

Constrains and solutions for the design of a long-term Ecotron experiment to study long term effects of climate change on agro-ecosystems

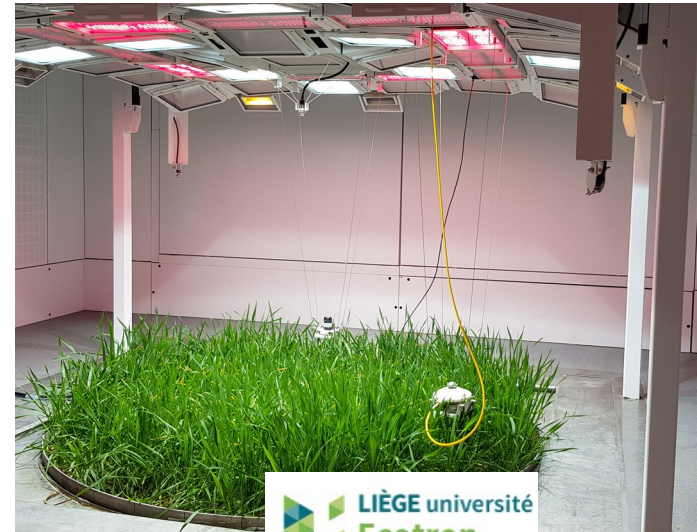
AnaEE Scientific Conference

2026

Menton

Ecological EcoFoodSystem Ecotron experiment - ECO³

Connect two research « infrastructures »



ECO³ - Aims

- Evaluate the performance of the EcoFoodSystem crop rotations under future climate scenarios



Long term experiment

- Stability, resistance and resilience (crop, micro-organisms, ...)
- Environmental impact (e.g., nitrate leaching and GHG emissions)
- Crop performance **across rotations, time and climates**
- Gain mechanistic insights into plant-soil interactions and water, carbon, and nitrogen cycling
- Provide empirical data for process-based modelling

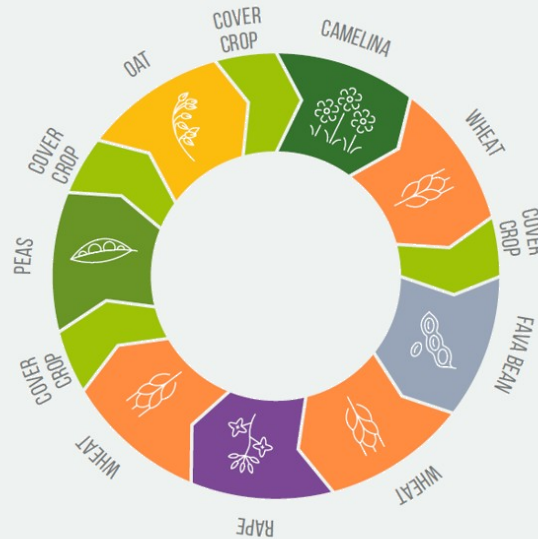
ECO³ – crop rotation

- Which scenario(s) from EcoFoodSystem do we experiment in the Ecotron?

