Adapting FLORSYS for climate change: implementing plant-plant competition for water in a 3D mechanistic model for predicting future crop/weed interactions and their consequences in arable cropping systems

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ID 95

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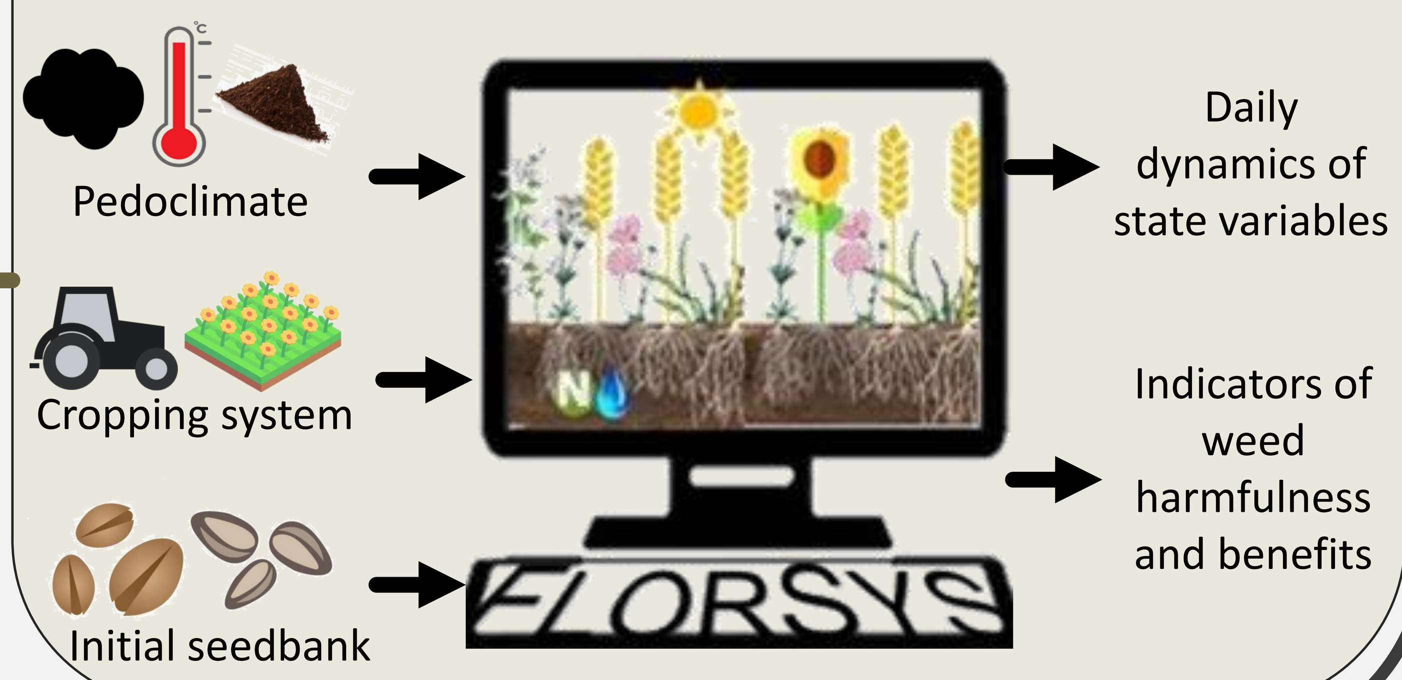
Context: How to design climate-resilient arable cropping systems to sustainably manage weeds?

