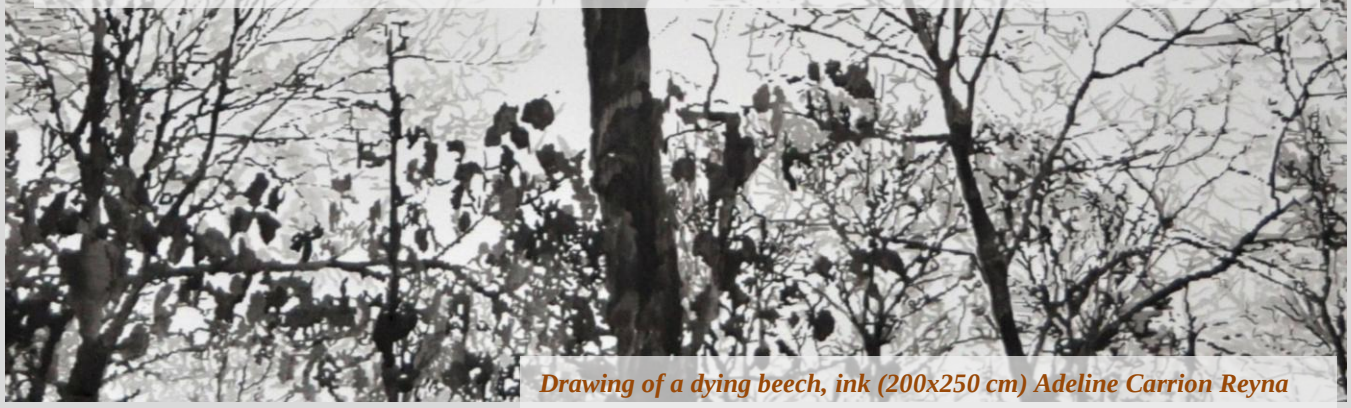
Influence of the spatial resolution of climate on tree range simulations

Nicolas Martin-StPaul, Julien Ruffault, Christophe François, Marc Stéfanon, P. Drobinsky, Kamel Soudani, Eric Dufrene, Serge Rambal, Florent Mouillot, Paul Leadley

Influence of the spatial resolution of climate on tree range simulations

Martin-StPaul NK., Ruffault J., Francois C., Stéfanon M., Drobinsky P., Cheaib A., Soudani K., Dufrêne E., Rambal S., Mouillot F. & Leadley P.

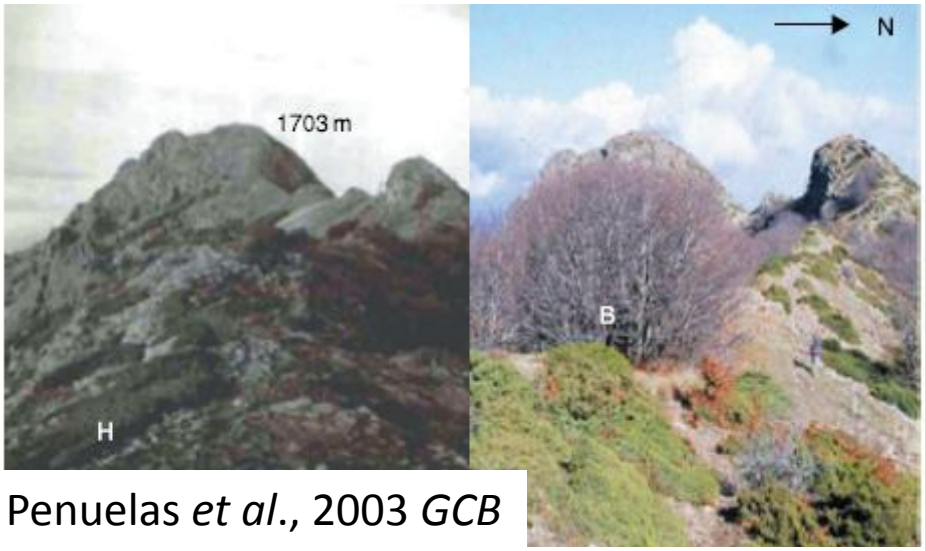
EGU 2013
Vienna April 04



Drawing of a dying beech, ink (200x250 cm) Adeline Carrion Reyna

Introduction
The footprint of climate change on forests

Beech upward shift (70m) to the top of the mountains



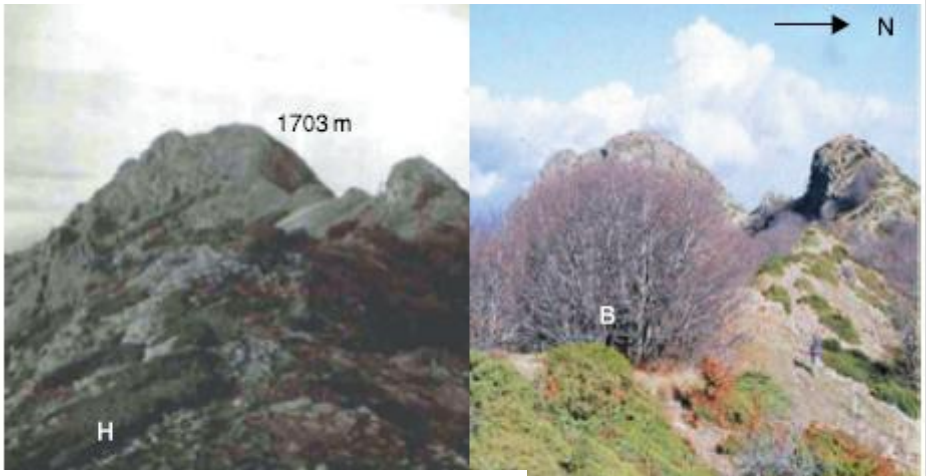
Penuelas *et al*., 2003 *GCB*

1945 1995

➢Migration toward higher elevation

Introduction
The footprint of climate change on forests

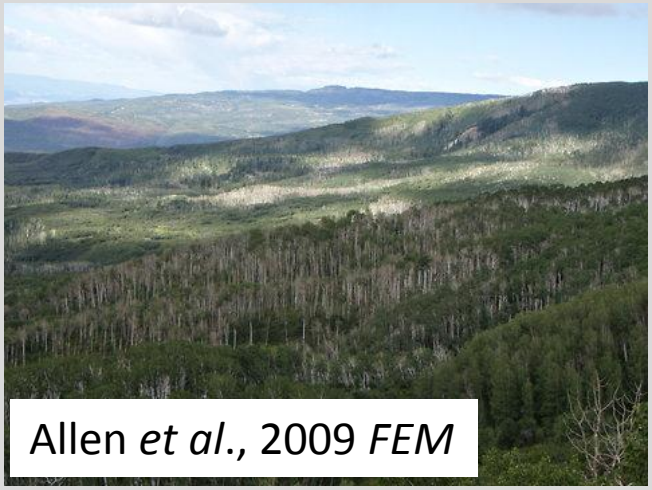
Beech upward shift (70m) to the top of the mountains



Penuelas *et al*., 2003 *GCB*

1945 1995

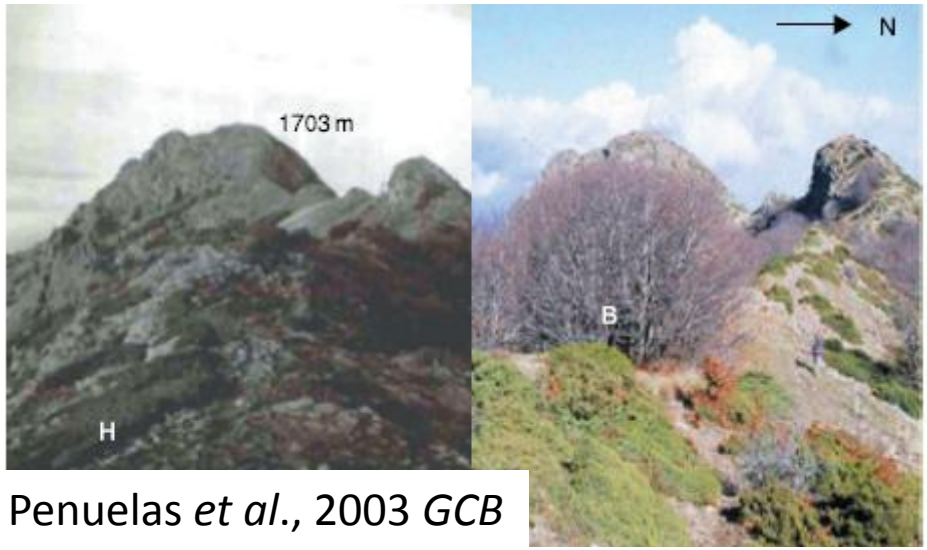
- Migration toward higher elevation
- Increase tree dieback



Allen *et al*., 2009 *FEM*

Introduction
The footprint of climate change on forests

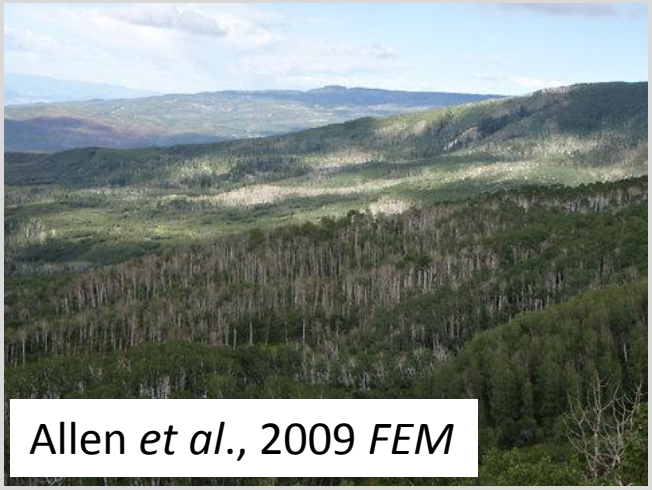
Beech upward shift (70m) to the top of the mountains