BAU



Vegan



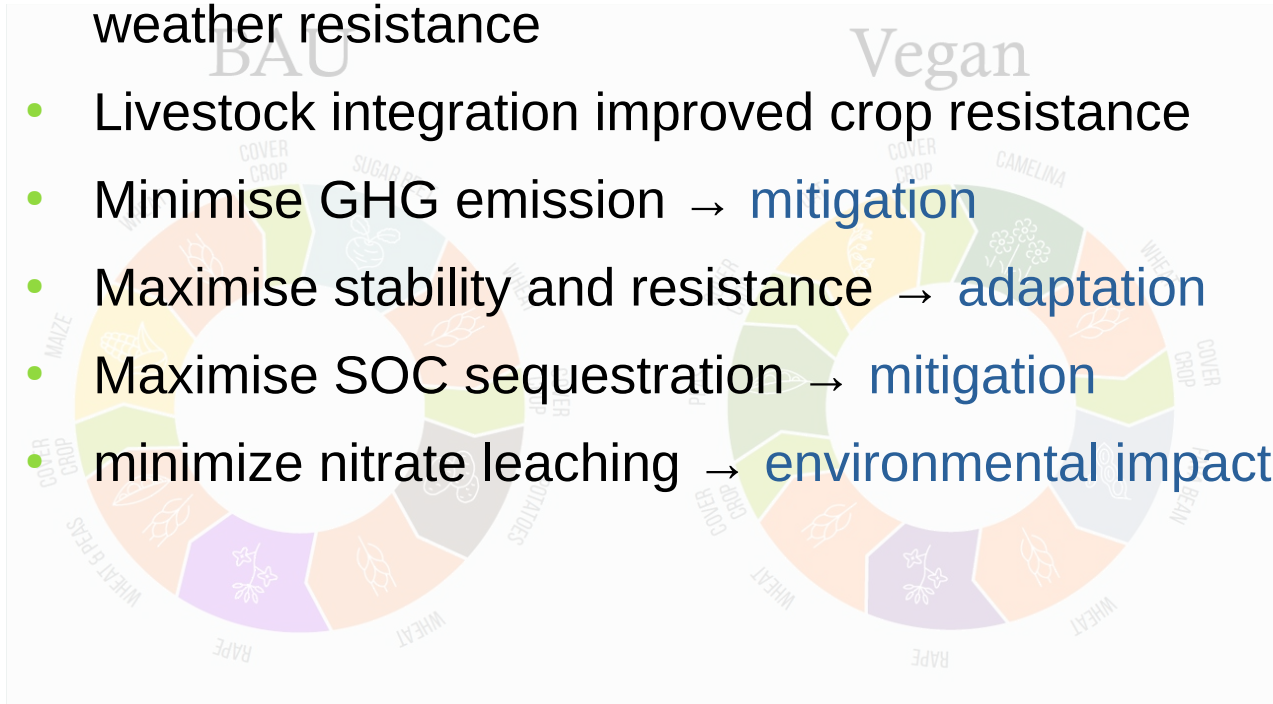
ICLS



ECO³ – crop rotation

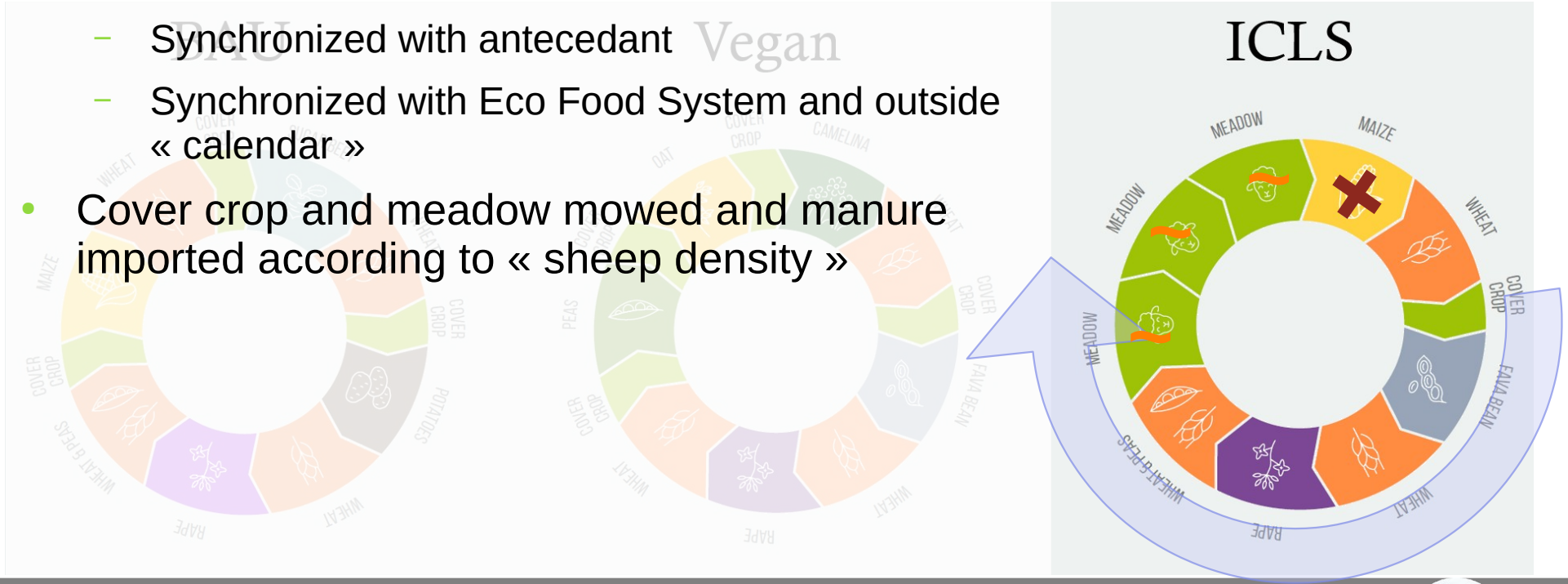
- Improve soil conditions and resistance to extreme weather resistance
- Livestock integration improved crop resistance
- Minimise GHG emission → mitigation
- Maximise stability and resistance → adaptation
- Maximise SOC sequestration → mitigation
- minimize nitrate leaching → environmental impact

integrated crop-livestock system



ECO³ – crop rotation

- ECO³ starting with Faba beans
 - Synchronized with antecedant *Vegan*
 - Synchronized with Eco Food System and outside « calendar »
- Cover crop and meadow mowed and manure imported according to « sheep density »



ECO³ – Research questions



Year 1 – Faba bean

CER1

CER2

CER3

CER4

CER5

CER6

CER7

CER8



Year 2 – Wheat

CER1

CER2

CER3

CER4

CER5

CER6

CER7

CER8



Year 3 – Rapeseed

CER1

CER2

CER3

CER4

CER5

CER6

CER7

CER8

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

‘Room-specific’, crop rotation-oriented,
long-term dynamic and evolution
(e.g., micro-organisms, stability,
resistance, resilience)

→ Crop-specific, **weather-oriented approach**

→ To get publishable results every year

→ Each team should have both crop-specific/weather-oriented and crop-rotation oriented research questions

→ Which measurements (e.g., yield, biomass, NEE)?

→ Which indicators (e.g., productivity, stability, resistance, NUE)?

