Yield potentials and yield gaps of soybean production in Austria – a biophysical and economic assessment

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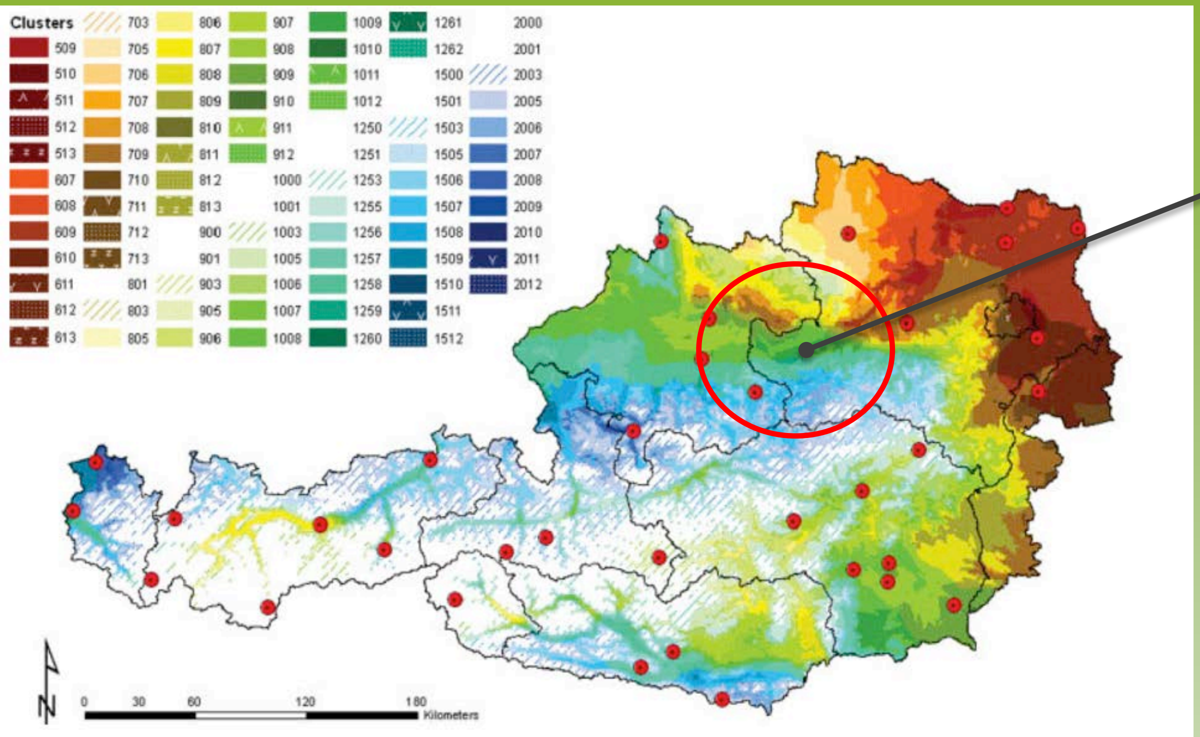
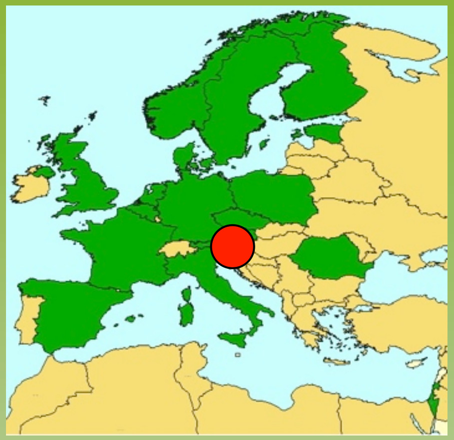
outline

- **context of analysis:**
  - **stakeholders. policy relevance: CC and protein crops**
- **research problem:**
  - how large is the yield gap and what can be done
- **data**
- **approaches**
- **findings**
- **discussion and outlook**



Mostviertel. Austria



Between plains of Danube valley and Alpine region
Higher temperatures. e.g. +1.6 C on both winter and summer

Regional capacities for adaptation/mitig. to CC:

