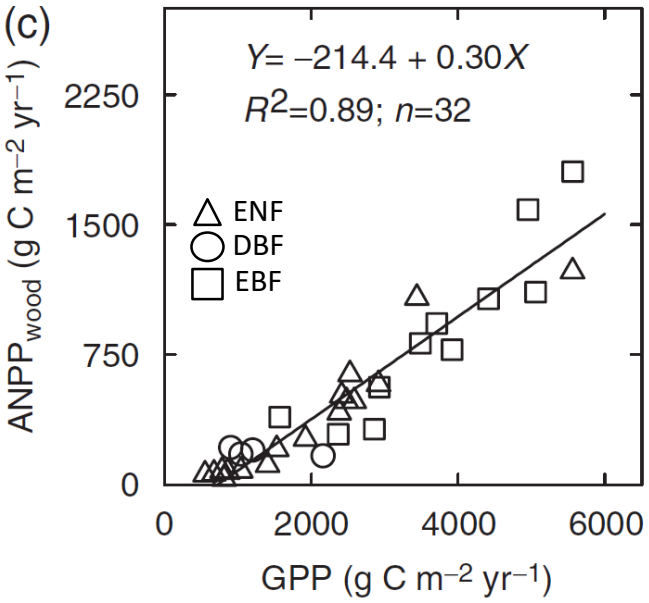
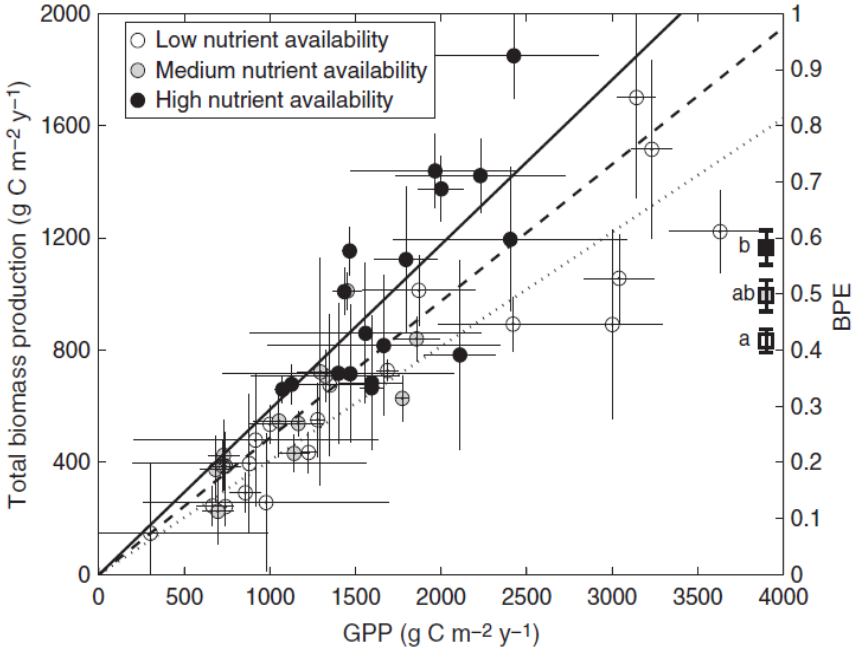
Wood phenology, not carbon input, controls the interannual variability of tree growth in a temperate oak forest

Nicolas Delpierre, Daniel Berveiller, Elena Granda, Eric Dufrêne

New Phytologist (2016) 210: 459–470

Flux-growth correlations
inter-biome



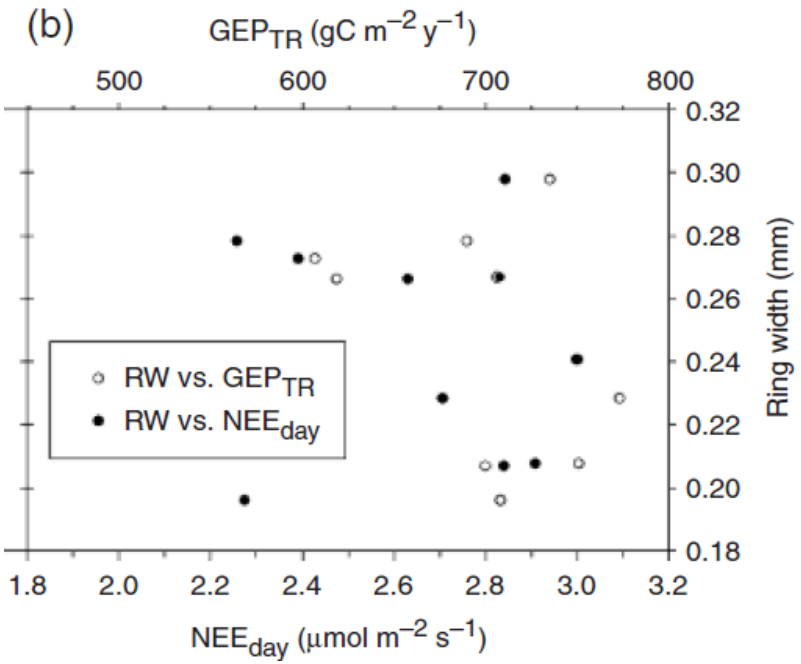


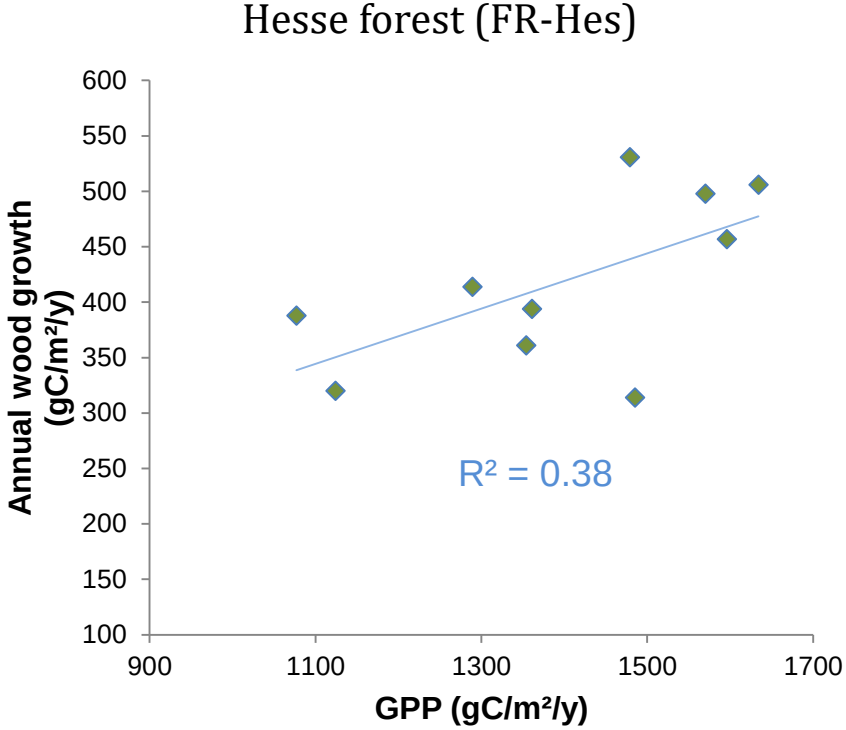
Tree growth is constitutively dependent on C inputs

Strong growth / C inputs correlations inter-biomes

Litton et al., 2007 *GCB*
Vicca et al., 2012 *Ecol. Lett.*

Flux-growth correlations
inter-annual

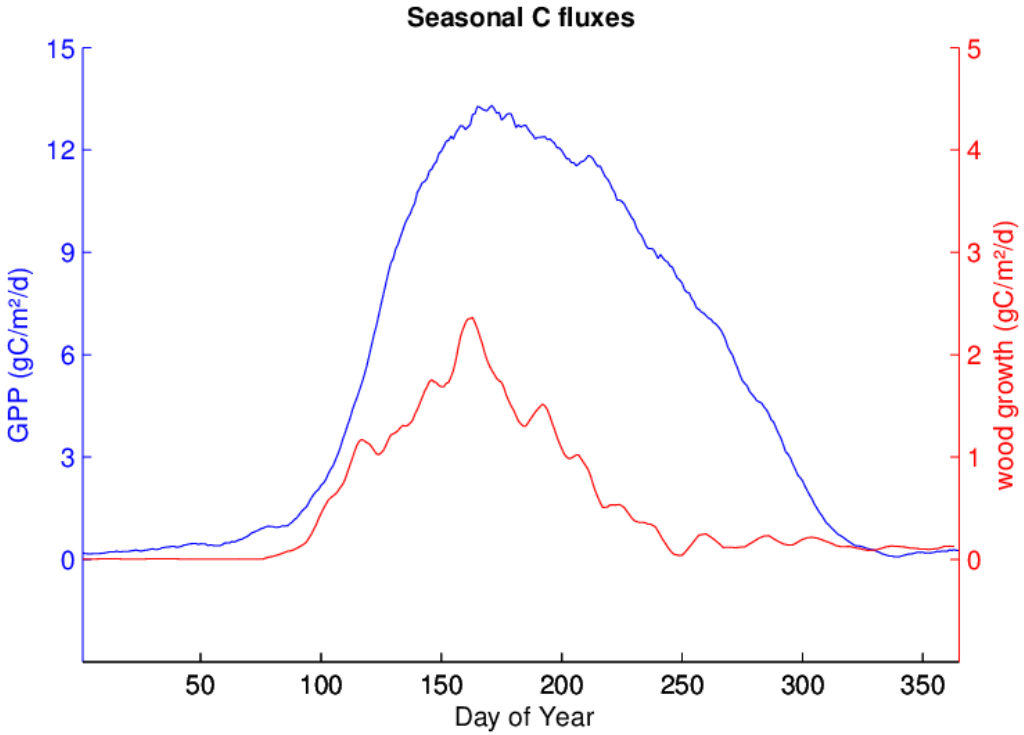




Annual wood growth is
not systematically dependent on annual GPP / NPP

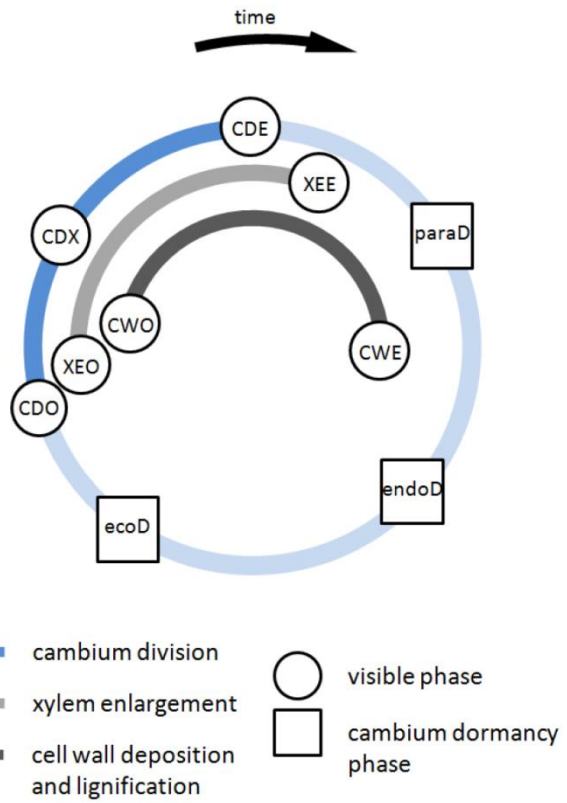
Rocha et al., 2006 *GCB*
Granier et al.. 2008 *AFS*

Flux-growth correlations
seasonal scale



FR-Fon Oak forest (2006-2015)

Wood growth is a seasonal process



Delpierre et al., 2016, *Annals of Forest Science*

Objectives

- Assess the dependence of aerial wood growth on:

  - Carbon inputs
    (growth is *source-limited*)

