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Uncertainties in assessing climate change impacts and adaptation in agriculture

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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 ecosystem and society
- ✓Can we quantify the uncertainty of impacts?
- ✓Can we quantify the decision and thus the adaptation process?

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Issues for studying agriculture and climate change

- Impacts on crop yield and quality
  - Direct effects from changes in CO_2, temperature and rainfall and their variability
  - Effects of extreme events (drought, flood, storms)
  - Indirect effects through nutrient availability, pests and diseases
- Adaptation
  - Autonomous adaptation (sowing date, crop choice, cultivar choice)
  - Planned adaptation (water supply for irrigation, breeding, support for adandonment)
- Environmental and resource effects
  - Nitrogen and phosphorous losses to the environment
  - Water overuse from surface and groundwater
  - Soil degradation
- Effects on greenhouse gas emissions
  - Changes in soil carbon from soil and crop management and from climate
  - Emissions of nitrous oxide and methane from farming systems
- Mitigating greenhouse gases from agriculture

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Methods of studying climate change impacts and adaptation

- Crop simulation models
- Empirical (statistical) models
- Agroclimatic indices
- Space for time / analogies
- Expert knowledge
- Manipulation experiments (controlled environment or free air)
- Analysis of farm level statistics
- Questionnaire surveys, stakeholder interviews

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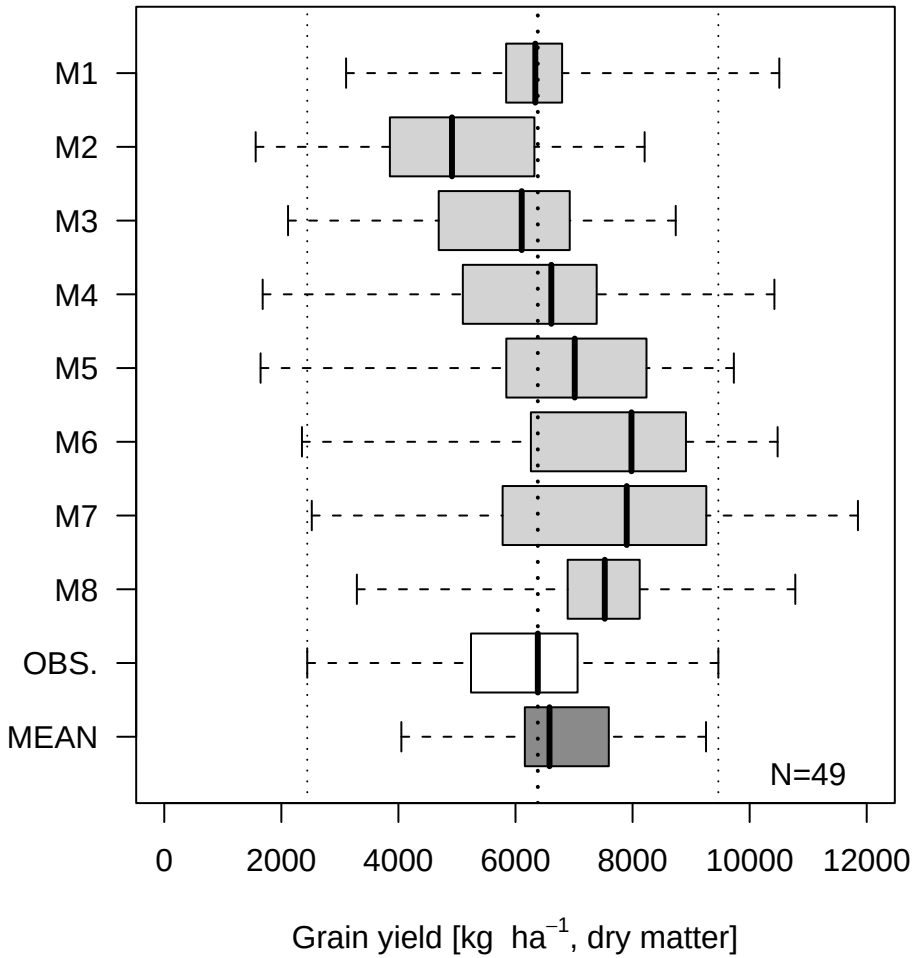
Can we trust current crop models?



