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Assessing the increase in wildfire activity with climate change in Southern France

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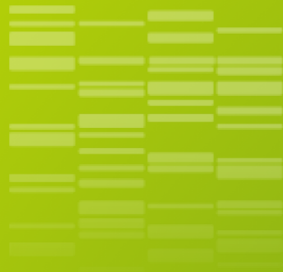
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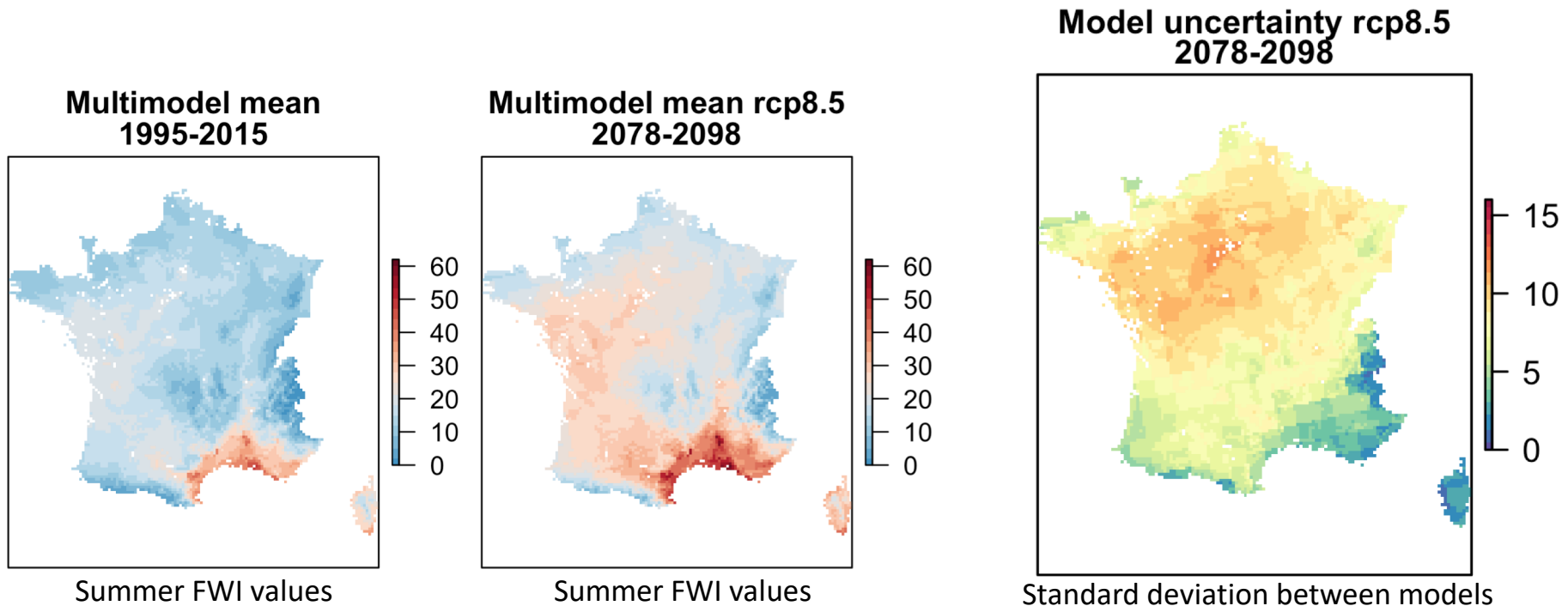
Assessing the increase in wildfire activity with climate change in Southern France

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Introduction: an expected increase in fire danger with climate change

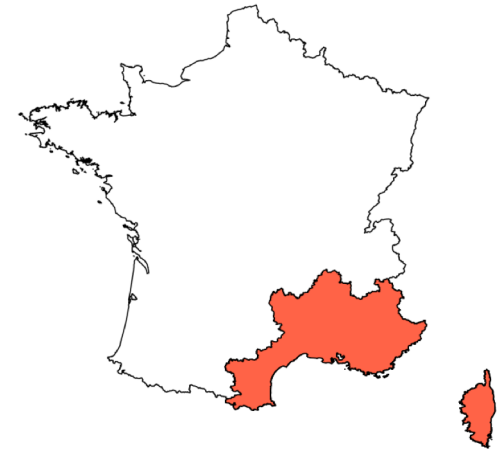
- Increasing temperature and drought duration/intensity in the Mediterranean area... Expected increase in fire activity
- Projections of the Fire Weather Index (FWI) on the French territory for 5 different climate models (*paper under review*)



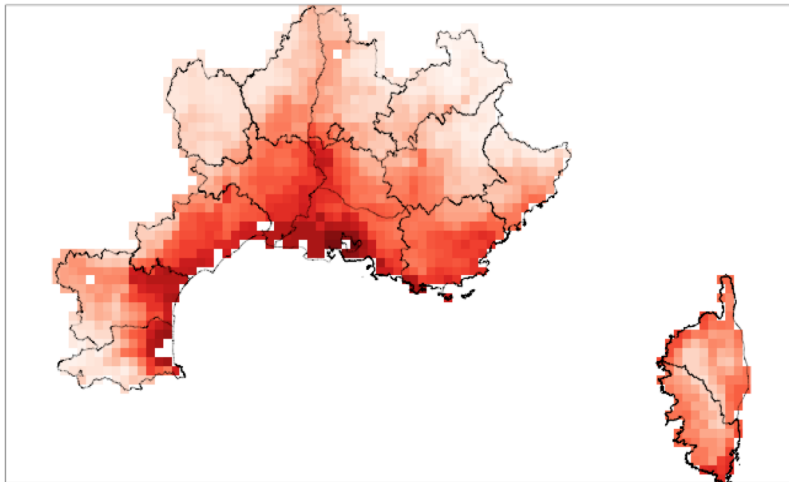
Climate alone does not explain fire records

