Importance of considering crop management adaptation in CC impact studies: A Pan-European integrated assessment

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Background

- Consideration of adaptation in integrated assessment (IA) of CC at large scale is limited
- Often restricted to economic modelling of crop acreages/production (often) and production intensity (sometimes)
- Adaptation of choice of varietes and sowing dates to changing climatic conditions only done at smaller scale without market feedbacks

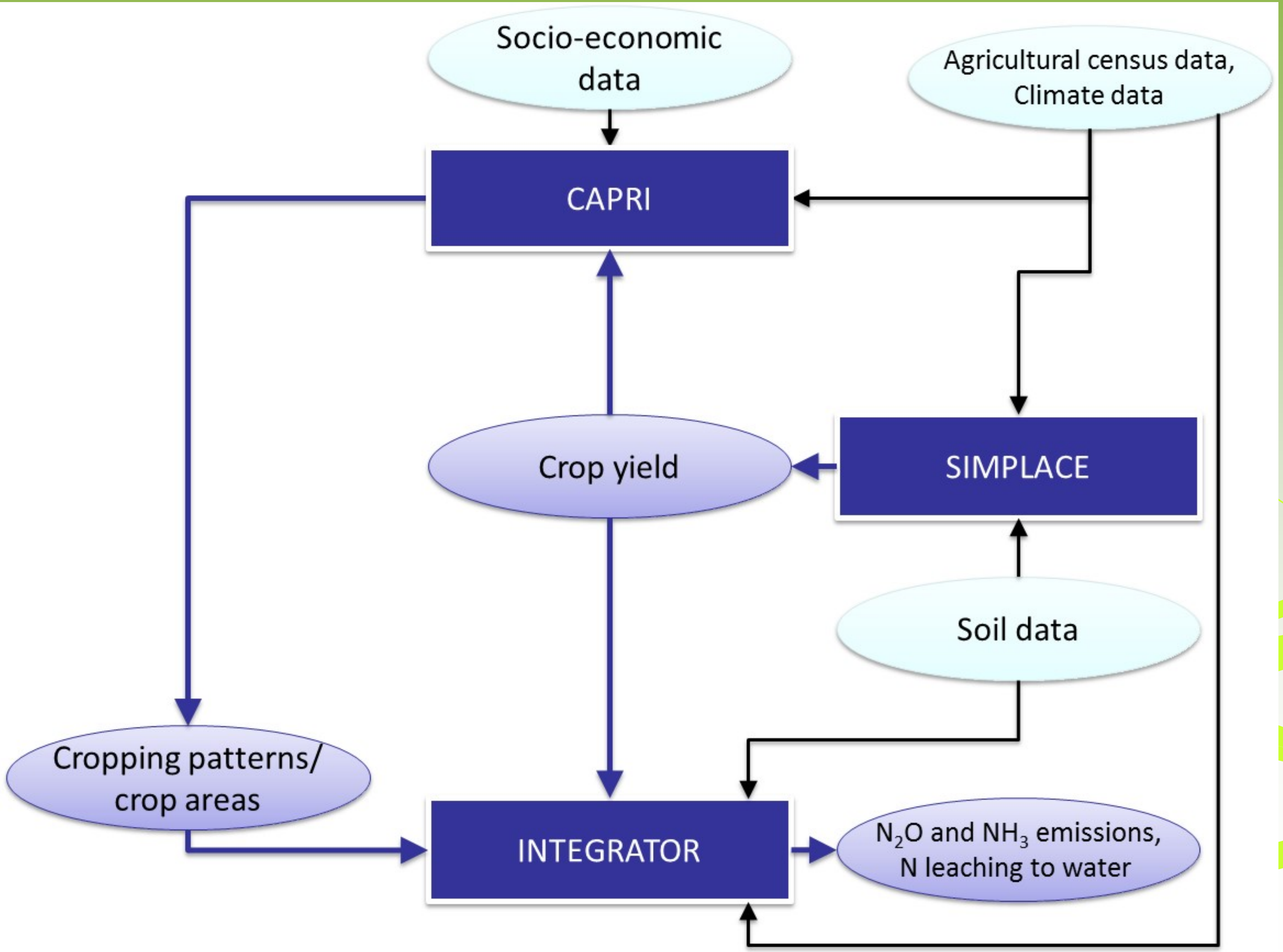
Objective

- Assessing the relevance of considering choice of variety and sowing dates for CC impacts
  - In the context of integrated biophysical-economic modelling at European scale
  - Under different CC scenarios
  - For results in simulation year 2050