Cover crops - A-E program

Reduced tillage and direct seed

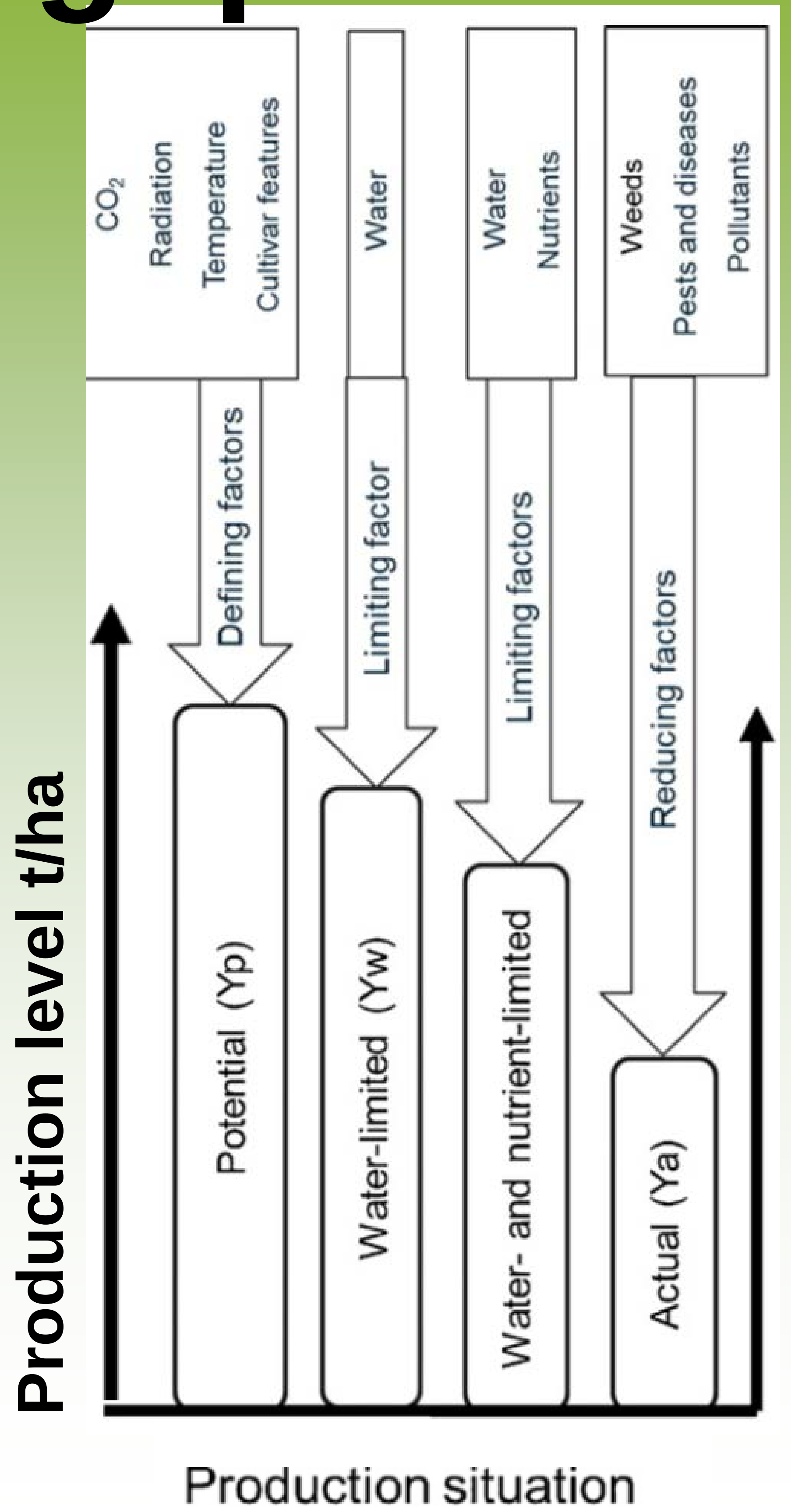
Avareness of **soil organic carbon**

Alternative crops emerge: **soy**. sorghum. wine

Irrigation. limited to valuable crops

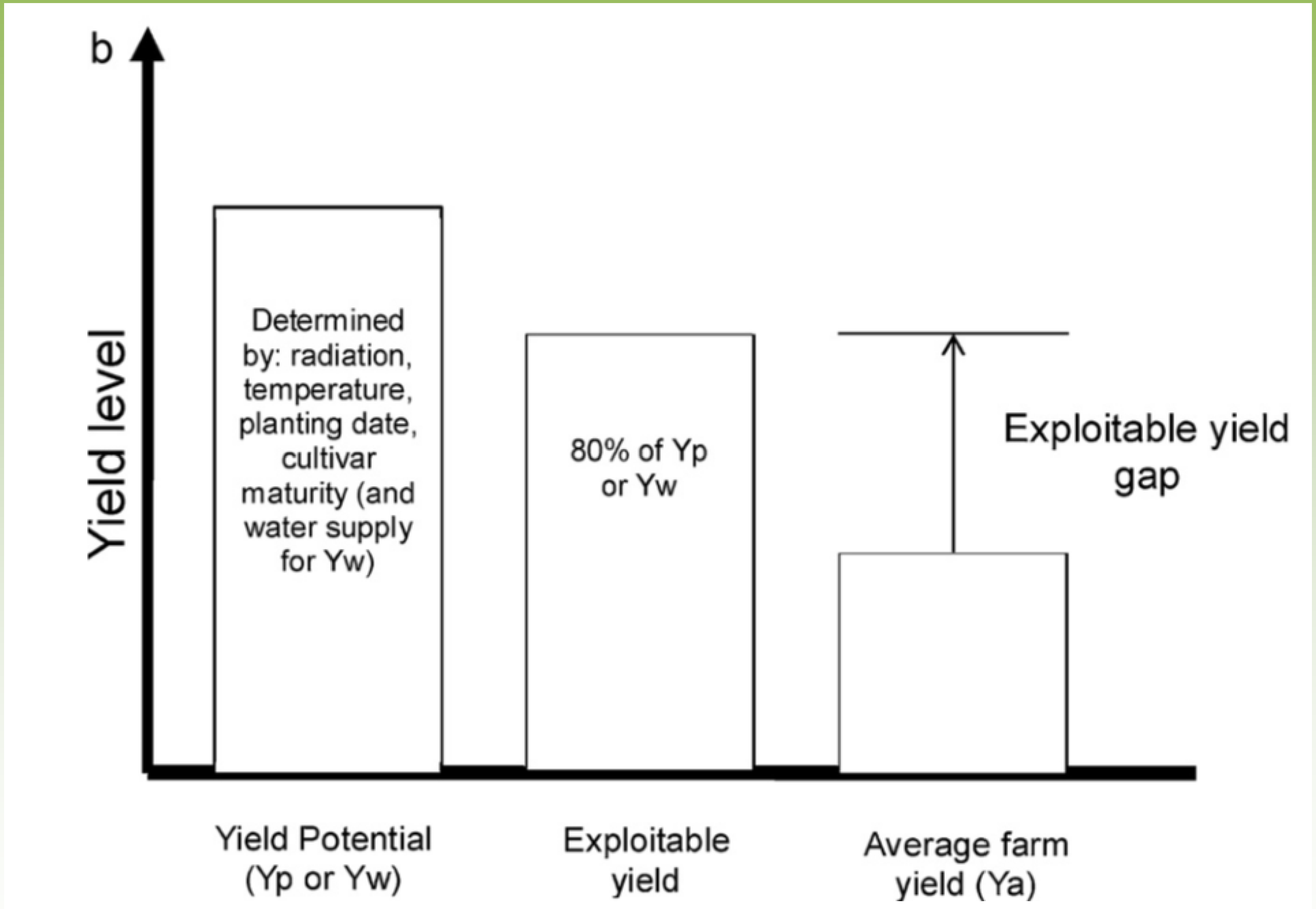
Source: Lehtonen. 2015

yield gap – the concept



Source: Ittersum et al. 2013

yield gap – the concept



Source: Ittersum et al. 2013

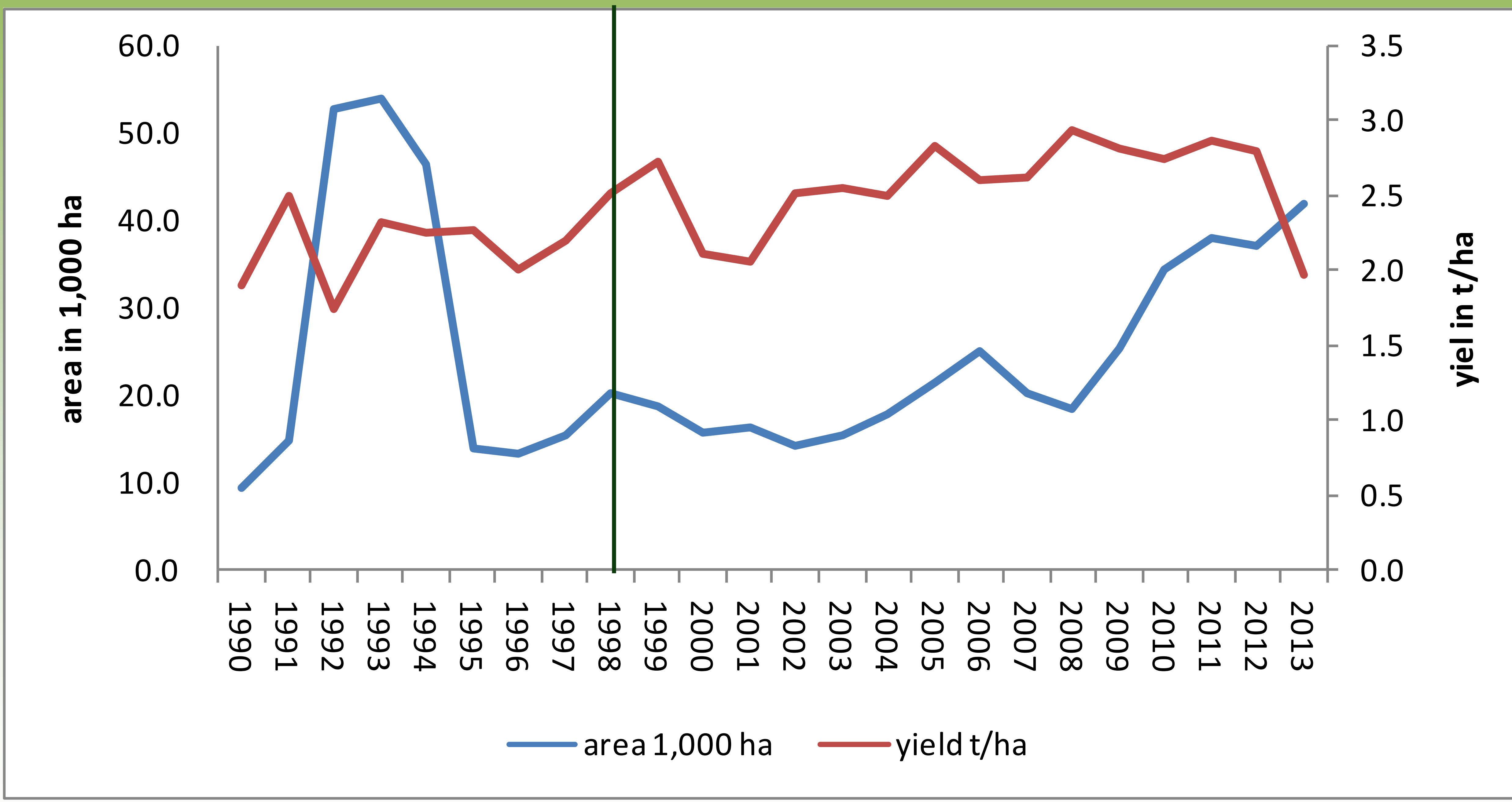
explanations for yield gap

- **field experiments:**
  - better management. soils. equipment. information
  - objective: maximum yield of specific crop
- **farmers:**
  - less than optimal management; crop-rotation not single crop
  - objective: farm income. if risk averse: non-volatile farm income
- **our objective – exploration of yield gap of soy**
  - levels. distribution. time variance
  - reasons and causes

