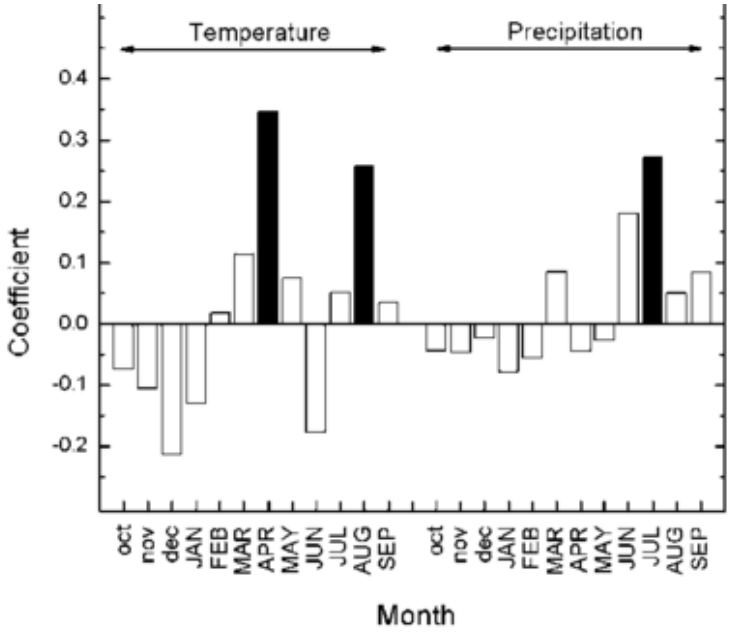
ECL7202 – DENDROECOLOGY

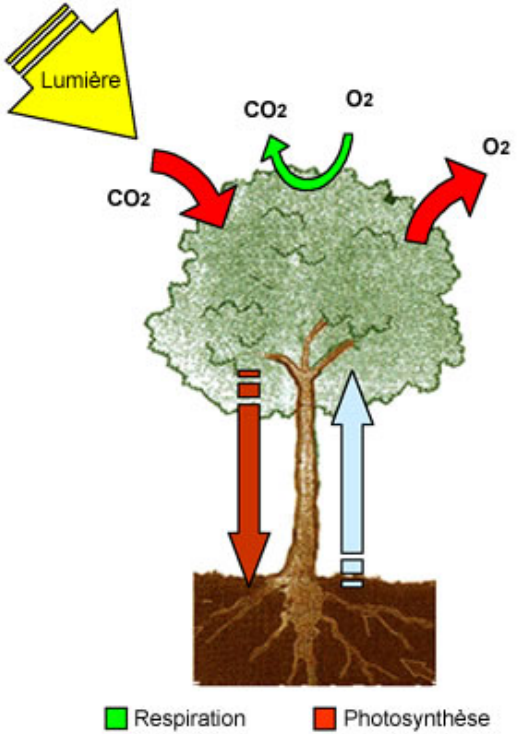
5 – Dendroecological models

Empirical models



They analyze observed relationships to predict tree responses

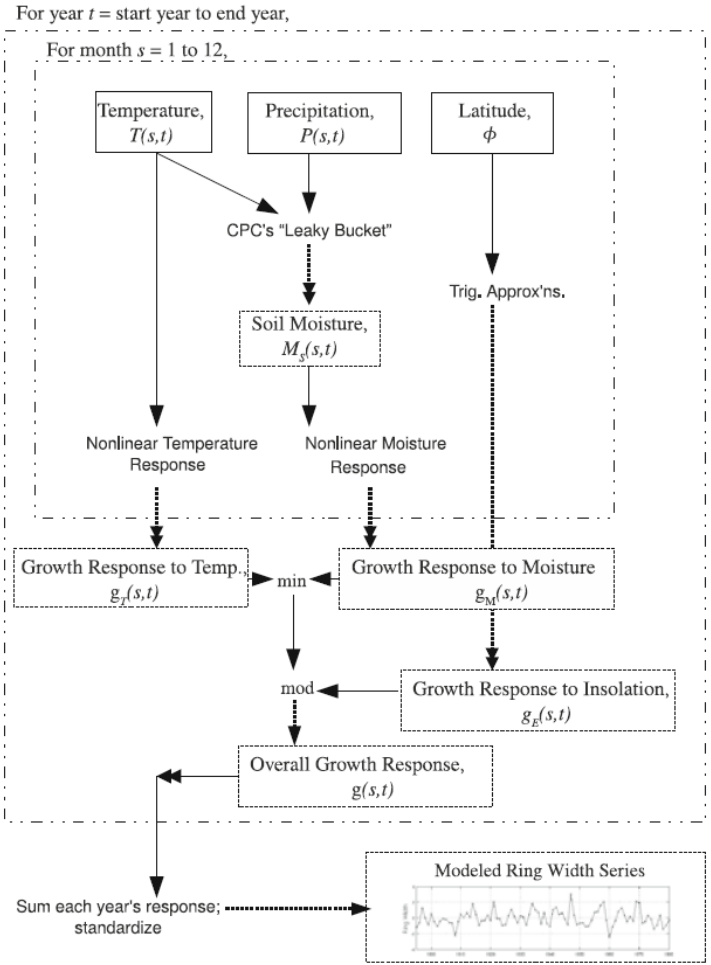
Mechanistic models