The projection of fire activity is of higher interest for policy makers and stakeholders than fire danger

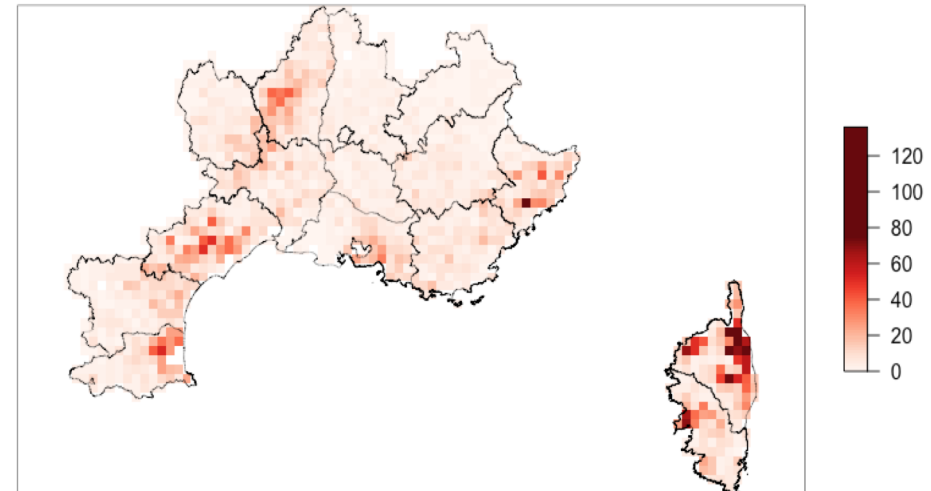
Focus on fire activity in the French Mediterranean area



Mean FWI per pixel
(1995-2015)



Observed number of fires > 1 ha
per pixel (1995-2015)



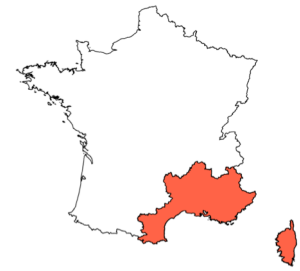


Programme



1. A model for fire occurrence and burnt area in Southern France
2. Projections under future climate

Developing a fire activity model based on daily FWI



- General idea of the model

1. What is the probability of occurrence?



2. Given ignition, what will be the size of the fire?

- Modelling framework

For each pixel-day

1st step
100 simulations of the Poisson process
0, 1, 2... fires

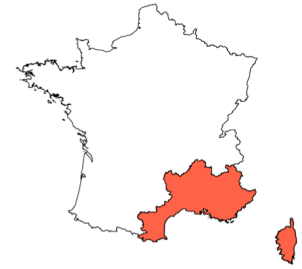
If at least one fire

2nd step
For each occurrence, we draw an associated burnt area in the Pareto distribution



- Fire observations are one single realization of a spatio-temporal process that includes some randomness.

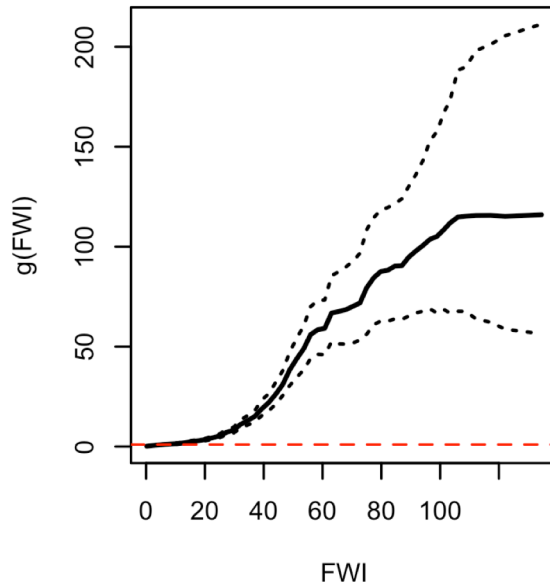
Fire occurrence is correlated with the FWI and forest cover, but response is non-linear



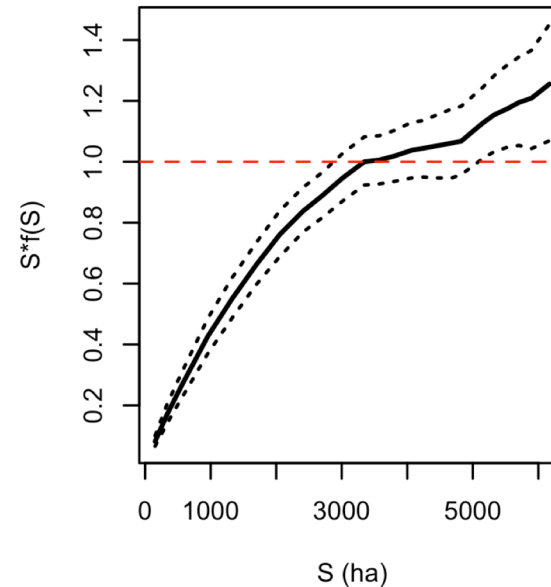
- We model the intensity of the Poisson process. The model is fitted in a Bayesian framework (INLA).
- FWI and forest cover are included as predictors:

$$\text{Fire number} \sim \text{Intercept} * S * f(S) * g(\text{FWI})$$

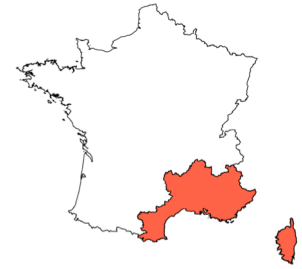
Climate effect



Forested area effect



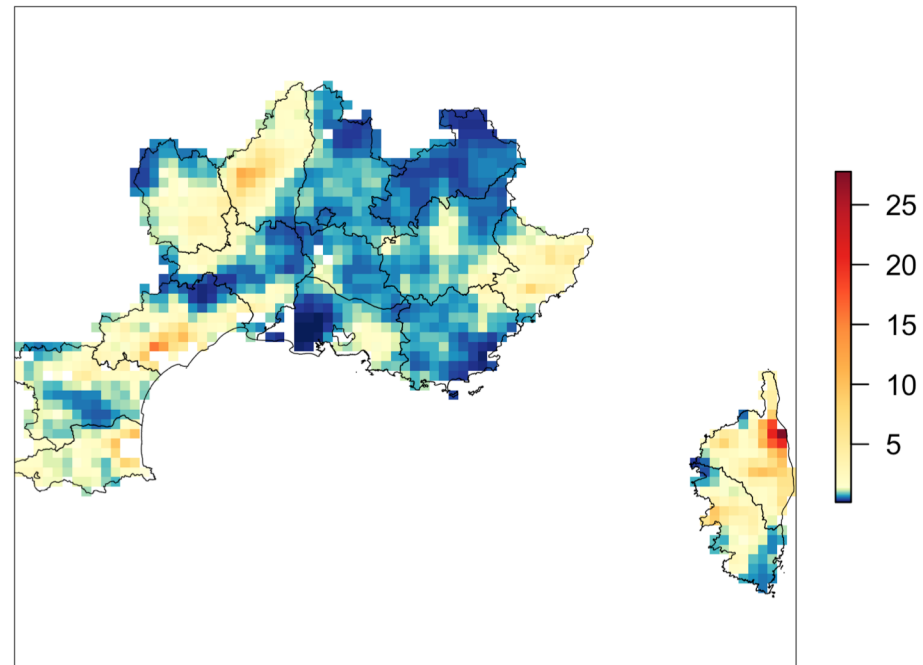
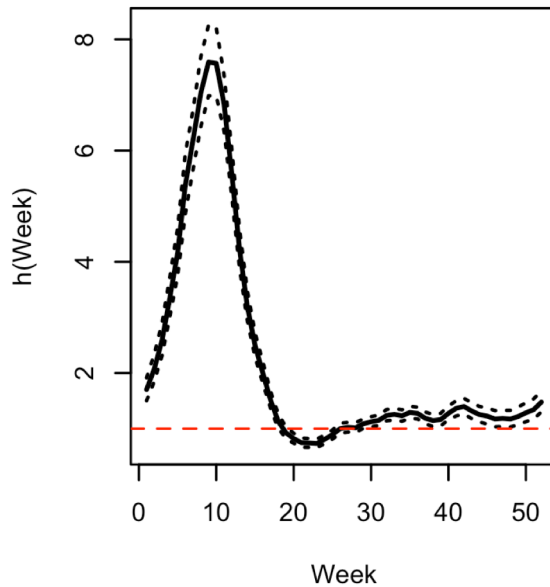
Modelling of spatial and temporal residuals



$$\text{Fire number} \sim \text{Intercept} * S * f(S) * g(\text{FWI}) * h(\text{Week}) * i(\text{Pixel})$$

Spatial effect

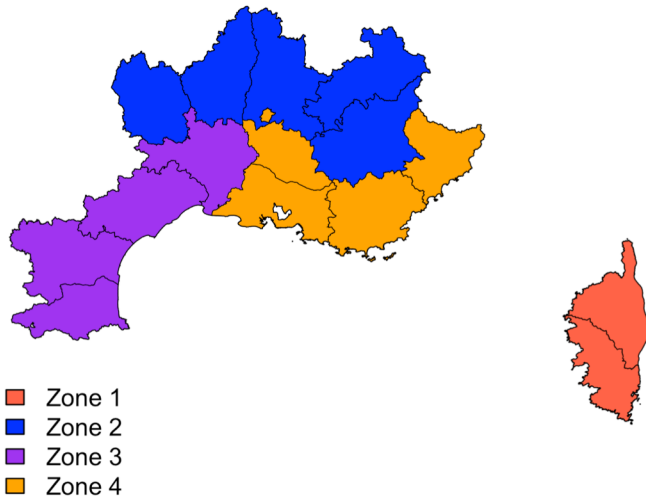
Seasonal effect



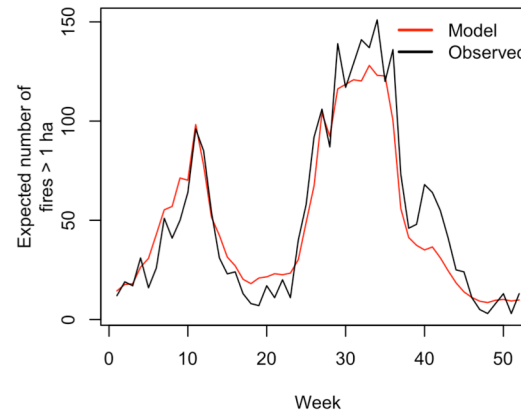
Resulting of : population density, land use, FWI limits, fuel characteristics, firefighting...