MACSUR / TradeM

soy bean production in Austria

soy bean production in AT

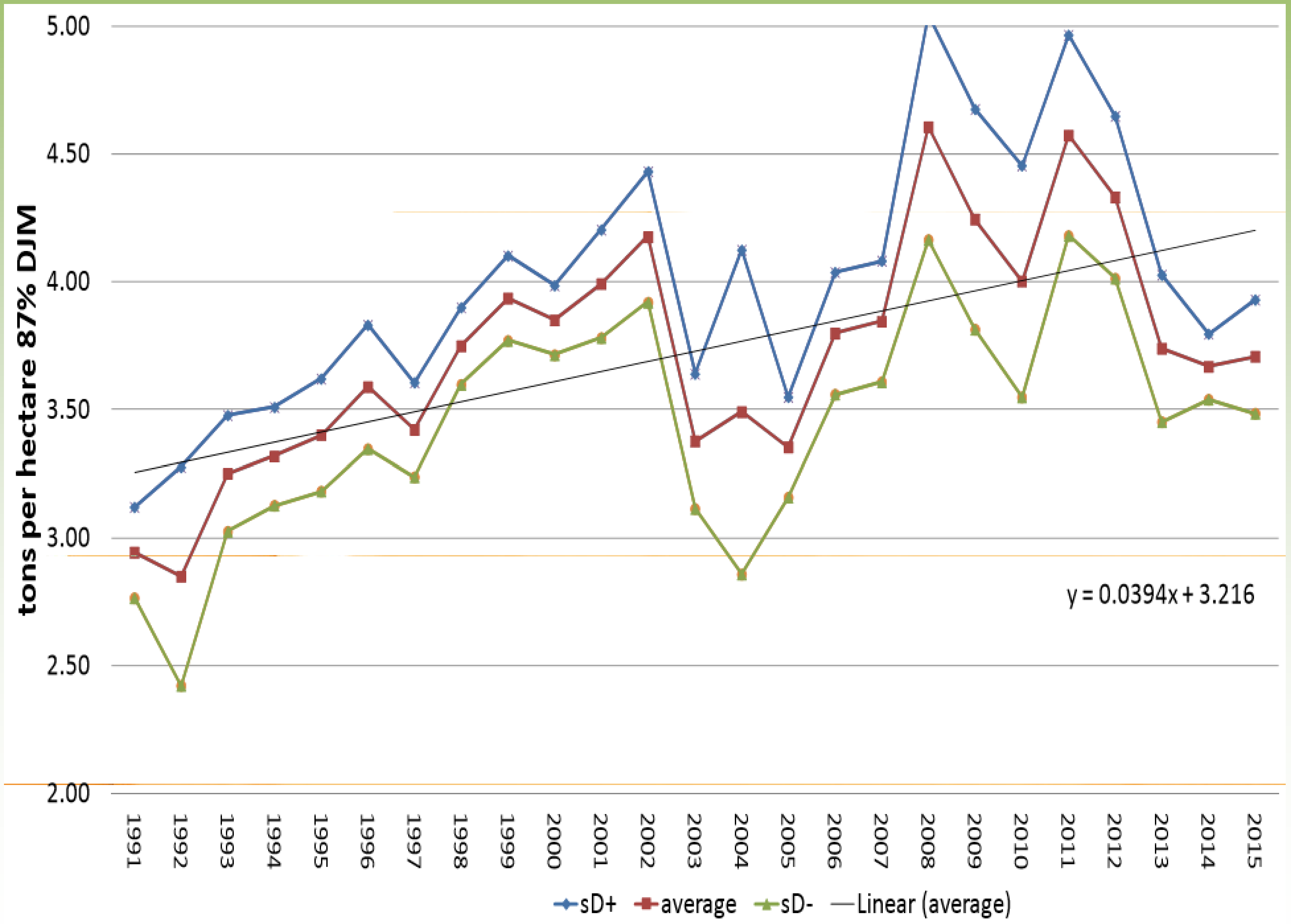


Source: STAT. Erntestatistik

yield gap soy bean in Austria

observations at experimental stations

