾, Isabel F. Trigo^(1,2), Malik Amraoui^(1,3)

(1) Instituto Dom Luiz, Universidade de Lisboa, Lisboa, Portugal

(2) Instituto Português do Mar e da Atmosfera, Lisboa, Portugal

(3) Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal

- Representing more than 85% of burned area in Europe, the Mediterranean is one of the regions of the world most affected by large wildfires that burn half a million of ha of vegetation cover every year causing extensive economic losses and ecological damage.
- The Land Surface Analysis Satellite Applications Facility (LSA SAF) has been developing a suite of applications related to wild fire activity which cover the identification of fire events, the mapping of burnt scars and the characterization of the risk of fire.



From Chuvieco et al.
(2010)

Fig. 1. Framework for fire risk assessment.

A quantitative definition of fire risk includes two main factors: **fire behavior probabilities** and **fire effects**.

This definition applies to a particular geographic area and time period and can be formulated as an expected net value change ($E[nvc]$):

$$E[nvc] = \sum_{i=1}^N \sum_{j=1}^n p(F_i) [B_{ij} - L_{ij}]$$

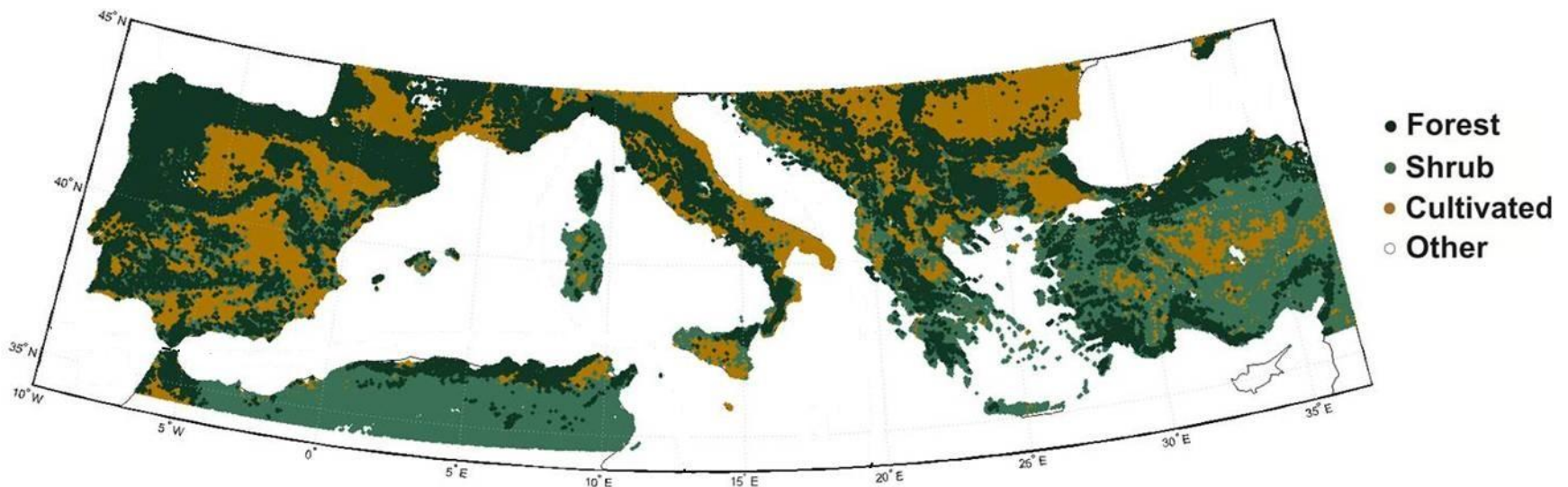
Probability of the i^{th} fire behavior

Benefits and losses afforded the j^{th} value received from the i^{th} fire behavior

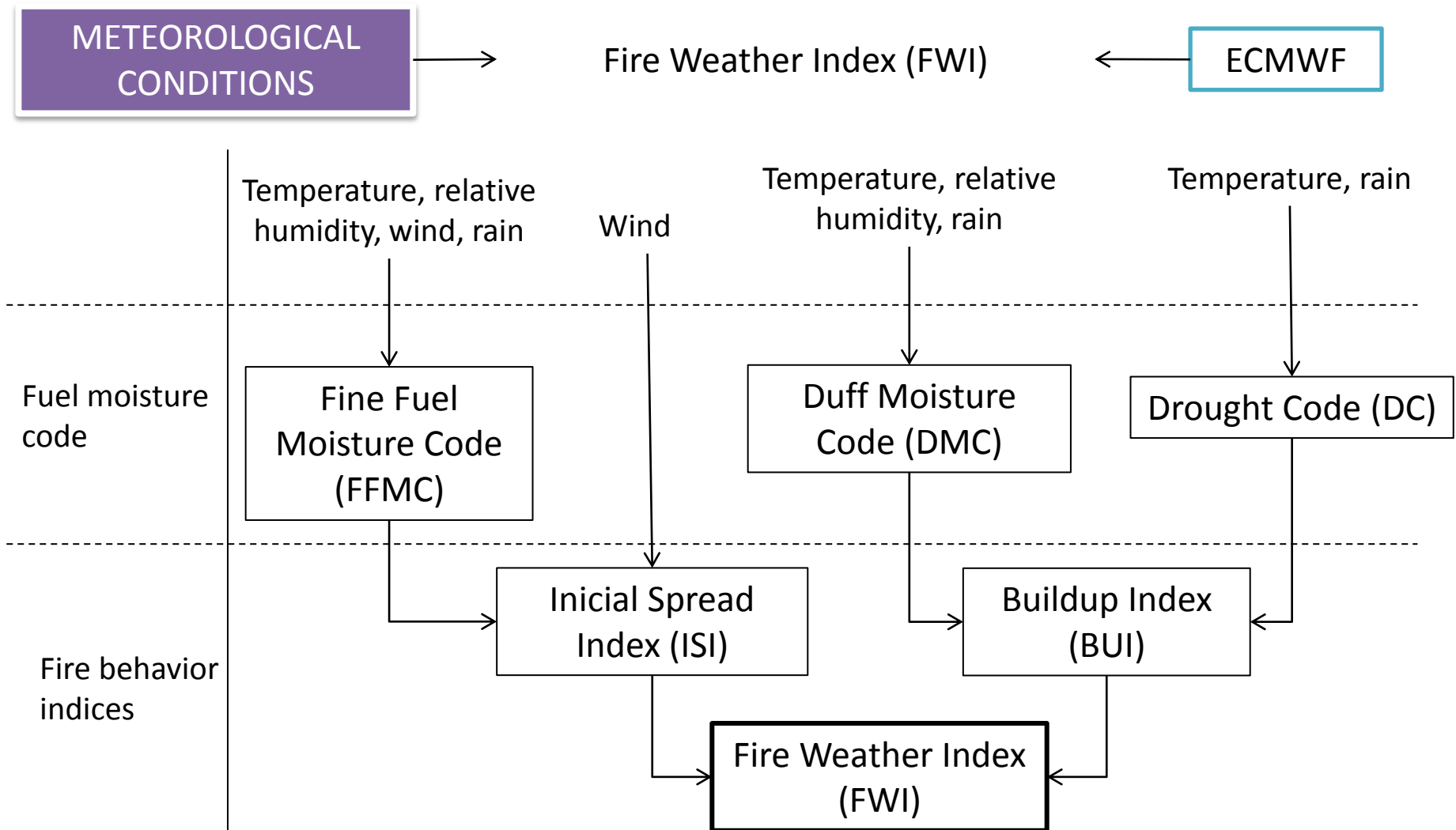
- We present a procedure that allows the operational generation of daily maps of fire danger over Mediterranean Europe.
- Generated maps are based on an integrated use of vegetation cover maps, weather data, and active fires as detected by remote sensing from space.
- The study covers the three-year period of July-August 2007 to 2009.

VEGETATION

→ Global Land Cover 2000



Geographical distribution of the three main vegetation types as derived from GLC2000.



