Uncertainties in climate change impact predictions

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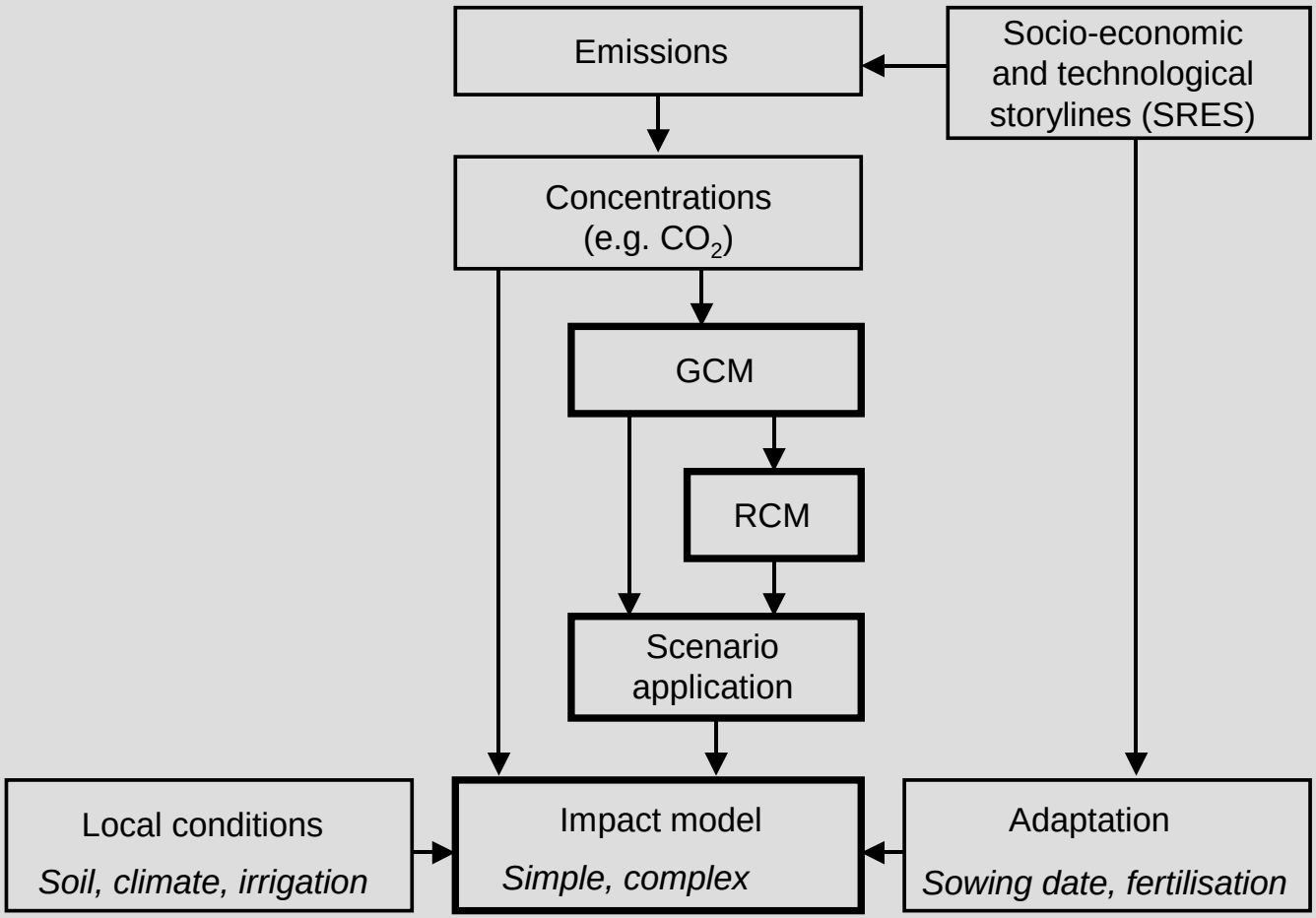
Importance of uncertainties

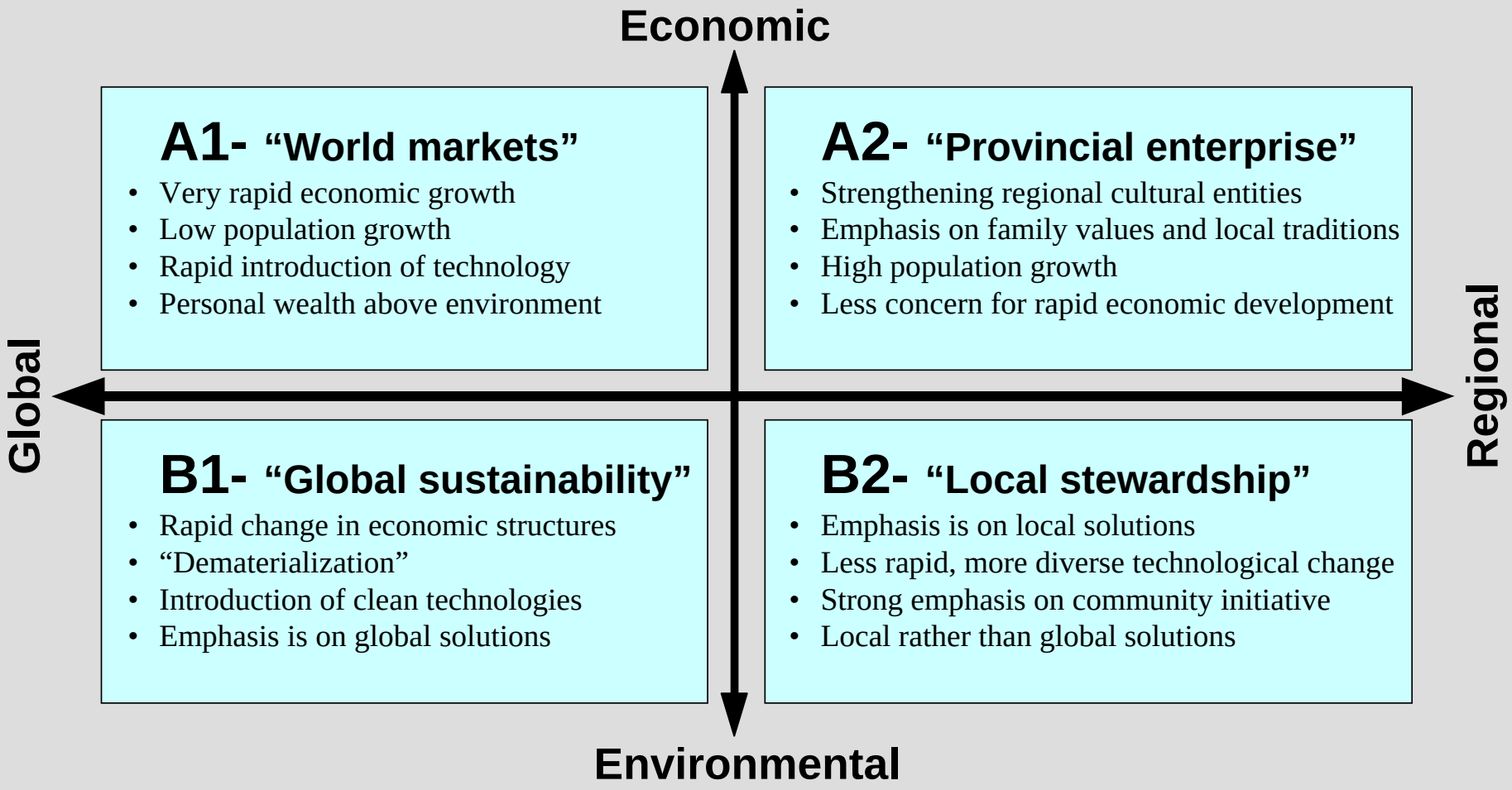
- ✓ Policy decisions and support for them depend on anticipations of future – and on percieved effects of policy measures
- ✓ Anthropogenic climate change has long lead times
- ✓ Many different factors will determine the effect of climate change on future society and human well-being
- ✓ Can we quantify the uncertainty of impacts?



