

Fire Weather Index: from high resolution climatology to Climate Change impact study

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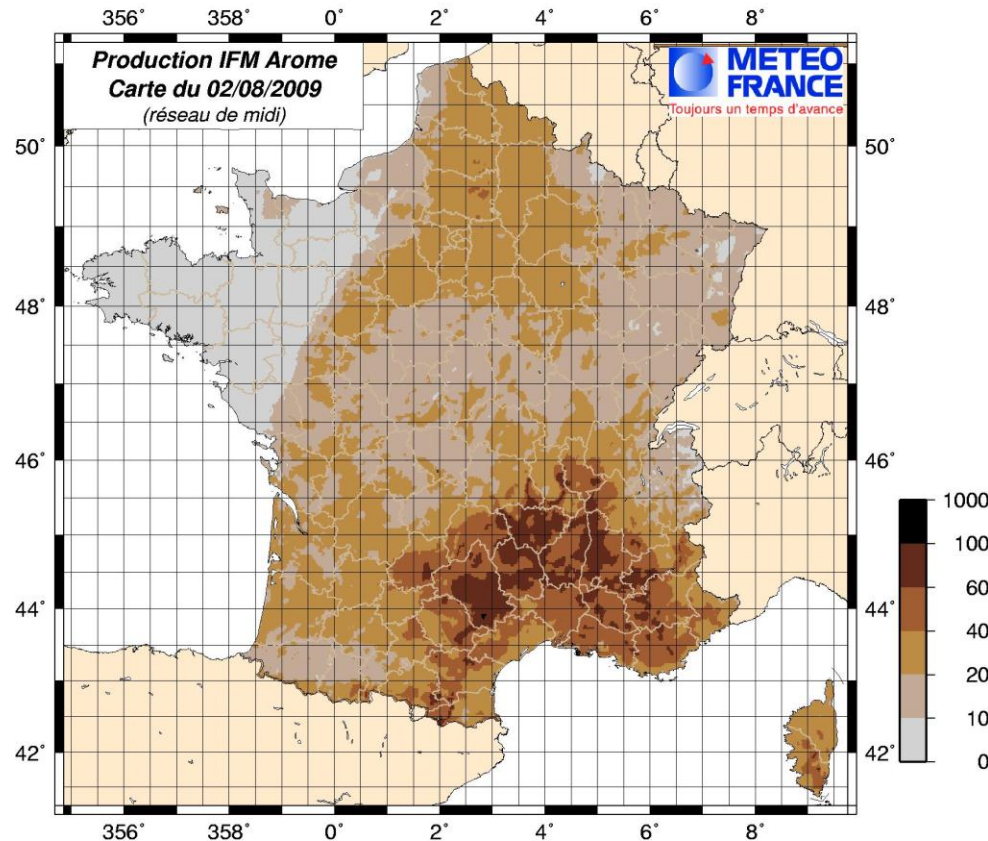
Context

- Fire meteo indices provide efficient guidance tools for prevention and early warning of forest fires. These indices are only based on meteorological input data.
- The underlying approach is to exploit meteorological information as fully as possible to model the soil water content, biomass condition and fire danger.
- Fire meteorological danger is estimated by Météo-France at national level through the use of Fire Weather Index (FWI).
- FWI is a numeric rating of fire intensity. FWI system consists of six components that account for the effects of fuel moisture and wind on fire behavior. Calculation of the components is based on consecutive daily observations of temperature, relative humidity, wind speed, and 24-hour rainfall.
- This kind of products can also be used for climatological purpose.

Operational context

- FWI national maps are produced twice daily and available for Civil Protection on a specific website.
- Fire risk level is assessed at regional level.
- Spatial resolution : 2.5 km
- Input data : Arome mesoscale weather forecast model and hourly high resolution rainfall analysis.
- Rainfall data are produced by merging rain gauge and rainfall radar data

IFM pour la journee du 01/08/2009



Study on the potential extension of areas subject to forest fires - Methodology

- A study on the potential extension of forest areas prone to forest fires commissioned jointly by the Ministry of Agriculture, the Ministry of Ecology and the Ministry of the Interior.
- This study was carried out by ONF (National Forest Office), IFN (National Forest Inventory) and Météo-France - in charge of FWI reanalysis and FWI forecast (2040 / 2060).
- Increasing trend in terms of fire frequency or fire severity is difficult to assess by using Civil Protection databases. Fire events databases are usually incomplete and inhomogeneous. Moreover this approach mainly identifies the anthropogenic effect (due to changes in human activities and soil occupation) rather than climate change impact.
- Fire meteorological danger trend can be studied through FWI reanalysis on a long period. In order to assess a long-term trend FWI has been recomputed on a 50 year period by Météo-France. Safran model has been used to derive a 50-year hydrometeorological reanalysis, running from 1958 to 2008 (Vidal 2009). FWI was modeled at daily time step on a 8km regular grid.
- Producing a high resolution FWI climatology allow us to downscale climate change scenarios. The Quantile-Quantile correction method was applied on a 8km grid.

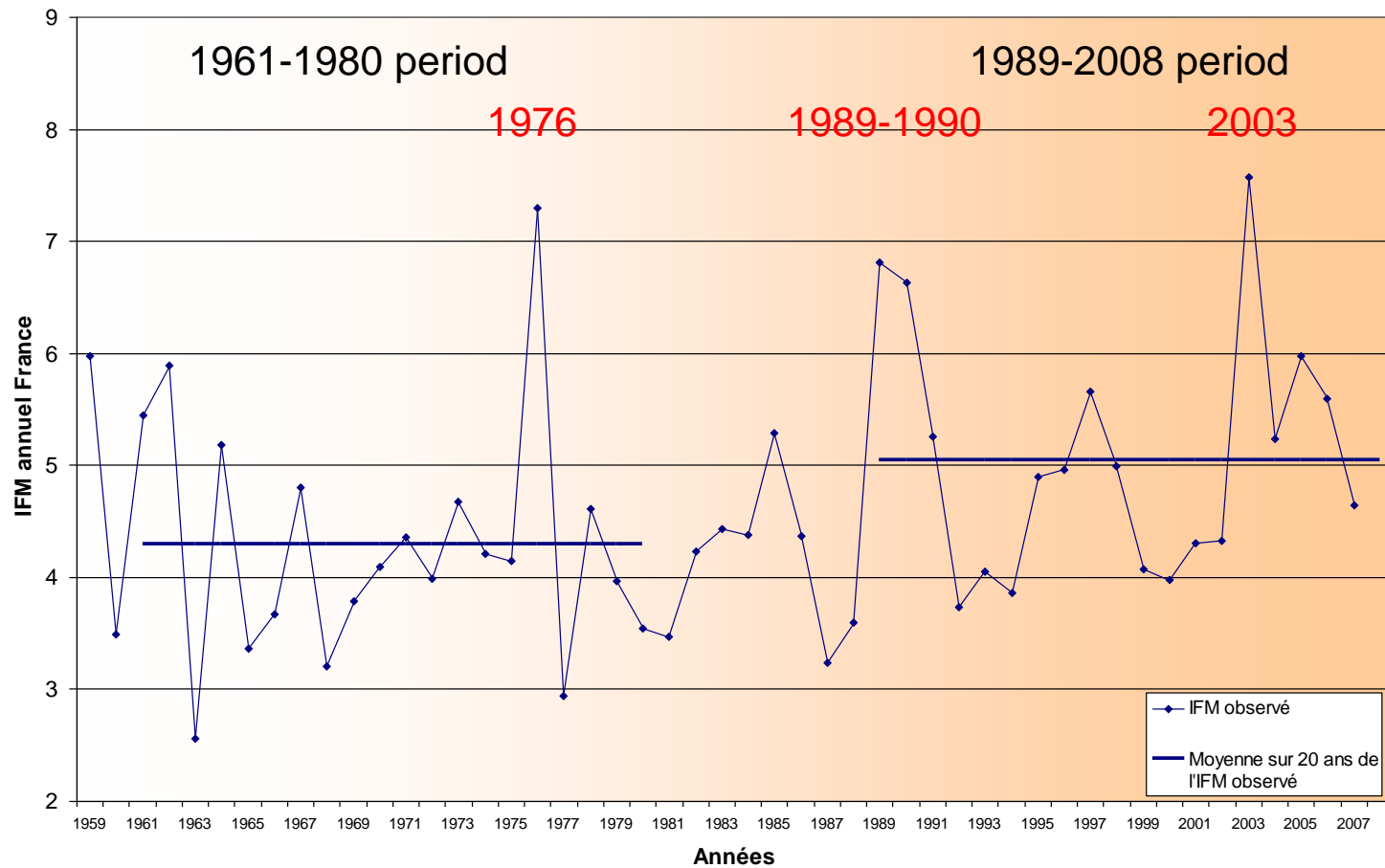
1958-2008 Fire Weather Index climatology