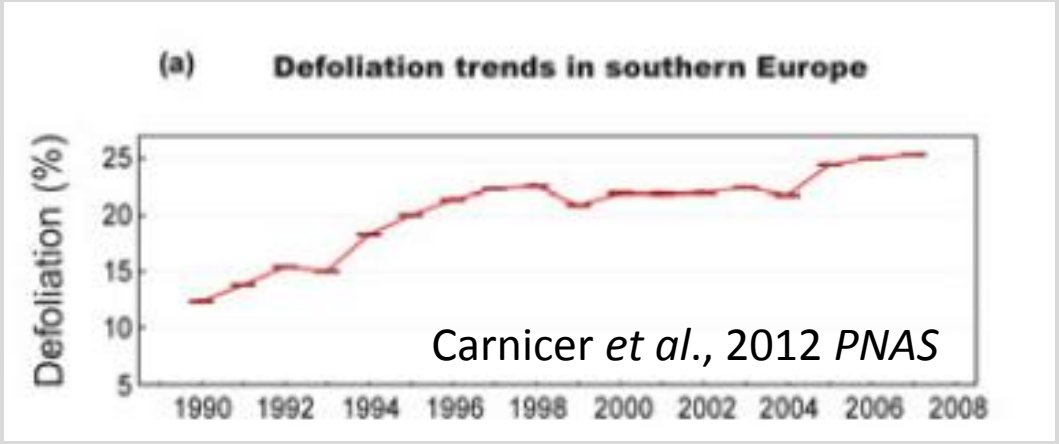
Penuelas *et al*., 2003 *GCB*

1945 1995

- Migration toward higher elevation
- Increase tree dieback
- Increase forest defoliation



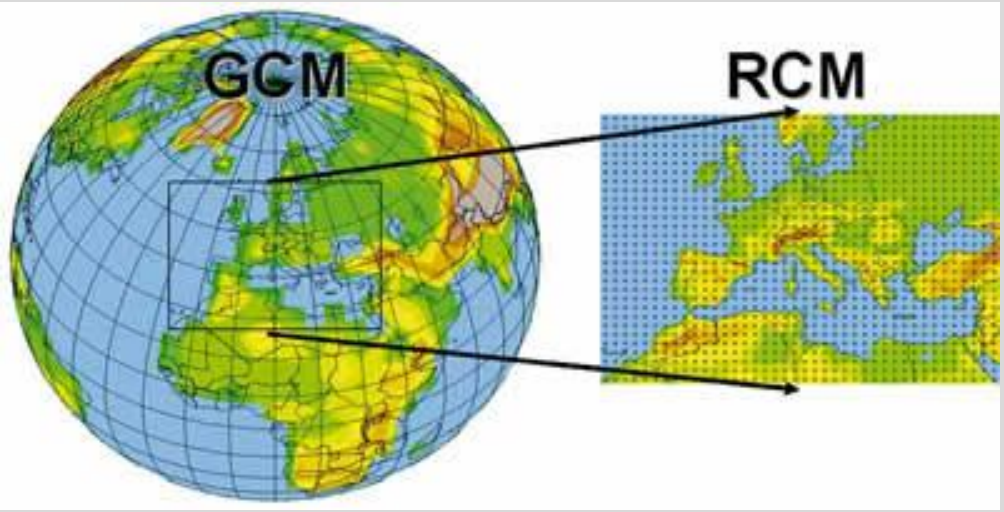
Allen *et al*., 2009 *FEM*



Carnicer *et al*., 2012 *PNAS*

Introduction

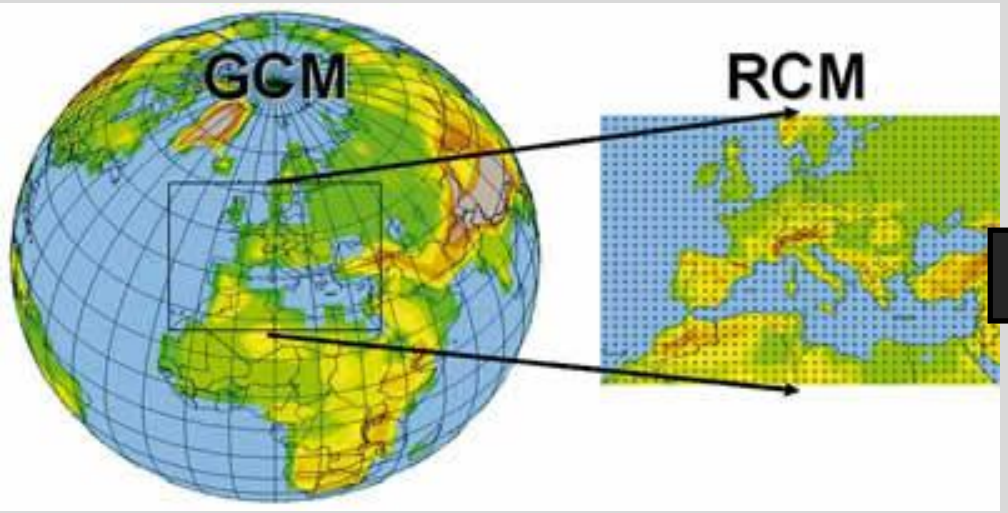
Anticipacting climate change effects on trees and forest

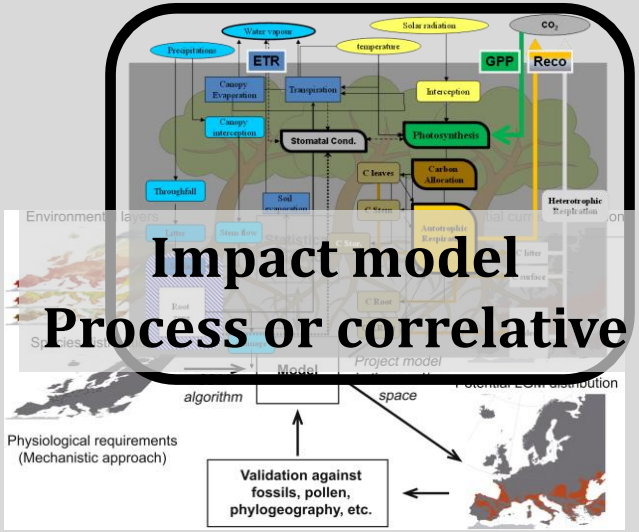


Climate projection (Resolution 300 to 50 km)

Introduction

Anticipacting climate change effects on trees and forest



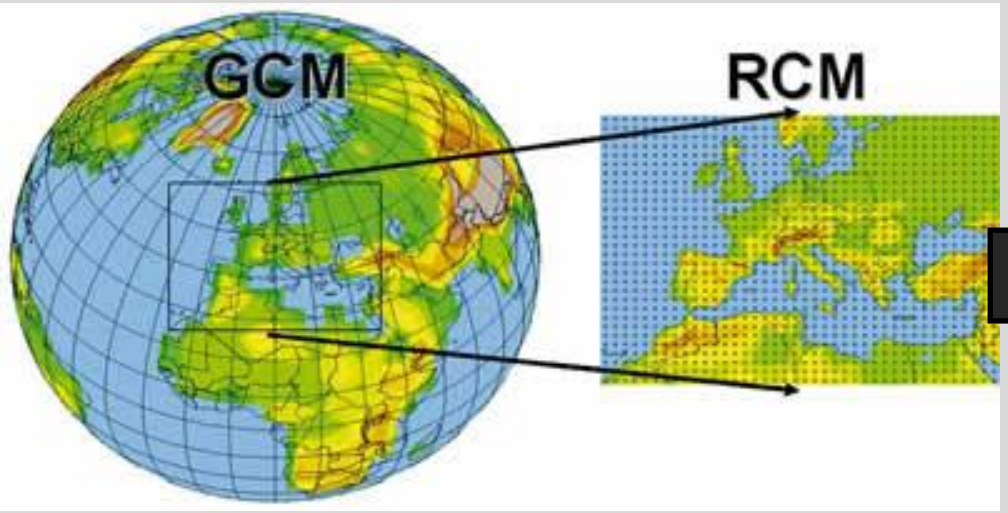


Impact model
Process or correlative

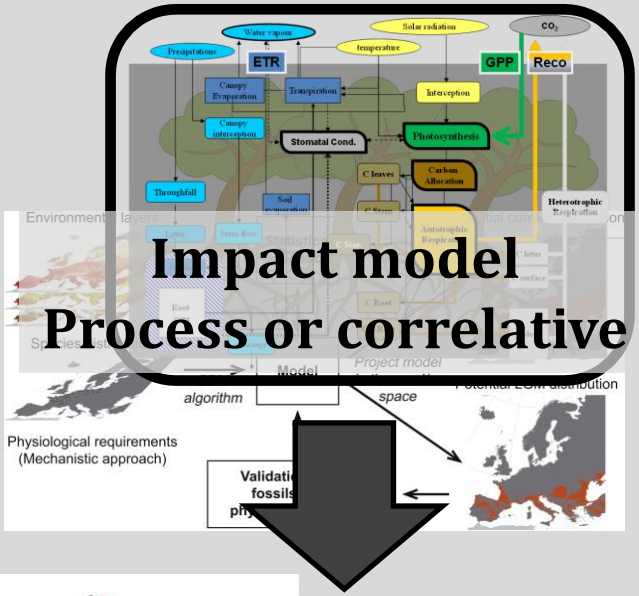
Climate projection (Resolution 300 to 50 km)

