Simulated effects of climate change on arable crop production and water and nitrogen management in different regions in Germany



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Outline

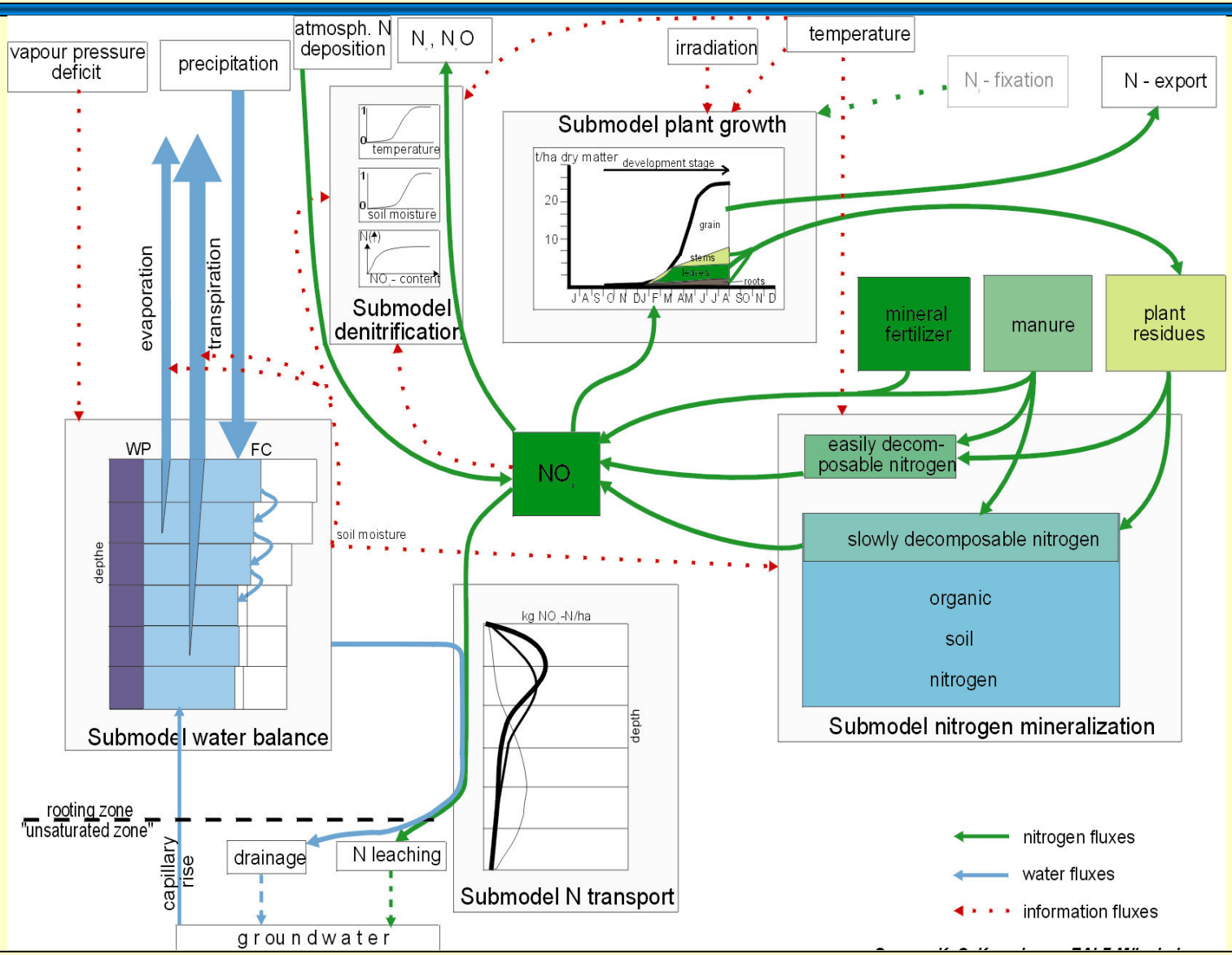
- Introduction
- Methods and sites
- Climatological trends
- Climate change impact on crop yield
- Response on nitrogen fertilization
- Summary

