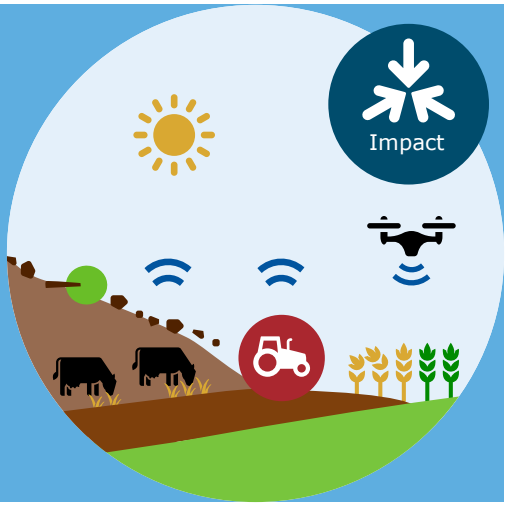
Assessment of realistic climate change impacts of cropping seasons

On start and length of cropping seasons in the Netherlands

Emerging DS/AI methods



WAGENINGEN
UNIVERSITY & RESEARCH

Data Driven Discoveries in a changing climate (D3C2)

Objective: Create a framework for the prediction of start and end of cropping seasons under projections of future climate in the Netherlands.

Activities

In this project, we developed a workflow that merges several data sources in the Netherlands. It builds a data-driven model to predict emergence and harvest dates of several crops under future climate. We combined data about:

- field and crop management (BRP)
- soil class (BOFEK2020)
- groundwater (BRO-WDM)
- weather from the national meteorological institute (KNMI)
- predictions from general circulation models (GCMs)
- information on start and end of cropping seasons obtained by the analysis of satellite data through the Groenmonitor platform of WEnR (Groenmonitor).

Crop, pedological and historical weather information were used as predictors, and satellite-derived emergence and harvest dates as target variables of a convolutional neural network (CNN) model. Predictions for the future were obtained by substituting historical with future weather.

