Incremental adaptation in crop management for integrated assessments of climate change impacts in Europe

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Background & methodology

Introduction

- Farmers are likely to make incremental adaptations in crop management by adjusting sowing dates and choosing longer season varieties in response to warming temperatures
- Failure to consider incremental adaptations can create negative bias in climate change impact studies
- Optimizing crop cultivar and sowing dates in the baseline period allows testing the assumption that the current management is optimal and can be used to indicate the limitations of management adaptions under future climates

Data and methods

- SIMPLACE<Lintul5> crop growth modelling framework simulated water-limited yields for grain maize, potato, silage maize, sugar beet, winter barley, winter oilseed rape, and winter wheat for the EU-27
- Simulation units are the spatial intersection of 13 environmental zones and 233 NUTSII administrative units (Fig. 1)
- Model performance was evaluated with historical yields from the Eurostat database (2010) for the period from 1982 to 2006 (Fig. 2)

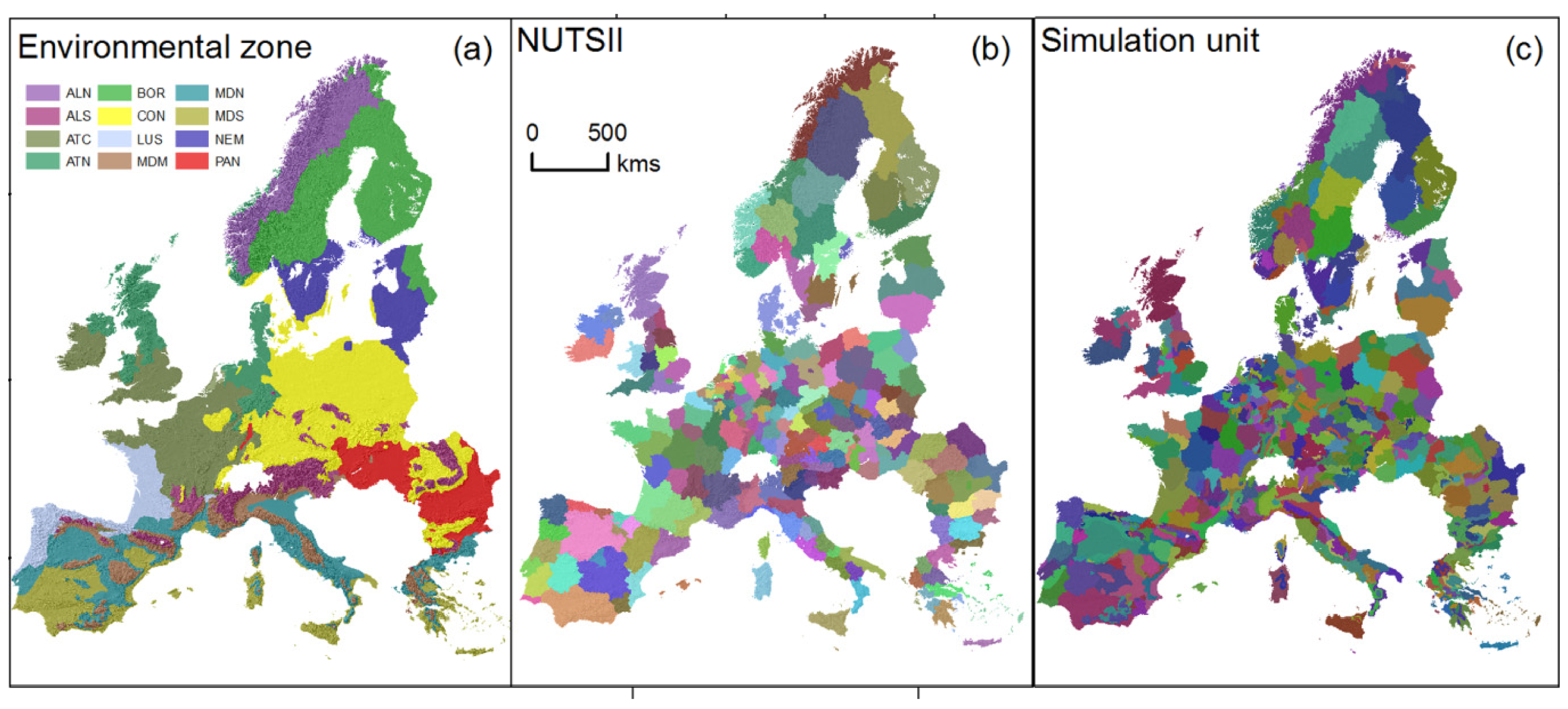
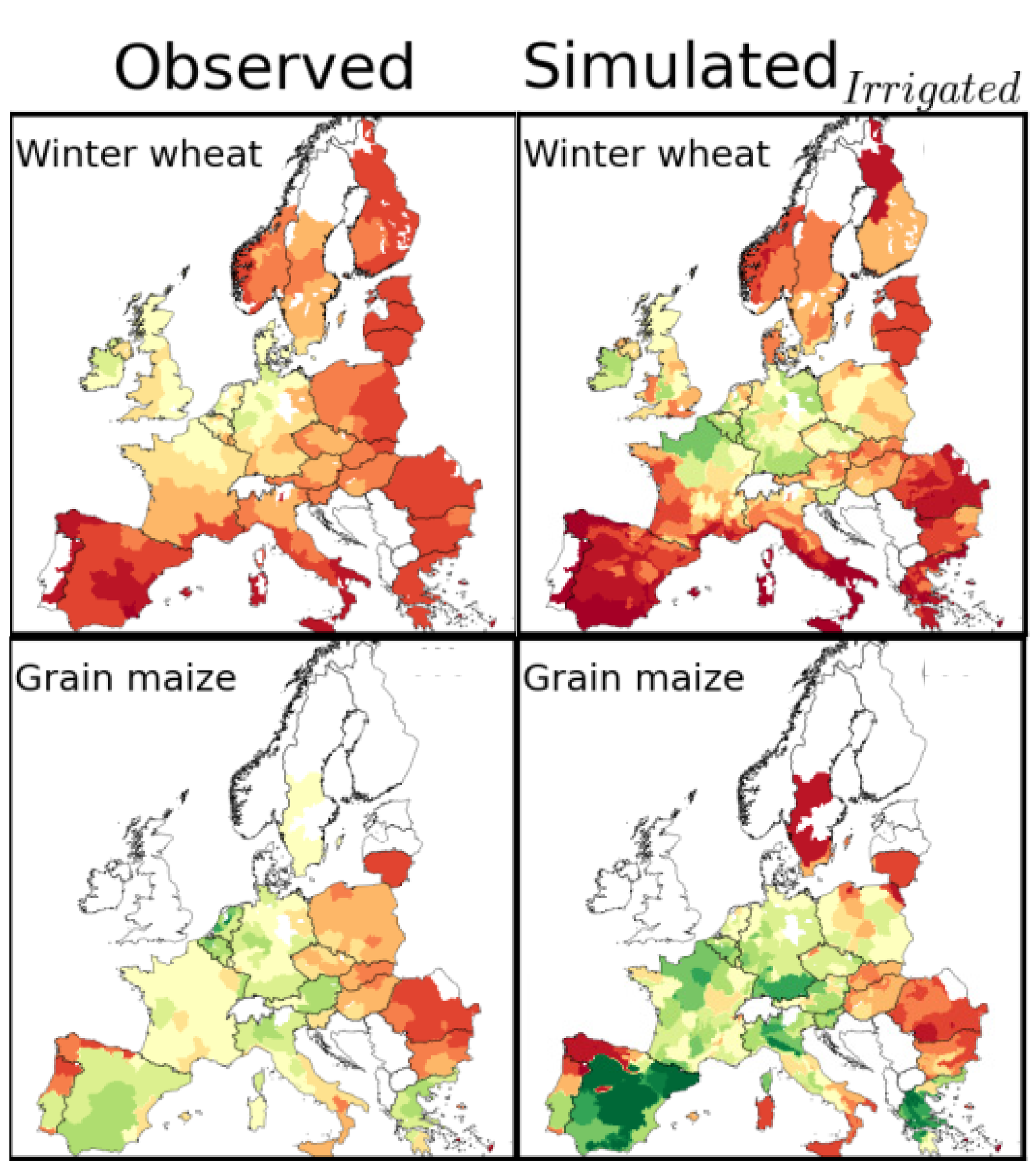


Figure 1. Schematic diagram of input and output aggregation (Zhao et al, in review).