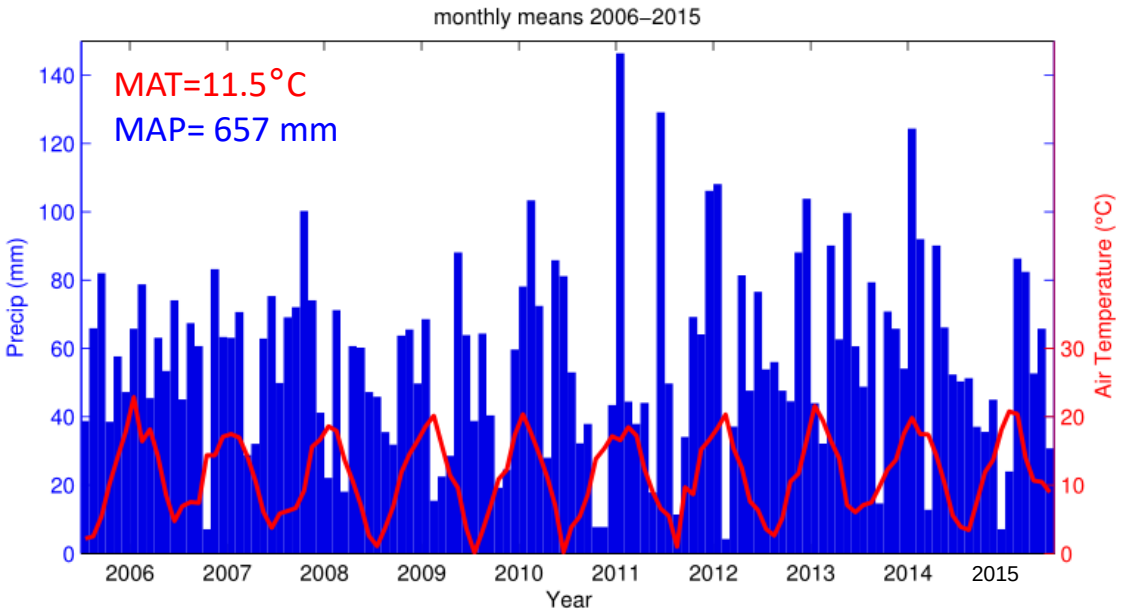
  - Wood tissues activity, modulated by environmental drivers
    (growth is *sink-limited*)

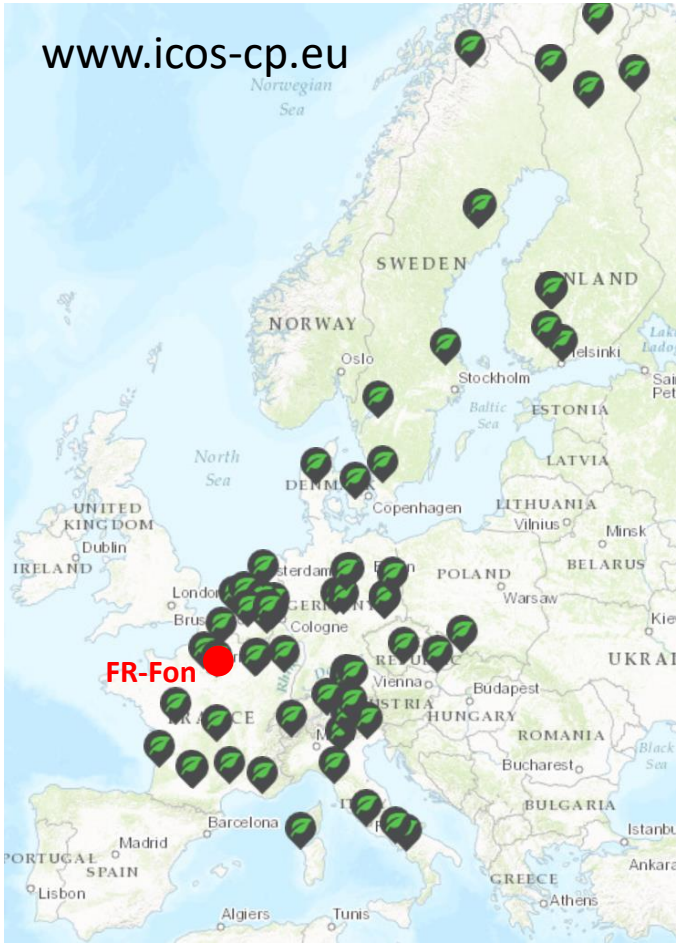
FR-Fon research station

Fontainebleau-Barbeau forest (405 ha)

Sessile Oak (*Quercus petraea*) – 150 yr old
Hornbeam (*Carpinus betulus*)

Flux + growth measurements
2005 – ongoing

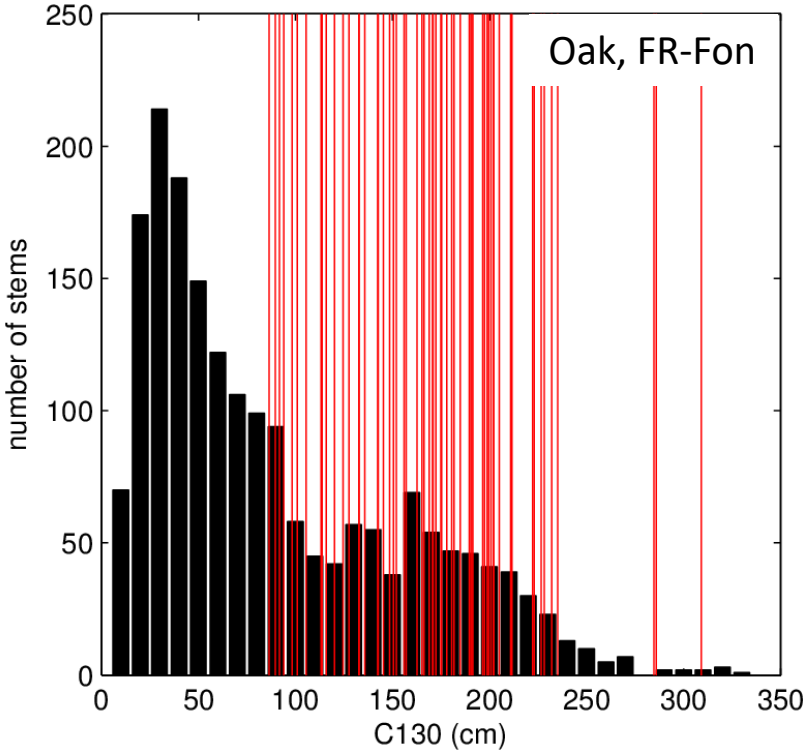




Assessing stand wood growth

$$\frac{dAWB}{dt} = \frac{dV}{dt} \times \rho$$

AWB= abv wood mass (kg C m^{-2})
V= volume (m^3 m^{-2})
ρ=volumetric mass (kg C m^{-3})



Vallet et al., 2006 *FEM*

Assessing stand wood growth

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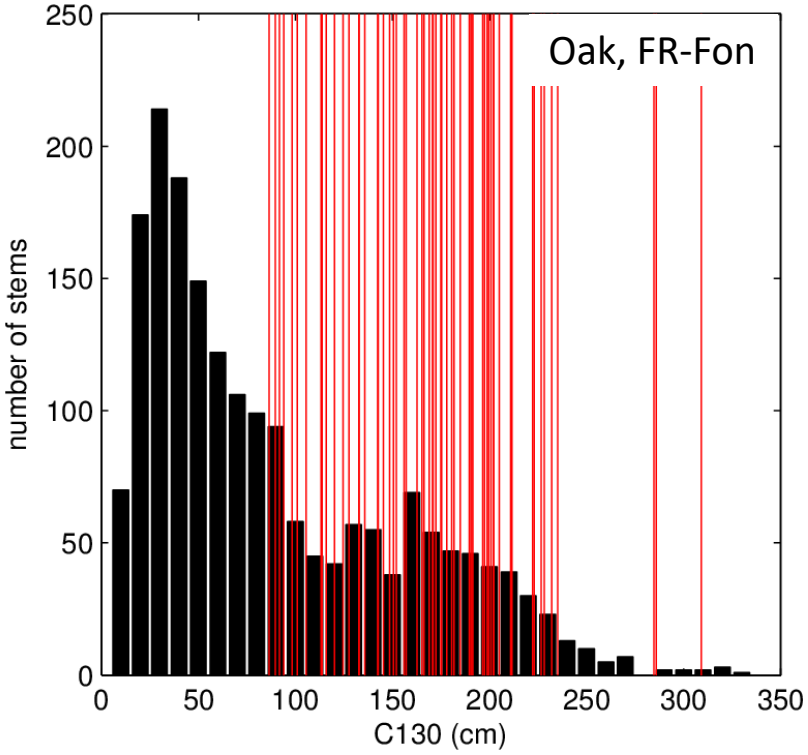
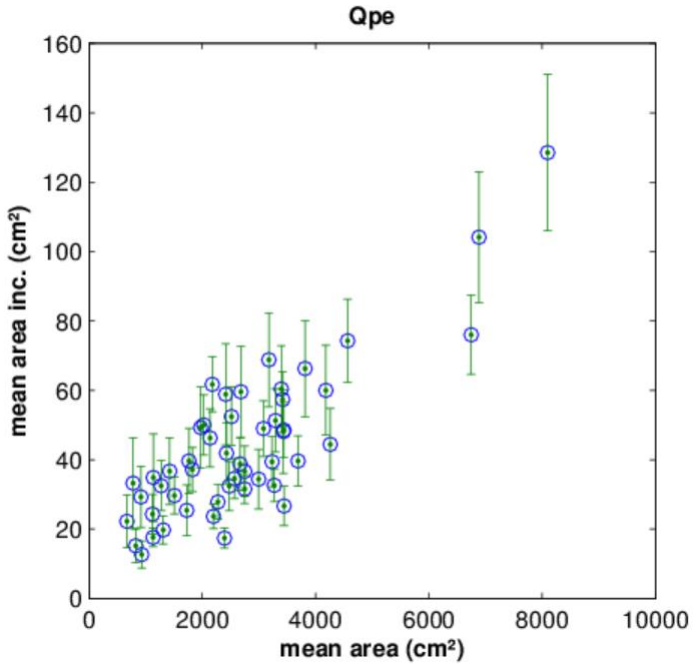
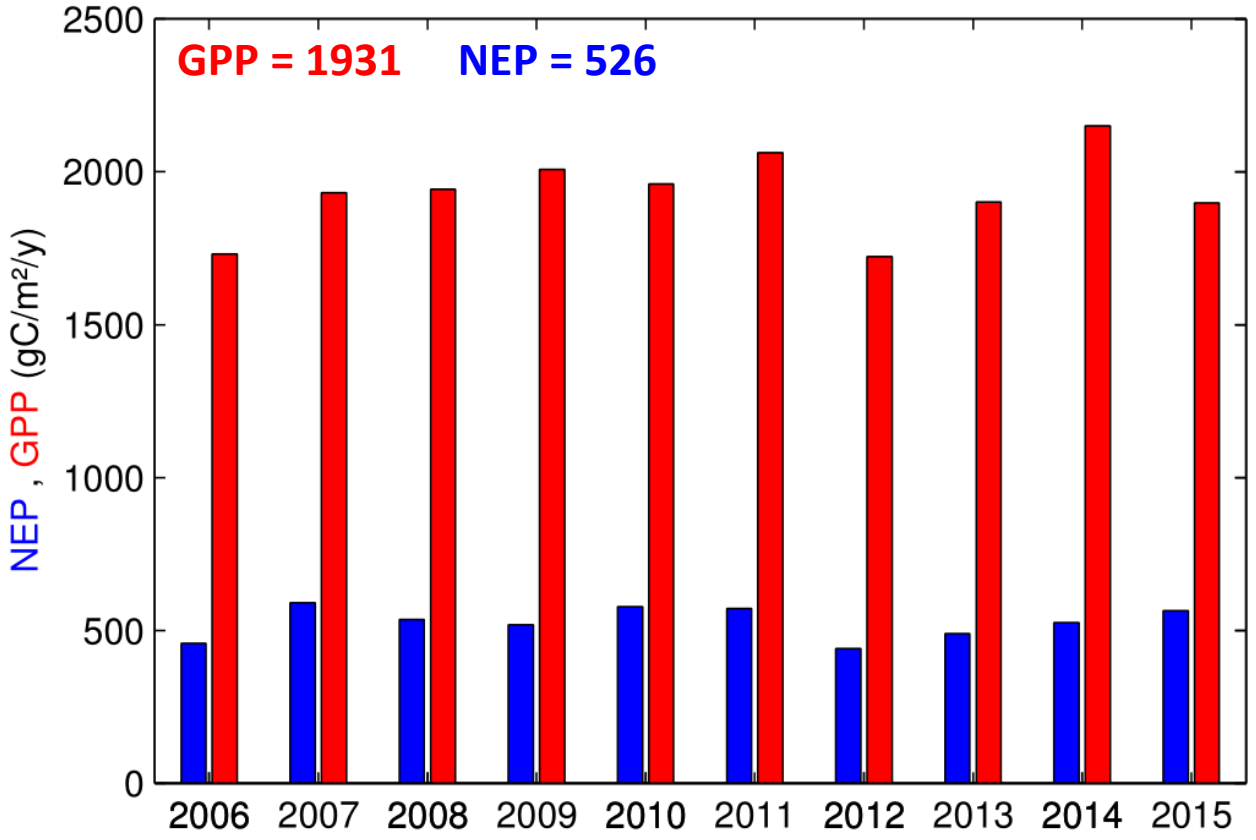


