Climate change impacts on forest fires : INRA contribution

Jean-Luc Dupuy, François Pimont, Nicolas Martin-StPaul, Hélène Fargeon, Eric Rigolot

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Outline

INRA researches on forest fires

Climate change impacts on forest fire risk

- conclusions from a survey of fire risk projections in Europe
- a PhD project on assessment of future forest fire risk in France
- some data issues

INRA researches on forest fires

Topics

- Fire behaviour modelling
- Fuel measurement and modelling
- Plant physiology, water stress and fuel moisture

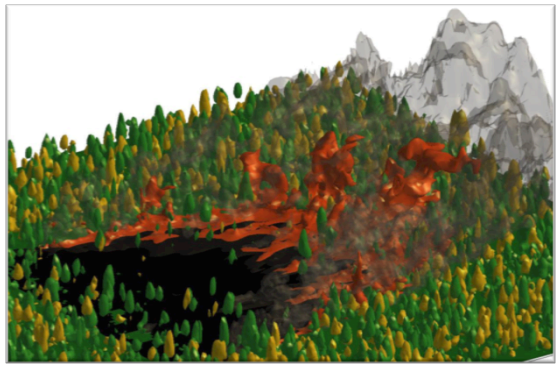
Approach

- Process-based modelling, as far as possible
- Stand to landscape scales

Applications

- Fire risk evaluation
- Fuel treatment evaluation
- Climate change impacts on forest fire risk

Fire simulation (FIRETEC)

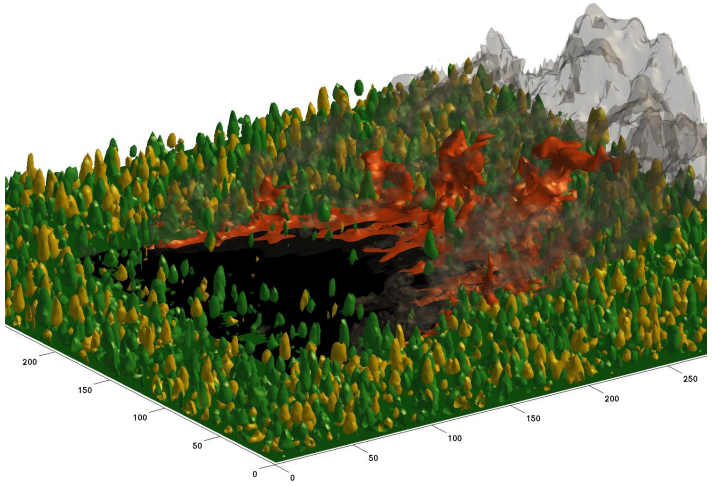


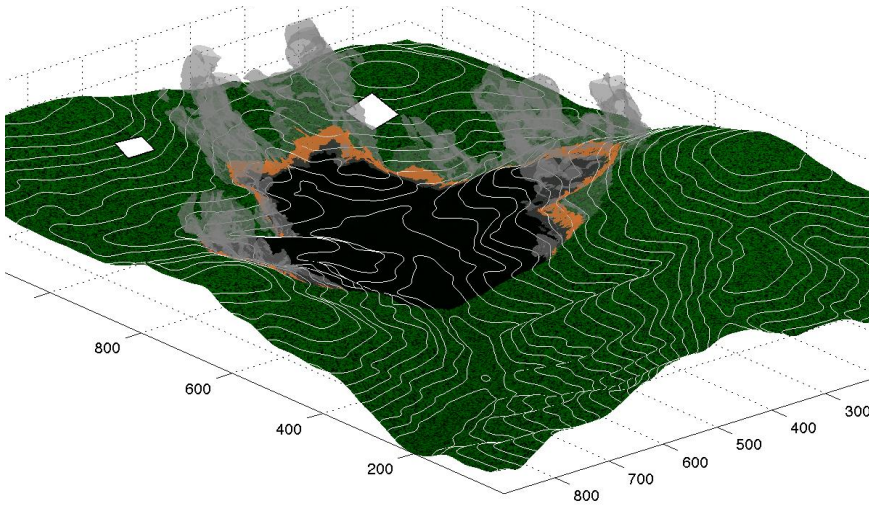
Fuel break

INRA researches on forest fires

Physically-based fire modelling : FIRETEC

- Coupling of physical processes driving fire spread, with atmospheric dynamics
- 3D fuel distribution (biomass, moisture)
- Equations solved on 3D grid





- Spatial resolution : 2 m
- Spatial scales: stand to landscape
- Predictions : fire contours, fire intensity, fluxes, temperatures,...

