Are dynamic vegetation models able to simulate accurately water stress: confronting δ13C predictions of the DVM CARAIB with field values?
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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
- CO₂

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)
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...
DVM simulations using Bioclimate Affinity Groups

- Lack of trait adaptation?


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**BAG composition**

1. Achillea, Achillea, Angelica, Campanula, etc.
2. Brassicaceae, Ranunculaceae, etc.
3. Anemone, Anemone, Bidens, Calystegia, etc.
4. Asteroideae, Cichorieae, Poaceae, etc.
5. Anserinae, Gypsophila, Helichrysum, etc.
6. Ephedra, Ulex
7. Alnus viridis, Arcostaphylois alpinus, Betula nana, etc.
8. Prunus abrus, Lonicera, Prunus, Rubus, Sorbus, Viscum, Vibernum
9. Berberis vulgaris, Crataegus, Genista, Rhamnus, Sambucus, etc.
10. Arctostaphylos 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 prinus
18. Olea europea, Pistacia, Philyrem, 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
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?

DVM to simulate an ensemble of grassland plants

Eddy covariance grassland site: Availability of productivity

**CHAIN OF PARAMETERS**

Dream_ZS algorithm
Monte-Carlo chain sampling of traits

Variations of the traits

- **Between species and species type** (climate, altitude, irradiance, site fertility...)
  - Between species and species type
  - Within species
  - Inside individuals

<table>
<thead>
<tr>
<th>Trait</th>
<th>Min</th>
<th>Max</th>
<th>Species</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sapwood N (%)</td>
<td>0.04</td>
<td>0.59</td>
<td>59</td>
<td>Martin et al. 2014, New Phytol., 204, 484-495</td>
</tr>
</tbody>
</table>

- **Within species** (climate, altitude, irradiance, site fertility...)
  - 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 ...)
Variations of the traits

- Relationships with environmental factors

\[ \frac{P}{PE} = \frac{\text{Precipitation}}{\text{Pan evaporation}} \]

\[ R^2 = 0.48, \quad P = 0.038 \]

\[ R^2 = 0.54, \quad P = 0.024 \]

Variations of the traits

Specific leaf area data for *Picea abies*, collected by Alain Hambuckers.
Variations of the traits

- Correlation between traits

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) (-)

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
• ~ 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)
Thank you!