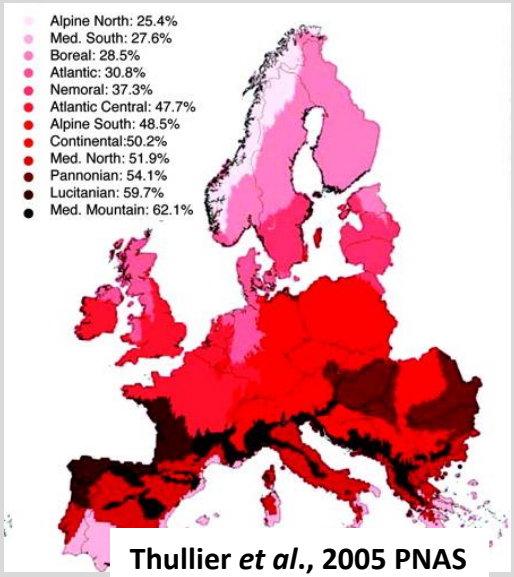
Introduction

Anticipacting climate change effects on trees and forest



Climate projection (Resolution 300 to 50 km)



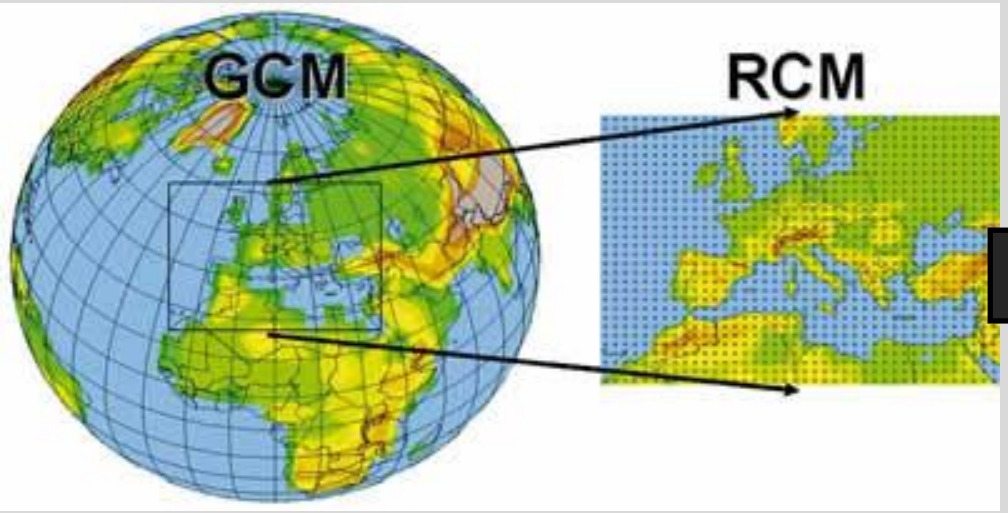


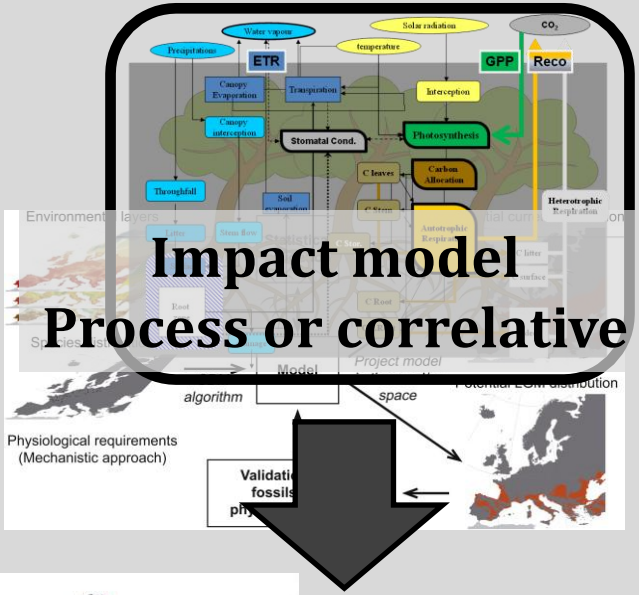
Thullier *et al.*, 2005 PNAS

Biodiversity Losses 2080-2100 Compared to 1970-1990 Using 50km Resolution climate

Introduction

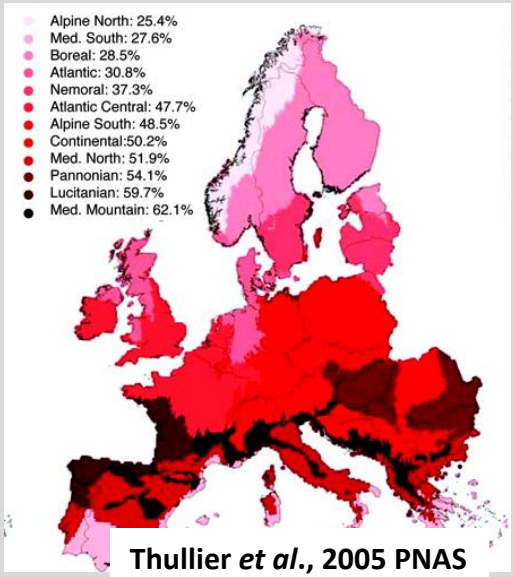
Anticipacting climate change effects on trees and forest





Climate projection (Resolution 300 to 50 km)

Very large biodiversity losses in europe >60% !

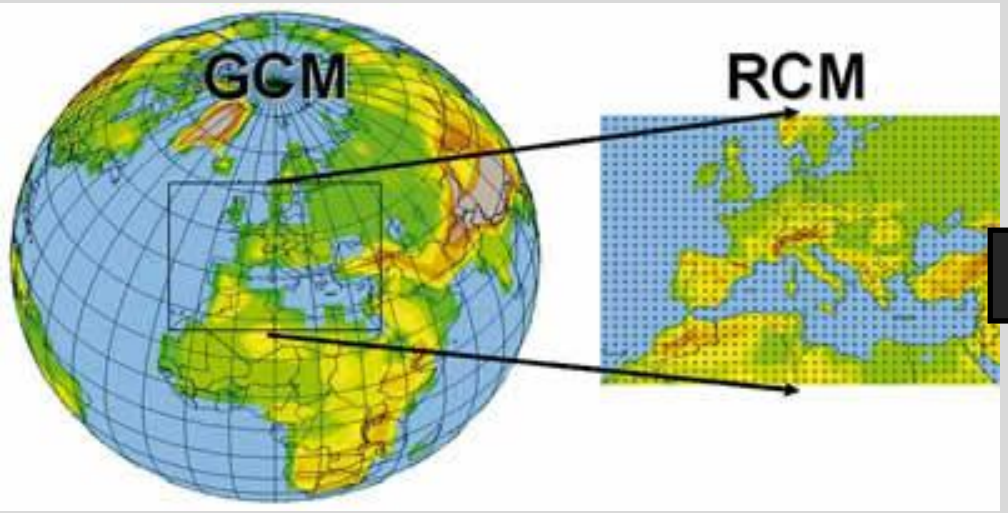


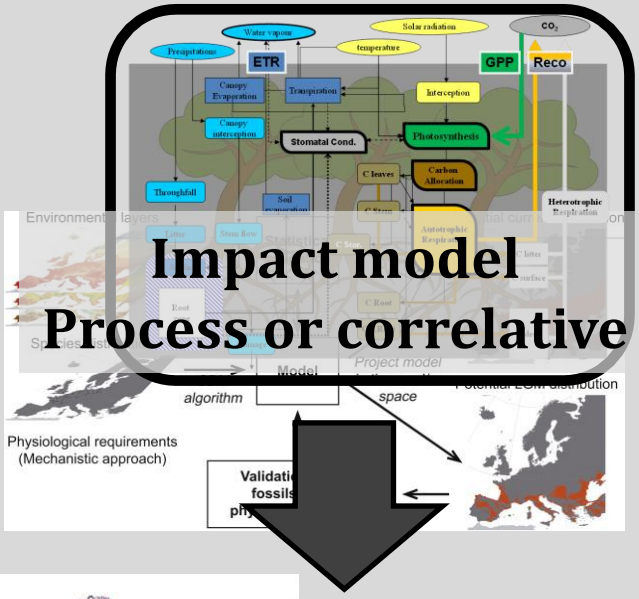
Thullier *et al.*, 2005 PNAS

Biodiversity Losses 2080-2100 Compared to 1970-1990 Using 50km Resolution climate

Introduction

Anticipacting climate change effects on trees and forest

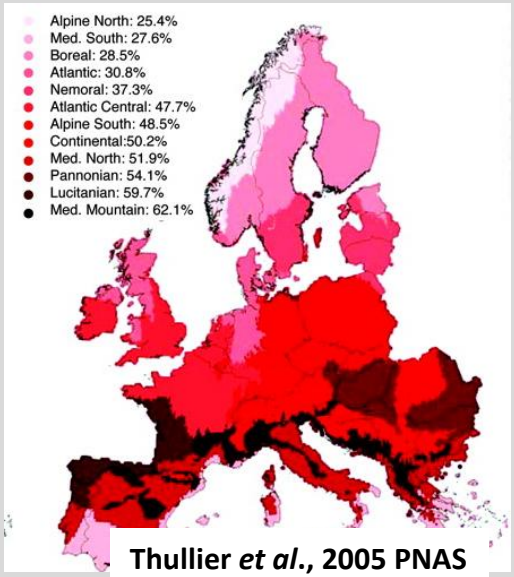




Climate projection (Resolution 300 to 50 km)

Very large biodiversity losses in europe >60% !

