Directly using plant traits to make global vegetation models more robust

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Introduction

- Dynamic global vegetation models (DGVMs) are central, but uncertain, in earth system models
- A firm ecological basis in DGVMs is needed
- Using Plant Functional Types (PFTs) as a basis (as in DGVMs) may hamper improvement
- Disadvantages of PFTs: i) mismatch discrete classes vs. continuous system's responses (Fig. 1), invariable attributes upon climate change and iii) strong effects on environment on traits

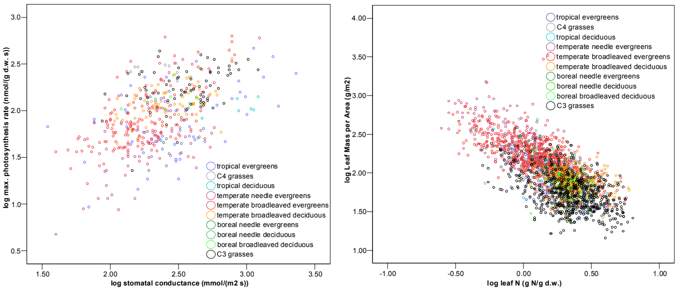

Fig. 1.: Relationships among some traits central in various DVGMs under influence of a plant functional type (PFT) classification. In this case, a PFT classification as used in LPJ has been applied, but other DGVMs have similar classifications. Important to note is the strong overlap in plant trait occurrences for several PFTs, indicating that ecosystem functioning (as affected by the traits depicted) does not differentiate among PFTs.

Aim

Testing the feasibility of developing a radical new design of DGVMs by making traits and trait modifications due to soil, hydrology and climate central

To maximize flexibility and differentiating power, there are two independent parts (Fig. 2): 1) model on the interactions between traits and environment, 2) Mixture density fitting to link traits to vegetation classifications

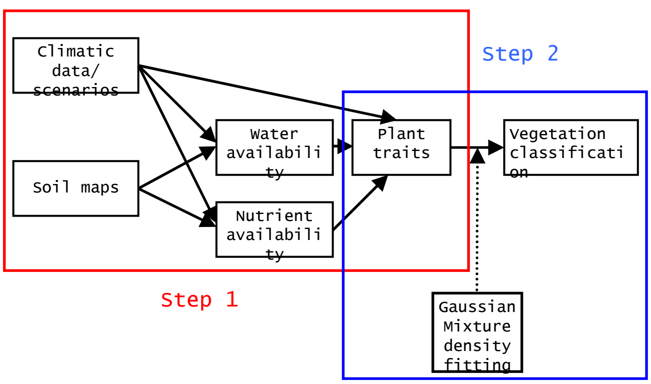

Fig. 2.: Our approach to tackle the difficulties inherent to developing a trait-based DGVM by explicitly separating ecosystems functioning (step 1) from the various possibilities to translate plant attributes into discrete classifications of vegetation or ecosystems (step 2). This allows us to focus on explaining variance in ecosystem properties affecting earth systems models without having to deal with interfering factors.

Results

- A conceptual model with the anticipated relationships between traits and environment has been developed (Fig. 3)
- Trait- environment relations have been quantified based on physiological theory and by meta-analysis of global databases (for relations not available in scientific literature; Fig. 4).
- Gaussian mixture density fitting has been proven to work in predicting vegetation (Fig. 5)

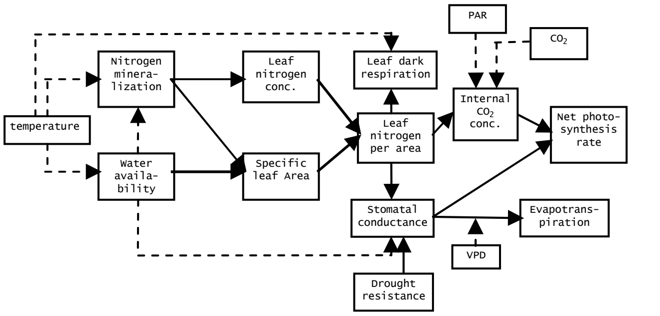

Fig. 3.: Conceptual model of trait-environment relationships based on mechanistic information. Note that this model explicitly accounts for carbon-nitrogen interactions, presently neglected in many DGVMs. Also note that photosynthesis is treated as in Katul et al. 2003, rather than as in Farquahar et al. 1980, although the latter is also possible.

Future perspectives

Next steps include: i) Incorporating and testing the conceptual model in code, ii) applying GMD to PFTs using traits and climate and iii) comparing its performance with existing DGVMs.

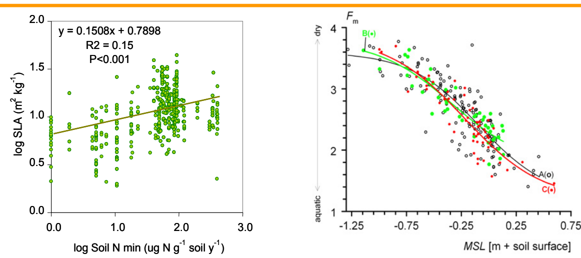

Fig. 4.: Environment-trait relationships derived from global databases. A) Quantification of the shift of traits characteristic of slow growth and resource conservation (e.g. low Specific Leaf Area; SLA) towards fast growth as soil nutrient availability (e.g. N mineralisation rate) increases (Ordoñez et al., submitted). B) Relationship between groundwater levels and indicator values for water (F_m) (Bartholomeus et al., submitted)

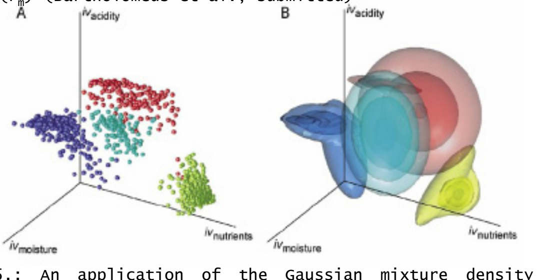

Fig. 5.: An application of the Gaussian mixture density (GMD) fitting procedure. A) Three dimensional scatter plot of A) observed relevés of 4 vegetation associations in the Netherlands and B) their corresponding GMD fits plotted in relation to their average indicator values. The figure presents isosurfaces of the probability density functions, obtained by plotting the values of 0.002, 0.02, 0.1 and 0.5 of the global maximum (Witte et al. 2007: J. Veg. Sci. 18: 605-612).

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