Observed trends

High resolution FWI climatology

Annual mean value from 1958 to 2008

- A strong interannual variability
- Four years stand out on this chart
- Unsurprisingly we can identify the most severe drought events in France
- +22% between 1961-1989 and 1989-2008 periods



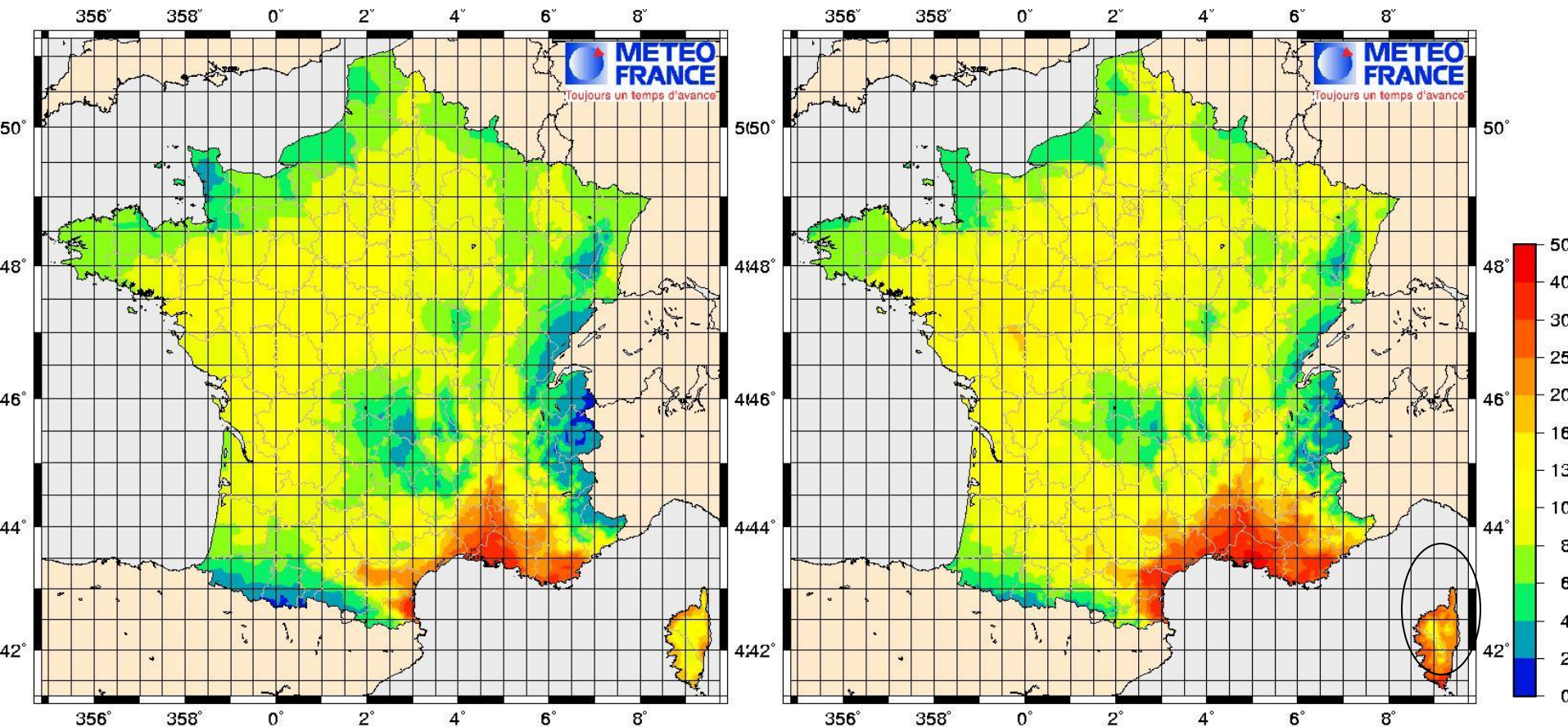
High resolution FWI climatology

Mean seasonal FWI over France (June-July-August period)

- Mean seasonal FWI calculated during summer increased all over French area.
- At regional level the highest increases in FWI were in Corsica, mediterranean area and on mountainous areas.

