Leibniz Centre for Agricultural Landscape Research (ZALF)

Site specific impacts of climate change on crop rotations and their management in Brandenburg/Germany

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BONARES

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Introduction

- Arable use of soils often result in problems with nitrogen emissions and soil degradation, e.g., loss in soil organic matter.
- Crop rotation, residue management and fertilization management have effects on soil carbon storage, water and nitrogen dynamics and crop yields on short to long term.
- Irrigation would be an option to stabilize yields under higher summer drought probability.
- Cover crops can reduce nitrogen load of seepage water to preserve water quality.
- Todays best management practices might not be best under future climate conditions.
- Modelling soil-crop-atmosphere interactions can be used to assess the multi-criteria performance of crop rotation designs and management.

Soil quality group specific crop rotations

SQG1 high soil rating

CR1	CR2	CR3	CR4	CR5
WWE	WWE	WWE	WWE	WWE
			RP	RP
WBa	WBa	WRA	SMA	SMA
		RP	ORa	ORa
WRA	WRA	SMA	WRye	TRI
		ORa		
WWE	WWE	SBt	Gra	AA
	ÖL			
	LUP	Pot	Gra	AA

SQG2 good soil rating

CR1	CR2	CR3	CR4	CR5
WBa	WWE	WWE	WRye	WRye
			RP	RP
WRA	WRA	WRA	SMA	SMA
		RP	ORa	ORa
WWE	WWE	SMA	WWE	TRI
		ORa		
WRye	WRye	SBt	Gra	AA
RP	RP			
SMA	SMA	Pot	Gra	AA
ORa	ÖL			
	LUP			

SQG3 medium soil rating

CR1	CR2	CR3	CR4	CR5
WBa	WWE	WWE	WRye	WRye
			RP	RP
WRA	WRA	WRA	SMA	SMA
		RP	ORa	ORa
WRye	WRye	SMA	WRye	TRI
		ORa		
WRye	WRye	SBt	Gra	AA
RP	RP			
SMA	SMA	Pot	Gra	AA
ORa	ÖL			
	LUP			

CR1 =most common crops
CR2 = dto. with lupins + demand crop
CR3 = irrigated (value) crops
CR4 = focus fodder (gras) and cereals
CR5 = like CR4 replace gras by alfalfa

With/without catch crops (CC1-5)
With/without irrigation
Shifted replications -> crop every year

SQG4 fair soil rating

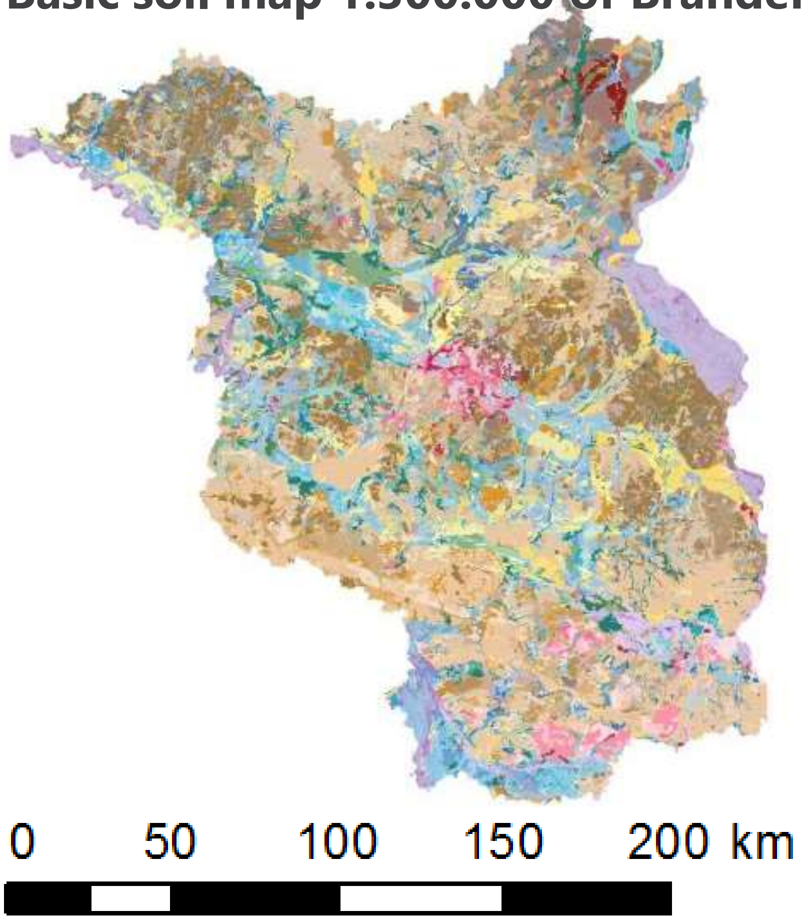
CR1	CR2	CR3	CR4	CR5
WRye	WBa	WWE	WRye	WRye
			RP	RP
WRye	WRye	WRA	SMA	SMA
		RP	ORa	ORa
WRye	WRye	SMA	WRye	TRI
RP	RP	ORa		
SMA	SMA	SBt	Gra	AA
ORa	ÖL			
	LUP	Pot	Gra	AA