Sources of uncertainty in impact projection

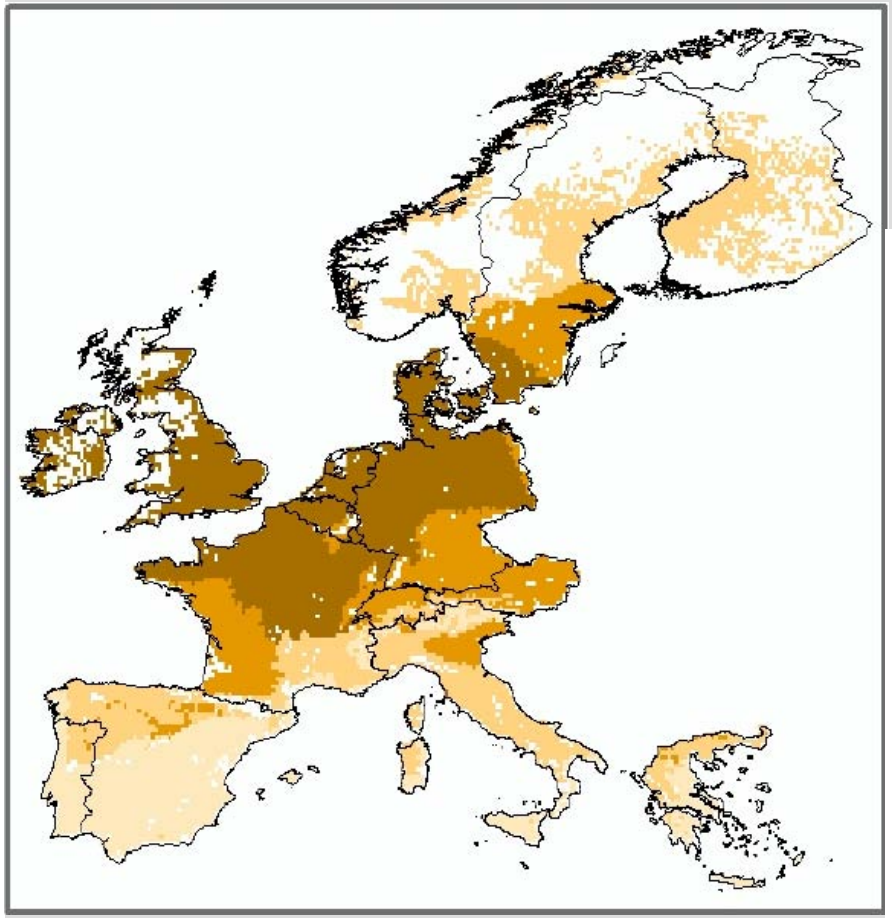


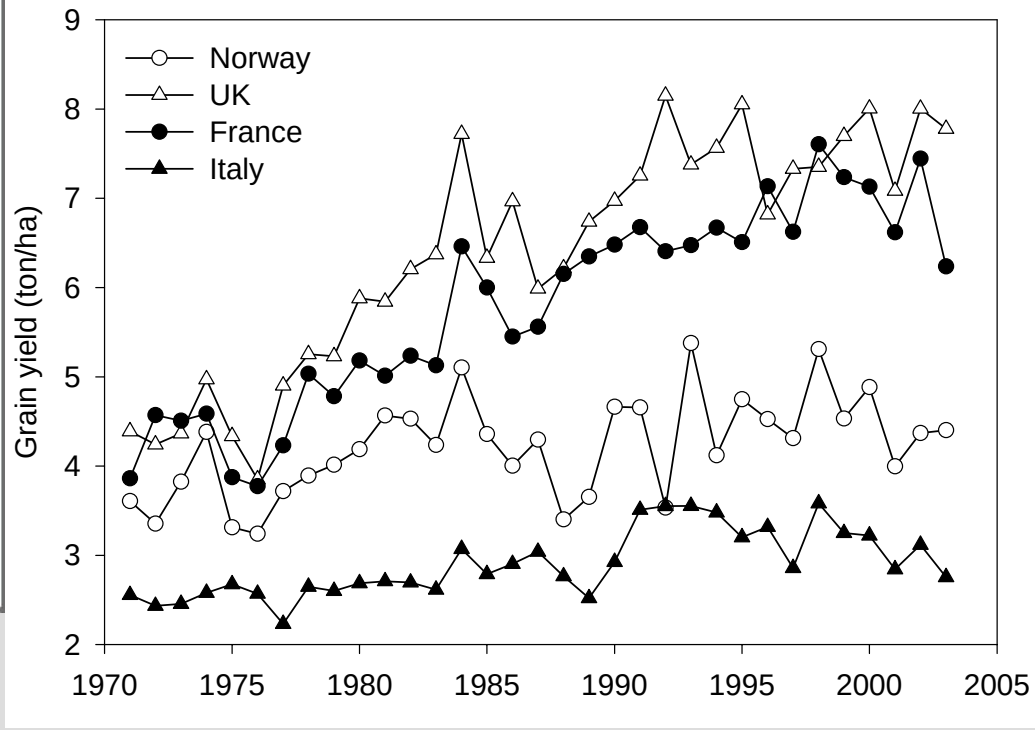
Characteristics of marker SRES scenarios



IPCC Special Report on Emission Scenarios (SRES)

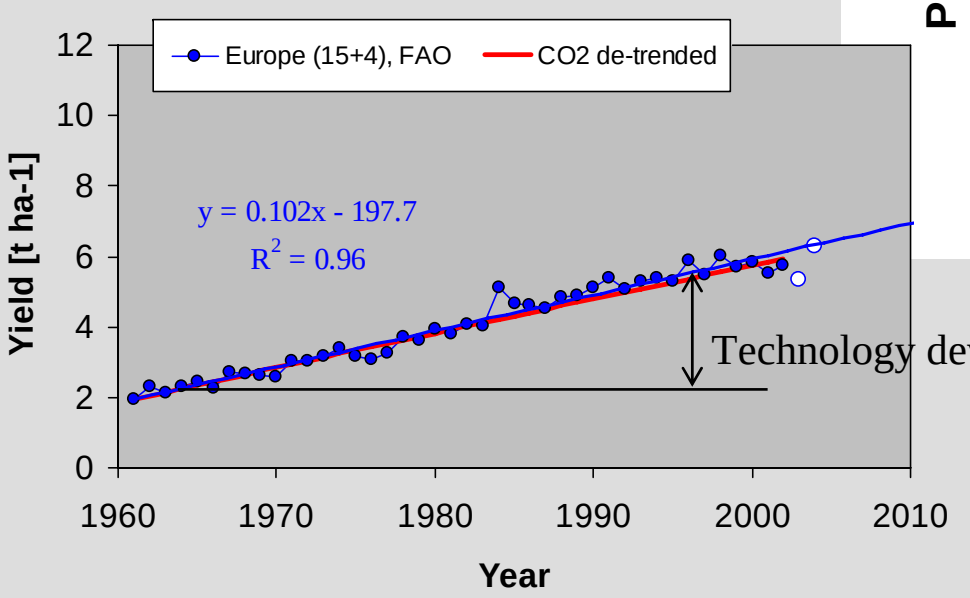
Wheat yields in EU



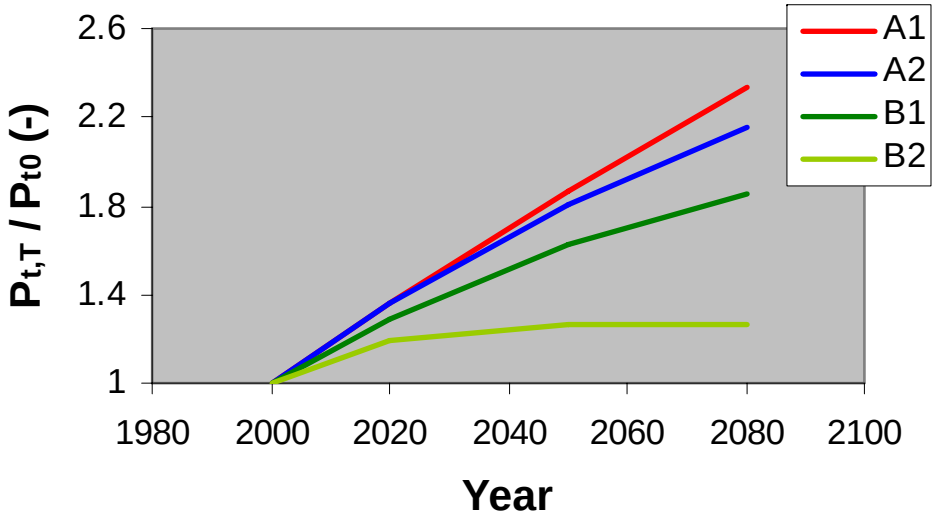


Projection of technology trends (wheat yields)

Historic yield trends (wheat)