INRA researches on forest fires

Fuel measurement : use of terrestrial LiDAR

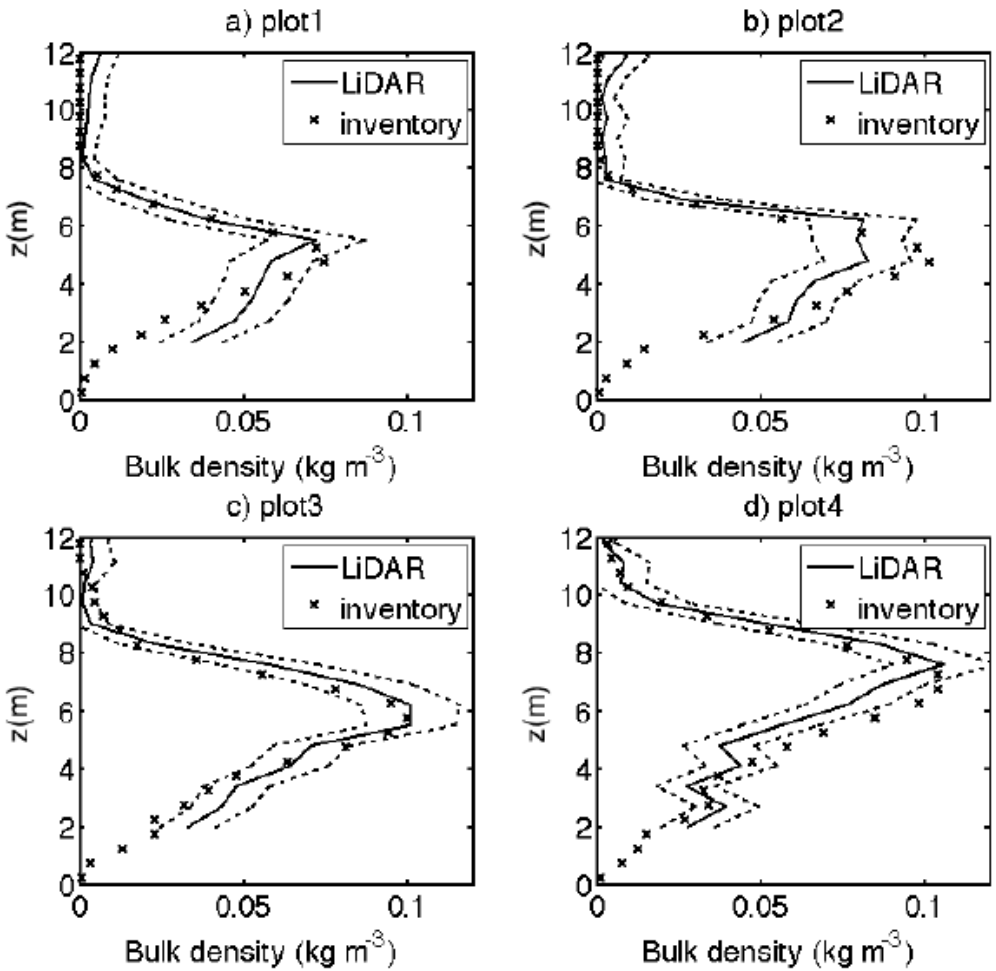
Estimation of foliage biomass in forest canopies

Theory : LiDAR point cloud density is proportional to foliage area

Development : calibration, post-processing algorithms

LiDAR scan of a plot

Canopy bulk density profiles in a Quercus pubescens stand

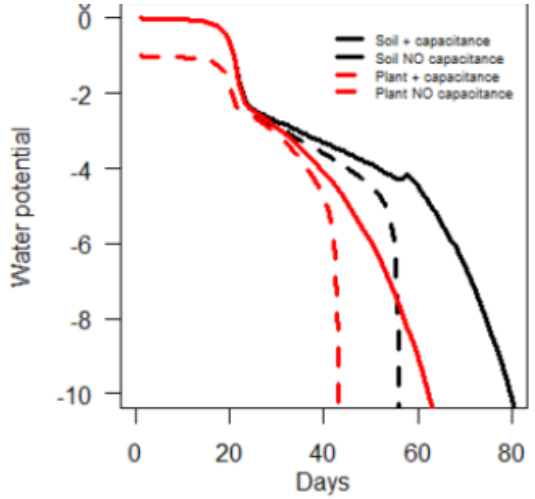


INRA researches on forest fires

Modelling live fuel moisture dynamics

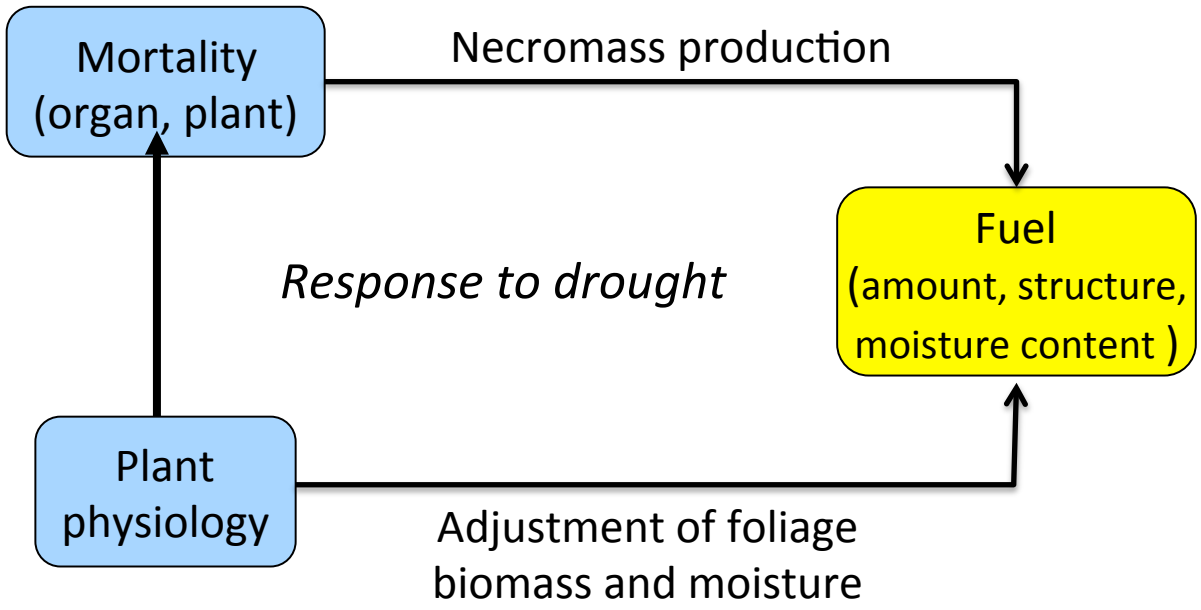
Development of a soil-plant hydraulic model to predict survival time to drought

Measurement of plant hydraulic traits, including shrubs



Chênes verts ayant subi la sécheresse dans l'Hérault

Photo : Pierre Girard, DSF.



Climate change impacts on forest fire risk

MEDWILDFIRELAB

"Global change impacts on wildfire activity and behaviour in southern Europe", a networking action funded by the ERANET FORESTERRA (2014-2017).