Weeds

Pest causing the most yield losses in arable crops (Oerke, 2006)

Modelling crop/weed interactions

FLORSYS: Simulates the effects of cropping systems on the multi-annual dynamics of crops, weeds and their consequences *(Colbach et al., 2021)*



Operational to design multi-performant and low-input systems

Workshops with farmers and crop advisors (Queyrel et al., 2023)

+/- **Partially operational** to design climate-resilient systems

Work in progress

Does not include all relevant mechanisms

Designing cropping systems

Objective

Build a water competition submodel for FLORSYS

The submodel is expected to:

- Extend FLORSYS' validity domain to climate change
- Represent water uptake, water competition and consequences on growth

The submodel will be:

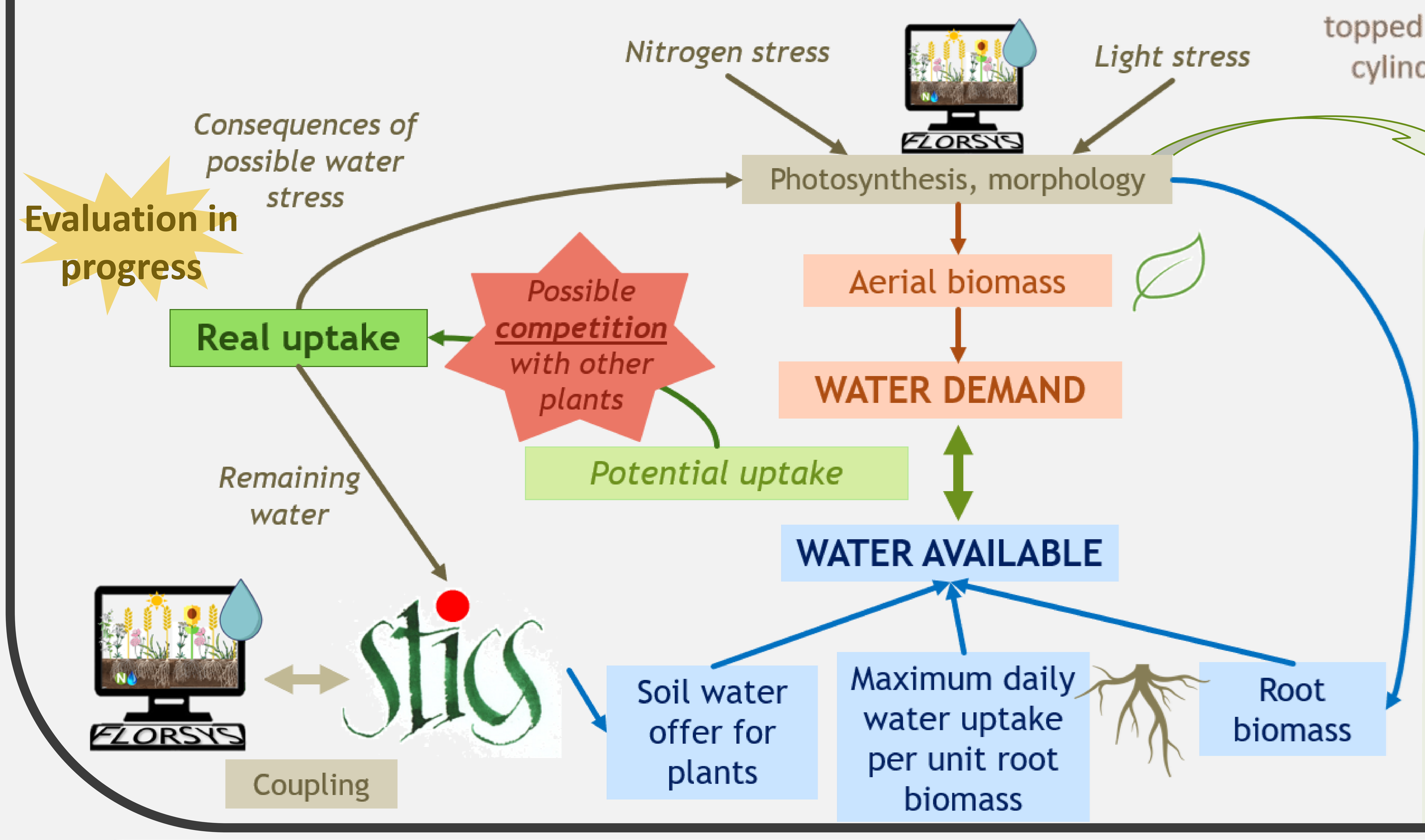
- Connected to other submodels *(phenology, nitrogen, light)*
- Based on either existing formalisms, or new experimental formalisms
- Generic, with few parameters

