Multi-model ensemble crop growth simulation by use of the model framework Expert-N

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1. Abstract

We present an example for generation of model ensembles by use of the model framework Expert-N.

Different crop models are obtained by choosing different sub-models which represent important processes and thus determine the dynamics of crop growth. In this way several different sub-models which can simulate a single process such as potential evapotranspiration, actual evaporation, actual transpiration, soil water flow, soil nitrogen transport, soil carbon and nitrogen turnover, crop development, canopy photosynthesis, potential and actual nitrogen uptake or crop growth are combined resulting in different crop models making up a crop model ensemble.

The sub-models are based on process descriptions that are included in the crop models CERES, SUCROS, SPASS and GECROS, but also stem from known soil models such as HYDRUS, LEACHM, SOILN, CENTURY.

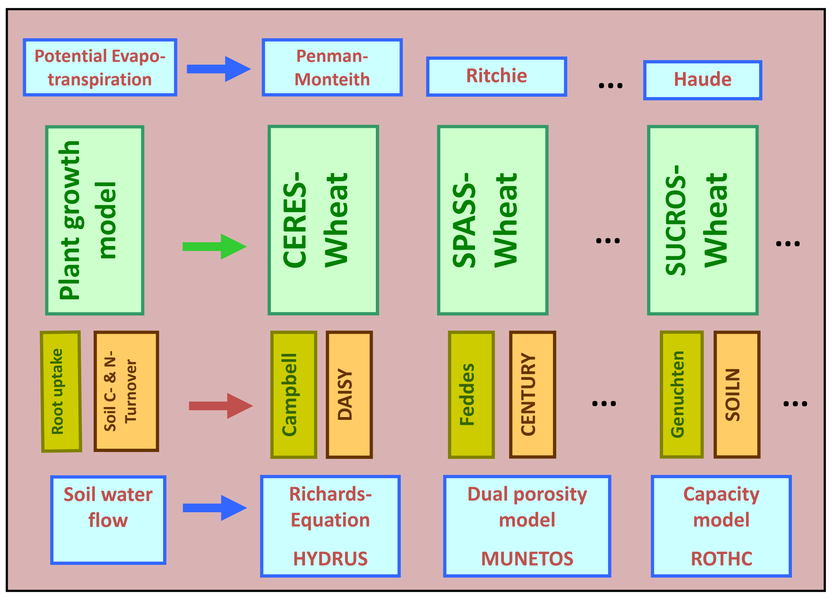
The generated model ensemble is applied to simulate winter wheat growth at three field sites in Southern Germany. Simulation results are compared to observed crop biomasses and yields and to soil water and nitrogen contents.

It is concluded that model frameworks as the model system Expert-N can help to analyse structural uncertainties leading to different simulation results by application of models chosen from a given model ensemble.

2. Sub-model Choice: 4 x 4 x 2

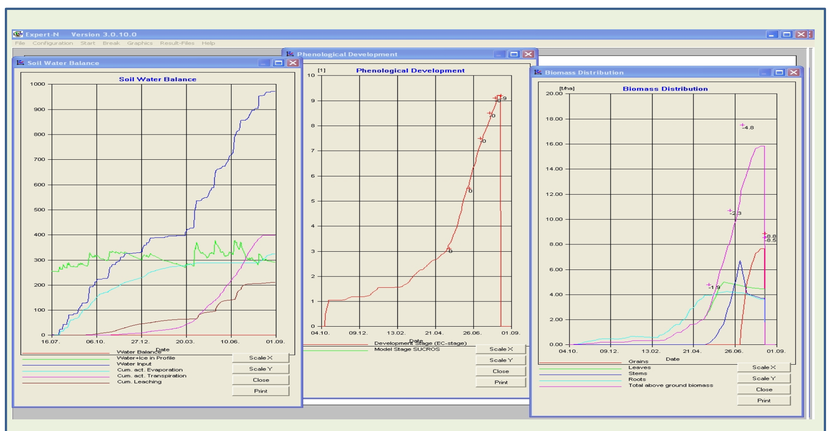
Crop growth model	Soil water flow model	Soil nitrogen model
CERES	HYDRUS	SOILN / LEACHN
SPASS	LEACHW	CERES
SUCROS	CERES	
GECROS	ROTHC	

