Fire Danger Assessment

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Introduction

- We want to characterize in an objective form the possibility of having a fire in a given region under specific conditions.

- We assume that the risk of having a fire depends greatly on the weather conditions (climate and meteorology), but also in the vegetation cover, land use, fire management and socio economic conditions of the region.

- The risk of fire is expressed in a scale of classes:
  - low,
  - normal,
  - high,
  - very high,
  - extreme.

- The characterization of these classes is very much dependent on the properties of each region.

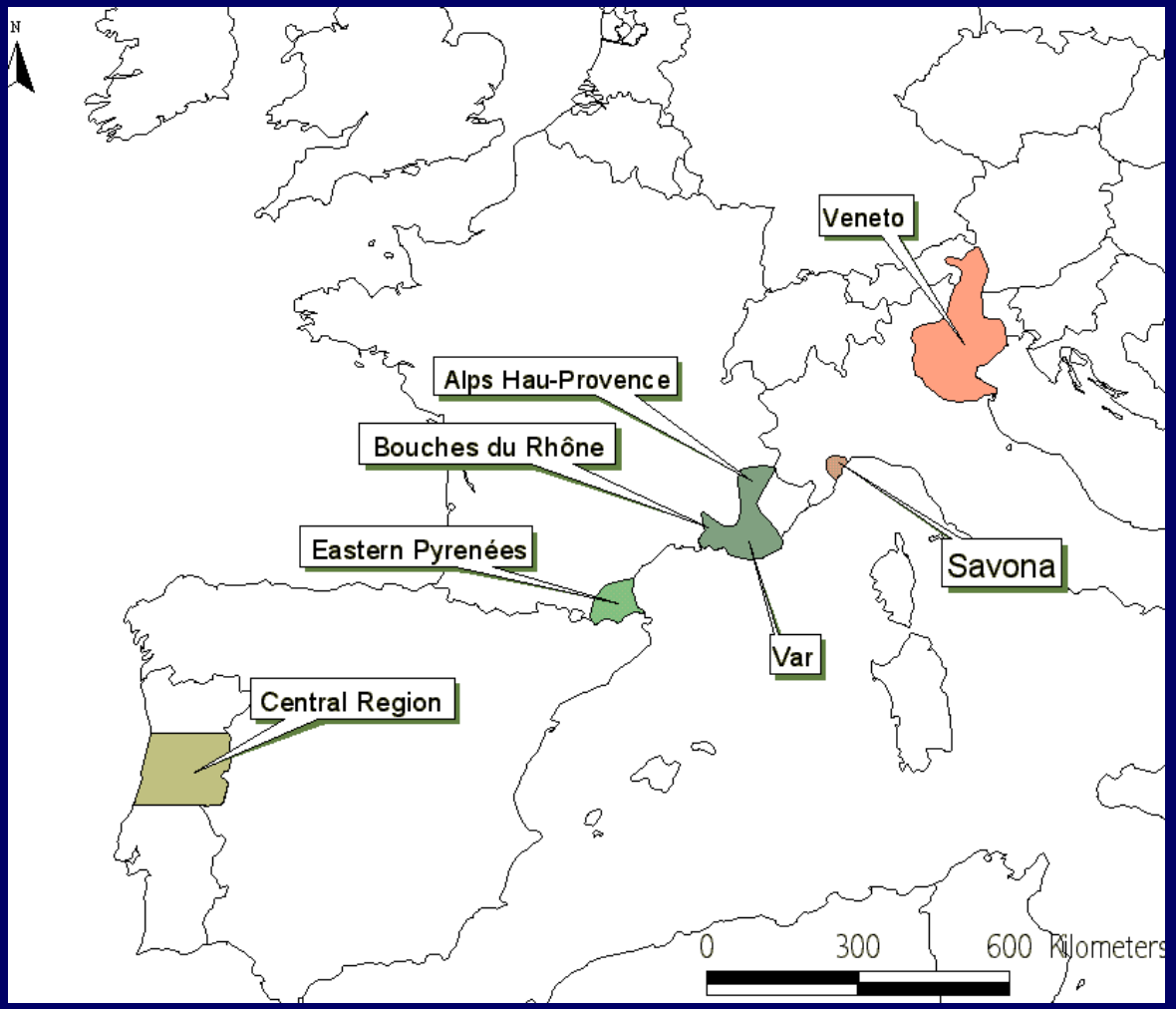
- If we are using a fire danger index based on meteorological data we have to calibrate it to take into account the specific properties of that region.

- In the first place we have to chose a method to estimate the fire danger index.

The Fire Weather Index

- There are several fire danger indexes available in the literature.
- In a study that was done in the scope of an EU project a comparative analysis between several methods to estimate the fire danger based on meteorological parameters was performed.
- We found that the best performing was the Canadian Fire Danger Rating System.

Regions that were considered in the comparative study



Methods considered in the comparative study

Country	Method	Remark
Canada	Fire Weather Index	Cumulative
France	Risque Numérique	Cumulative
Italy	IREPI	Cumulative
Portugal	Modified Nesterov Index	Cumulative
Spain	ICONA Index	Non cumulative

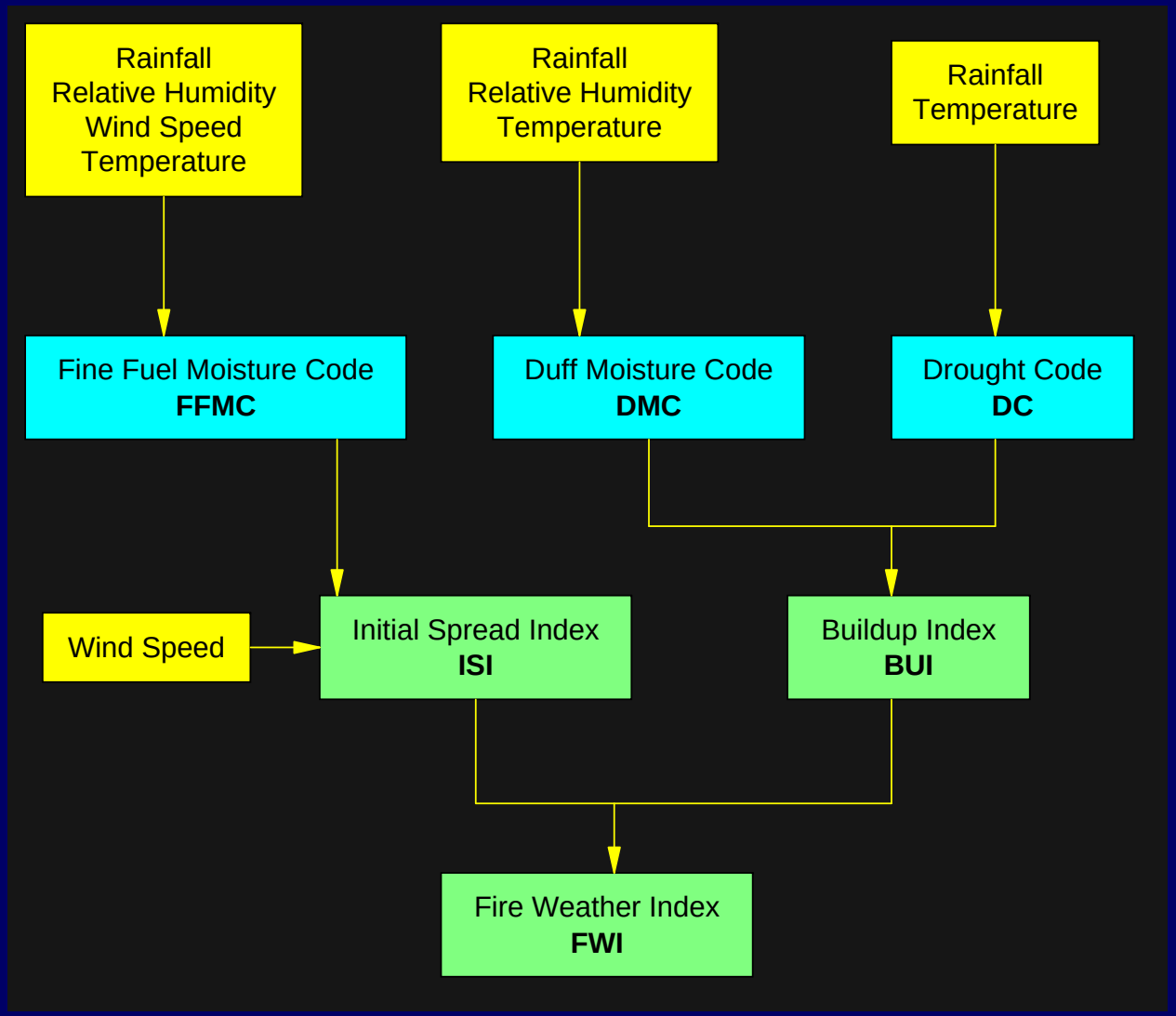
Best performing method in each region and season

Region	Season	Best Index
Veneto	Winter	Nesterov
Savona		IREPI
A. H. P.		FWI
Savona	Summer	Nesterov
B. Rhone, Var, E. Pyrenees		FWI
Central Portugal		FWI

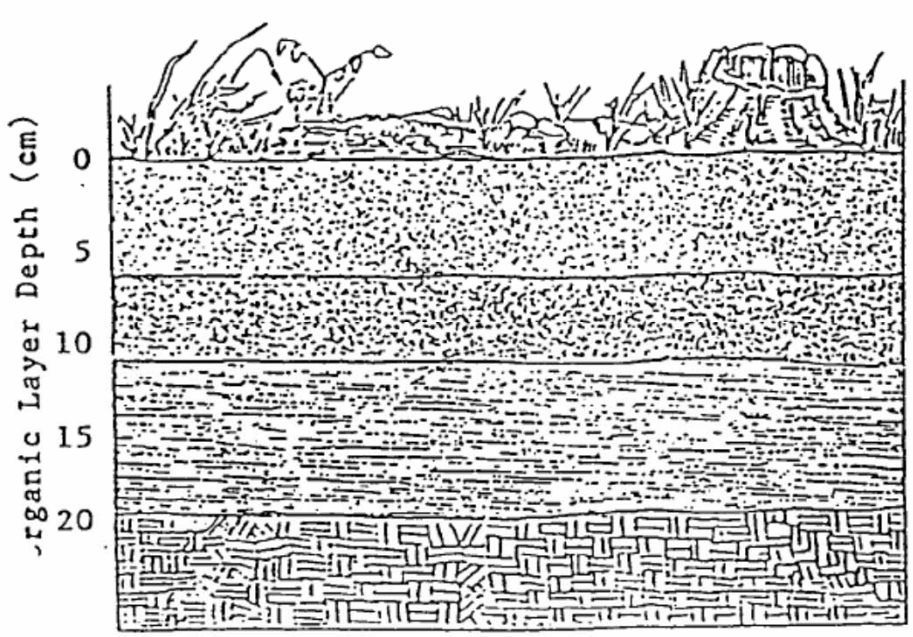
- As a consequence of this work in 1993 we recommended to the EU that the FWI be adopted as a common method in Europe. Nowadays the FWI is established as a common language both in science and in practice.

