CANQUA/AMQUA 2018 - Ottawa
Wednesday August 8 th 2018

Simulation of vegetation dynamics in eastern boreal North America during pre-industrial times using LPJ-LMfire

Emeline Chaste
PhD in Environmental Science
University of Quebec in Montreal (Canada)
École Pratique des Hautes Études (France)

Supervision :
Martin Girardin, Christelle Hély, Yves Bergeron

Collaboration:
Jed Kaplan

emeline.chaste@canada.ca

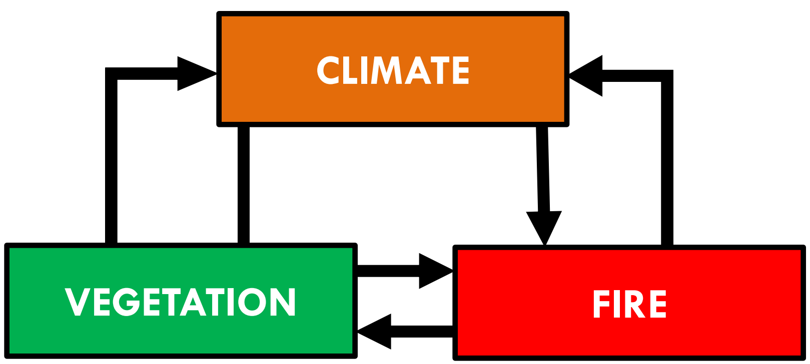
cef Centre d'étude de la forêt
Chaire industrielle CRSNG - UQAT - UQAM en aménagement forestier durable
UQÀM
EPHE
isem Institut des Sciences de l'Evolution-Montpellier

Context

The climate is changing and so are Canada's forest

Some uncertainties…

1 Natural variability



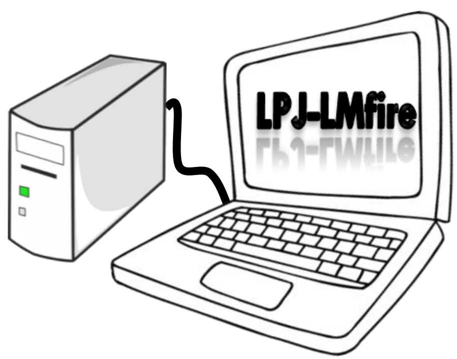
2 Paleoecology

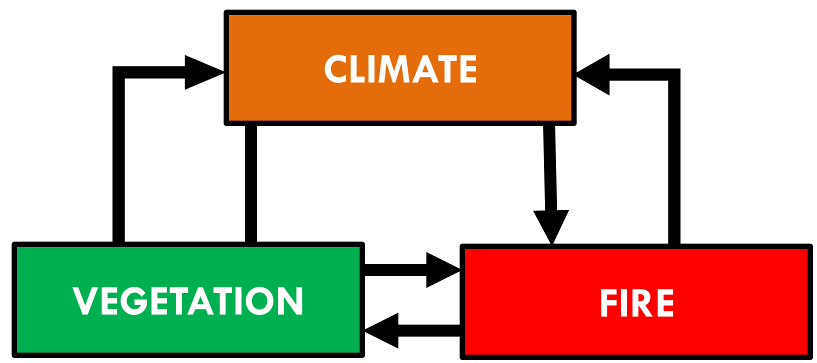
Weigth of drivers
Local processes
Costly
Time-consuming

Objectives

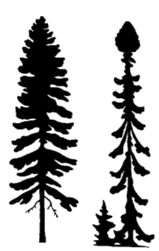
- Present advances made in the deployment of a DGVM to simulate at high spatiotemporal resolution the responses of vegetation and fire to changes in climate during the last 6000 years;
- Discuss the performance of the model at multi-millennial time-scales.

The tool used:





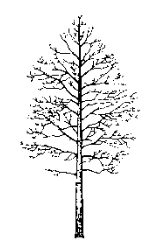
4 PFTs:
Chaste et al. 2018



Picea

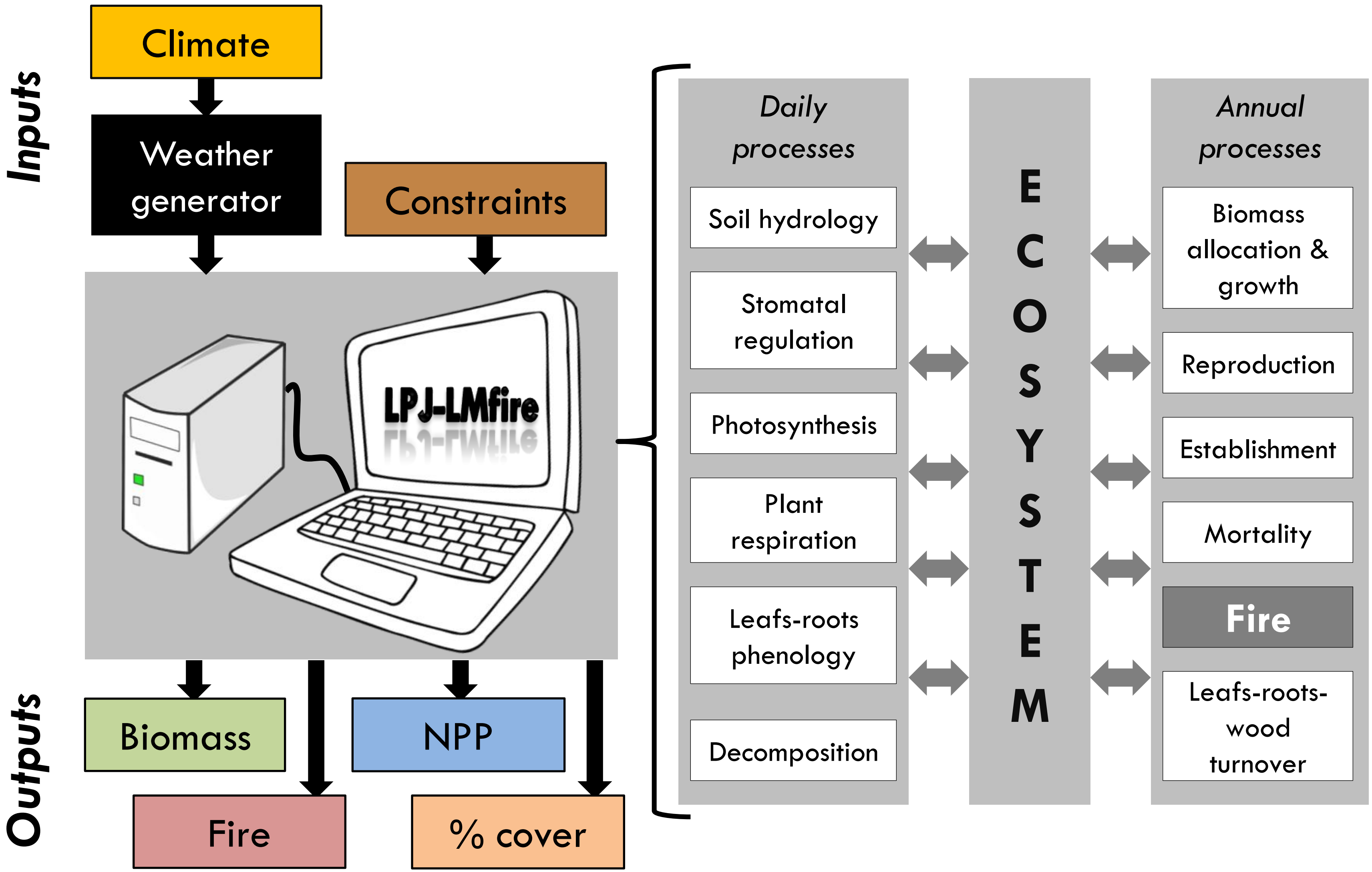
Abies

Pinus



Populus

LPJ-LMfire

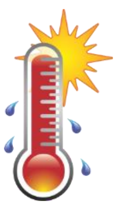

Inputs
Climate
Weather generator
Constraints
LPJ-LMfire
Outputs
Biomass
NPP
Fire
% cover
Daily processes
Soil hydrology
Stomatal regulation
Photosynthesis
Plant respiration
Leafs-roots phenology
Decomposition
ECOSYSTEM
Annual processes
Biomass allocation & growth
Reproduction
Establishment
Mortality
Fire
Leafs-roots-wood turnover