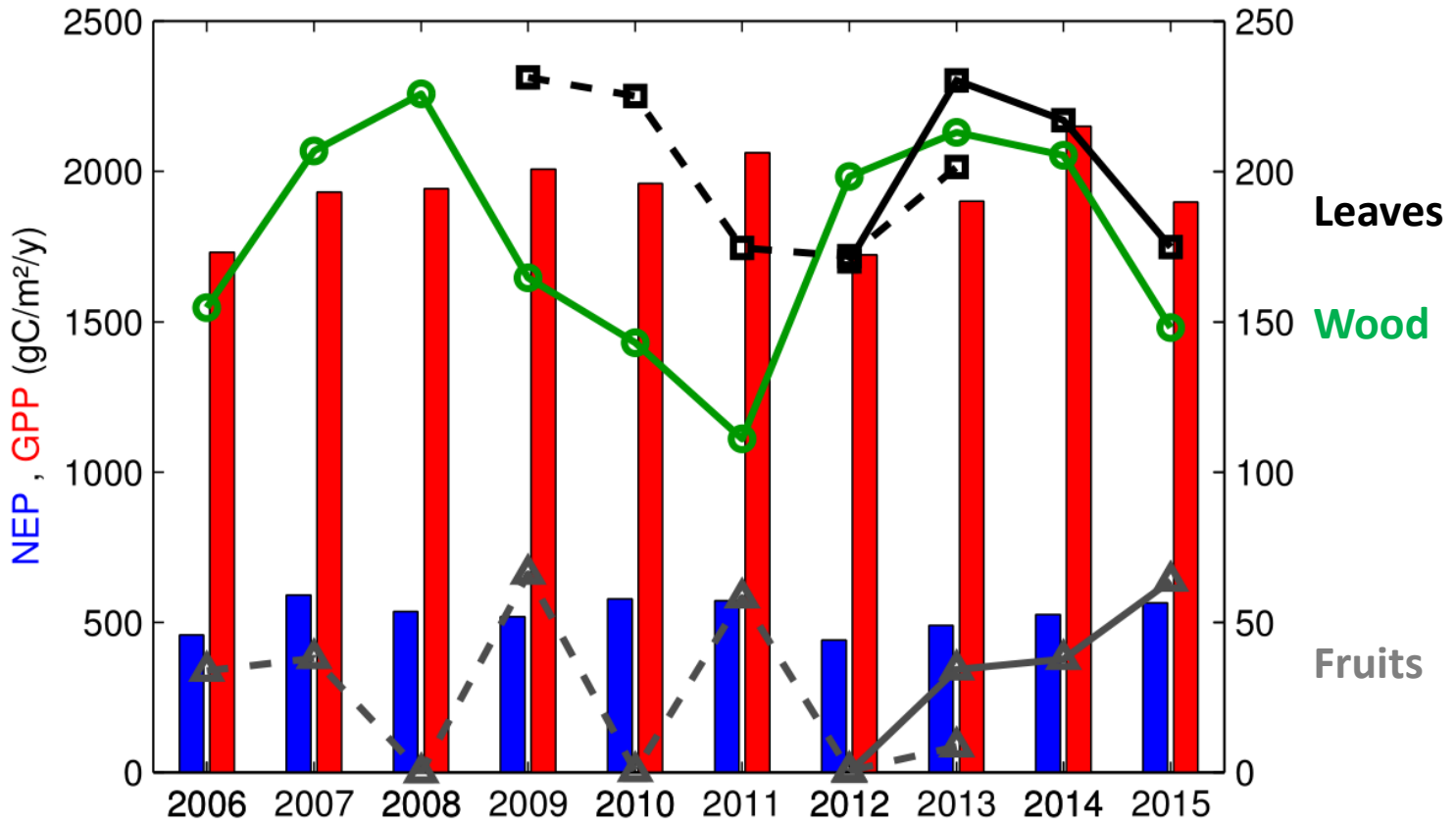


Dhote, 1999 *RFF*

Does wood growth depend on C inputs ?



Does wood growth depend on C inputs ?



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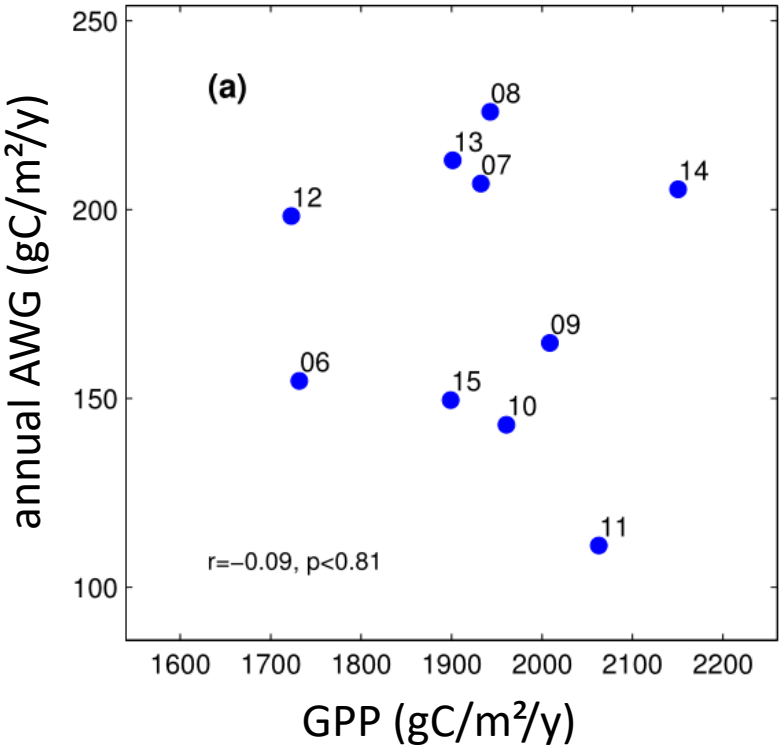