Results

Some formalisms derived from existing models
(Ritchie, 1998; Brisson et al., 2008; Louarn et Faverjon, 2018)

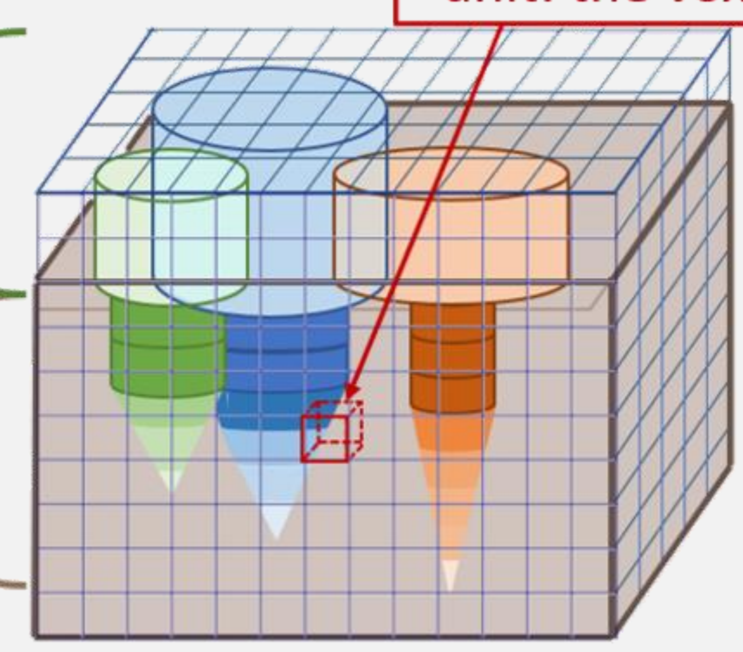
- Water availability *(STICS soil submodel)* and demand *(Virtual grassland)*
- Water stress → photosynthesis *(APSIM / DSSAT)*

Only 7 species-specific parameters
→ Plant demand and maximum root uptake
→ Water stress → morphology and photosynthesis