SQG5 poor soil rating

CR1	CR2	CR3	CR4	CR5
WRye	WBa	WWE	WRye	WRye
			RP	RP
WRye	WRye	WRA	SMA	SMA
		RP	ORa	ORa
WRye	WRye	SMA	WRye	TRI
RP	RP	ORa		
SMA	SMA	SBt	Gra	AA
ORa	ÖL			
	LUP	Pot	Gra	AA

Data base and study design

Basic soil map 1:300.000 of Brandenburg



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99 legend units containing 276 soil types

Each legend unit has several soils with their percentage

soil profiles selected for each unit to cover at least 66%

each soil type was assigned to soil quality rating 1-5

Groundwater levels are derived from Gr horizon depth

Intersected with 25x25 km climate grids (67)

Simulation of 30 years of individual combinations of
soil type,
climate grid
crop rotation x starting crop

Area weighted average of outputs for each legend unit according to contribution of each soil type

In total **146.156 combinations for each scenario**

Scenarios: **Baseline, HAD and MPI** with RCP 2.6/4.5/**8.5**

Two time slices to represent 2055 and 2085

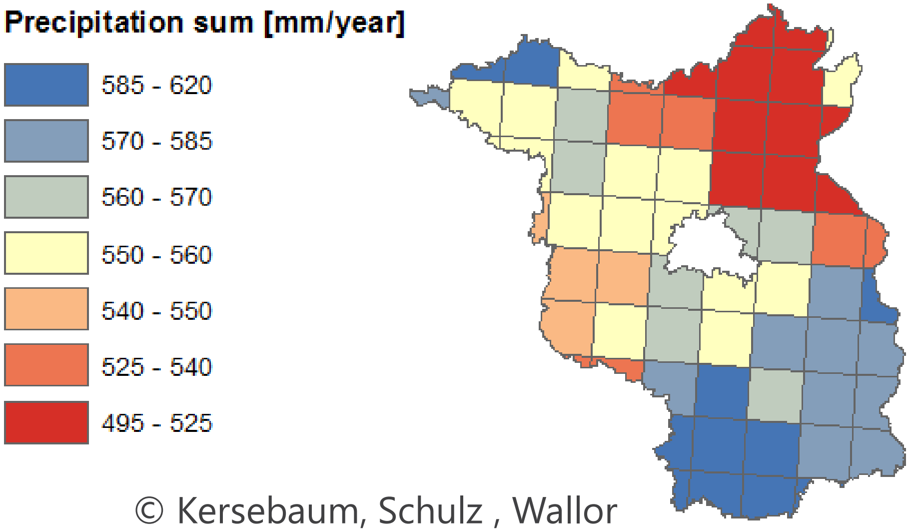
Modelling with **HERMES2Go**

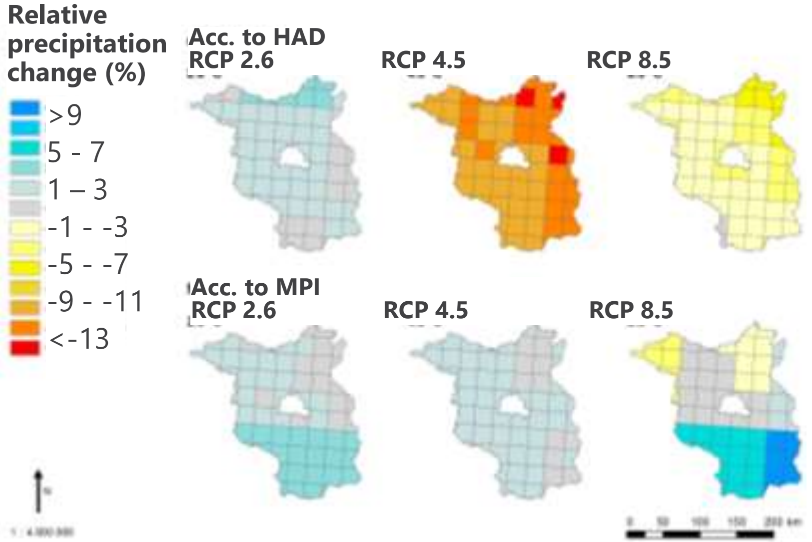