1961-1980 period

1989-2008 period

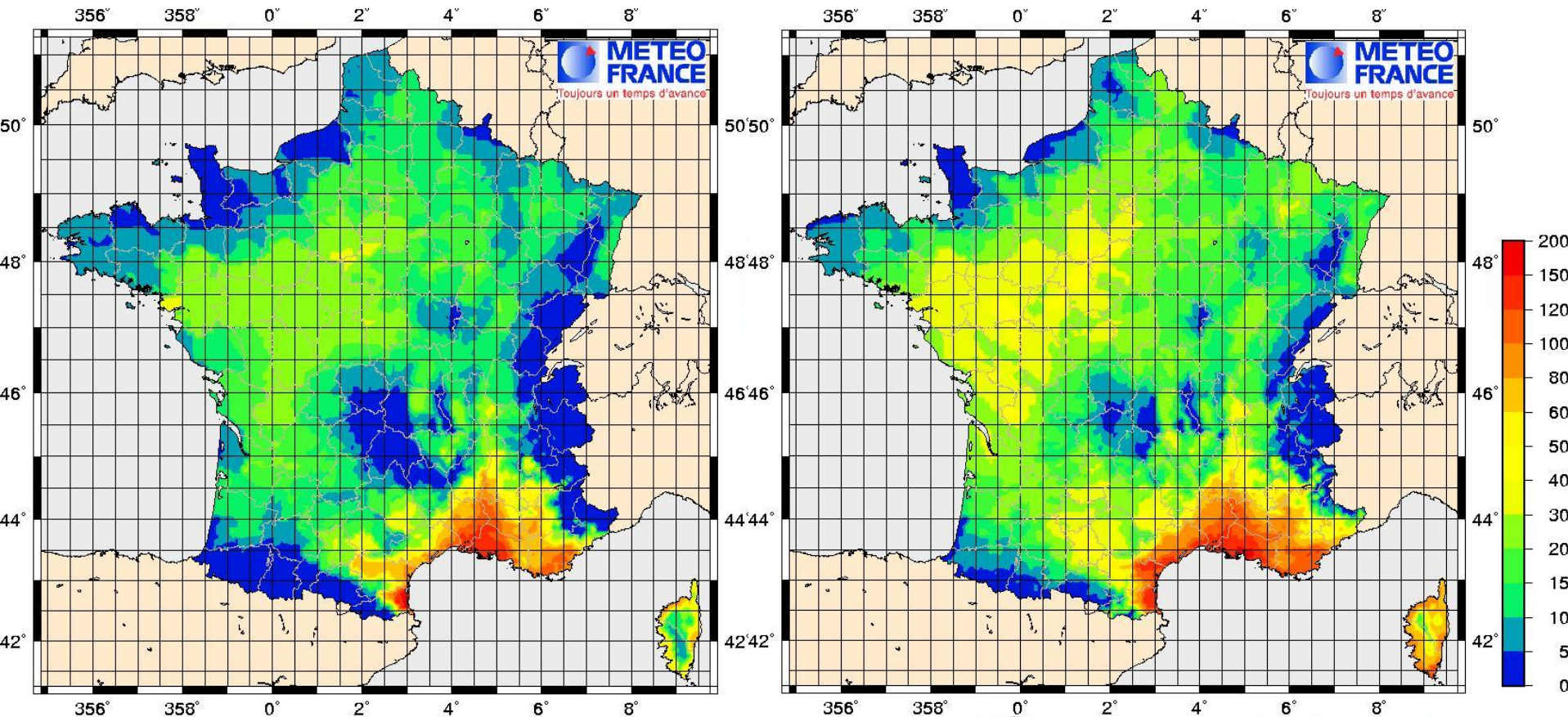


The number of days with $\text{FWI} > 20$

- We also studied the total number of daily FWI above a threshold (20, 40 and 60). This is a consistent indicator in order to characterize an increase in global meteorological fire danger.

1961-1980 period

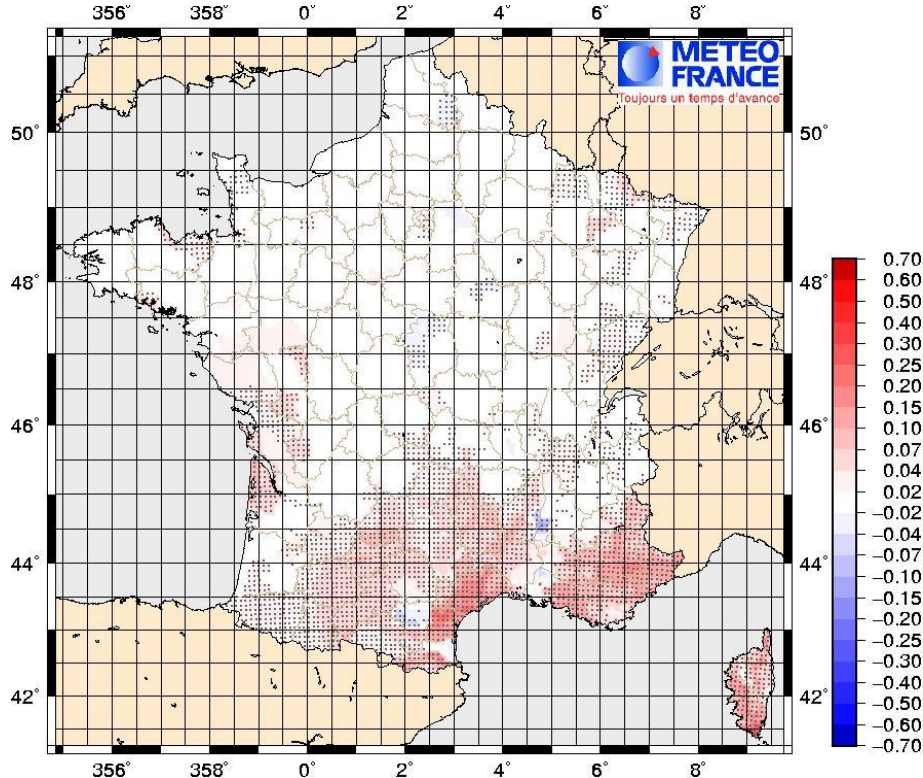
1989-2008 period



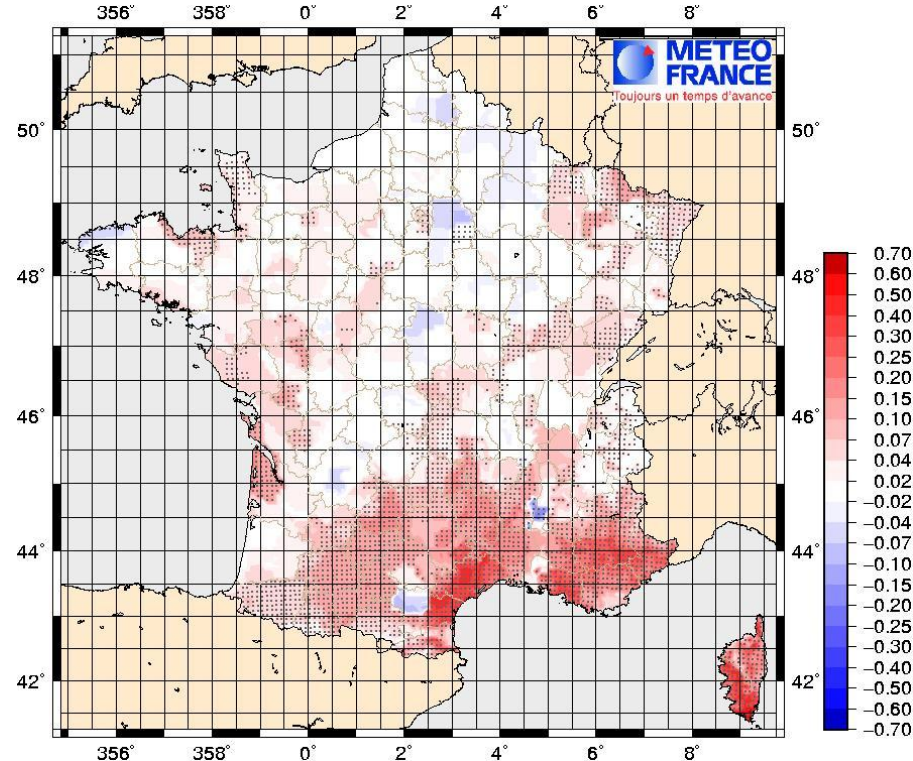
FWI linear trend over France on 1958-2008 period

- Linear trend of Fire Weather Index (year-1) on 1958-2008 period.
- Black dots indicate grid cell with statistical significance (Mann-Kendall test with 95% threshold)