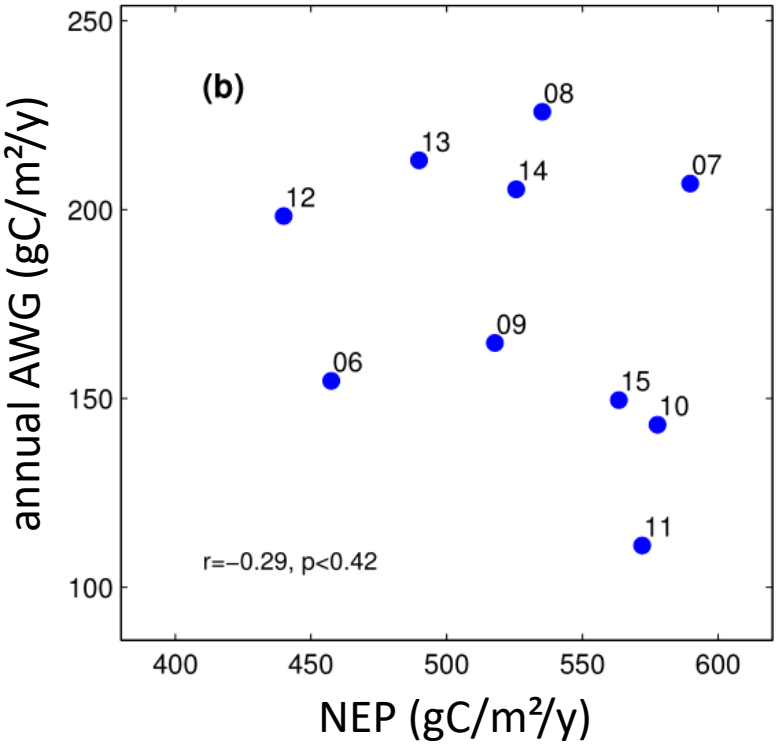

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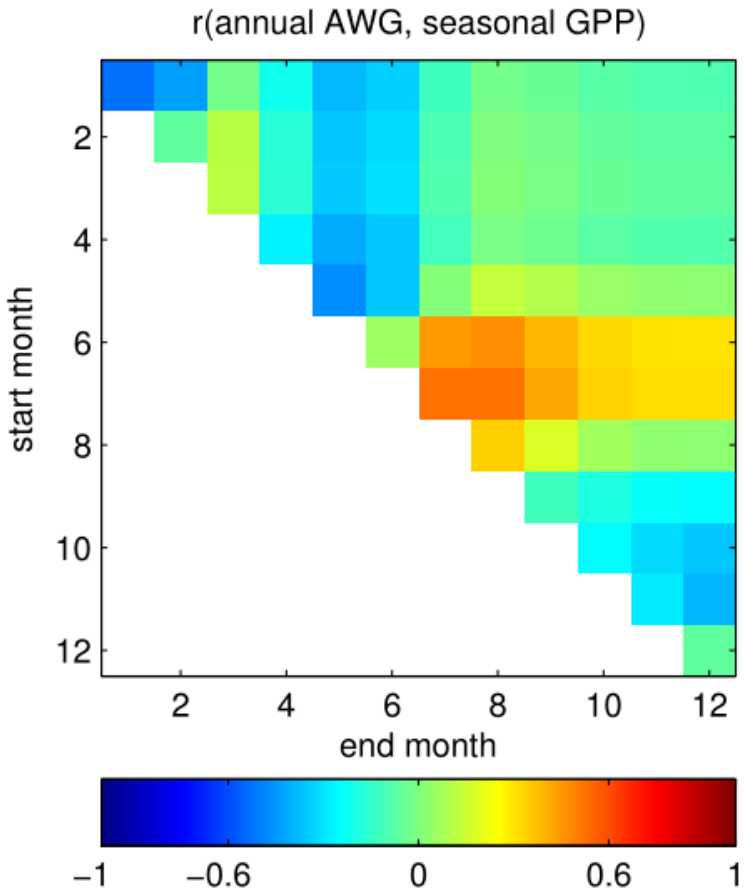
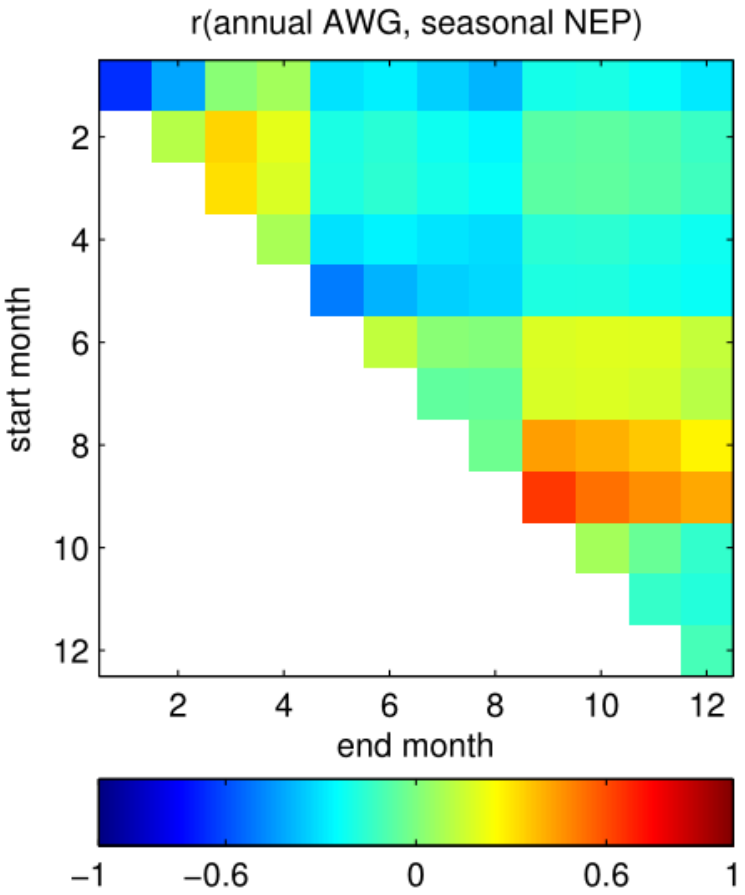
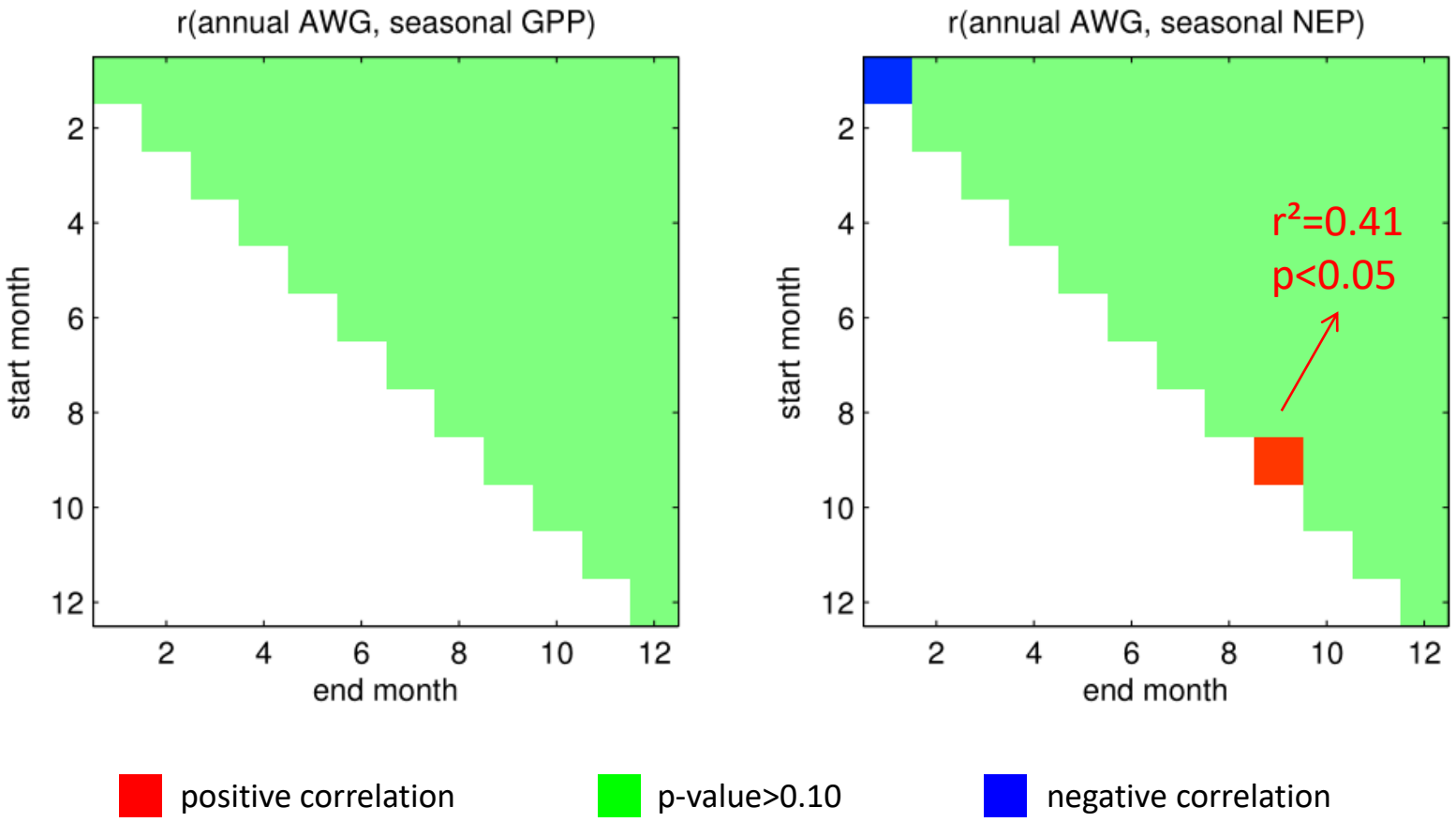


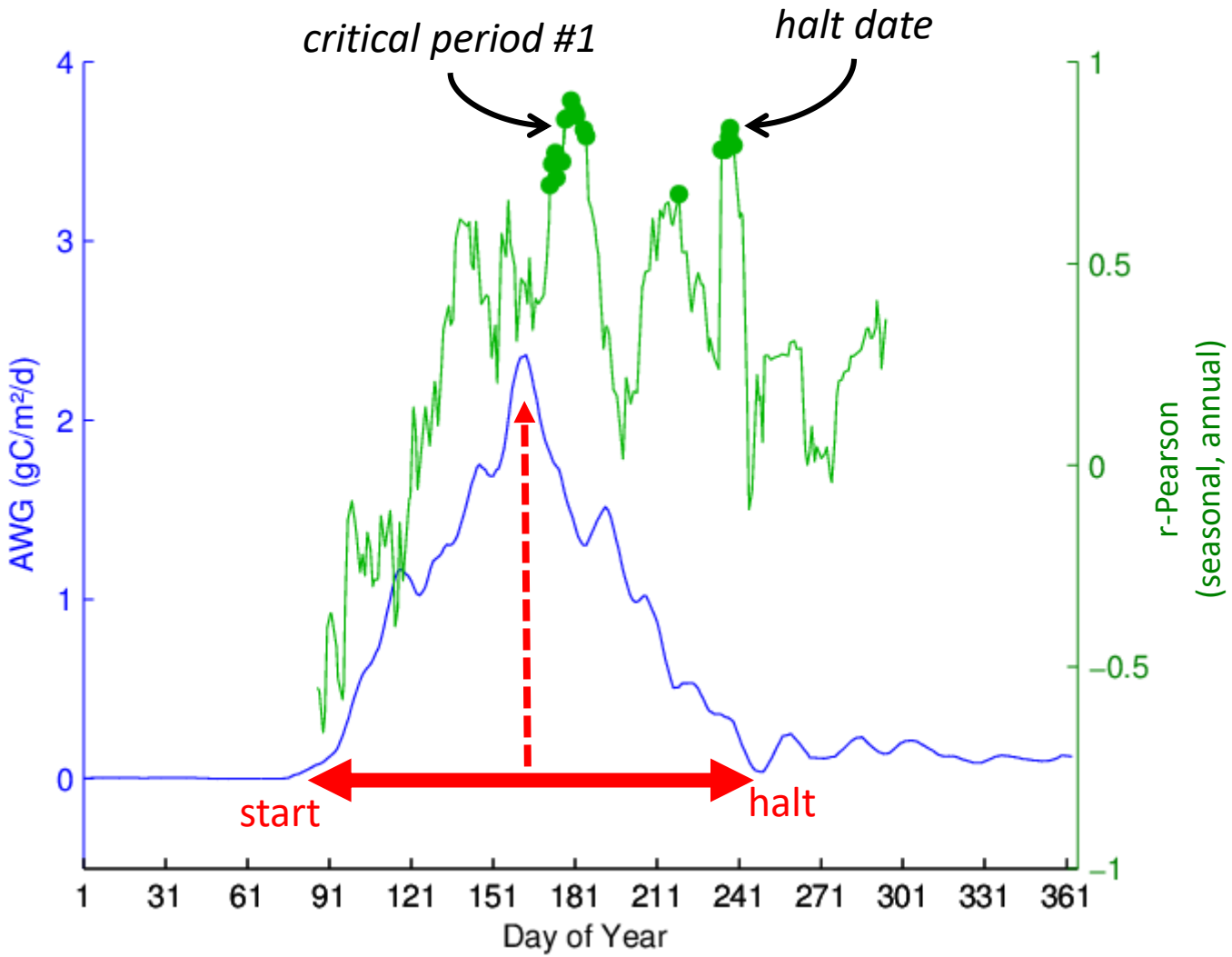


see also Babst et al. 2014, *New Phytol.*

Does wood growth depend on C inputs ?

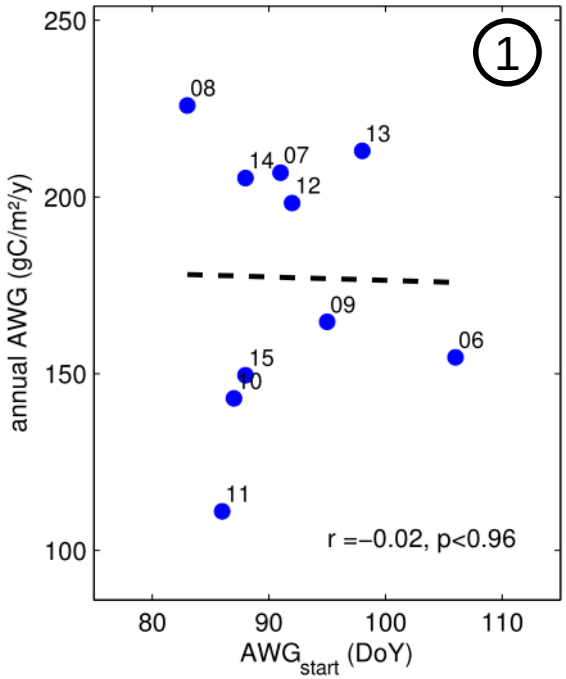


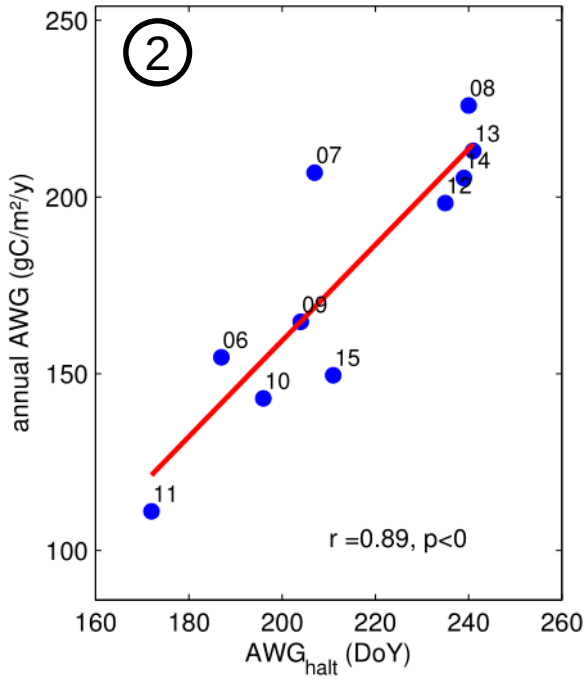
Intrinsic determinants of wood growth

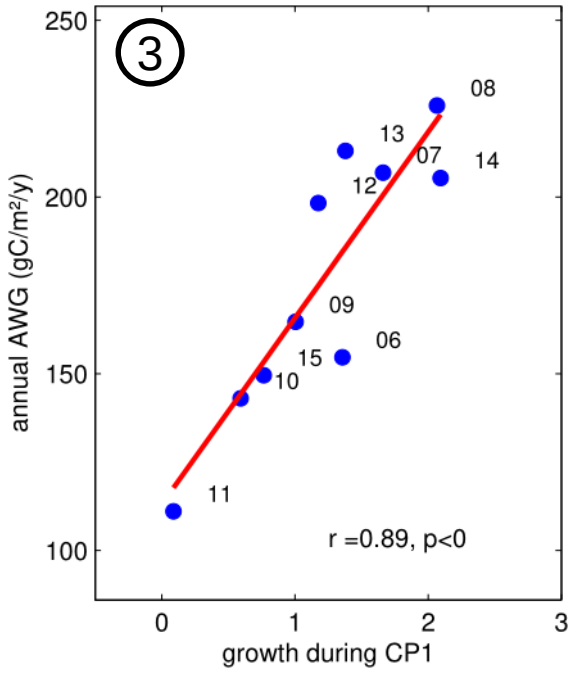


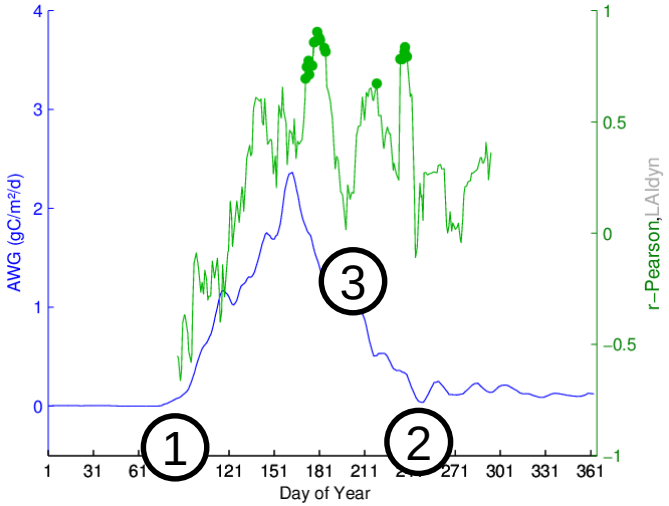
« critical periods » after Le Maire et al., 2010 *JGR*