Structure of the Canadian Forest Fire Weather Index System (CFFWIS): <http://cwfis.cfs.nrcan.gc.ca/>

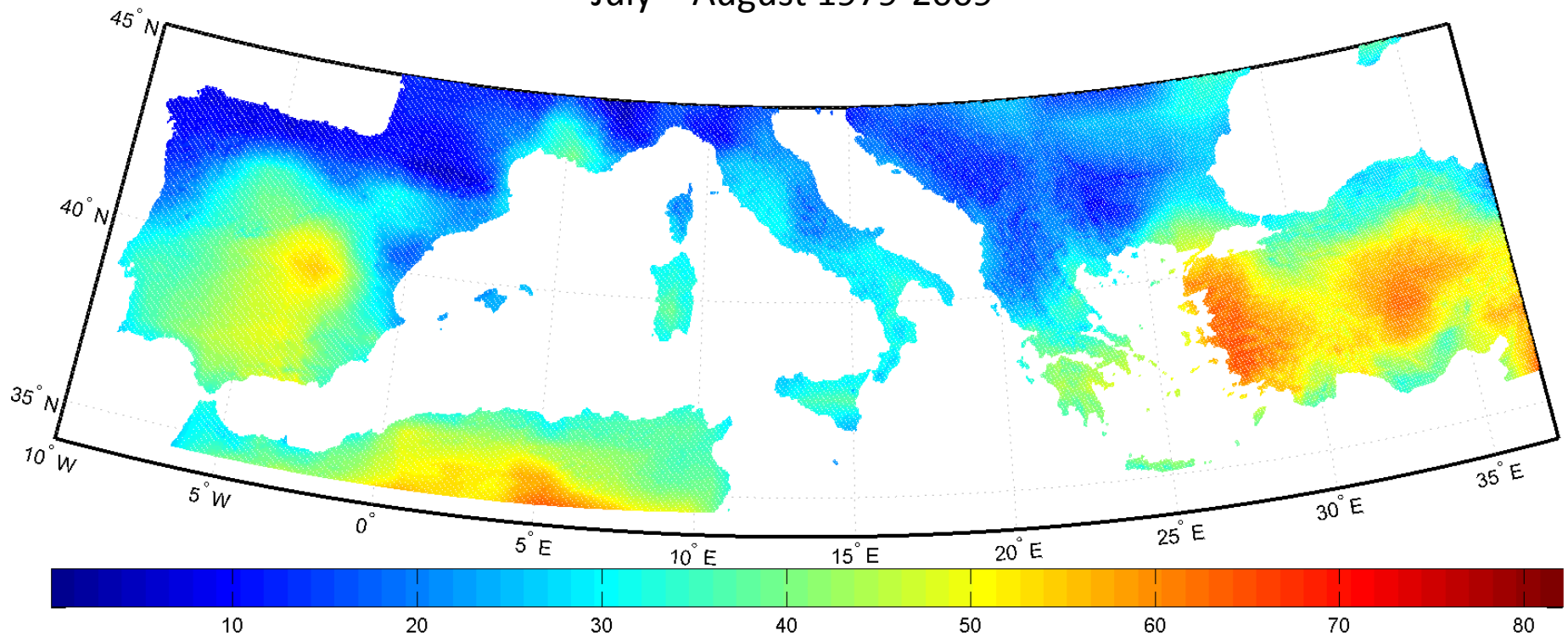
INPUT DATA

METEOROLOGICAL
CONDITIONS

Fire Weather Index (FWI)

ECMWF

July – August 1979-2009

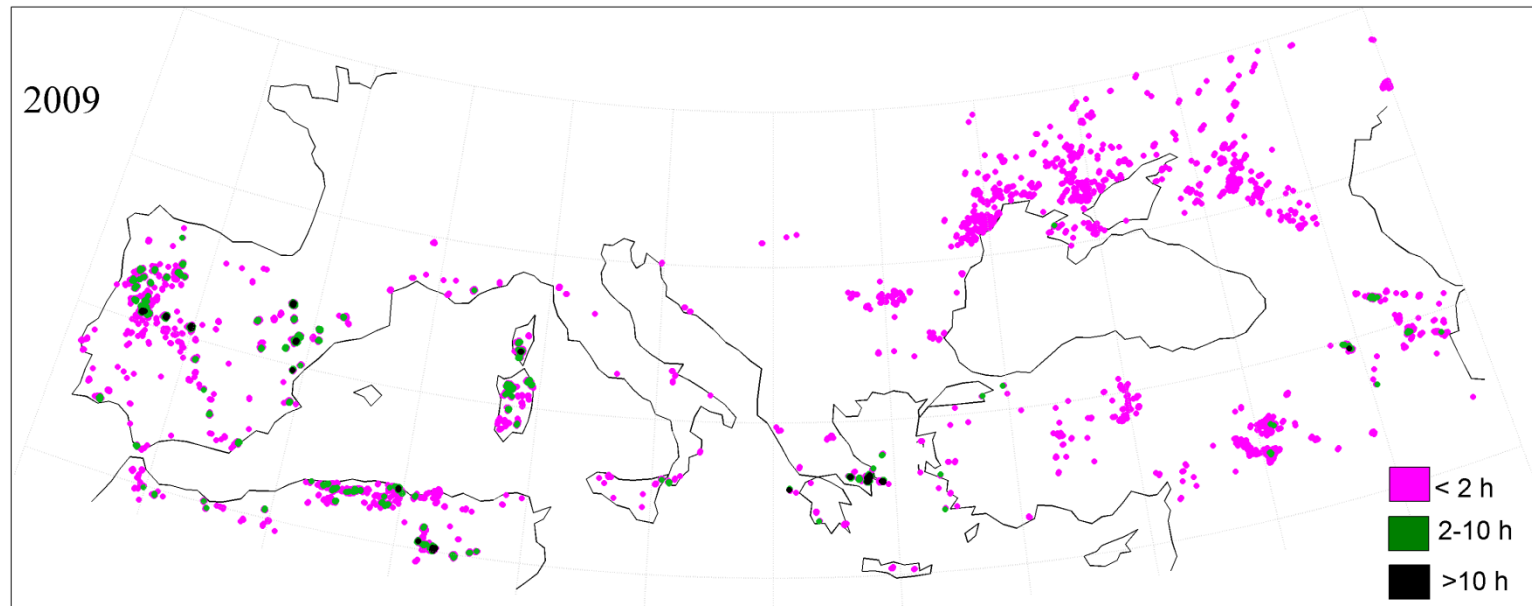


ACTIVE
FIRES

→ **Fire Detection and Monitoring (FD&M)**



Meteosat-8/SEVIRI



Fire pixels over Southern Europe during July-August of 2009. Persistence of fires is indicated by the colour of the pixel.

p : MSG pixel in the study area covering Mediterranean Europe
 d : day during the study period (July/August 2007-2009).

$1_{pd}(i)$: indicator function that is equal to one if the i^{th} MSG image has captured fire activity inside pixel p during day d and equal to zero otherwise.

Duration D_{pd} of fire activity in pixel p during day d will be defined as:

$$D_{pd} = 0.25 \times \sum_{i=1}^{96} 1_{pd}(i)$$

Duration of fire activity may vary from 0 (no fire activity detected at the considered pixel during the considered day) theoretically up to 24 h (fire counts detected in all 96 MSG images covering that day).

DURATION OF FIRE ACTIVITY



Duration of fire activity refer to the study period of July-August 2007-2009; for each class the absolute frequency is shown together with the relative frequency (% in *brackets*).