observations at experimental stations

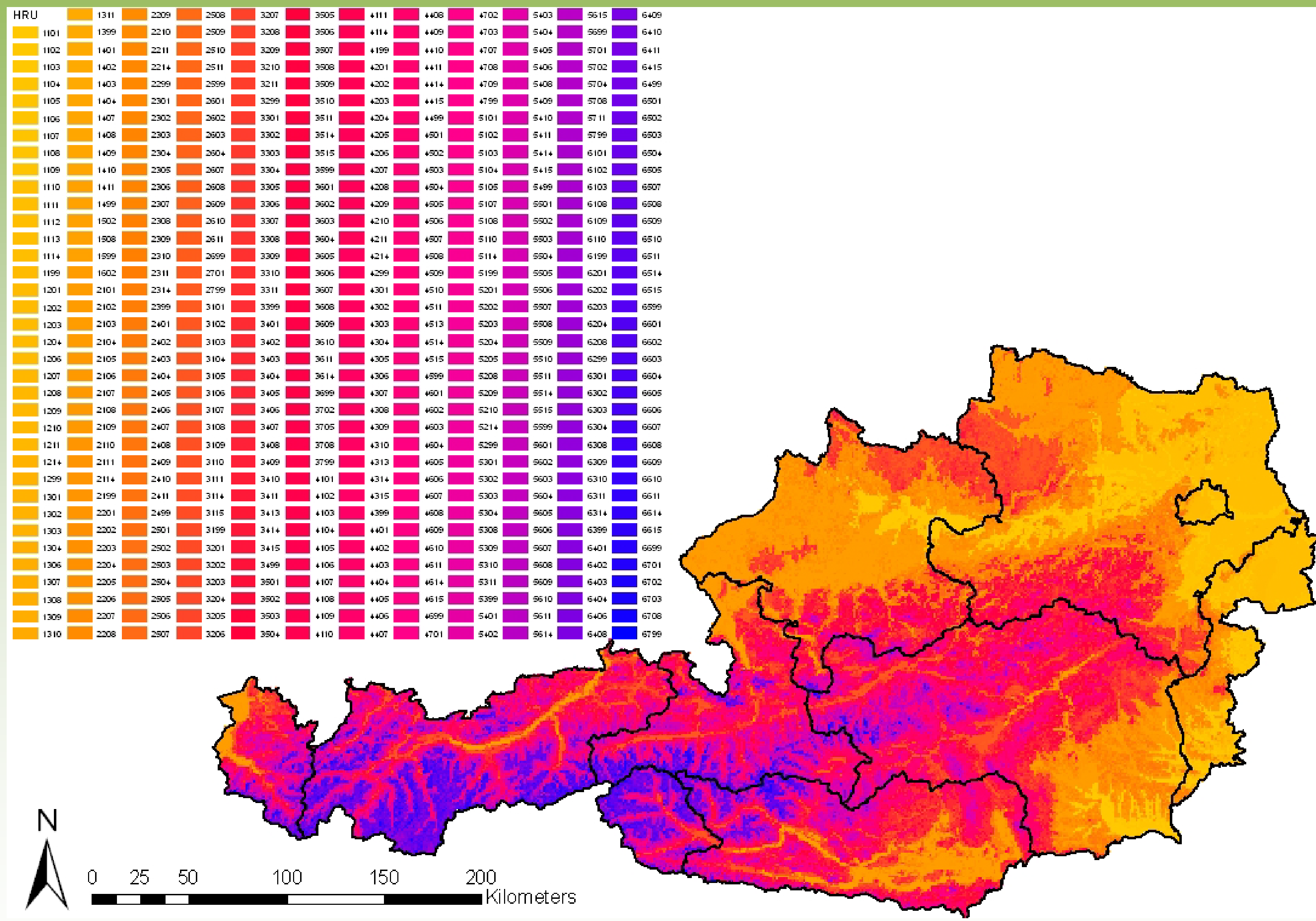


yield gap soy bean in Austria

results from

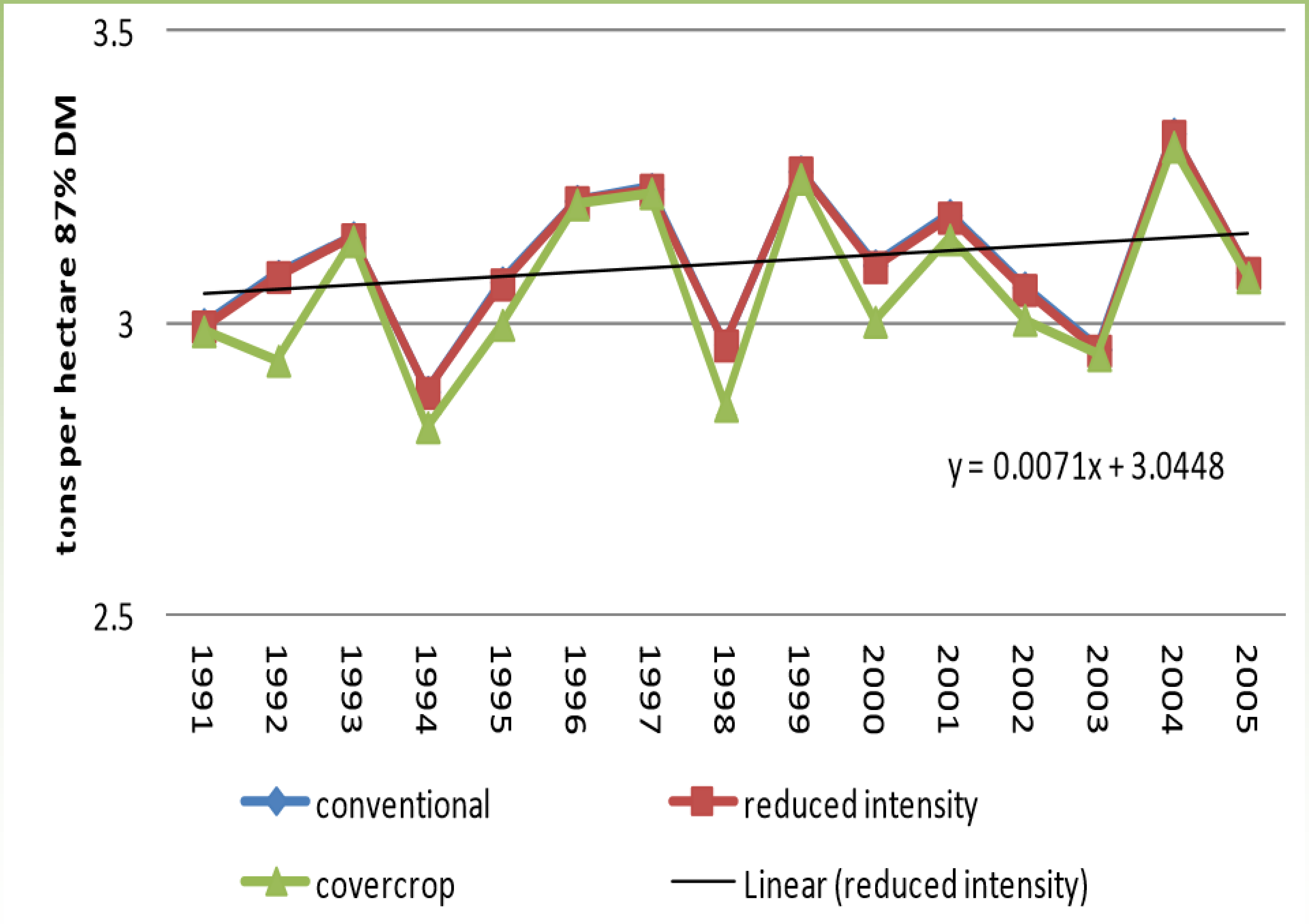
crop model (EPIC)