Methods

Background of the study

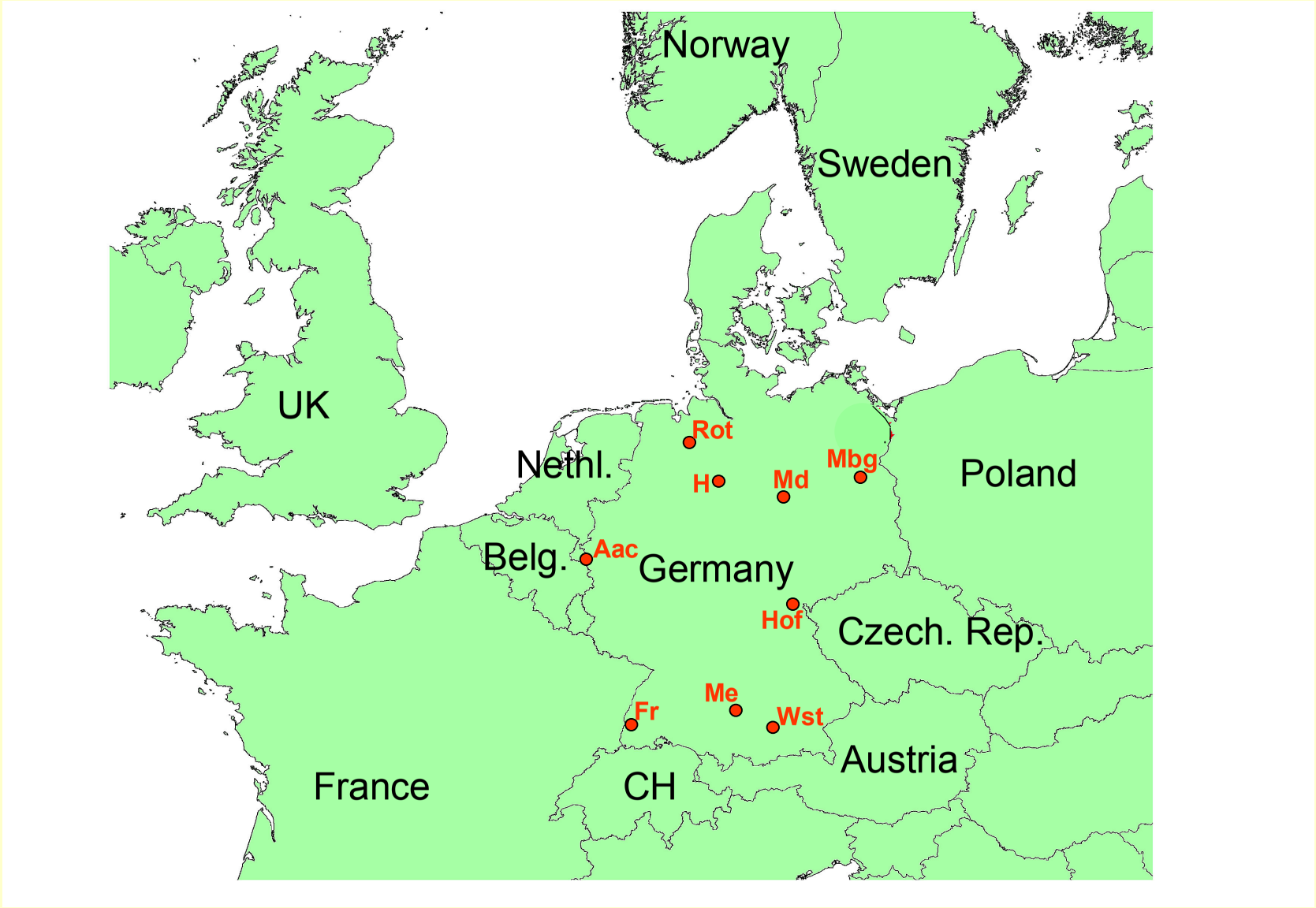
- GCM model **ECHAM5/MPI-OMT63L31**
- Scenario A1B (mixed use of fossile and alternative energy sources)
- Daily time series from statistical downscaling model **WETTREG** for weather stations in Germany (period 1961-2050) (SPEKAT et al. 2007)
- 3 representative realisations (wet, dry, normal) out of 8 statistical generated time series of weather situations classified for wetness
- Reference period 1970-1989, projected period 2031-2050
- 9 Meteorlogical stations across Germany each associated with a typical soil type of the region
- Simulation model HERMES (Kersebaum 2007)
- simulated crop: winter wheat
- Virtual fertilizer experiment using 20 fertilization levels in 5% steps down from 207 kg N/ha as maximum