Annual period

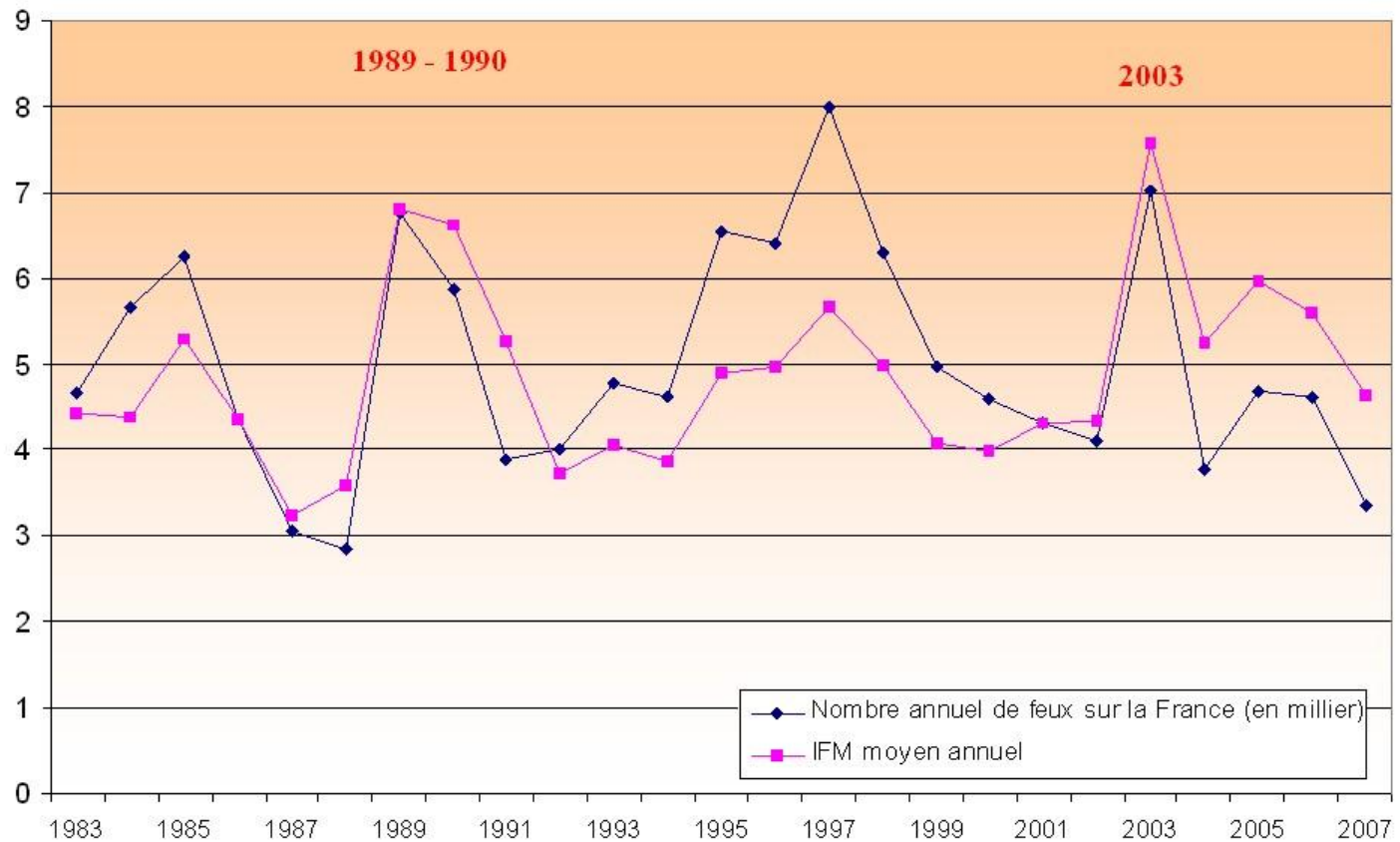


Summer period



..and a strong correlation between FWI and fire statistics

- On this chart we can notice a clear relationship between annual mean FWI and fire statistics (total number of fires) at national level.

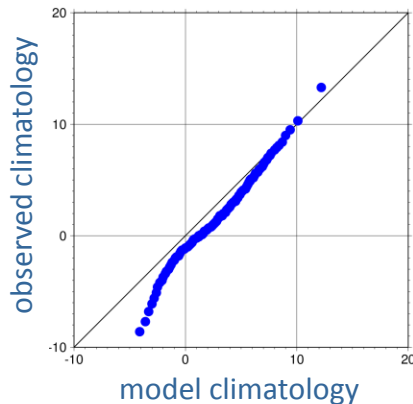


Potential impact of climate change on fire meteorological danger:

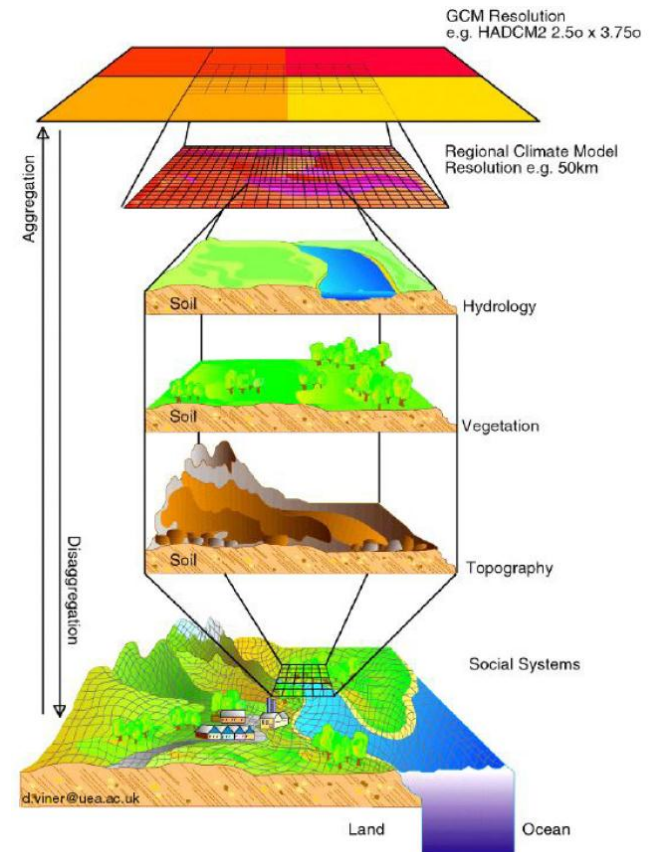
Predicting FWI trend with climate change scenarios

Methodology

- Climate model : French ARPEGE-Climat V4 model
- Emission scenarios : A2, A1B and B1
- Use of raw model outputs
- Use of Quantile-Quantile correction method on FWI daily values and downscaling at 8 km resolution



Quantile-quantile approach for winter mean temperature in Paris. Correction method applied for each statistical threshold.



Annual FWI anomaly (with Q/Q correction method and downscaling)

