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

To cite this version:
Nicolas Martin-Stpaul, Julien Ruffault, Christophe François, Marc Stéfanon, P. Drobinsky, et al.. Influence of the spatial resolution of climate on tree range simulations. EGU General Assembly 2013, 2013, Vienne, Austria. hal-02747225

HAL Id: hal-02747225
https://hal.inrae.fr/hal-02747225
Submitted on 3 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
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

- Migration toward higher elevation
- Increase tree dieback

Penuelas et al., 2003 GCB

1945 1995

Allen et al., 2009 FEM
Introduction

The footprint of climate change on forests

- Increase forest defoliation
  - Carnicer et al., 2012 PNAS

- Increase tree dieback

- Migration toward higher elevation

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

Penuelas et al., 2003 GCB

1945 1995

Allen et al., 2009 FEM

Defoliation trends in southern Europe

Carnicer et al., 2012 PNAS
Introduction
Anticipating climate change effects on trees and forest

Climate projection (Resolution 300 to 50 km)
Introduction
Anticipating climate change effects on trees and forest

Climate projection (Resolution 300 to 50 km)
Introduction

Anticipating climate change effects on trees and forest

Impact model

Process or correlative

Climate projection (Resolution 300 to 50 km)

Biodiversity Losses

2080-2100

Compared to 1970-1990

Using 50km Resolution climate

Thullier et al., 2005 PNAS
Introduction
Anticipating climate change effects on trees and forest

Very large biodiversity losses in Europe >60%!

Climate projection (Resolution 300 to 50 km)

Impact model
Process or correlative

Biodiversity Losses
2080-2100
Compared to 1970-1990
Using 50km Resolution climate
Introduction
Anticipating 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) ...

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?
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
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?

- European Beech
- Pedunculate Oak

Steep climatic gradient

Two wide spread tree species
Introduzione
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

-Dufrêne et al. 2005
-C, H₂O Fluxes
-NPP, Growth, wood production
-Presence
Materials & Methods

The model CASTANEA

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

Daily climatic input
- Rainfall; Temperature; Radiation; Wind speed; Humidity

Stand and species parameters
- LMA, Photosynthetic capacity, C Allocation…
- Soil available water content

-C, H₂O Fluxes
-NPP, Growth, wood production
-Presence
The model CASTANEA

Materials & Methods

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$_2$O Fluxes
- NPP, Wood production
- Presence

- Dufrêne et al. 2005
Materials & Methods
Databases & simulations

Climate:
- Analysis at different resolution: SAFRAN
- Period (1989-2010) \( \times 7 \): Forest rotation

Process model CASTANEA
- European Beech
- Deciduous Oak

Dufrêne et al. 2005
Climate:
- Analysis at different resolution: SAFRAN
- Period (1989-2010) × 7: Forest rotation

Materials & Methods
Databases & simulations

Soil AWC 8km

Process model CASTANEA
- European Beech
- Deciduous Oak

Dufrêne et al. 2005
Materials & Methods
Databases & simulations

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

Process model CASTANEA
- European Beech
- Deciduous Oak

Dufrêne et al. 2005

Soil AWC
8 km

Factors:
- Solar radiation
- Temperature
- Water vapour
- Interception
- Photosynthesis
- Precipitations
- Canopy interception
- Throughfall
- Stem flow
- Litter

Carbon Allocation
- Root C
- F.Root C
- Surface C
- C deep

Respiration
- Heterotrophic
- Autotrophic
- ETR
Materials & Methods
Databases & simulations

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

Process model CASTANEA
- European Beech
- Deciduous Oak

Dufrêne et al. 2005

Soil AWC
8 km

Climate
- 50 km
- 20 km
- 8 km

Wood production (gC m⁻²)

Beech
Oak
Results

Beech and oak productivity at variable climate resolution

The effect of spatial resolution is unbiased at France scale
Results
Beech and oak productivity at variable climate resolution

The effect of spatial resolution is:
- Unbiased at France scale
- Important locally, not only in the mountain areas.
Results

Beech and oak productivity at variable climate resolution

- **NPP\textsubscript{8km} vs. NPP\textsubscript{50km} (gC m\textsuperscript{-2} y\textsuperscript{-1})**
  - The effect of spatial resolution is
    - Unbiased at France scale
    - Important locally
    - Not only in the mountain
    - At the edge of the species range

- **Wood Production (gC m\textsuperscript{-2})**
Results

What resolution do we need and where?

European beech

- 20 km
- 50 km

Wood Production Difference (%) to fine resolution

- Blue: <-10
- Yellow: -10 - 10
- Red: >10

Deciduous oak

- 20 km
- 50 km
Results
What resolution do we need and where?

European beech

20 km

50 km

Wood Production Difference (%) to fine resolution

- Blue: <-10
- Light yellow: -10 - 10
- Red: >10

Deciduous oak

20 km

50 km

Best resolution

- White: 50 km
- Light orange: 20 km
- Red: 8 km
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?

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