Intrinsic determinants of wood growth









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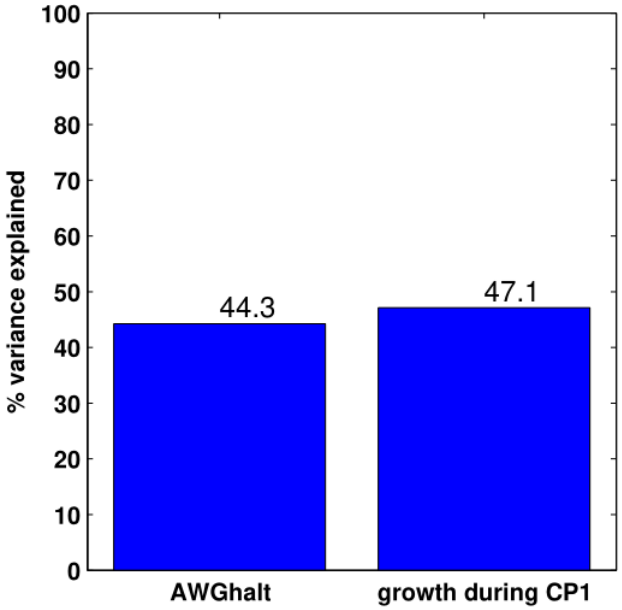
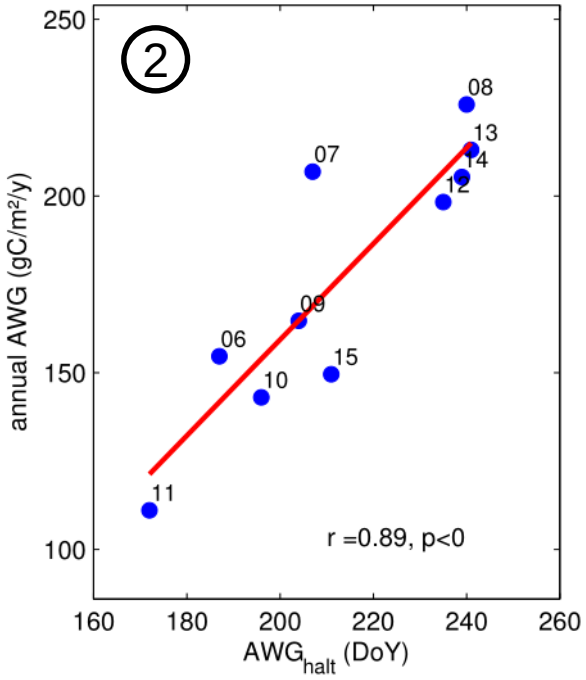
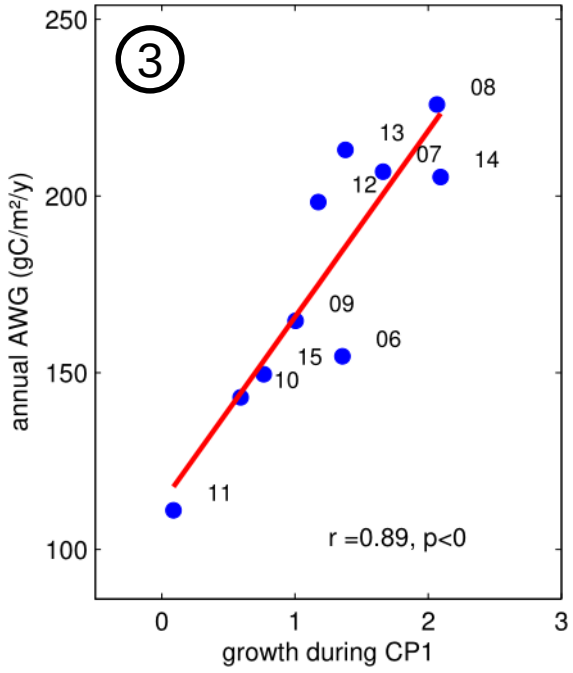
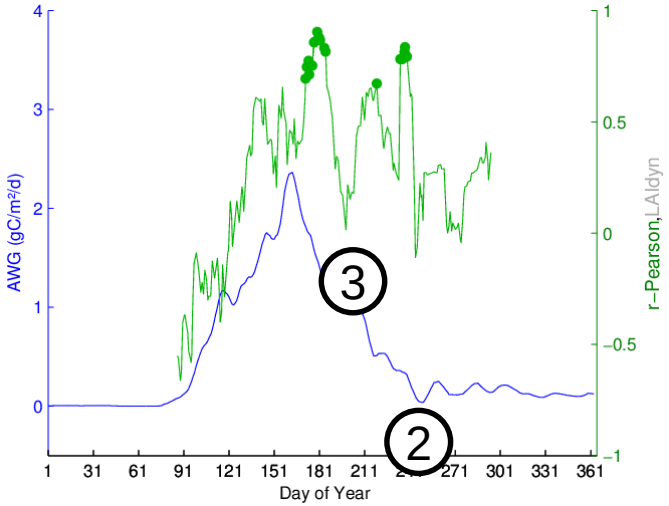


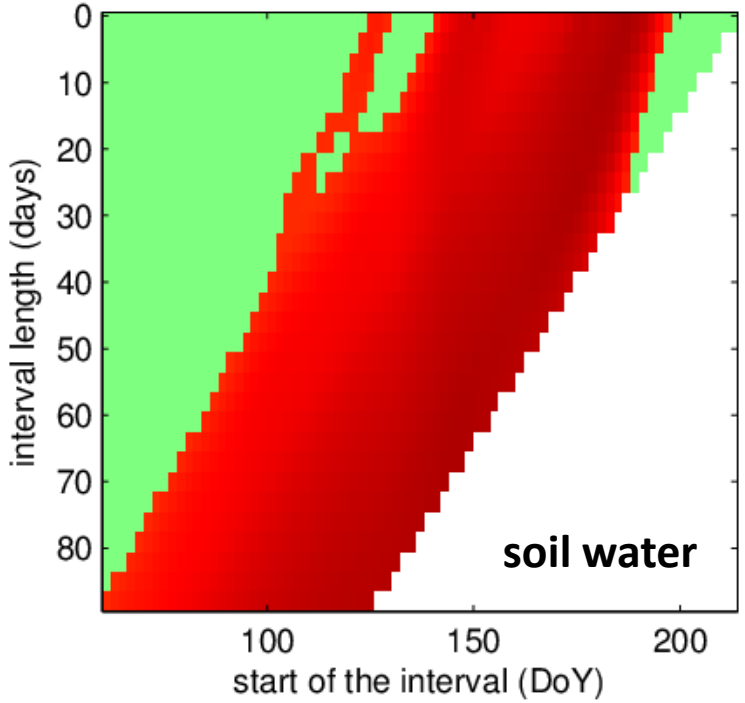
End date + growth during CP1 explain 91% of the IAV of wood growth