Methods: scheme of the simulation model HERMES



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Locations used for climate change impact modelling



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Characterisation of sites

Station (abr.) elevation a.s.l.		Soil	Temperature now	Temperature future	precipitation annual now	precipitation annual future	precipitation winter now	precipitation winter future	precipitation summer now	precipitation summer future	sunshine hours now	sunshine hours future
Rotenburg 32 m	Rot	loamy sand	9.1	9.9 (+9.1 %)	750	739 (-1.4 %)	377	373 (-1.0 %)	373	366 (-1.8 %)	1397	1524 (+9.1 %)
Aachen 202 m	Aac	silty loam	10.2	11.1 (+8.5 %)	714	706 (-1.1 %)	346	324 (-6.2 %)	368	382 (+ 3.7 %)	1625	1764 (+8.5 %)
Hannover 55 m	H	sandy loam	9.3	10.1 (+8.8 %)	628	596 (-5.1 %)	304	288 (-5.1 %)	325	308 (-5.1 %)	1528	1673 (+9.5 %)
Magdeburg 76 m	Md	silt	9.2	9.8 (+7.2 %)	478	456 (-4.5 %)	219	196 (-10.5 %)	259	260 (+0.05 %)	1648	1770 (+7.4 %)
Müncheberg 62 m	Mbg	sand	8.8	9.4 (+7.3 %)	533	506 (-5.1 %)	247	230 (-7.1 %)	286	276 (-3.4 %)	1678	1781 (+6.2 %)
Hof 474 m	Hof	sandy loam	6.8	7.5 (+10.8 %)	739	713 (-3.5 %)	351	335 (-4.6 %)	388	379 (-2.5 %)	1620	1711 (+5.6 %)
Weihenstephan 470 m	Wst	silty loam	7.8	8.6 (+10.9 %)	726	679 (-6.5 %)	294	286 (-2.8 %)	432	393 (-8.9 %)	1743	1827 (+4.8 %)
Metten 313 m	Me	sandy loam	8.1	8.7 (+7.6 %)	938	904 (-3.7 %)	457	450 (-1.6 %)	481	454 (-5.7 %)	1631	1673 (+2.6 %)
Freiburg 236 m	Fr	clay silt	11.3	12.2 (+8.1 %)	909	865 (-4.9%)	401	387 (-3.4 %)	509	478 (-6.1 %)	1788	1911 (+6.9 %)