The model reproduces well some characteristics of fire occurrence

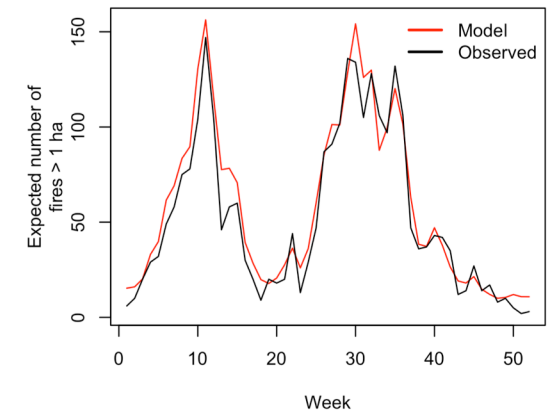
- AUC = 0.9
- The seasonal dynamic is correctly reproduced, independently of the region of interest



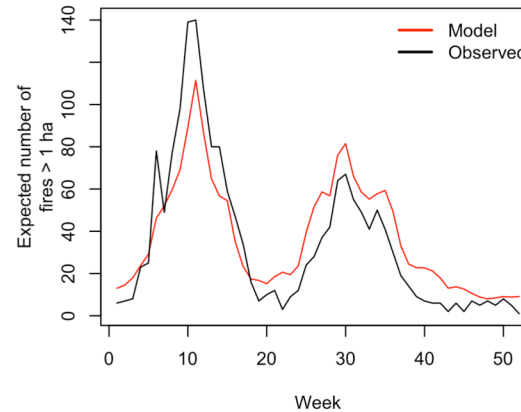
Zone 1



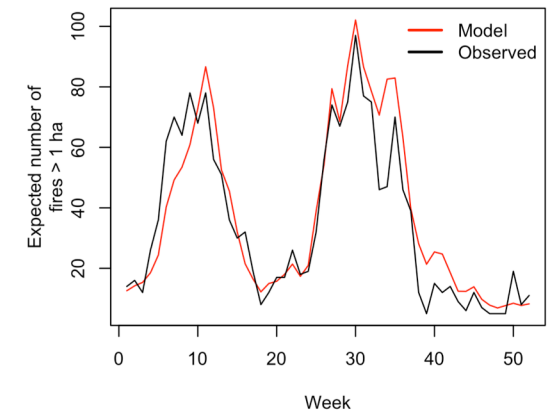
Zone 2