A1B scenario

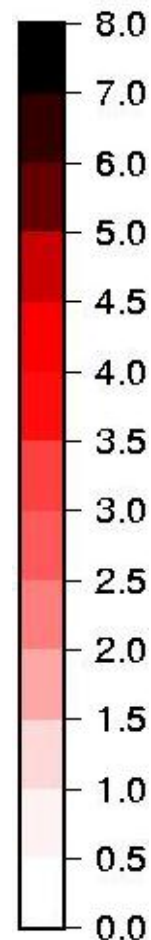
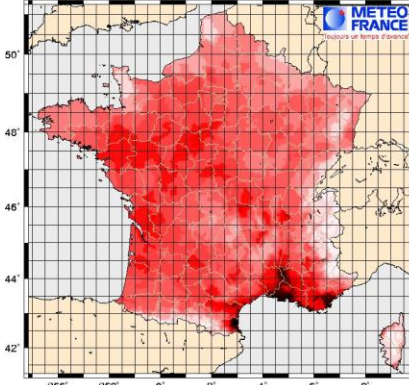
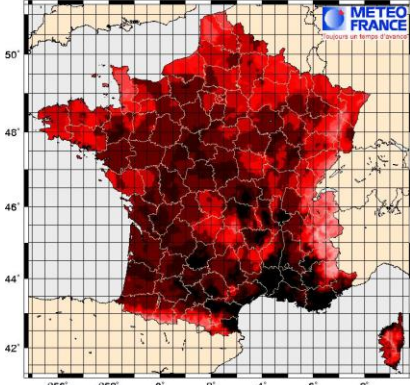
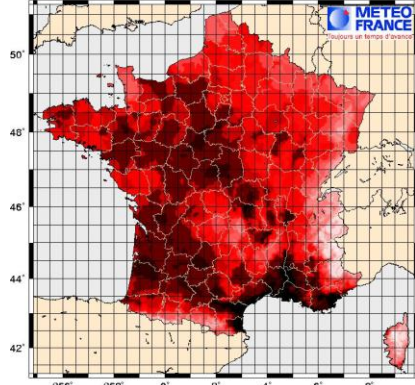
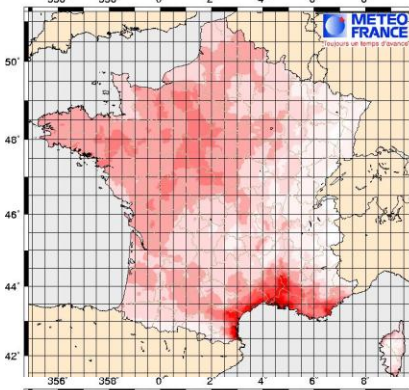
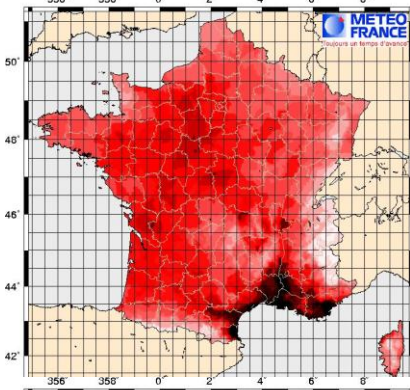
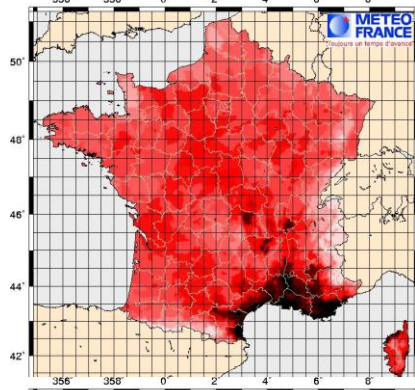
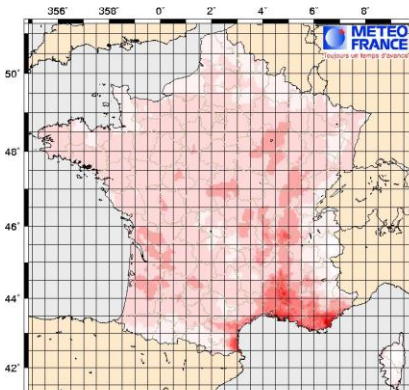
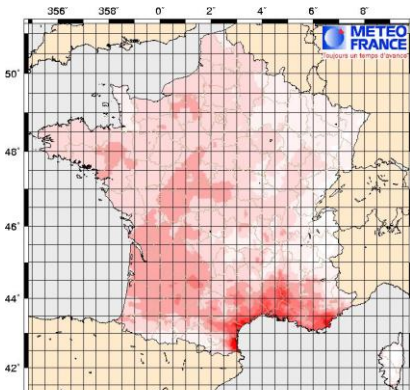
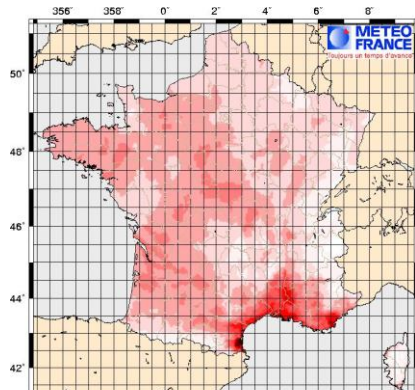
A2 scenario

B1 scenario

2040

2060

2090



Annual FWI anomaly (with Q/Q correction method and downscaling)

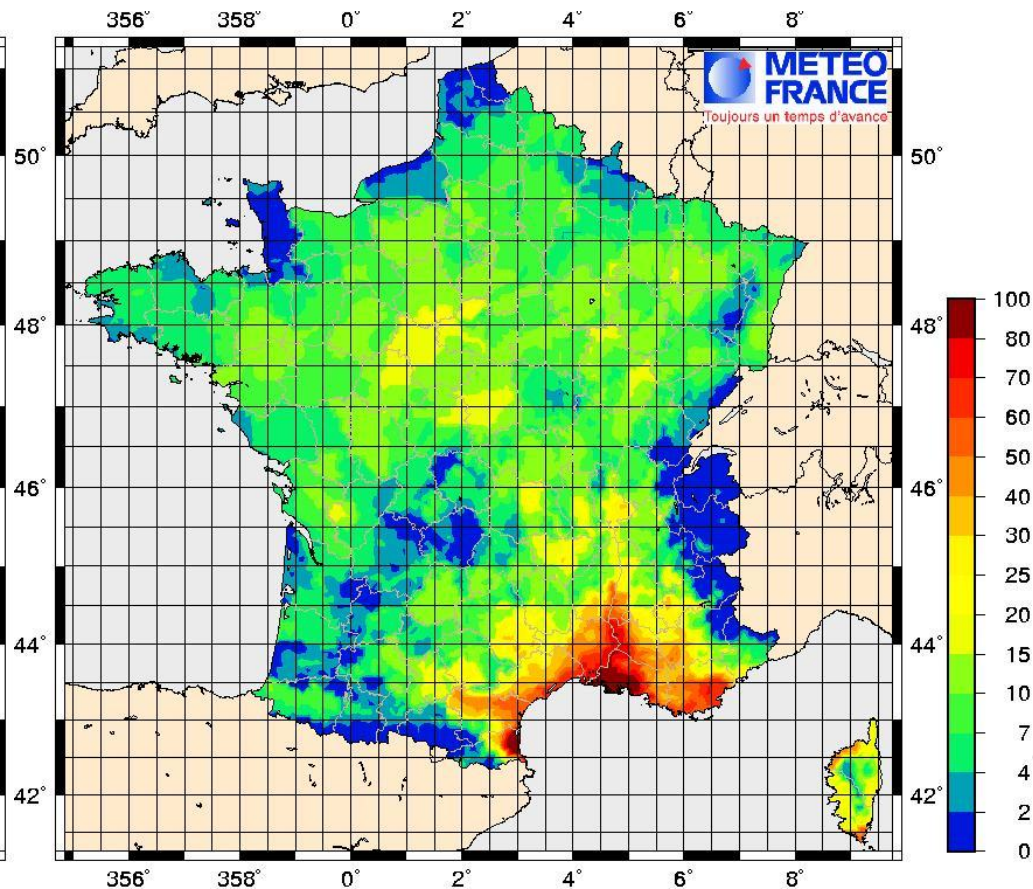
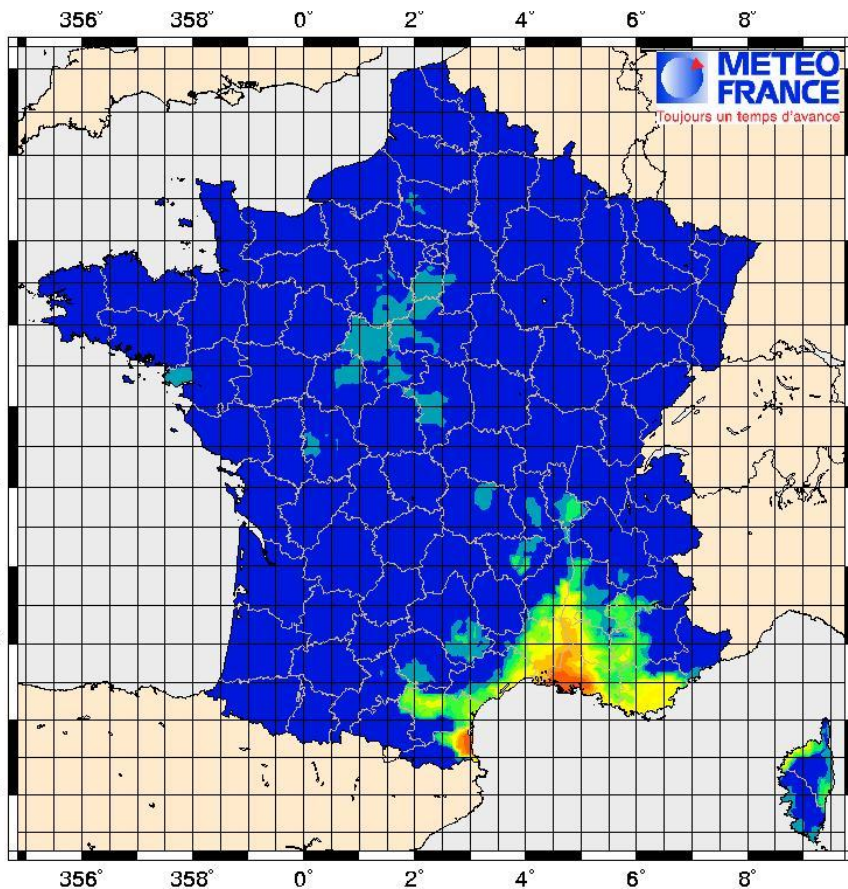
		FWI mean increase (ref: 1961-2000)	FWI relative increase (ref: 1961-2000)
Scénario d'émission A1B	2040	0,848	32,8%
	2060	2,5806	71,9%
	2090	3,5815	94,4%
Scénario d'émission A2	2040	0,58	26,8%
	2060	2,636	73,1%
	2090	4,411	113,1%
Scénario d'émission B1	2040	0,575	26,7%
	2060	0,782	31,4%
	2090	1,958	57,8%