Rötter et al., 2011

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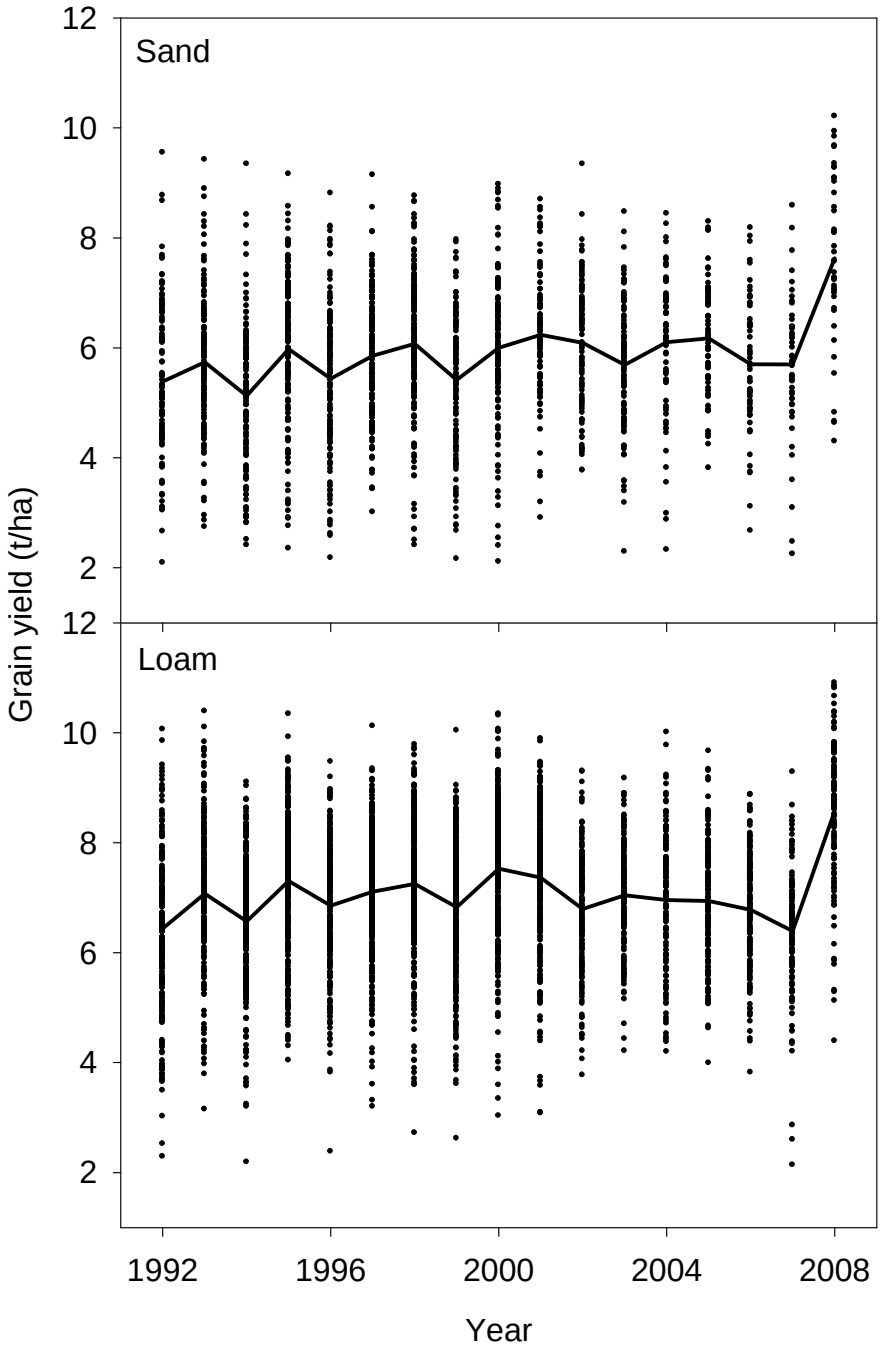
Data on yield of winter wheat 1992-2008 from Denmark



