Are dynamic vegetation models able to simulate accurately water stress: confronting δ13C predictions of the DVM CARAIB with field values?

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webinaire: « Appui à la politique agricole d'adaptation et résistance au changement climatique »
16 Décembre 2020 | 14h à 16h

Objectives

- general / summary -

- Improve the outputs of the DVM CARAIB model for wheat;
- Based on innovative traits parametrization;
- In Morocco and Belgium;

- Reveal species adaptations to climate and local conditions.

Dynamic vegetation models (DVM)

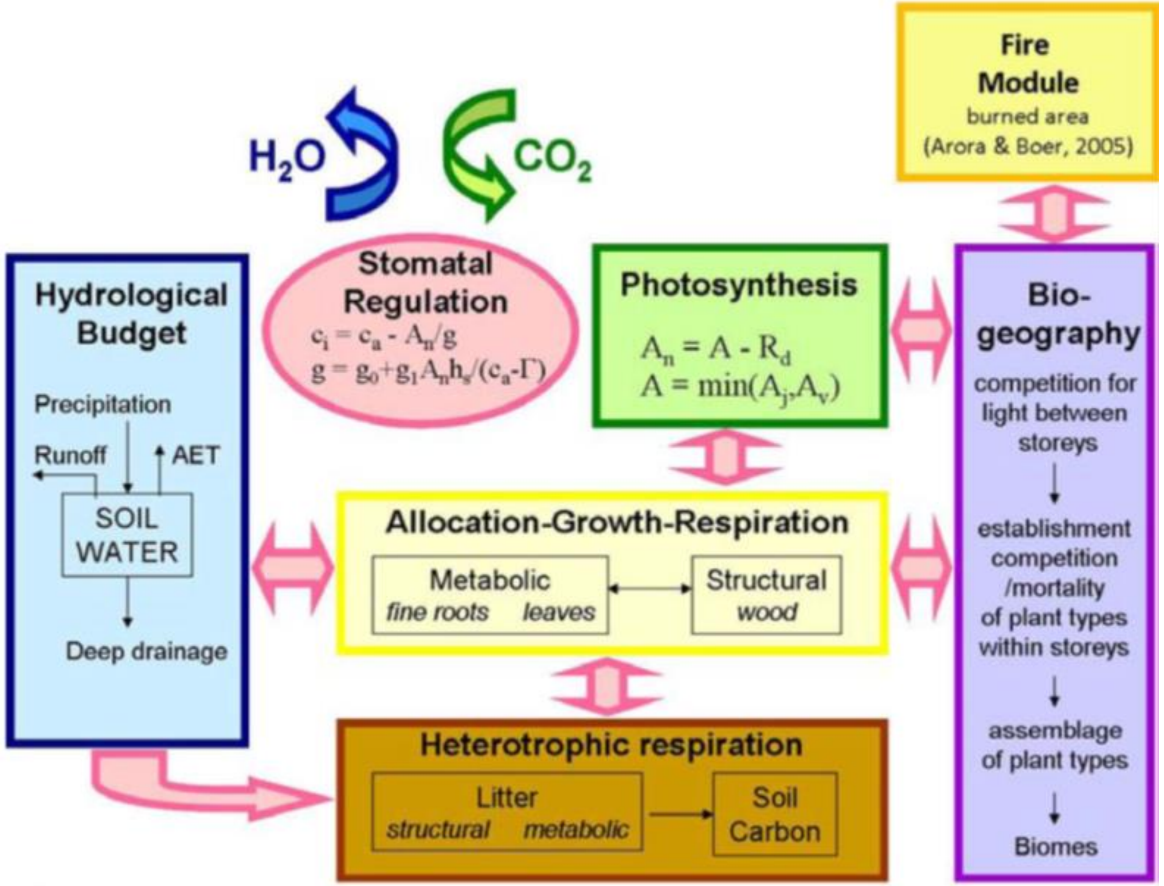
- inputs & outputs -

Inputs:

- monthly climate
- soil texture and colour
- elevation
- plant traits
- CO_2

Outputs:

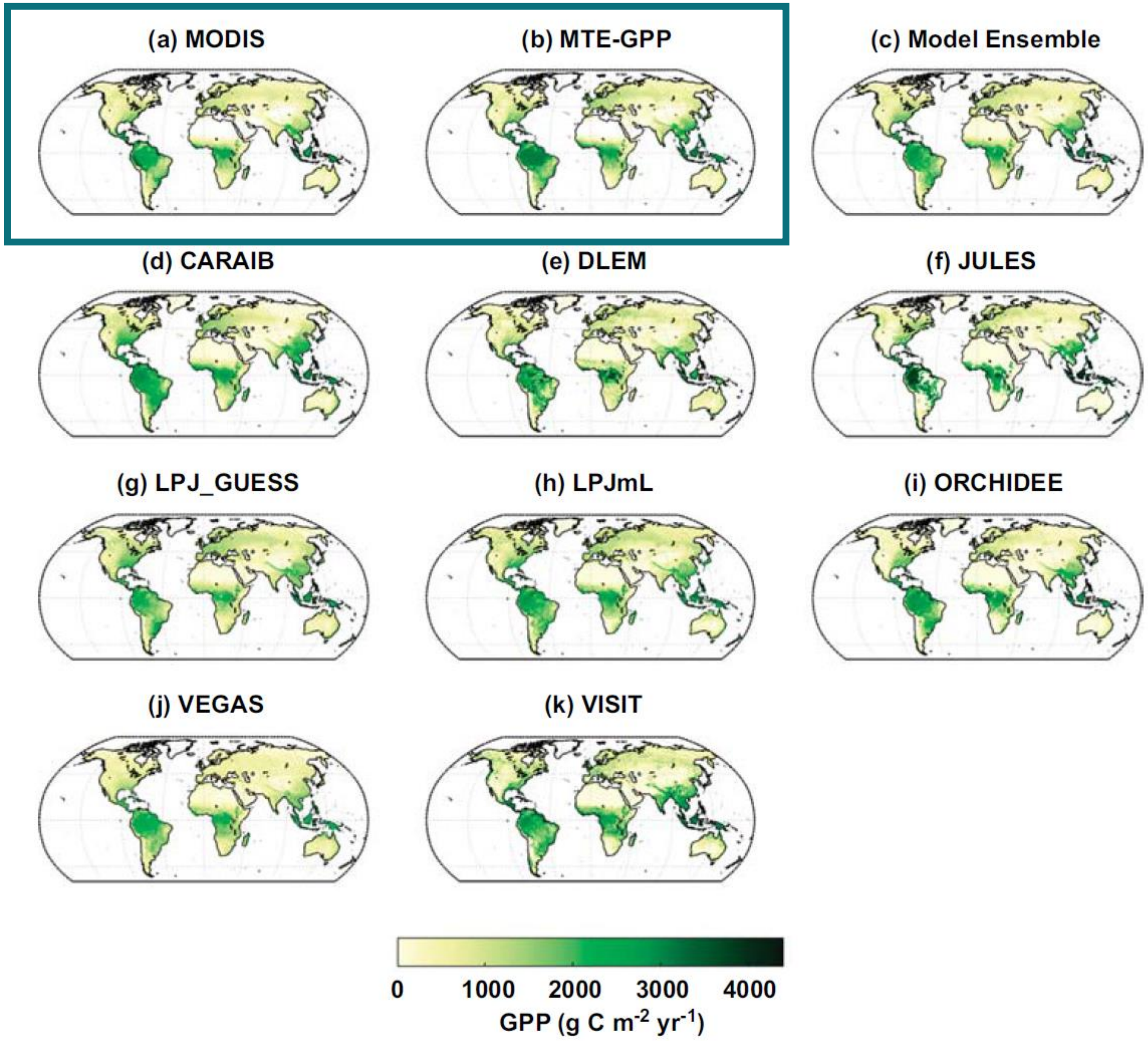
- hydrology
- net primary productivity (NPP)
- dark respiration
- soil respiration
- ~ type abundance (fraction)
- fire



CARAIB a DVM example

DVM simulations based on Plant Functional Types

- some examples -



Annual global terrestrial ecosystems gross primary production (GPP) from MODIS (2000-2010), MTE (1982-2010) and ISIMIP models (1971-2010)

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Which traits do we need ?

- to simulate more than PFT -

- *Bioclimate*: tolerance to cold and to drought, germination requirements …

- *Physiology*: respiration response to temperature, photosynthesis response to temperature, slope of stomatal conductance …

- *Structure:* max. height, specific leaf area, C/N ratios, longevity of the leaves, root depth, mortality rate…

Extracted from distribution ✓

Mean regional values or default values of PFT

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DVM simulations using Bioclimate Affinity Groups