- We actually repeated this comparison in other situations with several other methods and found similar results.

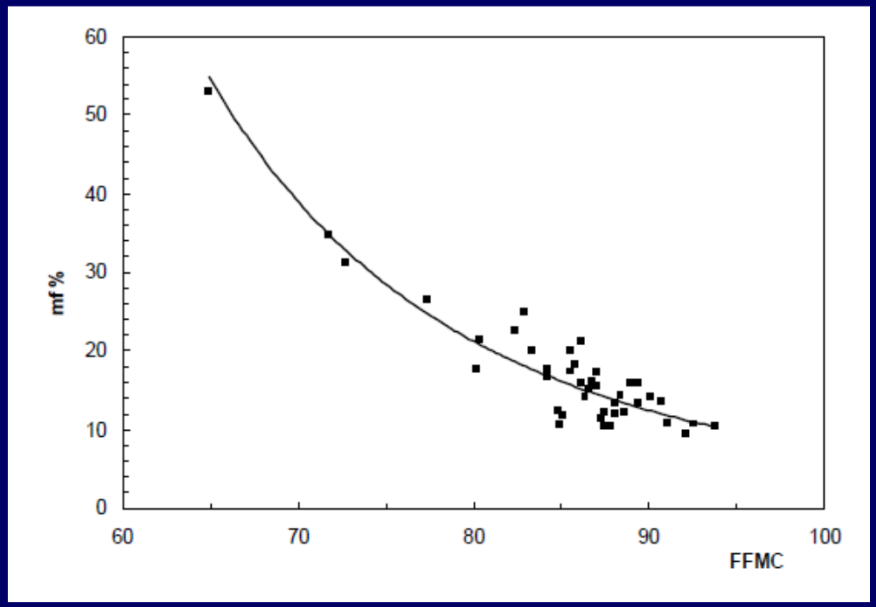
Structure of the Canadian FDR System

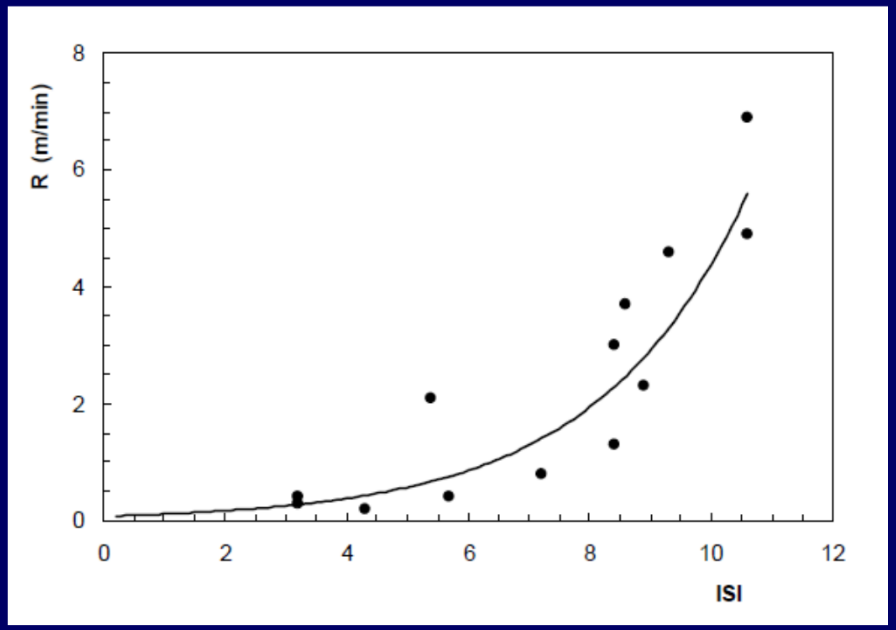


The fuel moisture codes



	Weight	Fuel Moisture Code
Duff Layer	5 t/ha	FFMC
Upper	50 t/ha	DMC
Middle		
Lower	440 t/ha	DC
Mineral Soil		

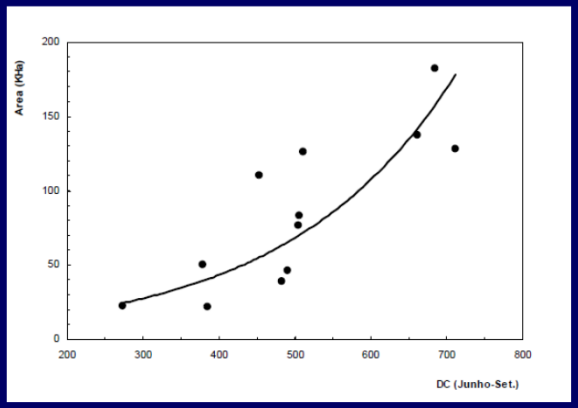




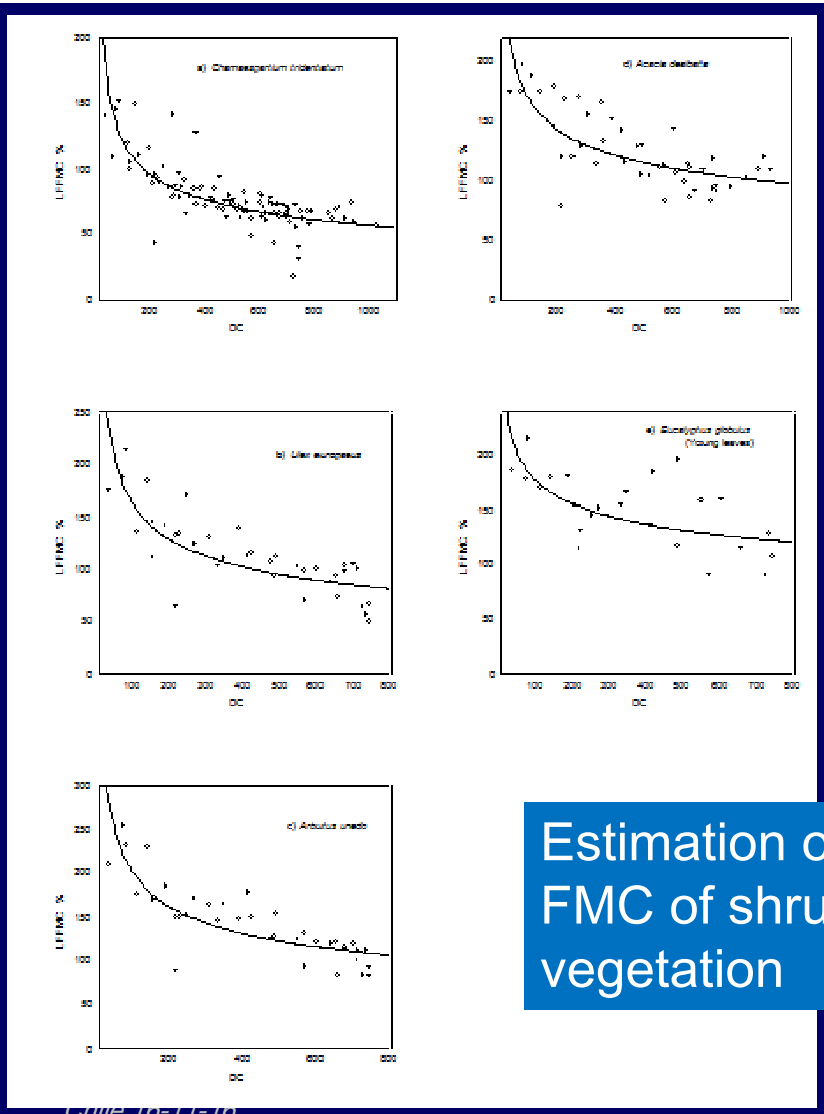
The FFMC as an estimator of dead pine needles moisture content