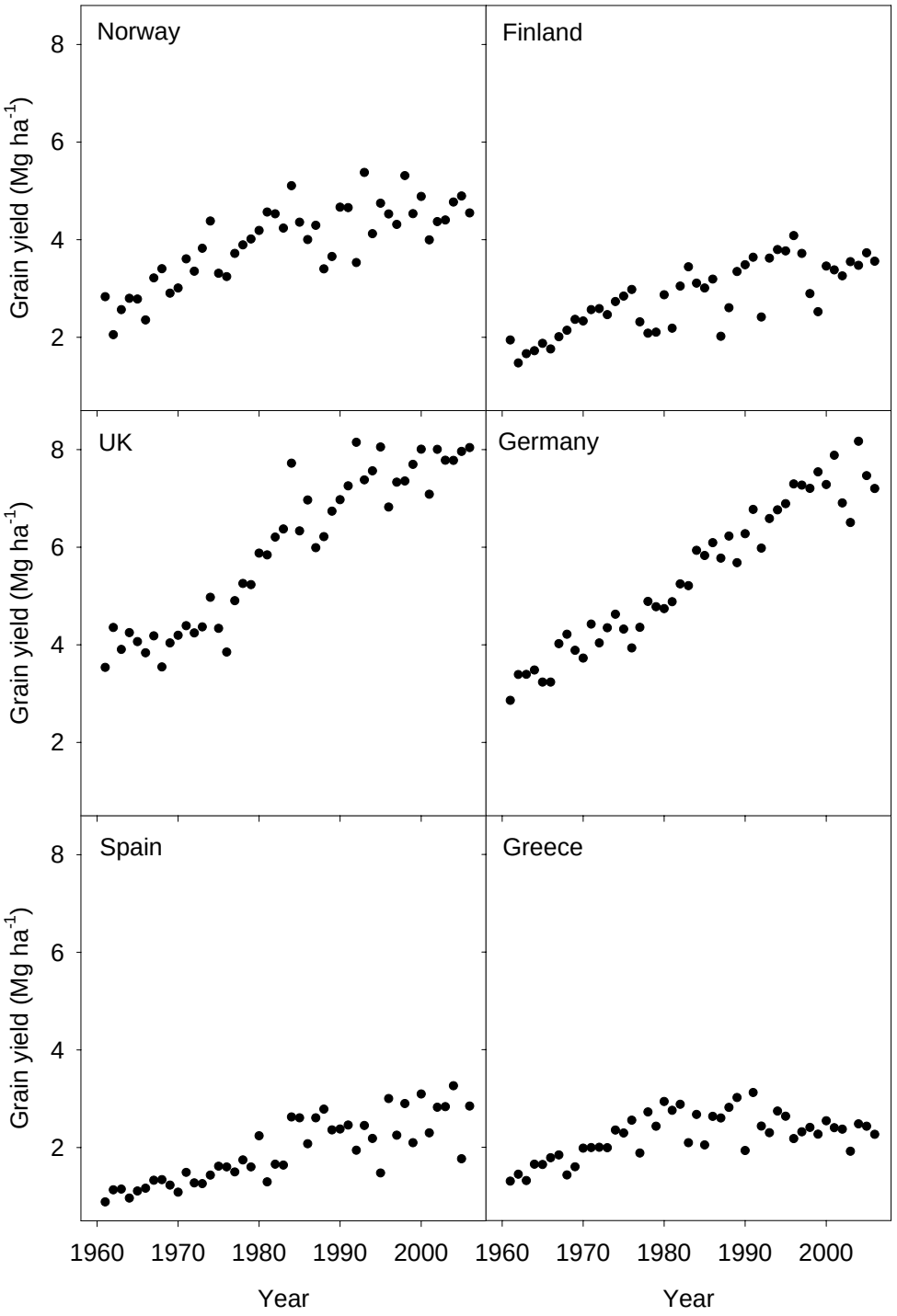


Assumed future technology effects

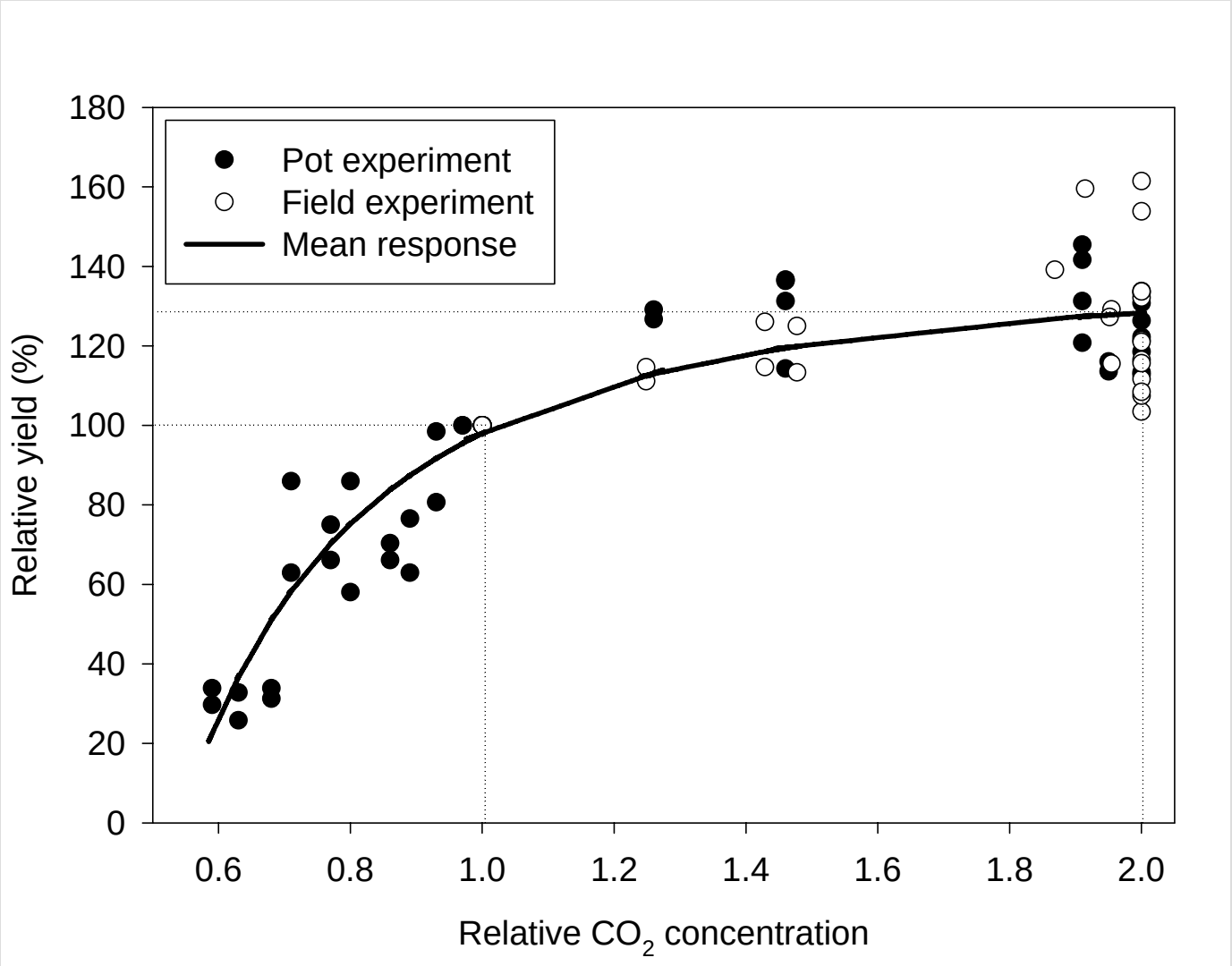


ATEAM

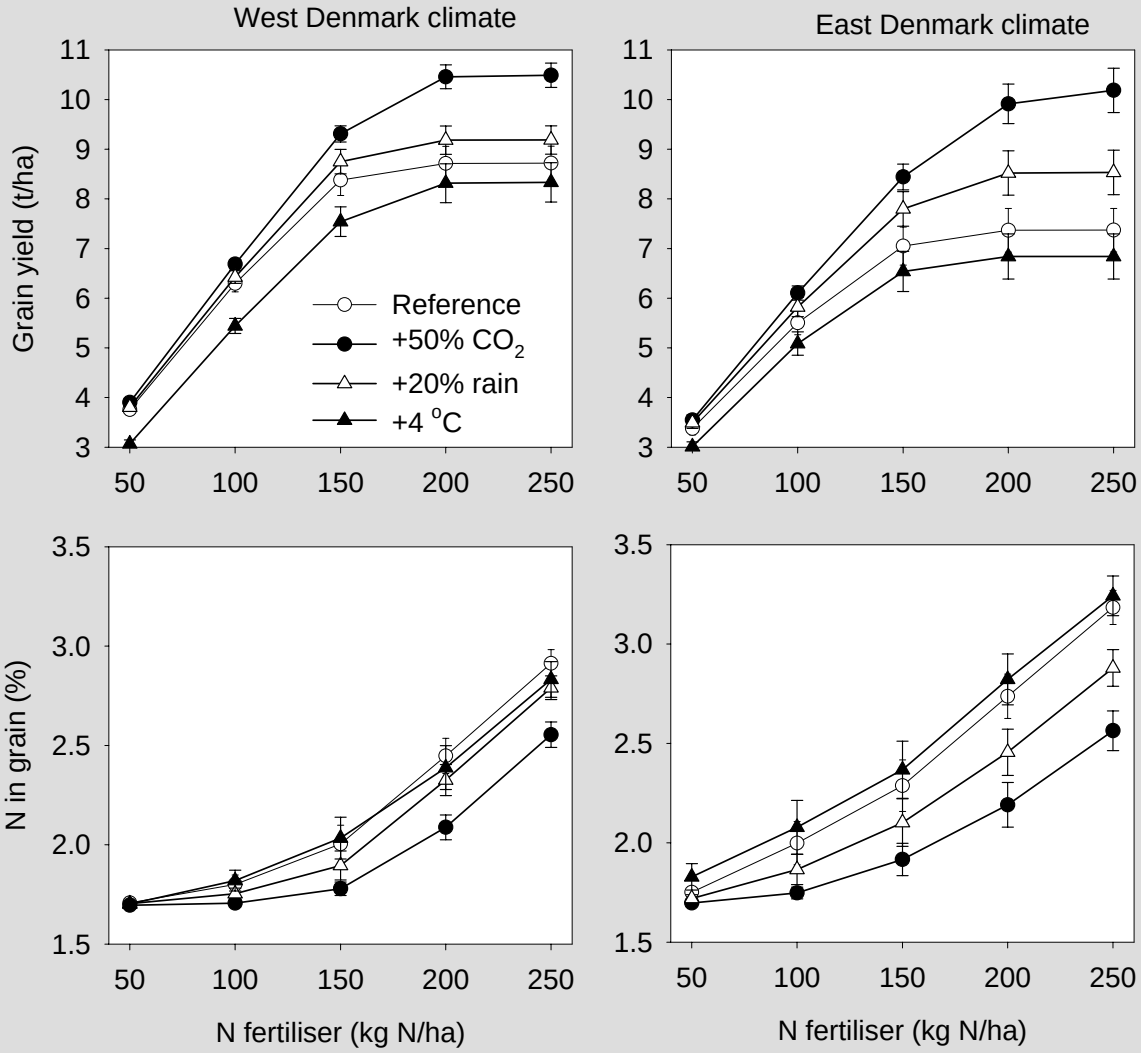
Wheat yields in Europe



Wheat yield at increasing CO_2 concentration

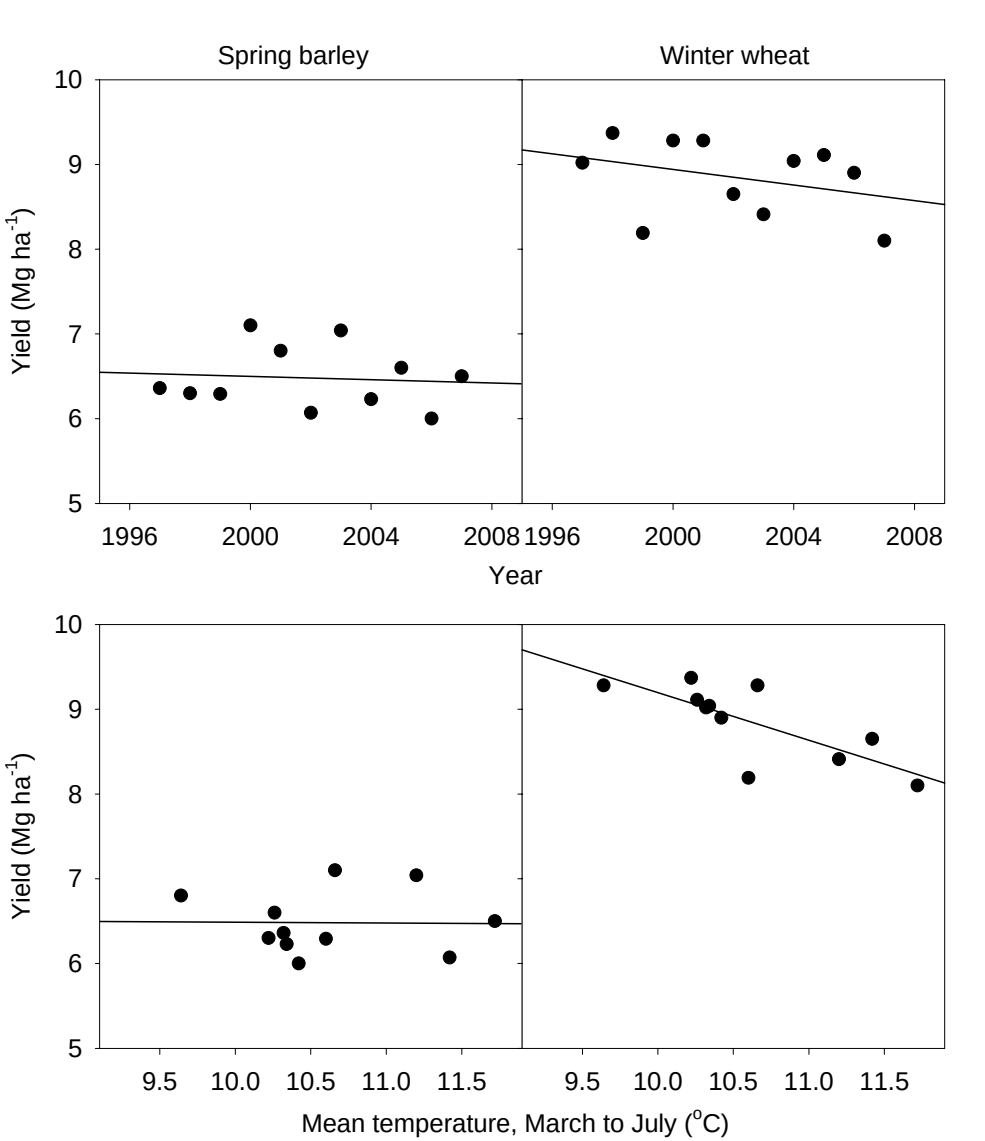


Yield and N content in winter wheat at increasing N

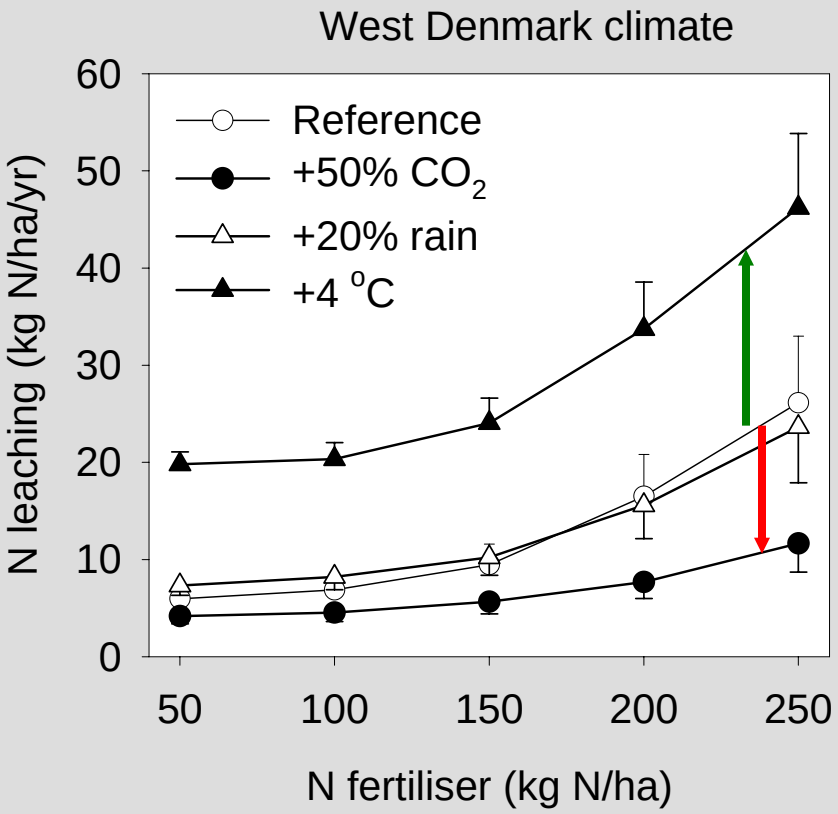


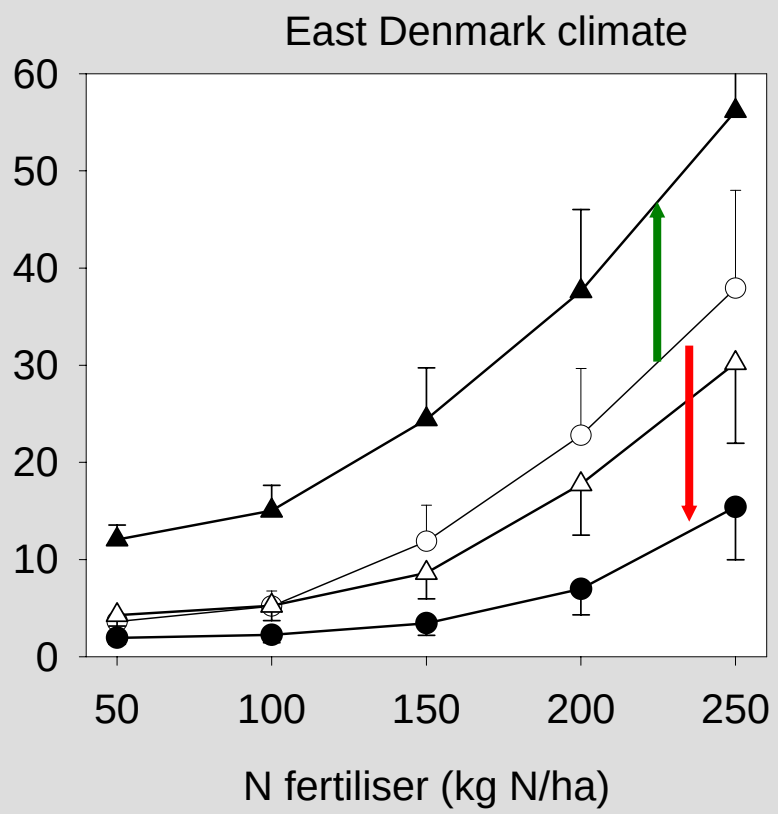
Simulations with Daisy model

Grain yields in experiments in DK, 1997-2007



N leaching for increased N fertiliser to winter wheat





Increased leaching at increased temperature

Decreased leaching at increased CO_2

Simulations with Daisy model

Downscaling methods

- M1: Direct RCM output
- M2: Standard Delta-Change, i.e. observed series corrected for difference between RCM projection and RCM control (mean change, observed variance)