- Lack of trait adaptation ? -

N	BAG composition
1	*Achillea, Alchemilla, Angelica, Campanula*, etc.
2	*Brassicaceae, Ranunculaceae*, etc.
3	*Anthemis, Artemisia, Bidens, Calystegia, etc.*
4	*Asteroideae, Cichorioideae, Poaceae, etc.*
5	*Anemone, Gypsophila, Helleborus, etc.*
6	*Ephedra, Ulex*
7	*Alnus viridis, Arctostaphyllos alpinus, Betula nana*, etc.
8	*Frangula alnus, Lonicera, Prunus, Rubus, Sorbus, Vaccinium, Viburnum*
9	*Berberis vulgaris, Crataegus, Genista, Rhamnus, Sambucus*, etc.
10	*Arctostaphyllos uva-ursi, Calluna vulgaris, Daphne*
11	*Buxus sempervirens, Hedera helix, Ilex aquifolium, Ligustrum vulgare, Viscum*
12	*Cistus, Myrtus communis*
13	*Betula, Salix*
14	*Alnus, Alnus glutinosa, Corylus avellana, Quercus, Quercus robur, Populus*, etc.
15	*Acer, Fraxinus, Fraxinus excelsior, Tilia cordata, Ulmus*
16	*Acer campestre, Carpinus betulus, Fagus sylvatica, Tilia platyphyllos*
17	*Castanea, Juglans, Ostrya, Quercus pubescens*
18	*Olea europaea, Pistacia, Phillyrea, Quercus ilex, Quercus suber*
19	*Larix decidua*
20	*Picea abies, Pinus, Pinus sylvestris*
21	*Abies*
22	*Cupressaceae, Juniperus, Juniperus communis*
23	*Pinus cembra*
24	*Abies alba, Taxus baccata*
25	*Cedrus, Pinus halepensis, Pinus pinaster*

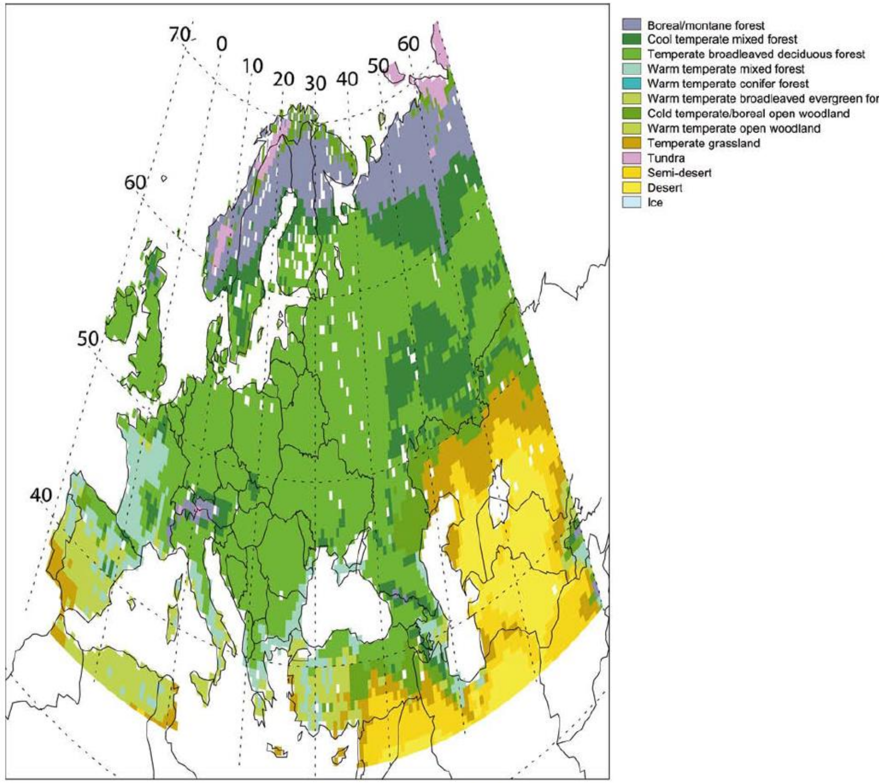
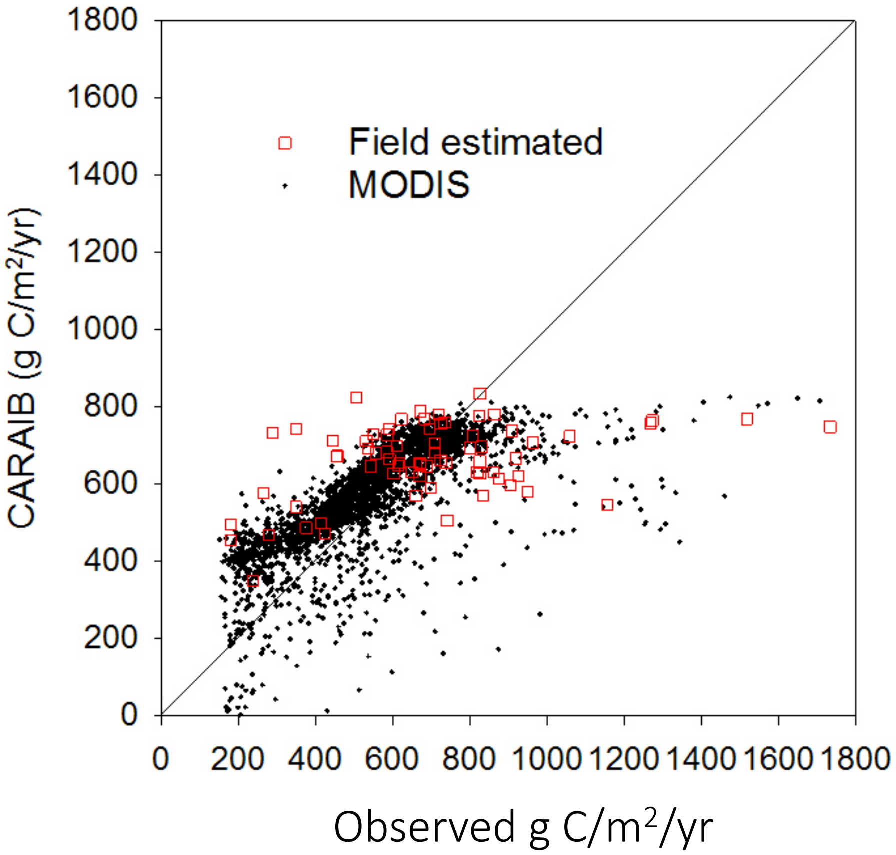