The ISI as an estimator of the ROS of shrub vegetation in field experiments

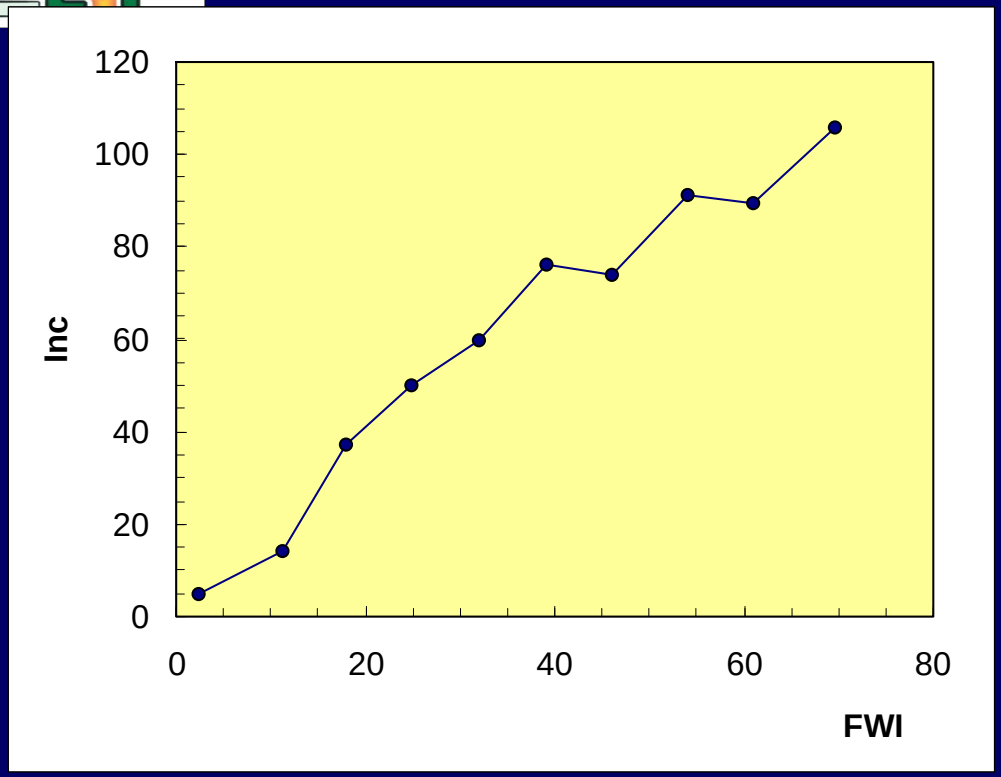
Role of DC



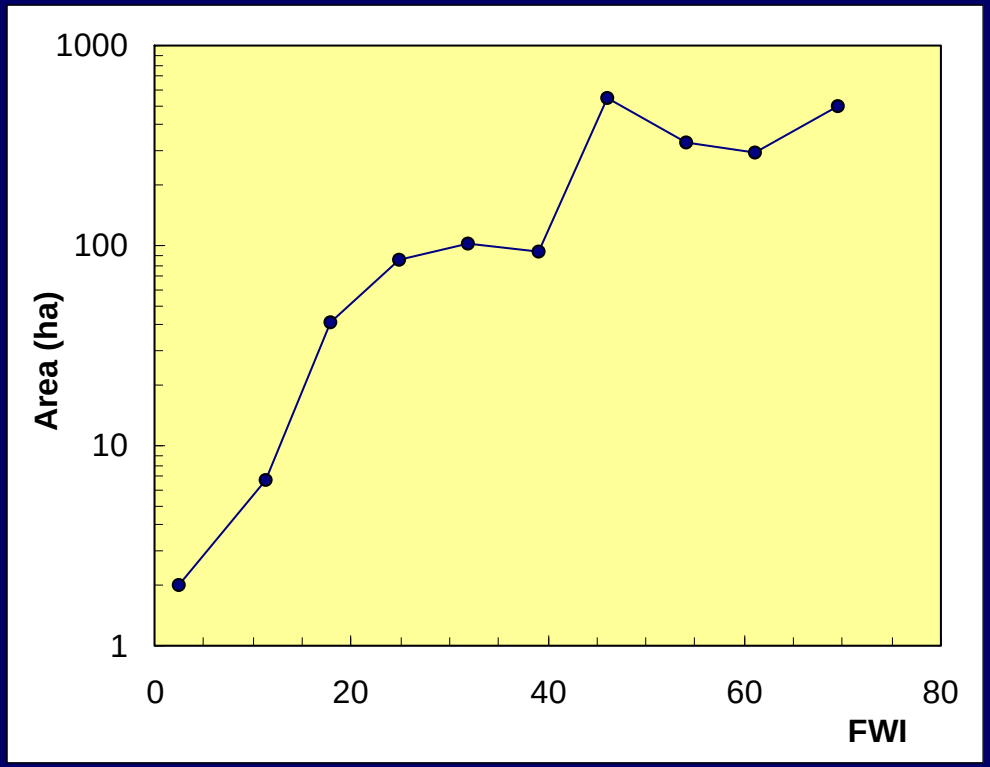
Overall assessment of the fire season



Estimation of the FMC of shrub vegetation



The FWI as an estimator of the average number of daily fires



The FWI as an estimator of the average area burned daily

FWI Class limits proposed by Van Wagner

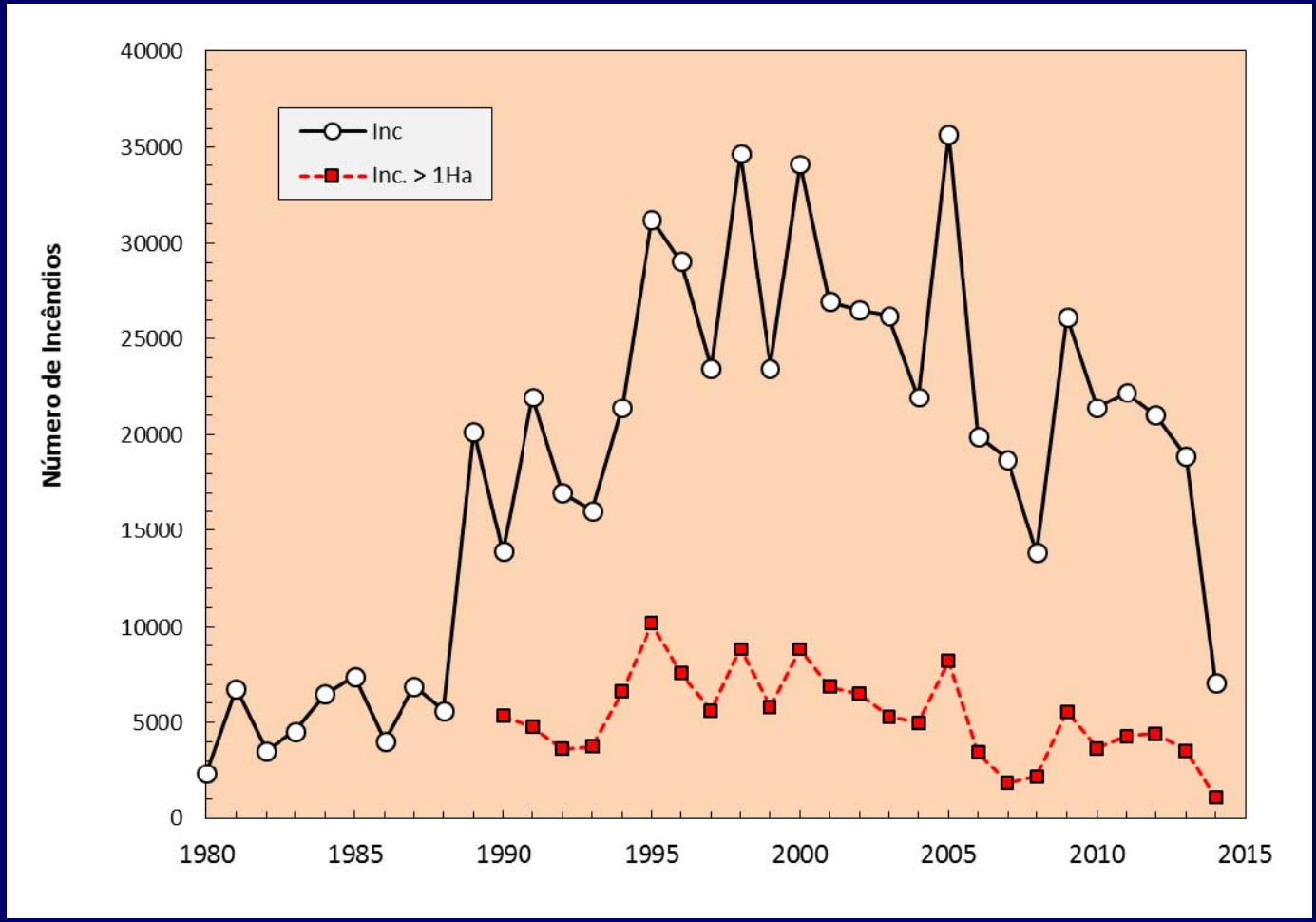
	1974		1987	
	From	*To*	*From*	*To*
Very Low	0	1	0	1
Low	2	5	2	4
Moderate	6	12	5	8
High	13	24	9	16
Very High			17	29
Extreme	25		30	