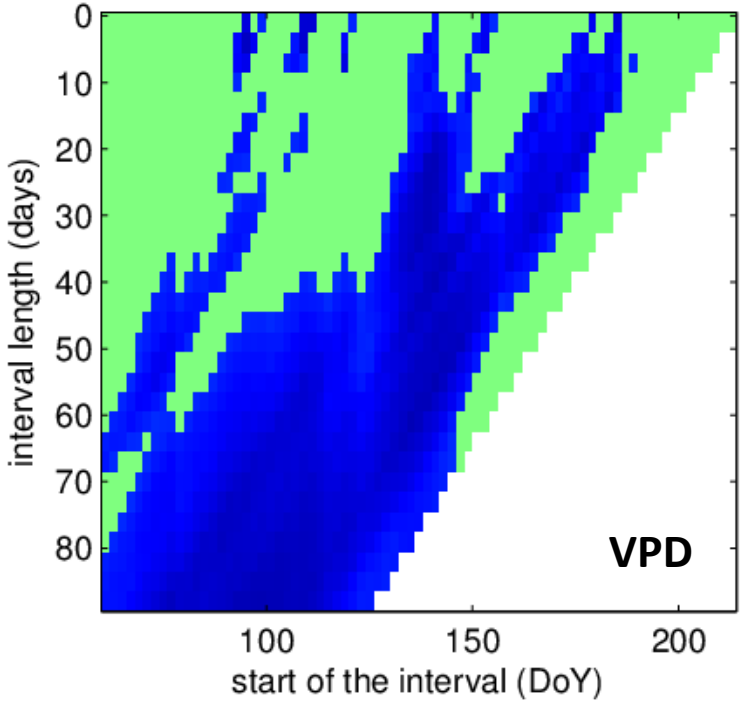


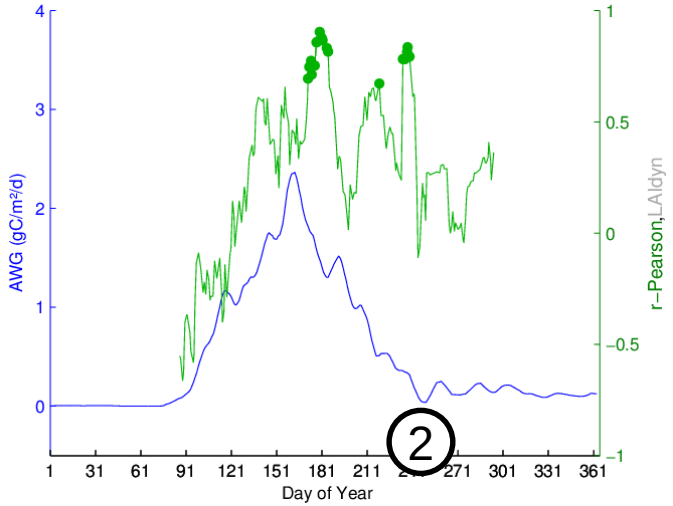




Intrinsic determinants of wood growth



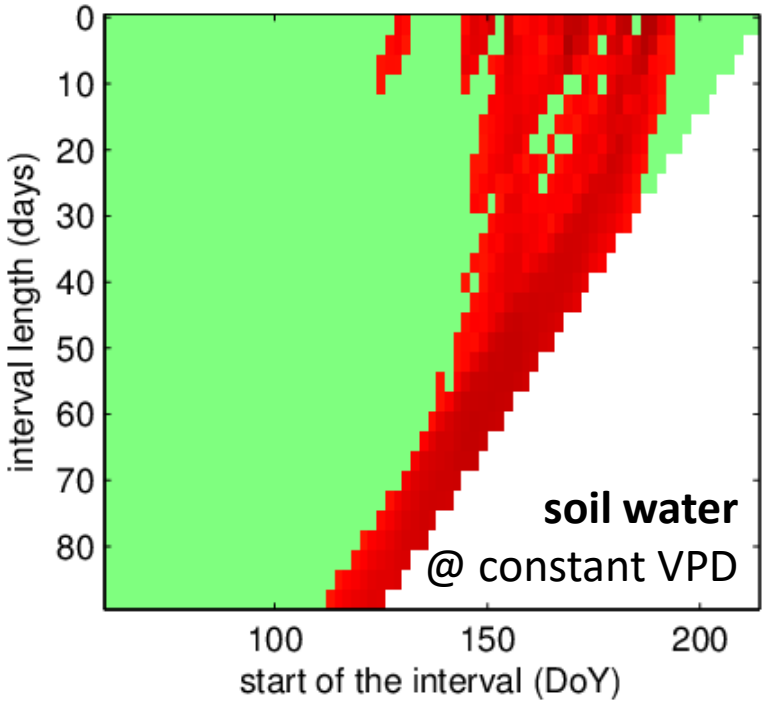


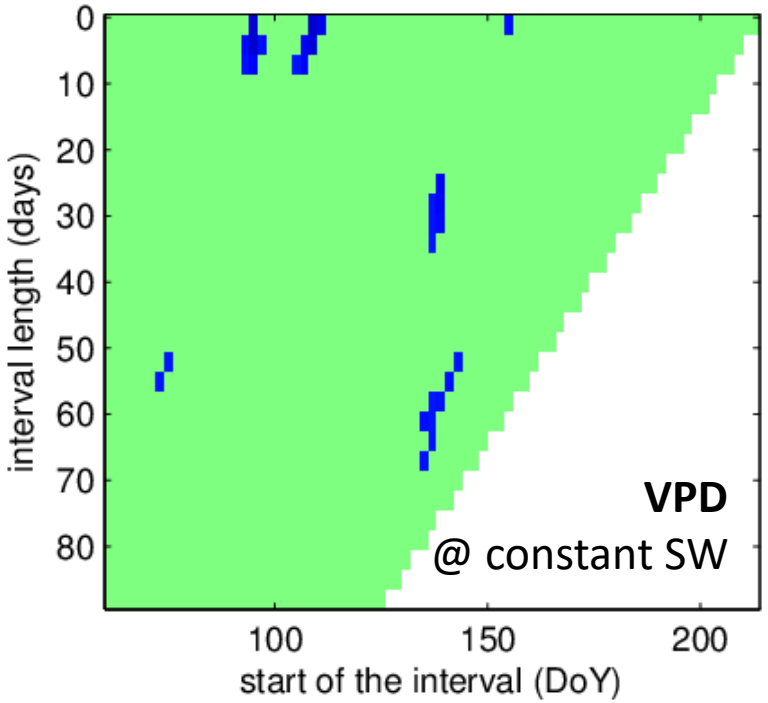


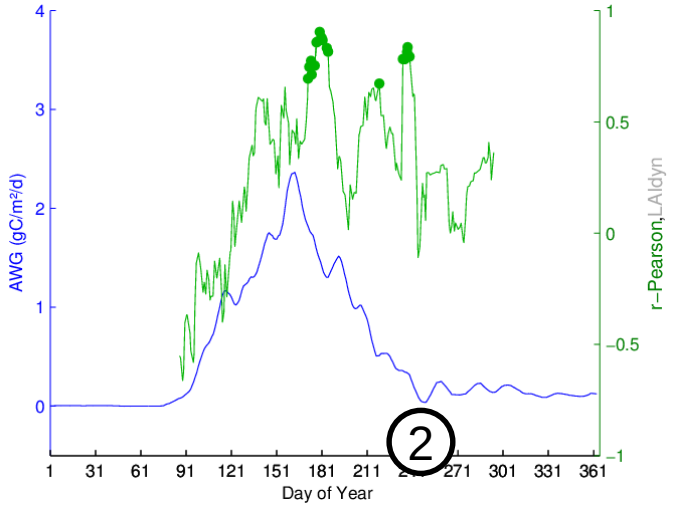
- Date of growth halt depends on SWC

See also Mund et al. (2010) Beech, Lempereur et al. (2015) Holm Oak

Intrinsic determinants of wood growth







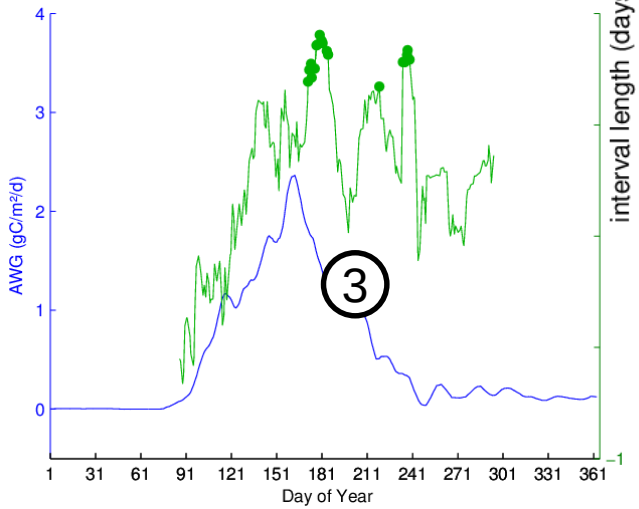
- Date of growth halt depends on SWC

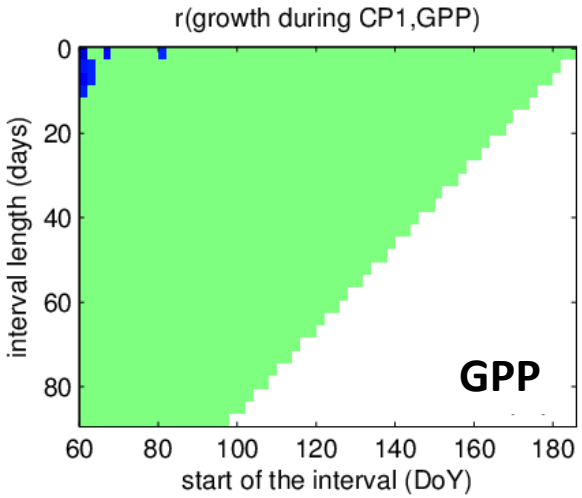
See also Mund et al. (2010) Beech, Lempereur et al. (2015) Holm Oak

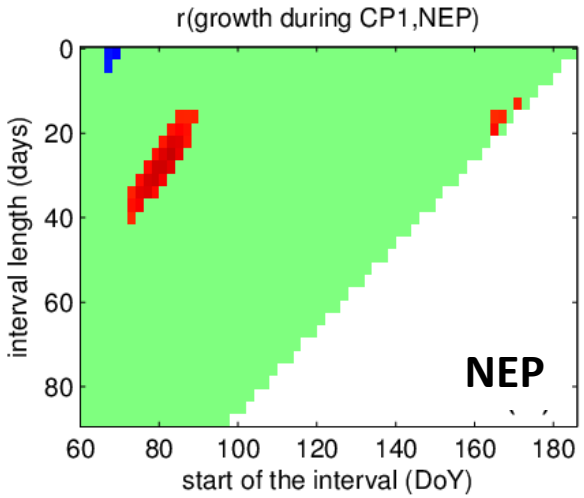
Intrinsic determinants of wood growth

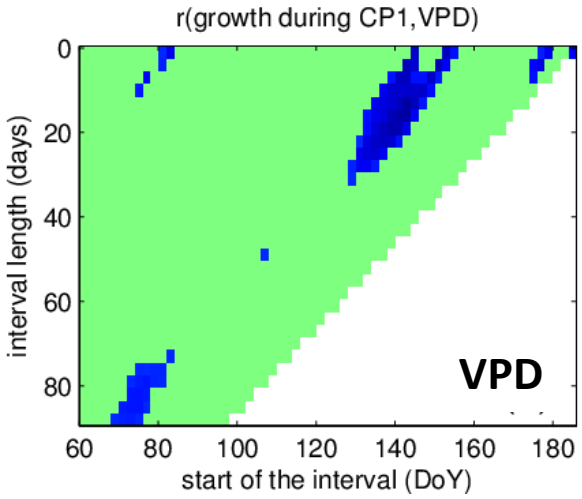
Growth during CP1

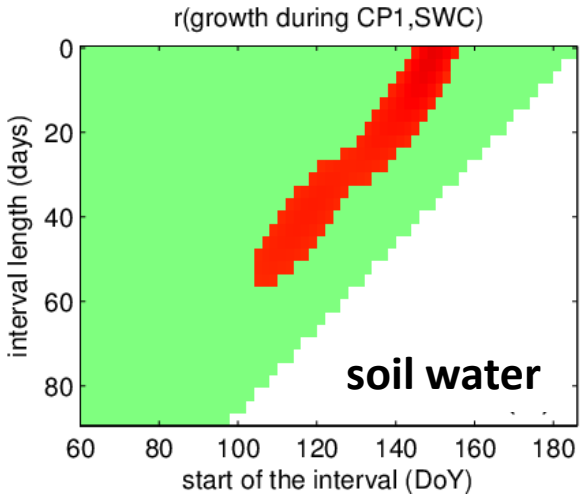
- Not strongly dependent on C fueling
- Constrained by water shortage



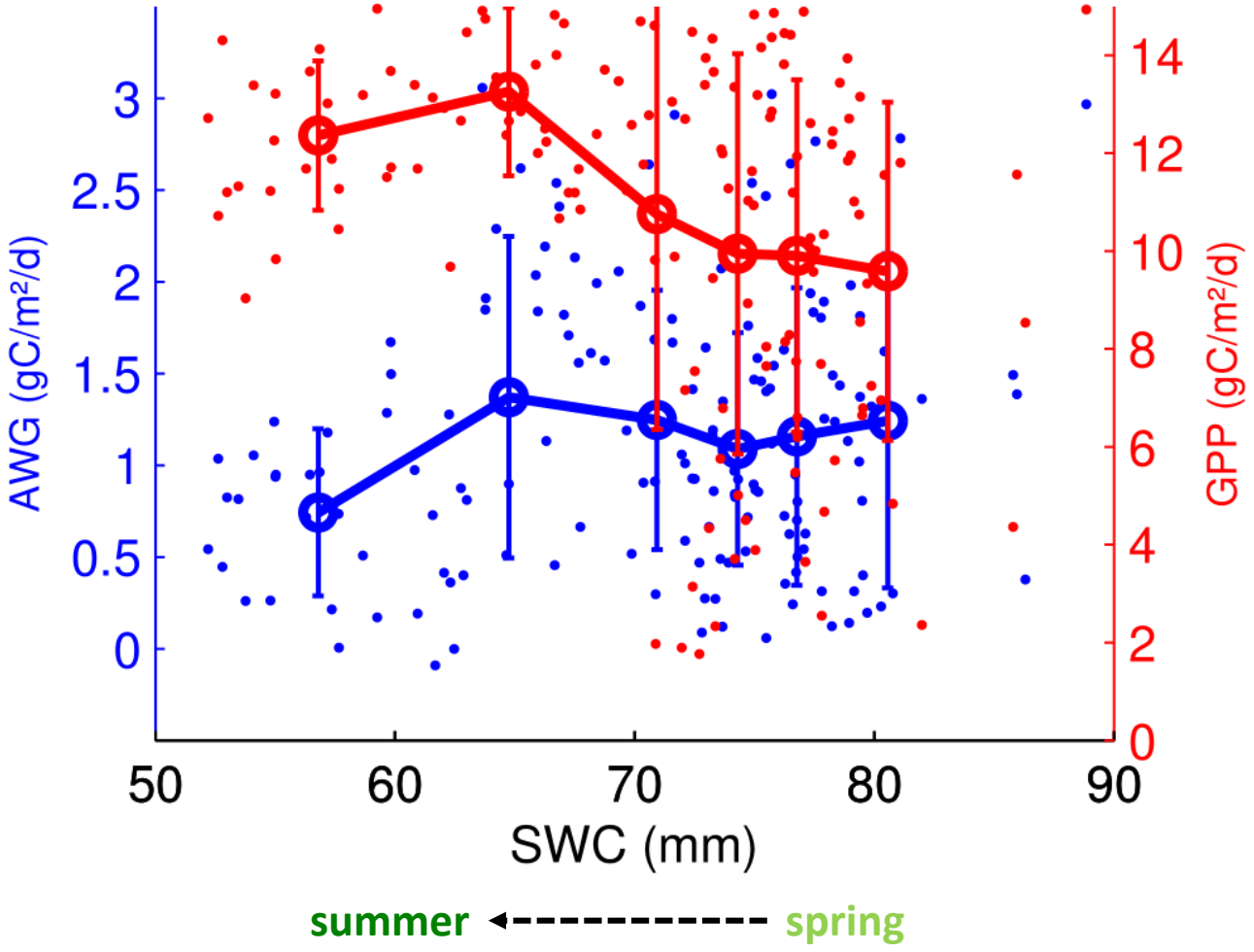








Intrinsic determinants of wood growth



Wood growth more sensitive to water shortage than GPP

(see Hsiao et al., 1976)