Deliverable D2.1: *Global change impacts on wildfire activity and behaviour in southern Europe***,** by J-L Dupuy, M. Guijarro, P. Fernandes

Literature survey of studies assessing changes in wildfire danger or activity in Europe under global warming:

- synthetic view of expected changes
- current limitations of the methods used to produce these projections

Climate change impacts on forest fire risk

MEDWILDFIRELAB

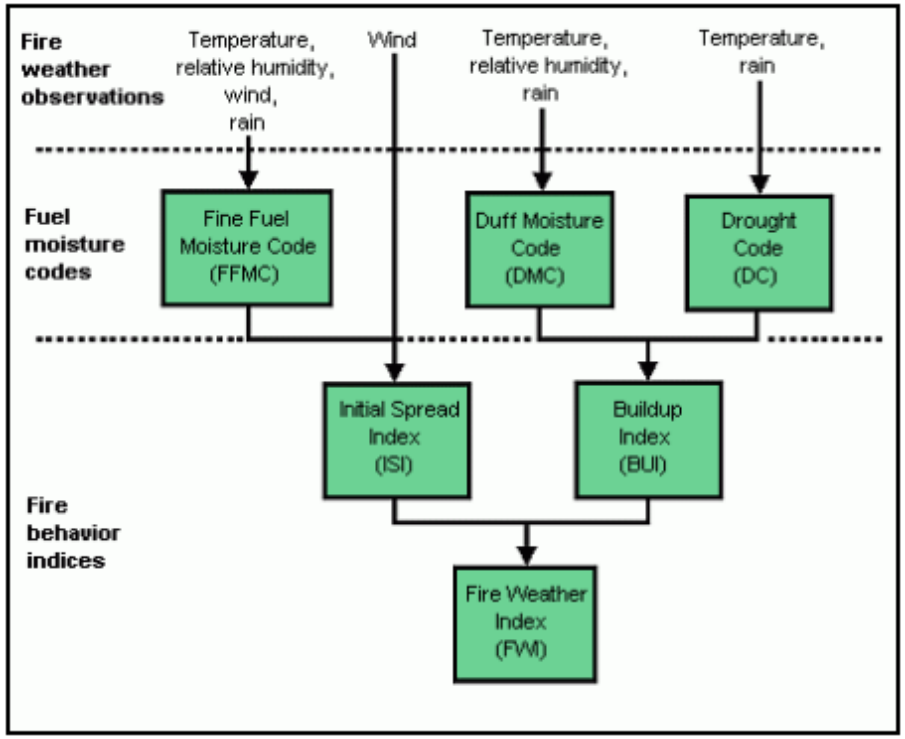
Projection methods

In Europe, most projections are based on the Fire Weather Index

These projections are useful to assess trends in potential fire danger and delimiting future fire-prone area

Some studies use statistical relations between climate and observed fire activity (*not applicable* in new fire-prone areas)

The Fire Weather Index (FWI)



Climate change impacts on forest fire risk

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Expected trends (summary)

Fire danger and fire season length are projected to increase everywhere in southern Europe.

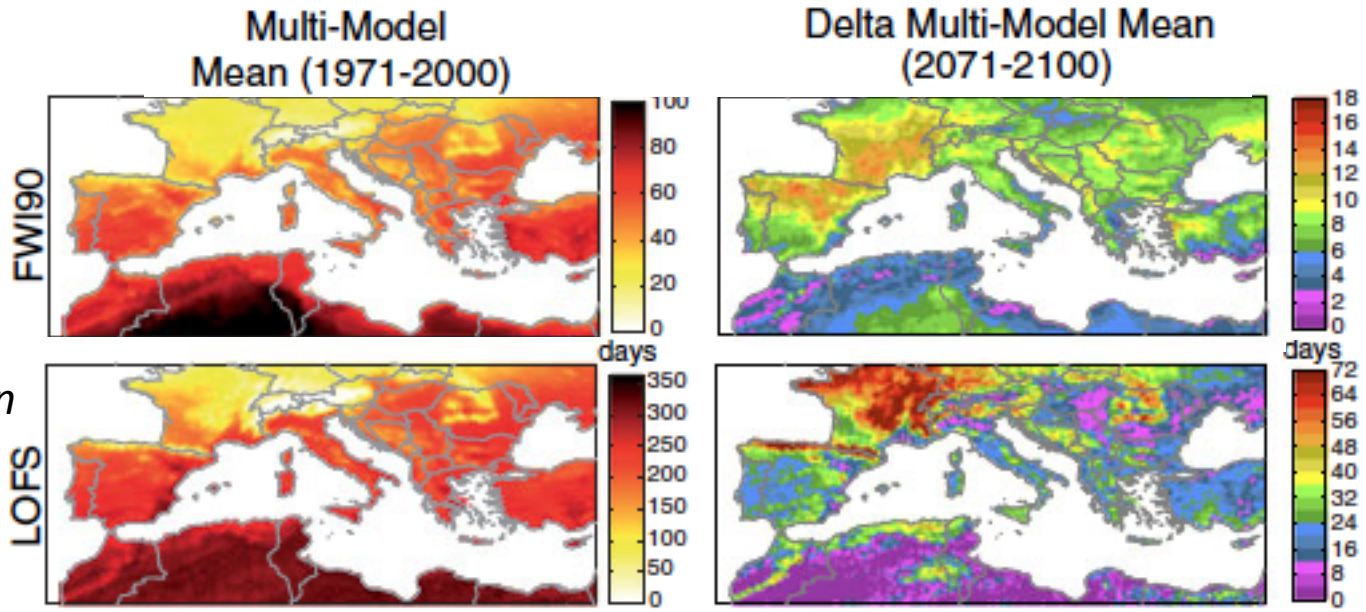
In the warmest and driest, currently fire-prone regions, fuel availability could become the main limiting factor of fire activity. Projections of burnt areas are very uncertain.