ECO³ – Research questions

- And yet, only about 2 m² available in the Ecotron ...
- Two containers are available
 - 9 Cubic 0,25 m², 0,125 m³ → good for repetitions (?)
 - 1 full lysimetre 2 m², 3m³ → much more realistic



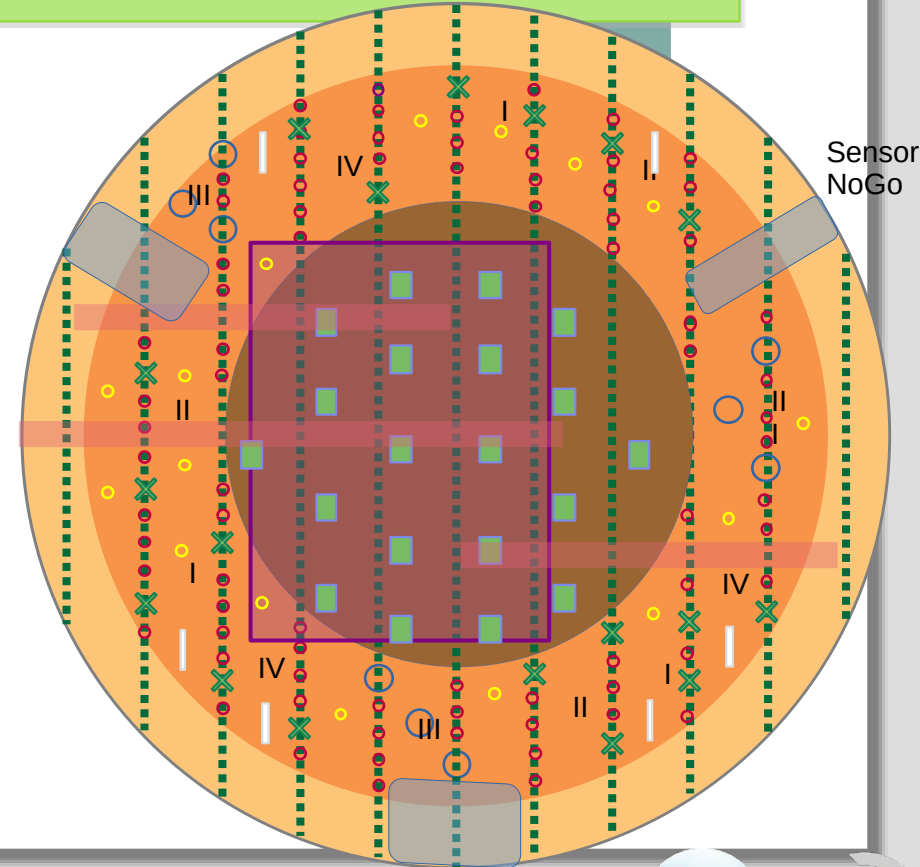
- ▶ Each team should have both crop-specific/weather-oriented and crop-rotation oriented research questions
- ▶ Which measurements (e.g., yield, biomass, NEE)?
- ▶ Which indicators (e.g., productivity, stability, resistance, NUE)?

ECO³ – Experimental design

- Phenology
 - Crop development dynamic
 - Samplings (○ & X) and camera
- Physiology, LAI and biomasses – epigeal part
 - Crop growth dynamic
 - Relation with phenology
 - Samplings (○ & X) and camera
 - Chlorophyll fluorescence
- Physiology, roots
 - Samplings (○) and root imager
- Mineral concentrations and transfers
 - Samplings (○, X, ● & ○)
 - Rhizons
 - CO₂ exchanges
- Hydrology
 - Lysimetre
- Microbial activity
 - Soil samplings (● & ○)
 - Soil solution samplings
 - Tee bags experiment

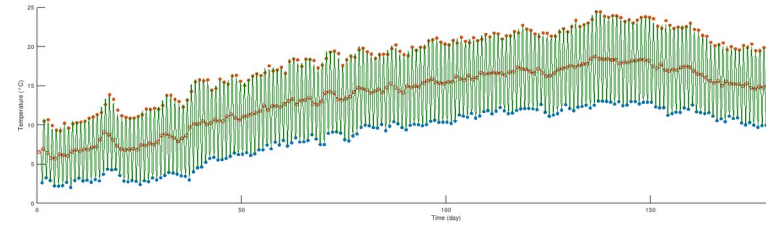
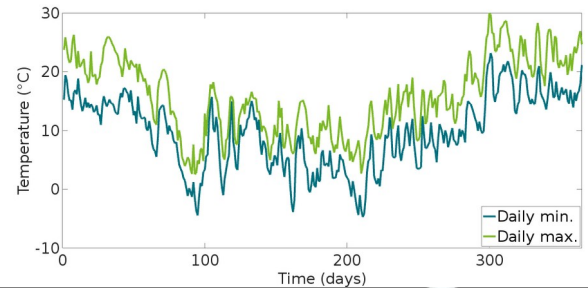
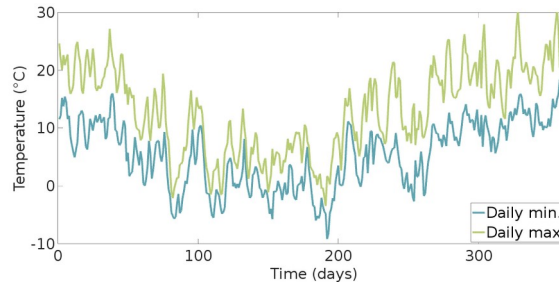
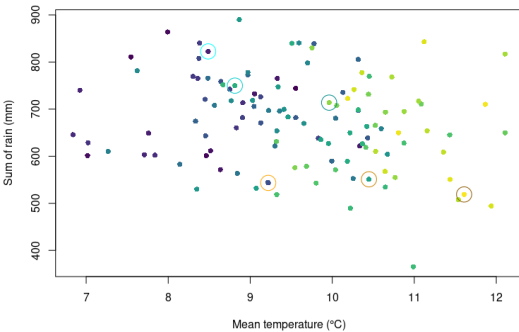
Around 150
measurements
and samplings