Conclusions

- No dependence of annual wood growth on GPP / NEP

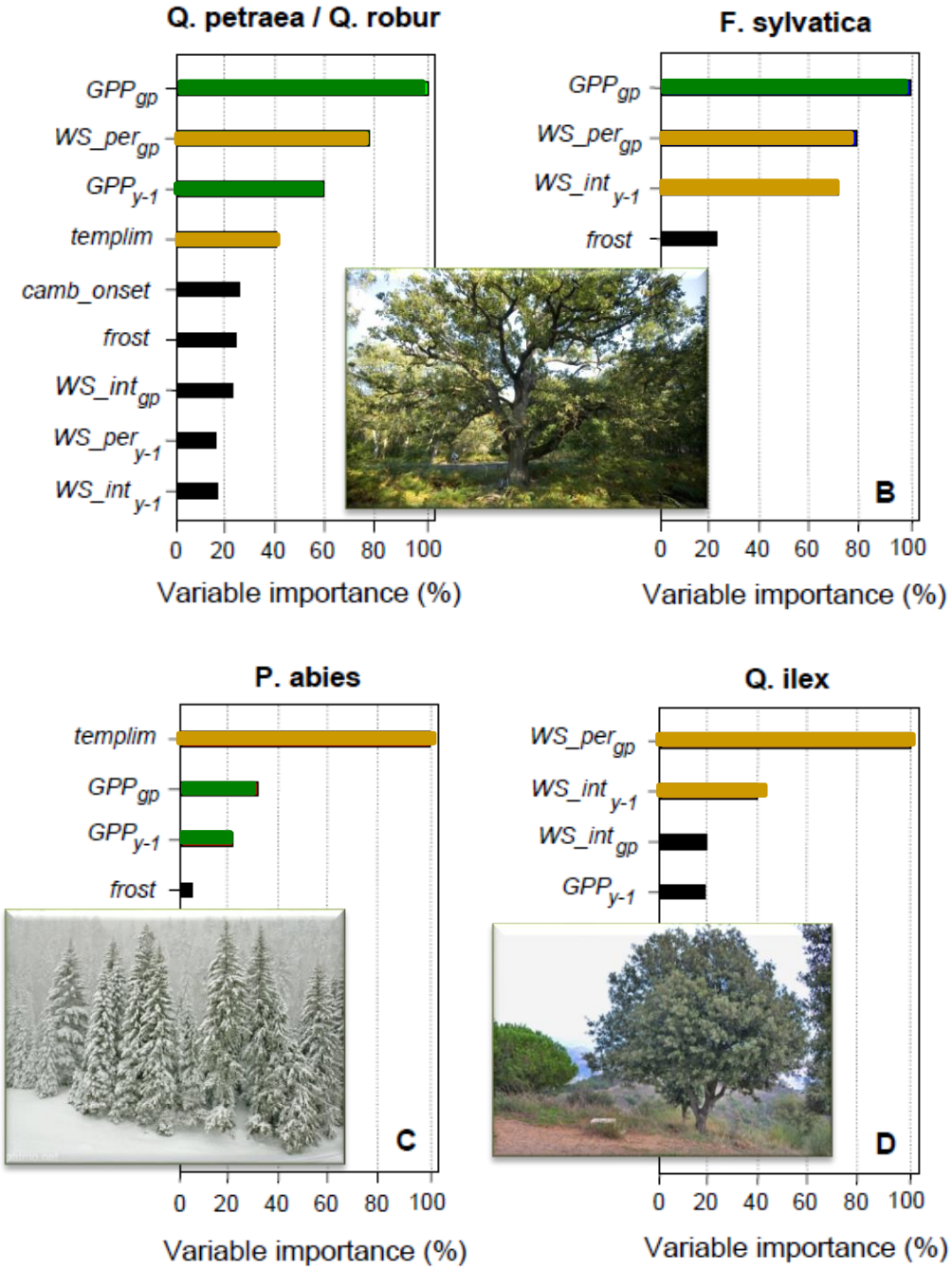
- Annual wood growth correlates with:

✓ the date of growth halt

✓ growth during a « critical period » (DoY 172-186)

- Clear dependence of wood growth on water shortage…

whilst GPP is not water-limited (mesic site)

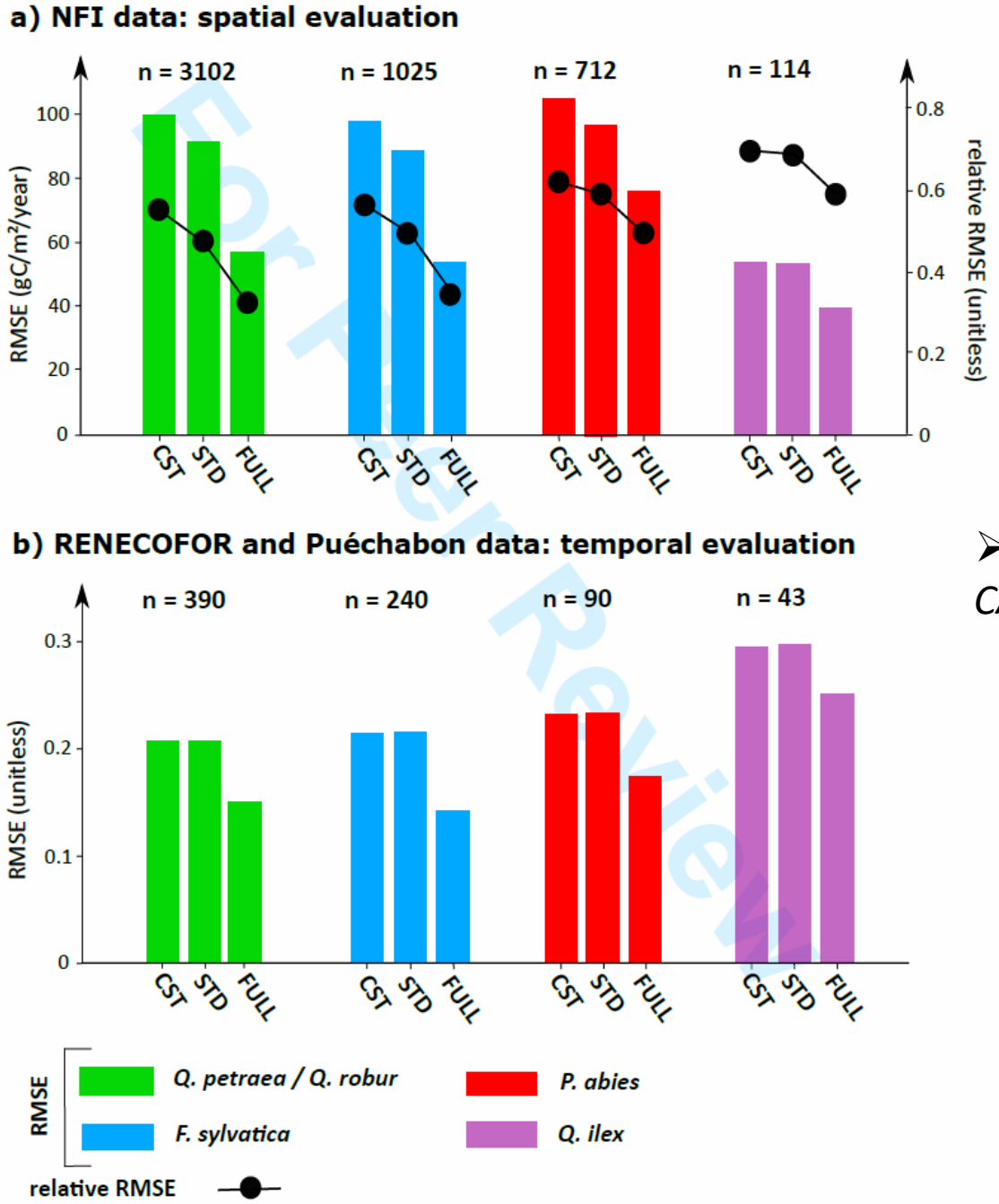


« source-limitation »

« sink-limitation »

- Analysis over 49 French forests, 941 site-years
- Source-limitation dominates in temperate conditions
- Sink-limitation dominates in montaineous / Mediterranean conditions

Guillemot et al., 2015 *Biogeosciences*



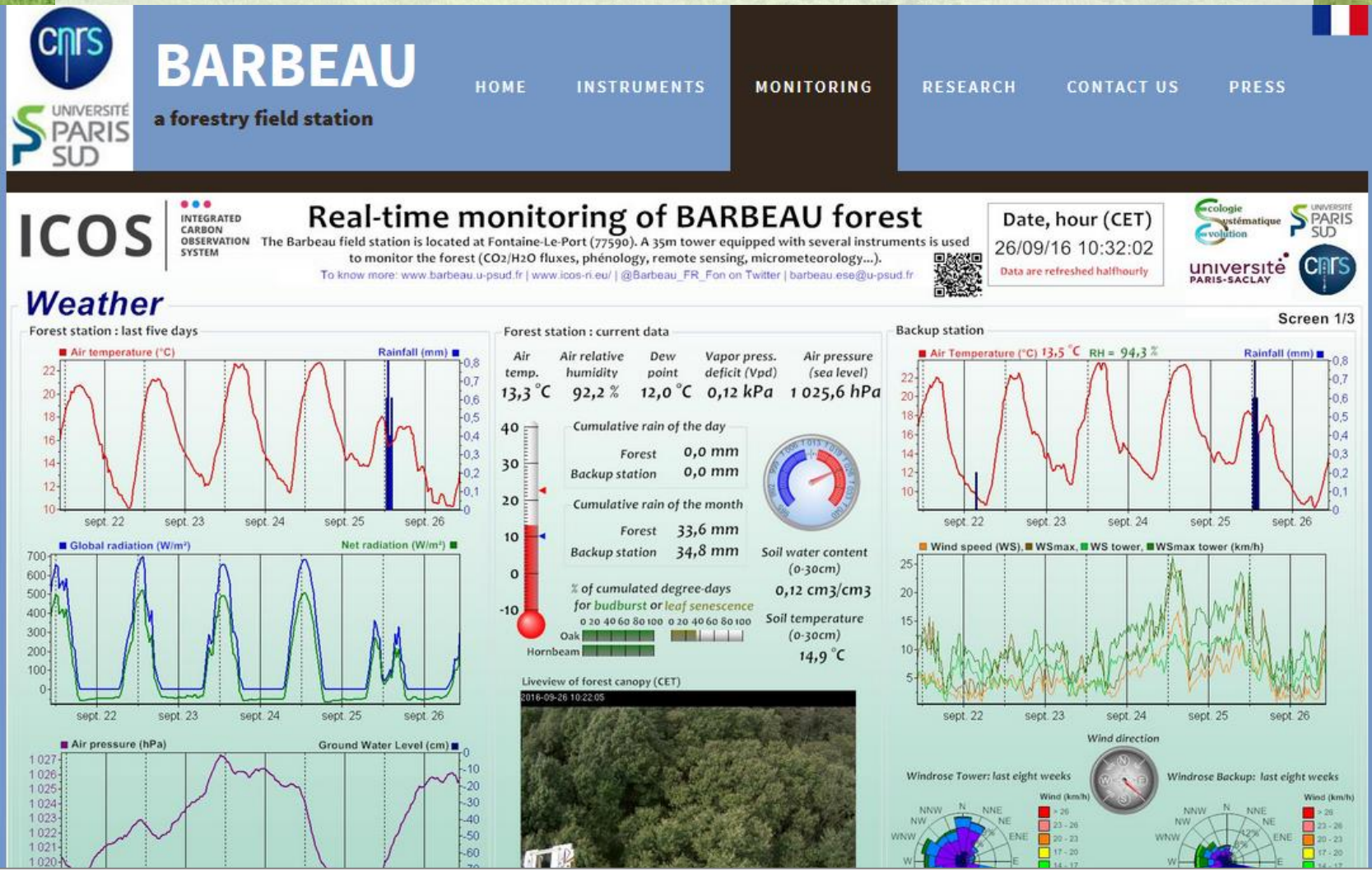
"Environmental control of carbon allocation matters for modelling forest growth"