Zone 3

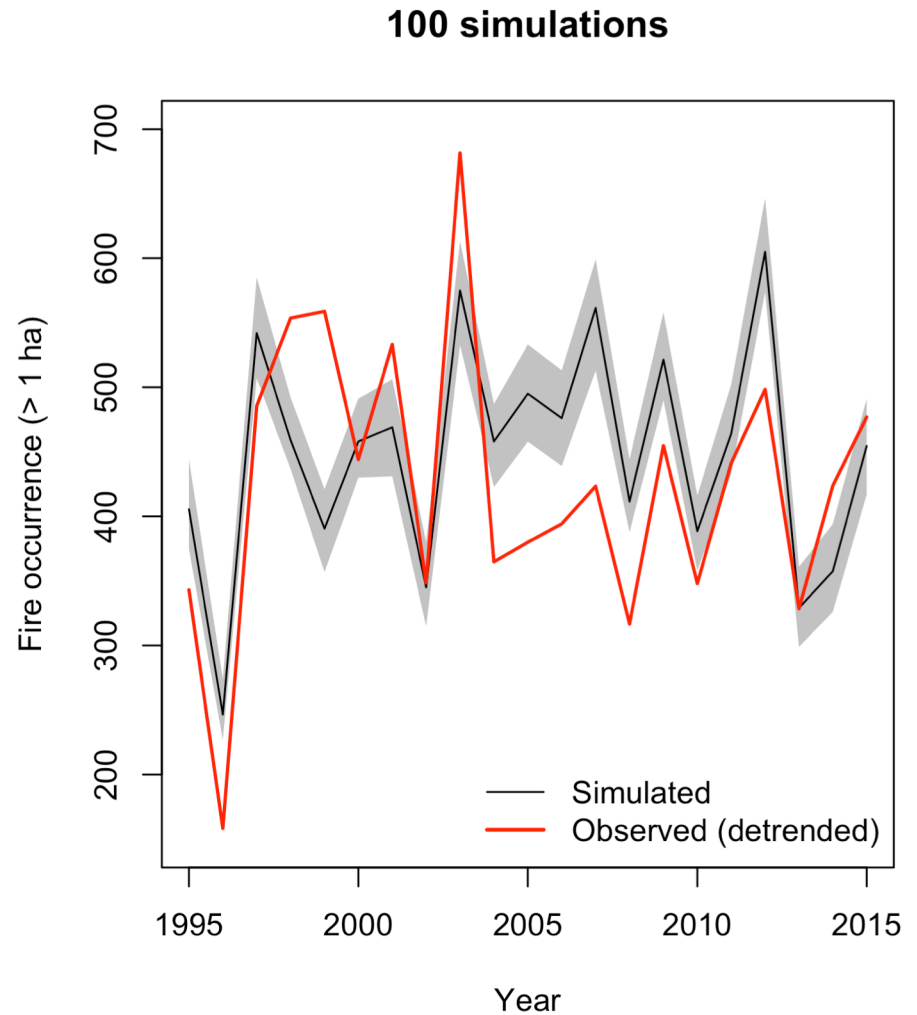


Zone 4



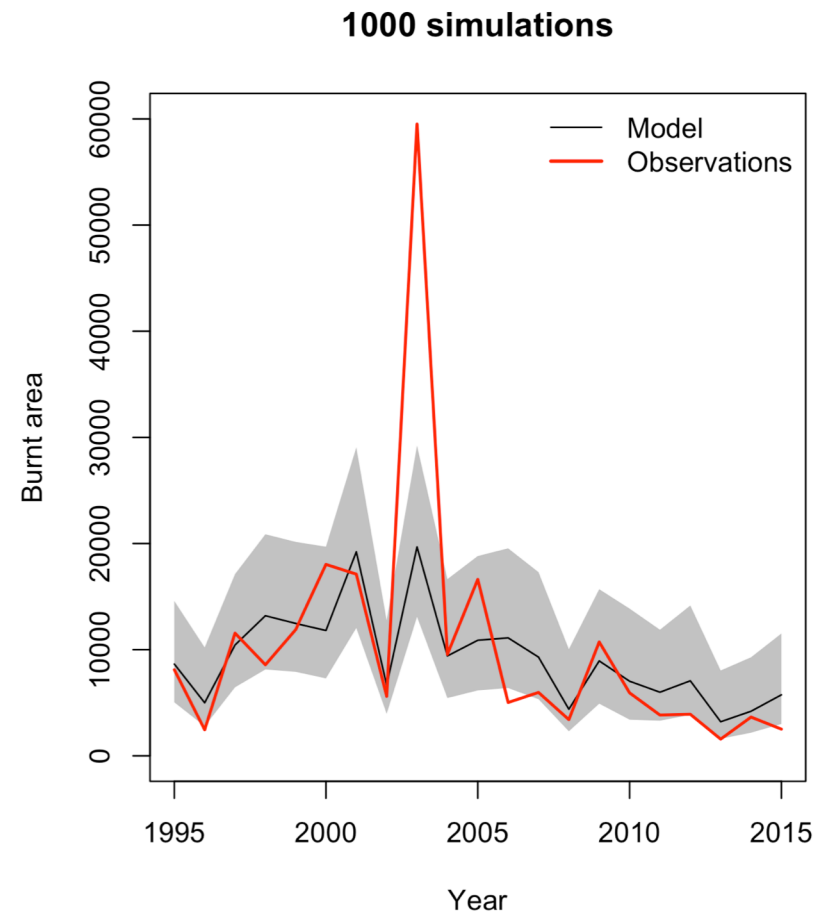
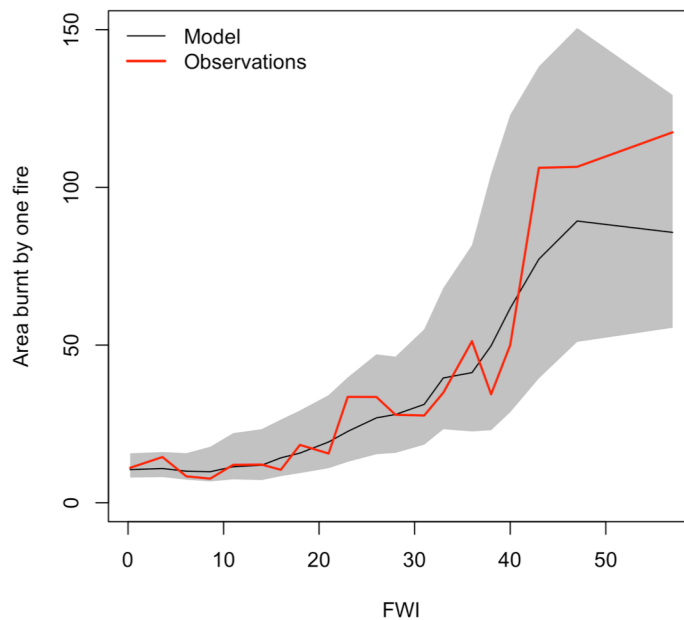
Interannual variability

- The model captures a part of the interannual variability
- Correlation = 0.67 (***)
- FWI is the only predictor that changes between years