Baseline climate and projected changes

Scenario	Tmean °C	Prec_mean mm/year	T_DJF °C	T_MAM °C	T_JJA °C	T_SON °C	Prec_DJF mm	Prec_MAM mm	Prec_JJA mm	Prec_SON mm	Hotdays days/year
Baseline	**9.5**	**557.1**	**0.9**	**9.1**	**18.1**	**9.7**	**121.0**	**128.7**	**182.7**	**124.7**	**7.7**
	Absolute changes compared to baseline										
HAD26 2055	1.8	10.4	0.8	1.2	2.3	2.0	0.7	-2.0	6.0	1.0	14.2
MPI26 2055	0.9	11.5	0.8	0.6	0.9	0.9	8.0	1.2	3.6	-3.0	5.3
HAD45 2055	3.0	-59.8	2.9	1.6	3.7	2.7	15.0	-3.9	-57.9	-11.5	27.5
MPI45 2055	1.5	9.2	1.5	1.1	1.7	1.4	17.8	0.9	-16.0	5.1	9.7
HAD85_2055	3.4	-17.2	3.0	1.9	4.2	3.7	19.2	1.2	-41.0	1.5	30.1
MPI85_2055	1.7	12.2	1.8	0.9	2.1	2.0	19.7	6.8	-16.3	-2.9	12.5
HAD85_2085	5.7	-31.8	4.9	4.2	7.3	6.2	34.7	11.9	-72.8	-5.6	59.8
MPI85_2085	3.1	3.1	3.3	2.3	3.6	3.3	20.1	12.3	-39.7	10.4	25.5

Baseline: 1980 – 2010

2055: 2040 – 2070 **2085:2070 - 2100**


Precipitation sum [mm/year]



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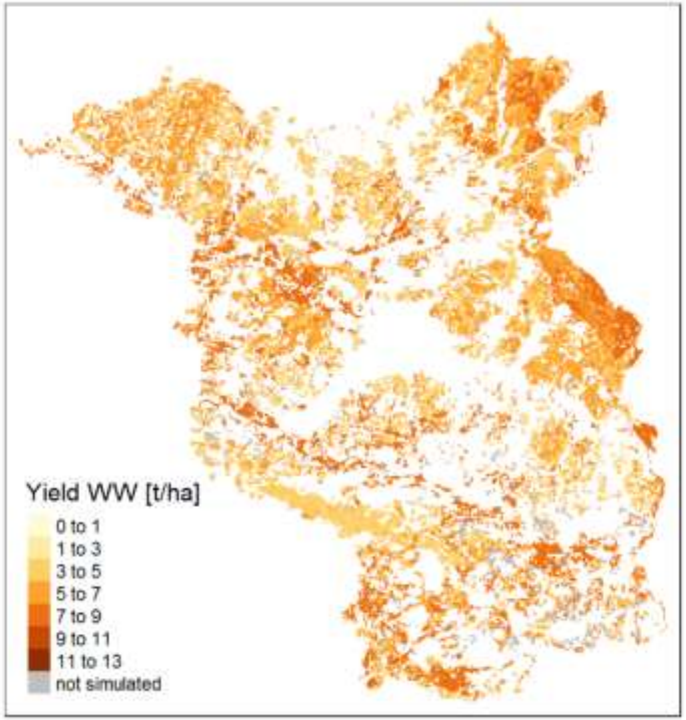
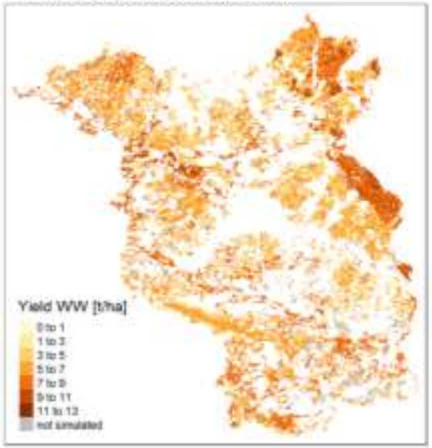
Current and projected winter wheat yields