Impact of climate change on the number of days with high fire risk (FWI > 40)

- From 1.8 to 10.1 days / year with FWI > 40
- 500 M€ are dedicated each year to forest fire fighting resources
- Additional 100 M€ could be spent per year in 2060 due to Climate Change

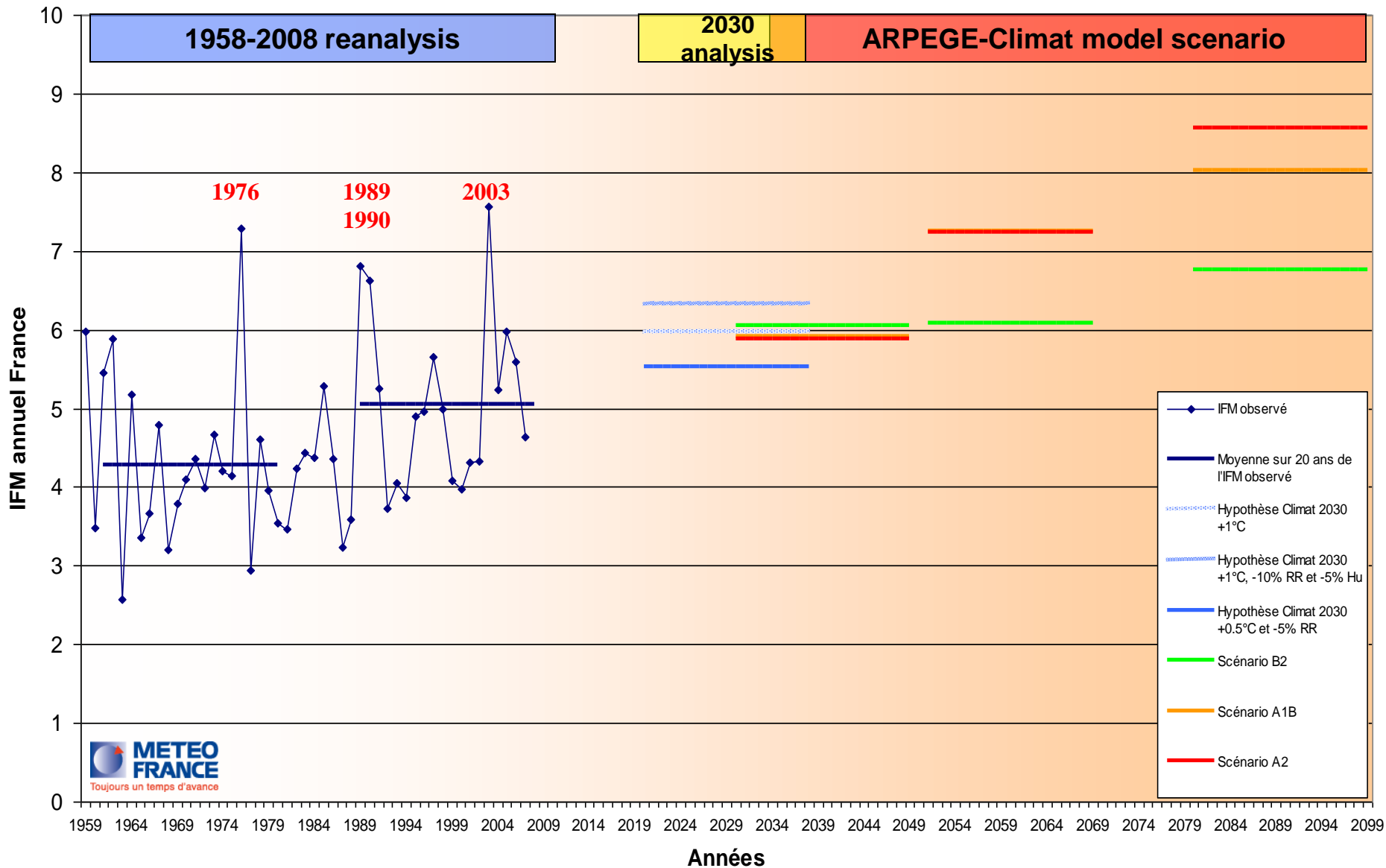
1961-1980 reference period

2060 – A1B scenario



Impact of climate change on the number of days with FWI above a threshold

		Number of days with FWI>20	Number of days with FWI>40	Number of days with FWI>60
Référence 1961-1980		16,2	1,8	0,3
Référence 1989-2008		23,7	2,9	0,4
Scénario d'émission A1B	2040	29,6	4,9	1,2
	2060	46,3	10,1	2,5
	2090	55,0	13,0	3,2
Scénario d'émission A2	2040	28,5	4,6	0,9
	2060	46,8	8,9	1,9
	2090	61,4	15,2	4,0
Scénario d'émission B1	2040	27,7	4,7	1,1
	2060	30,1	5,2	1,1
	2090	40,6	7,8	1,7