- M3: Alternative Delta-Change, i.e. RCM projection corrected for difference between RCM control and observed series (mean change, projected variance)

Model runs in PRUDENCE

RCM	GCM	SRES	No. ensembles
	CGCM2	Four	1 each
	CSIRO-MK2	Four	1 each
	GFDL-R30	Four	1 each
	ECHAM4/OPYC3	Four	1 each
	NCAR-PCM	Four	1 each
	HadCM3	Four	1 each
	Arpège*	B2	3
	Arpège*	A2	3
	HadAM3H	A2	1
HIRHAM (50 km)	HadAM3H	A2	3
HIRHAM (25 km)	HadAM3H	A2	1
HadRM3H	HadAM3H	A2	1
CHRM	HadAM3H	A2	1
CLM	HadAM3H	A2	1
REMO	HadAM3H	A2	1
PROMES	HadAM3H	A2	1
RegCM	HadAM3H	A2	1
RACMO	HadAM3H	A2	1
RCAO (50 km)	HadAM3H	A2	1
RCAO (25 km)	HadAM3H	A2	1
RCAO (50 km)	HadAM3H	B2	1
RCAO (50 km)	ECHAM/OPYC	A2	1
RCAO (50 km)	ECHAM/OPYC	B2	1
HIRHAM (50 km)	ECHAM/OPYC	A2	1
HIRHAM (50 km)	ECHAM/OPYC	B2	1
HadRM3P	HadAM3P	A2	3