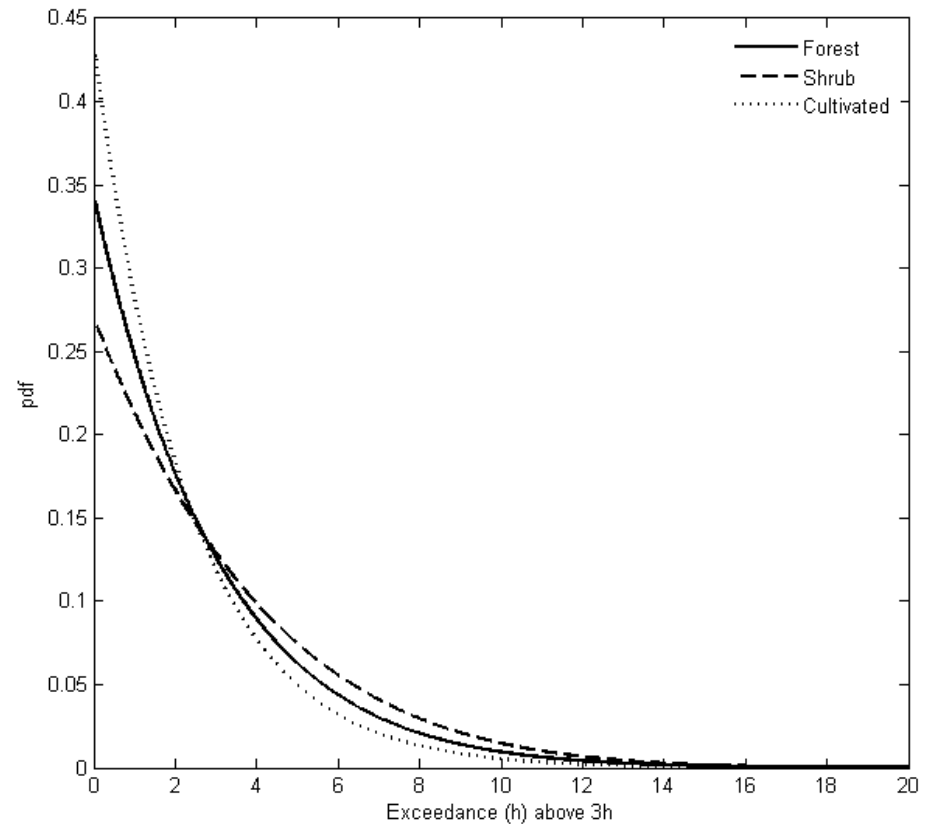
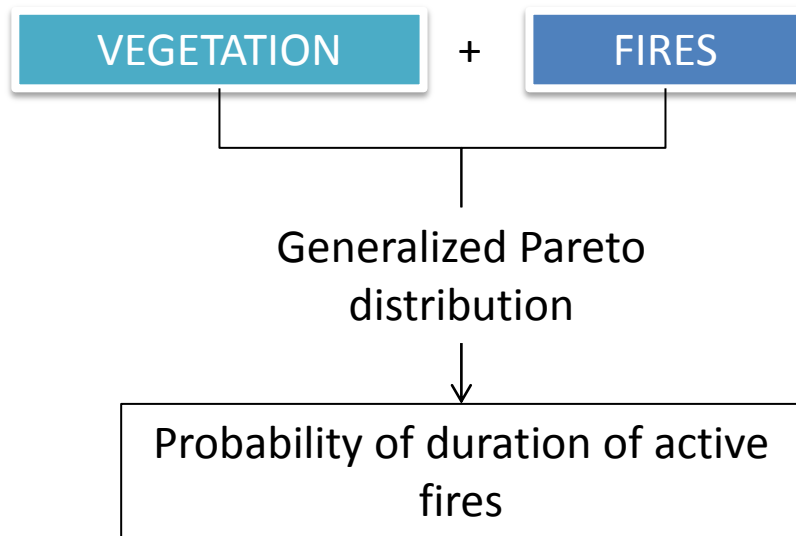
| Veg. types | Forest | Shrub | Cultivated | Total |
|------------|--------|--------|------------|---------|
| All pixels | 38 076 | 25 021 | 61 423 | 124 520 |
| [%] | [31] | [20] | [49] | [100] |
| D≤6 h | 3 708 | 2 532 | 2 323 | 8 563 |
| [%] | [43] | [30] | [27] | [100] |
| D>6 h | 182 | 185 | 31 | 398 |
| [%] | [46] | [46] | [8] | [100] |

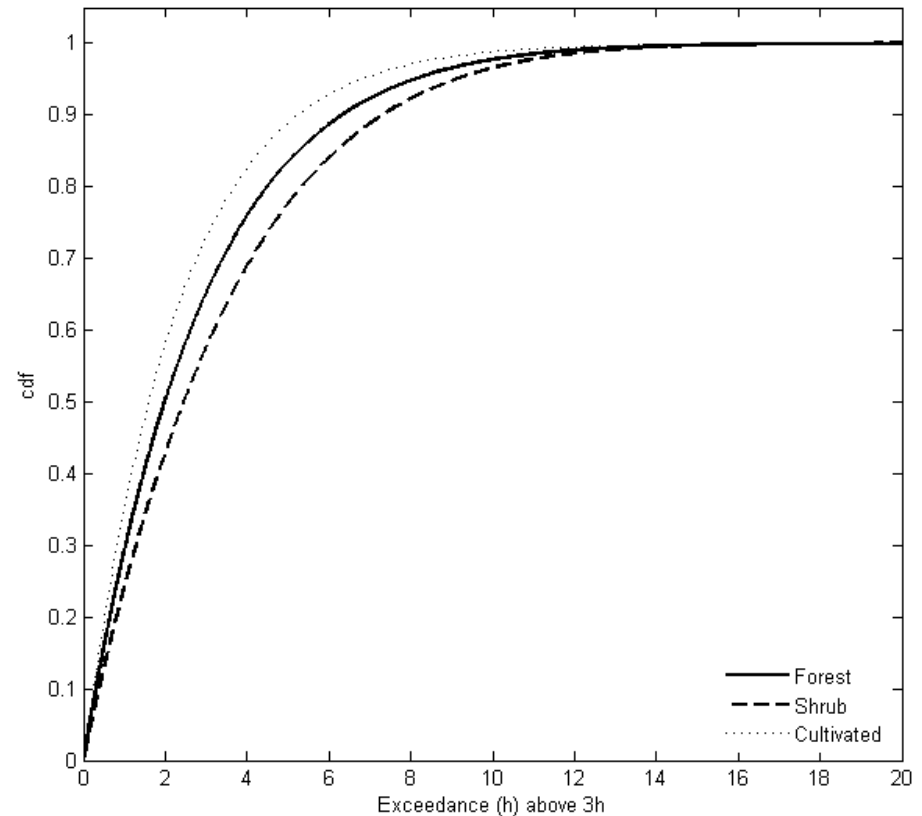
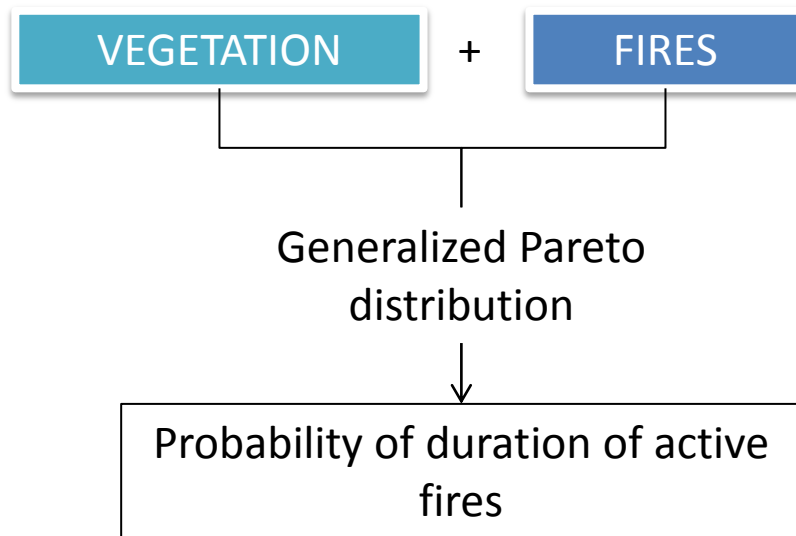
DURATION OF FIRE ACTIVITY