They make assumptions on tree functioning to predict tree responses

VS-Lite

The simplest mechanistic/empirical model for dendroecological applications based on the principle of limiting factors



Monthly Inputs

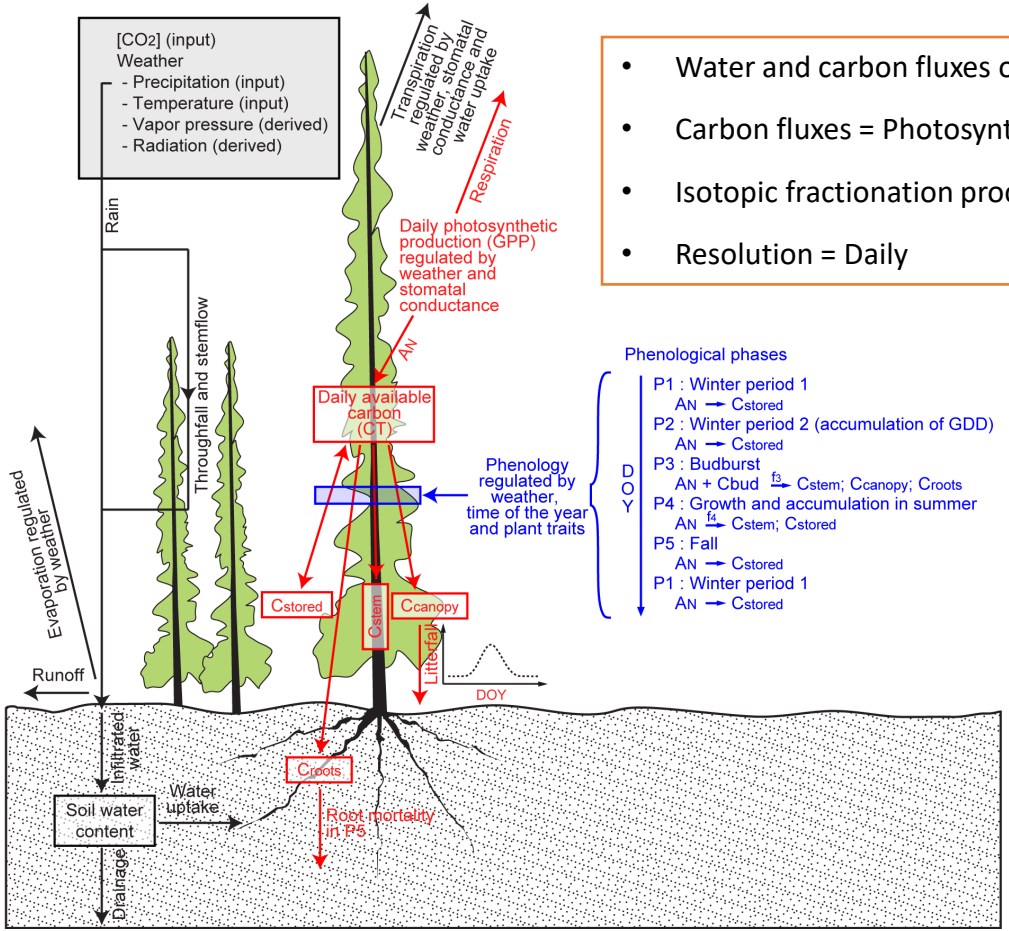
Threshold growth responses and limiting factors