Sources of variation for winter wheat in Denmark

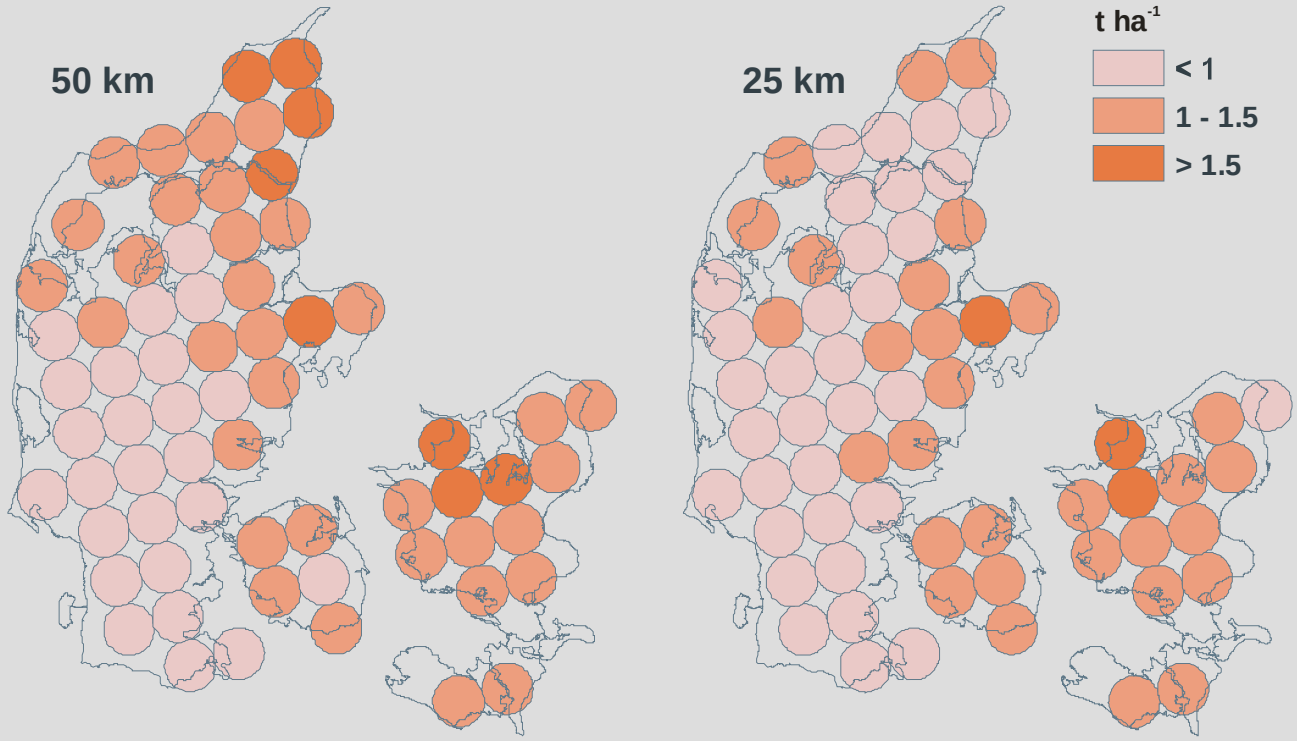
Site	RCM	1961-1990		2071-2100		
		Control	Observed	M1	M2	M3
Grain yield						
Jyndevad	HIRHAM	7.0 (30)	8.7 (22)	9.8 (13)	10.1 (10)	10.0 (13)
(West Denmark)	RCAO	8.5 (24)	8.7 (24)	10.4 (9)	10.3 (9)	10.3 (9)
Roskilde	HIRHAM	4.4 (50)	7.4 (34)	8.9 (17)	9.9 (11)	8.6 (19)
(East Denmark)	RCAO	7.4 (32)	7.4 (34)	10.3 (8)	10.3 (8)	10.3 (10)
N leaching						
Jyndevad	HIRHAM	21 (44)	13 (141)	23 (45)	17 (67)	19 (56)
(West Denmark)	RCAO	16 (77)	13 (141)	25 (35)	20 (50)	24 (39)
Roskilde	HIRHAM	60 (69)	25 (179)	24 (90)	10 (57)	24 (55)
(East Denmark)	RCAO	26 (65)	25 (179)	17 (48)	8 (71)	19 (63)

Sources of variation for winter wheat in Denmark (ANOVA)

Factor	d.f.	MS	P
Change in grain yield			
GCM	4	136	0.3010
RCM	8	565	<0.0001
Ensembles	2	44	0.6752
Scenario application	1	19089	<0.0001
Location	1	19614	<0.0001
Soils	3	3383	<0.0001
Change in N leaching			
GCM	4	2505	0.6627
RCM	8	8952	0.0320
Ensembles	2	485	0.8902
Scenario application	1	124767	<0.0001
Location	1	51419	0.0005
Soils	3	16905	0.0077

Change in wheat yields for 2071-2100

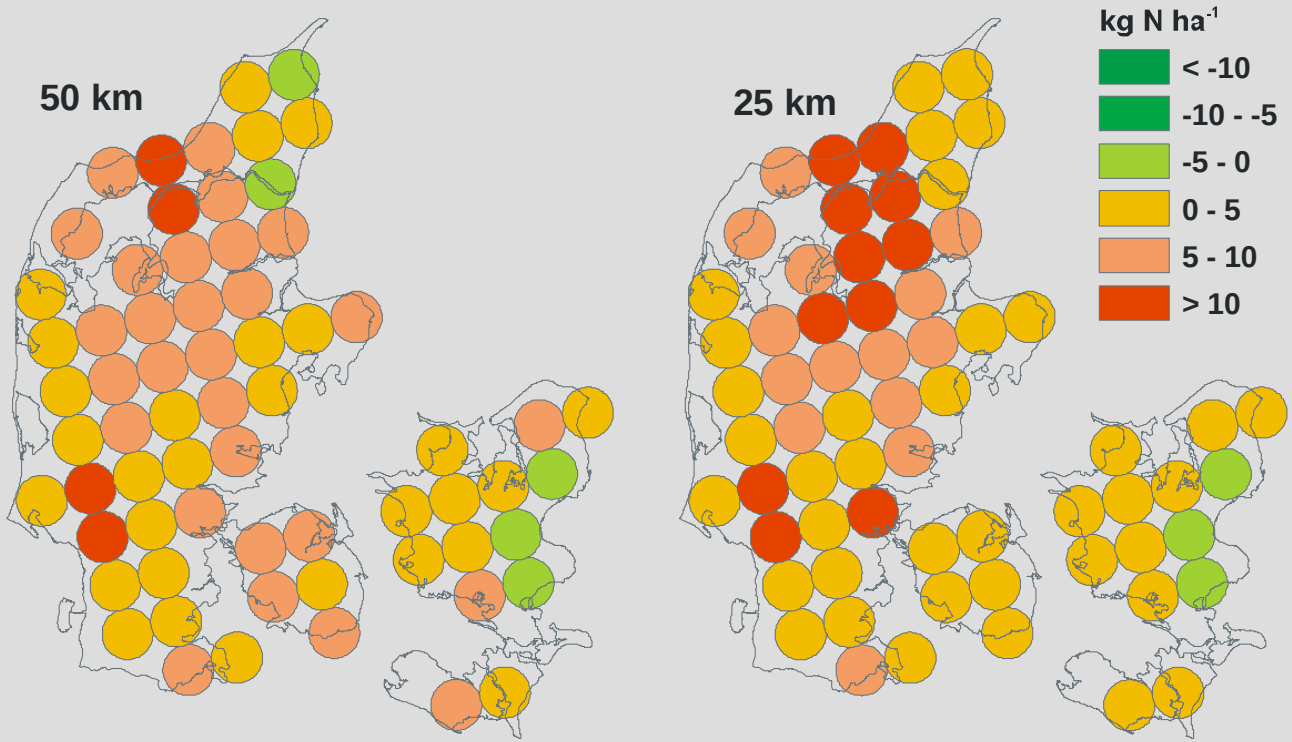
HIRHAM model med 2 spatial resolutions



PRUDENCE

Change in N-leaching from wheat for 2071-2100

HIRHAM model with 2 spatial resolutions



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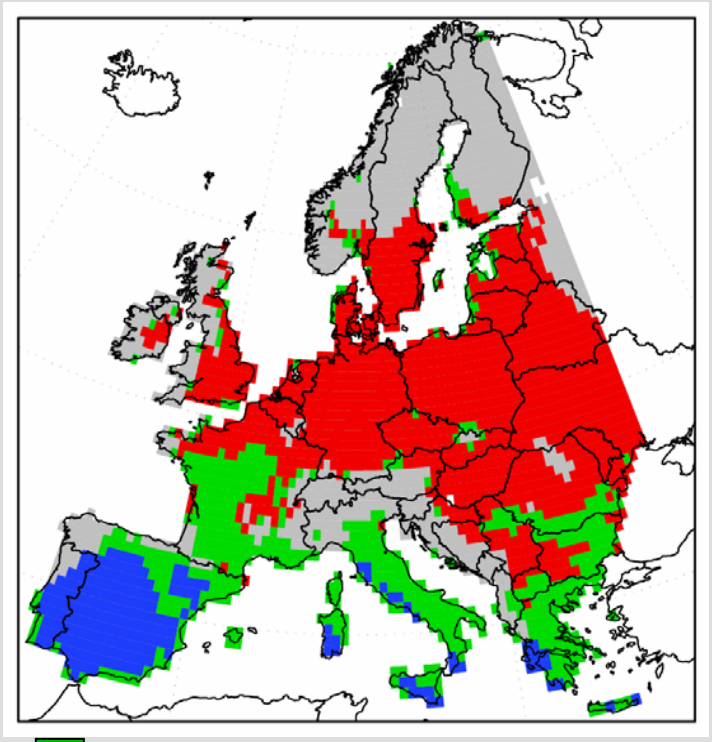
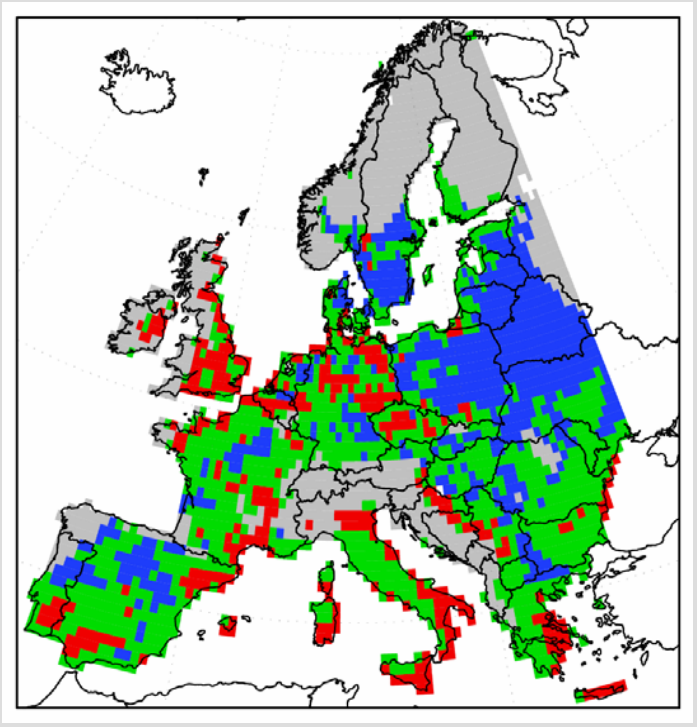
Wheat in 2080 – uncertainty for 9 RCM for A2