Input datasets

(6000 BP – 0 BP)

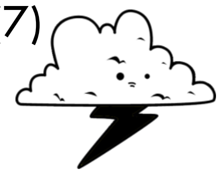
10 km x 10 km

Climate = 7 variables

(1) (2)

(3) (4)

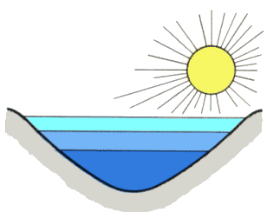
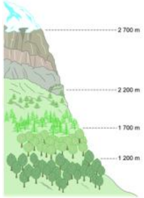
(5)

(6)

(7)


Environment = 4 variables

(1)

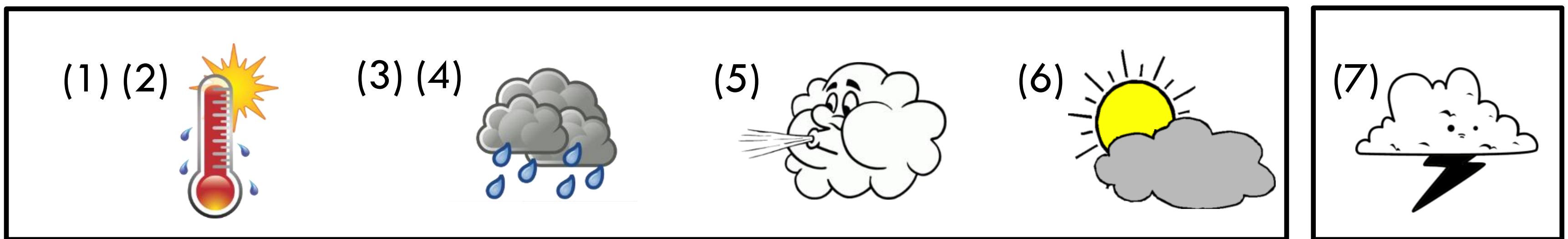

(2)

(3)

(4)


Input datasets

(6000 BP – 0 BP)

10 km x 10 km

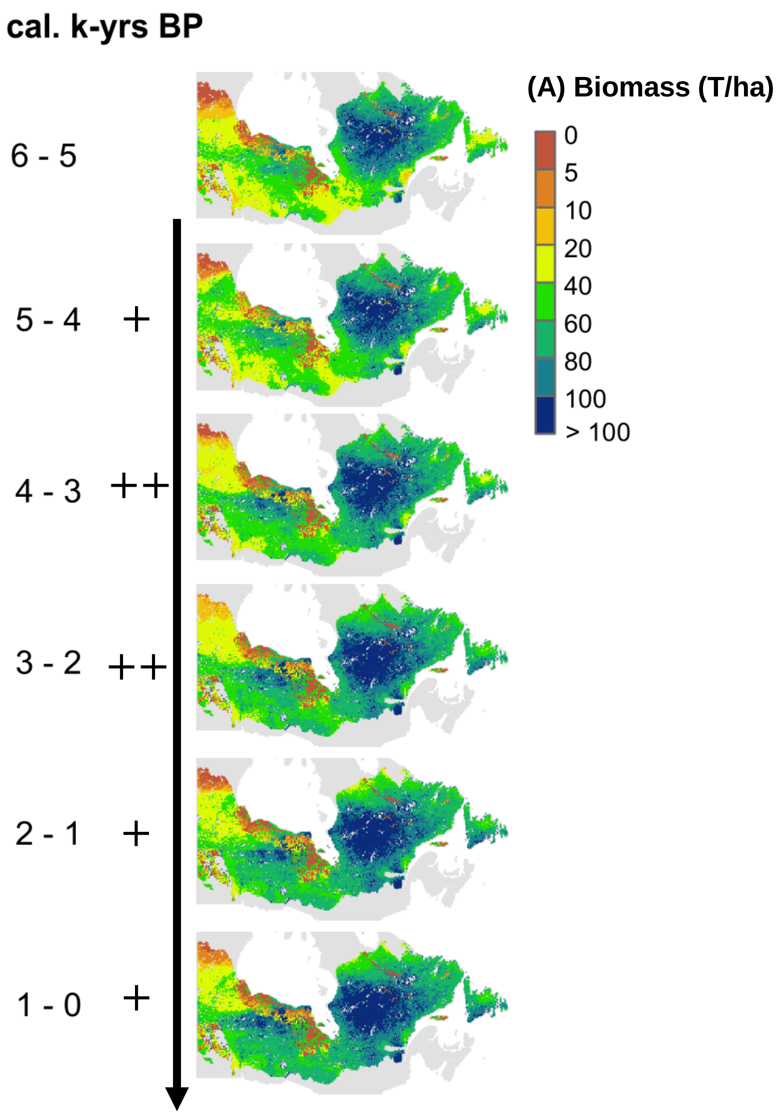
Climate = 7 variables



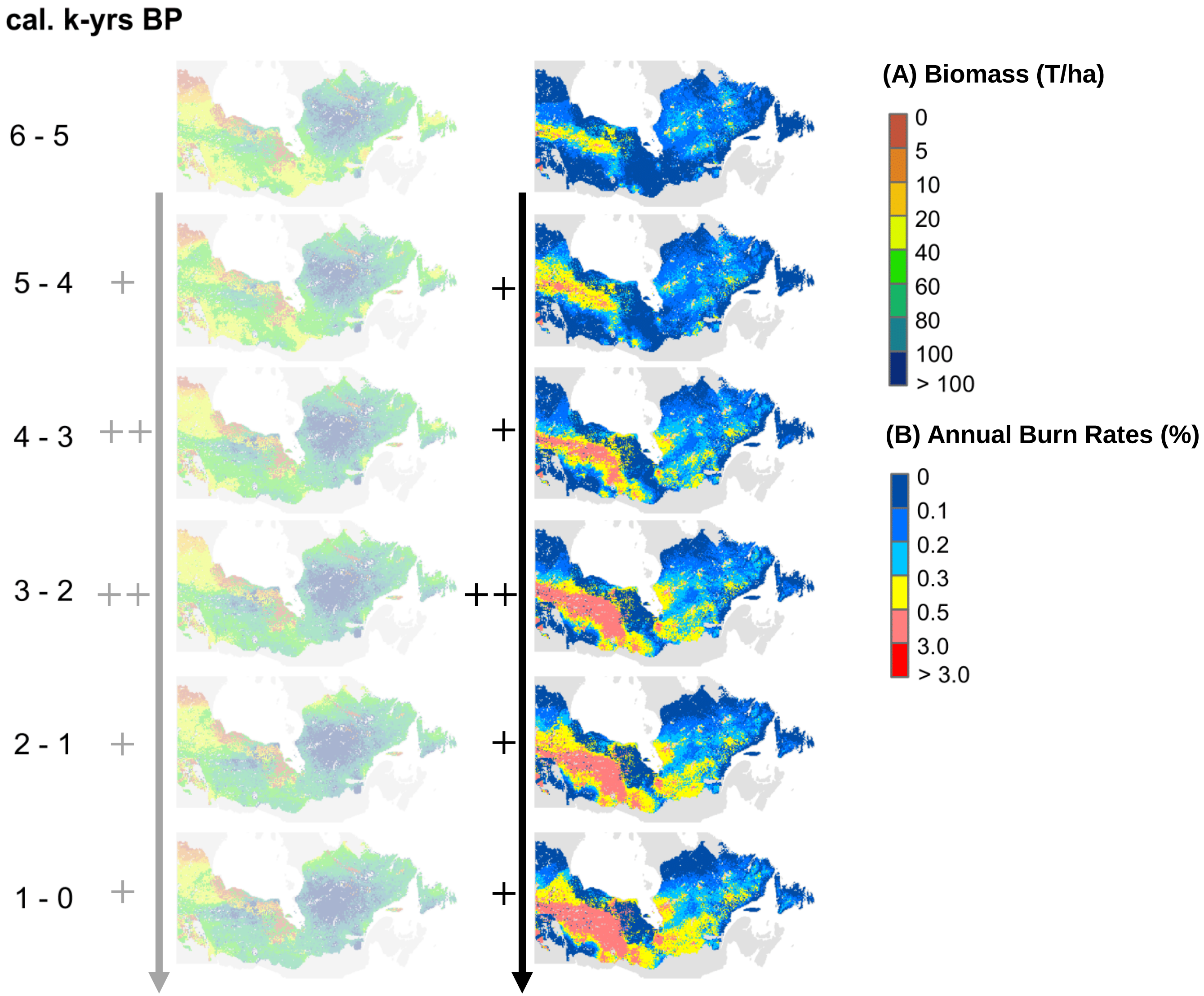
Directly from the French Pierre-Simon-Laplace Institute Earth system model IPSL-CM5A-LR (1.875°x3.75°)