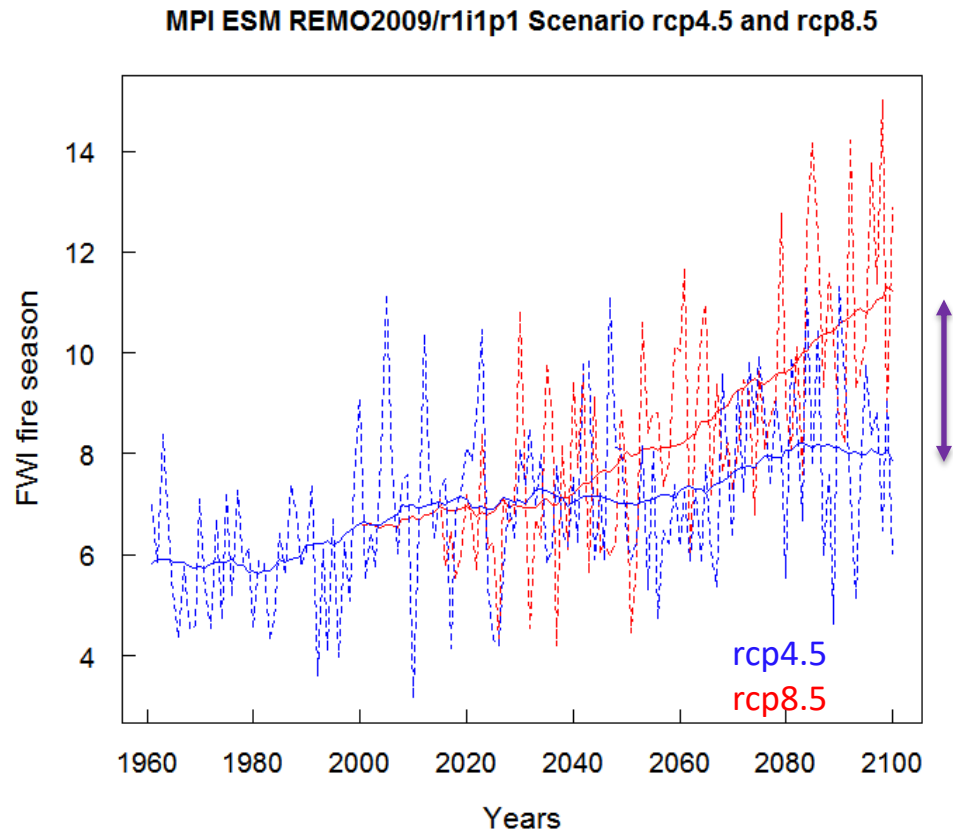
Performance of the burnt area model

- The model captures well the increase in burnt area with increasing FWI...
- ... And partly the interannual variability (correlation = 0.77 ***)
- In 2003, the model is not able to reproduce the severity of the loss

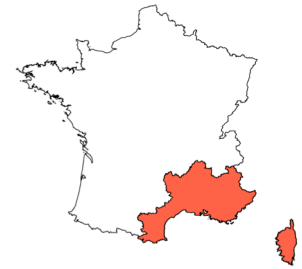


Projections: which fire activity in the future?

- One “intermediate” climate model under 2 emission scenarios



Projections: which fire activity in the future?



- The increase is similar around 2050, but changes a lot in 2090 regarding the scenario

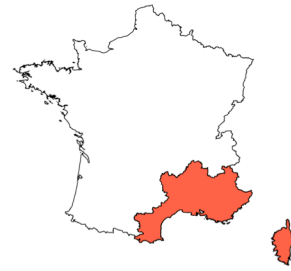
Fire occurrence

Time horizon	1996-2015	2041-2060	2081-2100
rcp4.5	Reference	+ 12%	+ 23%
rcp8.5		+ 18%	+ 75%

Burnt area

Time horizon	1996-2015	2041-2060	2081-2100
rcp4.5	Reference	+ 24%	+ 42%
rcp8.5		+ 31%	+ 169%

Projections: which fire activity in the future?



Seasonal FWI and expected fire activity

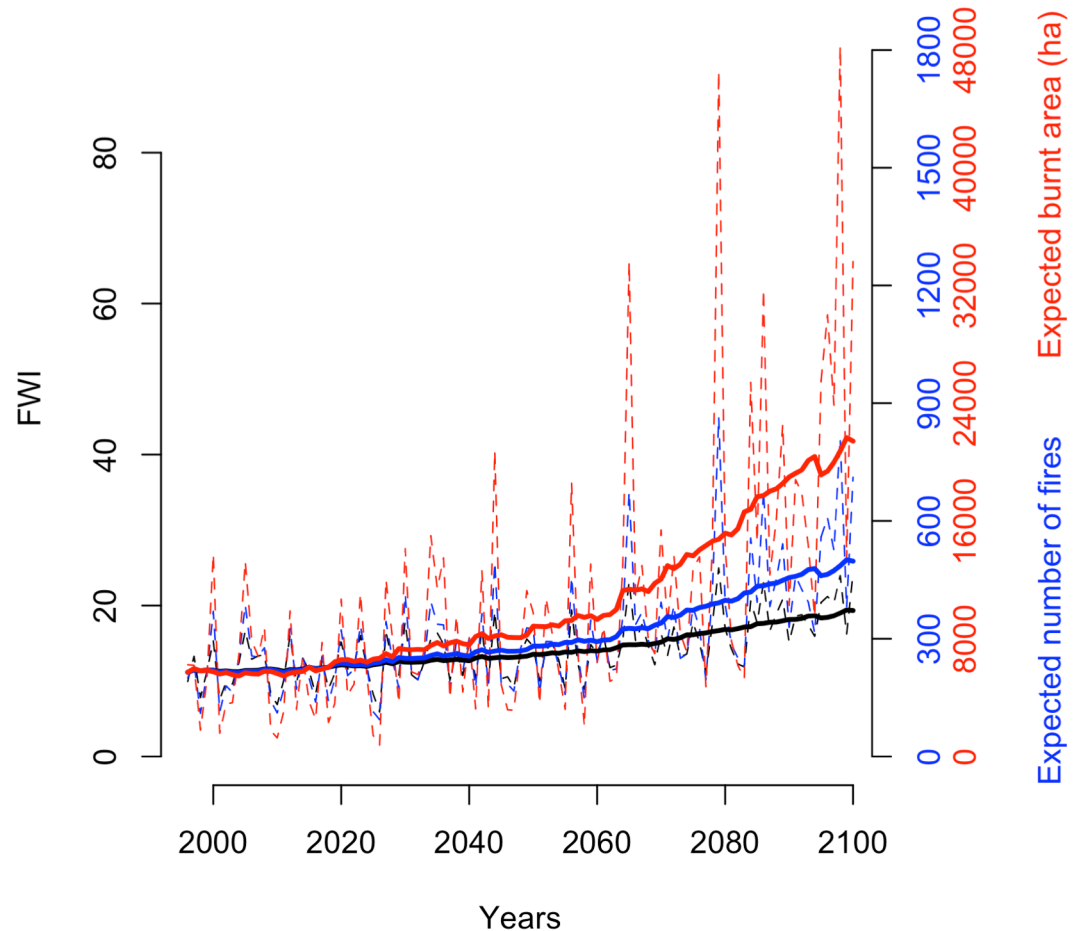
Focusing on the
“fire season” :
June > September
(rcp8.5)