Yield change



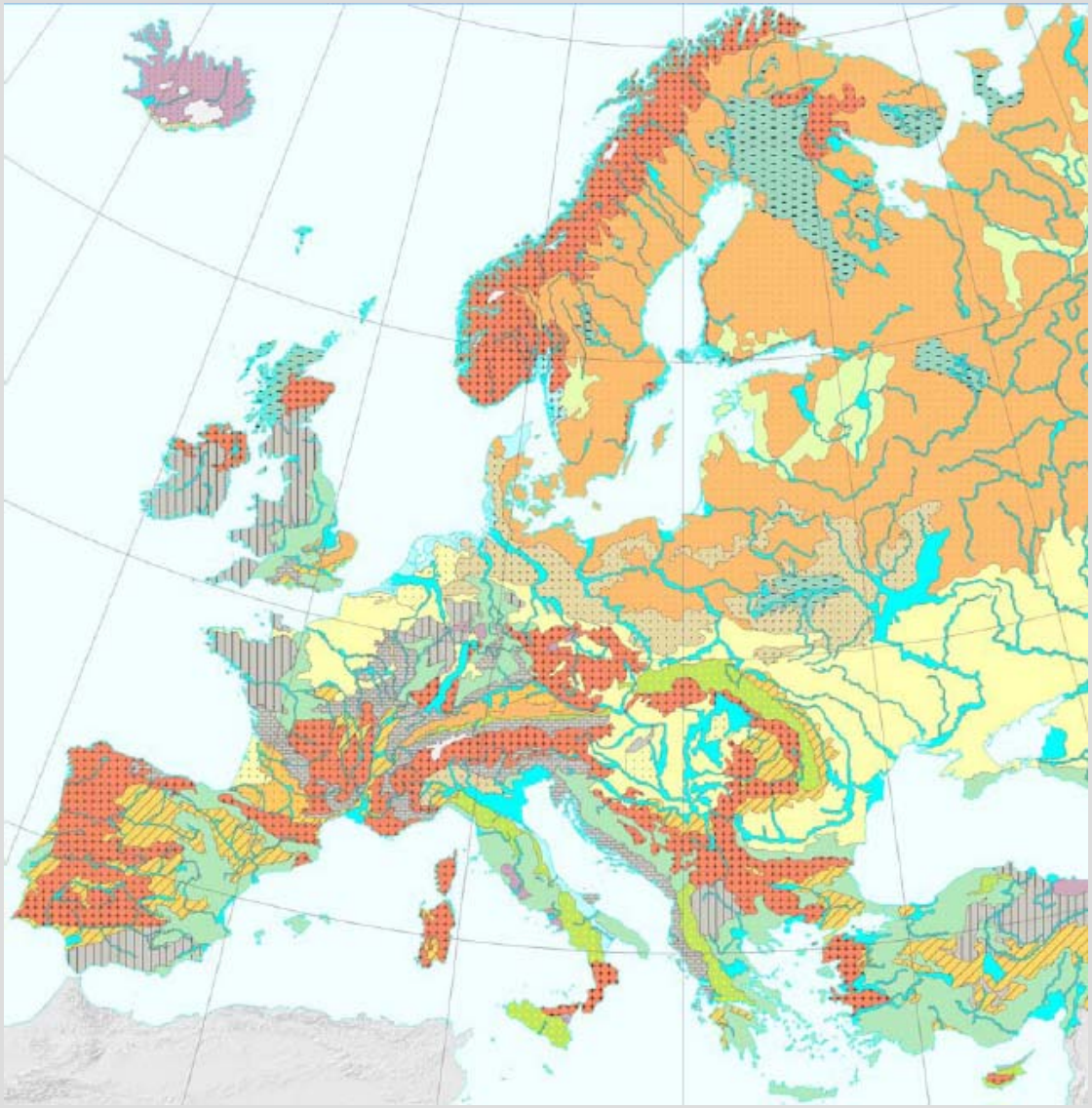
Change in N-leaching



Diverging results
Increases in all model runs
Decreases in all model runs

PRUDENCE

European soils (geological origin)



Crop yield change in Spain in 2071-2100 (percent change)

Crop	Model	Navarra	Castilla La Mancha	Badajoz
Spring wheat	HadAM3H	37	73	127
(rainfed)	9 RCMs	71 (43)	74 (47)	129 (129)
Winter wheat	HadAM3H	12	-18	-39
(rainfed)	9 RCMs	-6 (34)	-25 (34)	-35 (35)
Grain maize	HadAM3H	13	-21	-17
(irrigated)	9 RCMs	-19 (19)	-26 (7)	-24 (7)

Crop yield change in Spain (ANOVA)

Factor	d.f.	MS	P
Spring wheat			
GCM	1	1700	0.6384
RCM	8	3825	0.8304
Region	2	11147	0.2501
Winter wheat			
GCM	1	1129	0.0512
RCM	8	2834	<0.0001
Region	2	2456	0.0015
Irrigated maize			
GCM	1	124	0.3541
RCM	8	300	0.0803
Region	2	248	0.1928

Grain maize yield in Spain

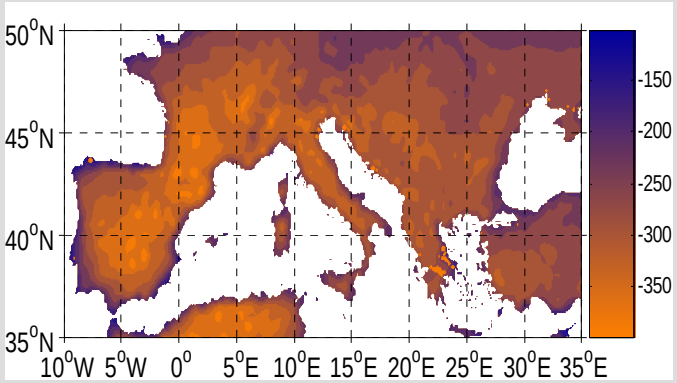
Period	Sowing date	Grain yield (t ha^{-1})		irrigation requirement (mm)	
		HIRHAM	PROMES	HIRHAM	PROMES
1961-1990	Current	10.5 (15)	11.6 (15)	546 (19)	1074 (9)
2071-2100	Current	6.0 (16)	8.6 (17)	653 (9)	739 (8)
2071-2100	1 month earlier	7.8 (7)	9.2 (10)	631 (6)	742 (10)
2071-2100	1.5 month earlier	8.2 (10)	10.8 (13)	629 (9)	712 (10)

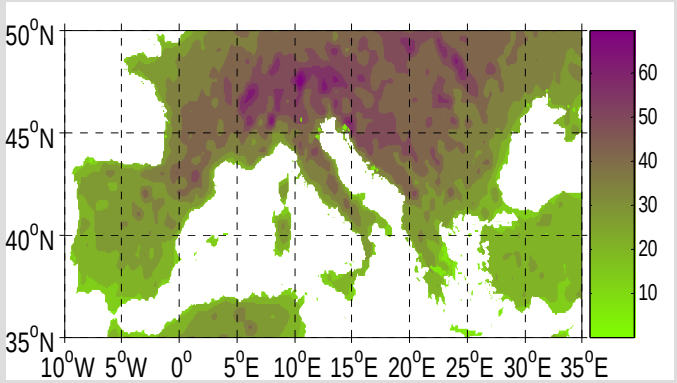
Water availability for A2 in 2071-2100
RCM uncertainty

Potential water availability (mm)