Reconstruct the monthly lightning flash density (number day^{-1} km^{-2}) from 6000 to 0 BP <u>**from**</u> the convective available potential energy (CAPE) available for the IPSL-CM5A-LR using the same methodology in Chaste et al. 2018

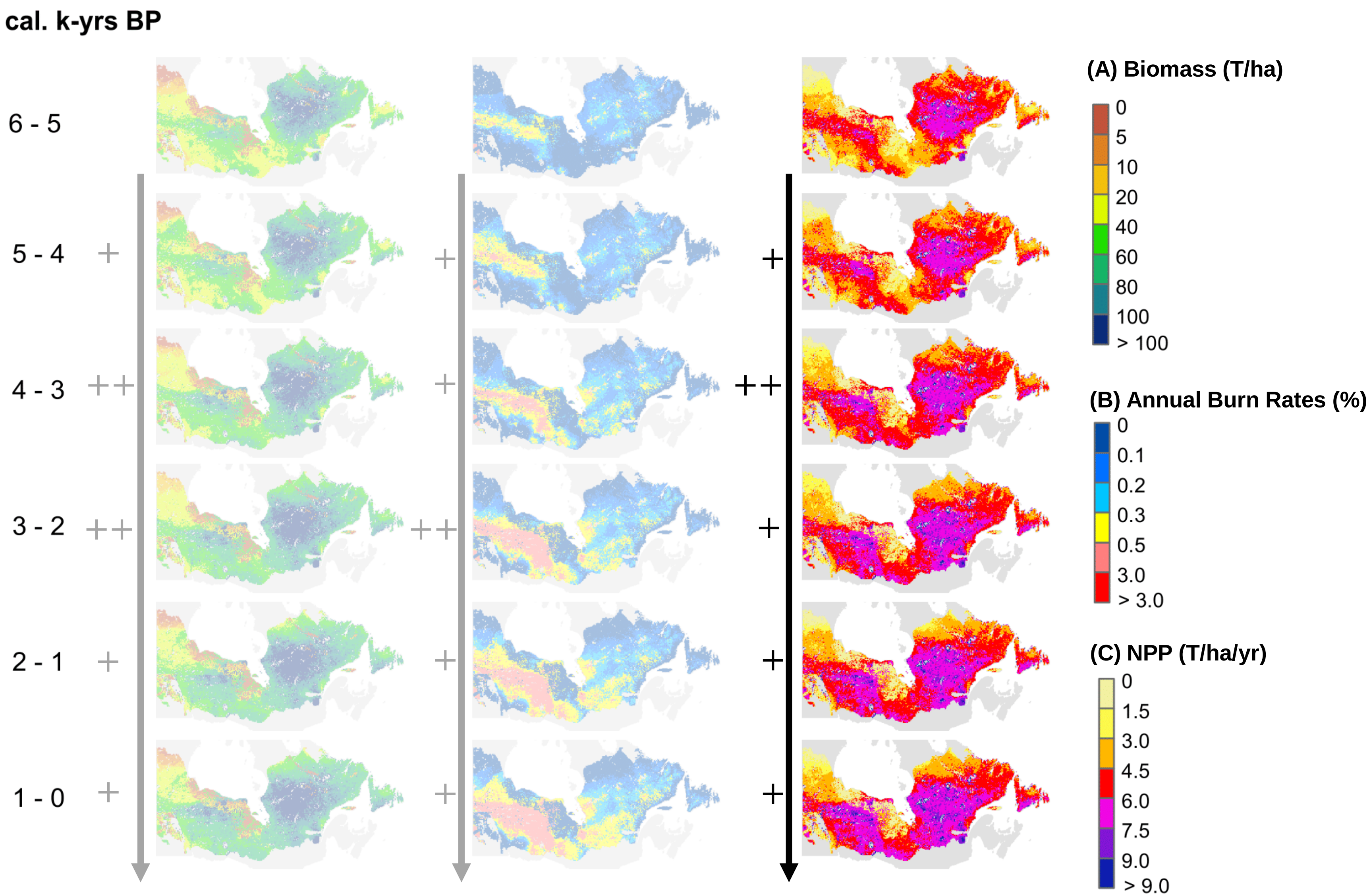
LPJ-LMfire: BIOMASS



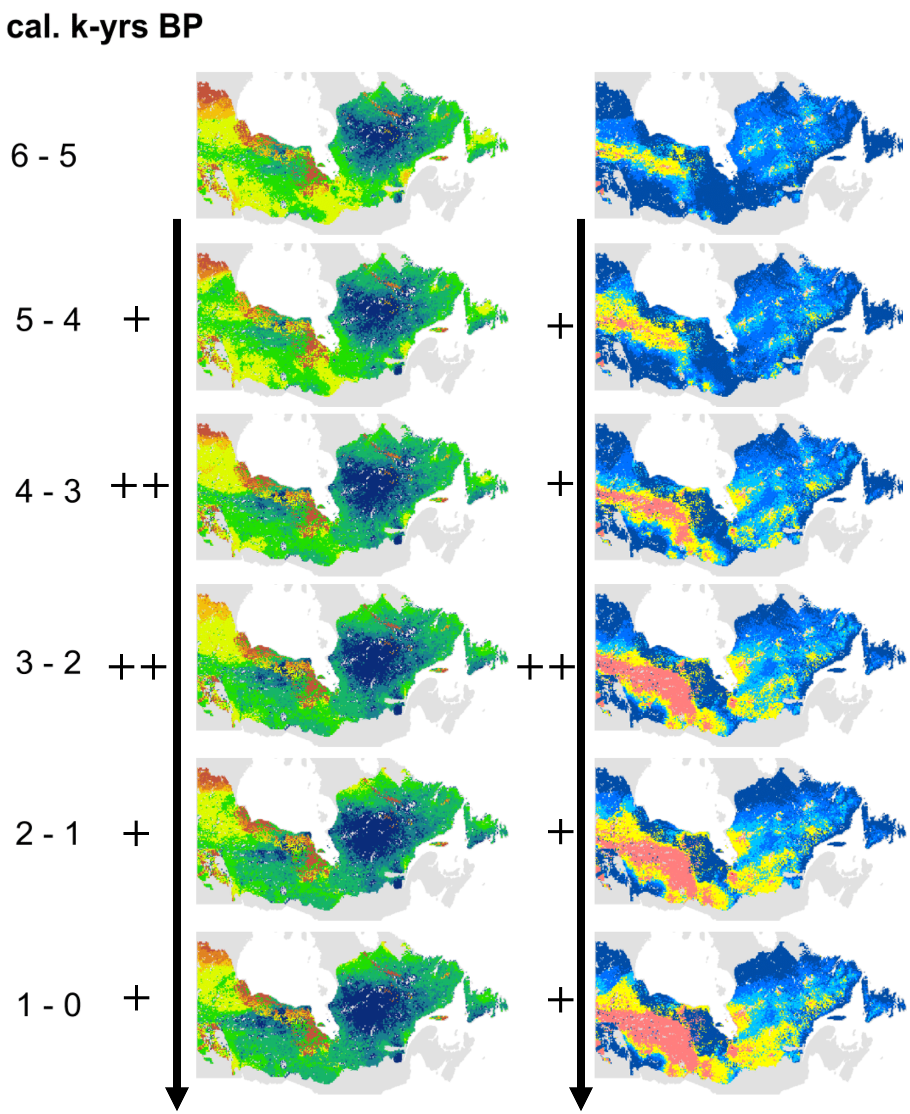
LPJ-LMfire: FIRES

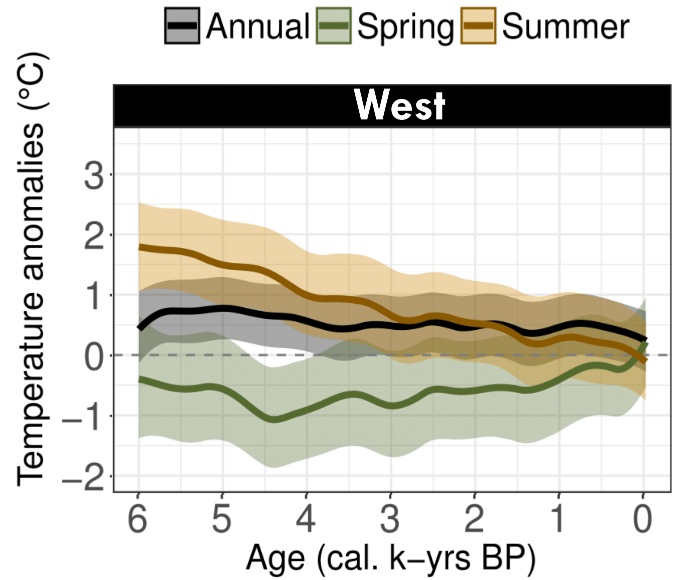