4 time periods
+ harvest



ECO³ – Meteorological conditions

- Height rooms are available
- Several main possibilities
 - Synthetics vs realist
 - Comparisons, with repetitions vs Gradient(s)



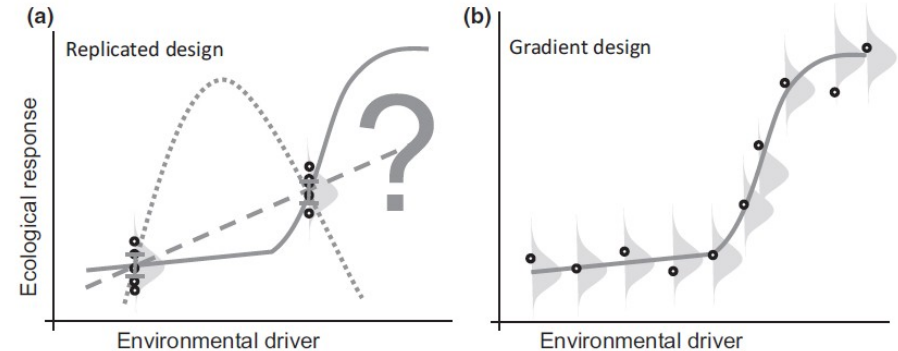
ECO³ – Meteorological conditions

- Height rooms are available
- Several main possibilities
 - Synthetics vs realist
 - Comparisons, with repetitions
 - vs Gradient(s)

Kreyling et al. (2018) recommend gradient designs for experiments dealing with ecological responses to continuous environmental drivers (e.g., temperature, precipitation, CO₂-level).

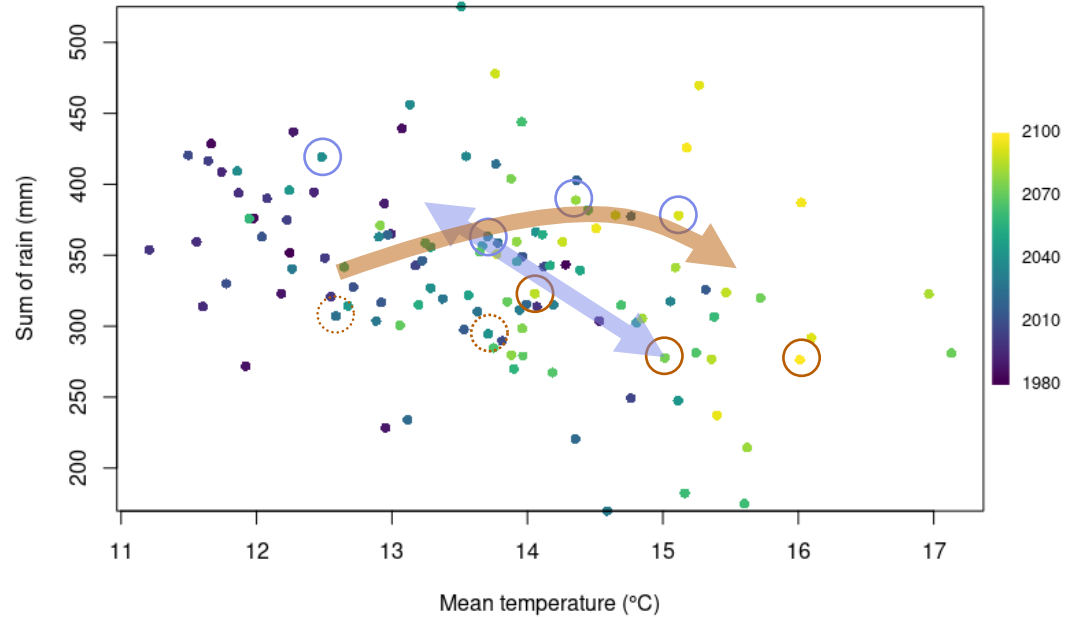
Gradient experiments should improve the value of the experimental outputs for process-based modelling.

Such gradient designs outperform replicated designs for both linear and nonlinear relationships, in terms of prediction success and whitening of residuals. They also outperform hybrid designs – a compromise between gradient and replicated designs with some minimal replication and maximal locations.