Kristensen et al., 2010

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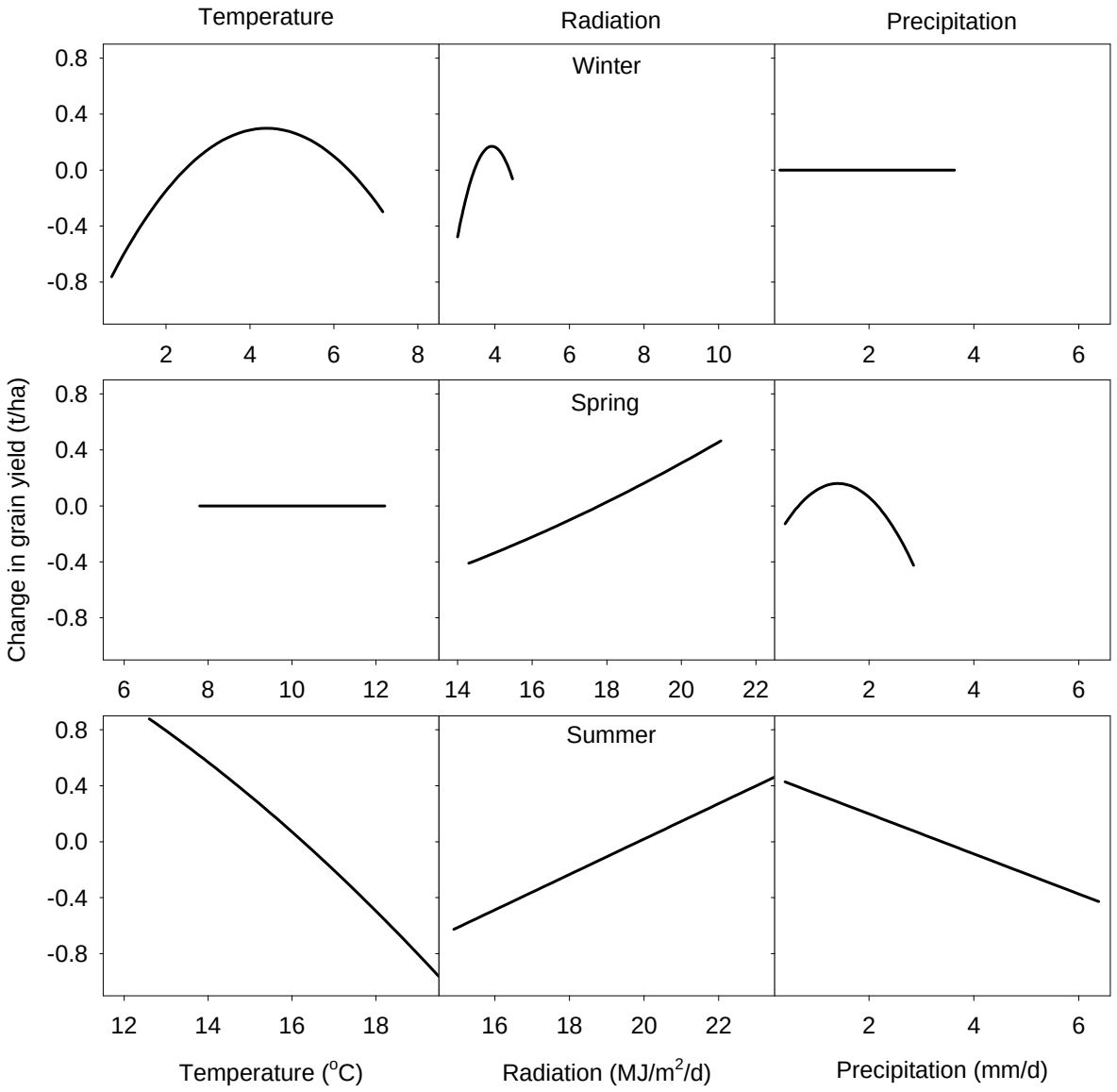
Winter wheat grain yield – response to climate