Fig. 4 - Biome distribution computed by CARAIB for the 1981-2000 period.

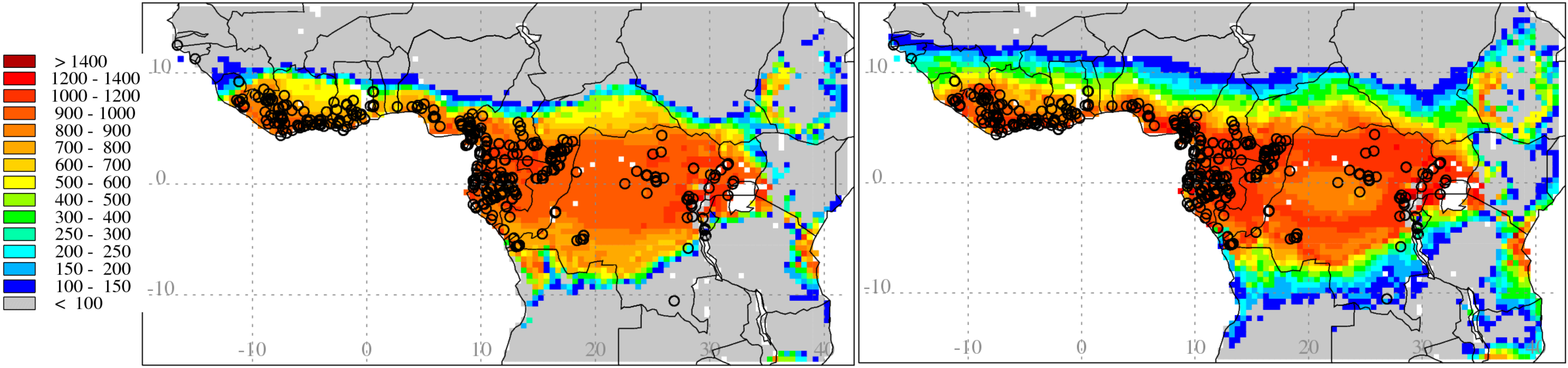


Dury M, Hambuckers A, Warnant P, Henrot A, Favre E, Ouberdous M, François L. 2010. Responses of European forest ecosystems to 21st century climate: assessing changes in interannual variability and fire intensity. *iForest* 4: 82-99

DVM to simulate a single species (1980-1999)

- Pycnanthus angolensis -

Net primary productivity (NPP, g C m^{-2} yr^{-1})