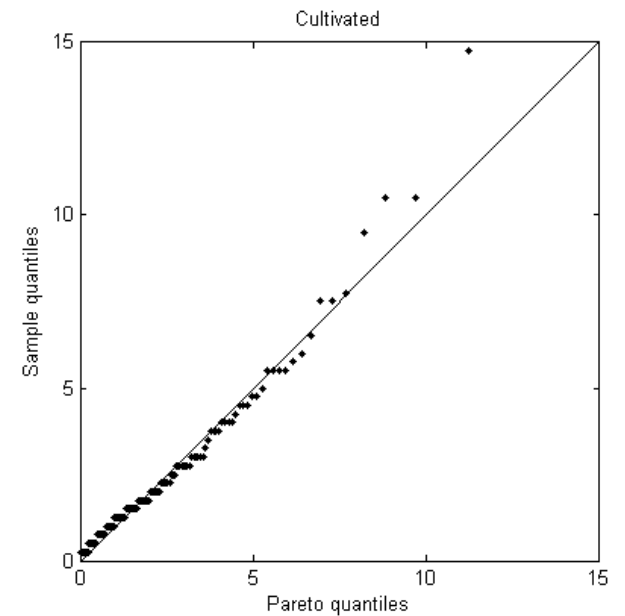
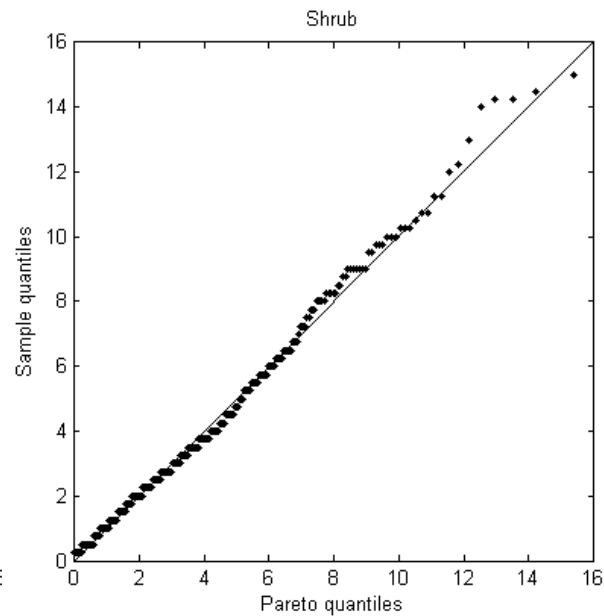
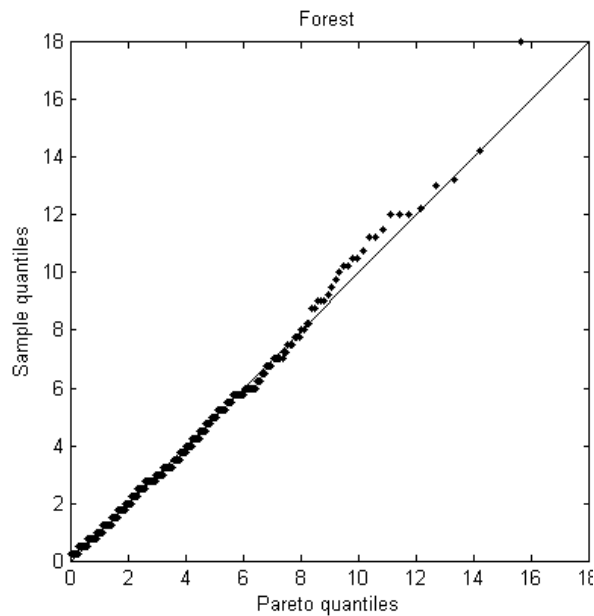
Table 2. Distribution frequencies of fire activity for the three types of vegetation.

The distributions of fire activity refer to the study period of July-August 2007-2009; for each class the absolute frequency is shown together with the relative frequency (% in *brackets*).

| Classes of duration of fire activity (h) | 0.25 to 3.00 | 3.25 to 6.00 | 6.25 to 9.00 | 9.25 to 12.00 | 12.25 to 15.00 | 15.25 to 18.00 | 18.25 to 21.00 | Total |
|--|----------------|----------------|---------------|---------------|----------------|----------------|----------------|-----------------|
| Forest | 3 321 | 387 | 128 | 34 | 15 | 4 | 1 | 3 890 |
| <i>[%]</i> | <i>[85.37]</i> | <i>[9.95]</i> | <i>[3.29]</i> | <i>[0.87]</i> | <i>[0.39]</i> | <i>[0.10]</i> | <i>[0.03]</i> | <i>[100.00]</i> |
| Shrub | 2 240 | 292 | 114 | 47 | 17 | 7 | 0 | 2 717 |
| <i>[%]</i> | <i>[82.44]</i> | <i>[10.75]</i> | <i>[4.19]</i> | <i>[1.73]</i> | <i>[0.63]</i> | <i>[0.26]</i> | <i>[0.00]</i> | <i>[100.00]</i> |
| Cultivated | 2 205 | 118 | 23 | 4 | 3 | 1 | 0 | 2 354 |
| <i>[%]</i> | <i>[93.67]</i> | <i>[5.01]</i> | <i>[0.98]</i> | <i>[0.17]</i> | <i>[0.13]</i> | <i>[0.04]</i> | <i>[0.00]</i> | <i>[100.00]</i> |