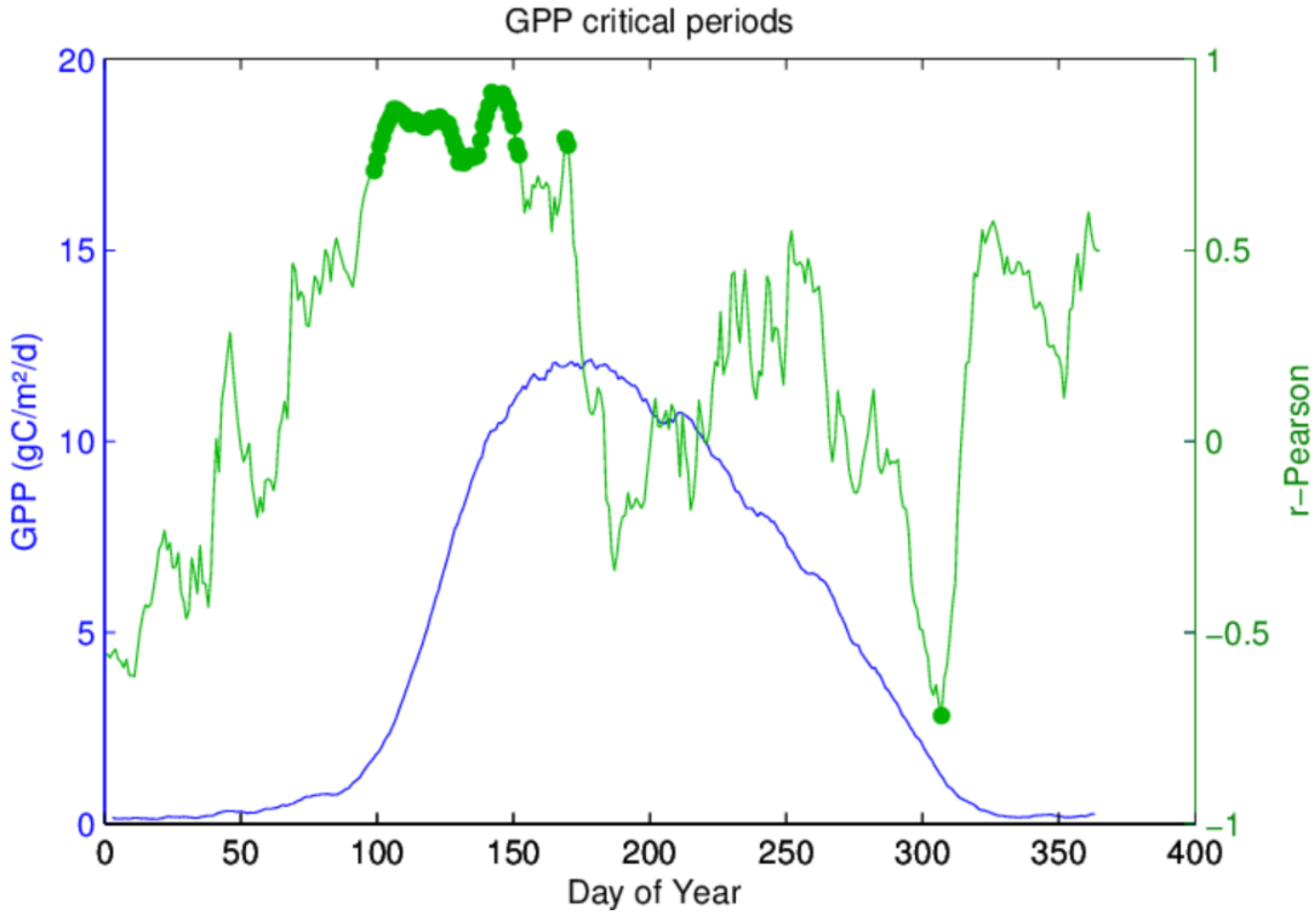
Guillemot et al., in revision, *New Phytol.*

- Incorporating sink-limitation in the *CASTANEA* process-based model reduced wood growth RMSE by 20-50%

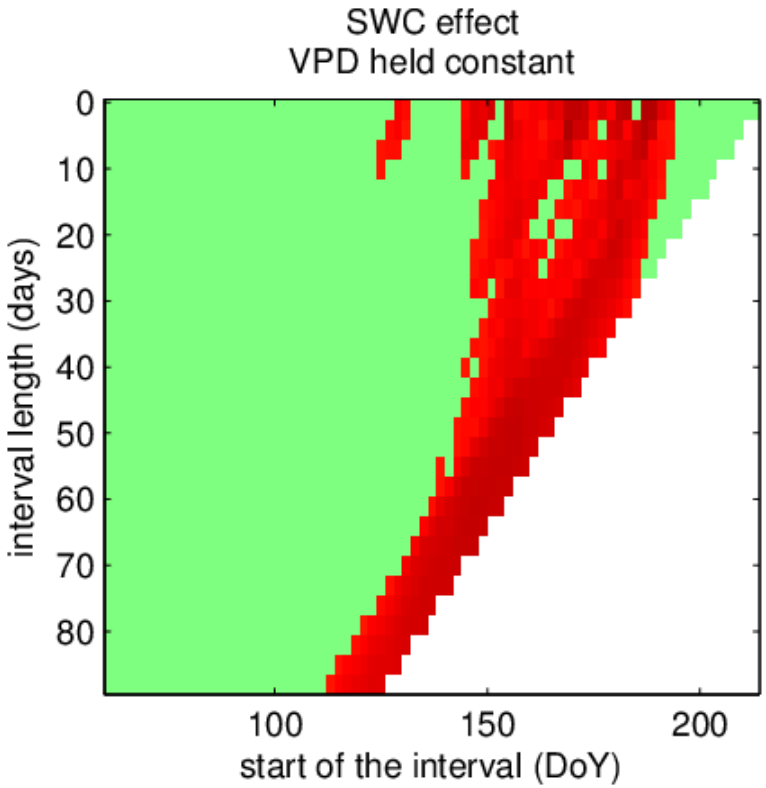
Thank you for your attention

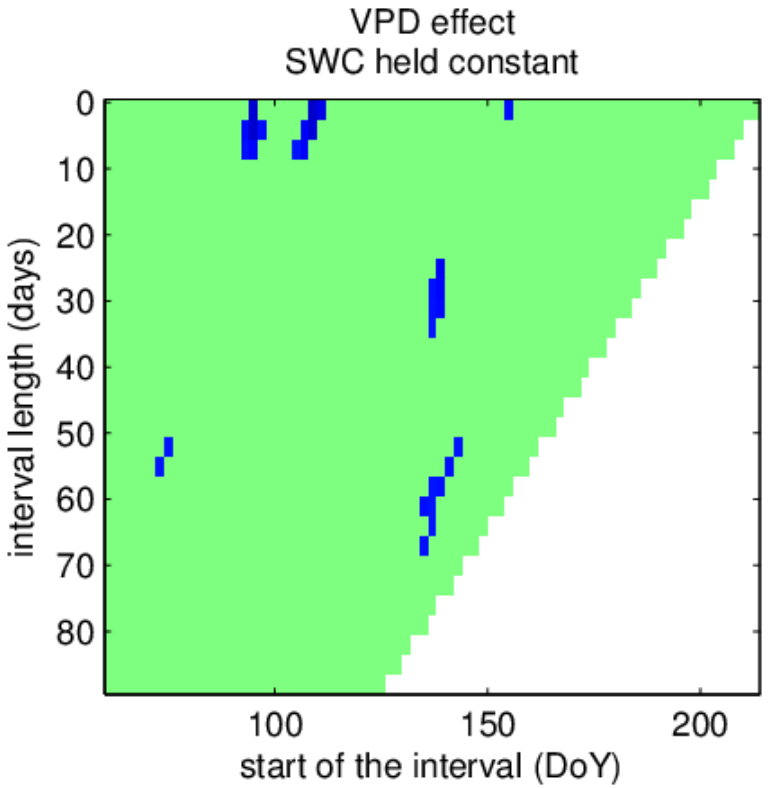
www.barbeau.u-psud.fr




GPP critical periods
GPP (gC/m²/d)
r–Pearson
Day of Year
0
5
10
15
20
0
50
100
150
200
250
300
350
400
1
0.5
0
−0.5
−1

Intrinsic determinants of wood growth





See also:

- Mund et al. (2010) : Beech
- Lempereur et al. (2015): Holm Oak

Microcoring @ FR-Fon

***WoodCap* project**

INRA-Nancy, Univ. Paris-sud, TU Dresde

Microcoring @ FR-Fon

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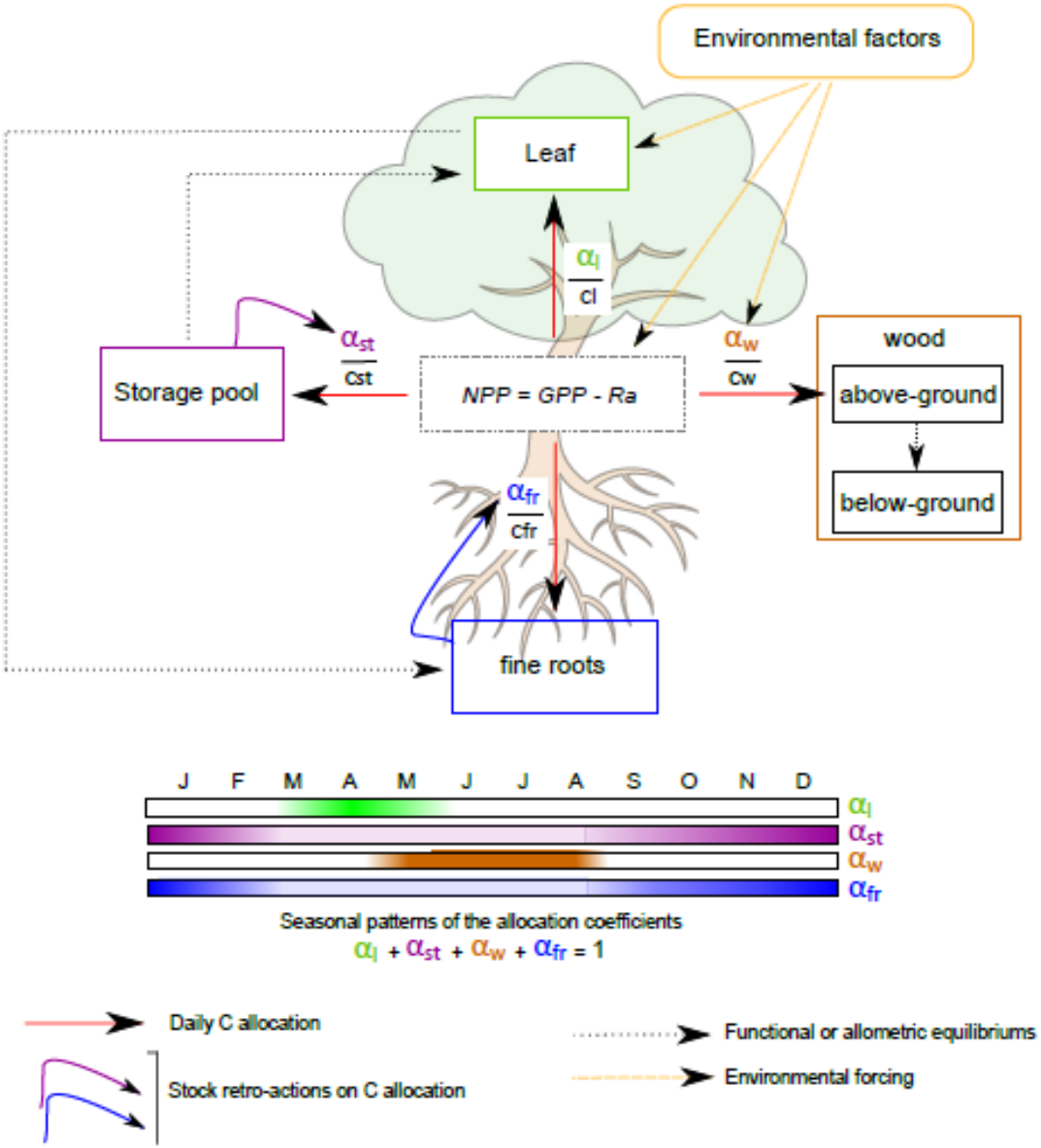

Guillemot et al., in revision, *New Phytol.*