Calibration of the FWI

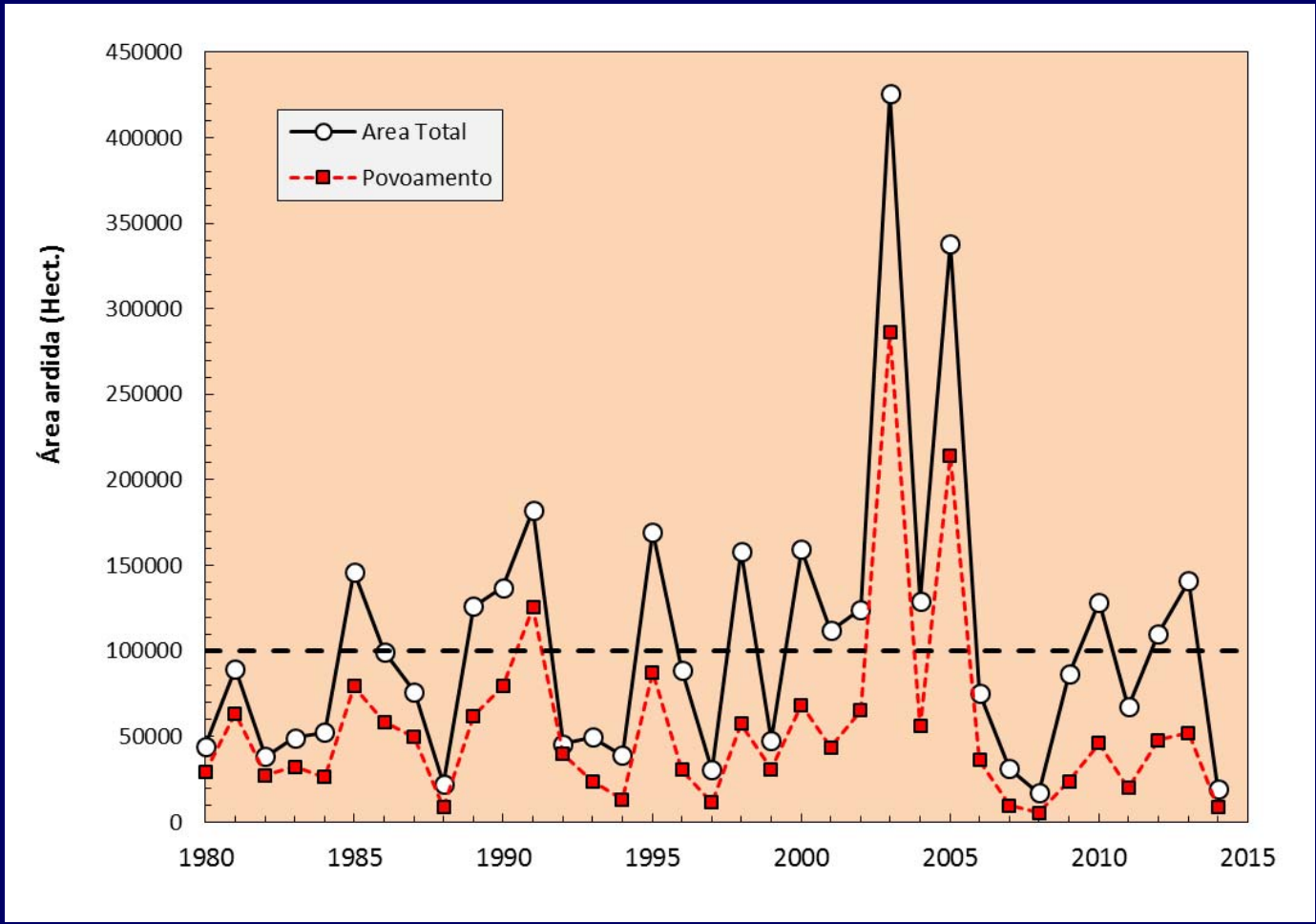
- In order to calibrate the FWI we propose to use historical data on fire occurrence (number of daily fires and burned area) in the same region.

- These data incorporate most of the structural factors: land cover, fire activity, fire management and suppression capacity, etc.

Number of fires per year in Portugal from 1980 to2014



Burned area per year in Portugal from 1980 to 2014

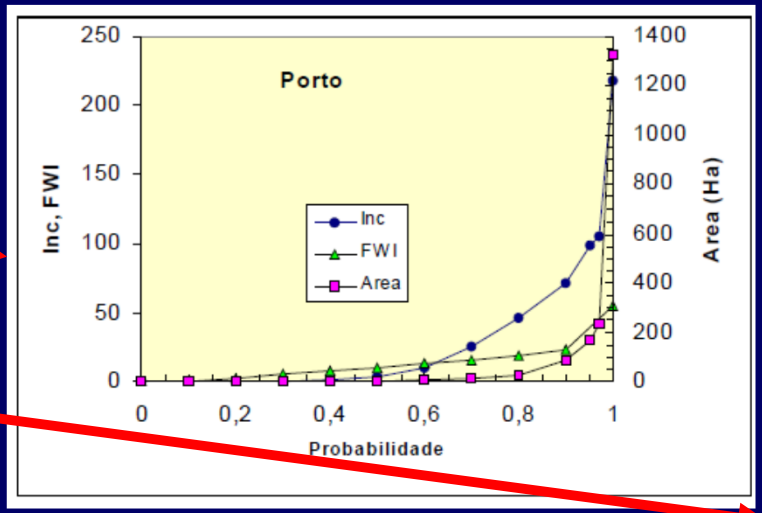


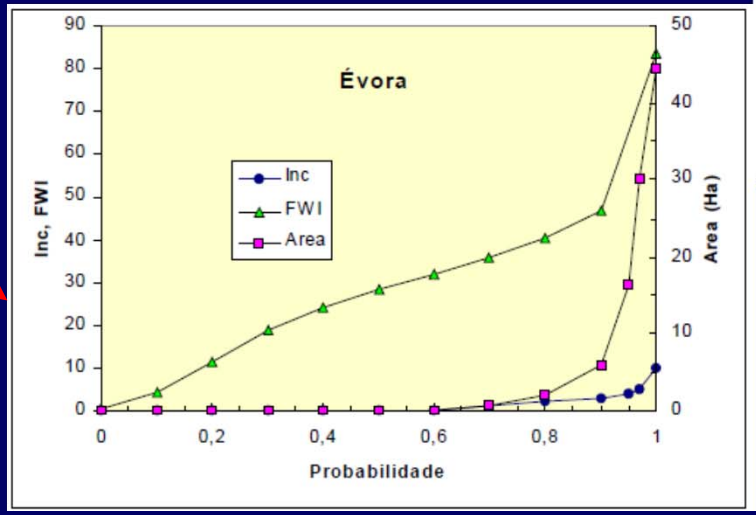
Calibration for Portugal at District level in 1999

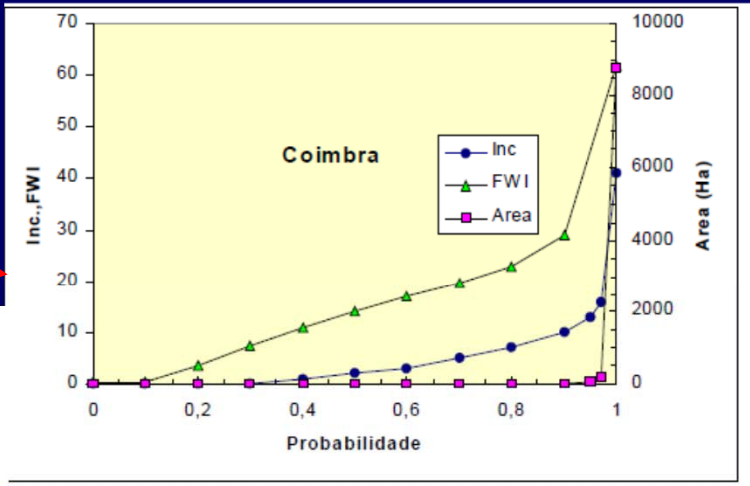
Distrito	Estação	Distrito	Estação
V. Castelo	V. Castelo	Coimbra	Coimbra/Cernache
Braga	Porto/ PR	Leiria	Coimbra/Cernache
Porto	Porto/ PR	Santarém	Lisboa/GC
Aveiro	Porto/ PR	Lisboa	Lisboa/GC
V. Real	V. Real	Setúbal	Lisboa/GC
Bragança	Bragança	Portalegre	Portalegre
Viseu	Viseu/ CC	Évora	Évora/ CC
Guarda	P. Douradas	Beja	Beja
C. Branco	C. Branco	Faro	Faro/ Aerop.

Data from 15 May to 15 Sept. of 1988 to 1996


Viana do Castelo
Braga
Vila Real
Bragança
Aveiro
Viseu
Guarda
Coimbra
Castelo Branco
Leiria
Santarém
Portalegre
Lisboa
Évora
Setúbal
Beja
Faro
N
0 25 50 100
Km
Legenda
Portugal Continetal por Distri
Espanha por Regiões


Porto
Inc
FWI
Area
Inc, FWI
Area (Ha)
Probabilidade
0
50
100
150
200
250
0
200
400
600
800
1000
1200
1400
0
0,2
0,4
0,6
0,8
1


Évora
Inc
FWI
Area
Inc, FWI
Area (Ha)
Probabilidade
0
10
20
30
40
50
60
70
80
90
0
10
20
30
40
50
0
0,2
0,4
0,6
0,8
1


Coimbra
Inc
FWI
Area
Inc.,FWI
Area (Ha)
Probabilidade
0
10
20
30
40
50
60
70
0
2000
4000
6000
8000
10000
0
0,2
0,4
0,6
0,8
1