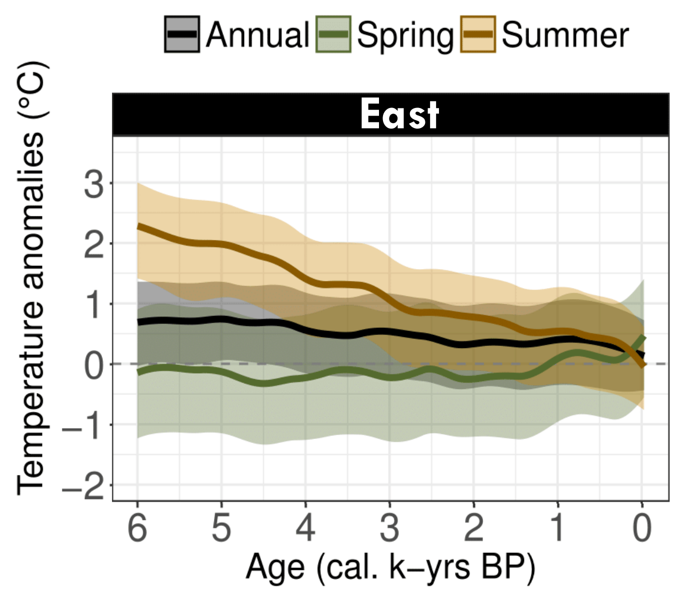
LPJ-LMfire: GROWTH



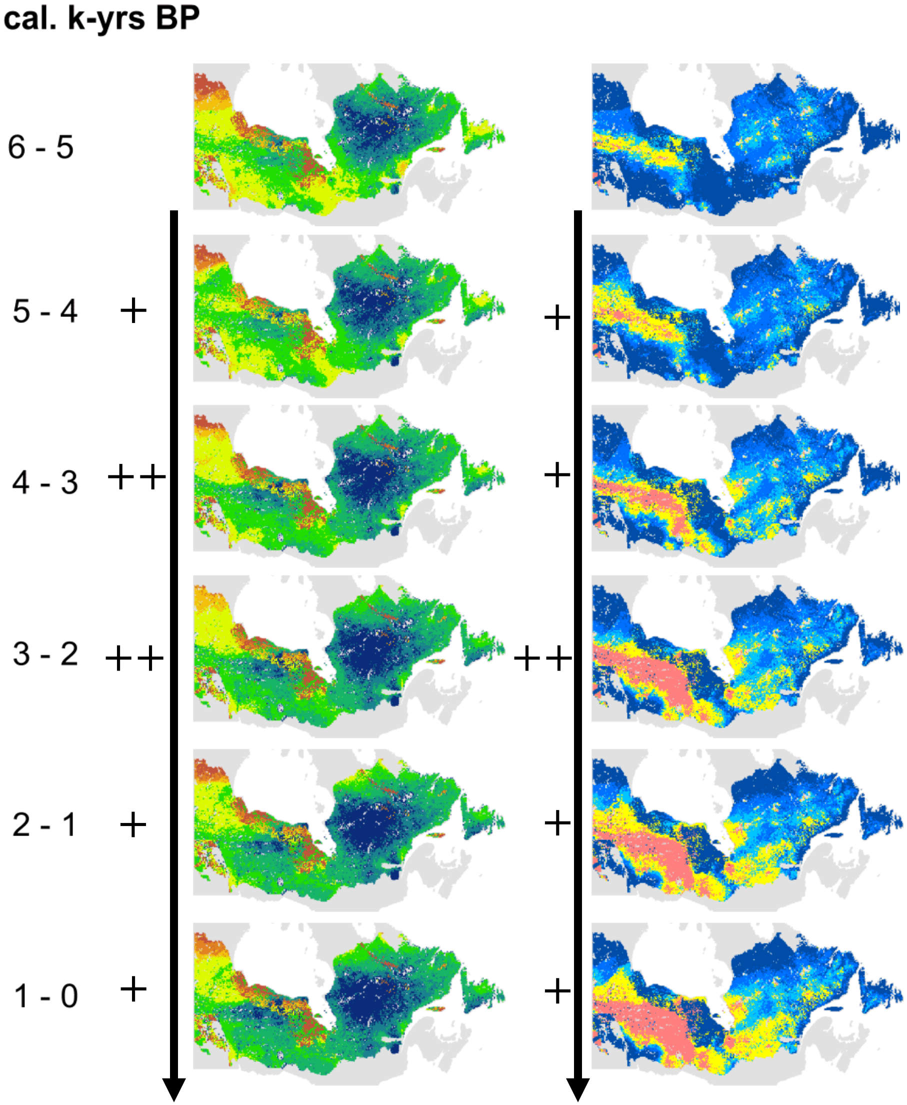
LPJ-LMfire

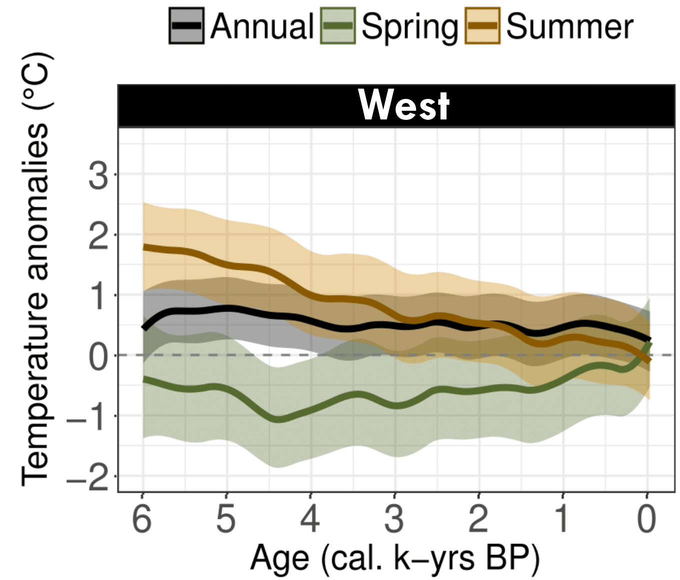

cal. k-yrs BP
6 - 5
5 - 4 +
4 - 3 ++
3 - 2 ++
2 - 1 +
1 - 0 +
+
+
++
+
+

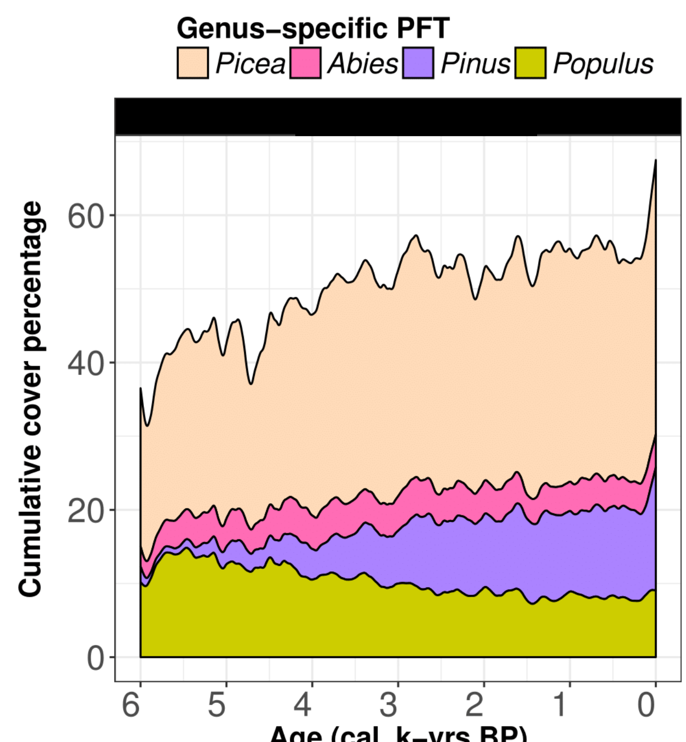

Annual
Spring
Summer
West
Temperature anomalies (°C)
3
2
1
0
−1
−2
6
5
4
3
2
1
0
Age (cal. k−yrs BP)