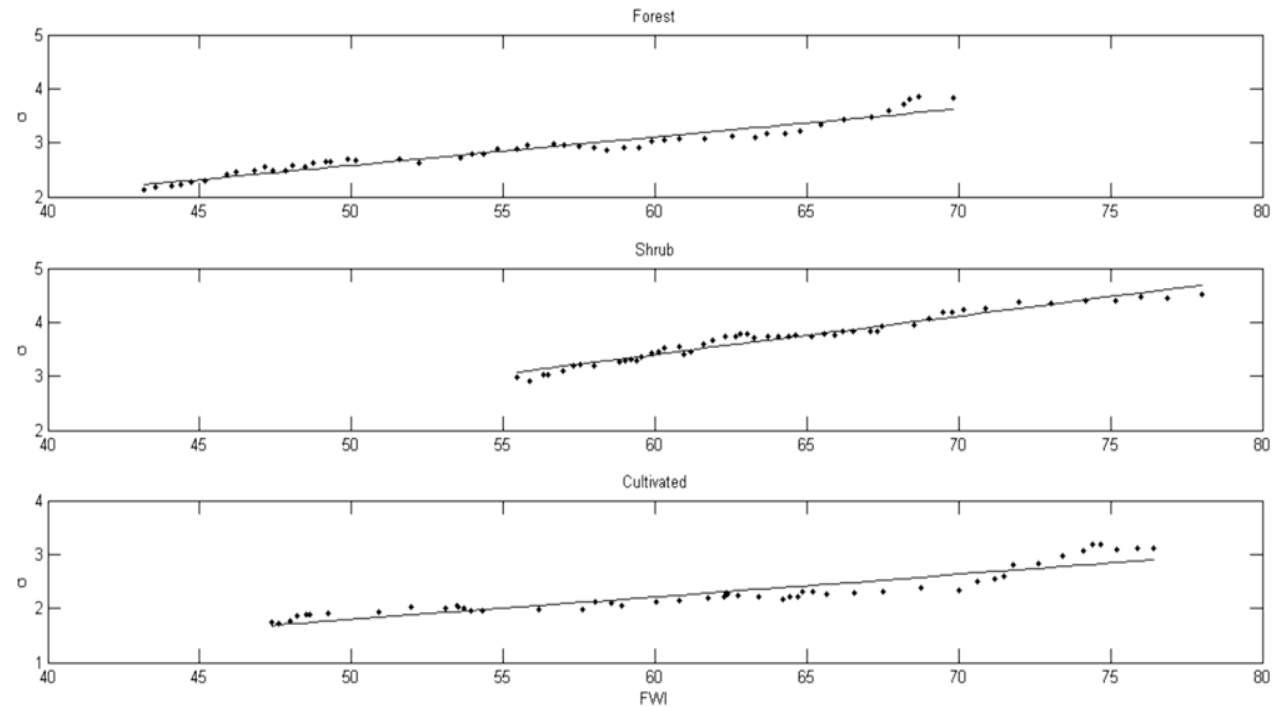


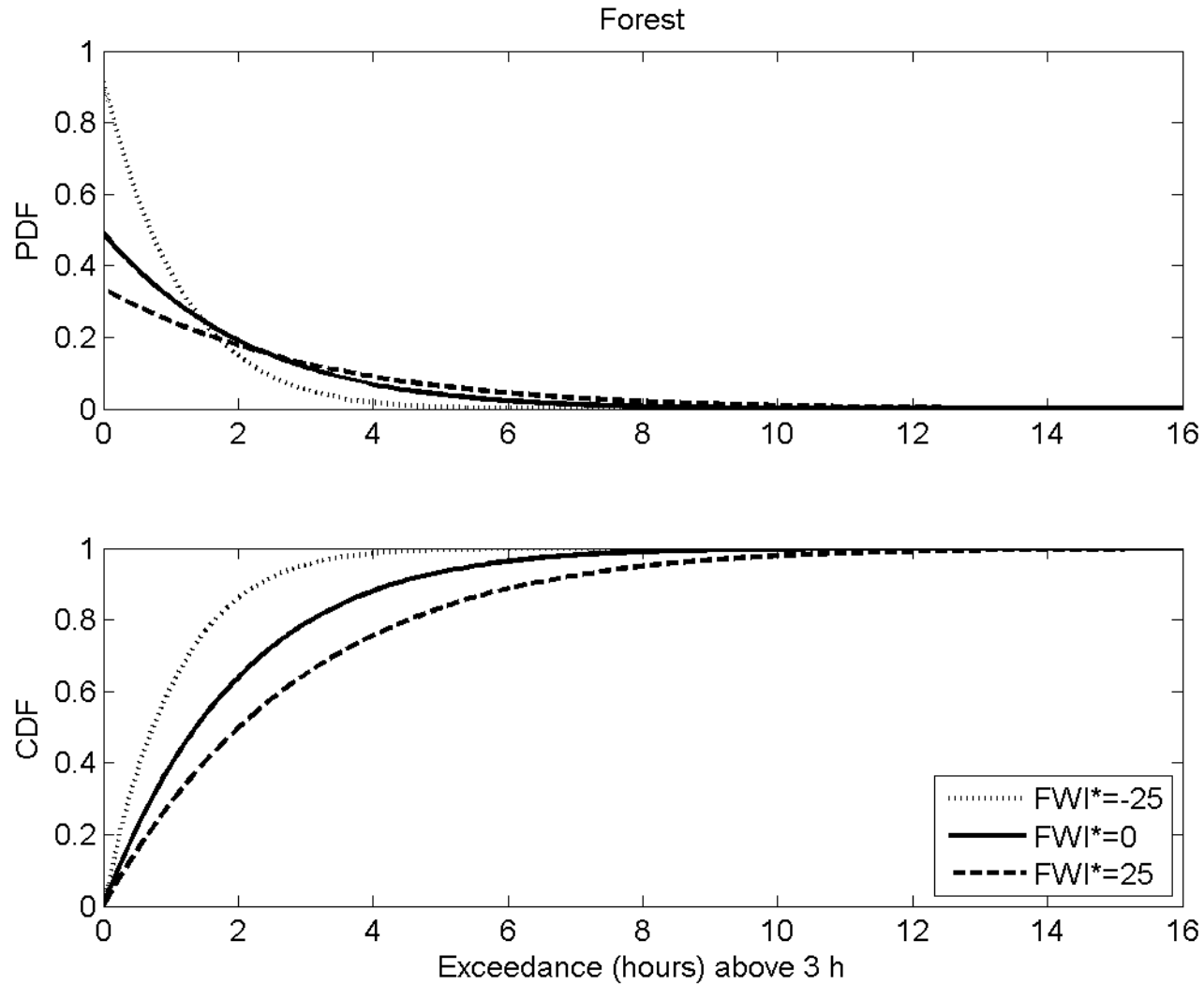
FIRES

METEOROLOGICAL
CONDITIONS

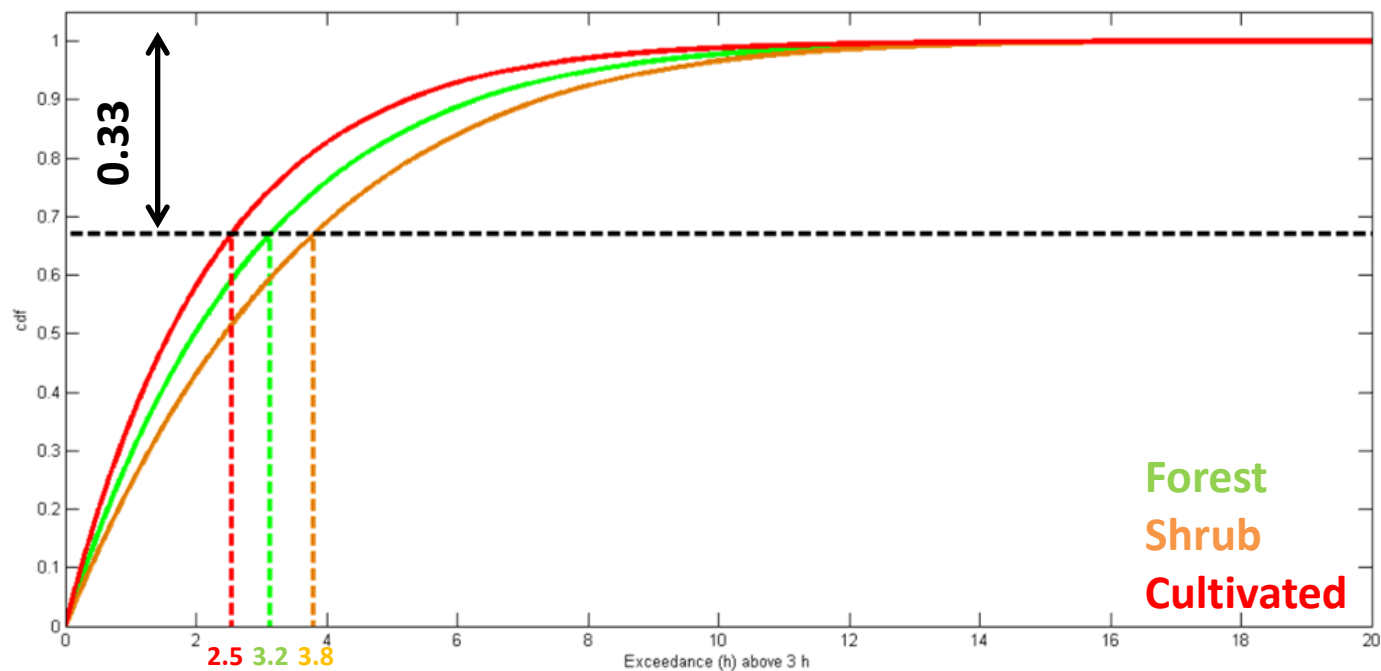
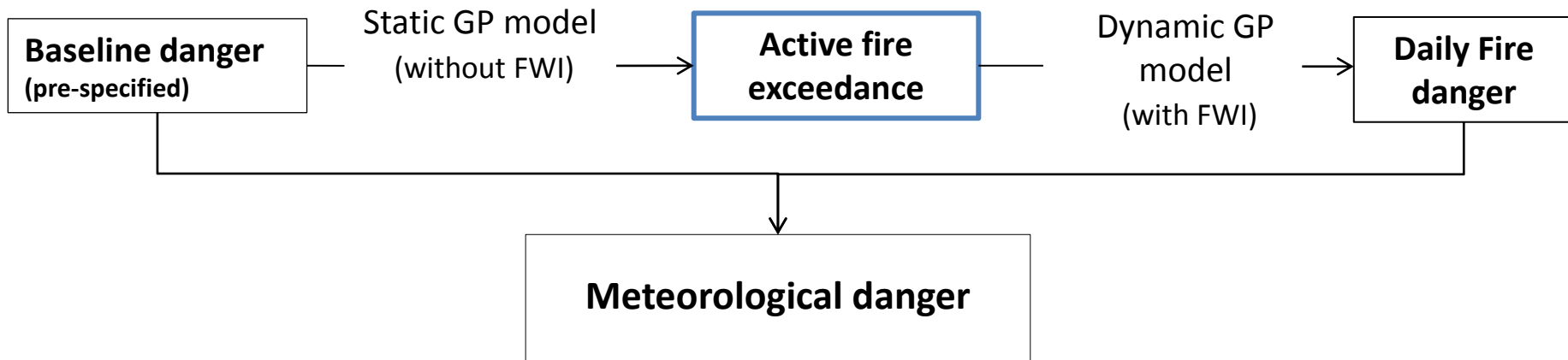
FWI