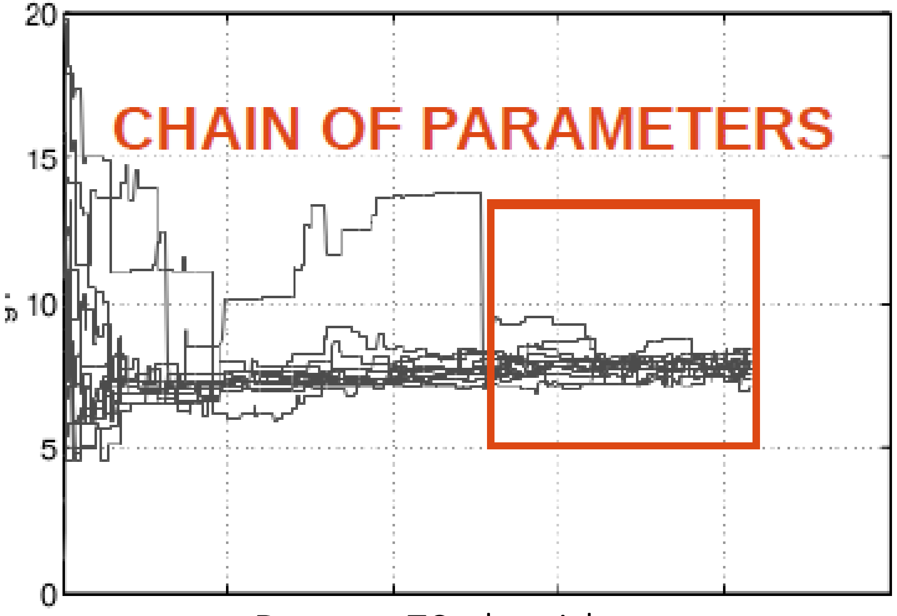
Here, adapting traits increases NPP

- Validation?
- Minimum threshold of presence?

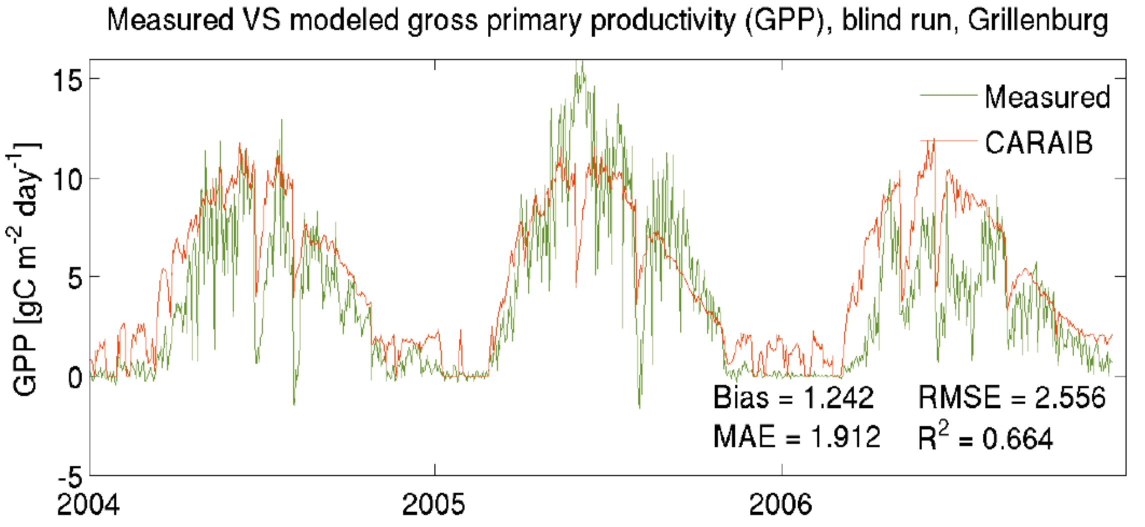
Dury, M., Mertens, L., Fayolle, A., Verbeeck, H., Hambuckers, A., François, L., 2018. Refining species traits in a dynamic vegetation model to project the impacts of climate change on tropical trees in Central Africa. Forests 9.

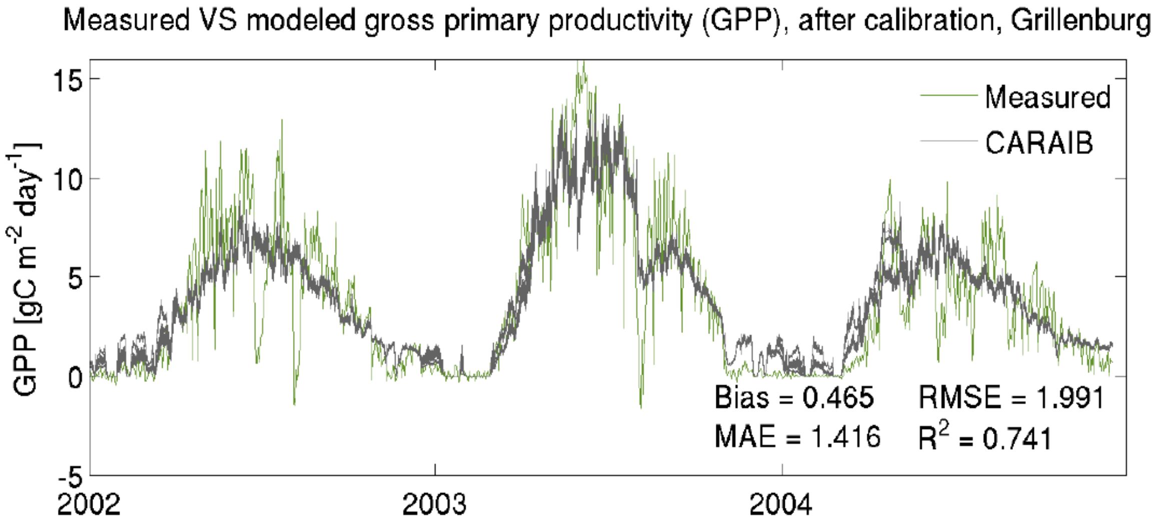
DVM to simulate an ensemble of grassland plants