Outputs: tree-ring indexes

Tolwinski-Ward, S., Evans, M., Hughes, M., & Anchukaitis, K. (2011). An efficient forward model of the climate controls on interannual variation in tree-ring width. *Climate Dynamics*, *36*(11–12), 2419–2439. doi: 10.1007/s00382-010-0945-5

Ecophysiological modeling of tree primary production and carbon allocation with MAIDEN

(Misson 2004; Gea-Izquierdo et al. 2015; Gennaretti et al. 2017)



- Water and carbon fluxes of an average tree
- Carbon fluxes = Photosynthesis + Carbon allocation
- Isotopic fractionation processes
- Resolution = Daily

Phenological phases

DOY

P1 : Winter period 1
AN → Cstored
P2 : Winter period 2 (accumulation of GDD)
AN → Cstored
P3 : Budburst
AN + Cbud $\xrightarrow{f_3}$ Cstem; Ccanopy; Croots
P4 : Growth and accumulation in summer
AN $\xrightarrow{f_4}$ Cstem; Cstored
P5 : Fall
AN → Cstored
P1 : Winter period 1
AN → Cstored

Photosynthesis (GPP – Gross Primary Production)

GPP modeling -> De Pury & Farquhar 1997; Leuning 1995; Gea-Izquierdo et al. 2015

Important climate dependences

Water stress level (Θg) influencing the stomatal conductance

$$\theta g_i = \frac{1}{1 + \exp(soilb \cdot (SWC_i - soilip))}$$

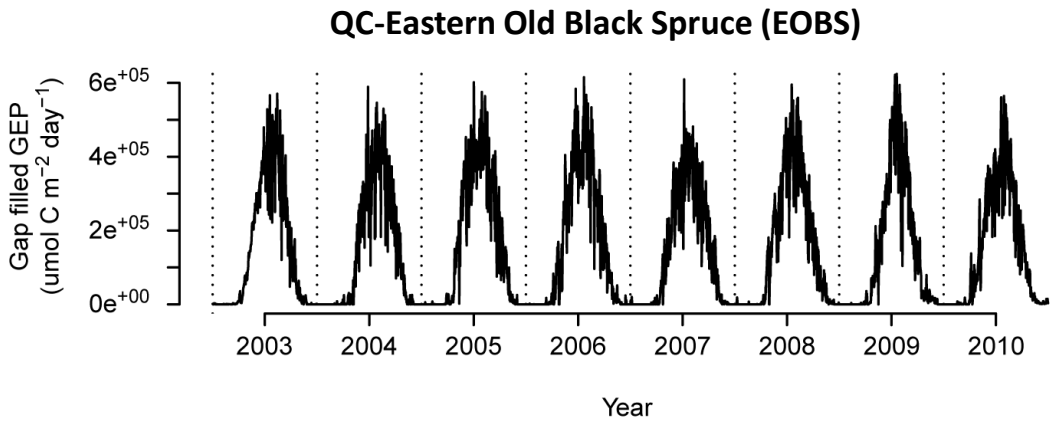
Temperature dependence of maximum carboxylation rate (*Vcmax*)

$$Vcmax_i = \frac{Vmax}{1 + \exp(Vb \cdot (Tday_i - Vip))}$$

Temperature transformation (S) to take into account acclimation of photosynthesis to temperature (Mäkelä et al. 2004)

$$\frac{dS_i}{di} = \frac{Tday_i - S_i}{\tau}$$

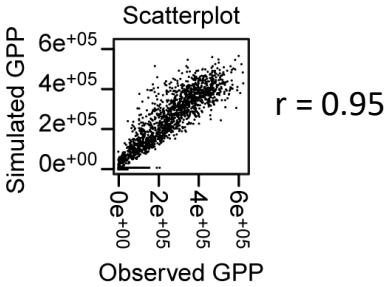
Observed GPP data from eddy covariance stations are needed to test the model



Photosynthesis (GPP – Gross Primary Production) - Model performance

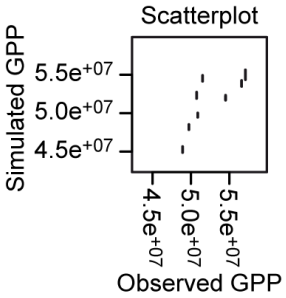
Comparison between simulated and observed values

Daily GPP values
(umol C m^{-2} day^{-1})