- Climate data:
  - baseline (1982-2006)
  - SRES scenarios A1B1, B1 and B2 (2040-2064)
  - CO_2 (532, 487 and 478 ppm, respectively)
- Irrigation
  - weighted average of full irrigation and rainfed simulations based on the irrigated fraction of each crop in each NUTSII zone

Figure 2. Model evaluation for nitrogen-water limited simulations including current irrigation compared to average historical yields (1982 and 2006) (Zhao et al, in review)

Incremental adaptations evaluated

- crop cultivars with thermal time requirements (+30%, +20%, +10%, no change, -10% from default values)
- sowing dates (-30 days, -20 day, -10 days, no change, + 10 days from default values)
- evaluated for baseline and scenarios by selecting the combination with the highest yield on average over the simulation period

Results & outlook

Climate change impacts without adapted crop management

- Averaged across Europe, yields of spring sown crops are negatively affected by all three climate change scenarios, with yield changes between -14% to 6%. For winter cereals and rape seed, climate change results in yield increases of between 3% and 13%, with largest increases for A1B1.
- Average yield changes hide a great deal of spatial variability (Fig. 3)

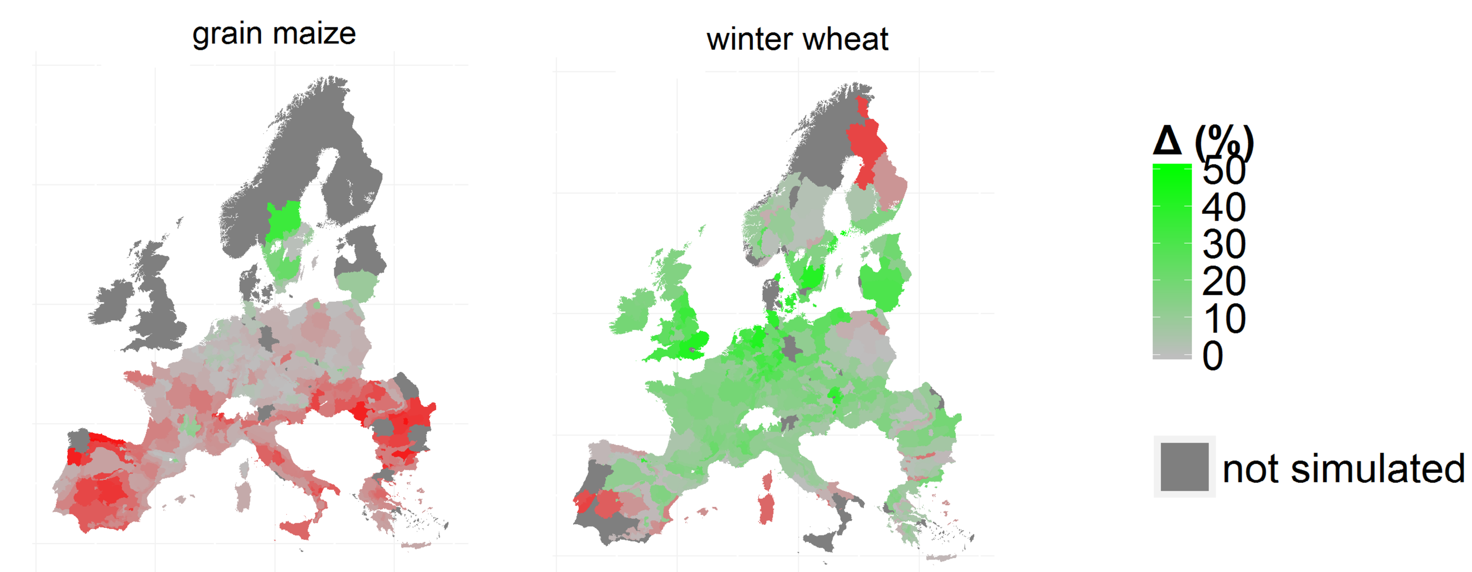


Figure 3. Relative yield changes in simulated rainfed yields over Europe due to climate change and elevated CO_2 levels in the A1B1 scenario for grain maize and winter wheat with no adaptations in crop management (Britz et al., in review)

Climate change impacts with adapted crop management

- Currently, sowing dates and cultivar characteristics are not optimized in the baseline period, due to factors constraining farmers not captured in the water-limited model (Table 1) with a slightly greater potential for current management improvement in Northern Europe (Fig. 4)
- To avoid an unrealistic view of how adaptation under future climate change could impact yields, these values were subtracted from the potential of the adaptations under the future climate scenarios, with the conservation assumption that the constraints remain constant (Table 2)

Table 1. Potential to increase yields in base period by optimizing sowing date and cultivar thermal time traits.