Kristensen et al., 2010

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Estimated yield change for winter wheat using empirical model

	Climate model	Yield (t/ha)	CV (%)
1985		7.3	16
2020	KNMI	7.2	20
	Met. Office	6.9	33
2040	KNMI	7.0	25
	Met. Office	6.5	46

Kristensen et al., 2010

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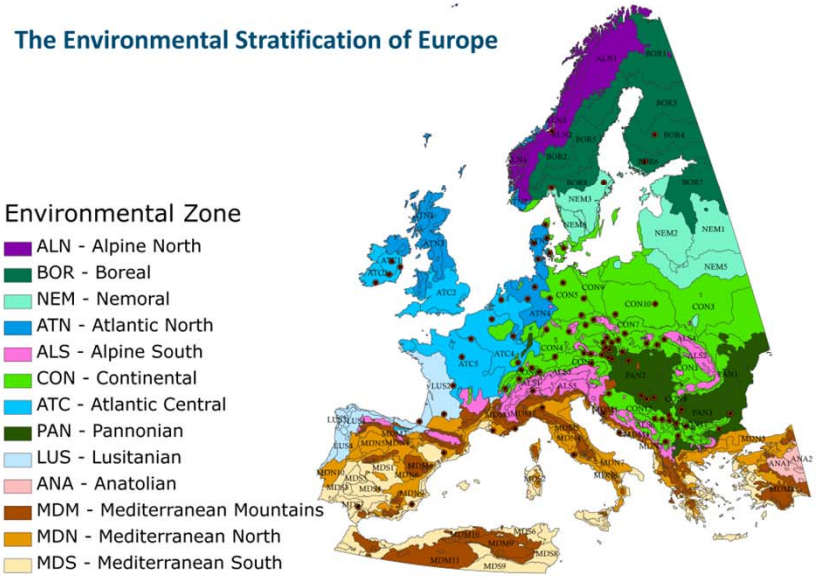
Change in agroclimatic indicators by 2030

Environmental Zone	Effective global radiation change (%)			Effective growing days change (days)			Huglin index change (%)			Date of the last frost change (days)			Proportion of dry days in AMJ change (%)			Proportion of dry days in JJA change (%)			Proportion of sowing days - early spring change (%)			Proportion of sowing days - fall change (%)		
	E	H	N	E	H	N	E	H	N	E	H	N	E	H	N	E	H	N	E	H	N	E	H	N
ALN	3	6	7	15	16	25	12	16	19	-5	-6	-8	0	0	1	-2	-2	-2	5	7	7	0	2	2
BOR	3	4	7	13	11	17	12	23	14	-4	-6	-4	-2	0	-1	-2	1	-6	4	5	5	3	4	5
NEM	4	5	4	14	9	20	12	22	13	-5	-5	-5	2	1	1	0	4	-3	5	5	6	5	6	7
ATN	0	0	3	7	3	17	11	15	11	-5	-7	-8	-1	-1	-3	7	11	3	4	3	5	3	3	4
ALS	0	1	3	4	2	8	12	16	10	-6	-9	-6	-1	-2	-2	8	9	3	5	5	3	4	4	5
CON	-3	-3	1	-1	-2	5	11	16	11	-4	-7	-5	-1	-1	-2	9	11	4	4	4	4	4	4	5
ATC	-2	-3	1	0	-4	7	11	16	10	-6	-9	-8	-3	-3	-6	9	14	5	2	3	3	2	1	3
PAN	-15	-11	-8	-18	-13	-9	11	15	10	-5	-6	-5	2	2	0	17	16	10	3	3	2	2	3	4
LUS	-9	-9	-3	-21	-21	-6	12	16	10	-6	-7	-6	4	5	3	22	23	8	3	2	1	2	2	3
MDM	-10	-7	-3	-10	-7	-3	12	15	10	-2	-3	-2	8	7	4	14	13	7	4	3	2	2	2	2
MDN	-10	-7	-2	-11	-5	-3	9	12	8	-24	-23	-20	8	6	3	9	7	4	2	1	1	1	-1	2
MDS	-15	-14	-7	-14	-10	-6	8	12	8	-10	-11	-11	8	8	5	1	1	1	-3	-2	-1	-5	-3	0