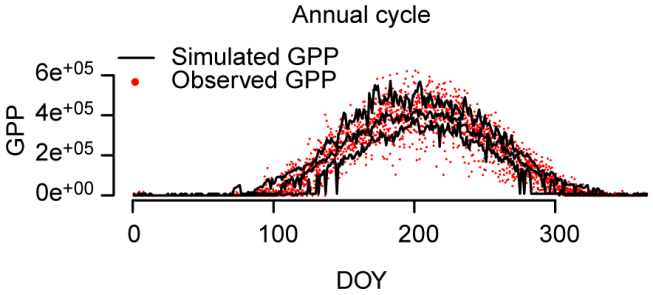


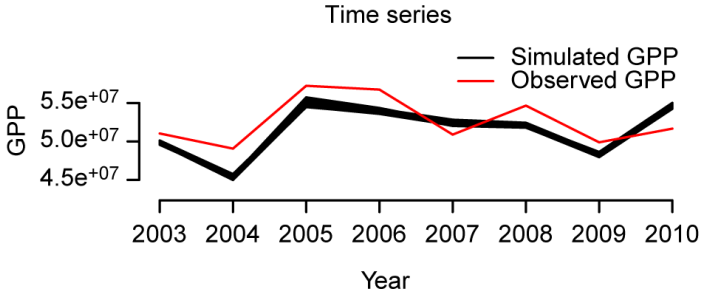
r = 0.95

Annual GPP values
(umol C m^{-2} $year^{-1}$)