3. Expert-N model framework



4. Research Station Scheyern

5. Wheat Growth Simulation

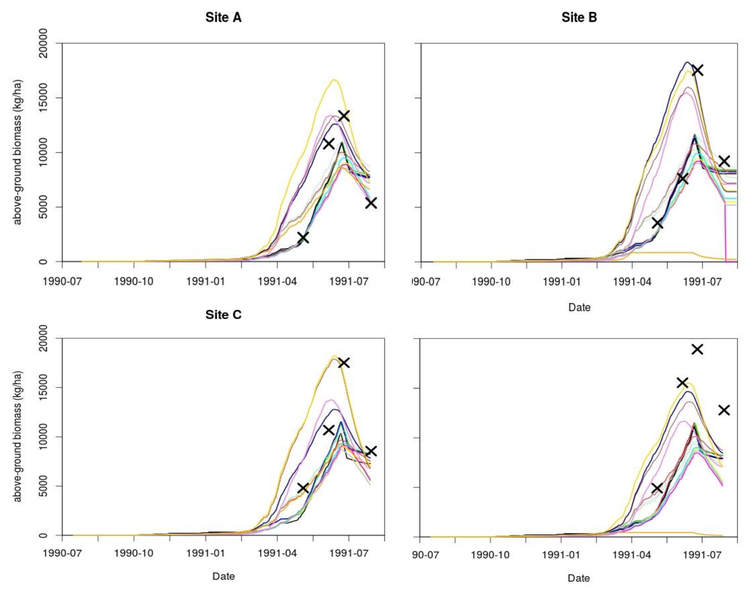


Simulation of winter wheat growth during the vegetation period 16.10.1990 – 15.08.1991 using the CERES model. Crop growth development rates were calibrated.

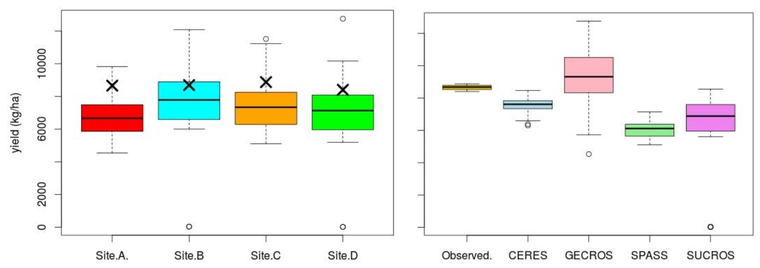
6. Comparison to observation

a) Wheat **biomass** growth at sites A-D [kg dry matter ha^{-1}] within a wheat field using 16 combinations of sub-models

- for crop growth CERES, SPASS, SUCROS and GECROS,
- for soil water flow models of HYDRUS, LEACHM, CERES and ROTHC
- and for the soil nitrogen model of SOILN:



b) Wheat **yield** grain dry matter [kg ha^{-1}] observed (crossmarks) and simulated (box plots) at sites A-D within a wheat field applying 32 different combinations of sub-models (table sub-model choice, section 2):



Overall, simulation results underestimate observed yields. This could be improved by a better calibration of crop growth rates using a similar method for all four crop sub-models.

7. Conclusions

- The model framework Expert-N can be applied to generate model ensembles to simulate wheat growth.
- Under well watered and sufficiently fertilized conditions differences between crop growth sub-models determine structural model variation.
- The impact of soil sub-model choice may be more important under water and nutrient deficiency and if crop rotations are simulated.
- Choice of different sub-models for plant processes such as photosynthesis, respiration, sap flow, root water- and N-uptake need to be further analysed.

References:

- Biernath, C., Gayler, S., Bittner, S., Klein, C., Högy, P., Fangmeier, A., Priesack, E.: Evaluating the ability of four crop models to predict different environmental impacts on spring wheat grown in open-top chambers. European Journal of Agronomy 35 (2011) 71-82.
- Priesack, E., Gayler, S., Hartmann, H.P.: The impact of crop growth sub-model choice on simulated water and nitrogen balances. Nutr. Cycl. Agroecosys. 75 (2006) 1-13.

Acknowledgement:

The TERENO infrastructure is funded by the Helmholtz Association and the German Federal Ministry of Education and Research.