A matter of resolution ? **Randin *et al.*, 2009 (GCB) ...**



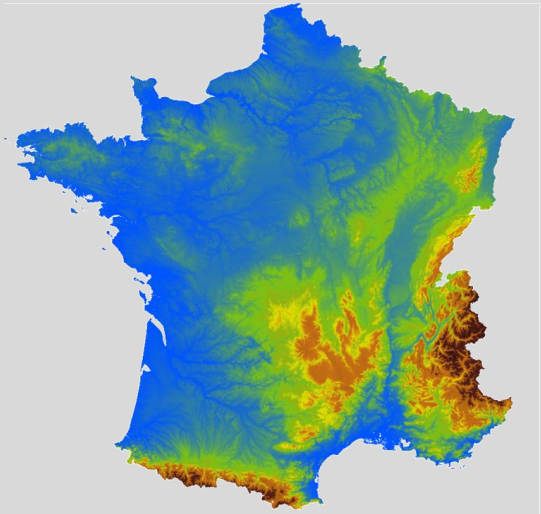
Thullier *et al.*, 2005 PNAS

Biodiversity Losses 2080-2100 Compared to 1970-1990 Using 50km Resolution climate

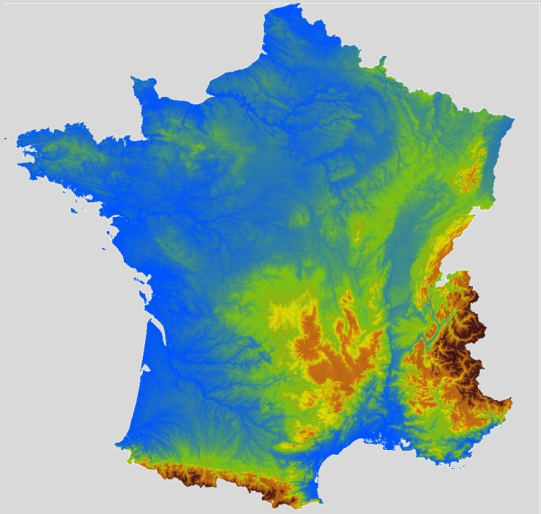
Introduction

A matter of spatial scale ?

Does the spatial resolution of climate affect the simulations of the productivity of beech and oak forest over France?



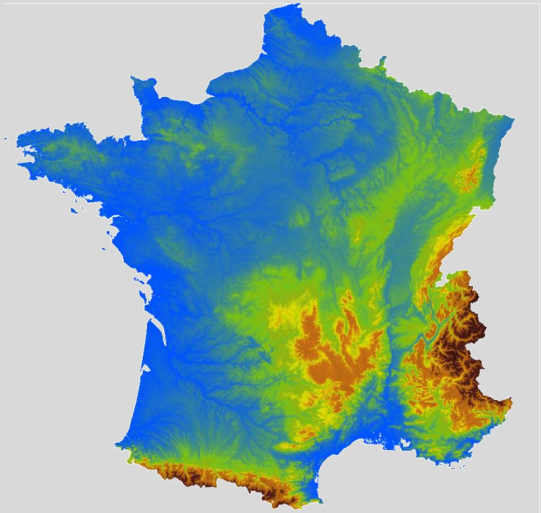
Does the spatial resolution of climate affect the simulations of the productivity of beech and oak forest over France?



➡ Steep climatic gradient

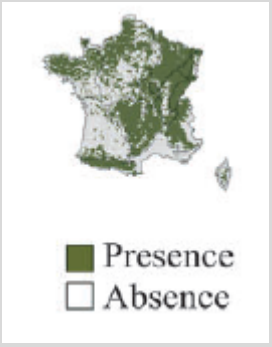
Introduction
A matter of spatial scale ?

Does the spatial resolution of climate affect the simulations of the productivity of beech and oak forest over France?

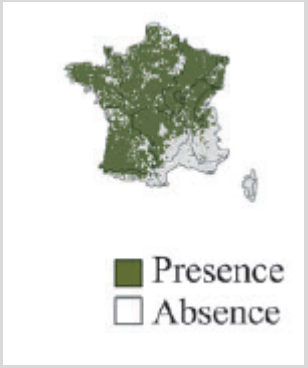


➡ Steep climatic gradient

▪ ***European Beech***



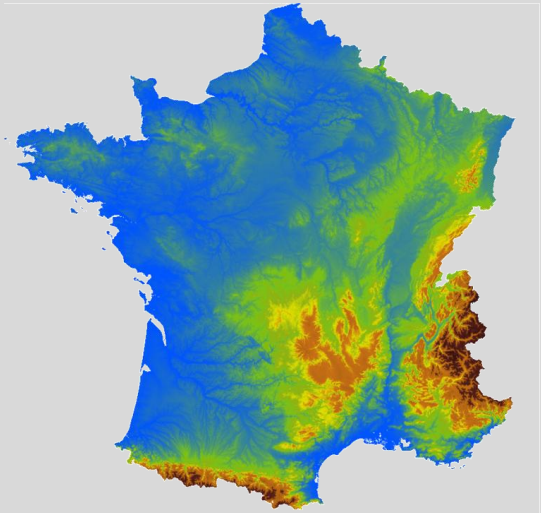
▪ **Pedunculate Oak**



➡ Two wide spread tree species

Introduction
A matter of spatial scale ?

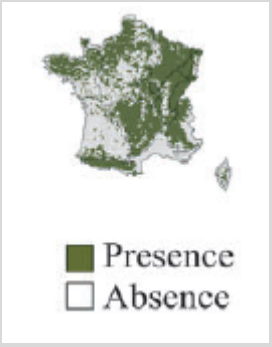
Does the spatial resolution of climate affect the simulations of the productivity of beech and oak forest over France?