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Characterisation of sites

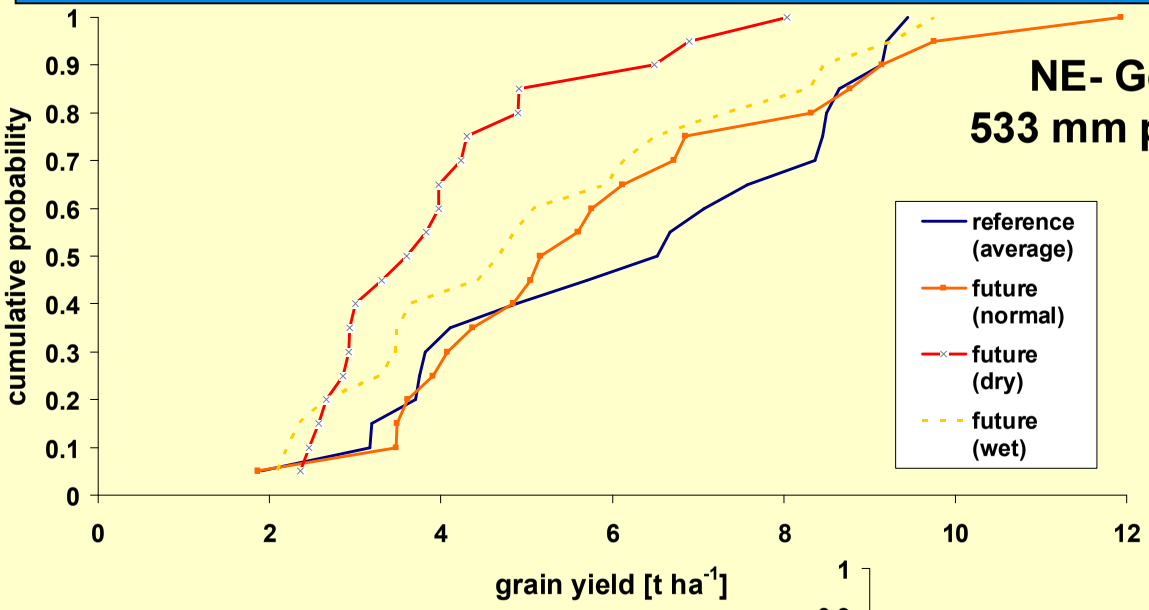
	Station	frost days (T_{min}<0 °C)		ice days (T_{max}<0 °C)		hot days (T_{max}>30 °C)		summer days (T_{max}>25 °C)		dry days (prec. = 0)	
		now	future	now	future	now	future	now	future	now	future
	Rotenburg	71.7	56.4	18.1	12.5	5.8	7.7	28.0	37.8	191.8	194.2
W	Aachen	46.9	33.8	9.4	7.3	4.0	6.8	26.3	36.2	181.8	192.5
↓	Hannover	73.7	58.5	16.6	11.3	4.4	6.1	27.6	37.2	186.2	197.9
↓	Magdeburg	80.4	65.9	18.7	14.2	7.2	10.9	37.6	50.3	205.5	208.2
E	Müncheberg	86.5	73.1	26.1	18.4	7.0	9.1	35.3	41.6	200.7	217.2
E	Hof	120.9	104.5	43.6	30.0	2.6	2.4	19.1	24.5	180.3	188.2
↓	Metten	105.2	92.7	29.6	19.9	6.2	7.0	41.1	48.3	192.3	199.4
↓	Weihenstephan	116.3	100.7	31.1	22.2	4.9	5.2	31.3	40.8	196.3	202.0
W	Freiburg	49.7	39.1	11.3	8.7	11.8	17.7	51.2	66.8	197.1	202.8
	General trend	↘		↘		↗		↗		↗	

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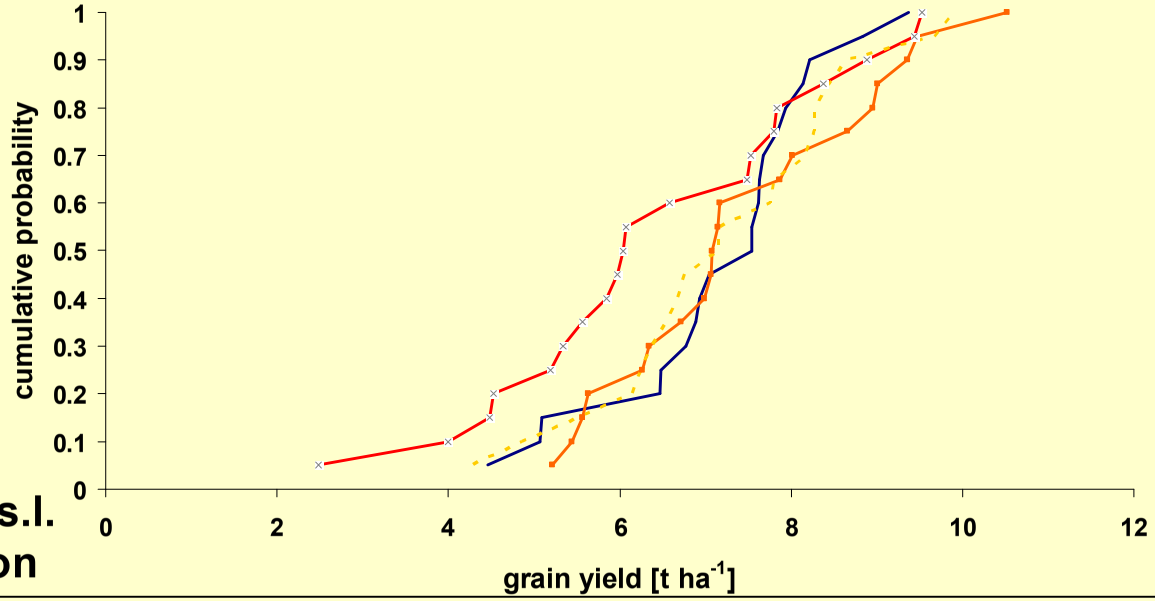
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Simulated yield variability now and in future