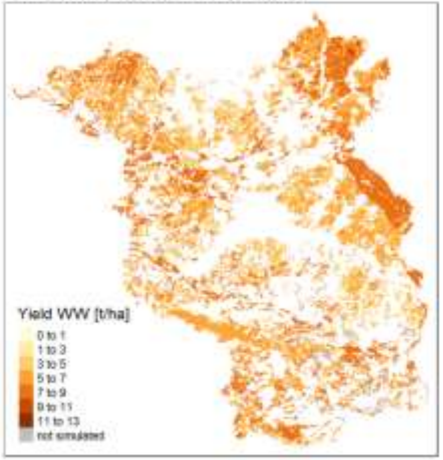
Baseline



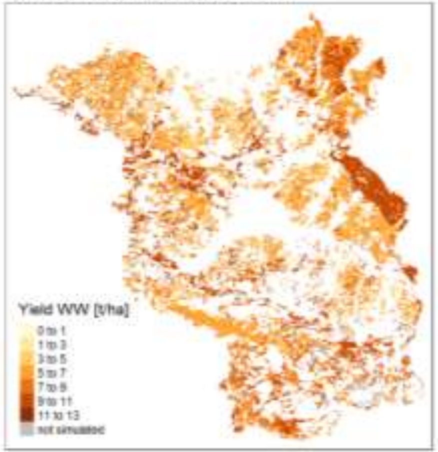
HAD 8.5 Scenario **(2055)**



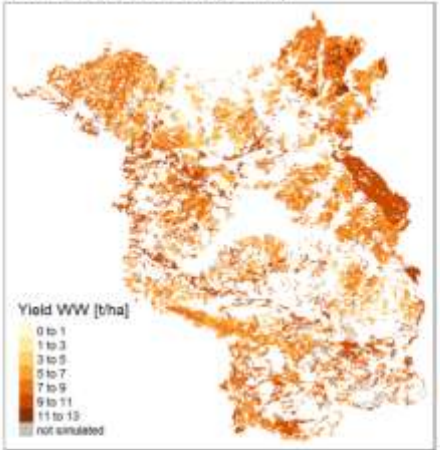