Annual
Spring
Summer
East
Temperature anomalies (°C)
3
2
1
0
−1
−2
6
5
4
3
2
1
0
Age (cal. k−yrs BP)

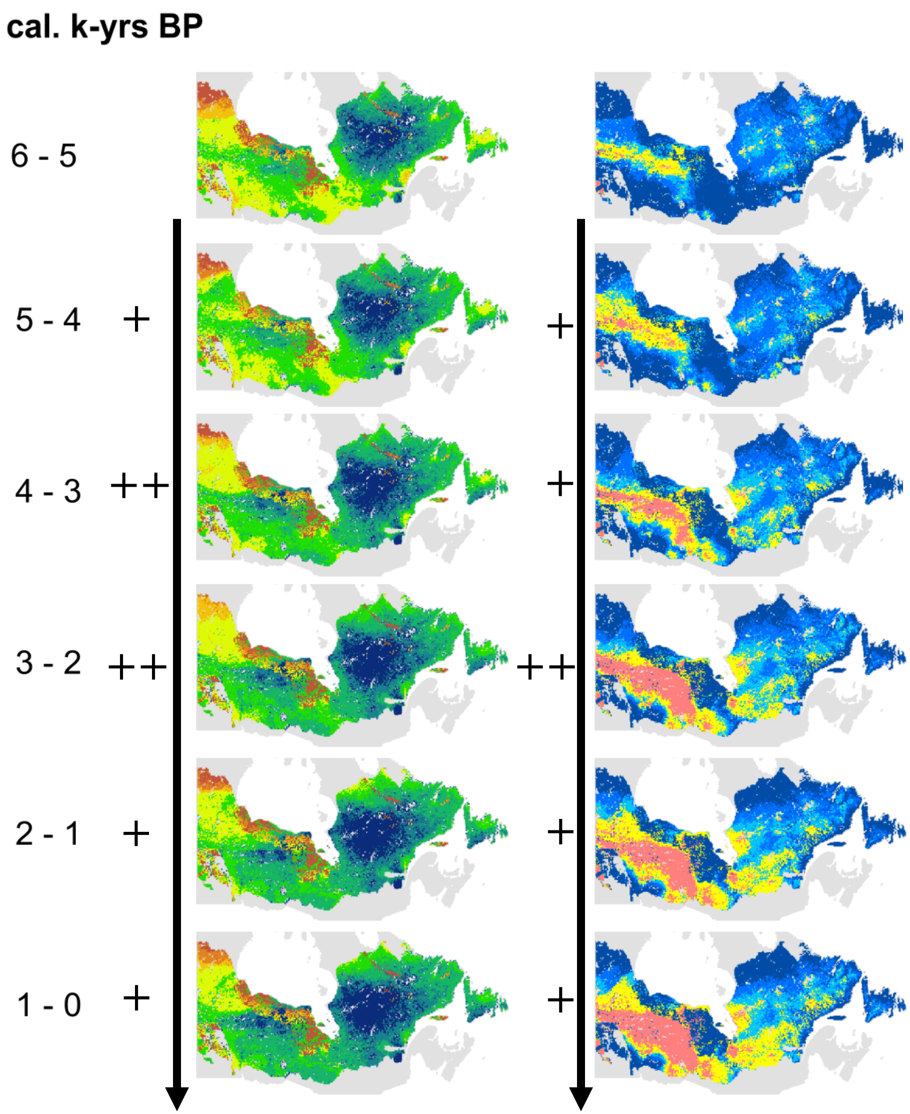
LPJ-LMfire

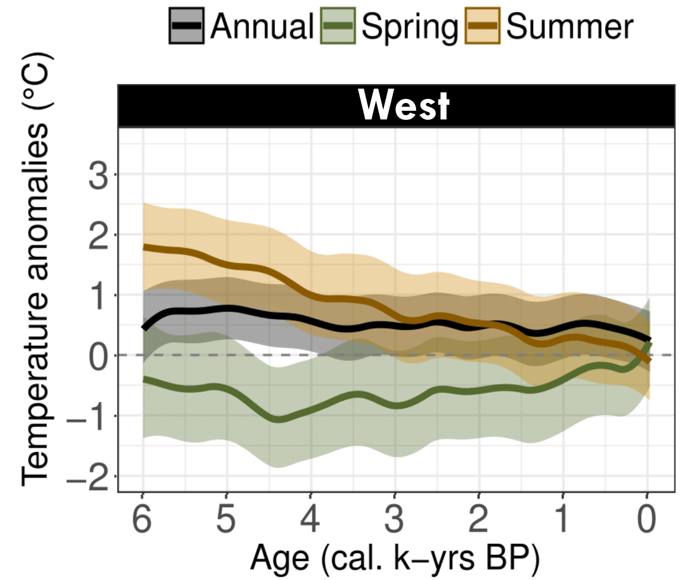

cal. k-yrs BP
6 - 5
5 - 4 +
4 - 3 ++
3 - 2 ++
2 - 1 +
1 - 0 +
+
+
++
+
+

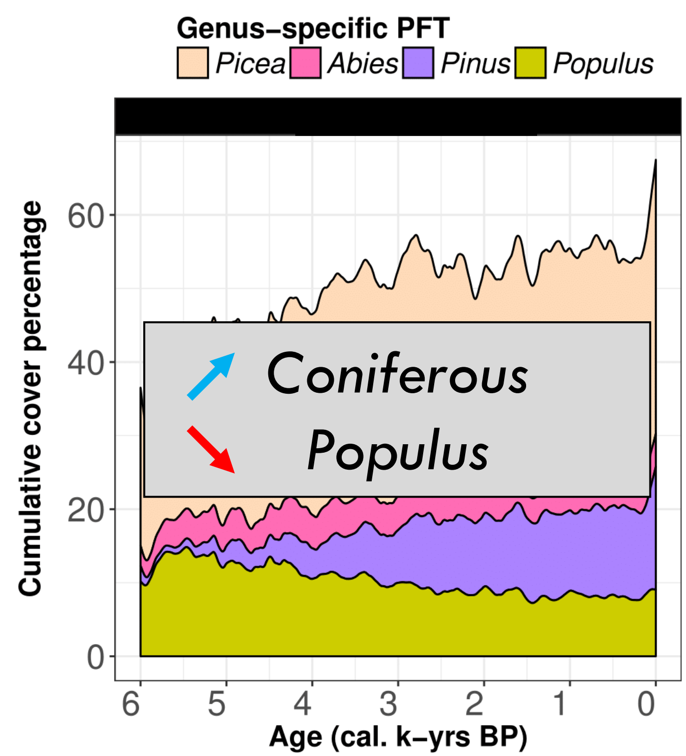

Annual
Spring
Summer
West
Temperature anomalies (°C)
3
2
1
0
−1
−2
6
5
4
3
2
1
0
Age (cal. k−yrs BP)


Genus−specific PFT
Picea
Abies
Pinus
Populus
Cumulative cover percentage
60
40
20
0
6
5
4
3
2
1
0
Age (cal. k−yrs BP)