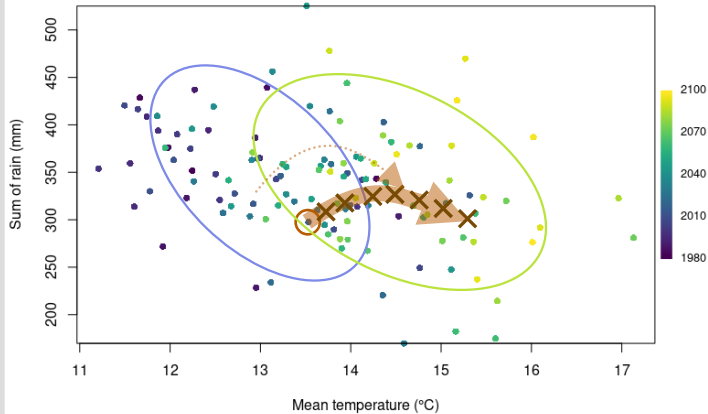
ECO³ – Meteorological conditions

- But which gradient?
 - Time ↔ Climate change
 - Intra-annual variability?
 - Both?

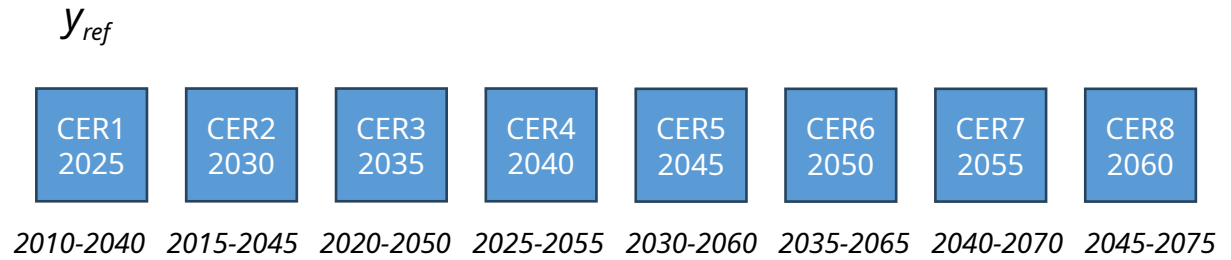


ECO³ – Meteorological conditions

- Methodology 1)
 - Reference year + modifications (m & s) according to a climatic scenario and a time lapse
 - Could be interesting for “mechanical response to drivers



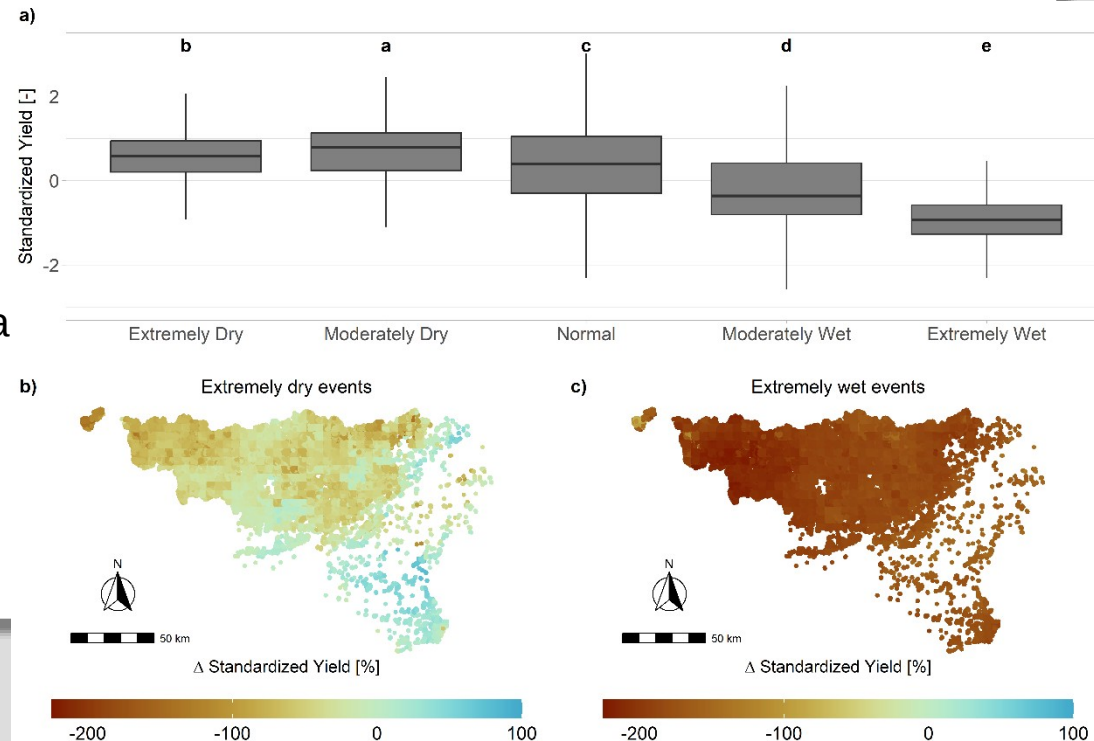
Increase in CO₂, yearly temperature, and other trends



ECO³ – Meteorological conditions

- Methodology
 - Reference year + modifications (m & s) according to a climatic scenario and a time lapse
 - Could be interesting for “mechanical response to drivers
 - How to chose the reference?
 - Another starting point may induce a different response
 - Only one “direction” & more inter annual variability than linked to climate change for short time interval

Delandmeter et al. (2026; GCB)