Eddy covariance grassland site:
<u>Availability of productivity</u>



Dream_ZS algorithm
Monte-Carlo chain sampling of traits





Minet J, Laloy E, Tychon B, François L. 2010. Bayesian inversions of a dynamic vegetation model at four European grassland sites. Biogeosciences, 12(9), 2809-2829.

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¡ Variations of the traits

- Between species and species type (climate, altitude, irradiance, site fertility…)

	Min	Max	Species	Examples
Sapwood N (%)	0.04	0.59	59	Martin et al. 2014, New Phytol., 204, 484-495
SLA (10^{-3} sq. m / g)	10	32	10	Verbeeck, et al. 2014 J. Trop. For. Sci. 26, 409-419.
Leaf N (%)	0.85	2.67	10	Luo, T., Luo, J., Pan, Y., 2005. Oecologia 142, 261-273.

- **Within species** (climate, altitude, irradiance, site fertility…)

  in Poorter et al (2018, New Phytol. doi: 10.1111/nph.15206) , 1300 individuals of 383 Amazonian species : 56 % of variation between species, 44 % within species (~acclimation)

- **Inside individuals** (light, age, height, season …)

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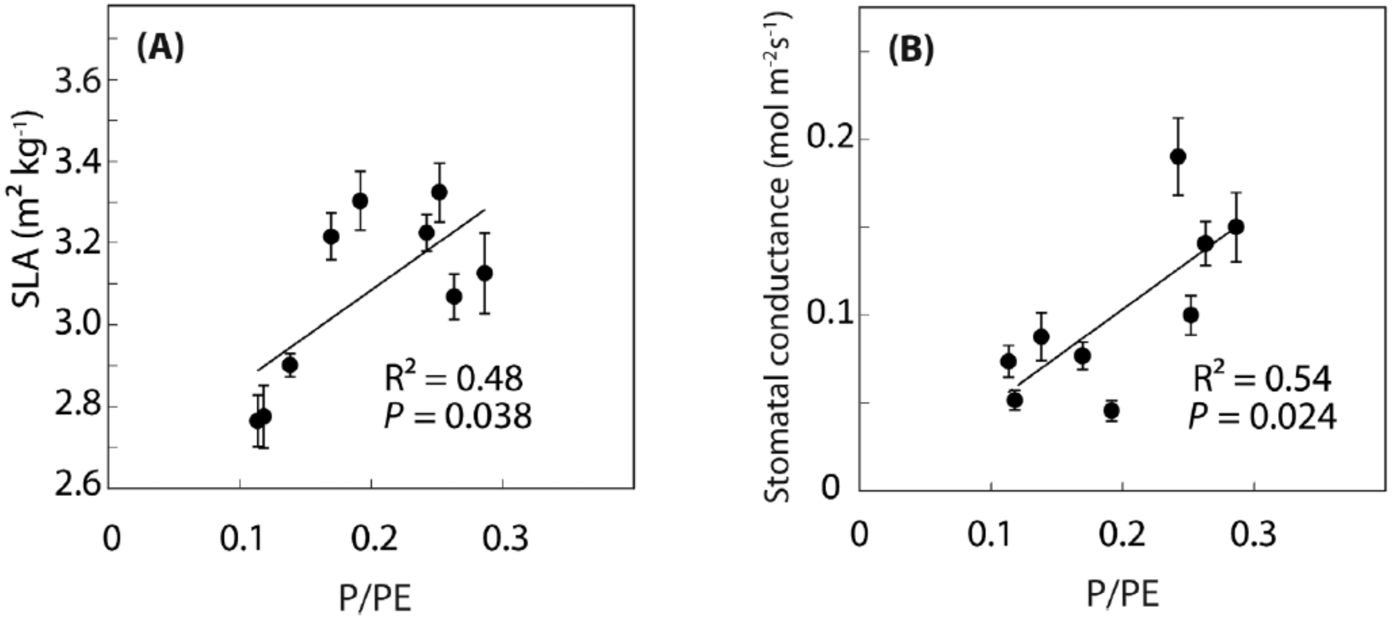
- Relationships with environmental factors