HAD 8.5 Scenario **(2085)**



MPI 8.5 Scenario **(2055)**



MPI 8.5 Scenario **(2085)**



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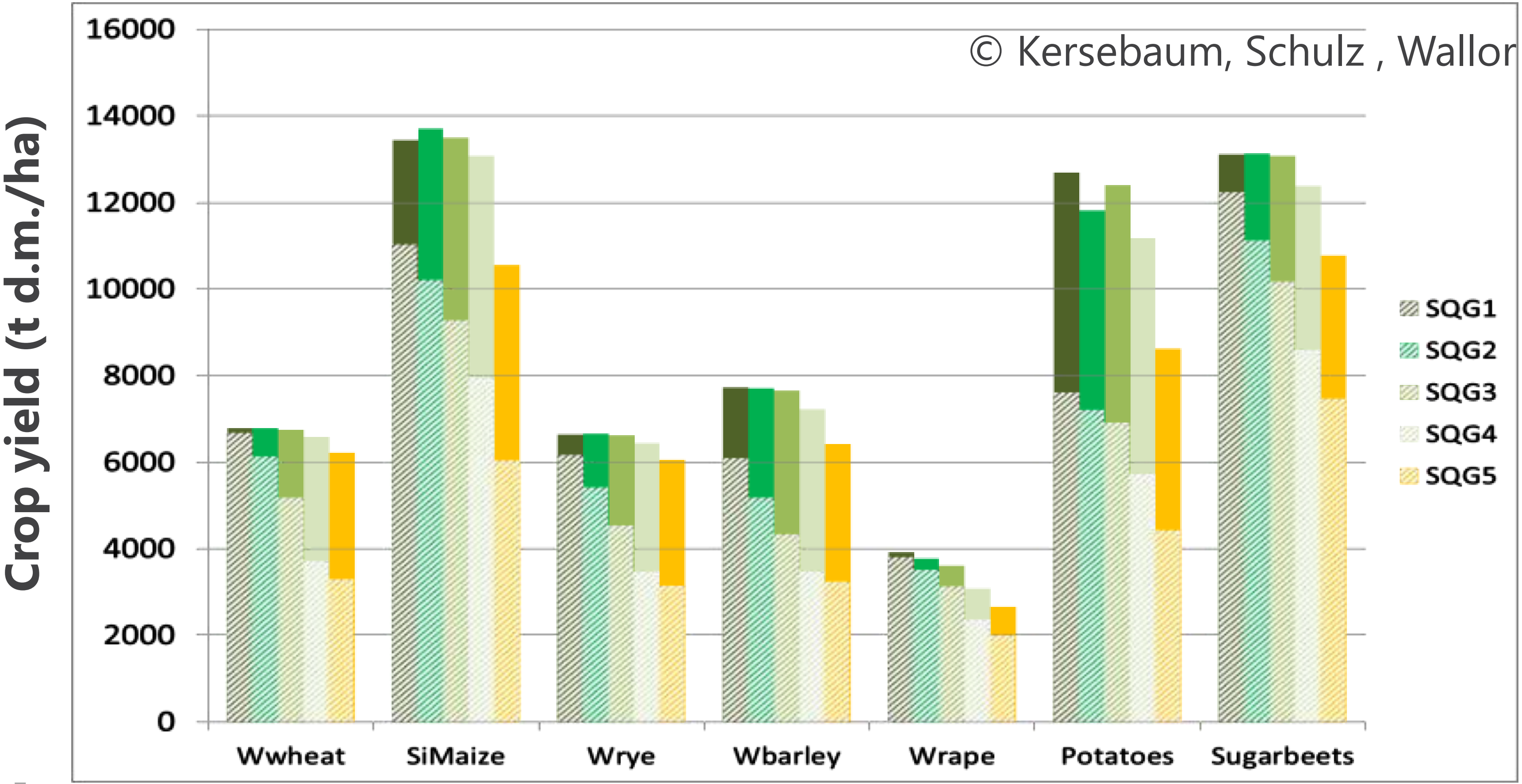
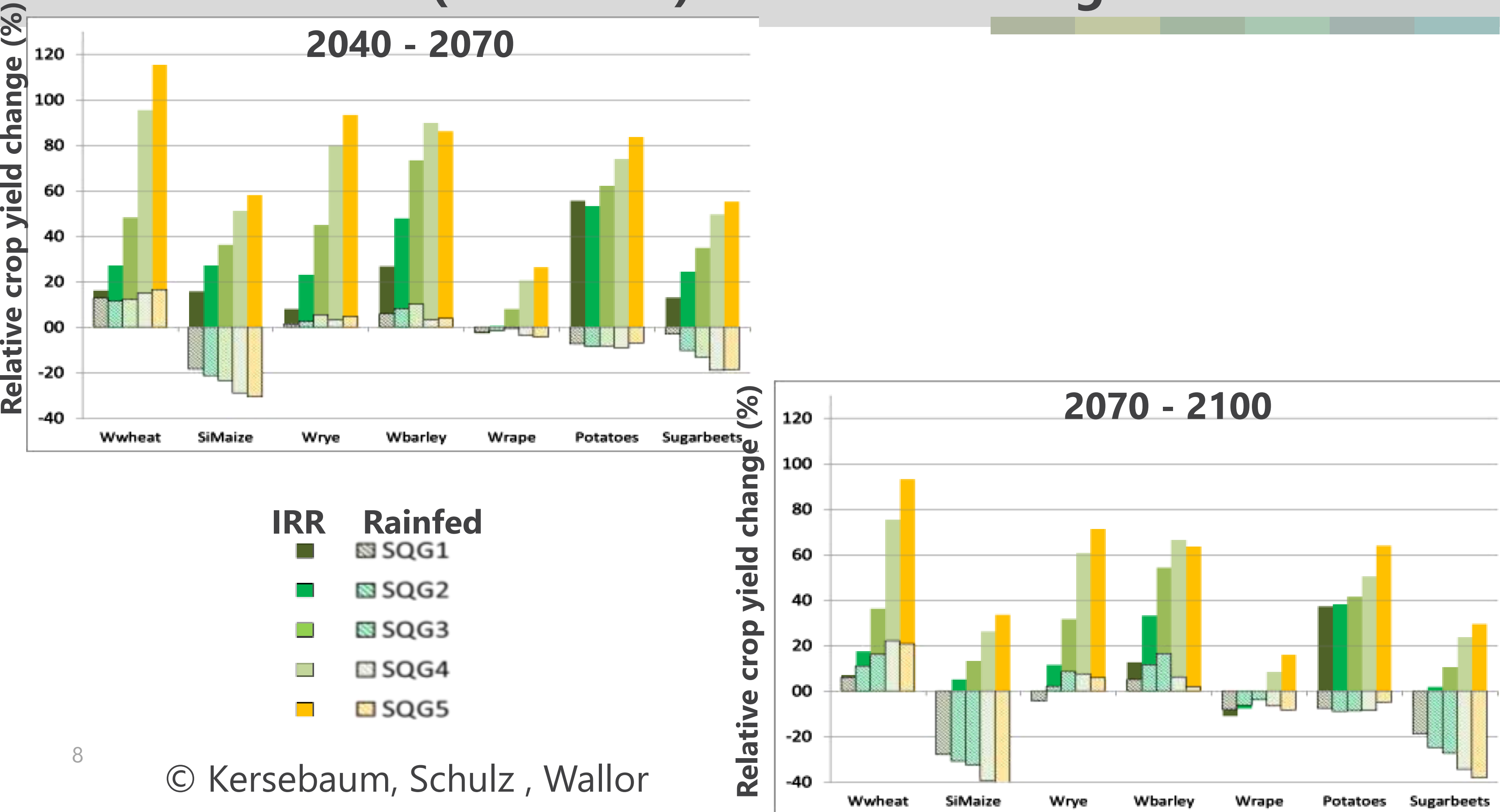
Crop yields during baseline phase with (solid bars) and without irrigation