Generalised Pareto
with *FWI as covariate*

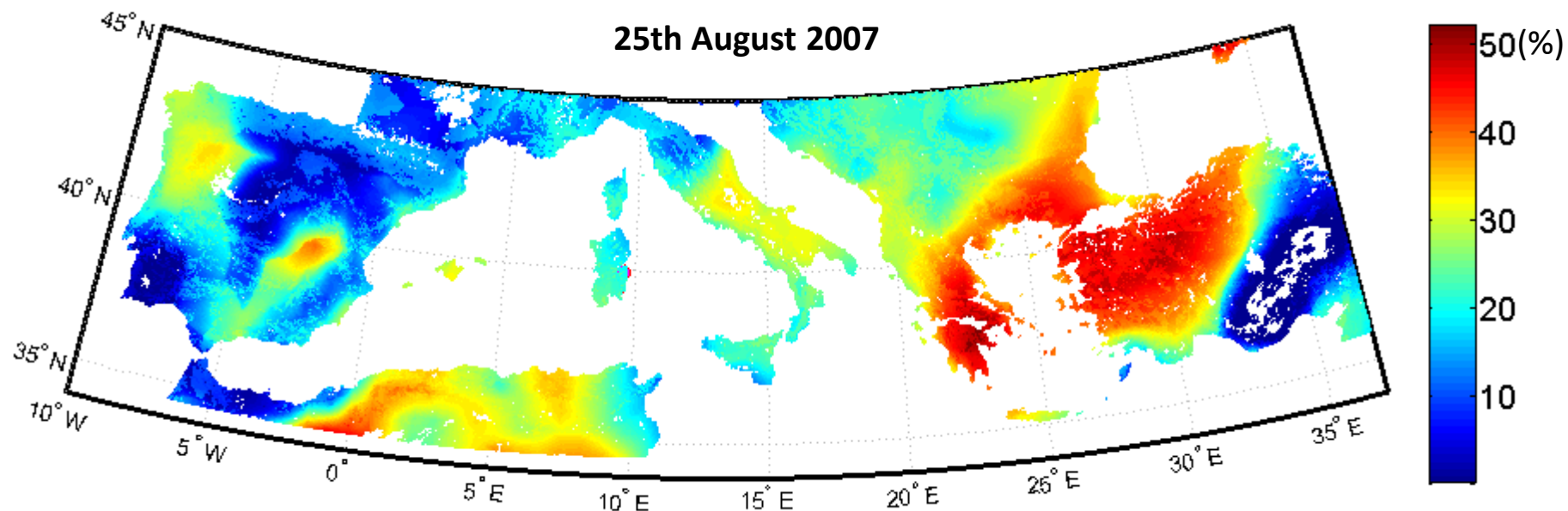
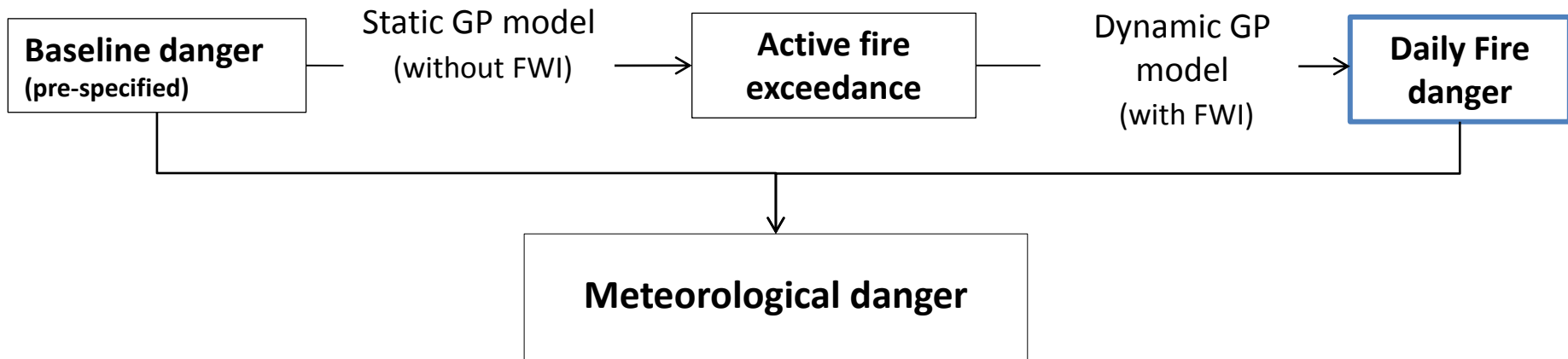