ECO³ – Meteorological conditions

- Methodology 2)
 - Run crop model on all the available data (1980 – 2100), according to a climate scenario (MPI with SSP370)
 - Find which SPEIs are best related to yield

Yield $\sim$ SPEI1_* + (SPEI1_*)² + CO₂ with * = from February to October

Yield $\sim$ SPEI3_* + (SPEI3_*)² + CO₂ with * = from February to October



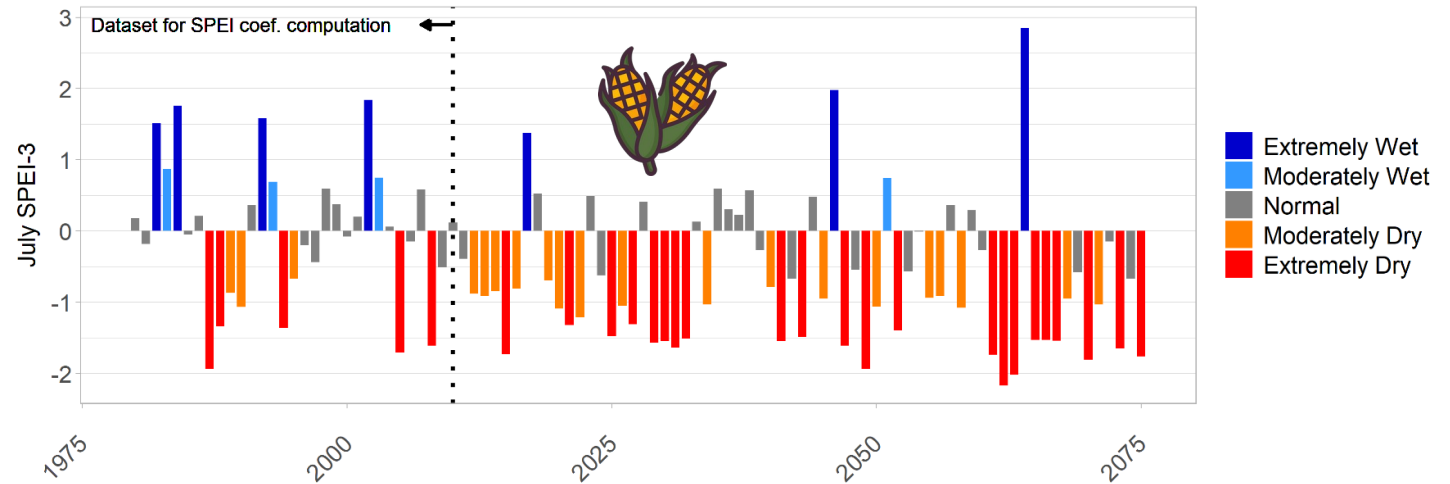
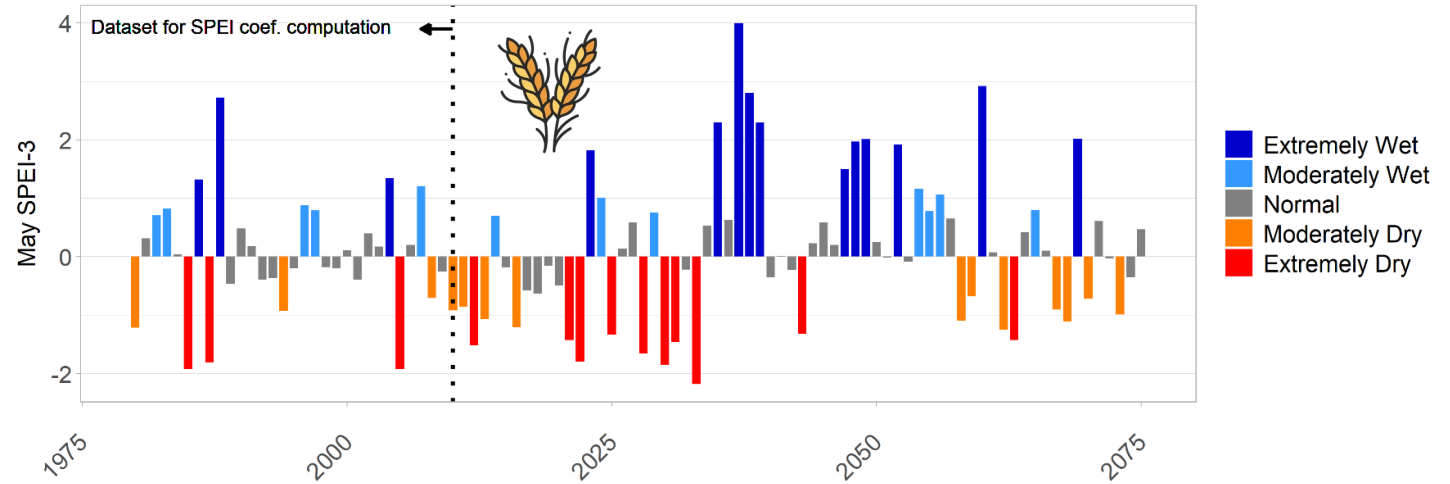
For winter wheat, it is **SPEI-3** in **May** (covering the March-May period) which is the most correlated with final yield, leading to the highest adjusted-R² and lowest AIC/BIC criteria.