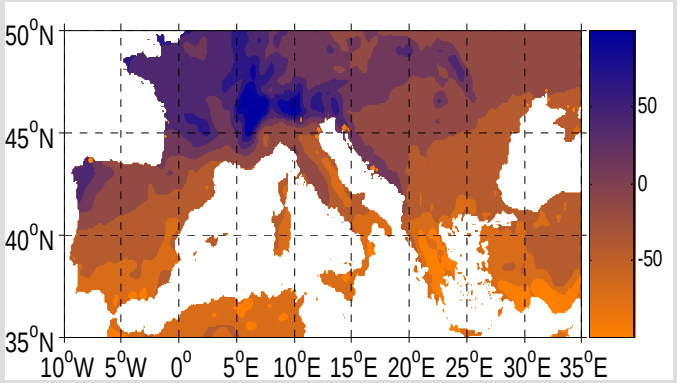
Uncertainty (mm)
5 % confidence limits

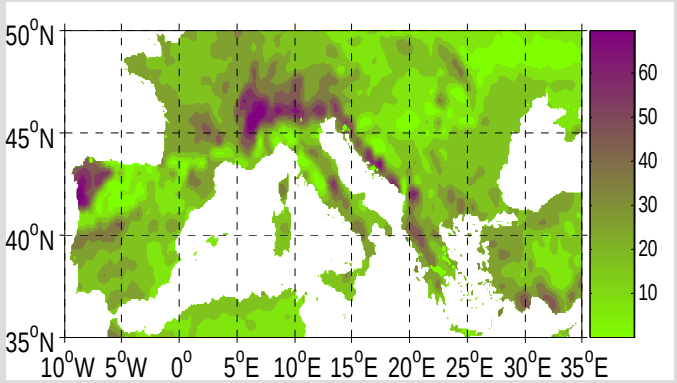
Summer





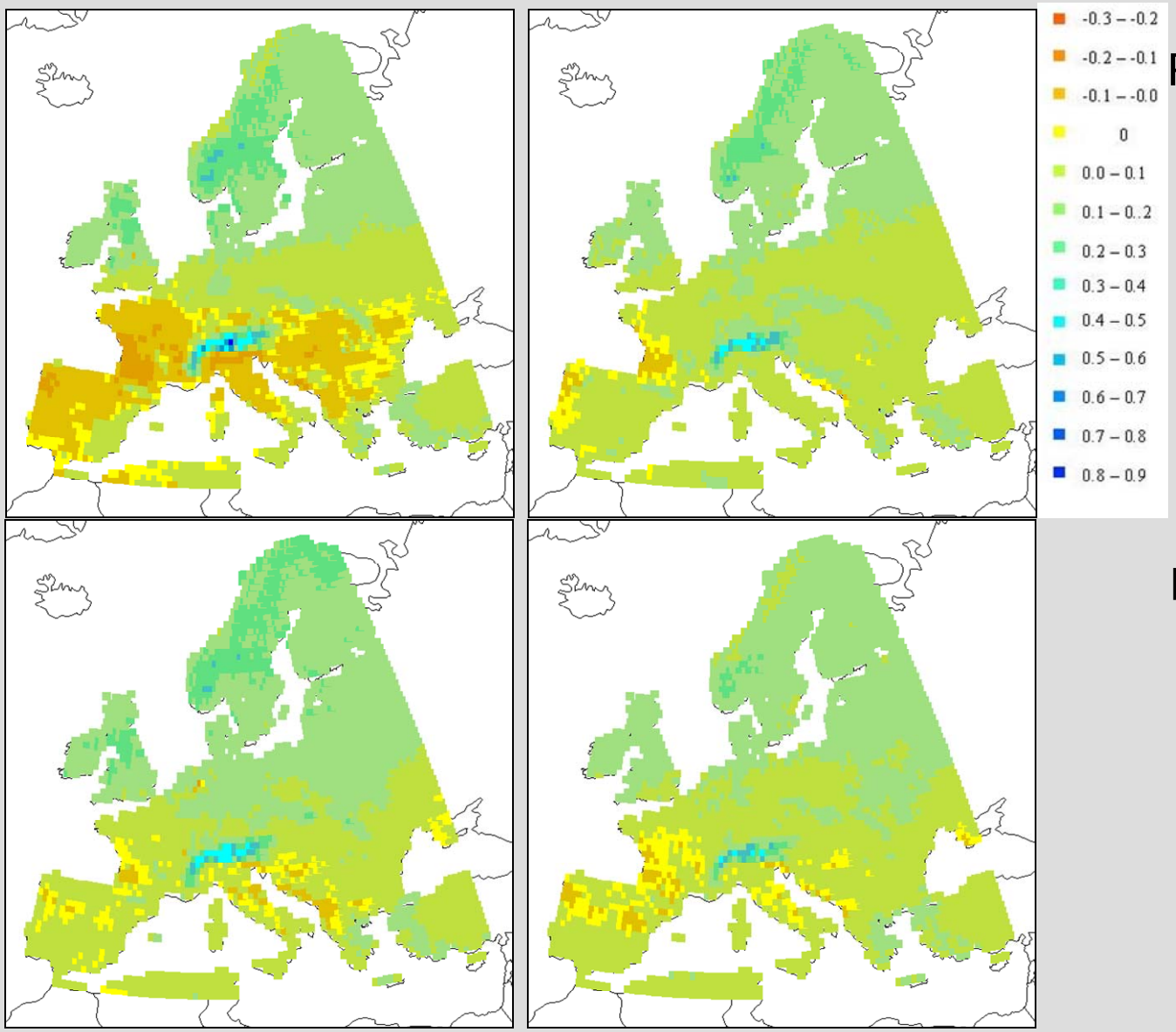
Winter





Change in Net Primary Productivity – 2071-2100

A2 B2



RCAO/ECHAM-OPYC

RCAO/HadAM3H

Change in NPP (2071-2100)

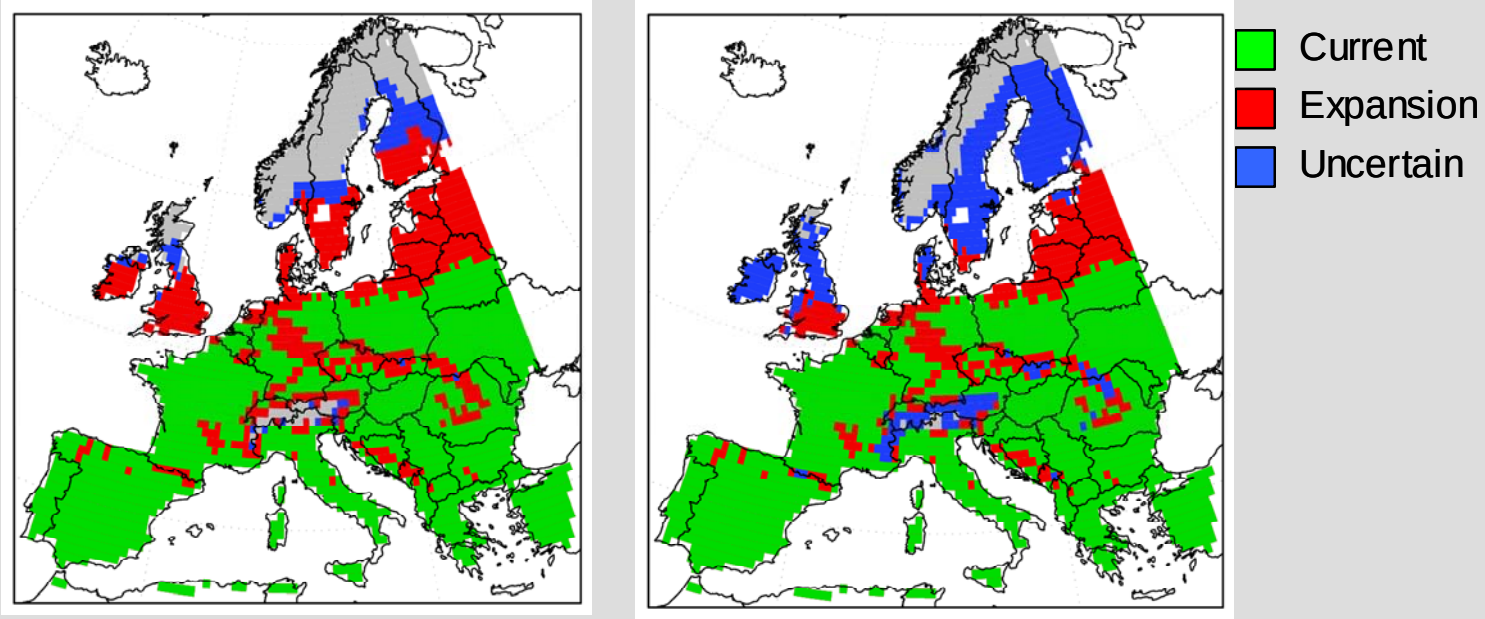
RCM	GCM	Emission scenario	European sub-regions				
			SW	SE	E	W	N
RCAO	HadAM3H	A2	8.4	13.6	19.3	27.0	48.3
HIRHAM	HadAM3H	A2	17.4	24.2	22.7	30.8	48.9
CLM	HadAM3H	A2	17.5	24.8	26.4	34.0	52.1
HadRM3H	HadAM3H	A2	8.9	16.3	14.5	25.4	54.3
REMO	HadAM3H	A2	13.0	26.4	28.0	29.2	44.3
RCAO	ECHAM/OPYC	A2	-4.8	10.0	9.7	16.8	44.3
HIRHAM	ECHAM/OPYC	A2	11.3	15.8	14.9	23.2	48.5
RCAO	HadAM3H	B2	7.9	15.3	17.7	20.1	35.4
RCAO	ECHAM/OPYC	B2	11.2	16.5	14.5	25.4	54.2
HIRHAM	ECHAM/OPYC	B2	11.2	16.5	14.5	22.1	41.1

Change in suitability area for grain maize (ANOVA)