The area at risk should expand to new fire-prone regions, such as the western and central France, Eastern Europe or the Mediterranean mountains.

Bedia et al. (2014)

Extreme fire danger

Length of fire season



Climate change impacts on forest fire risk

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Limitations of current methods

Underlying hypotheses (FWI-based projections)

- warming will only change the frequency of high flammability conditions (i.e. low fuel moisture)
- water balance is independent of soil and vegetation cover (drought codes)
- fuel moisture effect on fire does not depend on fuel structure

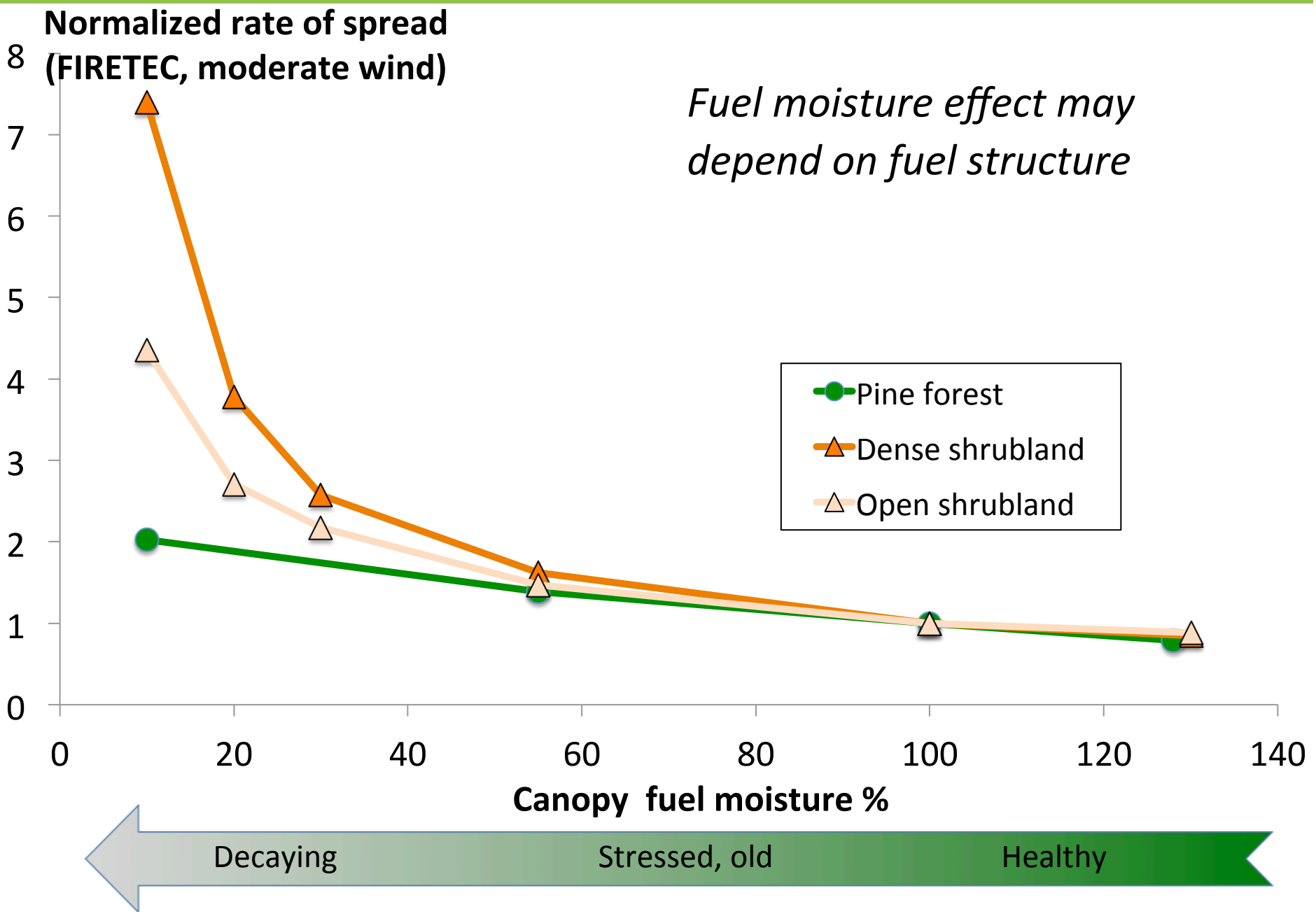
Moreover, warming and CO2 fertilization could affect current fuels

- aridification in driest areas -> fuel fragmentation
- biomass accumulation in wettest areas -> fuel continuity

But uncertainty on precipitations and complexity of biophysical processes preclude predictive simulations to date

Current state-of−the-art leads to consider climate impacts as if fuels and anthropogenic fire drivers do not change

Climate change impacts on forest fire risk



Climate change impacts on forest fire risk in France

PhD project (Hélène Fargeon, 2016-2019) : A process-based approach of climate change impact on forest fire risk in France