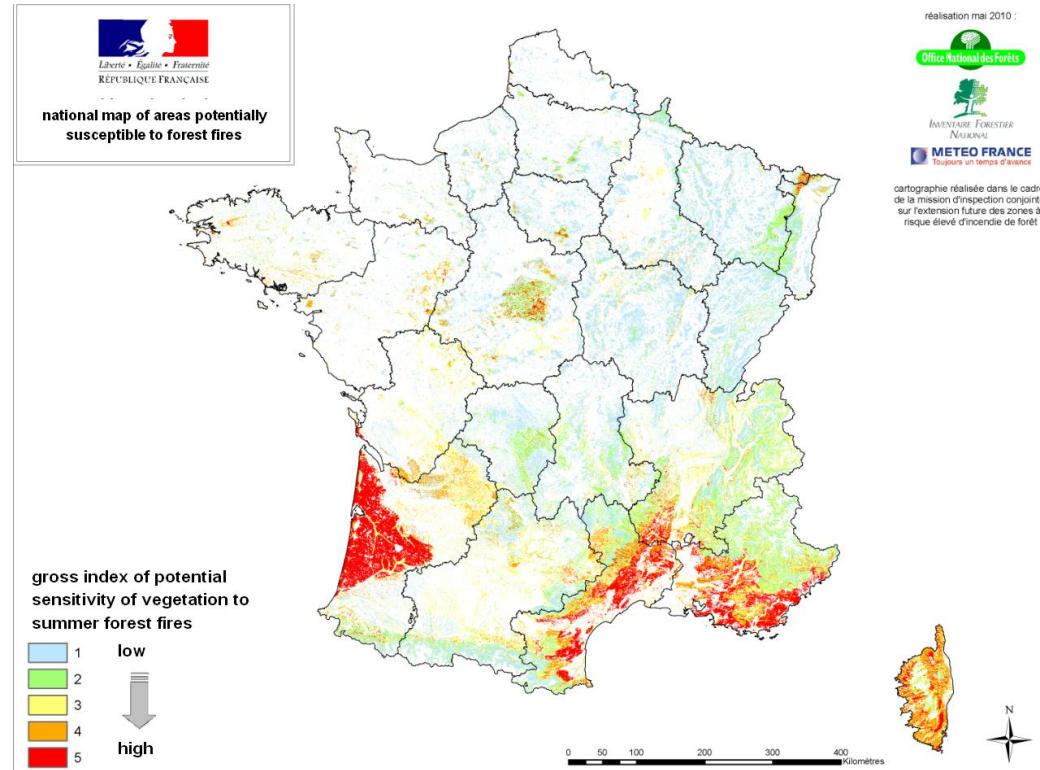


Conclusion

- A statistically significant increase in FWI in France between 1958 and 2008. (+22% between 1961-1989 and 1989-2008 period).
- Trends are very clear also in terms of total number of daily FWI above a threshold. In many French regions the annual number of days with FWI > 20 show an increase from 10 days up to 50 days locally.
- The surface of the metropolitan area concerned by at least one day every year with FWI > 20 doubled between the period 1961-1980 and the period 1989-2008. The trend is similar to the threshold 40.
- The use of Météo-France climate model suggests a similar increasing trend for FWI in 2040. A 30% increase (reference period:1961-2000) is predicted for three different emissions scenarios (A1B, A2 and B1). Interannual variability should also increase and leads to meteorological conditions which has never been observed yet.
- We predict a strong increase in fire meteorological danger in 2060. A 75% increase (reference period:1961-2000) is predicted for A1B and A2 emissions scenarios.
- Typical Mediterranean meteorological fire danger conditions could be observed all over the French area. Year 2003 could be considered as a consistent reference for 2060.

Conclusion (2) : final outputs of the project

- Final integration of results
- Meteorological conditions x forest sensitivity index
- Test mapping of forest potentially vulnerable to summer fires in 2040-2060
- Only summer fires are taken into account.
- Modelling assumptions : No changes in species at the horizons considered.
- Average sensitivity index by forest stands has been estimated by considering biogeographical regions, elevation, soil types, exposures, slopes, ranges of pubescent oak, etc...
- The potential sensitivity is expressed only in areas that have in 2040 or 2060 conditions equivalent to those of the Mediterranean area (based on FWI)



National map of areas potentially susceptible to forest fires



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**national map of areas potentially
susceptible to forest fires**

Reference period (1989-2008)

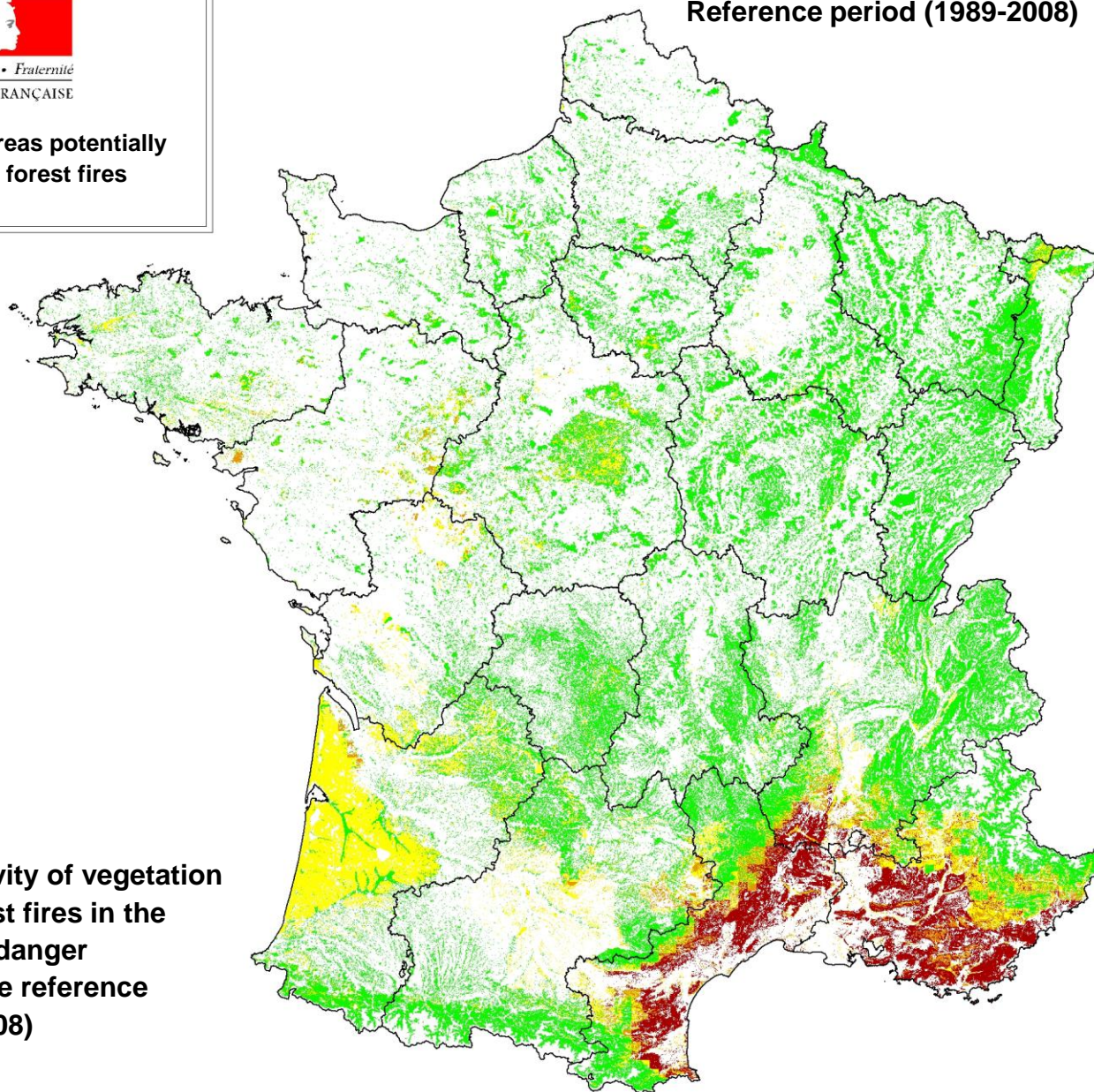
réalisation mai 2010 :



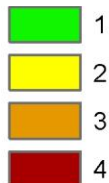
INVENTAIRE FORESTIER
NATIONAL



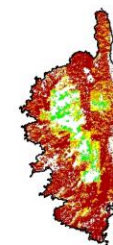
cartographie réalisée dans le cadre
de la mission d'inspection conjointe
sur l'extension future des zones à
risque élevé d'incendie de forêt



**Index of sensitivity of vegetation
to summer forest fires in the
meteorological danger
conditions of the reference
period (1989-2008)**



0 50 100 200 300 400
Kilomètres





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**national map of areas potentially
susceptible to forest fires**

Modeling 2040

réalisation mai 2010 :