PERCENTILE VALUES USED FOR THE INITIAL STEP

Code	Weather station
1	<40
2	60
3	80
4	95
5	>95

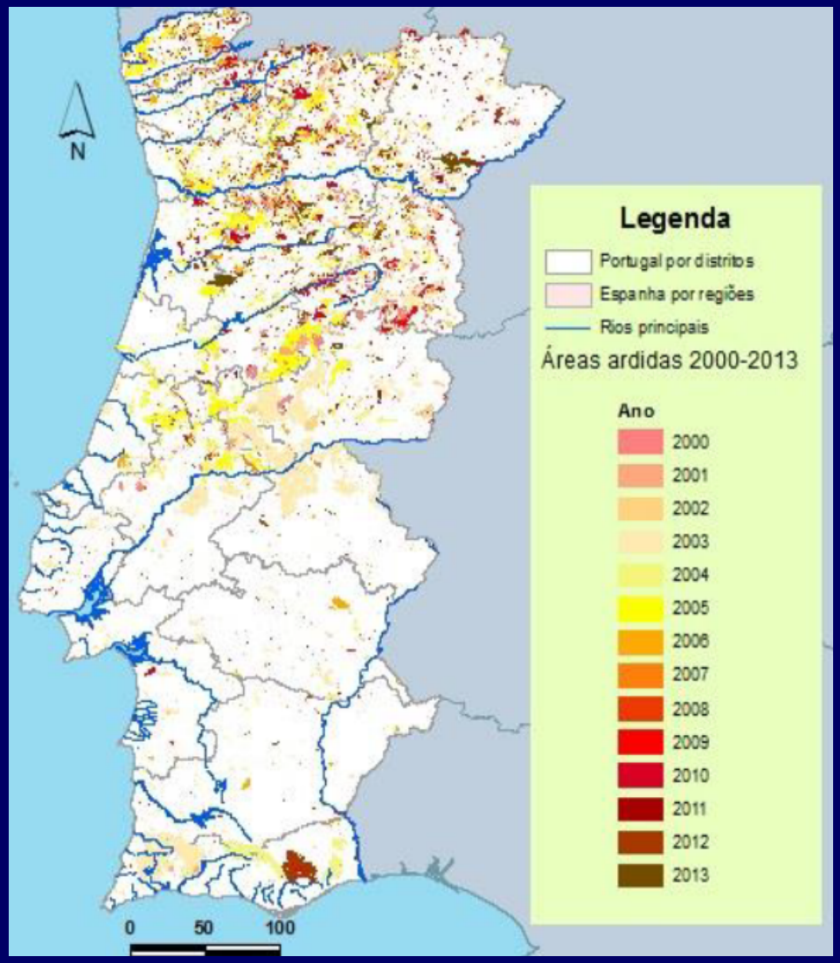
Ref.	District	1988-96			
		1	2	3	4
		L	*M*	*H*	*VH*
1	Viana do Castelo	15	20	30	40
2	Braga	5	20	30	40
3	Porto	8	20	25	40
4	Vila Real	25	40	50	65
5	Bragança	25	30	40	45
6	Aveiro	5	10	20	35
7	Viseu	20	30	47	55
8	Guarda	10	25	45	60
9	Coimbra	17	23	30	46
10	Leiria	5	20	35	55
11	Castelo Branco	30	35	45	60
12	Lisboa	25	40	50	60
13	Santarem	25	40	60	70
14	Setubal	20	30	40	45
15	Portalegre	40	65	70	85
16	Évora	36	47	65	75
17	Beja	20	50	60	90
18	Faro	15	45	80	95

Calibration for Portugal in 2015

- In 2015 a new calibration was performed using a new set of data from a different period and many more weather data.

- The same methodology for calibration was used in this study as well.

Burned areas in Portugal in the period from 2000 to 2013



Weather stations that were taken into consideration in the second calibration.

The FWI was calculated for the Geometrical center of each District using interpolation of meteorological data from nearby stations.

Nº	Nome	Distrito	Nº	Nome	Distrito
551	Viana do Castelo	Viana do Castelo	718	Leiria A	Leiria
605	Monção	Viana do Castelo	716	Ansião	Leiria
604	Vila Nova de Cerveira	Viana do Castelo	726	Alcobaça	Leiria
606	Melgaço	Viana do Castelo	570	Castelo Branco	Castelo Branco
615	Ponte de Lima	Viana do Castelo	806	Proença-a-Nova	Castelo Branco
622	Braga	Braga	803	Idanha-a-Nova	Castelo Branco
630	Cabeceiras de Basto	Braga	687	Covilhã	Castelo Branco
545	Matosinhos	Porto	532	Sintra BA	Lisboa
546	Vila Nova de Gaia	Porto	739	Torres Vedras	Lisboa
567	Vila Real	Vila Real	734	Alpiarça	Santarém
616	Chaves	Vila Real	729	Rio Maior	Santarém
611	Montalegre	Vila Real	744	Coruche	Santarém
575	Bragança	Bragança	724	Tomar	Santarém
632	Mirandela	Bragança	812	Abrantes	Santarém
635	Miranda do Douro	Bragança	571	Portalegre	Portalegre
637	Mogadouro	Bragança	835	Elvas	Portalegre
800	Torre de Moncorvo	Bragança	558	Évora	Évora
702	Aveiro	Aveiro	837	Estremoz	Évora
544	Ovar	Aveiro	770	Setúbal	Setúbal
705	Anadia	Aveiro	766	Barreiro	Setúbal
685	Nelas	Viseu	776	Alcácer do Sal	Setúbal
568	Manteigas	Guarda	541	Santiago do Cacém	Setúbal
671	Almeida	Guarda	562	Beja	Beja
666	Trancoso	Guarda	863	Mértola VF	Beja
683	Guarda	Guarda	864	Castro Verde	Beja
560	Pampilhosa da Serra	Coimbra	850	Amareleja	Beja
548	Coimbra CE	Coimbra	554	Faro	Faro

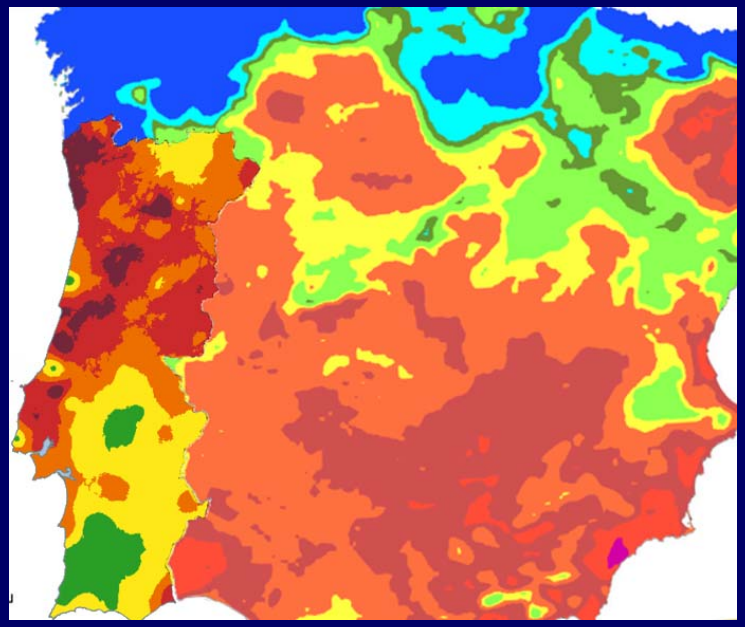
Results from the two calibrations

Ref.	District	1988-96				2000-12			
		1	2	3	4	1	2	3	4
		L	*M*	*H*	*VH*	*L*	*M*	*H*	*VH*
1	Viana do Castelo	15	20	30	40	10	15	30	45
2	Braga	5	20	30	40	10	15	30	45
3	Porto	8	20	25	40	8	15	25	40
4	Vila Real	25	40	50	65	13	20	30	50
5	Bragança	25	30	40	45	23	30	45	55
6	Aveiro	5	10	20	35	10	17	23	40
7	Viseu	20	30	47	55	15	25	45	70
8	Guarda	10	25	45	60	8	15	25	50
9	Coimbra	17	23	30	46	15	22	30	45
10	Leiria	5	20	35	55	15	25	30	50
11	Castelo Branco	30	35	45	60	20	35	45	60
12	Lisboa	25	40	50	60	25	35	50	70
13	Santarem	25	40	60	70	25	33	50	60
14	Setubal	20	30	40	45	30	40	55	70
15	Portalegre	40	65	70	85	35	50	65	75
16	Évora	36	47	65	75	40	50	65	75
17	Beja	20	50	60	90	40	50	65	75
18	Faro	15	45	80	95	30	40	60	75

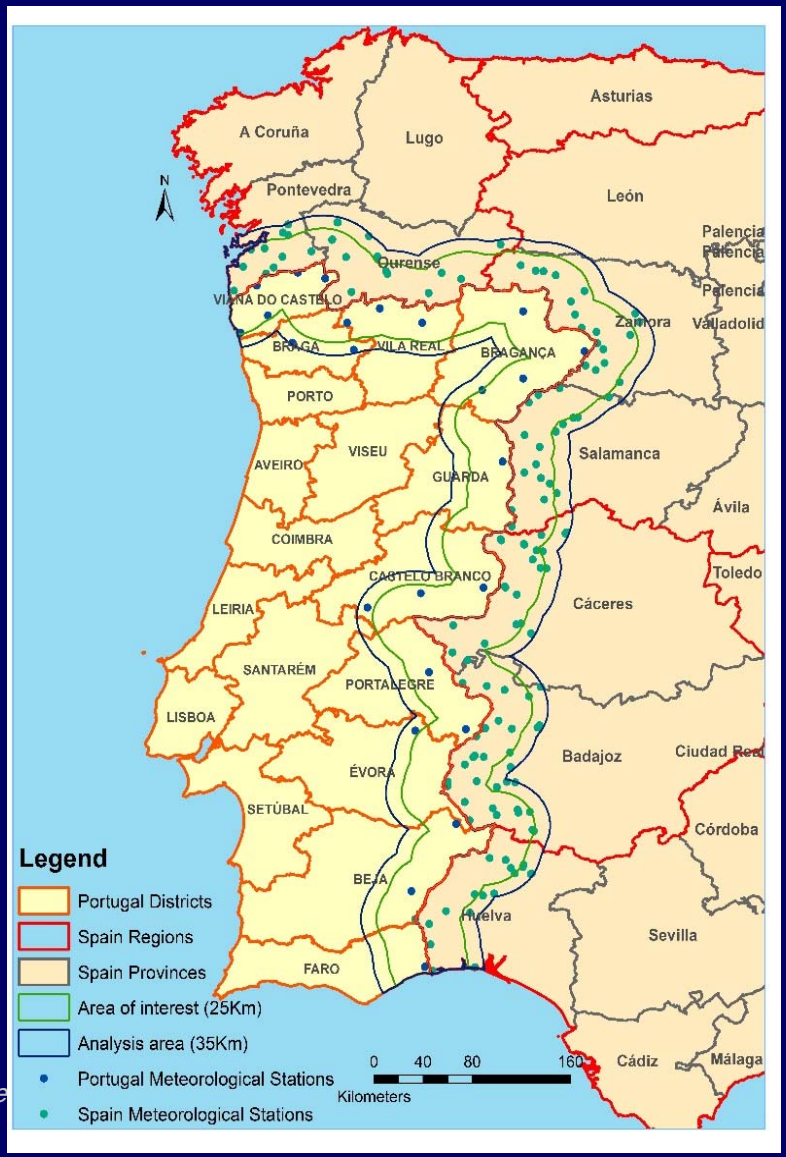
Variation between both calibrations

Ref.	District	Variation			
		1	2	3	4
		L	*M*	*H*	*VH*
1	Viana do Castelo	-5	-5	0	5
2	Braga	5	-5	0	5
3	Porto	0	-5	0	0
4	Vila Real	-12	-20	-20	-15
5	Bragança	-2	0	5	10
6	Aveiro	5	7	3	5
7	Viseu	-5	-5	-2	15
8	Guarda	-2	-10	-20	-10
9	Coimbra	-2	-1	0	-1
10	Leiria	10	5	-5	-5
11	Castelo Branco	-10	0	0	0
12	Lisboa	0	-5	0	10
13	Santarem	0	-7	-10	-10
14	Setubal	10	10	15	25
15	Portalegre	-5	-15	-5	-10
16	Évora	4	3	0	0
17	Beja	20	0	5	-15
18	Faro	15	-5	-20	-20