Methodological approach

1. Estimation of robust yield trends from historic data
   - Capture technological progress not reflected in crop models
   - Projection adjusted according to CC scenario
2. Crop modelling of yield changes due to CC
   - Optimizing choice of variety and sowing date
   - Ex-post and for 2050
3. Adjusting yield changes towards 2050 to reflect CC and adaptation at crop management level
4. Running economic model based on simulated yield changes in 2050 w/o adaptation
5. Assessing differences in Nitrogen emission w/o adaptation

Model and data integration



Scenario description

	B1	B2	A1_B1
	[2050]	[2050]	[2050]
Exogenous assumptions	Inflation rate of 1.9% per year		
	Constant exchange rates		
	GDP and population: SRES B1 assumptions	SRES B2 assumptions	SRES A1B assumptions
Commodity Prices	Extrapolated from market outlooks (AGMIP)	Simulation results	
Input Prices	Oil price estimated as a function of GDP growth, input costs of agricultural activities updated according to energy cost share		

Scenario description

Yield (w/wo adaptations)	**SIMPLACE simulation (BCCR_BCM2_0/SRES B1)**	**SIMPLACE simulation (Pattern-scaled SRES B2 15-model ensemble mean),**	**SIMPLACE simulation (SRES A1B 15-model ensemble mean)**
Set-aside and quota policies	Abolishing obligatory set-aside, expiry of milk and sugar quotas		
Premium scheme	2009 Health Check (decoupled payment, increased modulation) [2]		
WTO trade policy	Tariffs and TRQ as in 2004		Trade policy adjustments as proposed by Falconer (2009)

Temperature thresholds

Table 2. Characteristics of the heat tolerant varieties evaluated as potential adaptations

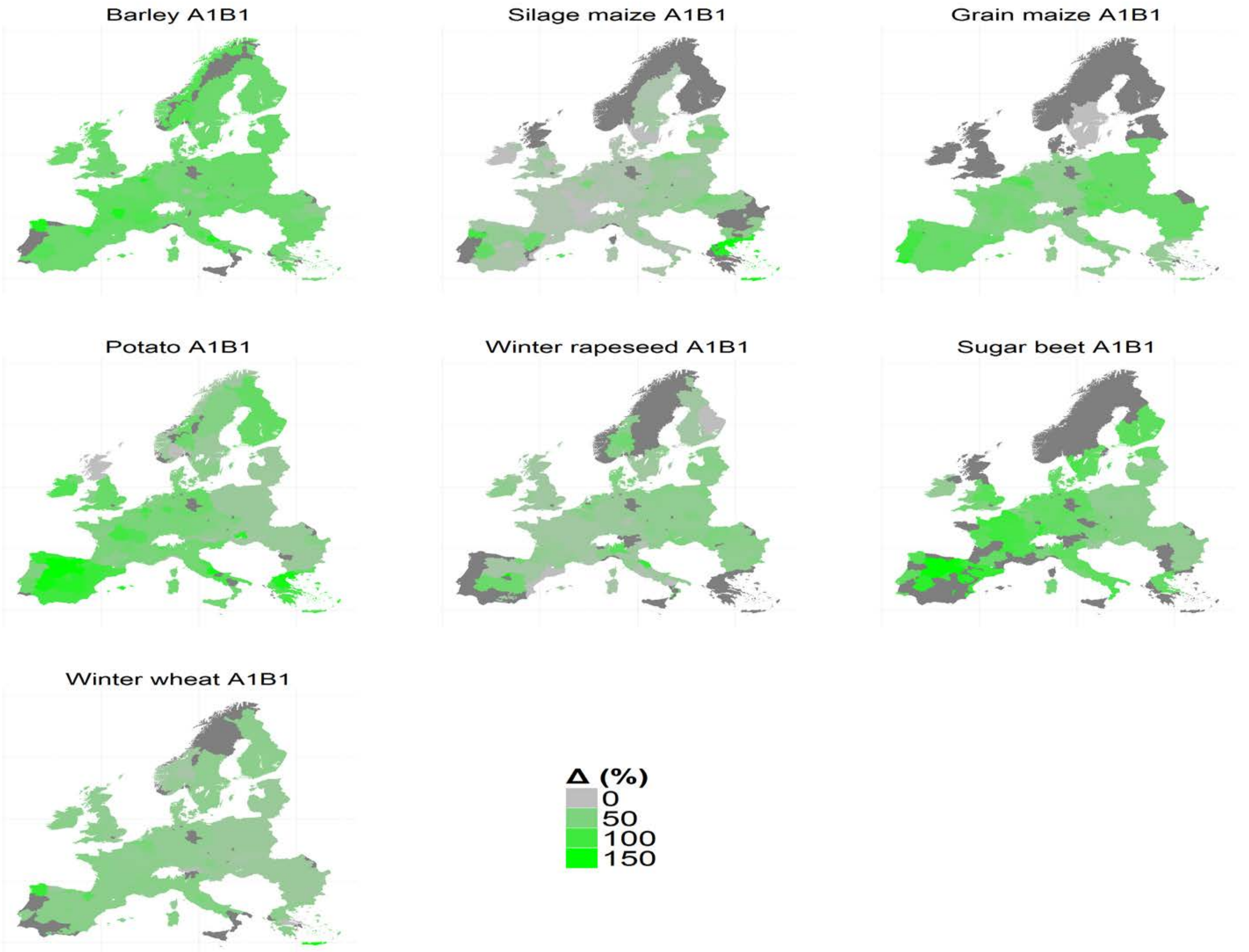
Crop	Current thresholds* critical and limit (°C)	Thresholds for tolerant variety critical and limit (°C)
Winter wheat	27 & 40	29 & 42
Winter barley	27 & 40	29 & 42
Grain maize	35 & 45	37 & 47
Silage maize	35 & 45	37 & 47