SQG (soil quality group) 1 (good) – 5 (poor) soils

Relative changes of crop yields for HAD 8.5 climate scenarios with (solid bars) and without irrigation



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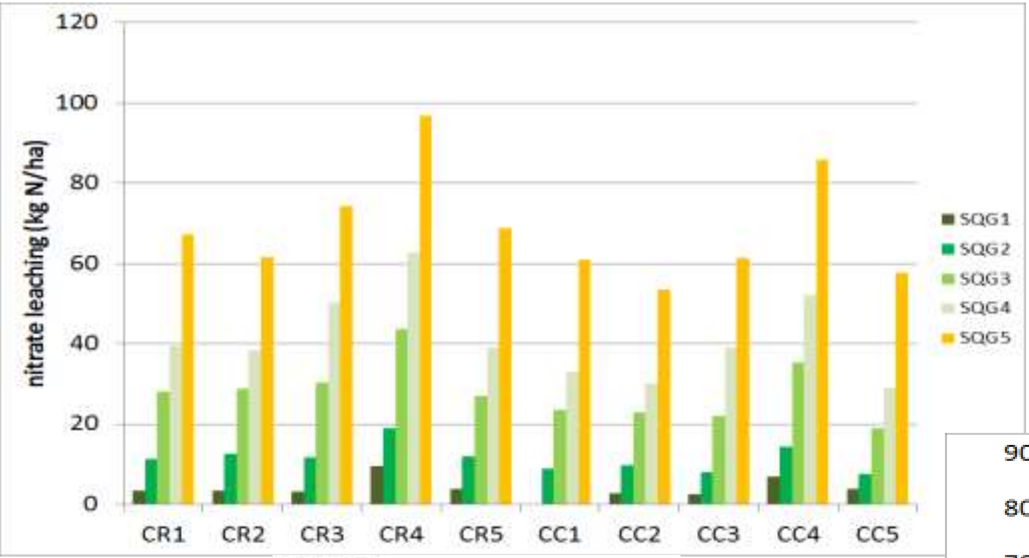
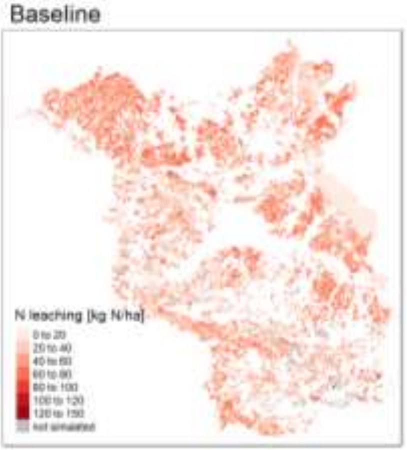
Current and projected future nitrate leaching





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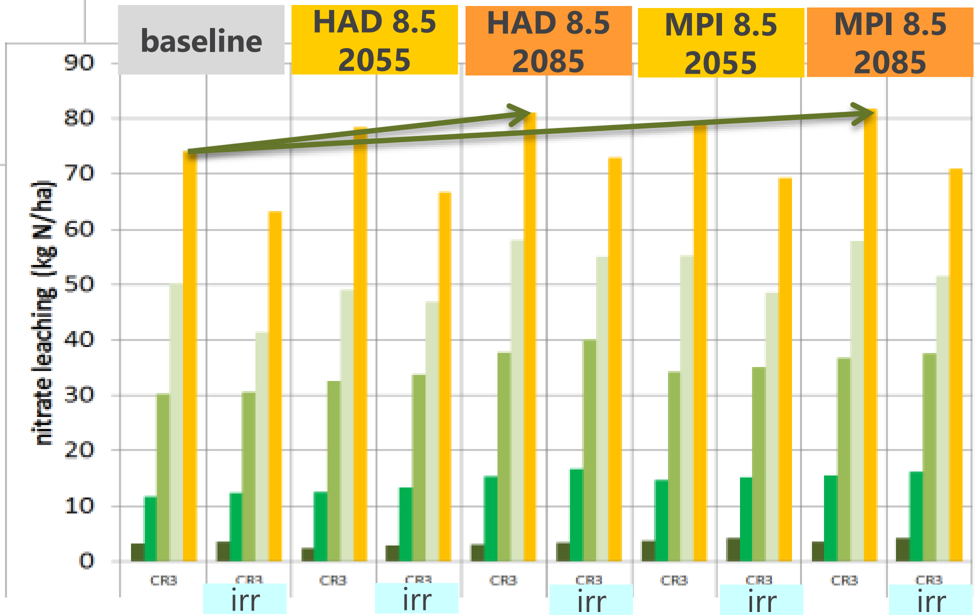

Summary

- The differences in crop yields among rotations seem to be rather small since differences in nitrogen availability are compensated by an automatic fertilization algorithm.
- The effect of climate change was mostly beneficial for winter crops due to higher water availability during their main growing season, while summer crops like maize and potatoes were strongly affected by increasing summer drought risk.
- Consequently, irrigation was most effective for summer crops on poor soils with low water holding capacity, but also on early autumn sown crops as winter oilseed rape.
- Nitrogen leaching decreased mainly on poor soils under irrigation due to a better NUE, but increased under both climate change scenarios due to higher winter precipitation and higher winter mineralization.