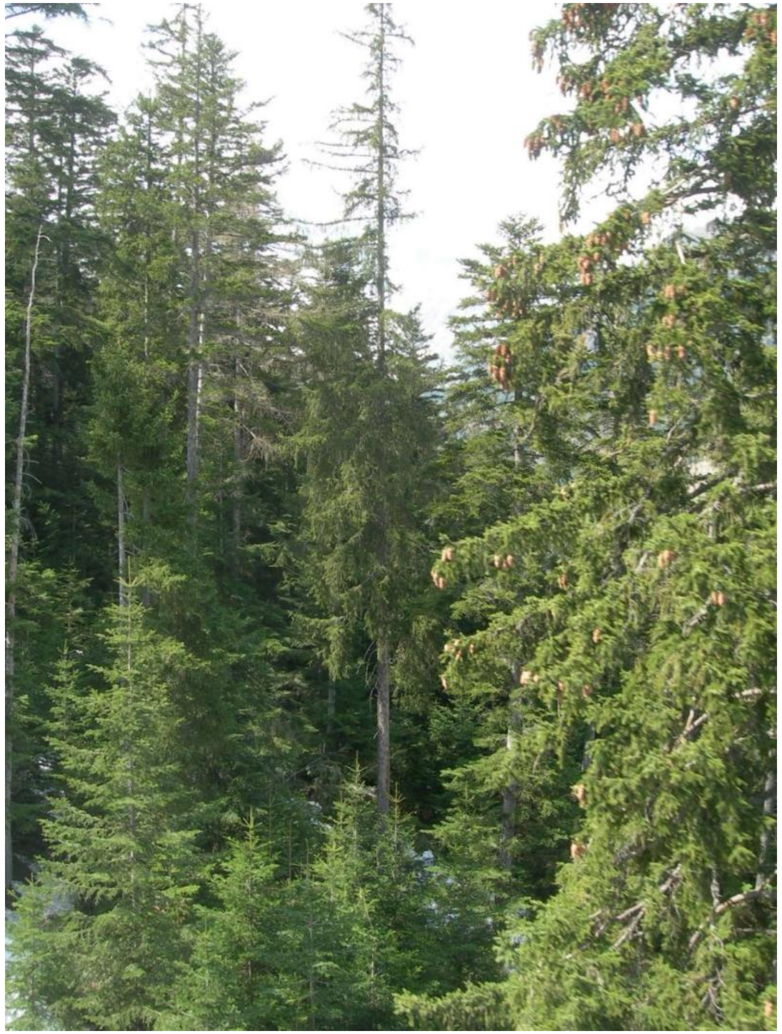


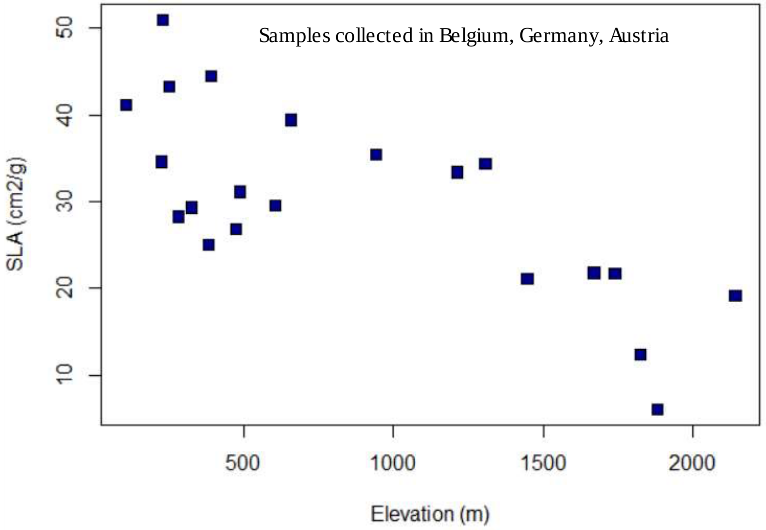
P/PE = Precipitation/Pan evoporation

Eucalyptus loxophleba ssp. *lissophloia*

Steane, D.A., McLean, E.H., Potts, B.M., Prober, S.M., Stock, W.D., Stylianou, V.M., Vaillancourt, R.E., Byrne, M., 2017. Evidence for adaptation and acclimation in a widespread eucalypt of semi-arid Australia. Biological Journal of the Linnean Society 121, 484-500.