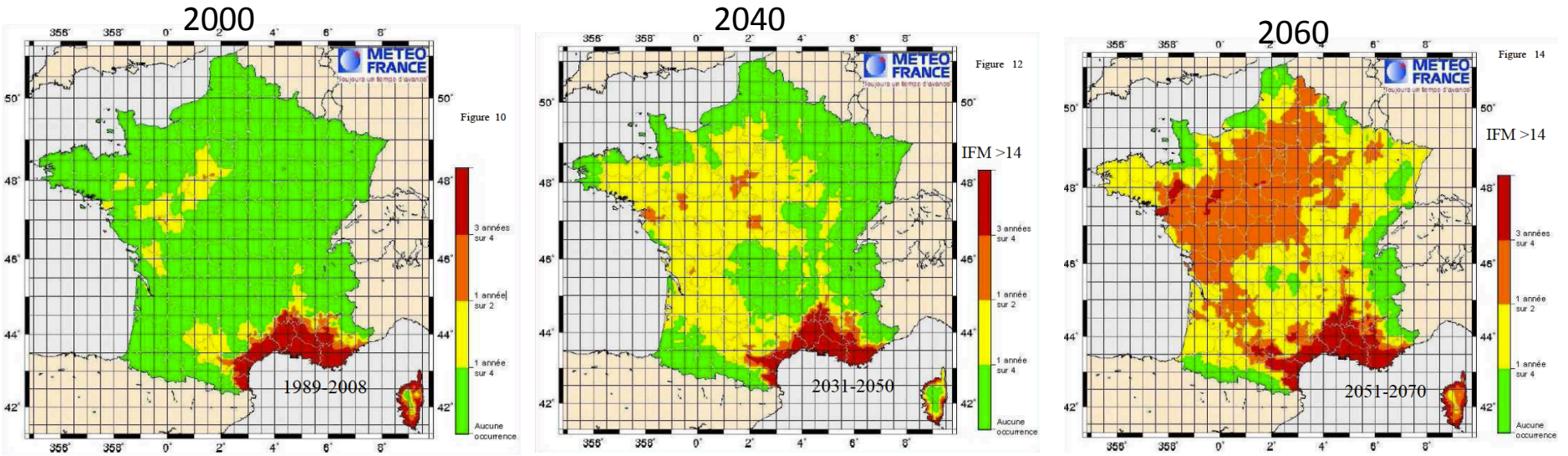
Projection of the FWI shows an expansion of the potential fire-prone area in France

The project aims to:

- incorporate the fuel structure effect in fire projections
- model the water balance and fuel moisture by a process-based approach

Typical question: what will be the future risk for deciduous oak stands in France ?

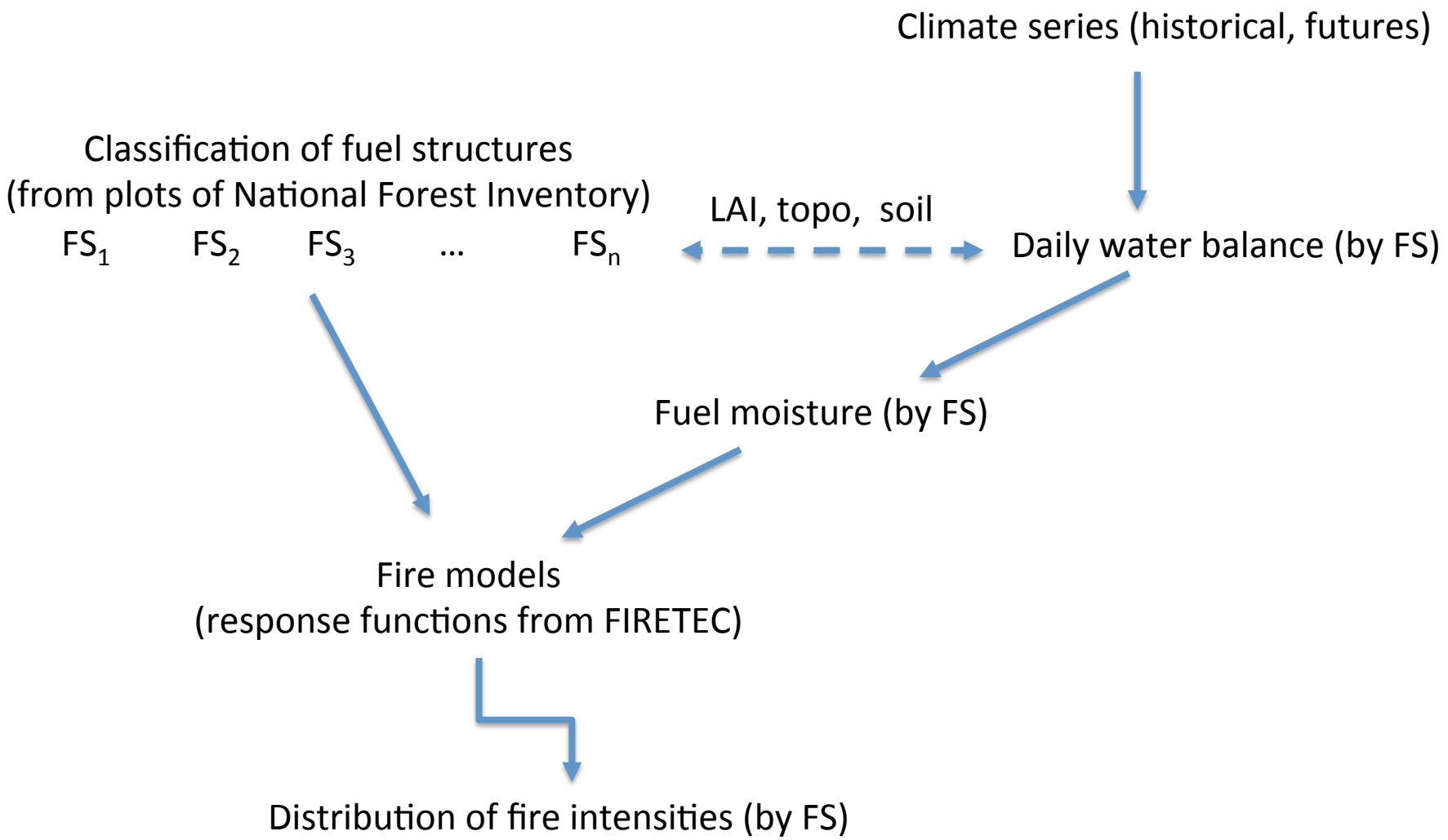
Fire danger projection (frequency of days with FWI > 14) (Chatry et al. 2010)



(FWI computed from May 15 to October 15)