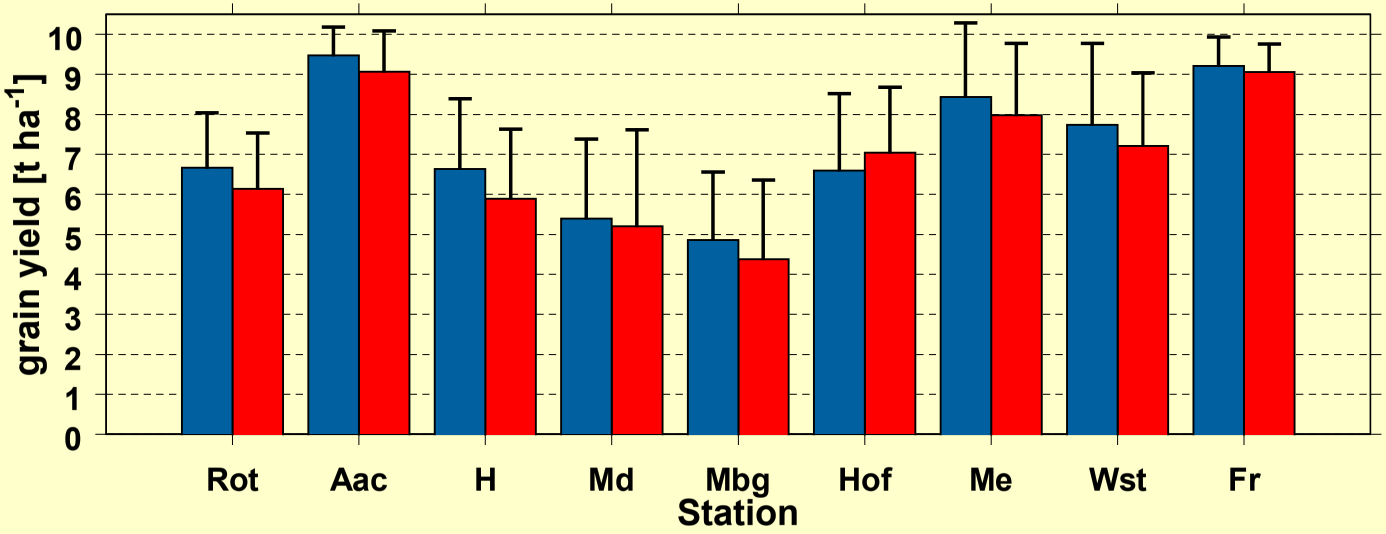
Müncheberg
NE- Germany, sand, 62 m a.s.l.
533 mm present annual precipitation