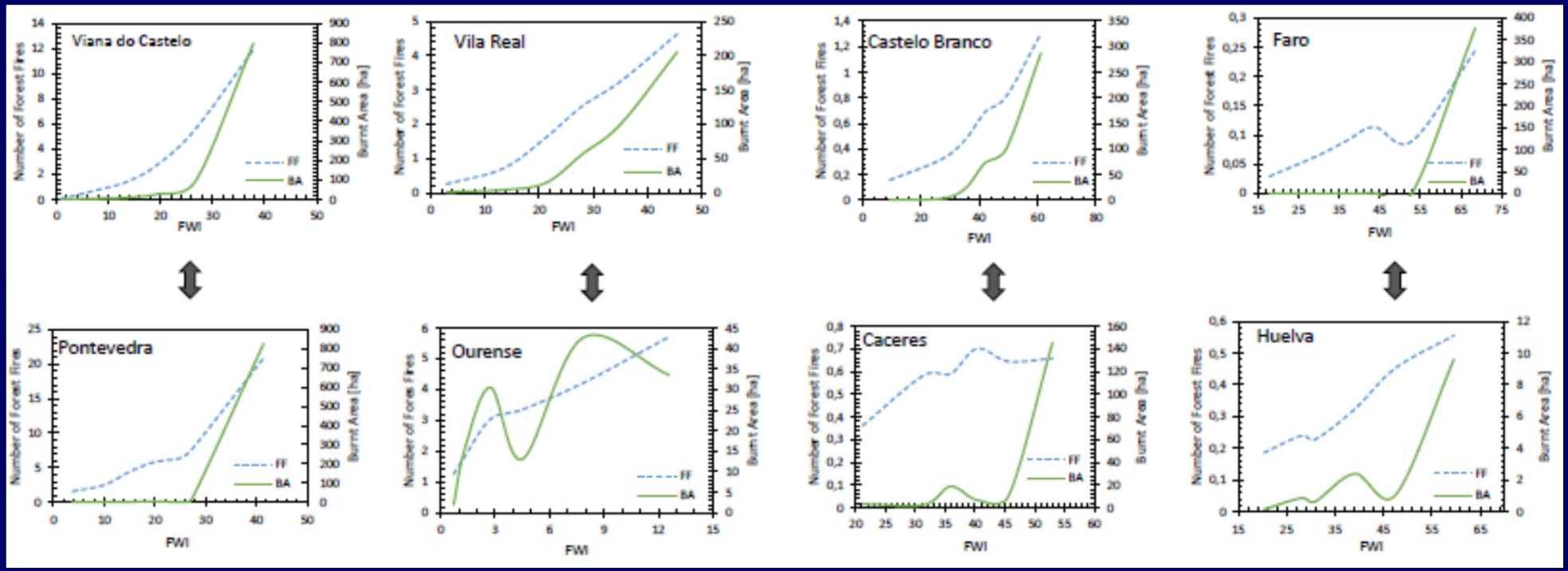
Harmonization between Portugal and Spain

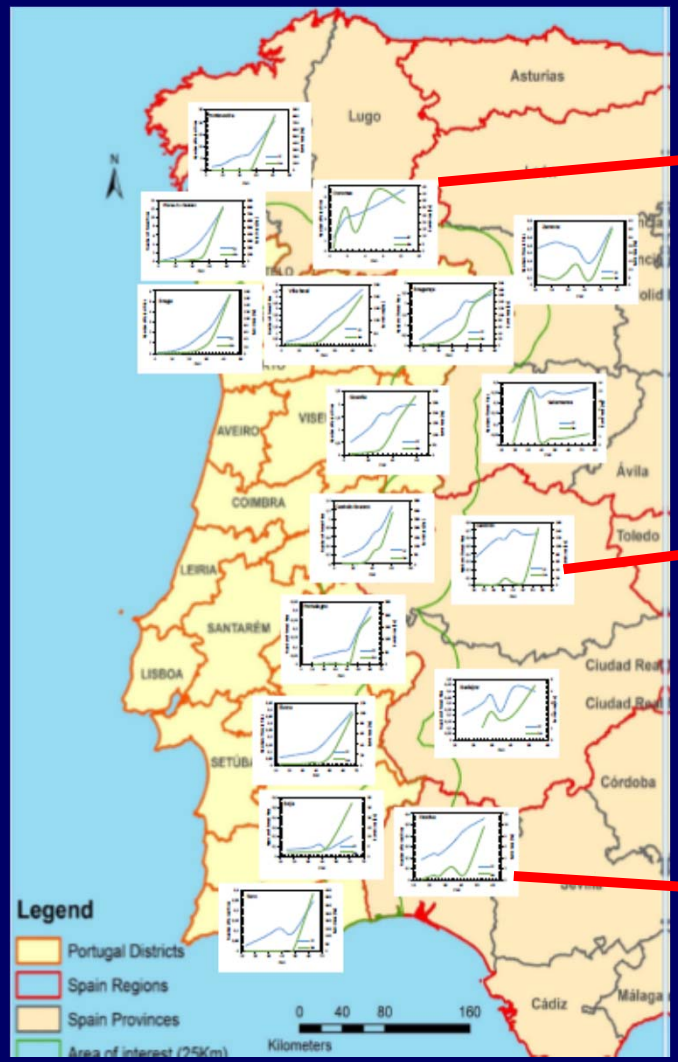


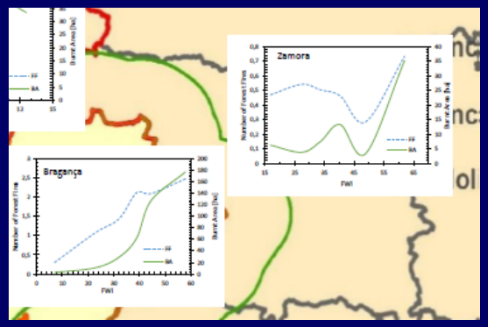
Selection of weather stations on both sides of the border

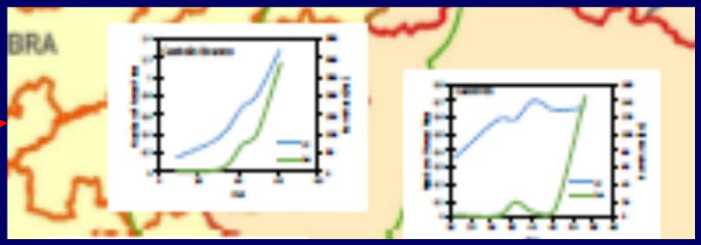


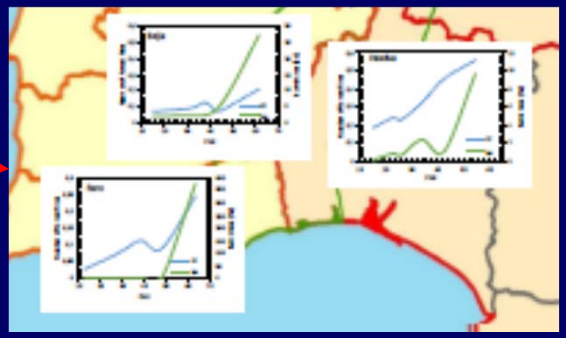
Different fire regimes in both sides of the border:




Asturias
Lugo
AVEIRO
VISEU
COIMBRA
LEIRIA
SANTARÉM
LISBOA
Ávila
Toledo
Ciudad Real
Córdoba
Cádiz
Málaga
Legend
Portugal Districts
Spain Regions
Spain Provinces
0 40 80 160
Kilometers


Zamora
Bragança





Initial Step

Harmonized values

PERCENTILE VALUES USED FOR THE INITIAL STEP

Code	Weather station
1	<40
2	60
3	80
4	95
5	>95

ADJUSTMENT OF FWI VALUES THAT LIMIT THE FIRE DANGER CLASSES – INITIAL PROPOSAL

	Fire risk classes – initial proposal				
	1	2	3	4	5
Viana do Castelo	<28	36	43	53	>53
Pontevedra	<12	17	22	35	>35
Braga	<21	27	33	43	>43
Ourense	<2	4	6	10	>10
Vila Real	<22	28	33	42	>42
Ourense	<2	4	6	10	>10
Bragança	<35	41	46	56	>56
Zamora	<31	37	44	55	>55
Bragança	<33	39	45	55	>55
Salamanca	<40	48	57	71	>71
Guarda	<30	37	43	54	>54
Salamanca	<40	48	57	71	>71
Castelo Branco	<35	42	48	57	>57
Caceres	<34	38	43	50	>50
Portalegre	<37	43	50	58	>58
Cáceres	<34	38	43	50	>50
Portalegre	<36	42	48	56	>56
Badajoz	<33	37	43	53	>53
Évora	<36	42	49	59	>59
Badajoz	<33	37	43	53	>53
Beja	<38	43	48	56	>56
Huelva	<30	36	43	54	>54
Faro	<39	45	52	68	>68
Huelva	<30	36	43	54	>54