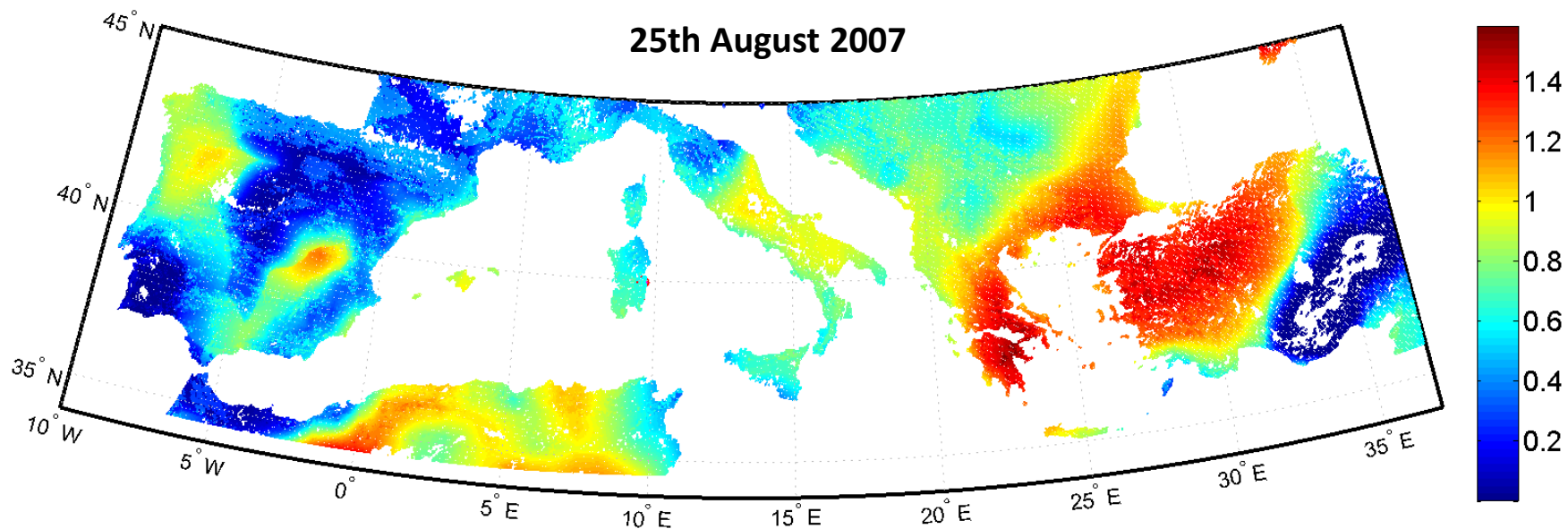
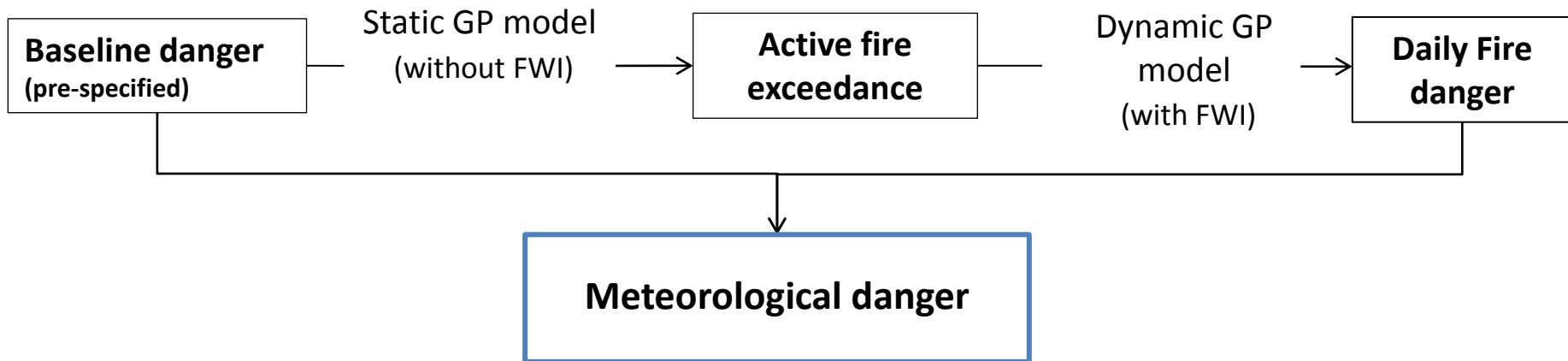
FIRE DANGER



FIRE DANGER

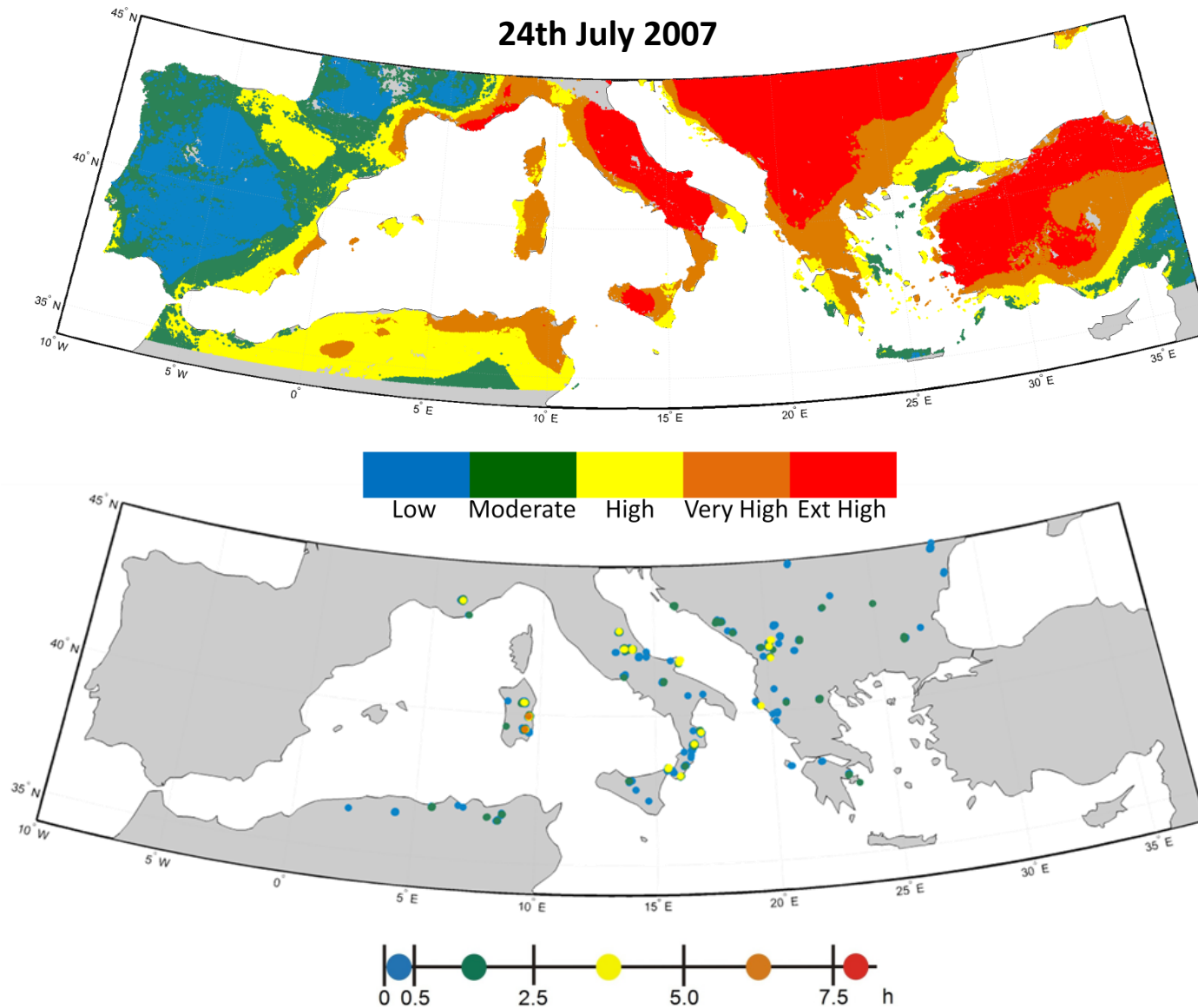


Daily Fire danger (fixed baseline danger of **33%**) for the extreme event of August 25th 2007.