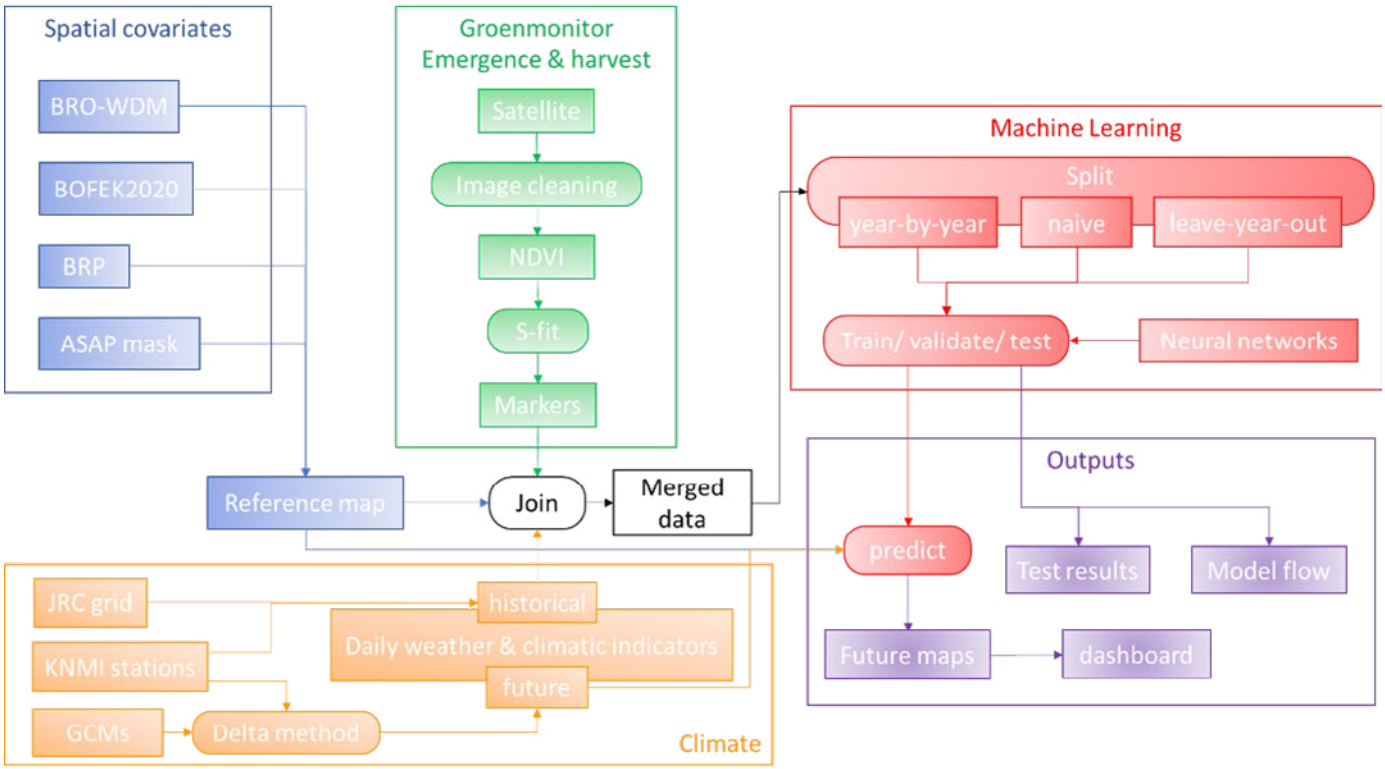
Achievement

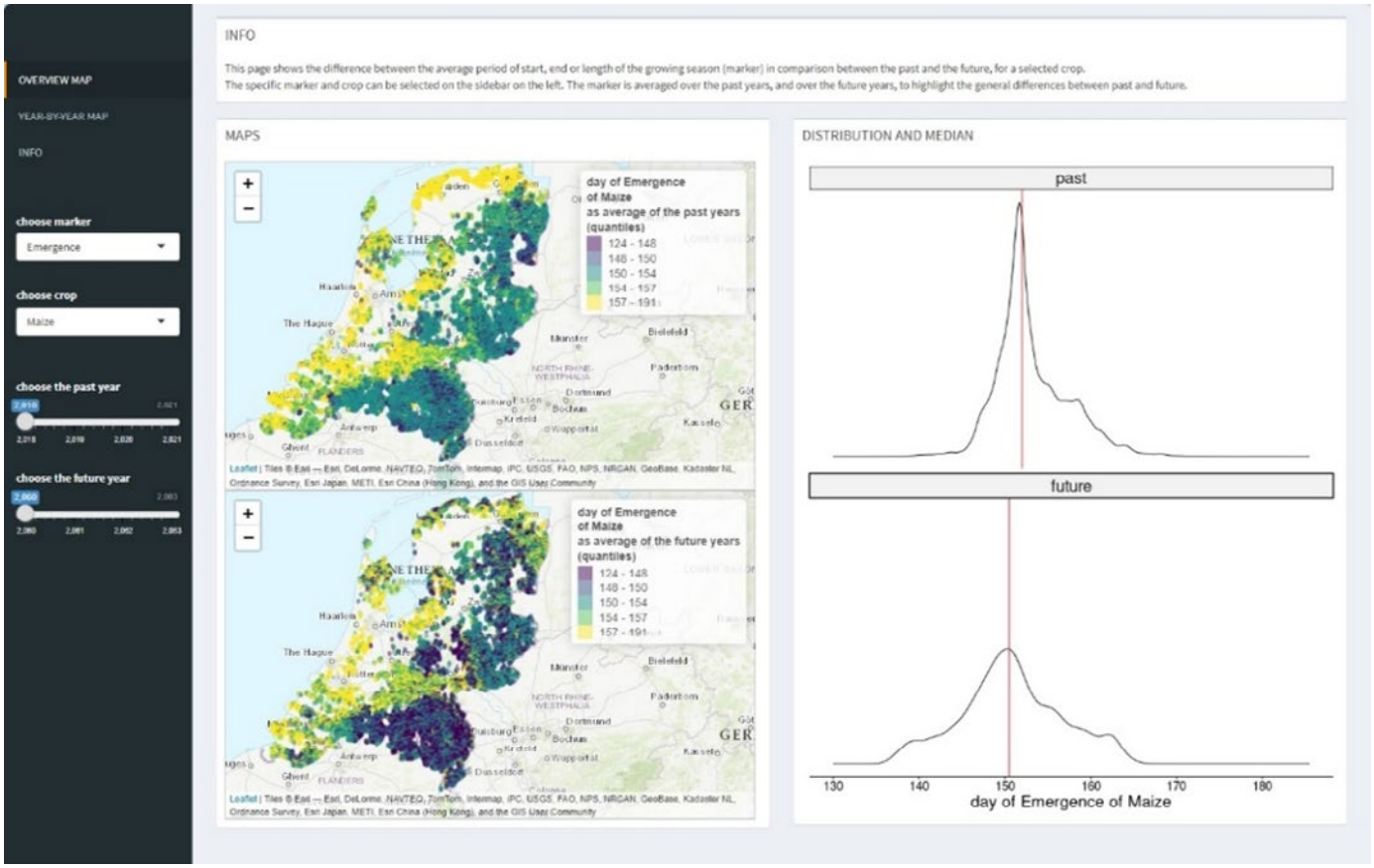
We produced a workflow of data cleaning, processing, machine learning modelling and visualisation of the results. It can potentially be expanded over the years as new satellite-derived data becomes available. This offers an alternative to the weather rule-based approaches that are often used to estimate start and duration of the cropping seasons. These estimations represent optimal conditions but might not reflect what happens in the field.