The Environmental Stratification of Europe



Trnka et al., 2011

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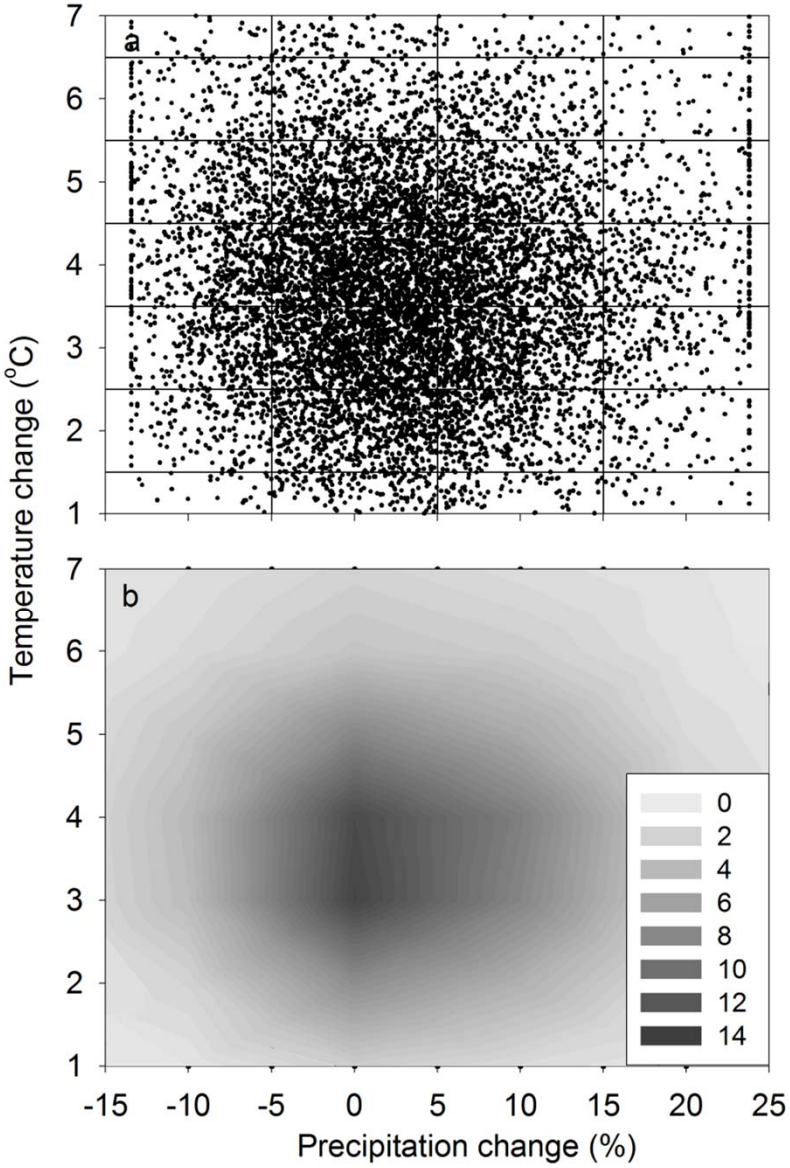
Probability of temperature and rainfall changes in Denmark in 2061-2080 under A1B