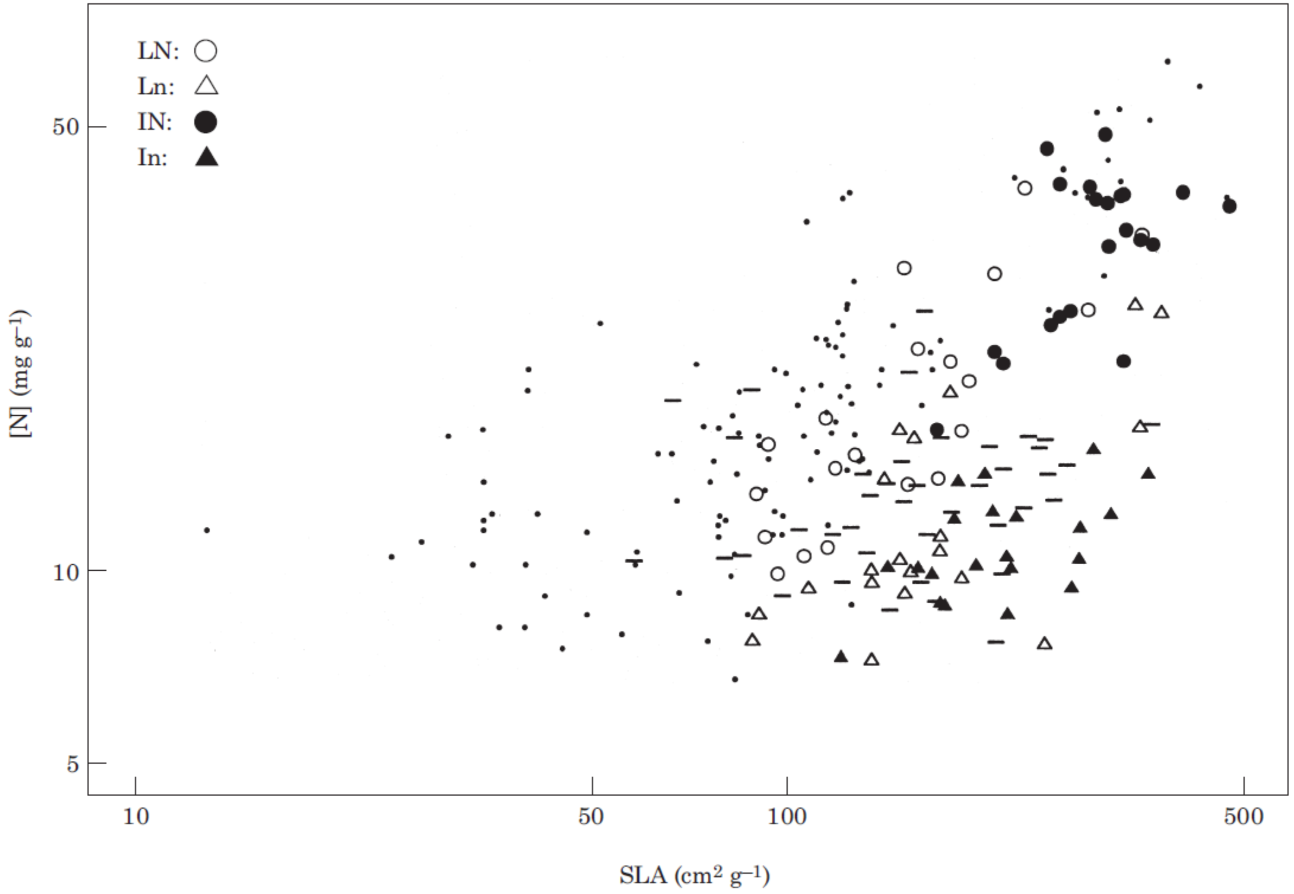
iii Variations of the traits





Specific leaf area data *for Picea abies*, collected by Alain Hambuckers

- Correlation between traits



22 herbaceous species

Species' means foliar nitrogen content vs. specific leaf area in each of the four treatment groups.
Also shown are data from Reich et al. (1999) (+) and from Shipley and Lechowicz (2000) (-)

Meziane, D., Shipley, B., 2001. Direct and indirect relationships between specific leaf area, leaf nitrogen and leaf gas exchange. Effects of irradiance and nutrient supply. Ann.Bot. 88, 915-927.

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Objectives

- to be detailed & discussed -

Evaluation of the importance of plant traits to improve prediction accuracy at tree species level with the DVM CARAIB

- SLA
- leaf C:N
- sapwood C:N

- Temporal evaluation: throughout the growing season
- Spatial evaluation: Morocco & Belgium

Methods

- ~ n sites, in Morocco & Belgium
- Biomass and growth: height, C/N, biomass, yield
- Biomass and production of leaves: LAI(hemispherical pictures), leaf longevity, SLA, C/N
- Comparison of CARAIB simulations with these productivity estimates
- Correlations between traits and climatic variables for further modelling developments (dynamic trait approach)

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Thank you !