* the critical temperature threshold refers to the temperature below which there are no heat stress impacts on grain yield, while the limit temperature threshold refers to the temperature above which there is no grain yield

Results: average yield growth

(robust estimation B1 + adjustment for A1B1 and B2)

Annual growth rate (% p.a.)			
	A1B1	B1	B2
Barley	0.78	0.66	0.42
Silage maize	0.33	0.33	0.12
Grain maize	0.70	0.66	0.30
Potato	0.39	0.43	0.06
Rapeseed	0.80	0.67	0.46
Sugar beet	0.93	0.81	0.50
Wheat	0.82	0.71	0.46


Barley A1B1
Silage maize A1B1
Grain maize A1B1
Potato A1B1
Winter rapeseed A1B1
Sugar beet A1B1
Winter wheat A1B1
Δ (%)
0
50
100
150

CC and CO_2 impacts on water limited yields

Relative yield changes between 2004 and 2050 (%), European average									
	A1B1			**B1**			**B2**		
	No adap-tation	Opt Only 2050	**Opt**	**No adap-tation**	Opt Only 2050	**Opt**	**No adap-tation**	Opt Only 2050	**Opt**
Barley	**7.4**	26.5	**13.6**	**7.1**	26.8	**13.9**	**2.6**	20.8	**7.9**
Silage maize	**-5.9**	25.1	**-0.1**	**-1.5**	27.6	**2.4**	**-6.0**	24.6	**-0.6**
Grain maize	**-10.1**	4.2	**-2.8**	**-2.9**	7.3	**0.3**	**-9.7**	4.0	**-3.0**
Potato	**-11.9**	14.4	**-8.5**	**-3.9**	21.4	**-1.5**	**-13.7**	11.3	**-11.6**
Rapeseed	**12.6**	27.1	**17.9**	**10.9**	24.2	**15.0**	**7.1**	20.7	**11.5**
Sugar beet	**3.2**	16.5	**10.1**	**4.9**	14.0	**7.6**	**-0.5**	11.9	**5.5**
Wheat	**10.4**	24.5	**14.5**	**10.9**	24.3	**14.4**	**5.6**	18.8	**8.8**

Adjustments in farm management and markets

- Farms change crop composition towards crops with (relative) favourable yield developments
- Market price reactions counteract yield effects → considerable moderation of impacts
- Comparing results for 2050 w/o adaptation
  - Crop acreage shares deviate not much (Rye -2.1% is strongest relative change)
  - Production quantities increase with adaptation (most for other cereals and fodder maize at 4%)
  - Price drop never more than -5% (sugar); oilseed at -3% and -2% for cereals;

Conclusions

- Yield changes due to „technological progress“ on average more important than CC and CO_2 impact
- Simple crop management adaptation matters a lot for simulated CC/CO_2 related yield changes
- European averages hide considerable regional differences
- Market feedbacks moderate differences in crop shares, production, prices w/o adaptation
- Limitations
  - Adaptation not reflected for non-European part of the world → relevance of adaptation for market impacts underestimated
  - Limited understanding of yield trend development