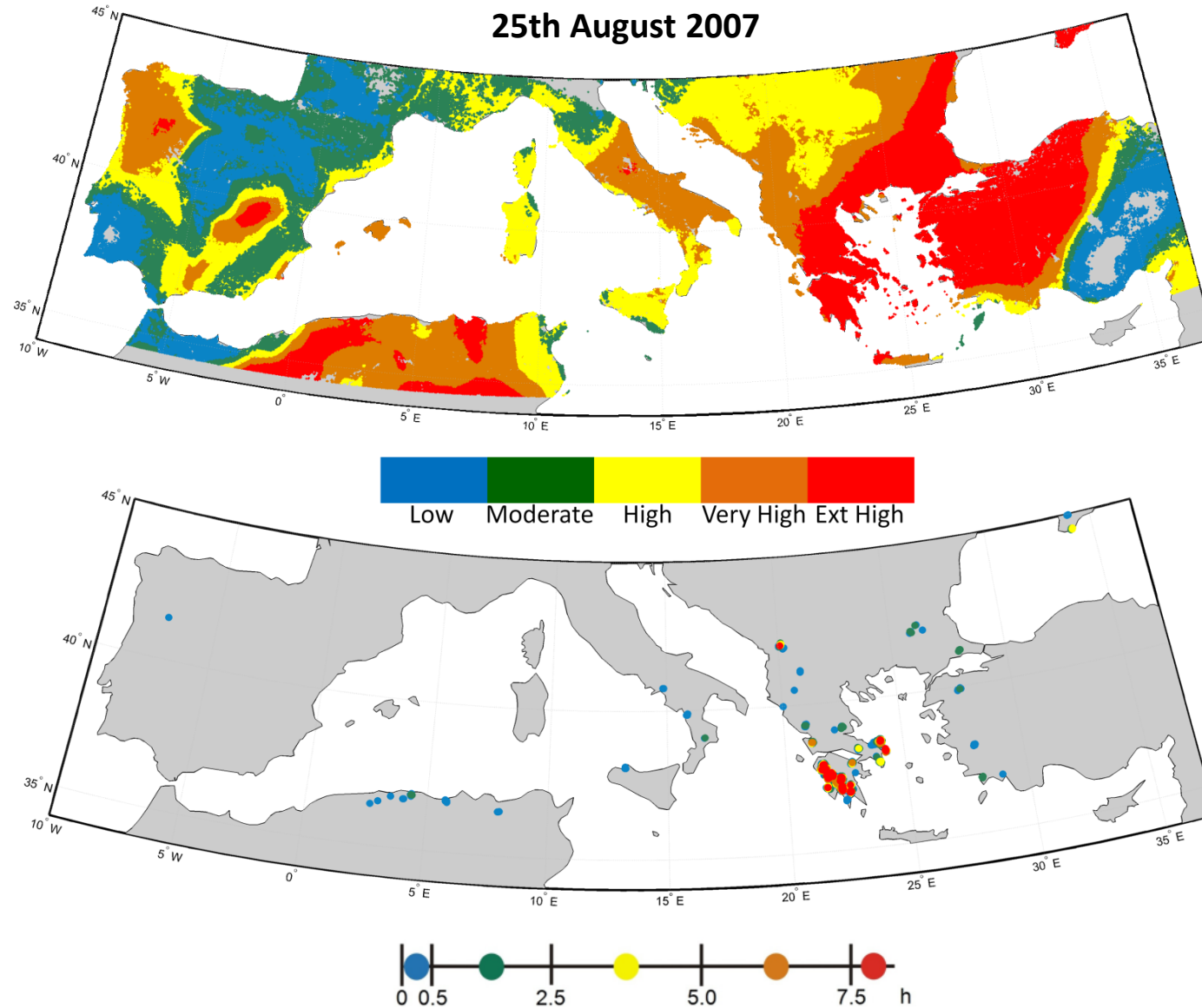


Meteorological danger(fixed baseline danger of **33%**) for the extreme event of August 25th 2007.

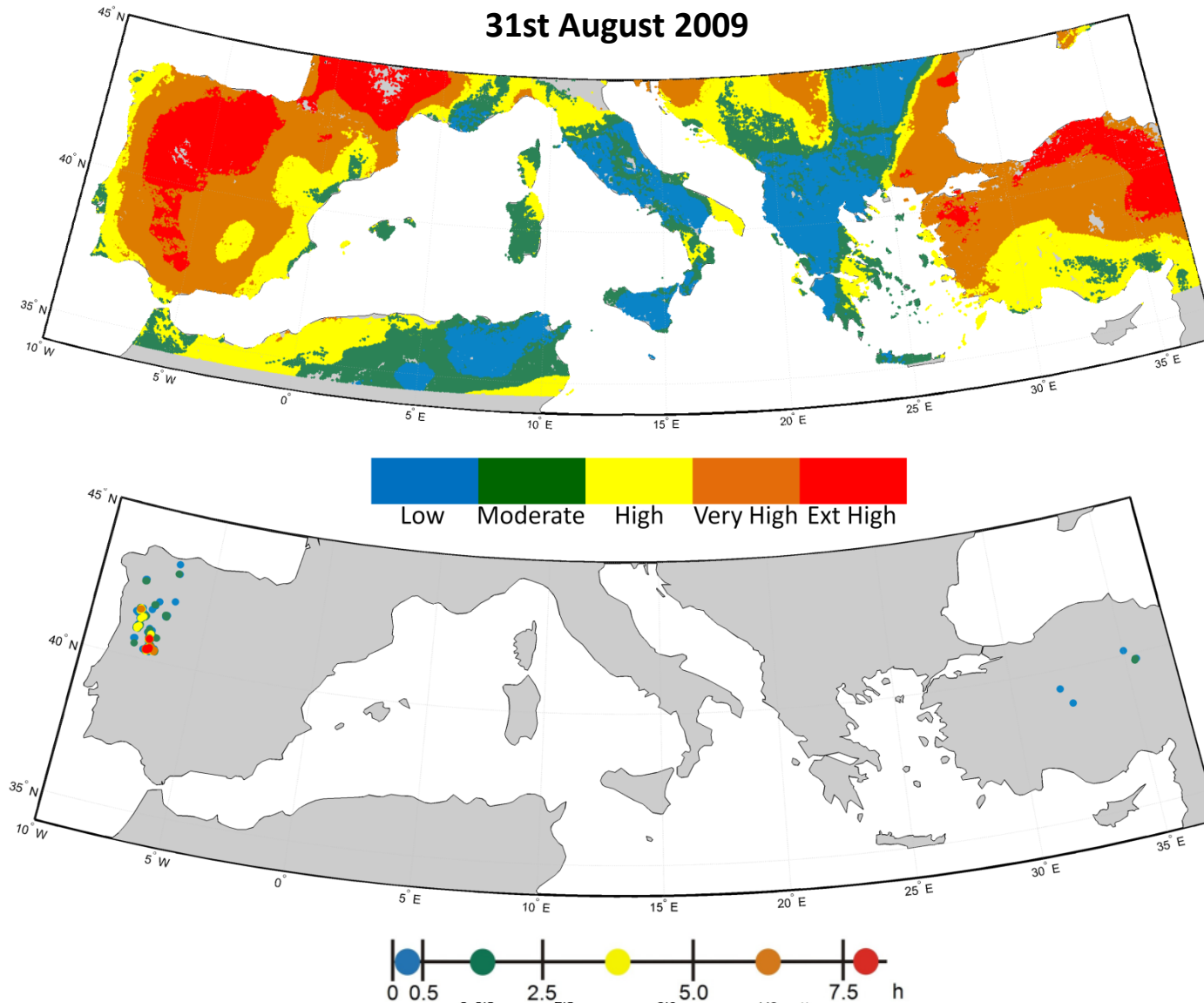
CLASSES OF FIRE DANGER



CLASSES OF FIRE DANGER



CLASSES OF FIRE DANGER



Fraction (%) of the total number of occurrences with the same duration interval

| | <=3h |]3, 6] |]6, 9] |]9, 12] |]12, 15] |]15, 18] |]18, 21] |
|----------------------|----------------|---------------|---------------|----------------|-----------------|-----------------|-----------------|
| Low | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Moderate | 99.1 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| High | 96.1 | 2.9 | 0.8 | 0.1 | 0.1 | 0.1 | 0.0 |
| Very High | 87.9 | 8,6 | 2.4 | 0.8 | 0.3 | 0.1 | 0.0 |
| Extremly High | 76.3 | 14.4 | 6.1 | 2.1 | 0.9 | 0.2 | 0.0 |

| | <=1h |]1, 2] |]2, 3] | Sum |
|----------------------|----------------|---------------|---------------|------------|
| Low | 100.0 | 0.0 | 0.0 | 100.0 |
| Moderate | 96.5 | 2.5 | 0.0 | 99.1 |
| High | 86.4 | 7.2 | 2.4 | 96.1 |
| Very High | 66.2 | 14.6 | 7.1 | 87.9 |
| Extremly High | 52.4 | 15.0 | 8.9 | 76.3 |

- Statistical models based on two-parameter Generalized Pareto (GP) distributions adequately fit the observed samples of active fire duration.
- These models are significantly improved when meteorological conditions are integrated as a covariate of scale parameters of the GP distributions.
- The procedure is on the basis of the Fire Risk Mapping (FRM) product that is currently being disseminated by the EUMETSAT Land Surface Analysis Satellite Applications Facility (LSA SAF).