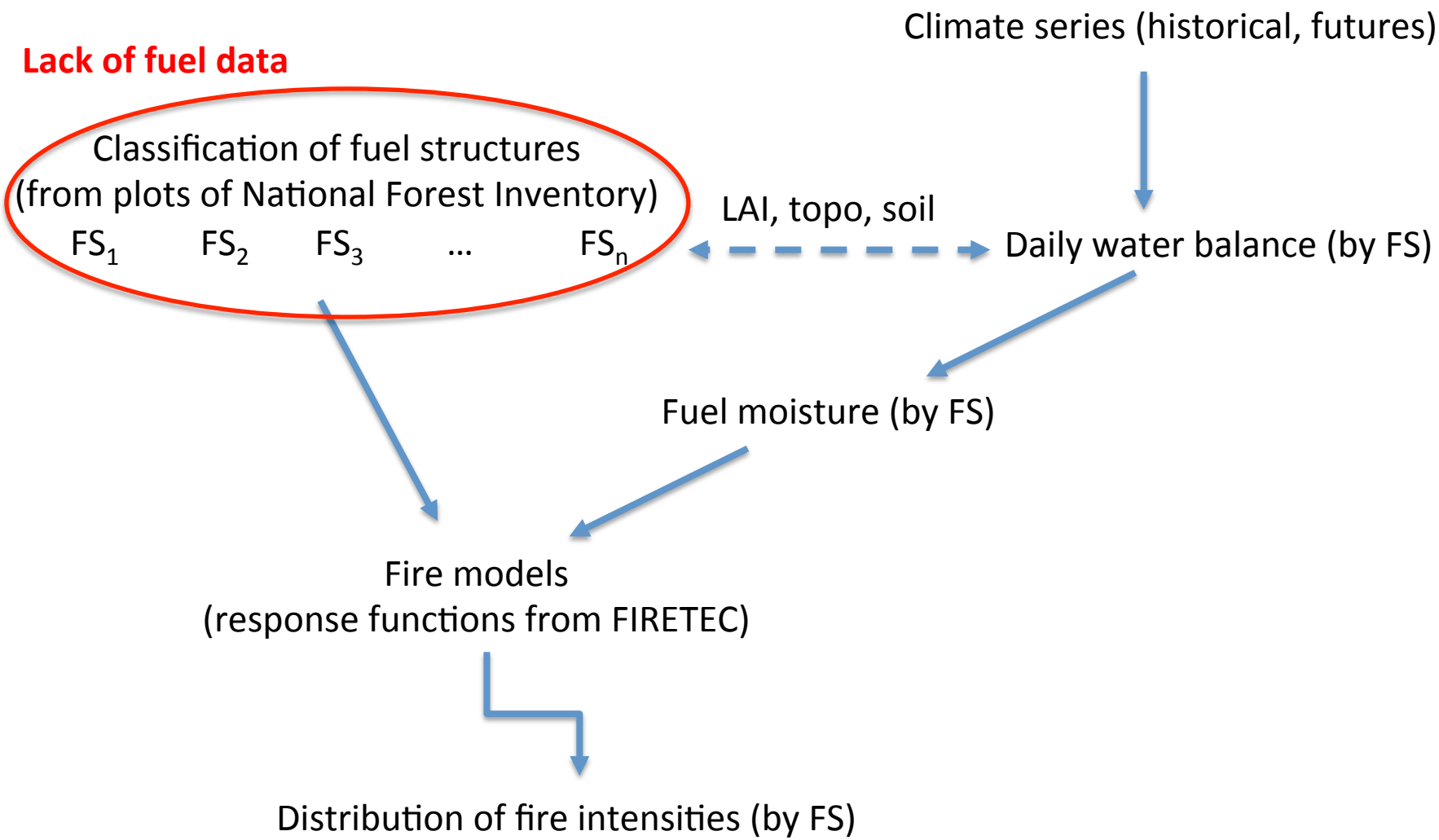
Climate change impacts on forest fire risk in France