For maize, it is **SPEI-3** in **July** which is the most correlated with final yield, leading to the highest adjusted-R² and lowest AIC/BIC criteria.

ECO³ – Meteor

- Methodology 2)
 - Run crop mod
 - Find which SF



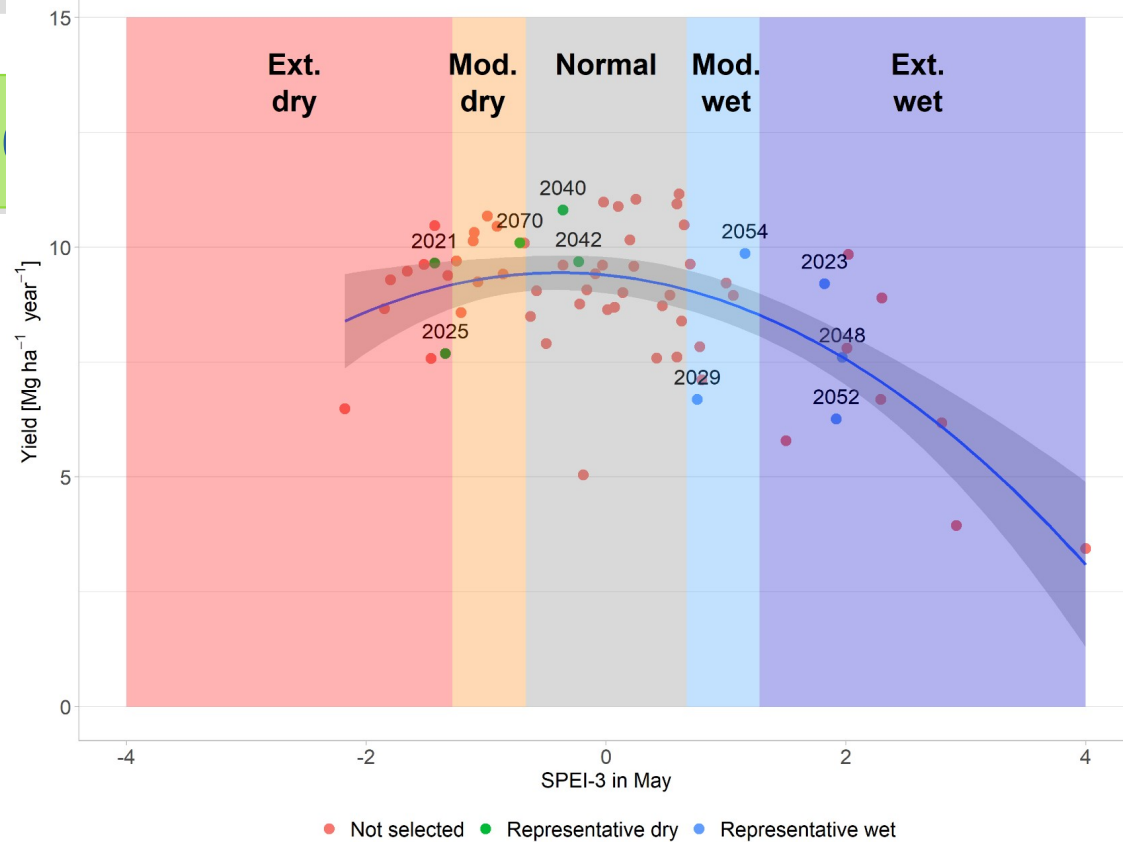
ECO³ – Meteorological con

- Methodology 2)
 - Run crop model on all the available data (1980 - 2100)
 - Find which SPEIs are best related to yield
 - Selection of the years close to percentiles 20 & 80 per period?
 - Five year step drive to inconsistencies...