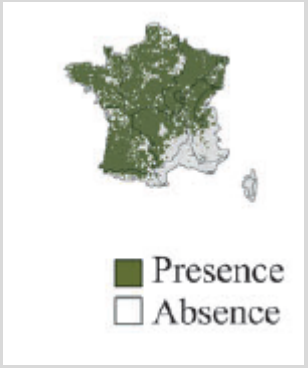
➡ Steep climatic gradient

Hyp:
Most changes should appear in montainous regions

▪ ***European Beech***

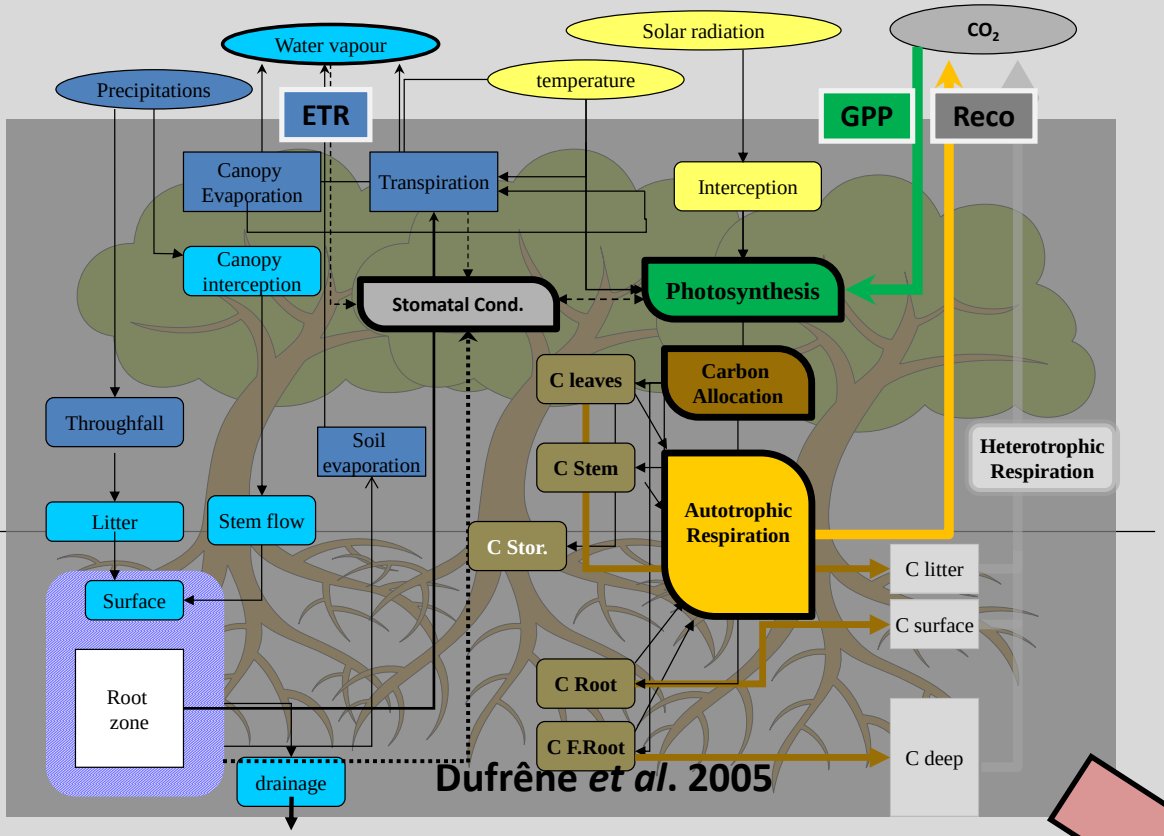


▪ **Pedunculate Oak**



➡ Two wide spread tree species

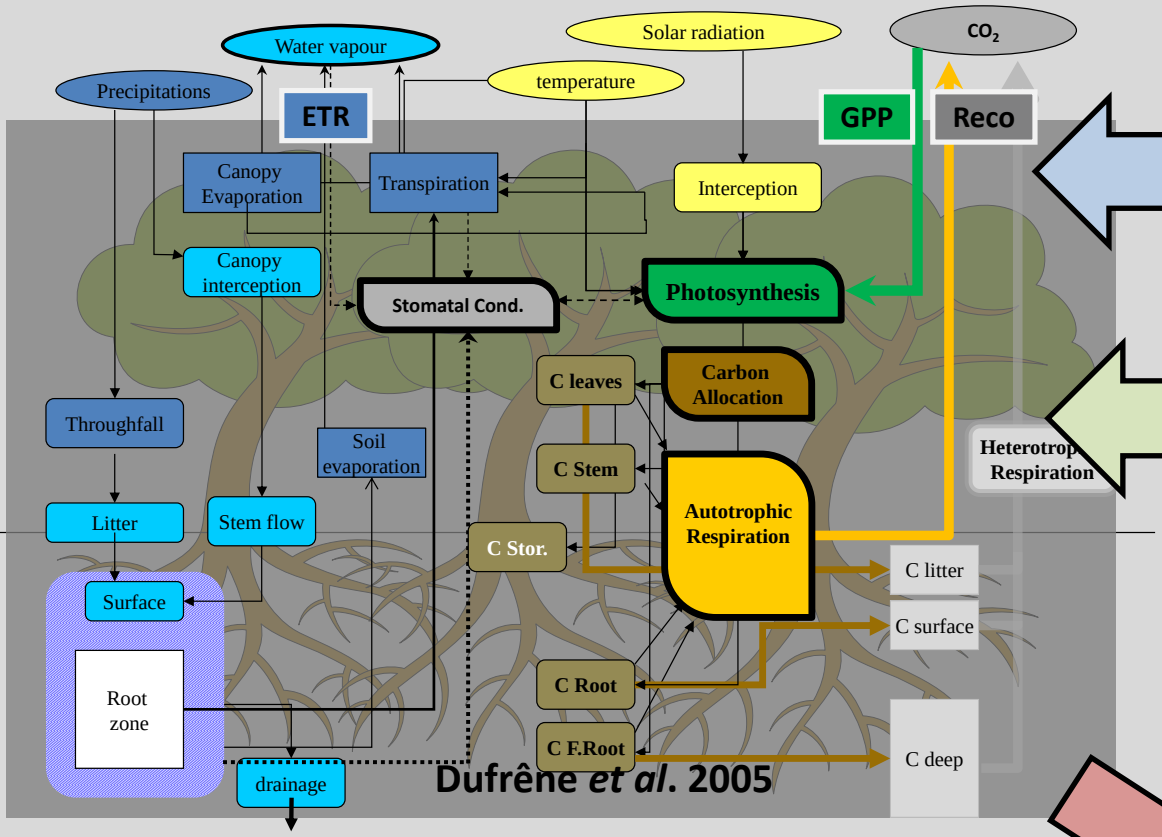
Materials & Methods
The model CASTANEA



- ✓ Process based model
- ✓ Monospecific
- ✓ Average tree
- ✓Daily time step

-C, H_2O Fluxes
-NPP, Growth, wood production
-Presence

Materials & Methods
The model CASTANEA



Daily climatic input

- Rainfall ; Temperature; Radiation ; Wind speed Humidity

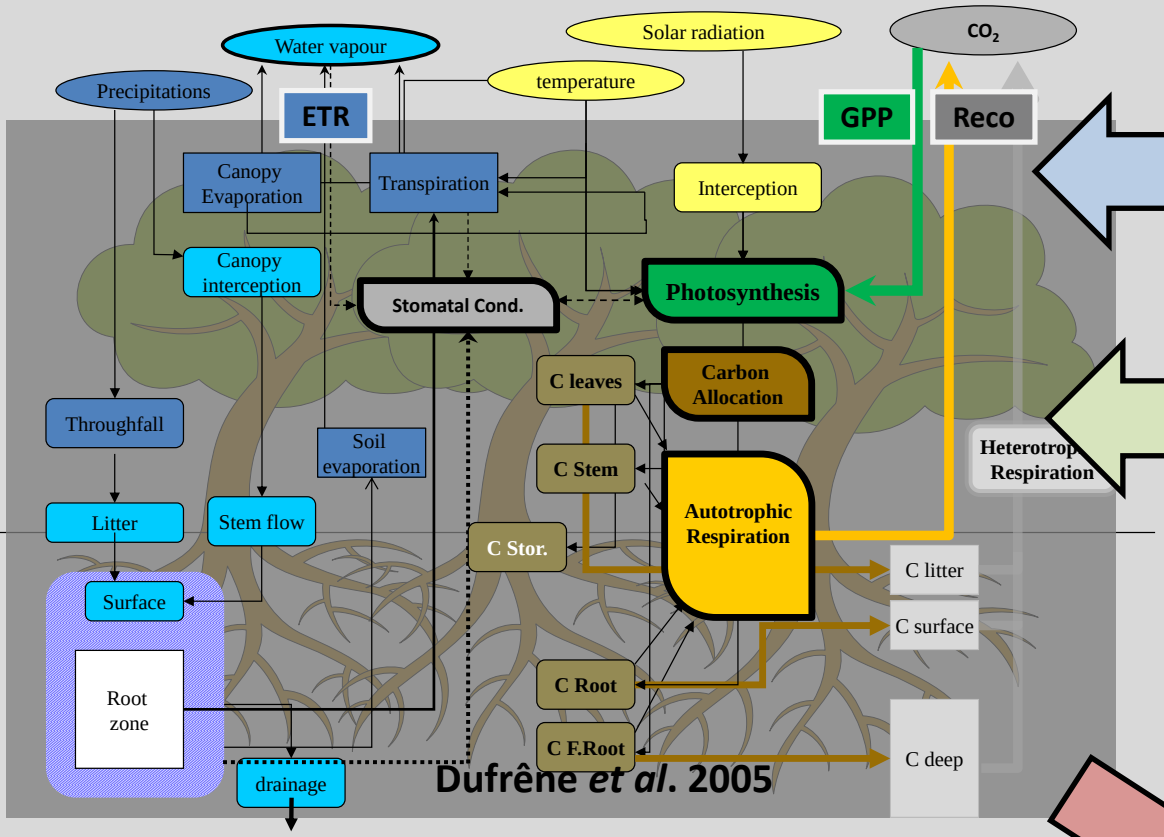
Stand and species parameters

- LMA, Photosynthetic capacity, C Allocation…
- Soil available water content

- ✓ Process based model
- ✓ Monospecific
- ✓ Average tree
- ✓ Daily time step

-C, H_2O Fluxes
-NPP, Growth, wood production
-Presence

Materials & Methods
The model CASTANEA



Daily climatic input

- Rainfall ; Temperature; Radiation ; Wind speed Humidity

Stand and species parameters

- LMA, Photosynthetic capacity, C Allocation…
- Soil available water content..

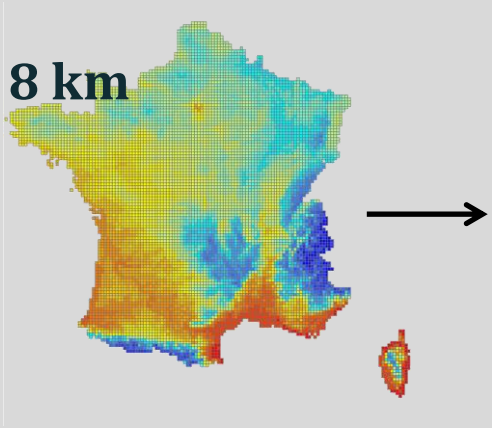
- ✓ Process based model
- ✓ Monospecific
- ✓ Average tree
- ✓ Daily time step

-C, H_2O Fluxes
-NPP, Wood production
-Presence

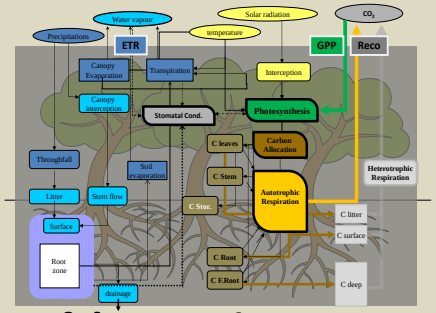
Materials & Methods
Databases & simulations

Climate :

- Analysis at different resolution : SAFRAN
- Period (1989-2010) × 7 : Forest rotation



Process model CASTANEA



Dufrêne *et al*. 2005

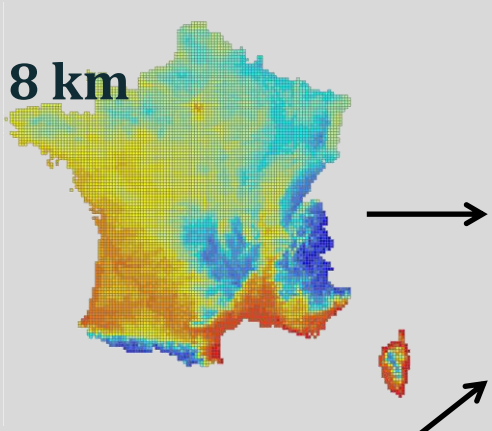
- European Beech

- Deciduous Oak

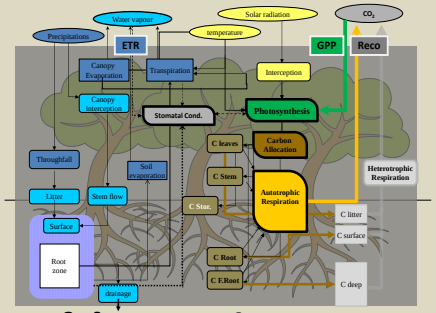
Materials & Methods
Databases & simulations