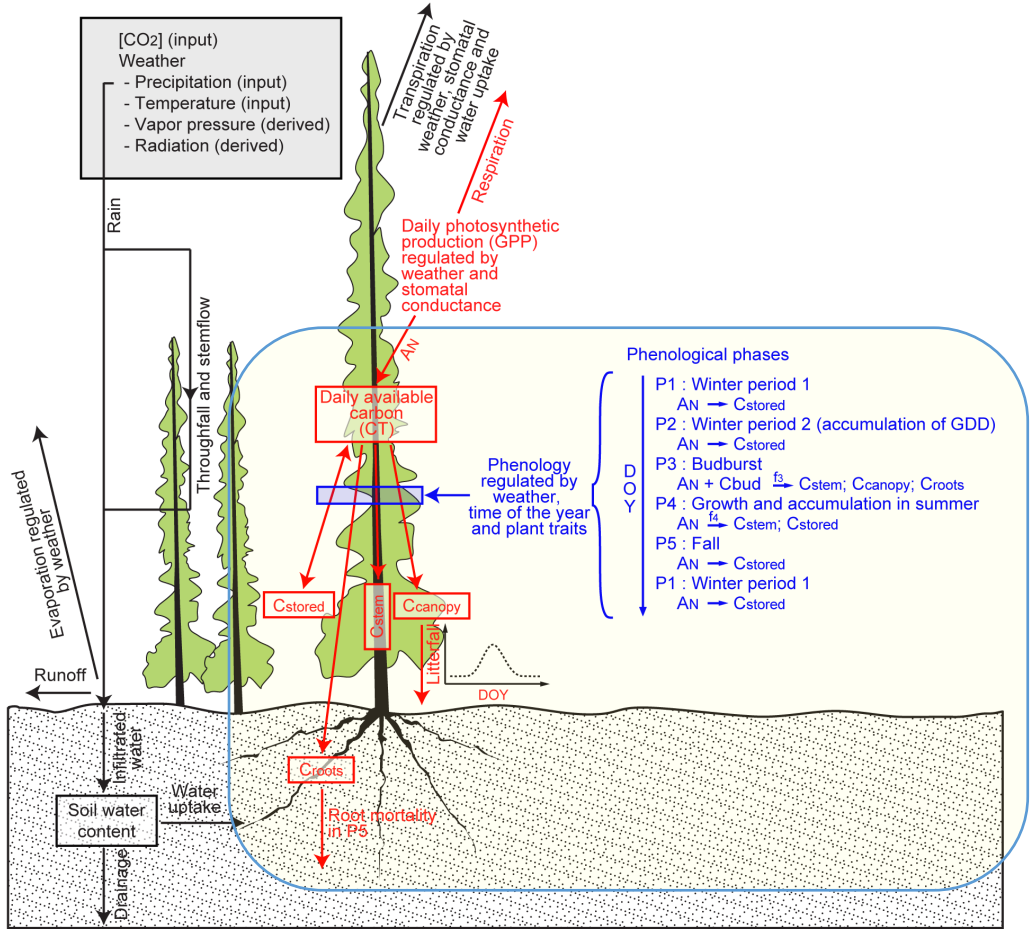


r = 0.76





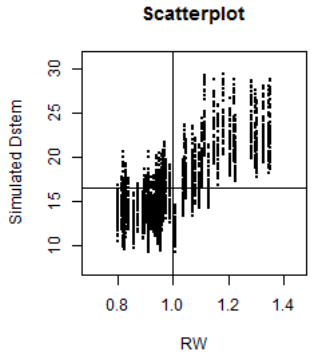
Carbon allocation to stem



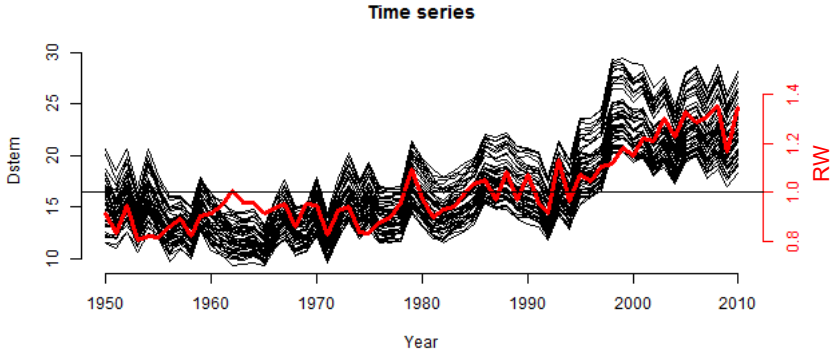
MAIDEN simulates the allocation of available carbon to different compartments (storage, canopy, roots and stems) using mechanistic rules depending on phenology (five phenological phases are simulated each year).

Carbon allocation to stem - Model performance

Simulated C allocation to the stem VS observed ring width

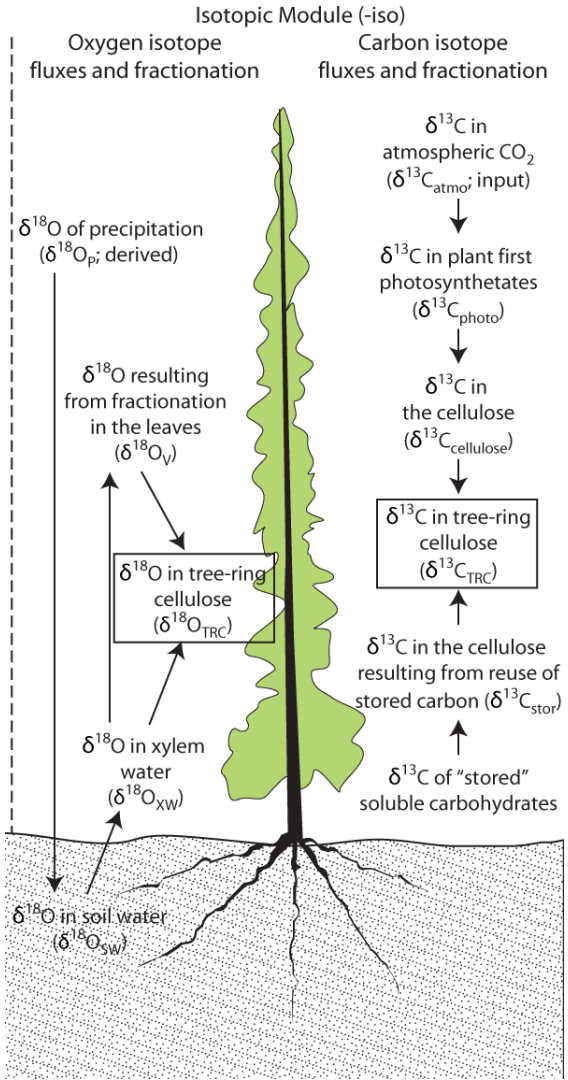


$R^2 = 0.73$



Isotopic fractionation processes

MAIDEN also simulates the fractionation of carbon and oxygen isotopes during their assimilation to determine the isotopic composition of tree-ring cellulose



MAIDEN applications :

- Study the impact of past and projected climate change (CO_2 changes; climate of future horizons) on forest carbon budget
- In inverse mode, MAIDEN can improve climate reconstructions (Boucher at al. 2014)

Our today exercise :

- Based on the results of Gennaretti et al. (2017; Biogeosciences)
- Read the code
- Compile and run MAIDEN
- Test effects pf environmental variables and parameters