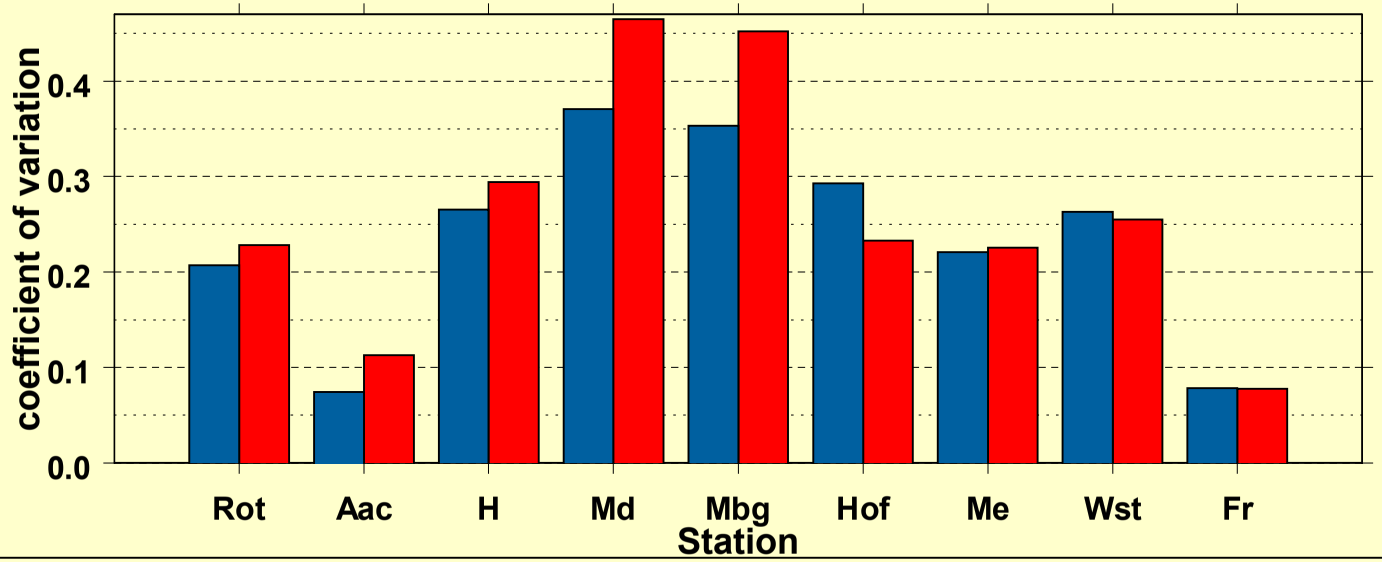


Hof
SE- Germany, sandy loam, 474 m a.s.l.
739 mm present annual precipitation

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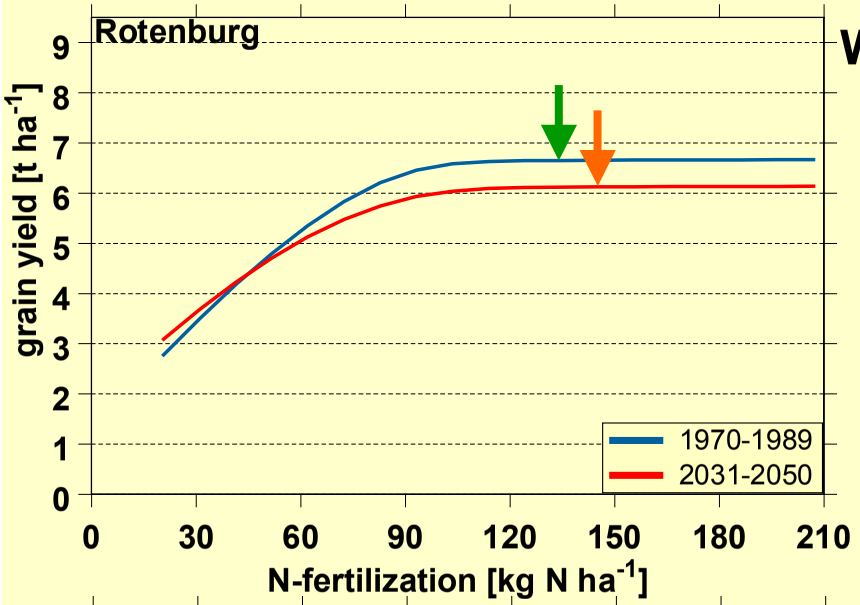
Simulated yield variability now and in future