By the end of the century:

FWI = + 70%

Occurrence = + 130%

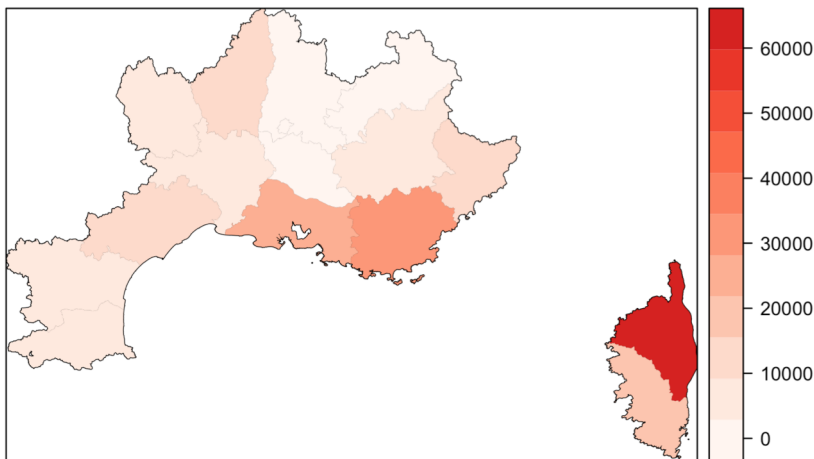
Burnt area = + 270%



Projections: the aggravation is more severe in some areas

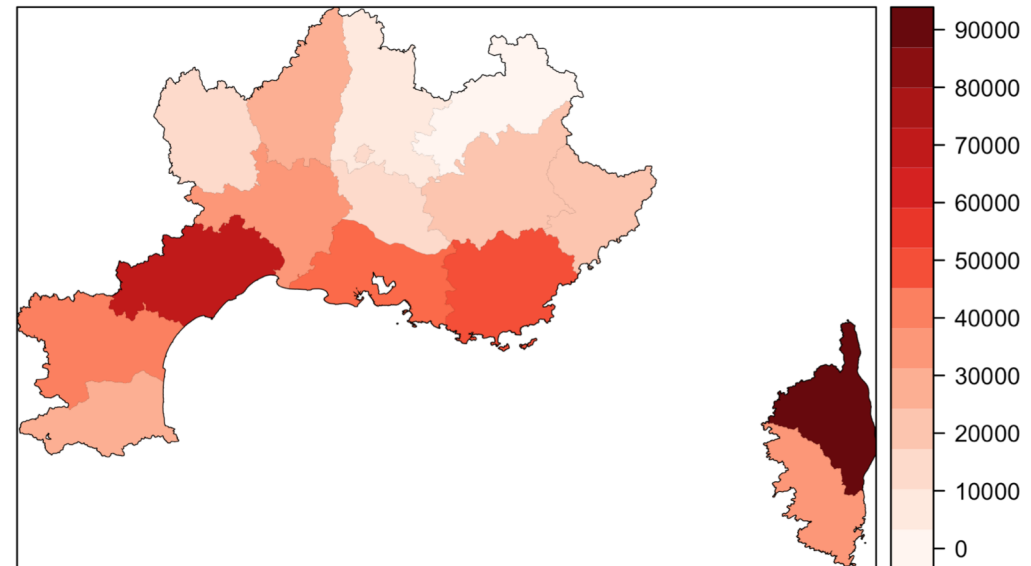
- The increase is stronger in some areas (Hérault, Corsica...)
- Importance of the emission pathway to avoid this dramatic increase

Current burnt area (ha)