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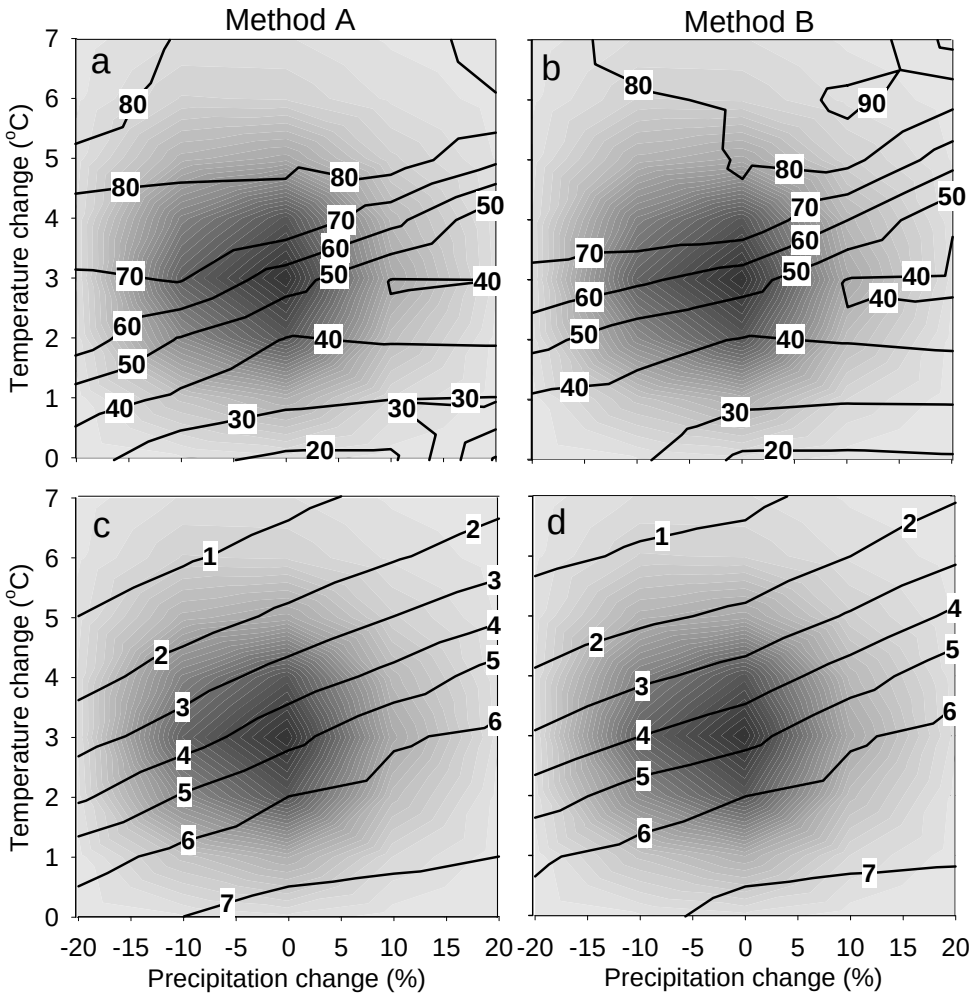
Probabilistic assessment of effects on grain yield and N leaching of winter wheat