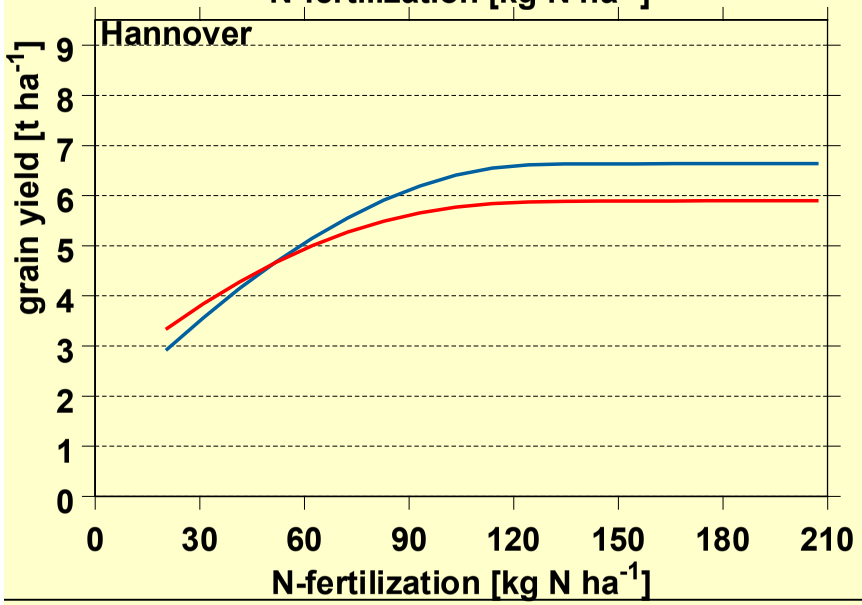


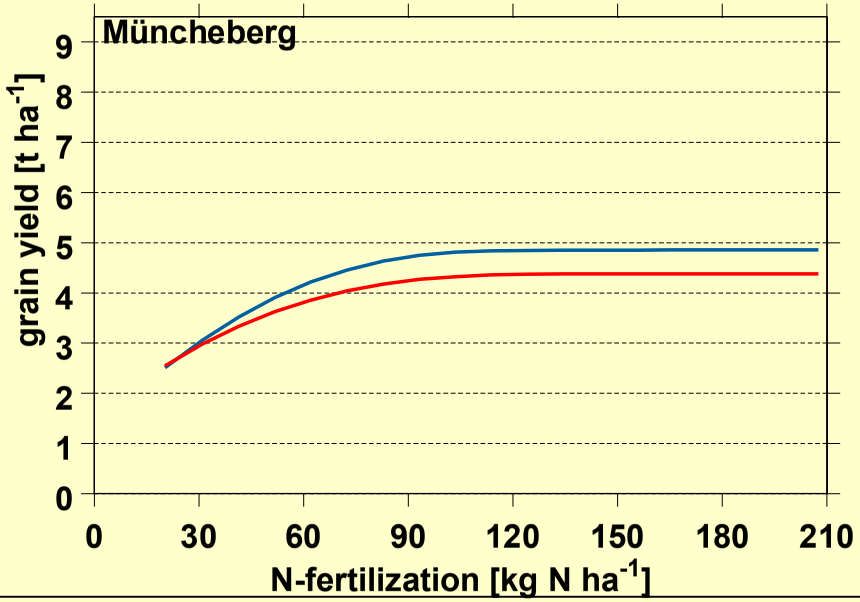
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Simulated crop yield response to nitrogen fertilization



