META-MODELING LIGHT INTERCEPTION IN CROP: WEED CANOPIES

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Weeds are harmful for crop production but crucial for biodiversity. To design cropping systems that reconcile crop production and biodiversity, we need tools that allow to test numerous and diverse cropping systems. FLORSYS[1] is a "virtual field" model that predicts weed dynamics in current and prospective cropping systems. It must be accelerated and simplified before it can be used to test weed management scenarios.

3D light interception sub-model

The 3D light interception sub-model[3] (Fig 1) is a bottleneck and takes 71% of the computation time.

AIM: Meta-model the 3D light interception sub-model of FLORSYS

Sensitivity analysis and meta-modelling

We used truncated Legendre polynomial chaos expansion (PCE) whose coefficients are estimated by PLS regression (Gauchi et al., 2016) in order to:

- Perform a **sensitivity analysis by** ranking correlated inputs as a function of their polynomial and total effects on outputs via the so-called PCE-PLS
- Provide a **meta-model** predicting outputs at the plant level

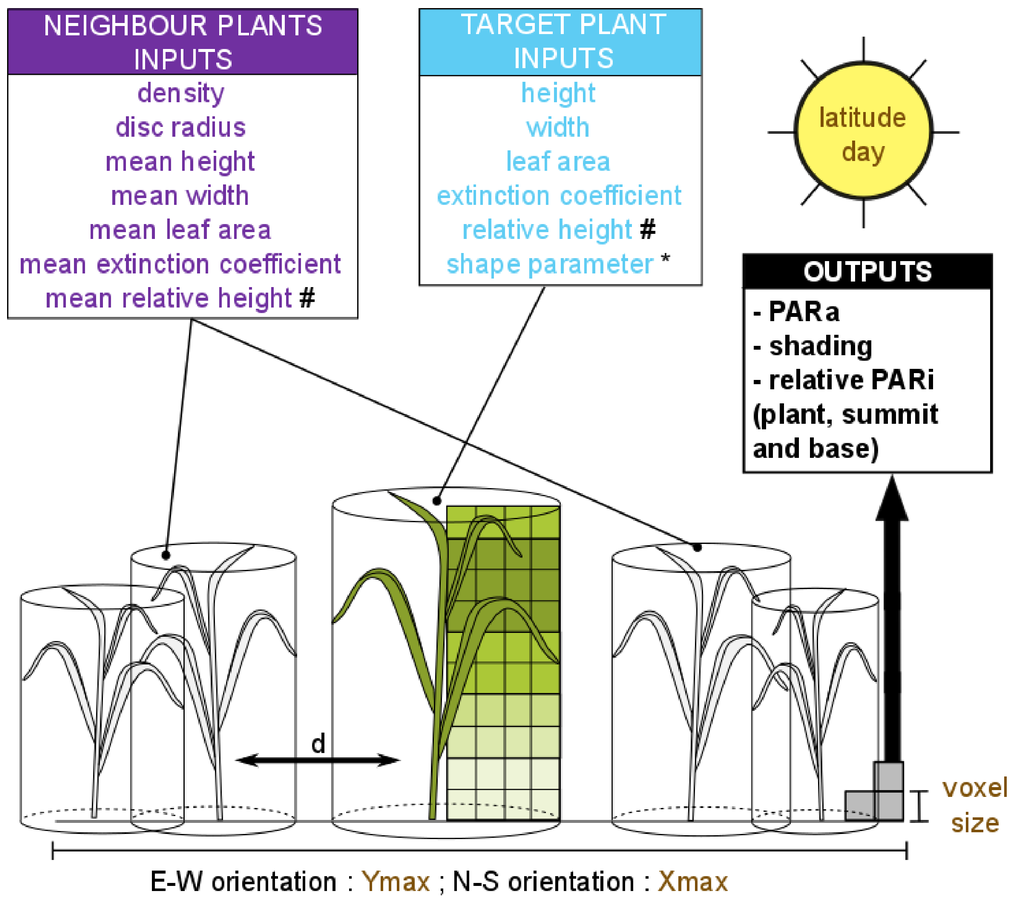

Figure 1: Schematic representation of the inputs and outputs of the 3D light interception submodel of FLORSYS. #relative plant height below which is located half of the cumulated leaf area, *shape parameter for leaf distribution vs. plant height.