Climate :

- Analysis at different resolution : SAFRAN
- Period (1989-2010) × 7 : Forest rotation



Process model CASTANEA



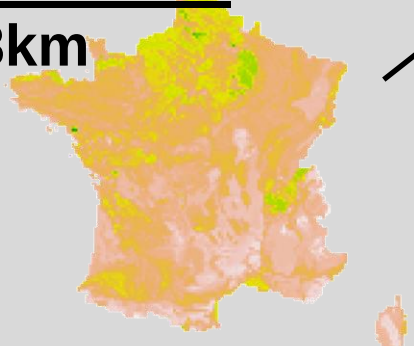
Dufrêne *et al*. 2005

- European Beech

- Deciduous Oak

Soil AWC

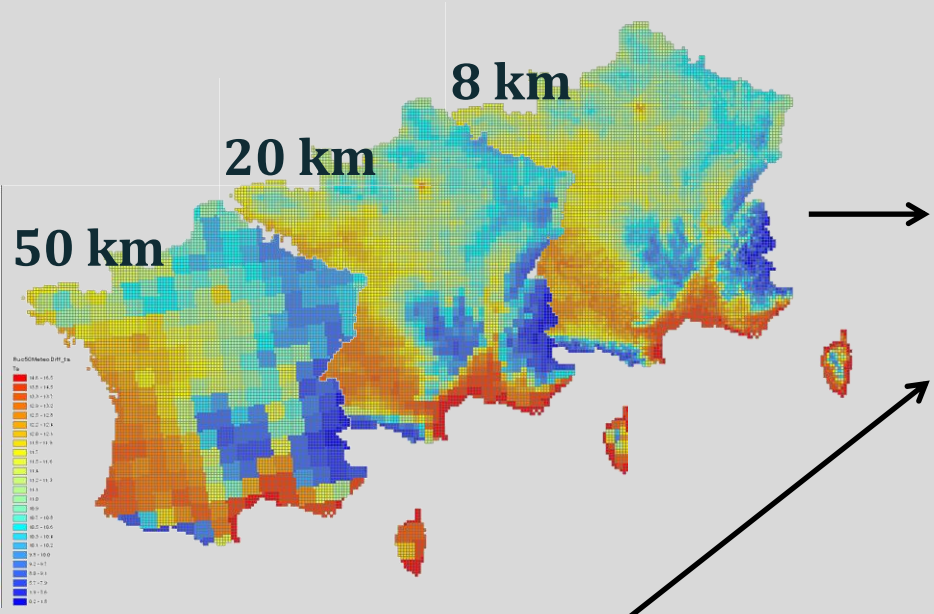
8km



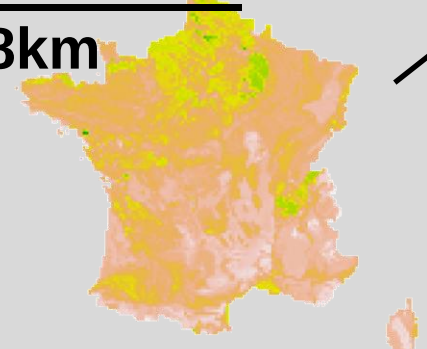
Materials & Methods
Databases & simulations

Climate :

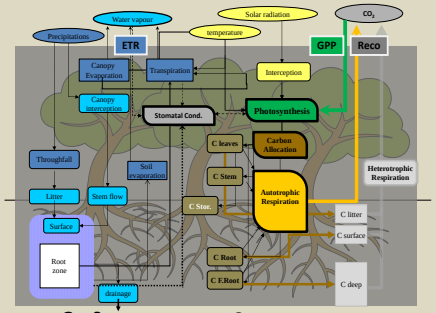
- Analysis at different resolution : SAFRAN
- Period (1989-2010) × 7 : Forest rotation



Soil AWC
8km



Process model CASTANEA



Dufrêne *et al*. 2005

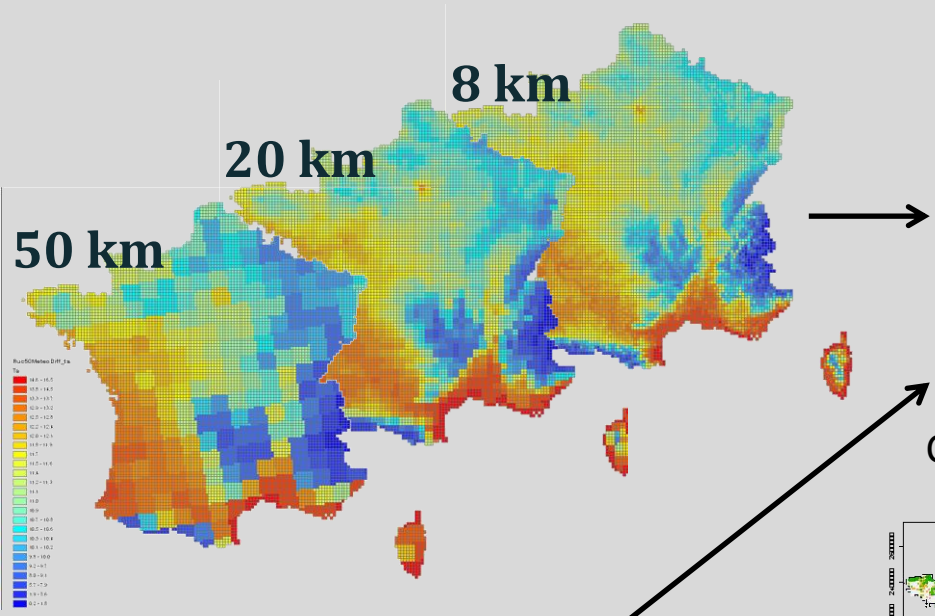
- European Beech

- Deciduous Oak

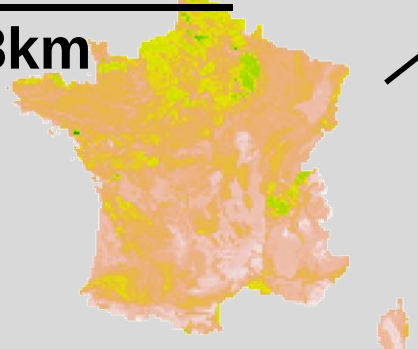
Materials & Methods
Databases & simulations

Climate :

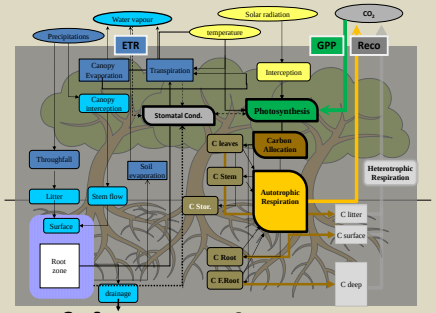
- Analysis at different resolution : SAFRAN
- Period (1989-2010) × 7 : Forest rotation



Soil AWC
8km



Process model CASTANEA

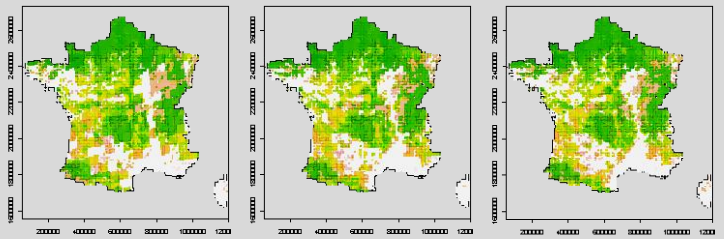


Dufrêne *et al*. 2005

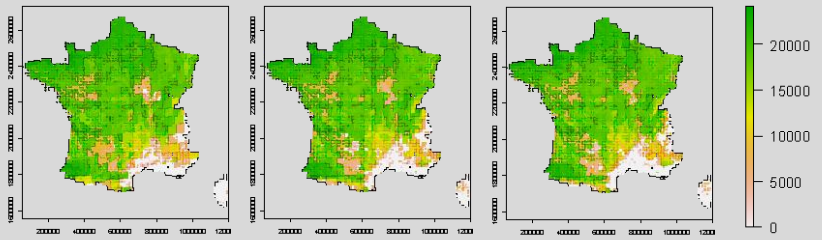
- European Beech
- Deciduous Oak

Climate 50km | Climate 20km | Climate 8km

Wood production (gC m^{-2})



