Integrating machine learning and mechanistic modelling towards adaptation of plants to climate change

Emerging DS/AI methods

WAGENINGEN
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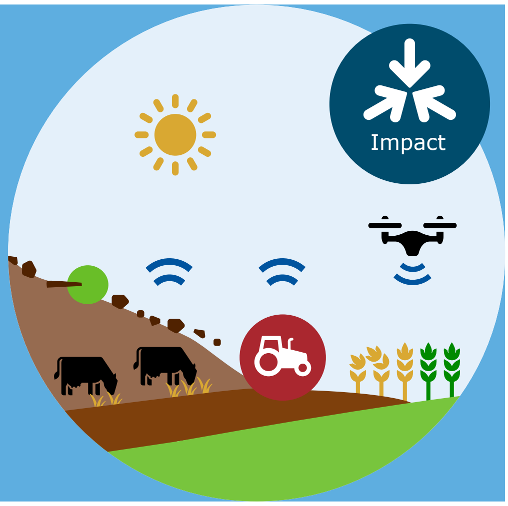


Data Driven Discoveries in a changing climate (D3C2)

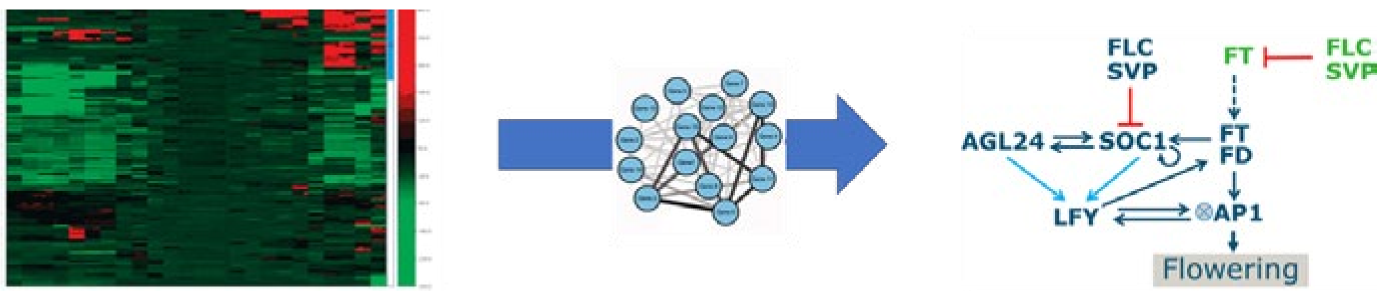
Objective: This project aims to develop a new model with quantitative, predictive power that provides detailed mechanistic insights, based on machine learning and high-level mechanistic models.

Activities and results

The world faces a growing demand for affordable food, at a time where climate change makes growth and harvest ever more unpredictable. Instead of plants that perform well only under perfect, tightly managed conditions, we need to develop robust crop varieties that can withstand extreme and unpredictable stresses such as droughts, floods, and diseases.

Traditional plant breeding techniques, that rely on direct statistical predictions of traits based on genetic information, do not offer insight into the complex trade-offs between robustness, growth and development. We therefore need a new approach, integrating genetic and molecular information through machine learning with high-level mechanistic models of plant physiology under combinations of stresses. This is a combination of bottom-up and top-down modelling.

With this project, we take a first step in this direction by developing an integral model for the response of the model plant *Arabidopsis thaliana* to elevated temperature. This model will have quantitative, predictive power and provide detailed mechanistic insights. This enables us to extract actionable knowledge, delivering concrete opportunities for plant breeders to focus their breeding on better climate adaption. Eventually, models and machine learning approaches will be used to steer experimental efforts, critical to move from *big* to *smart* data approaches. We will develop our approach in a generalizable, modular and robust manner, ensuring its suitability for future usage and extension.



Gene expression gene modules mechanistic model

Achievement

We re-implemented an existing mechanistic model in python code, obtained relevant datasets from literature, built an initial version of module finding methodology (machine learning approach). Furthermore, we co-organised meetings with others who did related work, to exchange ideas and knowledge. The initial model development is promising. More time is needed to connect the approaches. This is partly because we could start later than anticipated. Further development of the model is ongoing.

Outlook

CROP-XR, a new large-scale collaboration including various universities and companies has recently been granted. In this collaboration, we will continue to work on the combination of mechanistic models with machine learning. Researchers initially hired via the D3C2 project will continue in this project.

Deliverables

We were involved in establishing the WUR Scientific Machine Learning Network. Our research and that of other D3-C2-projects was presented there. This website will provide a stage for WUR projects on SciML and will serve as communication medium between Wageningen researchers. A symposium will take place later in 2023, funded by a D3C2 wildcard.

Lessons learned

The first lesson we learned, is that cooperation with people from other WUR-disciplines who are working to develop SciML implementations, is highly valuable. Starting cooperation early, like we have done, can help save time and duplicate work. The cooperation with others doing similar research was highly valuable to get inspired and to test our own ideas and to obtain feedback. This yielded the WUR Scientific Machine Learning Network, which is now official due to a D3-C2 Wildcard grant. In terms of collaboration, the project delivered far more than expected (more than just a temporary collaboration).
In terms of output, due to delayed start, we have delivered somewhat less than expected. However, activities of the D3-C2 project will continue in the newly funded CROP-XR project.

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