LPJ-LMfire


cal. k-yrs BP
6 - 5
5 - 4
+
+
4 - 3
++
+
3 - 2
++
++
2 - 1
+
+
1 - 0
+
+

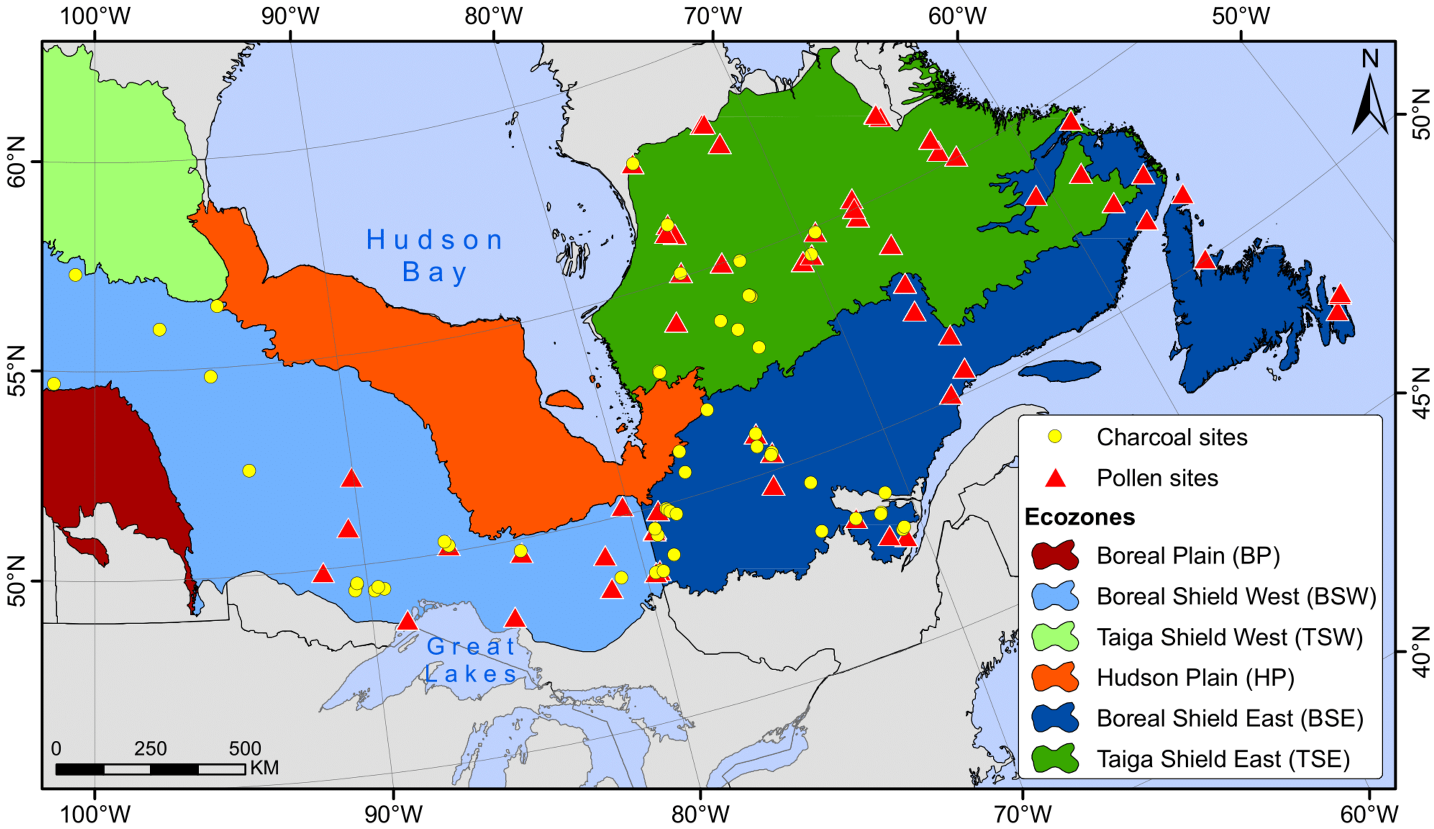

Annual
Spring
Summer
West
Temperature anomalies (°C)
3
2
1
0
−1
−2
6
5
4
3
2
1
0
Age (cal. k−yrs BP)


Genus−specific PFT
Picea
Abies
Pinus
Populus
Cumulative cover percentage
60
40
20
0
Coniferous
Populus
6
5
4
3
2
1
0
Age (cal. k−yrs BP)

Results

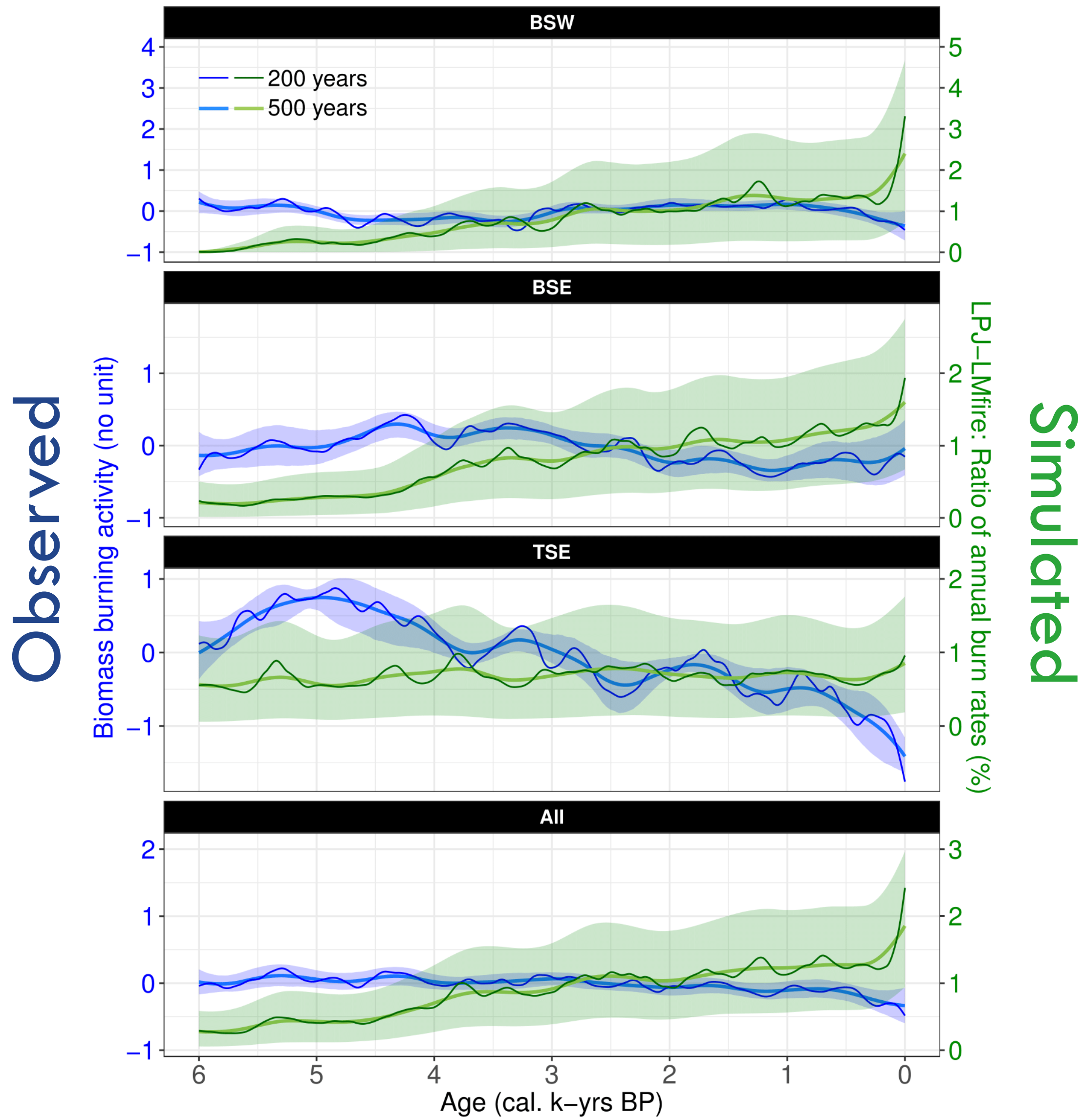
LPJ-LMfire : validation

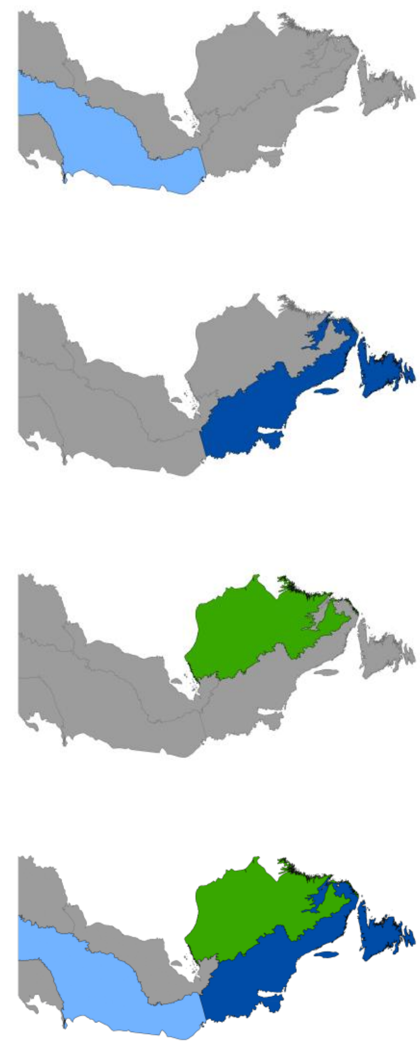
Comparison of LPJ-LMfire model simulations with reconstructions obtained from pollen and lacustrine-charcoal records