Sensitivity indices

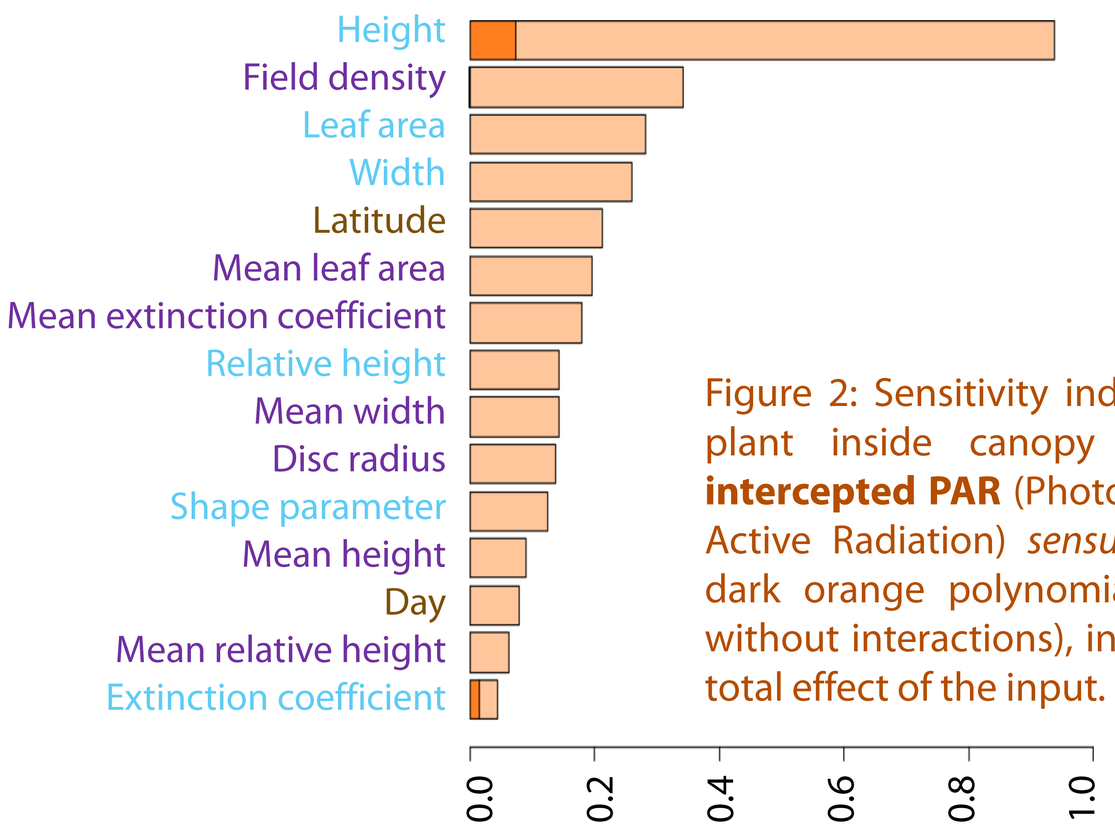

Figure 2: Sensitivity index for target plant inside canopy of **relative intercepted PAR** (Photosynthetically Active Radiation) *sensu* PCE-PLS, in dark orange polynomial effect (i.e. without interactions), in light orange total effect of the input.

Meta-model and simulation time

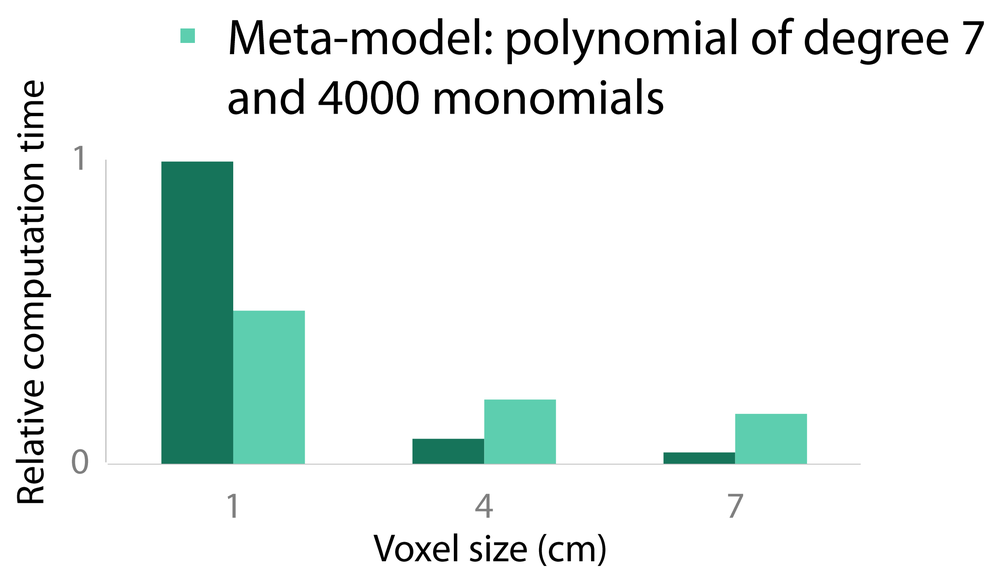

Figure 3: Simulation time of the original FLORSYS (dark green) and meta-modelled FLORSYS (light green), for 3 voxel sizes.

Discussion and conclusion

- Target-plant characteristics >> Physical environment
- Density >> Canopy structure variables
- Time saving thanks to the meta-model depend on the precision wanted (voxel size)
- Mechanistic models can be faster for complex, interactive processes than "empirical" meta-models
- The transformation of the statistical meta-model into a simulation meta-model for FLORSYS requires complementary algorithms (e.g. how close must a neighbour be to be included in the canopy inputs?).

FUTURE: Compare meta-models with FLORSYS and field observations to determine best use practices.

[1]Colbach N., Biju-Duval L., Gardarin A., Granger S., Guyot S.H.M., Mézière D., Munier-Jolain N.M., Petit S., 2014. The role of models for multicriteria evaluation and multiobjective design of cropping systems for managing weeds. Weed Research 54, 541–555.

[2]Gauchi J.P., Bensadoun A., Colas F., Colbach N. 2016. Metamodelling and global sensitivity analysis for computer models with correlated inputs: a practical approach tested with a 3D light-interception computer model. Submitted to Environmental Modelling and Software.

[3]Munier-Jolain N.M. – Guyot S.H.M. – Colbach N.: 2013. A 3D model for light interception in heterogeneous crop:weed canopies. Model structure and evaluation. Ecological Modelling 250:101–110.

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