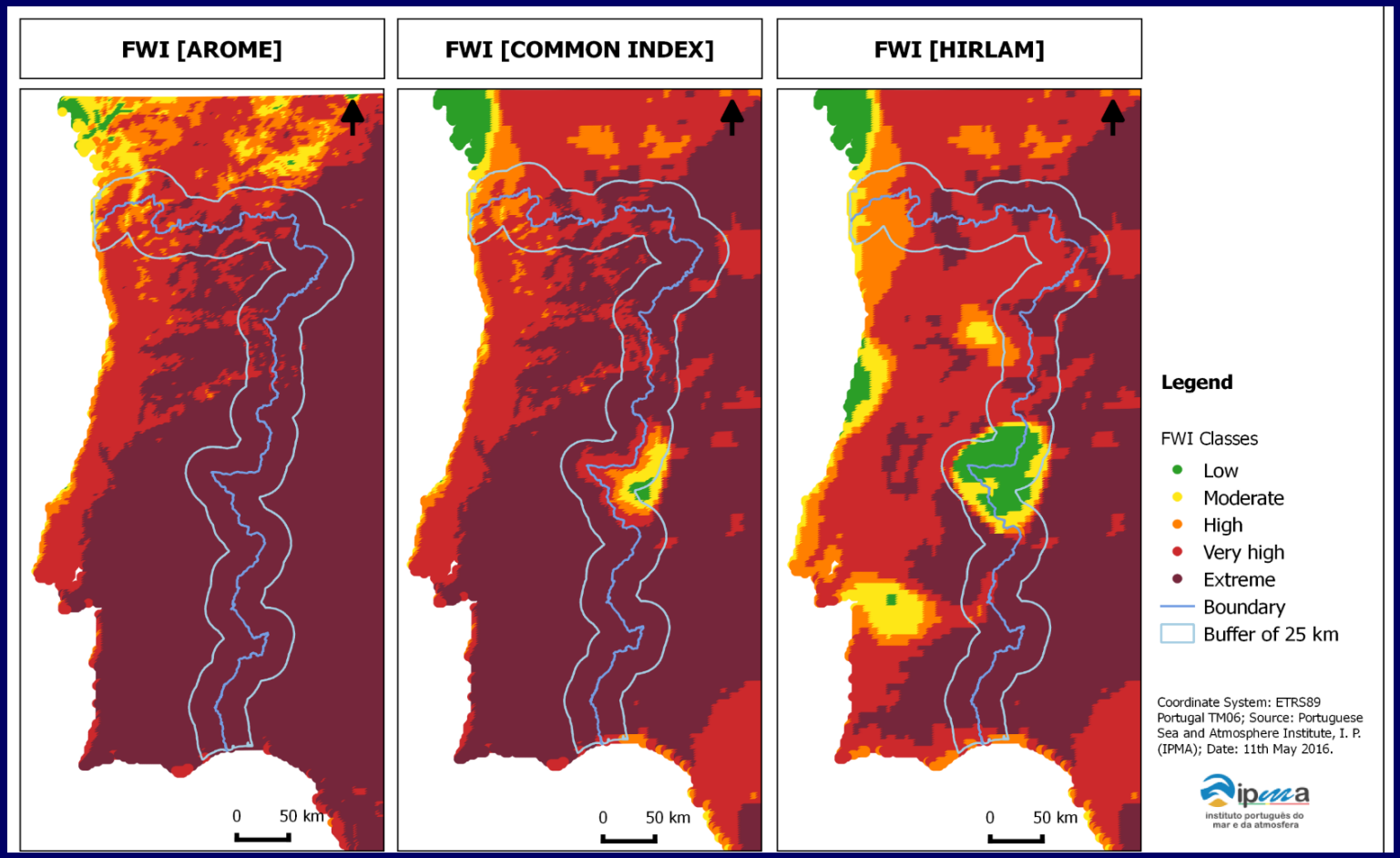
ADJUSTMENT OF FWI VALUES THAT LIMIT THE FIRE DANGER CLASSES – FINAL PROPOSAL

	Fire risk classes – final proposal				
	1	2	3	4	5
Viana do Castelo	<24	36	42	61	>61
Pontevedra	<10	17	22	42	>42
Braga	<21	28	33	47	>47
Ourense	<2	4	6	13	>13
Vila Real	<22	29	34	45	>45
Ourense	<2	4	6	12	>12
Bragança	<32	40	48	56	>56
Zamora	<27	36	46	55	>55
Bragança	<33	39	45	55	>55
Salamanca	<40	48	57	71	>71
Guarda	<18	37	46	57	>57
Salamanca	<30	48	61	74	>74
Castelo Branco	<20	40	48	71	>71
Caceres	<25	37	43	58	>58
Portalegre	<37	43	50	58	>58
Cáceres	<34	38	43	50	>50
Portalegre	<30	43	48	58	>58
Badajoz	<28	38	43	54	>54
Évora	<32	44	50	60	>60
Badajoz	<29	38	44	53	>53
Beja	<23	35	48	59	>59
Huelva	<19	28	43	60	>60
Faro	<33	44	55	69	>69
Huelva	<26	34	45	54	>54

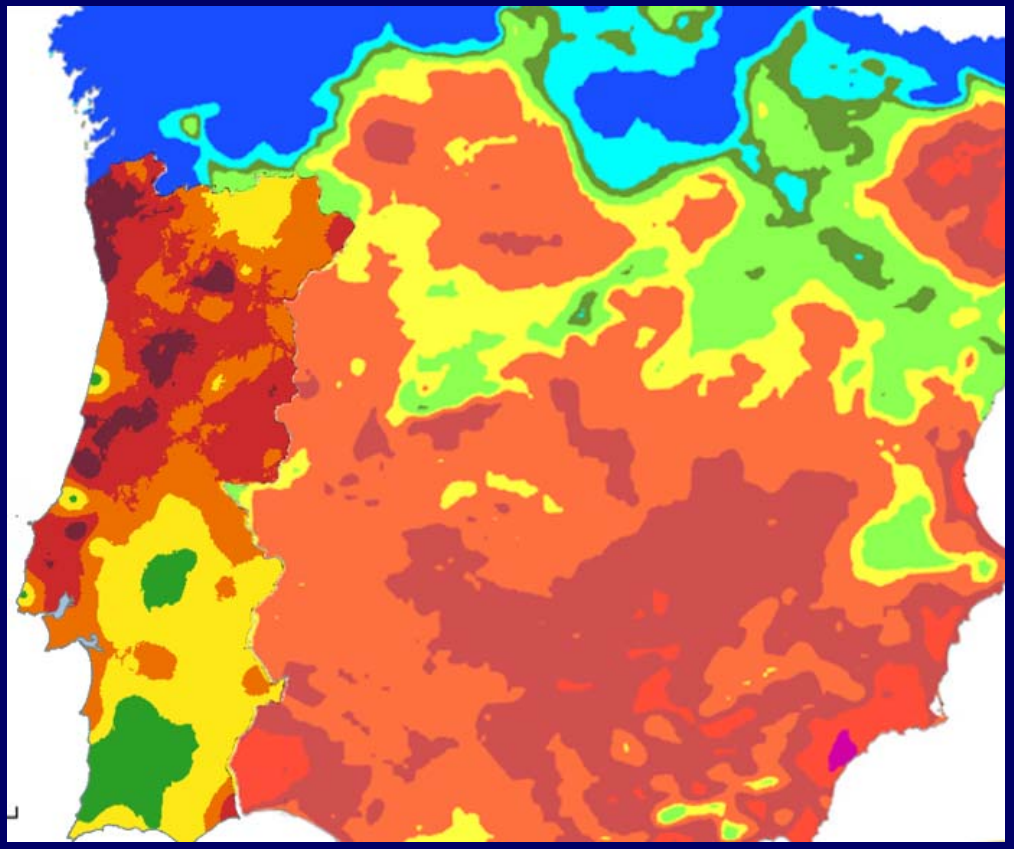
Assessment of overall adjustment

TABLE V
SET BETWEEN THE LIMITS OF FWI CLASSES

Districts - Provinces	Differences					
	Initial			Final		
	-1	0	1	-1	0	1
Viana do Castelo - Pontevedra	38	604	4	8	634	4
Viana do Castelo - Ourense	28	778	75	2	861	18
Braga - Ourense	56	814	12	29	853	0
Vila Real - Ourense	13	813	55	15	858	8
Bragança - Zamora	14	573	7	1	590	3
Bragança - Salamanca	1	765	8	1	765	8
Guarda - Salamanca	0	744	30	0	769	5
Castelo Branco - Cáceres	11	778	11	0	793	7
Portalegre - Cáceres	0	793	7	0	793	7
Portalegre - Badajoz	2	660	20	12	668	2
Évora - Badajoz	3	633	46	6	674	2
Beja - Huelva	1	339	9	0	339	0
Faro - Huelva	0	338	9	0	347	0


FWI [AROME]
FWI [COMMON INDEX]
FWI [HIRLAM]
0 50 km
0 50 km
0 50 km
Legend
FWI Classes
Low
Moderate
High
Very high
Extreme
Boundary
Buffer of 25 km
Coordinate System: ETRS89 Portugal TM06; Source: Portuguese Sea and Atmosphere Institute, I. P. (IPMA); Date: 11th May 2016.
ipma
instituto português do mar e da atmosfera