spatial heterogeneity
HRU Homogenous Response Units



Source: own construction

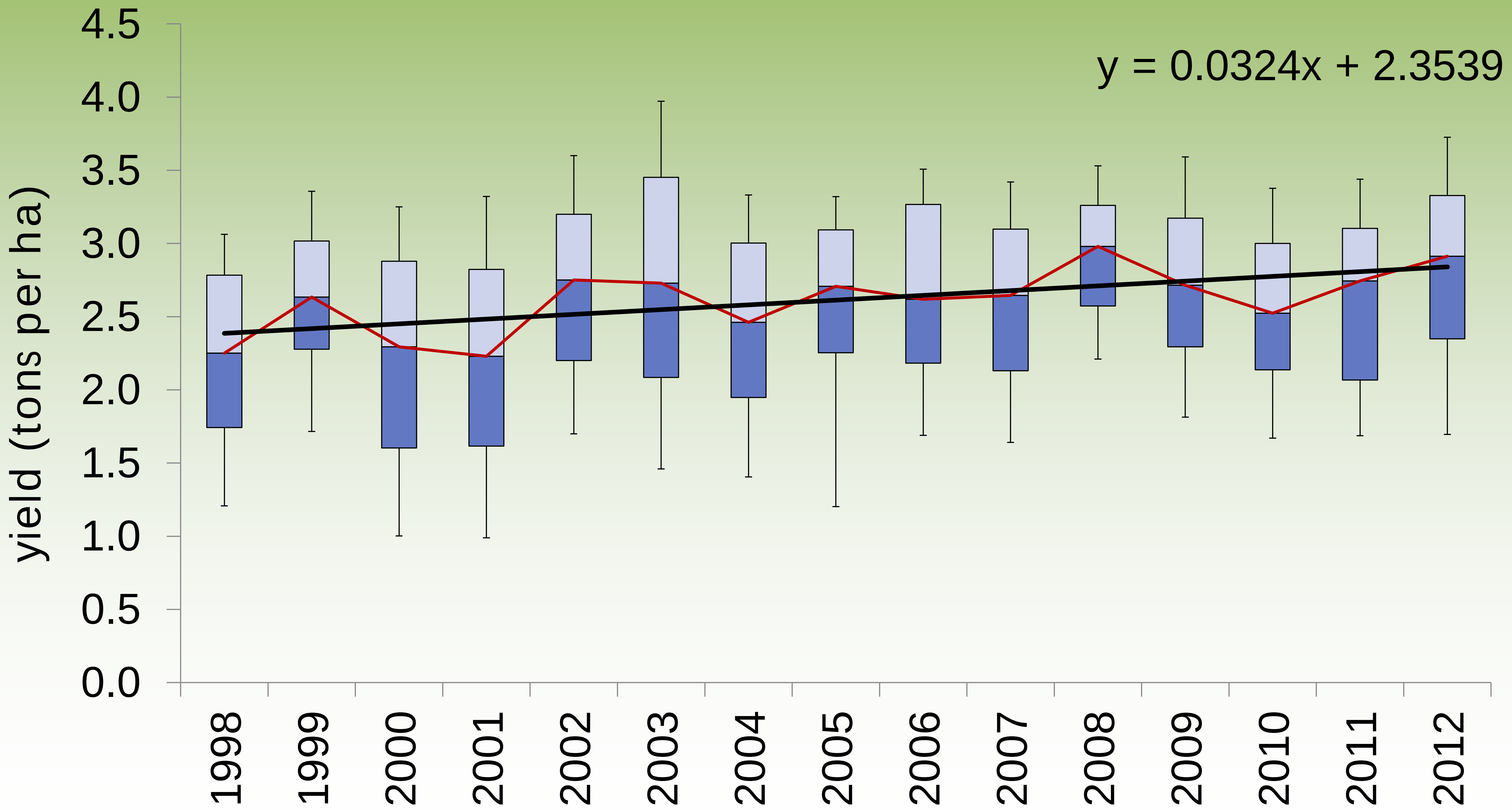
results from a crop model on farm land



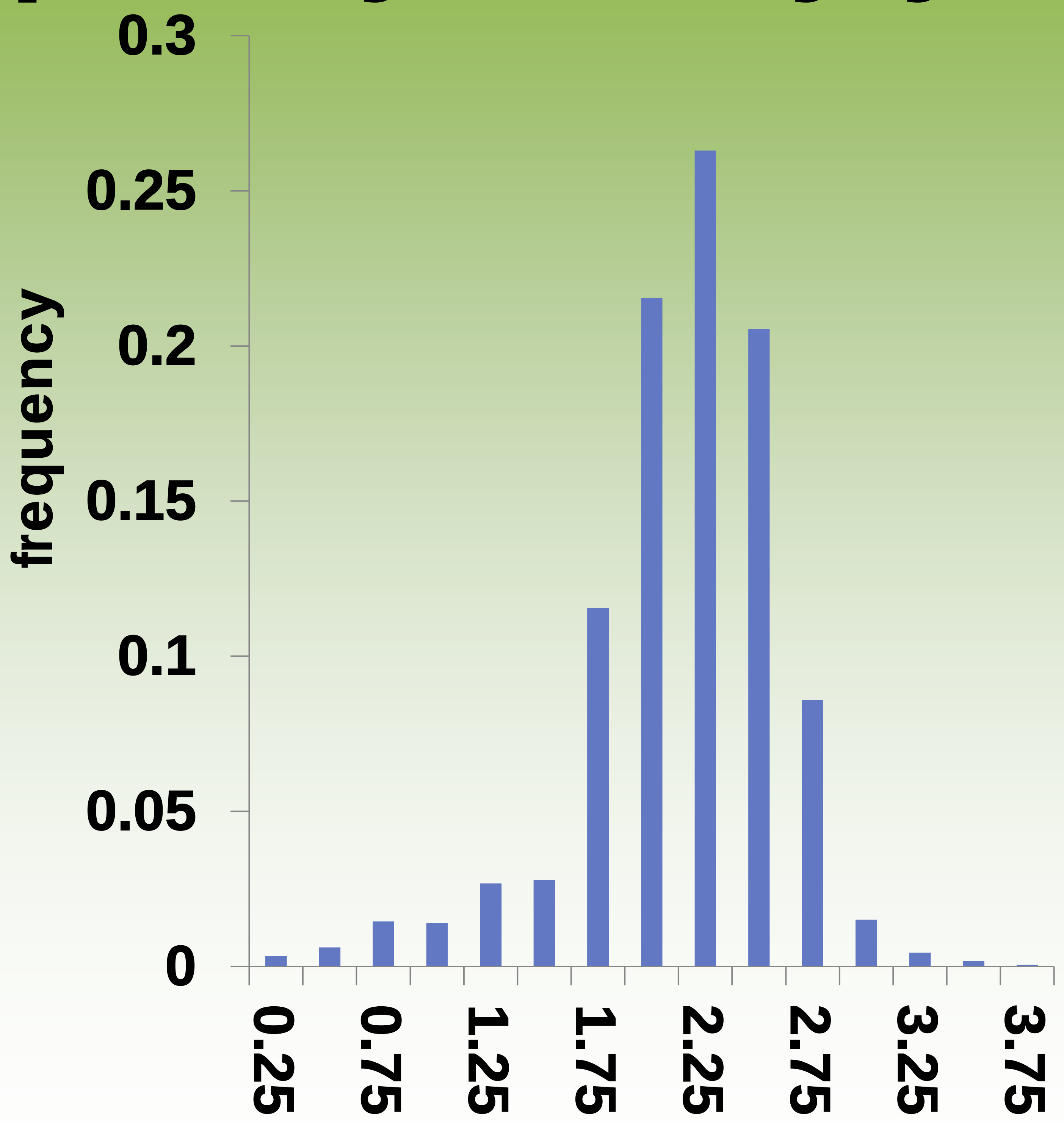
yield gap soy bean in Austria

observations at farm level
FADN

FADN yield in t per ha



observations at farm level frequency of soy yields

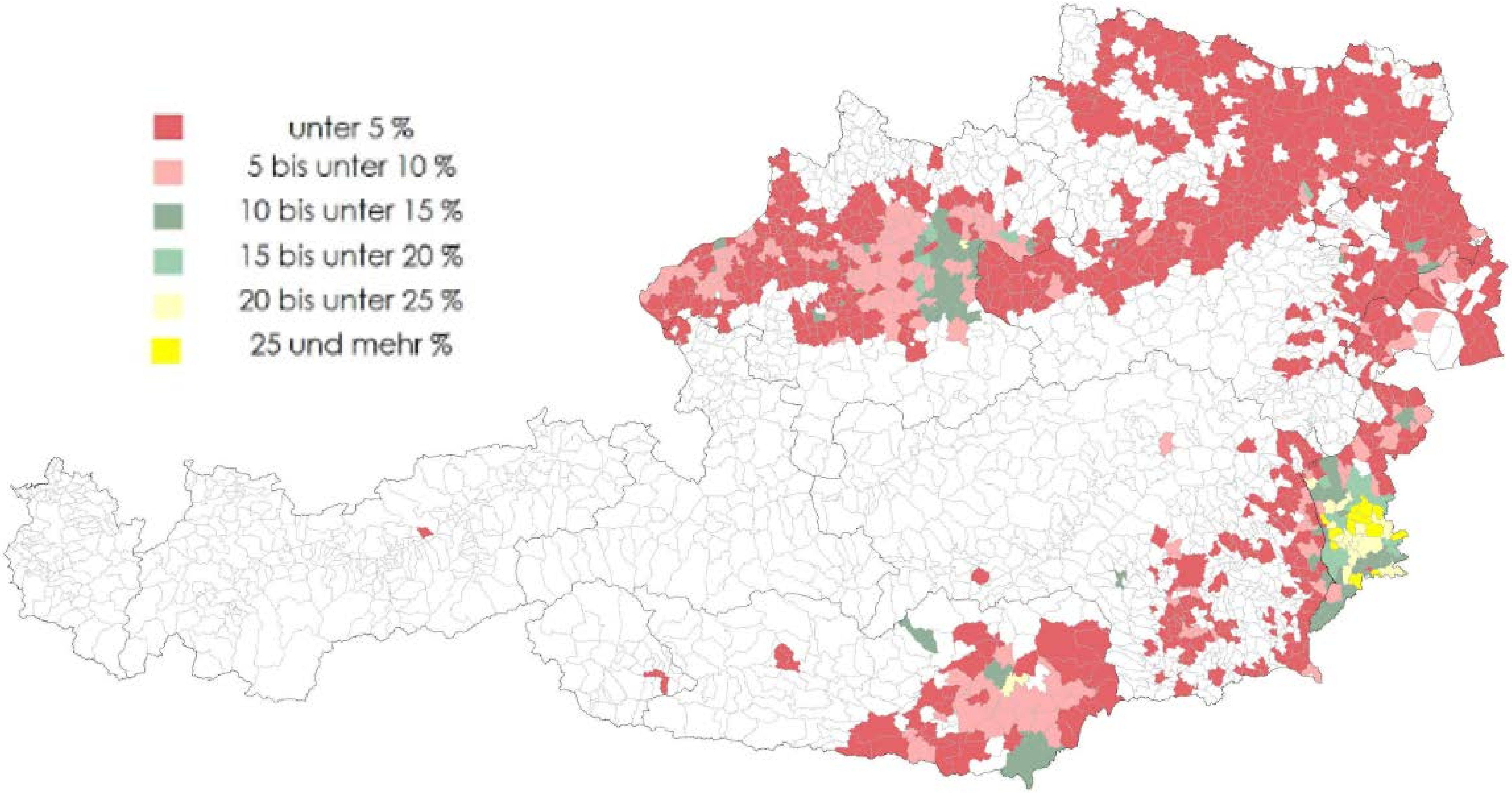


Source: FADN. LBG. BMLFUW. own calculations ; observations for 1998-2012

yield gap soy bean in Austria

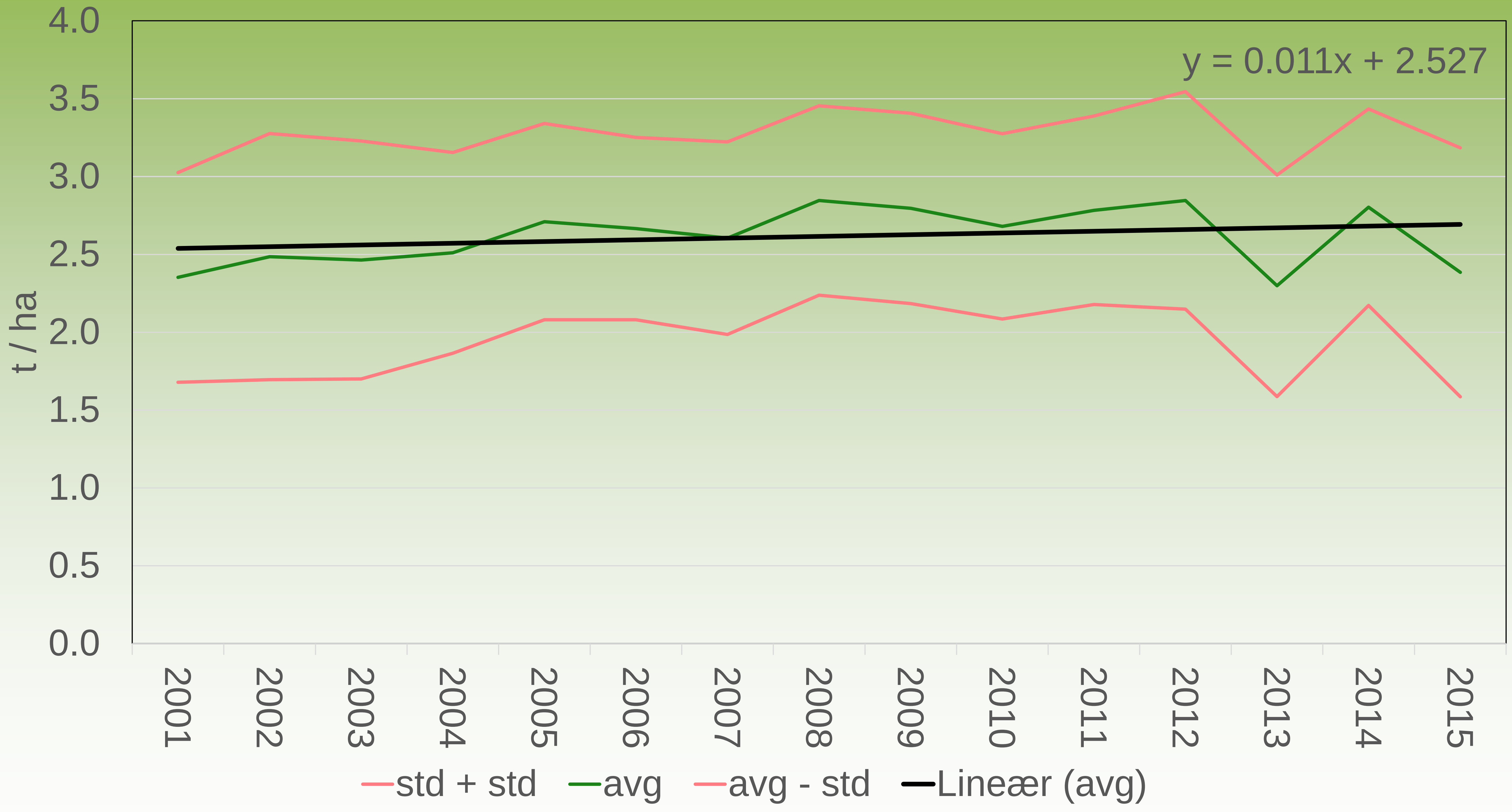
observations at municipality level

regional production of soy 2012



Source: STAT. Agrarstrukturerhebung 2012

yield at municipality level



summary of findings

- **crop model results**
  - trend: yield + 7kg/ha partly due to higher temperatures
  - yield trend depressed by land expansion
  - based on simulations on 1x1 km grids
  - soy is part of an observed crop rotation
- **experimental data**
  - trend: yield + 40 kg/ha due to genetics and CC
  - variance between cultivars is increasing
  - at least 5 years until best varieties are adopted on farms

summary of findings

- **municipality crop statistics**
  - trend: yield + 11 kg/ha likely due to CC and others
  - much lower average yields than model and experiments
  - volatility over time lower than in experiments and model
  - yield trend increase is depressed by land expansion
- **FADN crop yield results**
  - trend: yield + 32 kg/ha
  - yields of best farms match lower bound of experiments
- **yield gap is stochastic**

yield gap soy bean in Austria

what explains the
yield levels
in municipalities

methodology

- **meteorological effects**
  - unbalanced panel 2001 to 2014, 4891 obs
  - fixed effects: for non-time-varying characteristics
  - linear and non-linear terms with and wo interaction
  - 1x1 km grid: weather (5 variables daily)
- **price effects**
  - country: prices of soy beans and other crops
- **land use shares**
  - municipality: yields. prices. acreage soy and maize