After building the workflow, we investigated how much of the variability could be explained by the data-drive approach, by testing the models' performances on a hold-out set, using different approaches. Using a random split of the whole dataset to generate the hold-out set, the model showed a moderate explanatory power at best (0.38 for the emergence of sugar beet and seed potatoes), while the performance dropped drastically when the model was tested against a hold-out year (leave-year-out approach).

Outlook

We built a novel collaboration among different WUR departments to integrate knowledge of agronomy, climate change, data science and earth observation. We are currently working on a manuscript related to the project, and we will consider how to further advance the partnership, leveraging on the possibilities to expand the Groenmonitor system.


Spatial covariates
BRO-WDM
BOFEK2020
BRP
ASAP mask
Groenmonitor
Emergence & harvest
Satellite
Image cleaning
NDVI
S-fit
Markers
Machine Learning
Split
year-by-year
naive
leave-year-out
Train/ validate/ test
Neural networks
Reference map
Join
Merged data
Outputs
predict
Test results
Model flow
Future maps
dashboard
JRC grid
KNMI stations
GCMs
Delta method
historical
Daily weather & climatic indicators
future
Climate


OVERVIEW MAP
YEAR-BY-YEAR MAP
INFO
choose marker
Emergence
choose crop
Maize
choose the past year
choose the future year
INFO
This page shows the difference between the average period of start, end or length of the growing season (marker) in comparison between the past and the future, for a selected crop.
The specific marker and crop can be selected on the sidebar on the left. The marker is averaged over the past years, and over the future years, to highlight the general differences between past and future.
MAPS
day of Emergence of Maize as average of the past years (quantiles)
124 - 148
148 - 150
150 - 154
154 - 157
157 - 191
day of Emergence of Maize as average of the future years (quantiles)
DISTRIBUTION AND MEDIAN
past
future
130
140
150
160
170
180
day of Emergence of Maize

Deliverables

- We wrote a project report (D3-C2_FCS_report.docx), with details on the workflow and insights on the potential and limitations of the approach.

- We built a shiny interactive app (app) for mapping and plotting the results. The app includes the processed historical data of emergence and harvest and the predictions for a sample of future years. We are exploring the possibility to deploy the app to WUR Posit account (https://shiny.wur.nl/connect/).

Lessons learned

With this project we highlighted that the explanatory power of a data-driven approach for the objective detailed above is limited. This indicates that farmers' decisions are only partially explained by pedoclimatic conditions.
A model trained on a limited number of years also performs poorly on an 'unseen' year, and this feature should be tested when building data-driven approaches.
As more years of data become available, the model performance is expected to improve.

Finally, when investigating the predictions for the far future, we noted the inability of the model to extrapolate outside of the range of the training data, despite the clear-cut direction taken by the changing climate.
This points to the limits of fully-automated data-driven approaches. It calls for solutions that integrate them with strict human supervision and expert knowledge.

Contact

Massimo Tolomio
Project leader
massimo.tolomio@wur.nl

Wageningen University & Research
P.O. Box 47
6700 AB Wageningen
The netherlands
T +31 317 48 07 00
www.wur.eu

Project members
Massimo Tolomio (PPS)
Majid Ali Magham (PPS)
Bernardo Maestrini (AGRO)
Gerbert Roerink (WENR)
Arumugam Ponraj (WENR)