N-leaching

Grain yield



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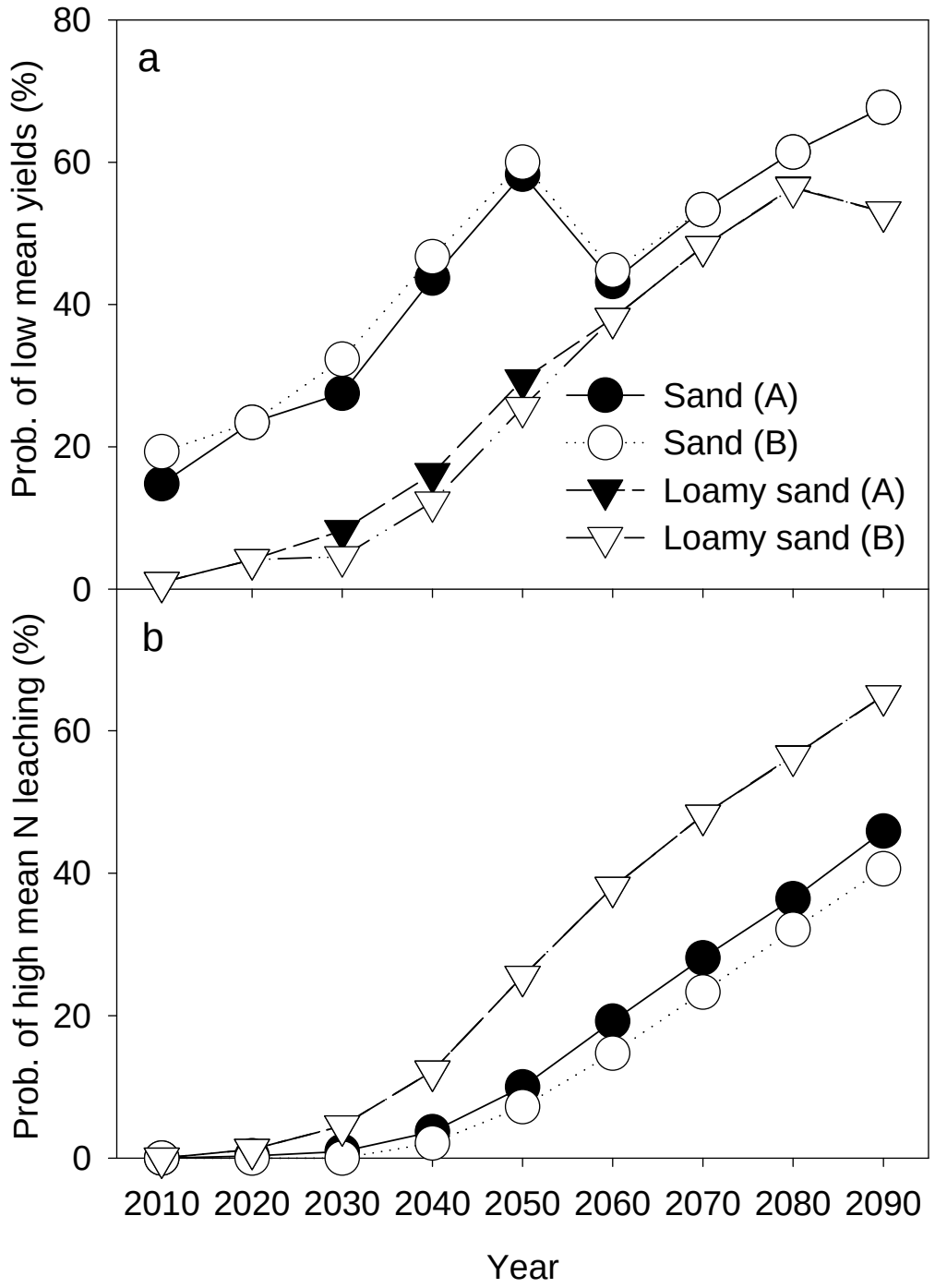
Probabilistic assessment of effects on grain yield and N leaching of winter wheat



Børgesen et al., 2011

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Challenges (and opportunities) for research

- Include indirect effects of climate change into impact studies
- Study effects of climatic extremes on impacts and adaptation
- Study effects of climate change on resources (soil quality, water availability)
- Study effects of climate change and agricultural management on environmental impacts (N and P losses, GHG emissions)
- Link impact studies with adaptation and mitigation
- Estimate costs of adaptation and mitigation measures at regional scale
- Apply a wider range of methodologies in the studies

- **All this is needed to quantify uncertainties related to impacts and adaptation**
- **We have done the easy stuff – now lets deal with whats important**