West-East transect North Germany, sandy soils

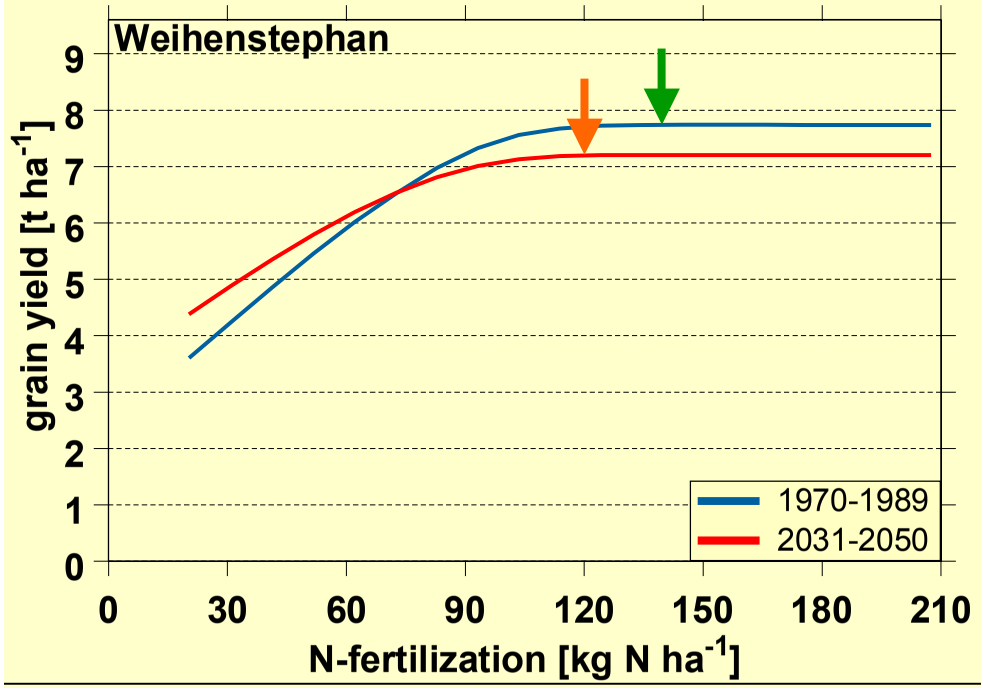


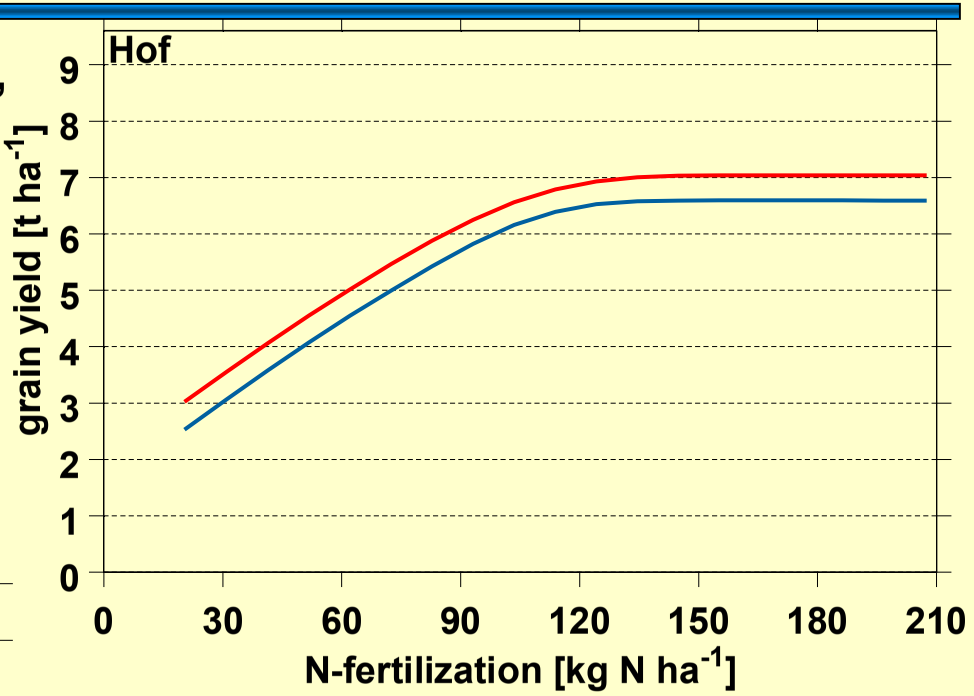


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Simulated crop yield response to nitrogen fertilization

North-South transect in South Germany, elevated sites (470 m)





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Summary

- Downscaled climate change scenarios can be used to simulate crop growth, water and nutrient dynamics in agro-ecosystems
- In Germany, the general trend of the A1B scenario projected beside an increase in temperature an increase of sunshine hours, but a decrease of annual precipitation. The number of frost and ice days will decrease, hot and summer days will increase as well as the number of days without rain.
- Yields of winter wheat are simulated to be mostly reduced, but at one elevated location projected conditions will favour crop growth due to inceased temperature.
- Yield variability is predicted to increase most in the North-Eastern part of Germany.
- Changed yield expectations and changed nitrogen dynamics in soil will lead to site specific changes of yield/fertilization response curves.
- In most cases nitrogen use efficiency will decrease due to longer drought periods which limit nitrogen uptake. This will require a site specific adaptation of nitrogen fertilization schemes due to changed economic optimum fertilization.
- Yield reductions are in a magnitude that they might be compensated by elevated CO_2 effects, which will be analysed in a next step using a modified model version.

Thank you for your attention