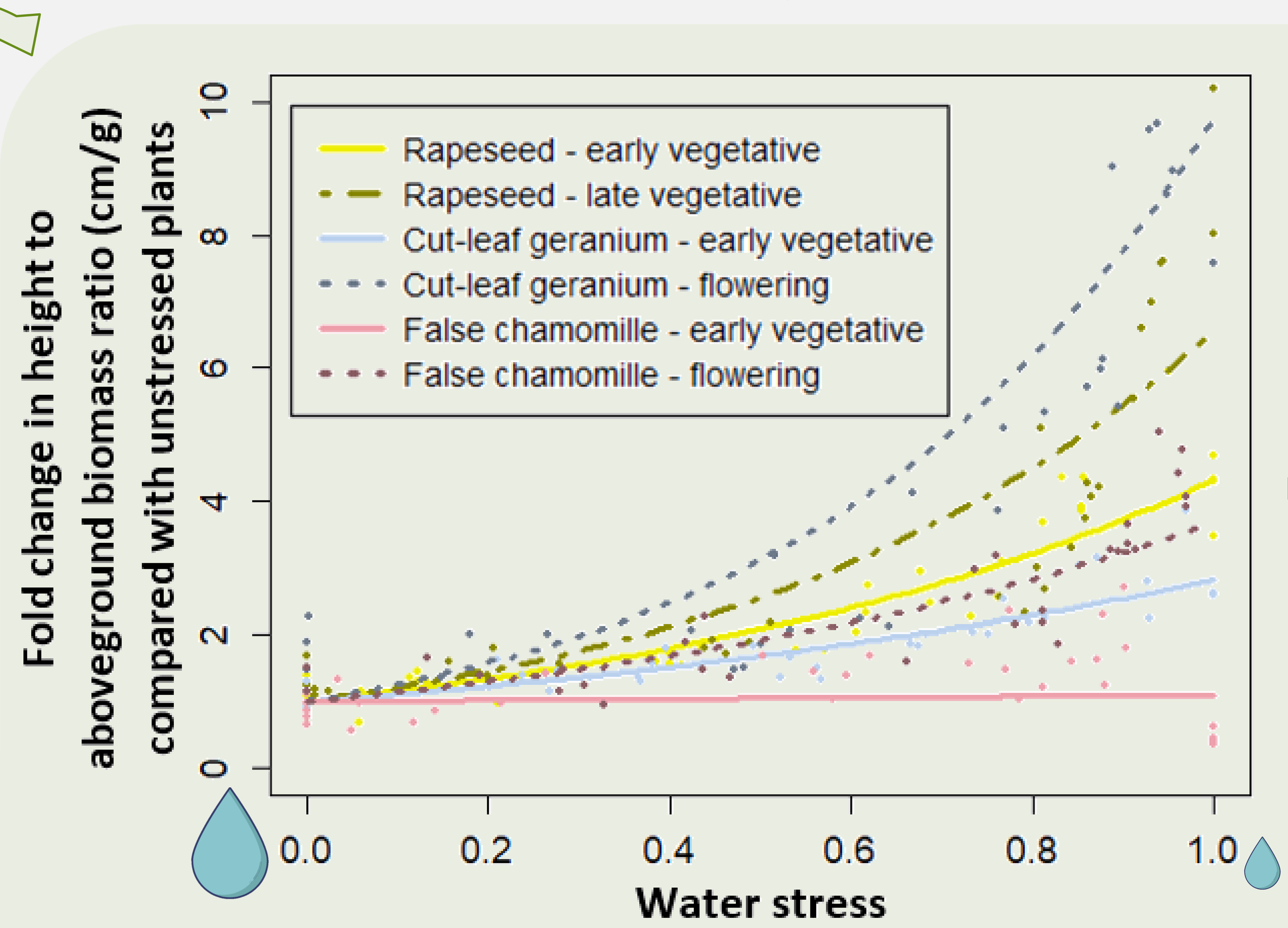
FLORSYS base unit: the voxel

A two-scale modelling



Water uptake is modelled **at the plant level** and depends on plant demand and soil water available for the plant

Competition occurs **at the soil voxel level**, when the demand of all plants with roots in the voxel exceeds water availability



Example of results from experiments to model the interspecies diversity in morphological responses to water stress

The parameters of the response curves reflect species- and stage-specificities

Perspectives: Determine the characteristics of future weed floras for better management

WCRP World Climate Research Programme CMIP6

Predicted global climate *(Xu et al., 2021)*

Downscaling

High resolution daily climate over France

Current and virtual arable cropping systems

FLORSYS

Projected weed flora in arable cropping systems
↓
Traits of climate-selected weeds
↓
Decision rules to design innovative systems

Conclusion: FLORSYS becomes the first weed model to simulate competition for light, water and nitrogen. Fed with high resolution climate datasets, FLORSYS will help co-designing sustainable and climate-resilient cropping systems, for long-term weed management

Literature:

Brisson N., 2008. Quae Editions. ISBN: 978-2-7592-0169-3; **Colbach N. et al., 2021.** Field Crops Res., 261, 108006. DOI: 10.1016/j.fcr.2020.108006; **Louarn G. et Faverjon L., 2018.** Ann. Bot., 121(5). DOI: 10.1093/aob/mcx154; **Oerke E-C., 2006.** J. Agric. Sci., 144 (1), 31-43. DOI: 10.1017/S0021859605005708; **Queyrel W. et al., 2023.** Agric. Syst., 208 (6), 103645. DOI: 10.1016/j.agsy.2023.103645; **Ritchie J.T., 1998.** Springer Netherlands, p. 41-54. DOI: 10.1007/978-94-017-3624-4_3; **Xu Z. et al., 2021.** Sci. Data, 8 (1), 293. DOI: 10.1038/s41597-021-01079-3