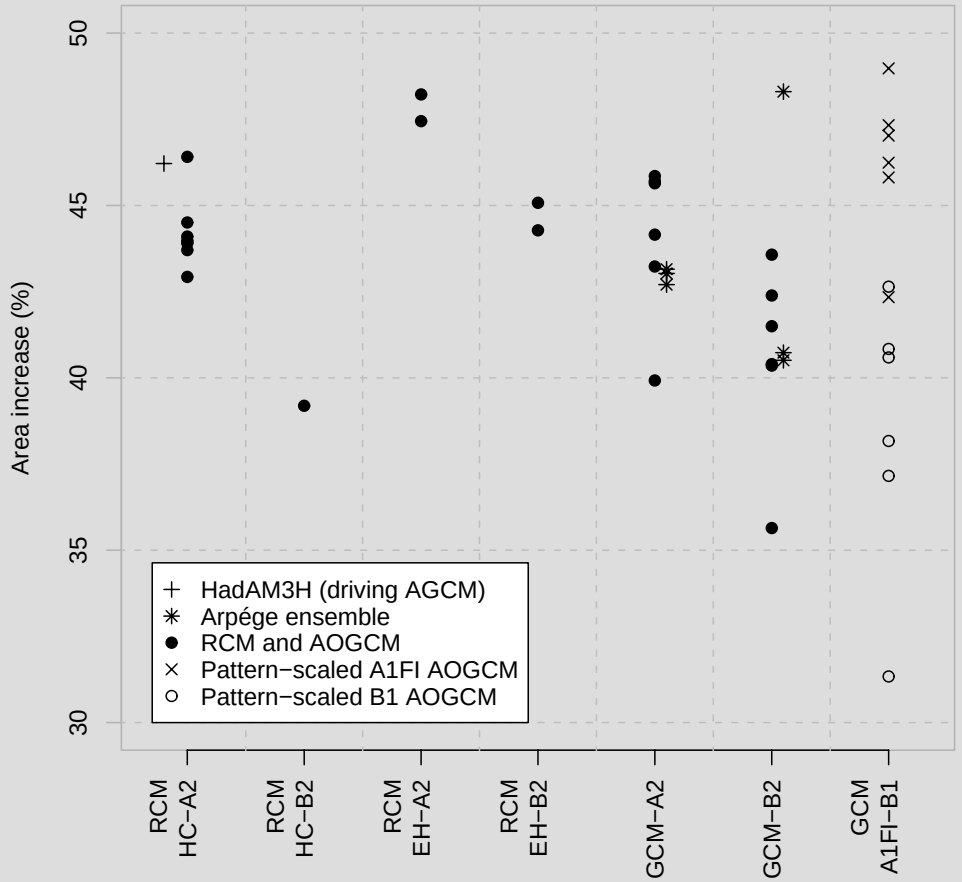
Factor	d.f.	MS	P
Emission scenario	3	72.8	<0.0001
GCM	8	13.0	0.0298
RCM	9	2.1	0.5404
Ensembles	2	10.9	0.0230

Uncertainty in expansion of grain maize area 2071-2100

7 RCMs – A2 (HadAM3H) 6 GCMs – A1FI, A2, B1, B2



Projected area increase of grain maize (2071-2100)

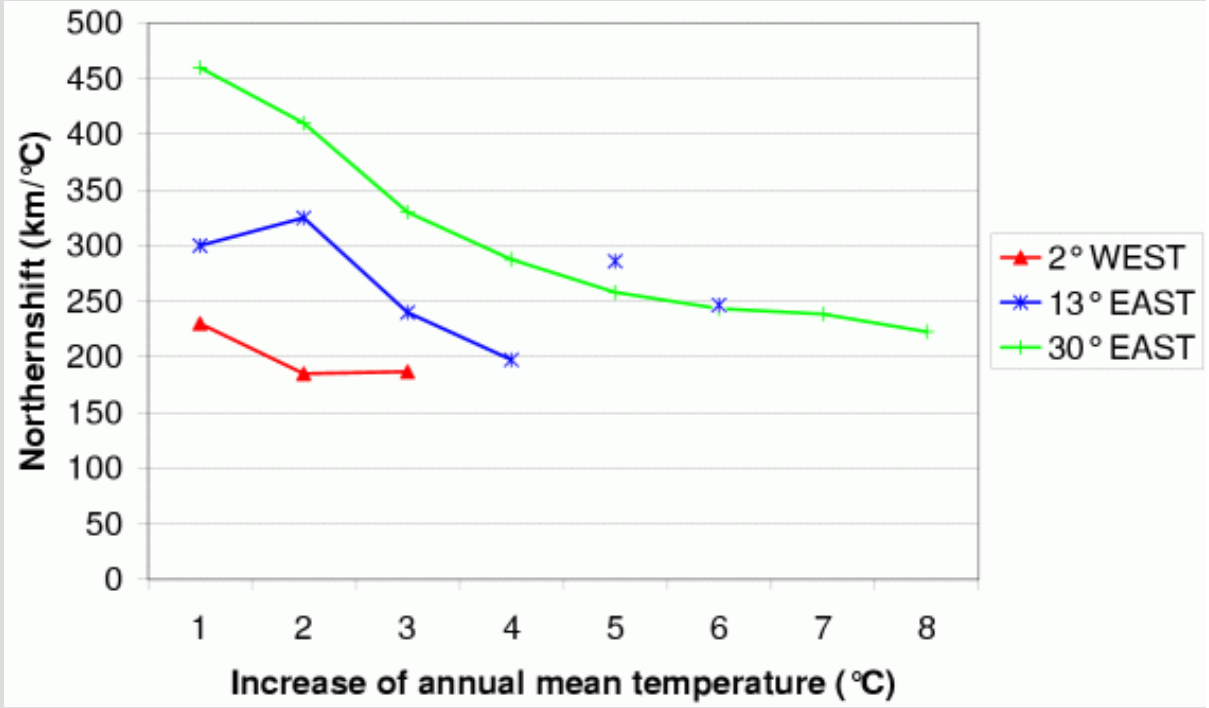


NPP changes across Europe (ANOVA)

Factor	d.f.	MS	P
Emission scenario	1	1	0.8241
GCM	1	113	0.0562
RCM	4	93	0.0313
Region	4	827	<0.0001
Region × Emission	4	19	0.5913
Region × GCM	4	30	0.3701
Region × RCM	16	16	0.8132

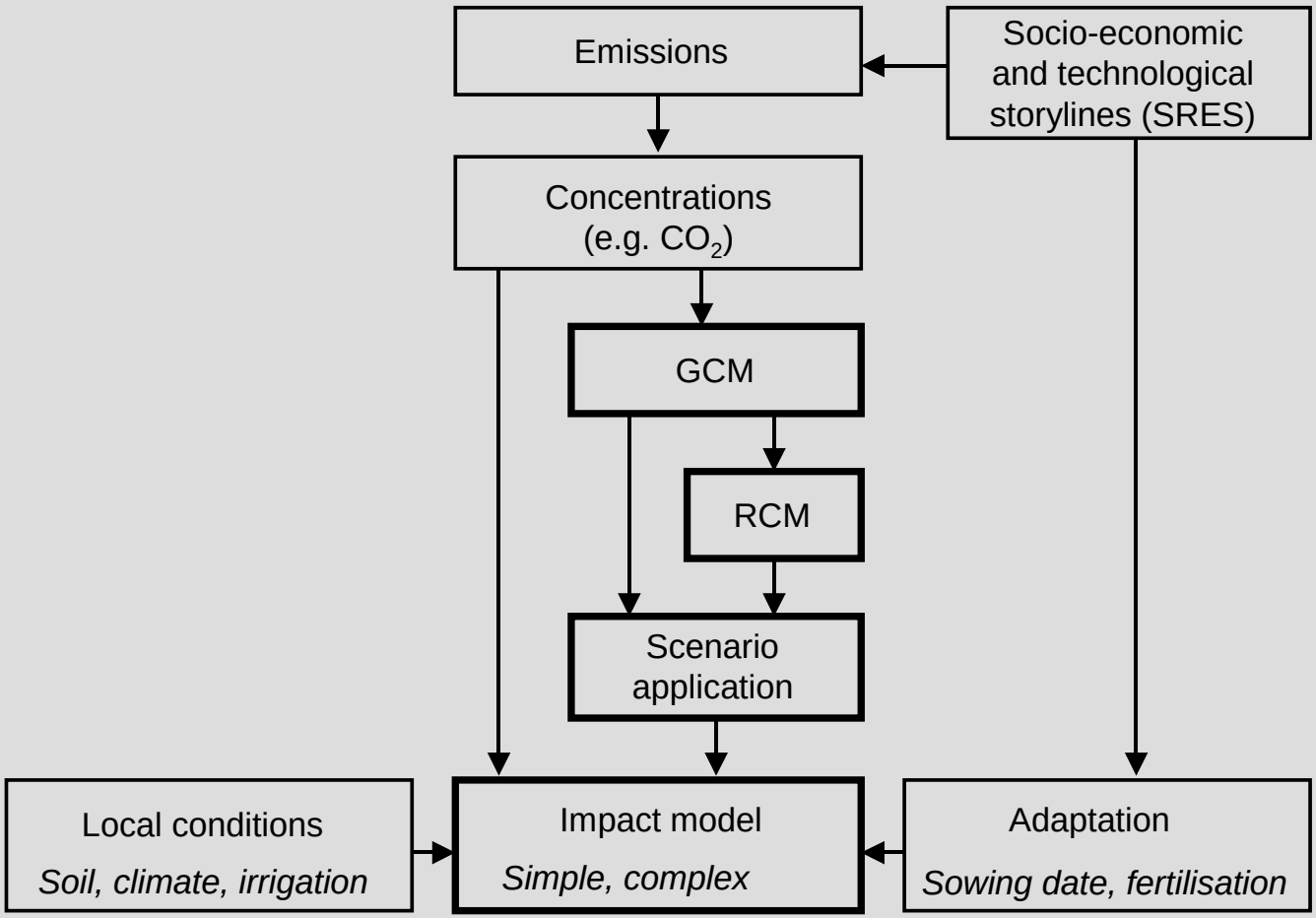
Grain maize suitability

Shift in the northern limit for cultivation



Carter & Frozek (2003)

Sources of uncertainty in impact projection



Conclusions

- There are many sources of uncertainty in climate change projections
- We need to be aware of all the uncertainties (and try to quantify and minimise them)
- No general guideline on which uncertainties are most important in a given situation can give given
- Uncertainty assessment should therefore be part of any climate change impact assessment