Before



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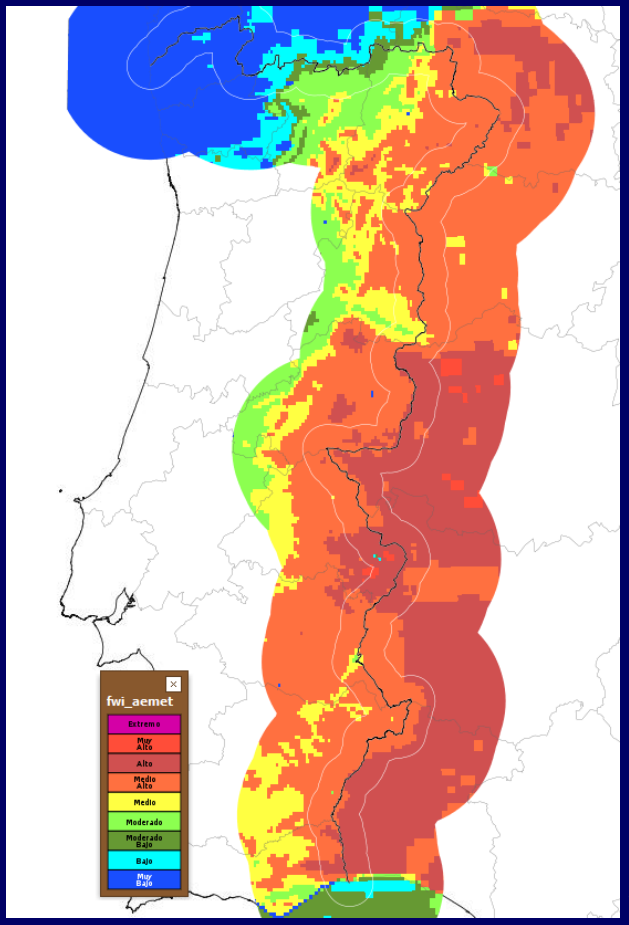


Conclusion

- The Canadian FWI is a good method to estimate the fire danger in a given region.
- For it to be effective it needs to be calibrated in each case using historical data to take into account the meaning of the meteorological parameters and the role of structural factors.
- The proposed methodology seems to be consistente and stable.

- It is possible to apply this method also to neighbouring regions in order to harmonize the operational use of the fire danger.

- We intend to extend this analysis to other regions of Europe.

References

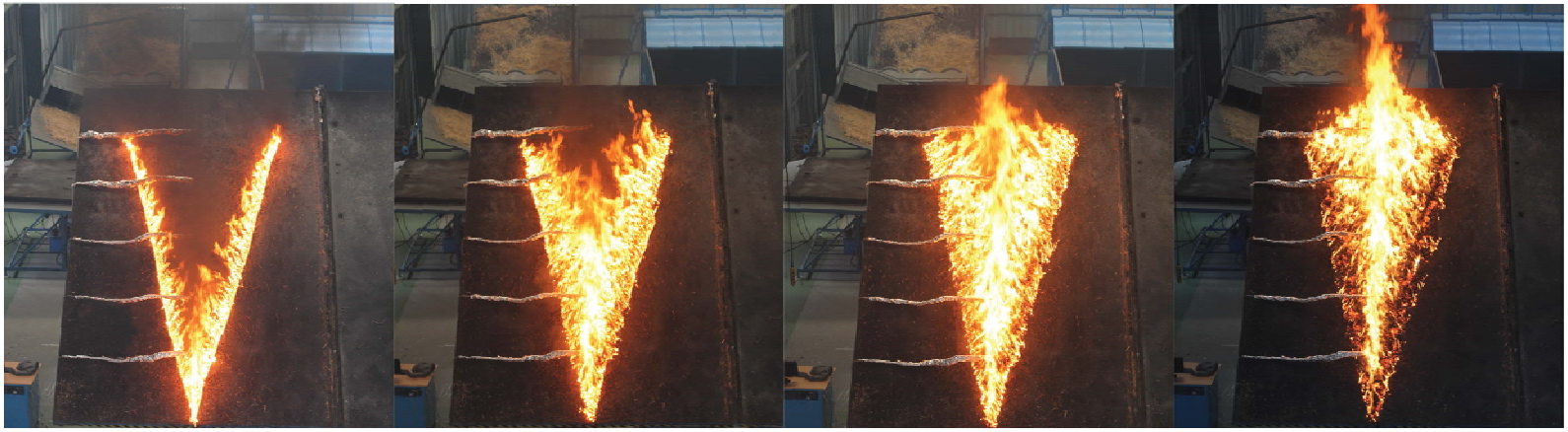
- Bachmann A., Allgower B. (2001) A consistent wildland fire risk terminology is needed! *Fire Management Today* **61**, 28–33.
- Bachmann A., Allgower B. (1999) The need for a consistent wildfire risk terminology. The Joint Fire Science Conference and Workshop, Boise, Idaho, U.S.A.
- Van Wagner, C.E. 1987*. Development and structure of the Canadian Forest Fire Weather Index System*. Can. For. Serv., Ottawa, Ontario. For. Tech. Rep. 35. 34 p.
- Viegas DX, Bovio G, Ferreira A, Nosenzo A & Sol B, 1999. Comparative Study of Various Methods of Fire Danger Evaluation in Southern Europe. *International Journal Wildland Fire* 9(4): 235-246, 1999.
- Viegas DX, Piñol J, Viegas MT & Ogaya R, 2001. Estimating live fine fuels moisture content using meteorologically-based indices. *International Journal of Wildland Fire* 10(2): 223-240, 2001.
- Viegas DX, Reis RM, Cruz MG & Viegas MT, 2004. Calibração do Sistema Canadiano de Perigo de Incêndio para aplicação em Portugal. *Silva Lusitana.* Vol. 12, nº1, Junho 2004.
- Viegas DX, 2016. Development and testing of the fire risk indexes. Deliverable D.03.01 of Spitfire project (Project SpitFire - Spanish-Portuguese Meteorological Information System for Trans-Boundary Operations in Forest Fires ECHO/SUB/2014/693768)

8th INTERNATIONAL CONFERENCE ON

FORREST FIRE RESEARCH

Conference Chairman: Professor Domingos X. Viegas (ADAI, University of Coimbra, Portugal)

10 – 16 November 2018
Coimbra, Portugal



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Conference Topics

A wide range of topics involved in this pluri-disciplinar problem can be covered by the authors during the Conference. Papers or posters dealing with the most relevant topics related to forest fires on a scientific basis will be accepted. These topics are only indicative therefore submissions can cover other relevant aspects:

- Human and Institutional factors
- Forest management and Fire Prevention
- Fire at the Wildland Urban Interface
- Forest Fire Risk assessment and Climate Change
- Fire Detection and Monitoring
- Remote Sensing
- Fire Management
- Fire Suppression and New technologies
- Large Fires
- Fire Safety
- Economic Issues
- Fire Ecology
- Evaluation and management of burned areas

Related events

V Short Course on Fire Safety(10 November 2018) | VIII Short Course on Fire Behaviour (11 November 2018)

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Deadlines

The deadlines for participating in the Conference are:

• Presentation of Abstracts	15 February 2018
• Acceptance of Abstracts	30 April 2018
• Full version of Papers or Posters	30 June 2018
• Early Registration	30 September 2018
• Early Hotel Reservation	30 September 2018
• Definitive Program	31 October 2018

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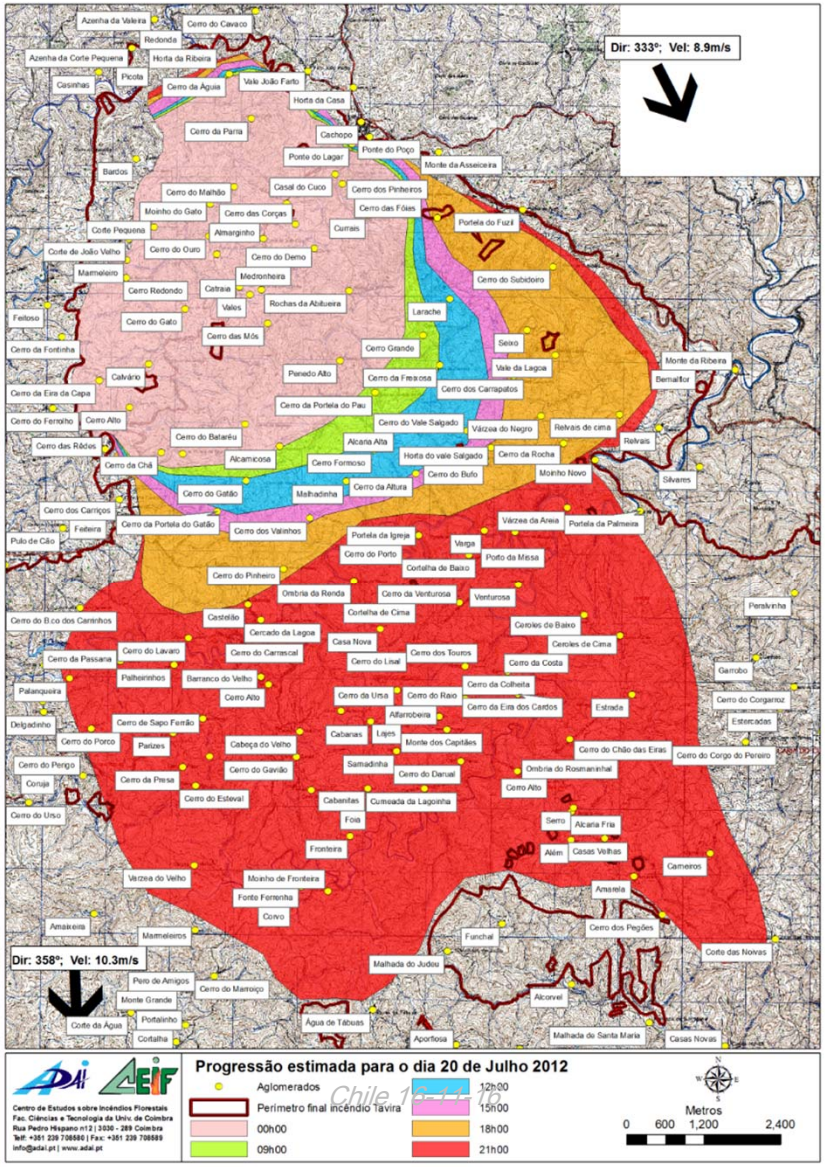
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Progressão estimada para o dia 20 de Julho 2012
Aglomerados
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