	Relative yield change (%) in base period
Barley	12.9
Silage maize	25.2
Grain maize	7.0
Potato	22.9
Rapeseed	9.2
Sugar beet	6.4
Wheat	10.0

Table 2. Europe-wide mean relative yield changes due to climate change and increased CO_2 in the A1B1 scenario with no adaptations (NA), adaptations relative to current management to give highest yields (ACB), and adaptation relative to optimal baseline sowing dates or cultivar thermal time traits to give highest yields (AOB).

Relative yield change (%) in A1BI scenario between 2004 and 2050			
	NA	ACB	AOB
Winter barley	7.4	26.5	13.6
Silage maize	-5.9	25.1	-0.1
Grain maize	-10.1	4.2	-2.8
Potato	-11.9	14.4	-8.5
Rapeseed	12.6	27.1	17.9
Sugar beet	3.2	16.5	10.1
Winter wheat	10.4	24.5	14.5

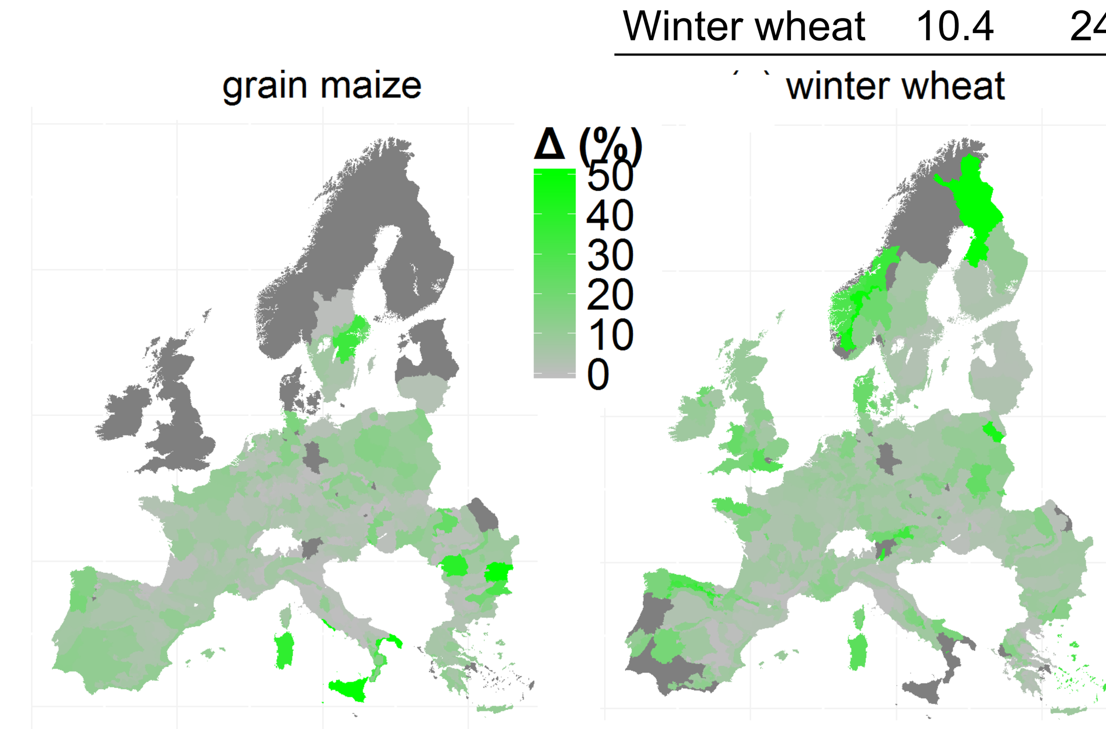


Figure 4. Relative yield changes in rainfed yields over Europe, if sowing dates and crop cultivars are optimized for the base period to give highest yields (Britz et al., in review)

- Accounting for crop management adaptations, and possible constraints to their adoption, is important to understand future climate change impacts
- These results indicate only yield changes associated with climate change, thought past yield changes have largely been explained by technological progress and improvements in yield potential

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