Beech



Oak

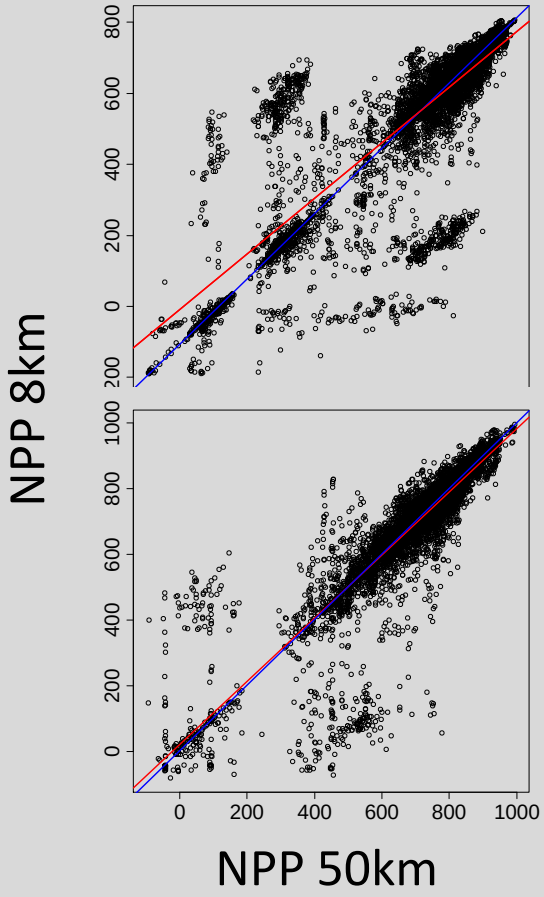
Results

Beech and oak productivity at variable climate resolution

Beech

Oak

NPP_{8km} *vs.* NPP_{50km} ($gC\ m^{-2}\ y^{-1}$)



The effect of spatial resolution is

Unbiased at France scale

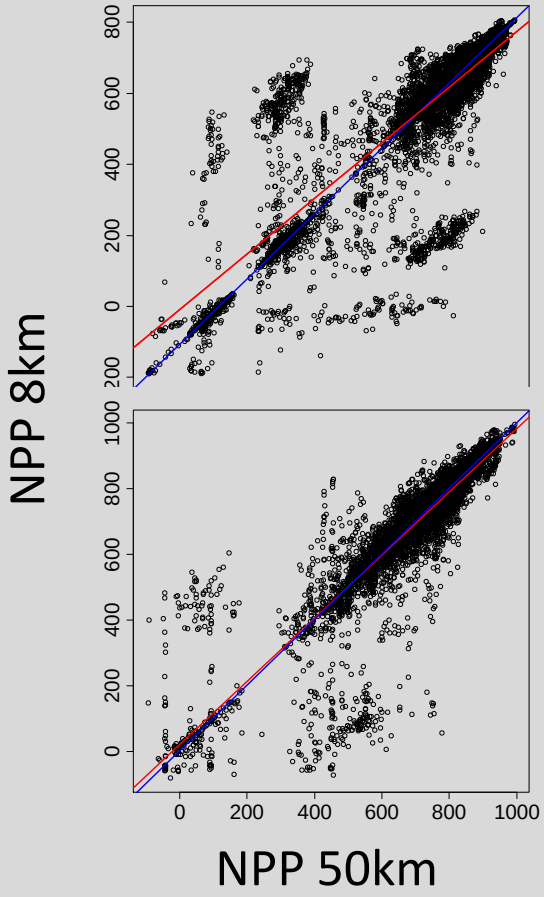
Results

Beech and oak productivity at variable climate resolution

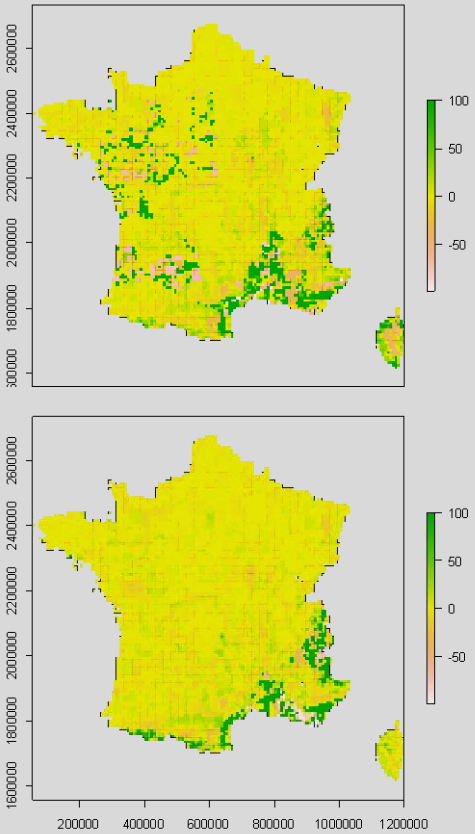
Beech

Oak

NPP_{8km} *vs.* NPP_{50km} ($gC\ m^{-2}\ y^{-1}$)



$$100 \times \left(\frac{NPP_{coarse} - NPP_{fine}}{NPP_{fine}} \right)$$



The effect of spatial resolution is

Unbiased at France scale

Important locally
Not only in the mountain

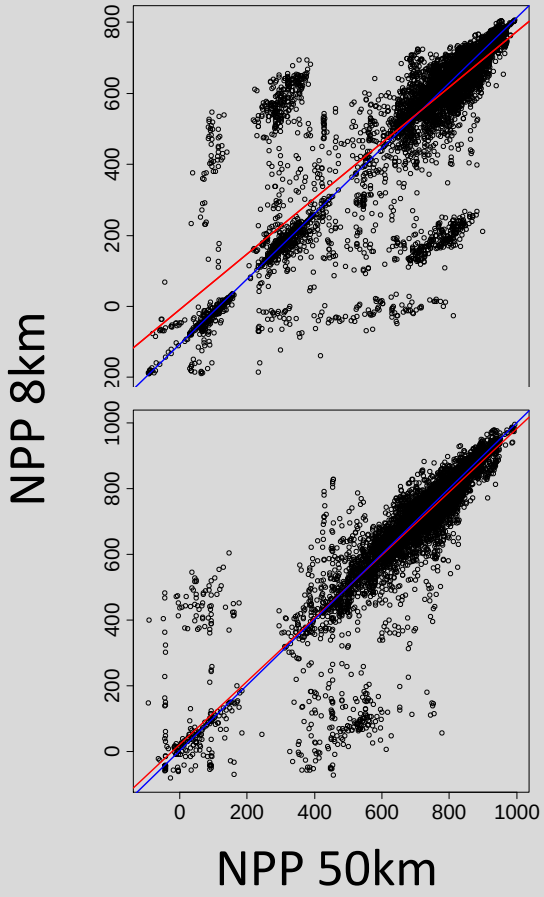
Results

Beech and oak productivity at variable climate resolution

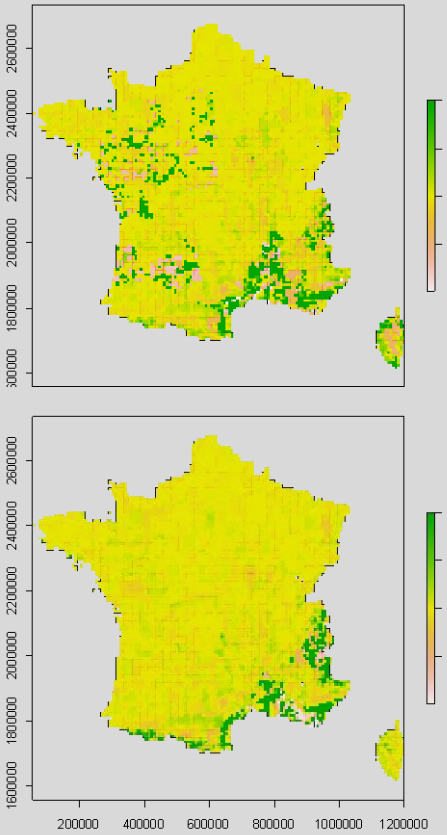
Beech

Oak

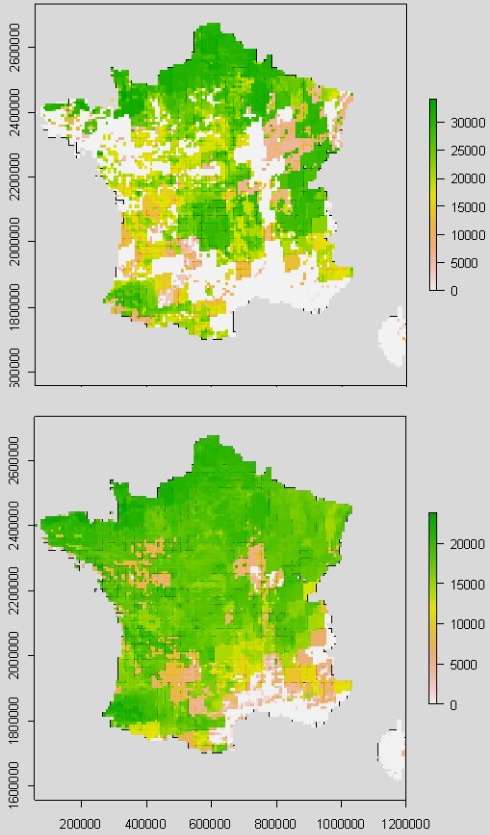
NPP_{8km} *vs.* NPP_{50km} ($gC\ m^{-2}\ y^{-1}$)



$$100 \times \left(\frac{NPP_{coarse} - NPP_{fine}}{NPP_{fine}} \right)$$



Wood Production ($gC\ m^{-2}$)



The effect of spatial resolution is

Unbiased at France scale

Important locally Not only in the mountain

At the edge of the species range

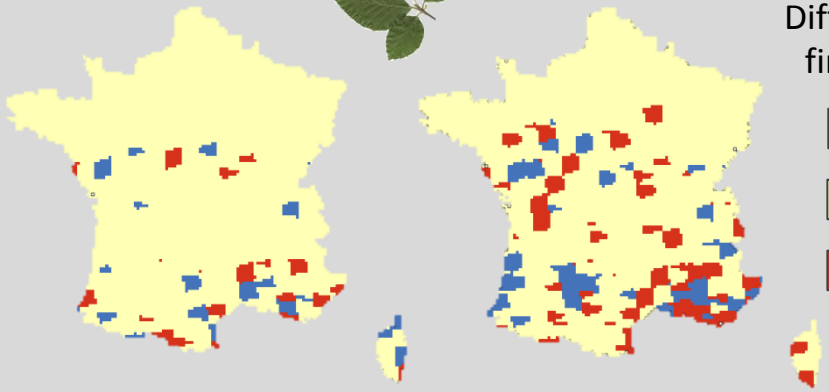
Results

What resolution do we need and where ?