LPJ-LMfire : validation

With **lacustrine-charcoal** records

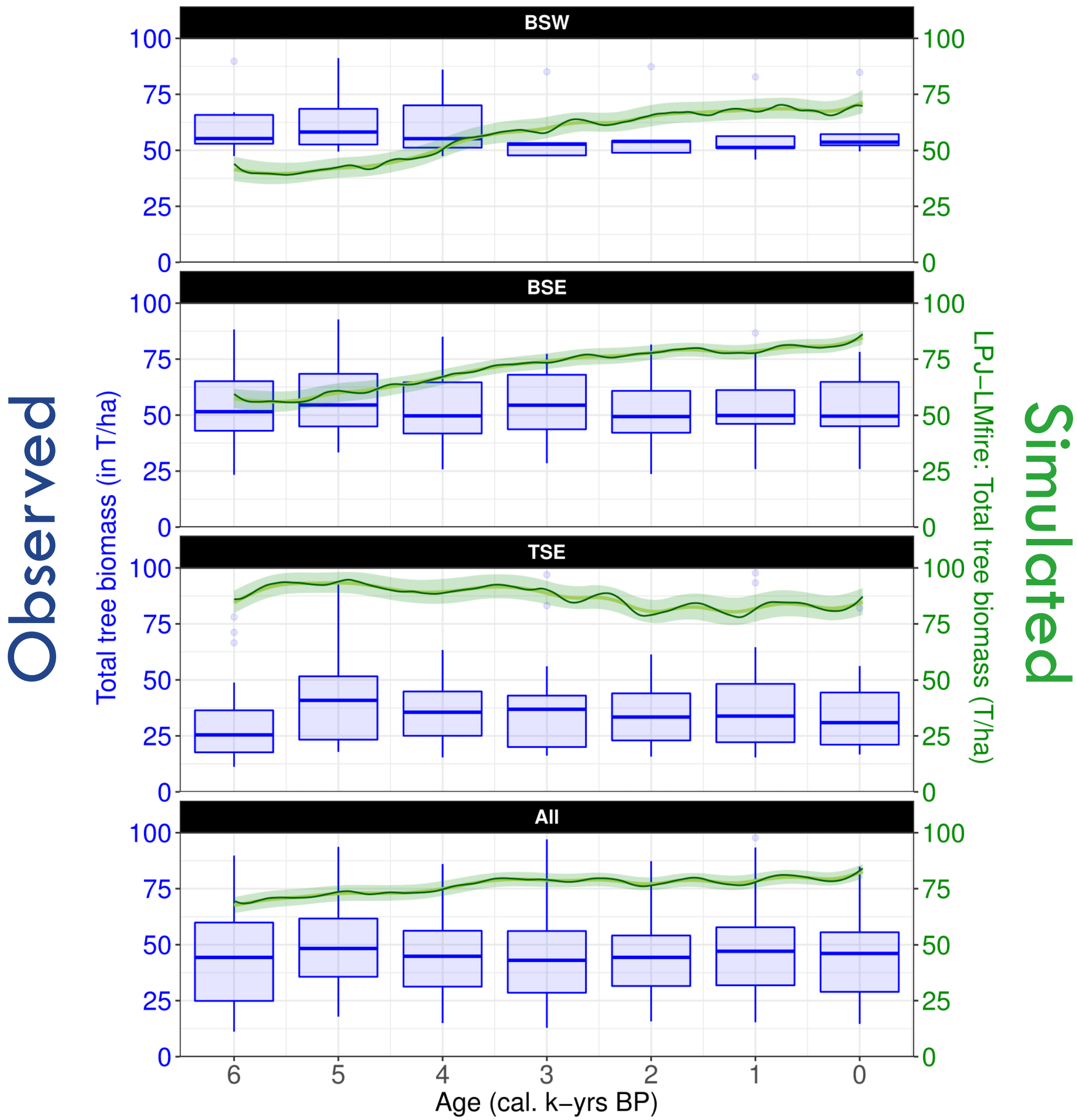


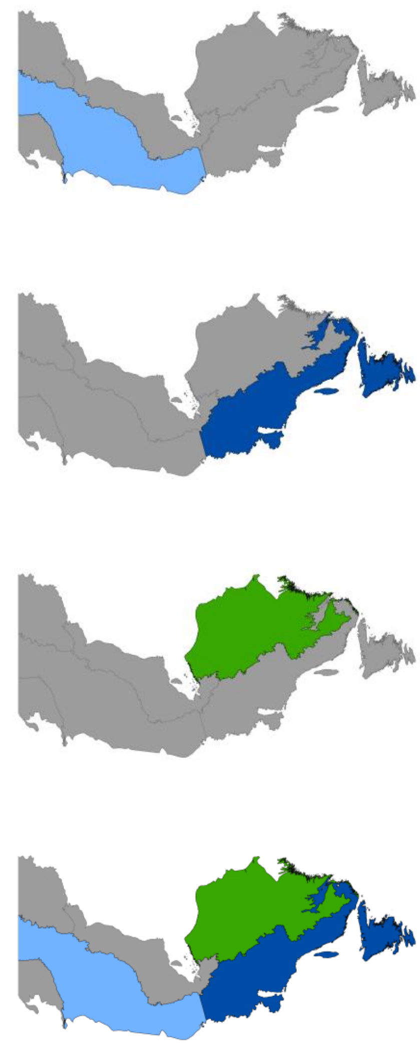


Results

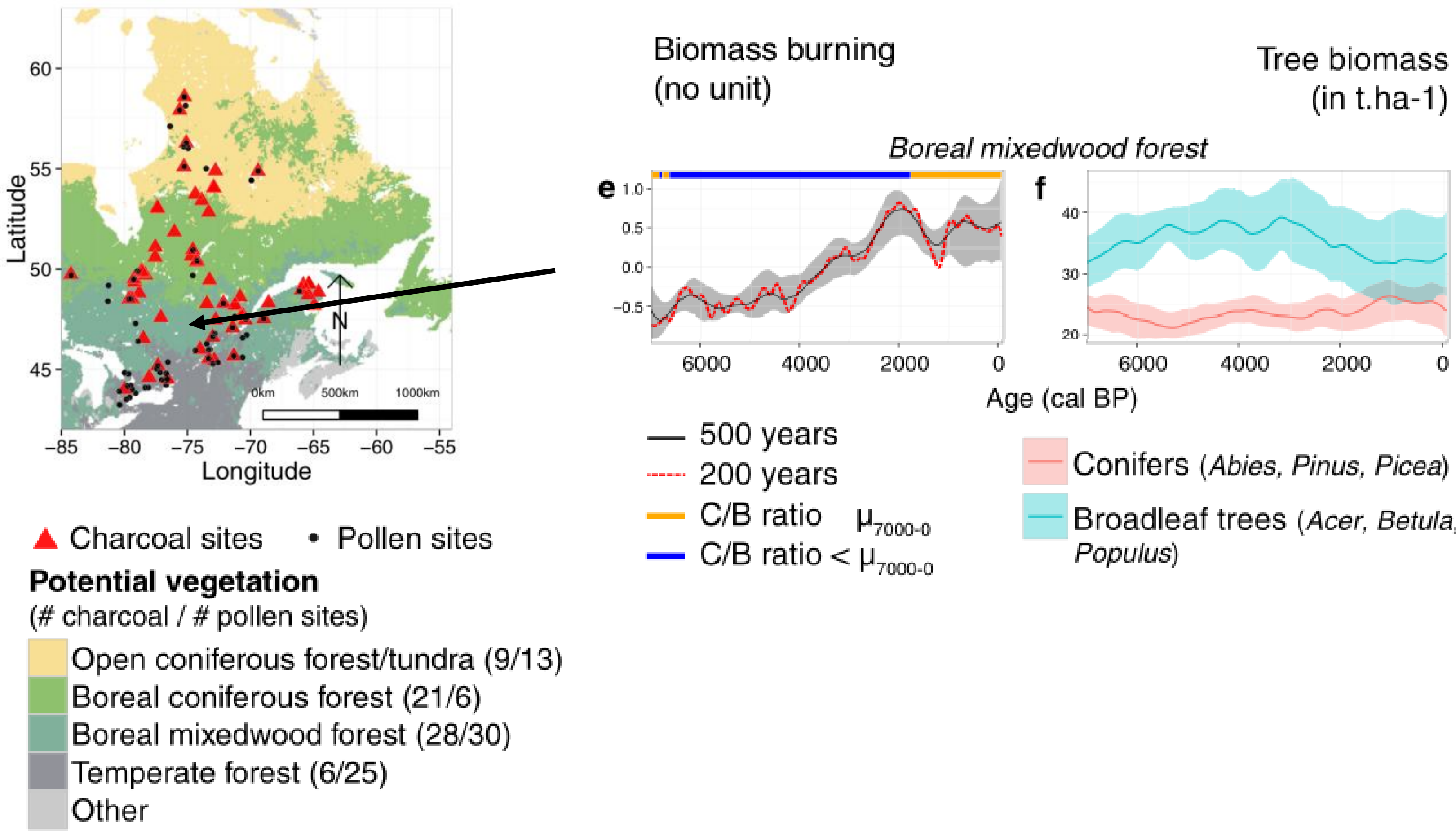
LPJ-LMfire : validation

With **pollen** records





LPJ-LMfire : validation



Blarquez, O., Ali, A. A., Girardin, M. P., Grondin, P., Fréchette, B., Bergeron, Y. and Hély, C.: Regional paleofire regimes affected by non-uniform climate, vegetation and human drivers, Sci. Rep., 5(1), doi:10.1038/srep13356, 2015.

To keep in mind (1):

- The first study: Holocene vegetation dynamics simulations with high spatial and temporal resolution in eastern boreal Canada;

- Long-term regional climate largely influences the vegetation dynamics: warm growing seasons at 6000 BP allowed a rapid vegetation establishment in the east, whereas cold spring temperatures have limited biomass growth in the west;

- Vegetation acts as an important "bottom-up" control on fire frequency at long time-scales.

To keep in mind (2):

- Low biomass and high *Populus* cover percentage contributed to low simulated fire activity;
- Simulated trajectories in fires and vegetation changes during the last 6000 years were not entirely synchronous with reconstructions of fire frequency and tree biomass: LPJ-LMfire simulations captured the changes in forest dynamics further south in the west and further north in the east compared to the empirical data;