PhD project - General approach



Climate change impacts on forest fire risk in France

PhD project - Main issues & research needs



Climate change impacts on forest fire risk in France

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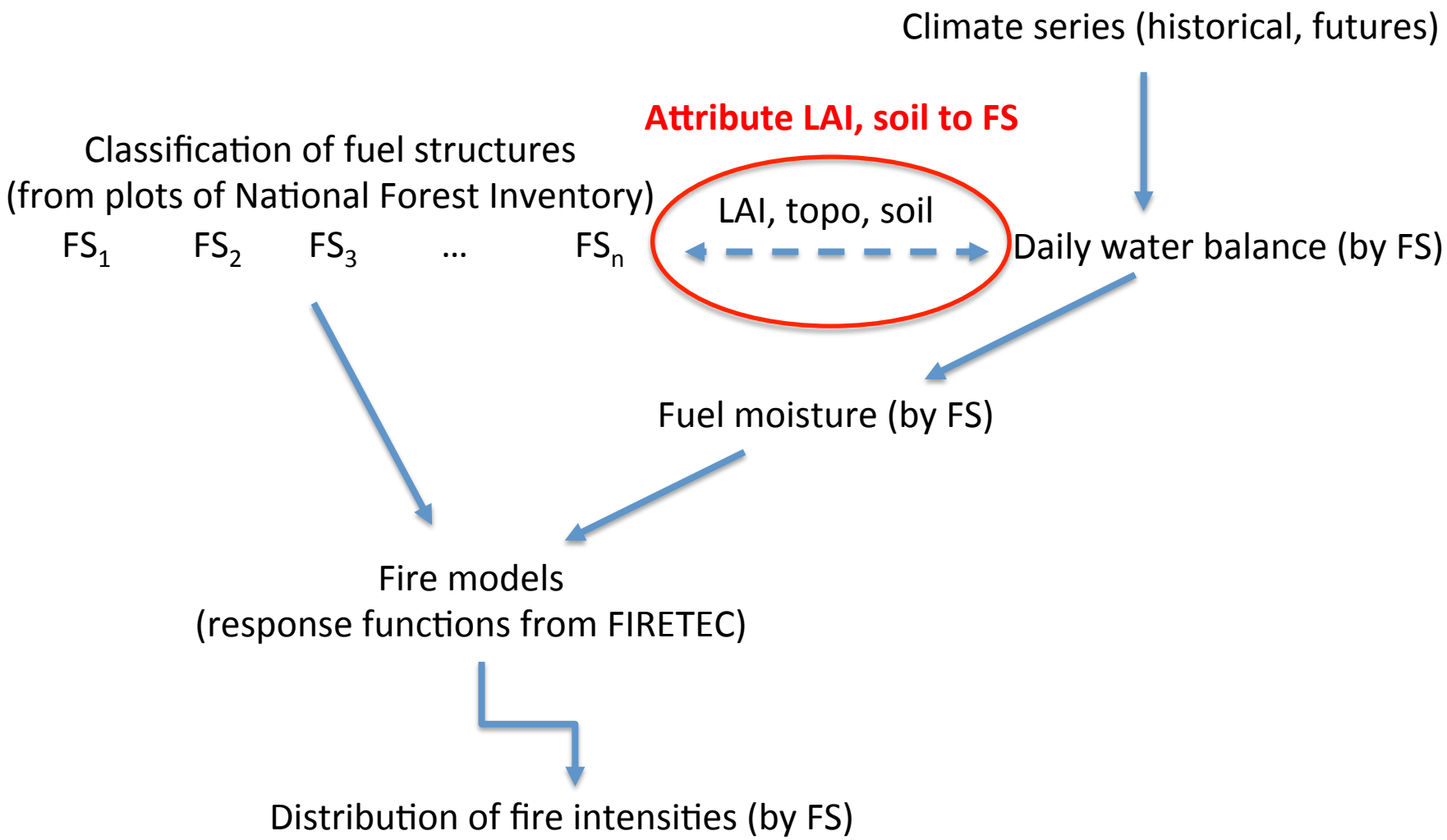
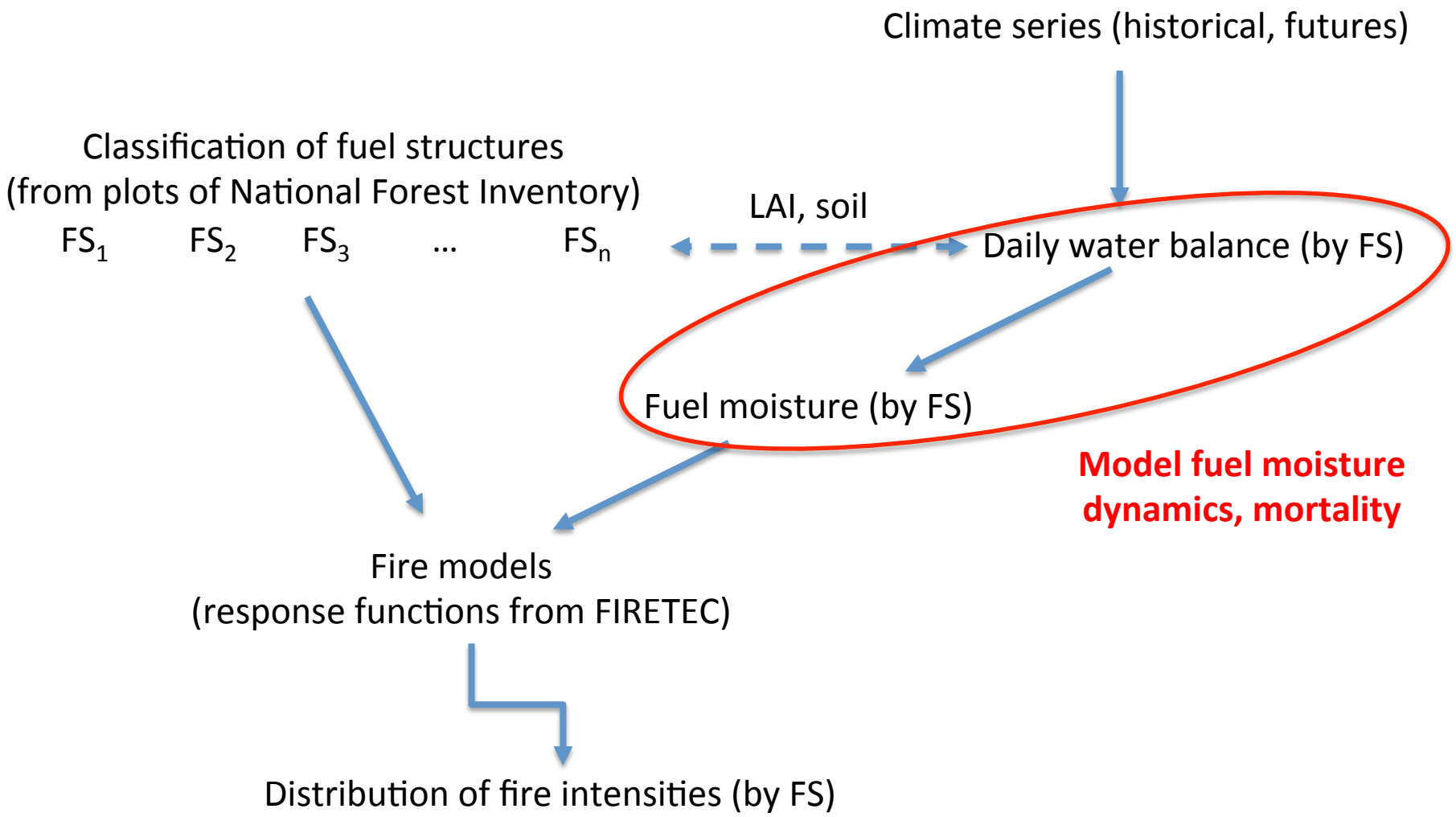


