Improving understanding of wood formation: A comparison of two models

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Background

- Wood formation is critical for long-term sequestration of atmospheric CO_2
- Global vegetation models need to incorporate wood formation
- Here we examine whether two of the existing approaches are sufficient: Deleuze et Houllier (1998) and Vaganov et al., 2006
- We test the models using observations from Grandfontaine, France in P. sylvestris to assess their usefulness to forecast global wood formation (= carbon storage) responses in the future.

Study site Grandfontaine, France.

Conclusions

- VS: More biological resolution of processes
- DH: Carbon dynamics better resolved
- Both struggle to replicate intra annual dynamics (VS) and intra-ring density (DH), important for modeling wood formation dynamics in the future
- Model code and data should be made available with publications for better model-comparison studies

Methods

- code up models from the literature
- run them under the same conditions (= same site)
- compare model outputs against each other and available observations (table 1)

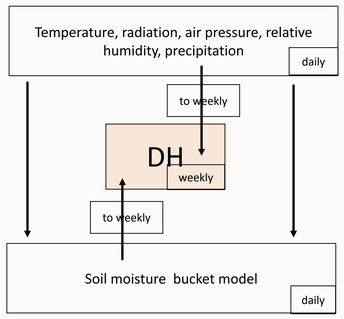
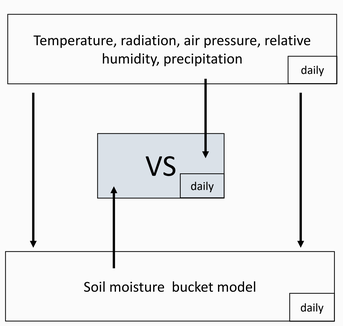


Table 1: Observations against which the two models could be compared. Both models can be compared against each other and data only in cell numbers. Each model can be compared against different kinds of "finer-grained" observational data.

	Cell Dyna-mics	Cell anatomy	Intra-ring density & MXD	Final ring width	Cell Numbers
DH	X	X	✓	✓	✓
VS	(✓)	X	X	X	✓



Model descriptions

Deleuze and Houllier (DH) model

Aim: to understand or simulate the effect of changing environmental conditions on forest production and wood quality.

Model assumptions:
Environmental drivers were chosen based on the most limiting factors and their influence on intra-annual variations of wood density (Deleuze et Houllier 1998).

All three processes happen simultaneously and are concluded after a week, driven by the environmental factors during week i:

Cell production:

$$\Delta_{n,i} = \Delta_{n,max} * [1 - e^{-\beta(T_{air,i} - T_{min})}]$$

Cell enlargement (volume gain):

$$\Delta_{v,i} = \Delta_{v,max} * R_{w,i}$$

Cell wall thickening (mass gain):

$$\Delta_{m,i} = \Delta_{m,max} * [1 - e^{-\delta Cpool_i}]$$

Vaganov-Shashkin (VS) -model *)

Aim: to describe cambial cell behaviour; to study climate-tree growth relationships.

Model Assumptions:
Growth (=cambial activity) results from the most limiting factor of temperature, soil water content and is weighted for daylength. On day (d) the integrated growth rate G is thus calculated as (Vaganov et al 2006 eq. 7.1):

$$G(d) = g\_rate\_e(d) * \min\{g\_rate\_t(d), g\_rate\_w(d)\}$$

Cambium is key: The environment gets expressed in TRW via cambial activity: The Integrated growth rate G is translated into position-dependent cellular growth rate.

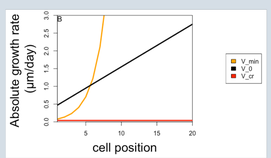
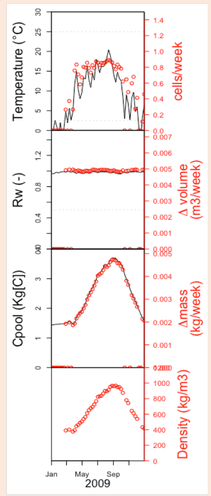


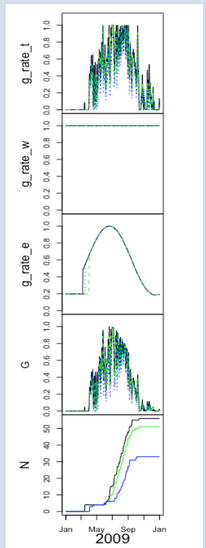
Fig 5: Cambial blocks' framework for position-dependent evaluation of G into absolute growth rate

Resulting cell numbers, N are transformed it into relative tree-ring width , TRWi, by:

$$TRW_i = N / N_{mean}$$

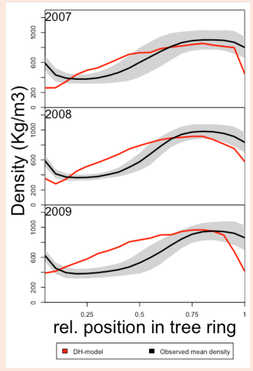
Simulated dynamics



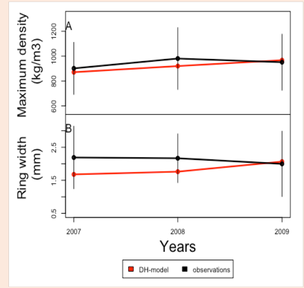


Comparisons with observations

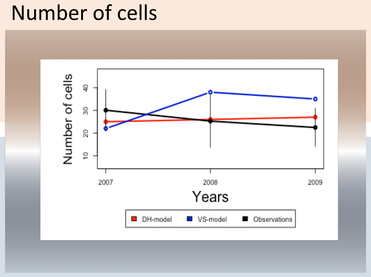
Density profile



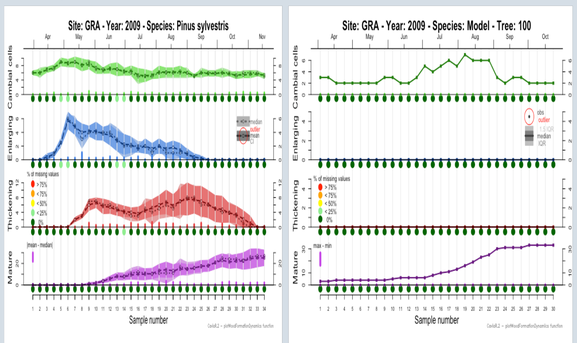
Maximum Density and Ring width



Number of cells



Cell dynamics



Applicability

☺ Parsimonious, intra-annual, intra-tree ring

☹ Simultaneity & fixed duration of cell development

☁ Transposable to other environments?

☺ Biological, high resolution, used successfully

☹ Cell seasonality, carbon not simulated

☁ Too much detail?

*) This particular VS-model version uses G to generate cell numbers, which is why we chose it for the model comparison. *Thank-you to Alexander Shashkin for the useful conversations around the VS-model.*

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Vaganov, E. A., Hughes, M. K., & Shashkin, A. V. (2006). *Growth Dynamics of Conifer Tree Rings: Images of Past and Future Environments*. Berlin Heidelberg: Springer-Verlag. Retrieved from //www.springer.com/gb/book/9783540260868

Data and code producing the figures of this poster can be found here: https://egu2019poster.netlify.com/

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