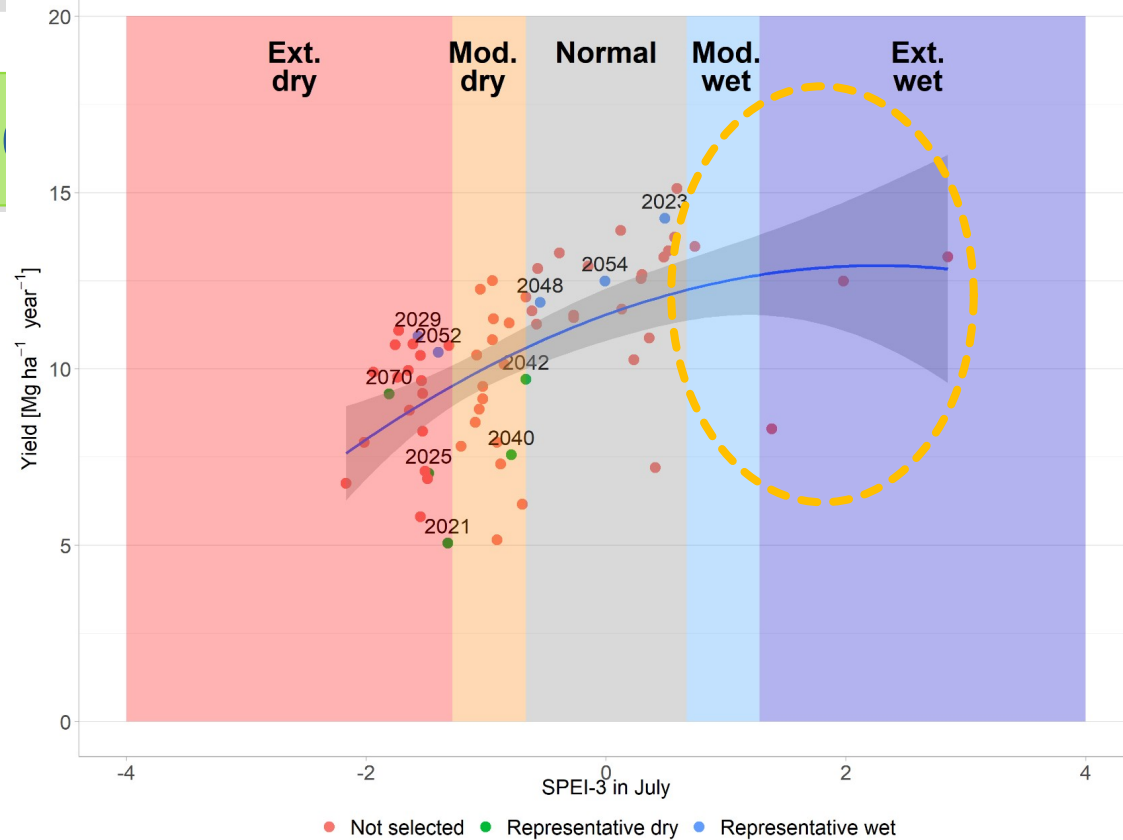
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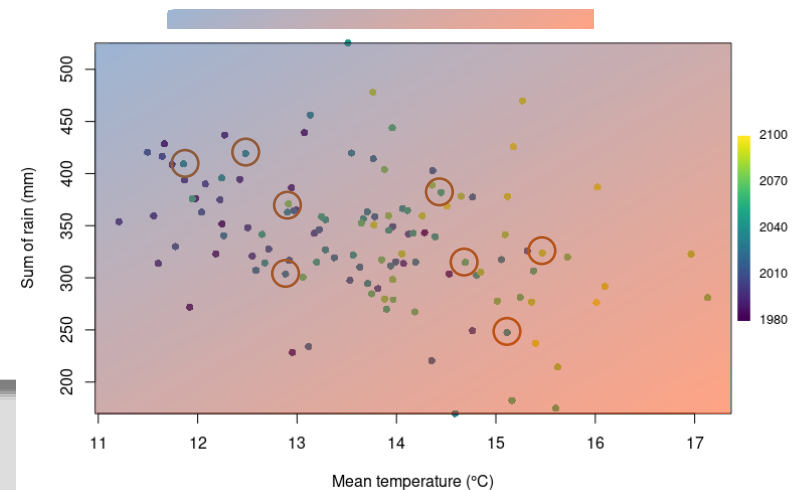
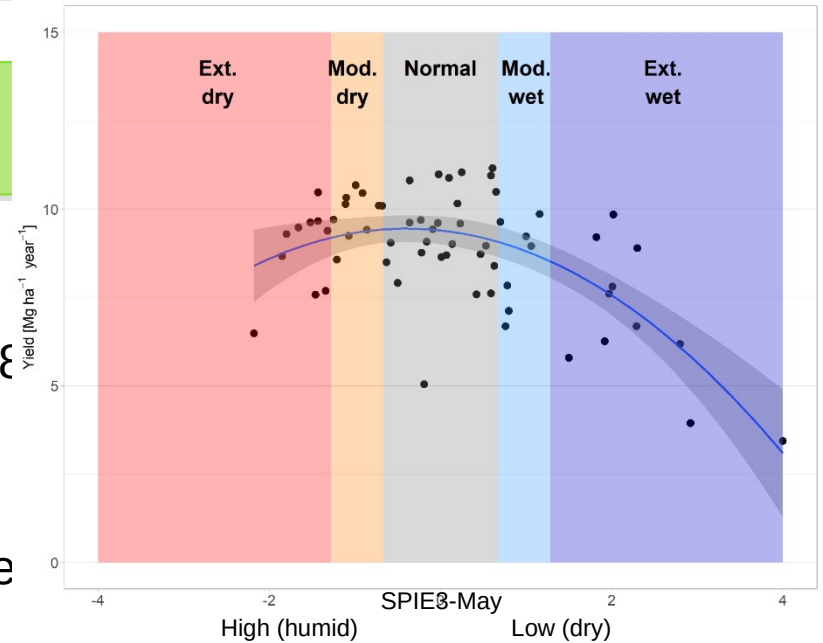
ECO³ – Meteorological con

- Methodology 2)
 - Run crop model on all the available data (1980 - 2100)
 - Find which SPEIs are best related to yield
 - Selection of the years close to percentiles 20 & 80 per period?
 - Five year step drive to inconsistencies...



ECO³ – Meteorological conditions

- Methodology 2b)
 - Run crop model on all the available data (1980-2100)
 - Find which SPEIs are best related to yield
 - Selection of years close to the representative curve ?
 - 2 ext. dry, 1 dry, 2 normal, 1 wet, 2 ext. wet
 - With a repartition in years → CO₂



Thank you for your attention

& thanks to the  **EcoFoodSystem** team