1996-2015

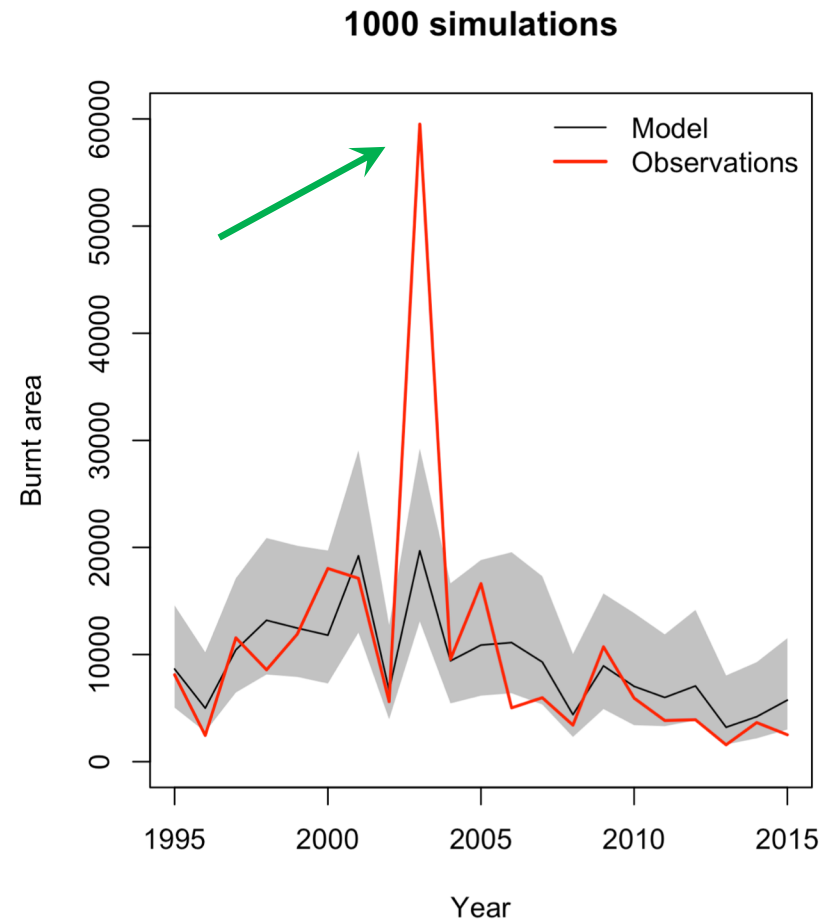
Projected burnt area (ha)



2081-2100 (rcp 8.5)

Perspectives and discussion

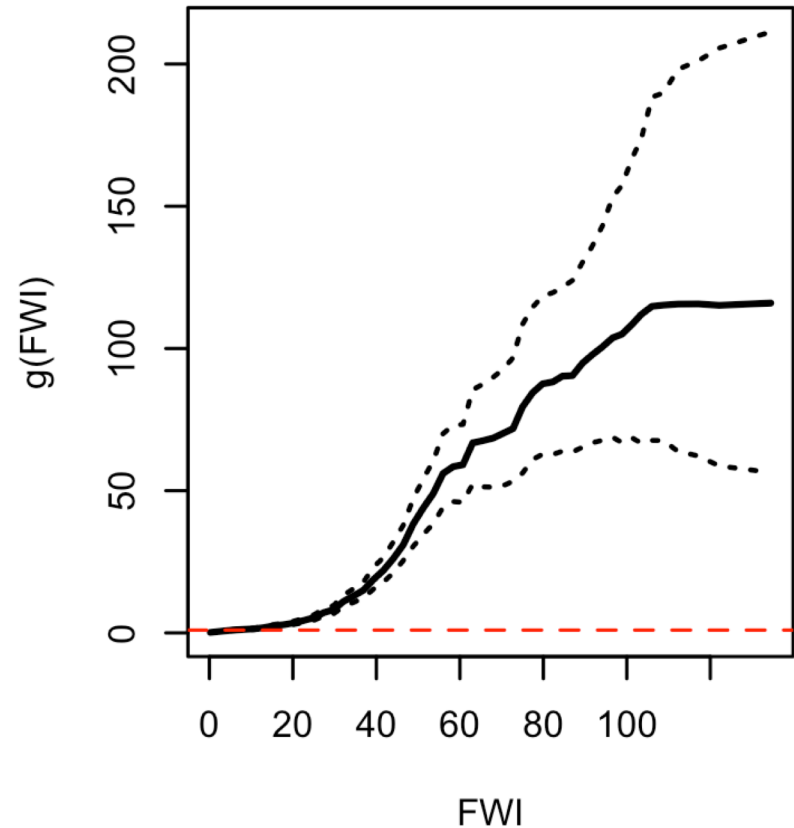
- Hypotheses about 2003:
 - Limits of the FWI under extreme conditions
 - Fires that (unluckily) began in areas with important and continuous forest cover [*under progress...*]
 - Intentional fires
 - The model might underestimate variability



Key points

- An increasing fire danger
- The isolation of a *non-linear* climate-fire relationship, that is also working under *winter conditions*
- The increase in burnt area and fire occurrence is much bigger than what is expected for fire danger indices

Climate effect



Thank you for your attention



INRA
SCIENCE & IMPACT

References

- Fargeon H, Martin-StPaul NK, Pimont F, De Caceres M, Ruffault J, Opitz T, Allard D, Dupuy J-L. 2018. Assessing the increase in wildfire occurrence with climate change and the uncertainties associated with this projection. In *Advances in forest fire research* (Ed DX Viegas). pp. 23–32. (Imprensa da Universidade de Coimbra).
- Fargeon H, Pimont F, Martin-StPaul NK, De Caceres M, Ruffault J, Barbero R, Dupuy J-L. 2019. Projections of fire danger under climate change over France: where do the greatest uncertainties lie? *Climatic Change*, submitted.