Climate change impacts on forest fire risk in France

PhD project - Main issues & research needs



Climate change impacts on forest fire risk in France

Data issues

- Lack of fuel data, especially in temperate areas
- French NFI : very few data on litter, herbaceous and shrub layers; crown base height not measured

  ➔ Find proxies, build models

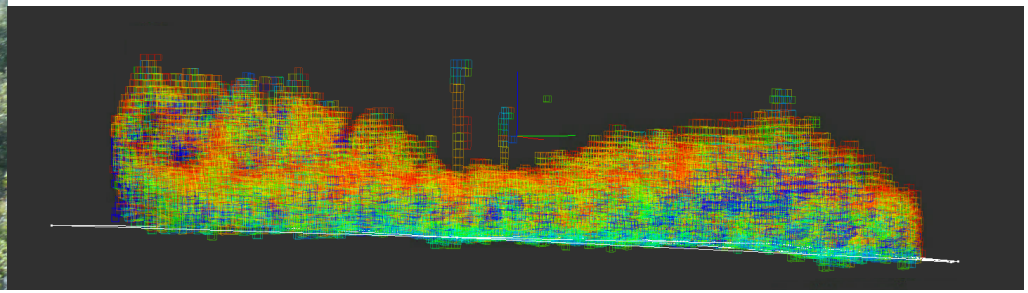
  (e.g. Spanish NFI has much more fuel-oriented data)

  ➔ Use T-LiDAR scans of the NFI for shrub or tree canopy structure

  ➔ Use available allometries for loads, LAI

  ➔ Perform field fuel inventories for validation

T-LiDAR scan of a shrub layer



Climate change impacts on forest fire risk in France

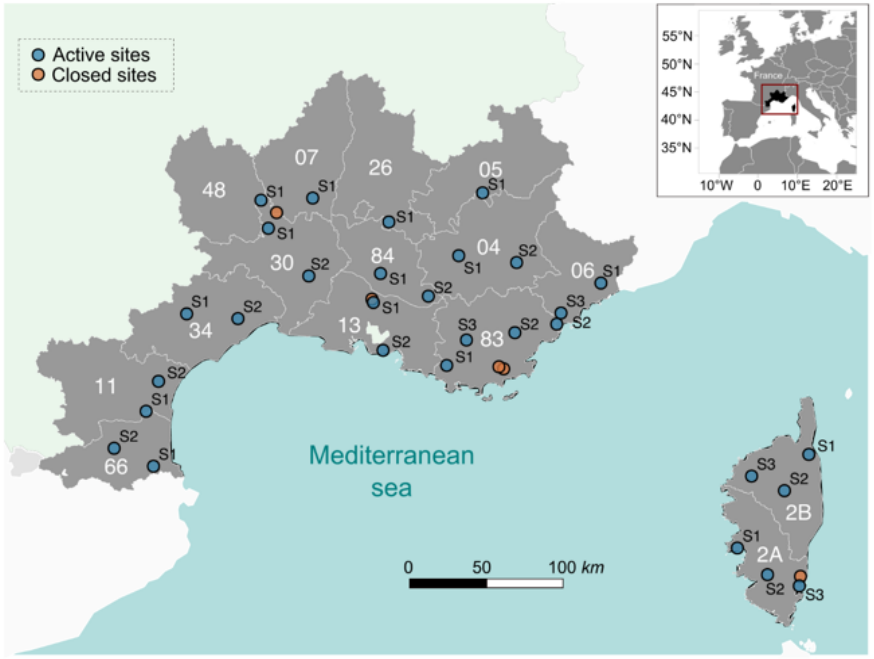
Data issues

- Fuel moisture data for model validation

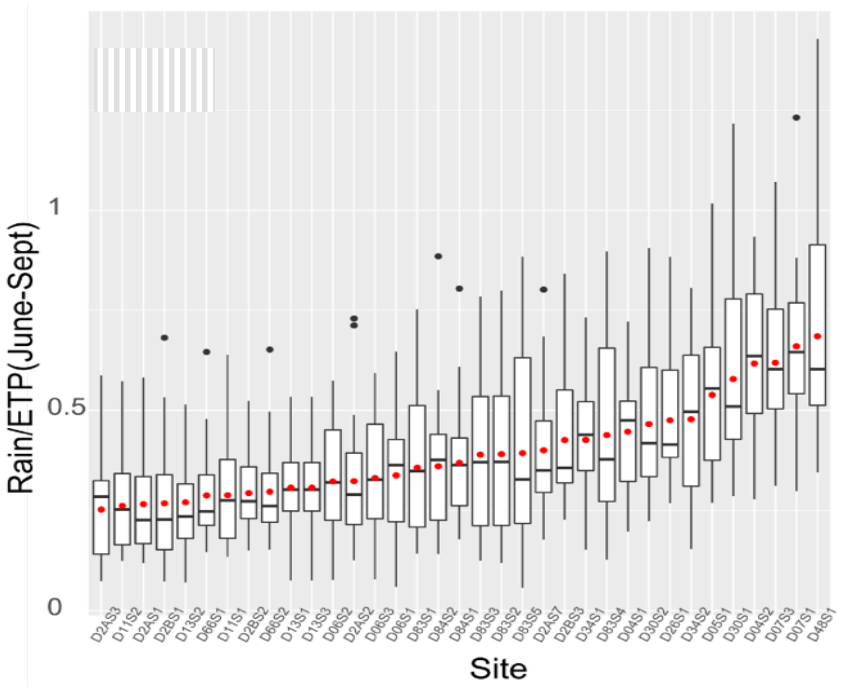
  ➔ A French network for field monitoring of shrub fuel moisture content :

  - 30 active sites in the Mediterranean region, 24 species,
  - 1 sample/week at least (~15 June-15 September), up to 20 years of data
  - operated by the ONF

The "Réseau hydrique" *network*



Sites on a water deficit gradient



Thank you for your attention !