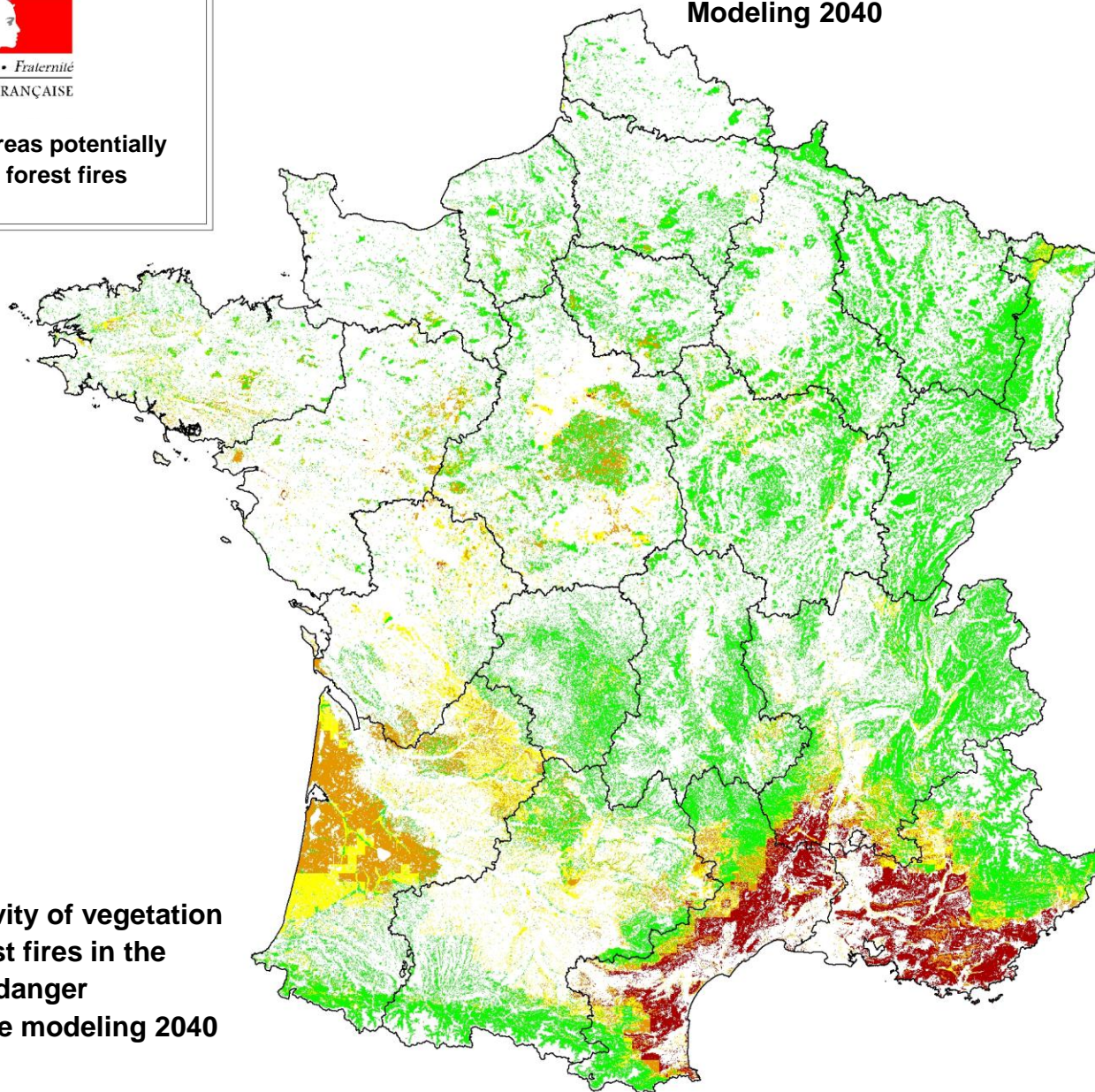


INVENTAIRE FORESTIER
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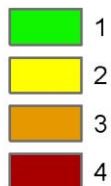


Toujours un temps d'avance

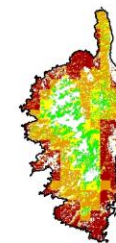
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**Index of sensitivity of vegetation
to summer forest fires in the
meteorological danger
conditions of the modeling 2040**



0 50 100 200 300 400 Kilomètres





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**national map of areas potentially
susceptible to forest fires**

Modeling 2060

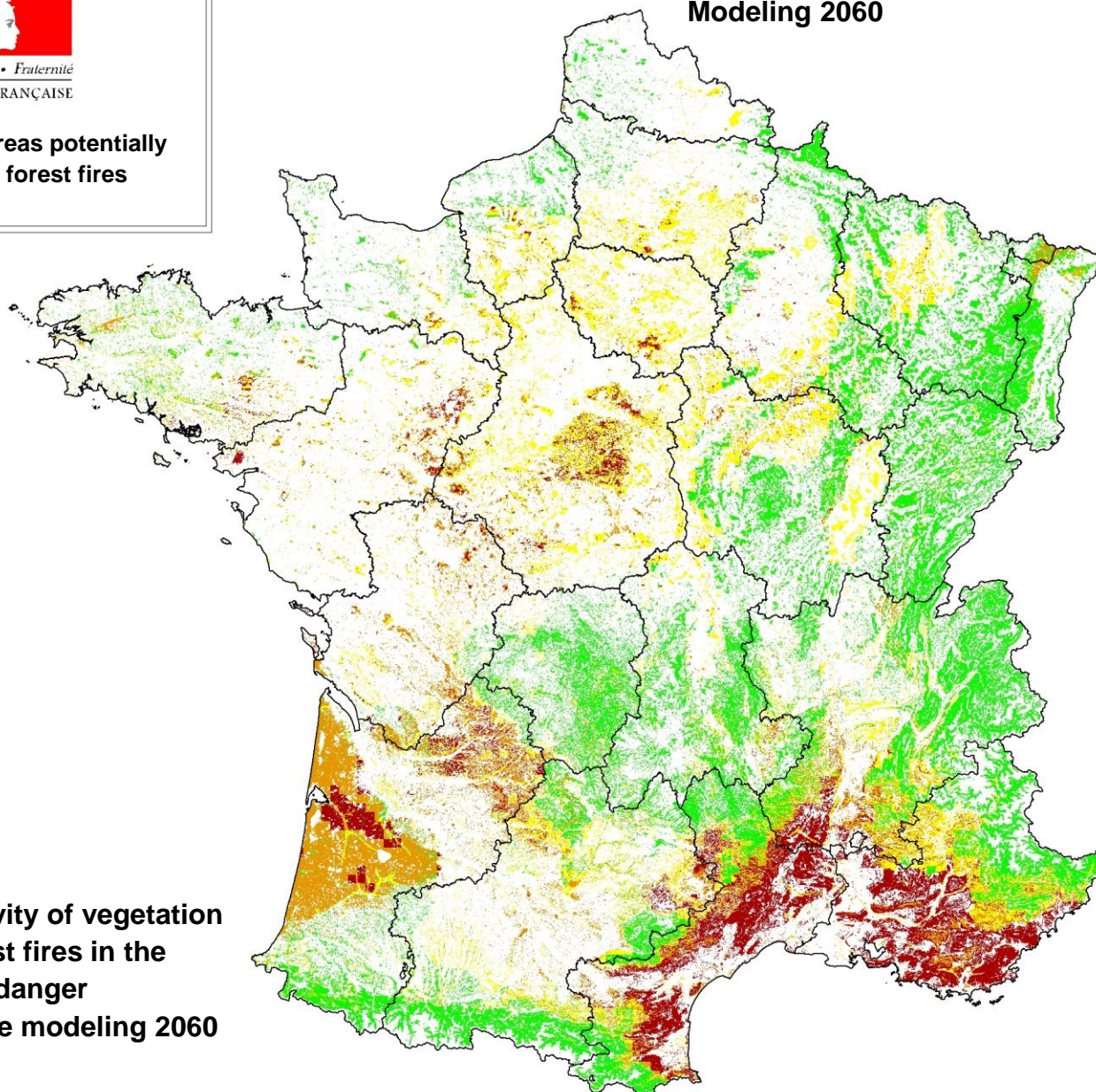
réalisation mai 2010 :



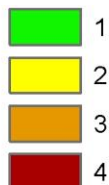
INVENTAIRE FORESTIER
NATIONAL



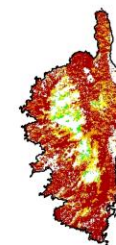
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**Index of sensitivity of vegetation
to summer forest fires in the
meteorological danger
conditions of the modeling 2060**



0 50 100 200 300 400 Kilomètres



Thank you for your attention !



July 27, 2003: Néron Mountain near the city of Grenoble. This fire will last nearly one month.