European beech

20 km

50 km



Wood Production Difference (%) to fine resolution

<-10

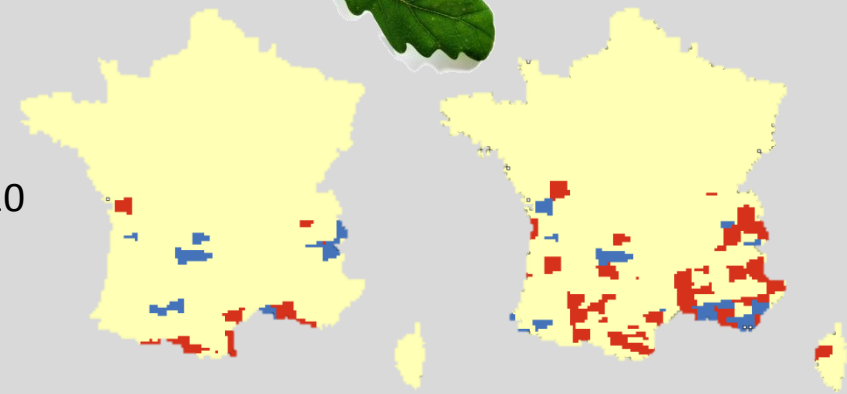
-10 - 10

>10

Deciduous oak

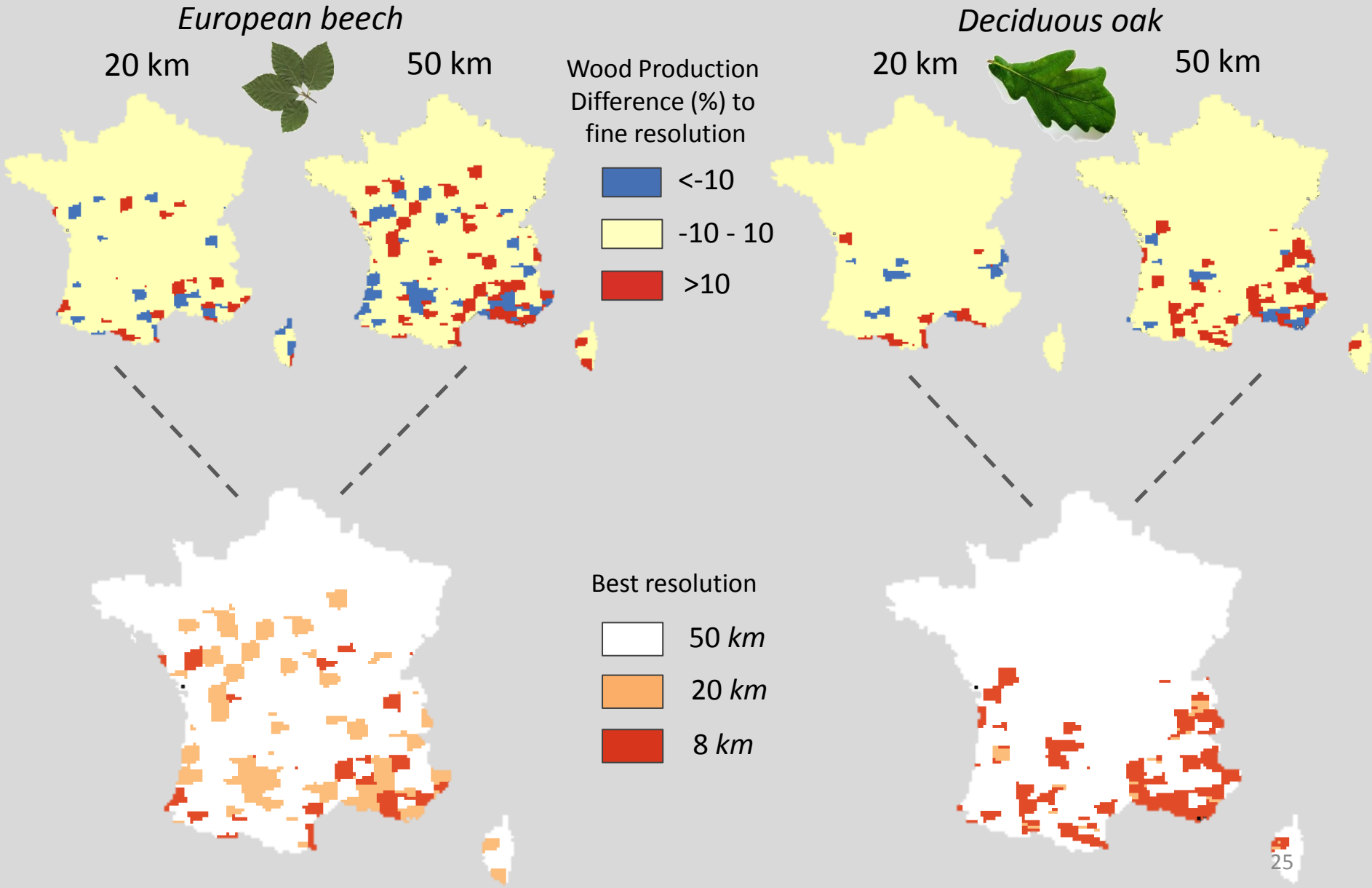
20 km

50 km



Results

What resolution do we need and where ?



Summary

- Climate resolution affects the simulation of beech & Oak productivity
- Not only in mountainous area… At the edge of species range
- Patterns of the optimal resolution differ between species :

Summary

- Climate resolution affects the simulation of beech & Oak productivity
- Not only in mountainous area… At the edge of species range
- Patterns of the optimal resolution differ between species :

Conclusion

Difficult to assess if there is an optimal resolution :
The finer the better…

Summary

- Climate resolution affects the simulation of beech & Oak productivity
- Not only in mountainous area… At the edge of species range
- Patterns of the optimal resolution differ between species :

Conclusion

Difficult to assess if there is an optimal resolution :
The finer the better…

Perspectives

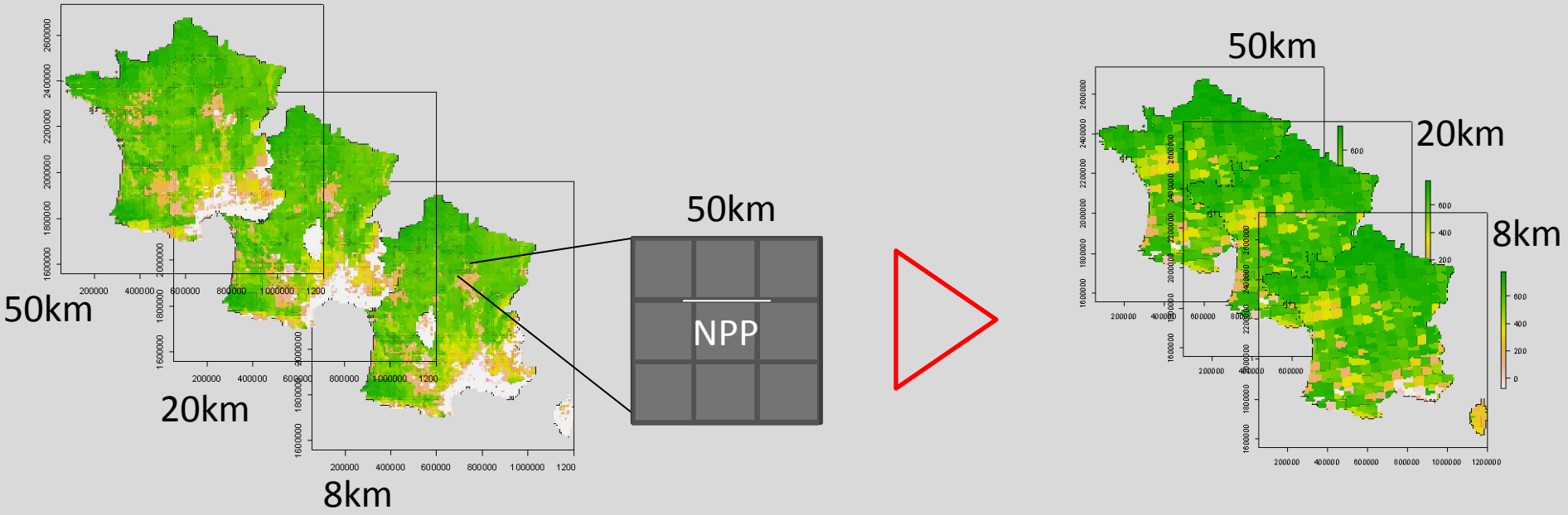
- Simulations at 1km resolution using statistical downscaling
- Other species; Climate change scenarii

Thank you for your attention

Drawing of a dying beech, ink (200x250 cm) Adeline Carrion Reyna

Results

What resolution do we need and where ?



$$100 \times \left(\frac{NPP_{\text{coarse}} - NPP_{\text{fine}}}{NPP_{\text{fine}}} \right)$$