- We suggest that the discrepancies between simulated and observed trajectories are associated to uncertainty in the IPSL-CM5A-LR climate dataset that has been used as an input to LPJ-LMfire.

Many thanks to:

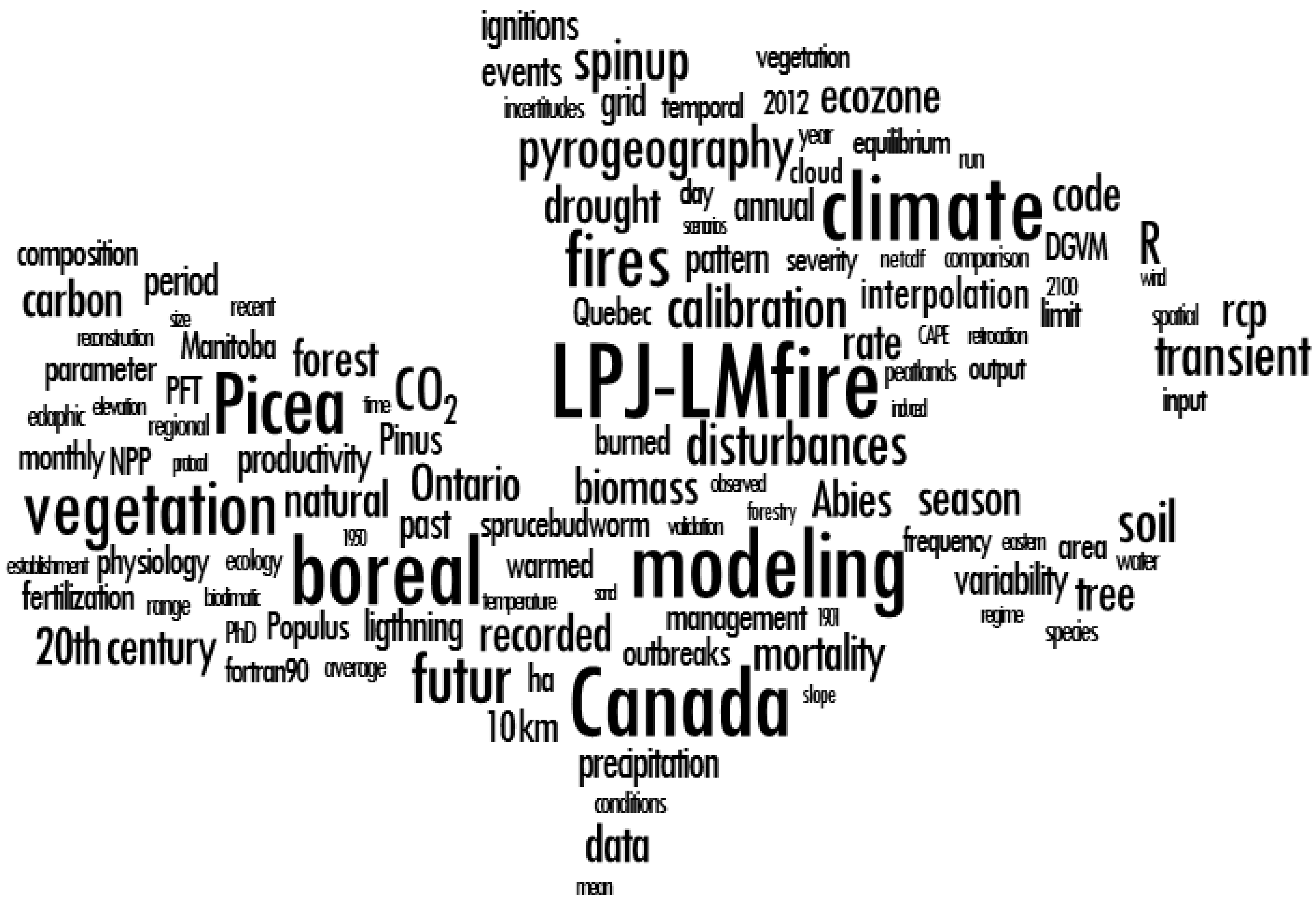
- My supervisors
- Professor **Jed Kaplan** from the University of Lausanne
- **Xiao Jing Guo**, biostatistician at the Laurentian forestry center
- Olivier Blarquez, professor at the University of Montreal
- Daniel Stubbs, scientific analyst at Calcul Quebec
- Our partners:

Modélisation de la Complexité de la Forêt

NEWFORESTS

CRSNG NSERC

Questions?


ignitions
events
spinup
vegetation
incertitudes
grid
temporal
2012
ecozone
pyrogeography
year
equilibrium
run
cloud
drought
day
annual
climate
code
scenarios
fires
pattern
severity
netcdf
comparison
DGVM
R
wind
composition
period
carbon
recent
size
Quebec
calibration
interpolation
2100
limit
spatial
rcp
reconstruction
Manitoba
forest
rate
CAPE
retroaction
transient
parameter
PFT
Picea
fire
CO_2
LPJ-LMfire
peatlands
output
input
edaphic
elevation
regional
induced
Pinus
burned
disturbances
monthly
NPP
productivity
Ontario
biomass
observed
vegetation
natural
forestry
Abies
season
past
sprucebudworm
validation
soil
1950
modeling
frequency
eastern
area
establishment
physiology
ecology
boreal
warmed
water
variability
fertilization
range
temperature
sand
tree
regime
management
1901
20th century
PhD
Populus
ligthning
recorded
species
outbreaks
mortality
fortran90
average
futur
ha
Canada
slope
10km
precipitation
conditions
data
mean