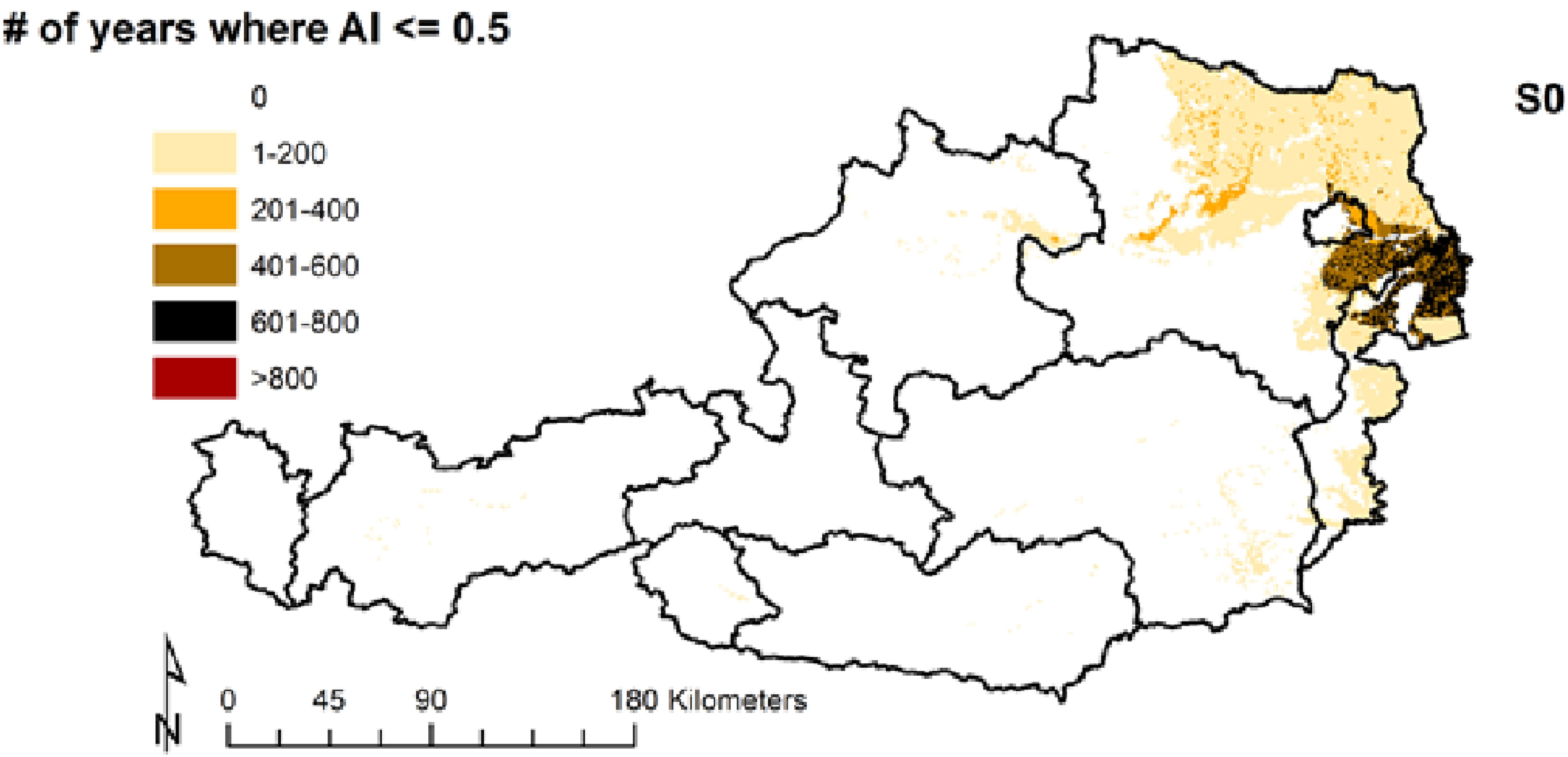
model results

	Ertrag1		Ertrag2		Ertrag3		Ertrag4	
endogene Variable	Ertrag Soja		Ertrag Soja (in logs)		Ertrag Soja		Ertrag Soja (in logs	
Variable								
Anteil Fläche_Sojabohnen an gesamter Ackerfläche in Gemeinde (in %)	-0,09534	**	-0,00421	***	-0,09233	**	-0,00406	***
	(0,0377)		(0,0016)		(0,0377)		(0,0016)	
Anteil Fläche_Mais an gesamter Ackerfläche in Gemeinde (in %)	-0,02861		-0,00163	*	-0,02974		-0,00169	**
	(0,0206)		(0,0009)		(0,0206)		(0,0009)	
Fläche (in ha) Ackerland in Gemeinde	-0,00139		-0,00007		-0,00144		-0,00007	
	(0,0012)		(0,0001)		(0,0012)		(0,0001)	
Zahl der Tage zwischen 10. und 30. Juni mit weniger als 12 Grad Tiefsttemperatur	0,02949		0,00201		0,06439		0,0037	**
	(0,0410)		(0,0017)		(0,0442)		(0,0019)	
Summe Regen zwischen 1. Juli und 31.08. (Gewichtung: gew_CORINE21)	0,00123	***	0,00005	***	0,00119	***	0,00005	***
	(0,0002)		(0,0000)		(0,0002)		(0,0000)	
Summe Regen zwischen 15.09. und 10.10. (Gewichtung: gew_CORINE21)	-0,00224	***	-0,00009	***	-0,00196	***	-0,00008	***
	(0,0003)		(0,0000)		(0,0003)		(0,0000)	
Durch_Tx_Juli_gew_CORINE_kl24	-0,76056	**	-0,03288	**	-0,74168	*	-0,03197	**
	(0,3793)		(0,0159)		(0,3792)		(0,0159)	
Durch_Tx_Juli_gew_CORINE_gr28	-1,15358	***	-0,05084	***	-1,30932	***	-0,05837	***
	(0,2665)		(0,0112)		(0,2763)		(0,0116)	
Durch_Tx_August_gew_CORINE_kl24	-0,40802		-0,01951		-0,32917		-0,0157	
	(0,2867)		(0,0120)		(0,2889)		(0,0121)	
Durch_Tx_August_gew_CORINE_gr28	-1,06835	***	-0,05605	***	-0,86898	***	-0,04641	***
	(0,2964)		(0,0124)		(0,3107)		(0,0130)	
lnPreise_Sojabohnen_t_1	-7,45078	***	-0,34025	***	-6,34294	***	-0,28665	***
	(0,9128)		(0,0382)		(1,0503)		(0,0439)	
lnPreise_Soja_Weltmarkt_Juni	-0,0496		-0,00571		-1,12862		-0,05792	
	(1,5593)		(0,0652)		(1,6389)		(0,0686)	
lnPreise_Soja_Weltmarkt_Juli	2,4417	**	0,09245	**	2,93078	***	0,11611	***
	(1,0197)		(0,0427)		(1,0448)		(0,0437)	
Zeit	0,67612	***	0,03121	***	1,31959	***	0,06234	***
	(0,0779)		(0,0033)		(0,3120)		(0,0131)	
Zeit^2					-0,01811	**	-0,00088	**
					(0,0085)		(0,0004)	
Konstante	43,70832	***	4,15716	***	35,23753	***	3,74734	***
	(4,7180)		(0,1974)		(6,1694)		(0,2581)	
N	4891		4891		4891		4891	
r2_o	0,0345		0,03398		0,03533		0,03488	

summary of findings

- **meteorological effects**
  - rain matters: good in June and Juli bad in late September/October
  - soy is senstive to high temperatures in July and August
- **price effects**
  - slight negative effect of soy price t-1
  - slight positive effect of soy price in July
  - slight negative effect of durum wheat price t-1
- **land use shares**
  - higher share of land $\rightarrow$ lower yields
- **time trend positive and strong**
  - depending on model: 60 kg / year and more

drought risk in Austria



Source: Strauss et al. 2013

yield gap soy bean in Austria

efficiency analysis

the scope of farm management

methodology

- **stochastic frontier analysis**
  - 104 FADN-data with 1082 observations
  - period 1995 to 2011
  - yields on average from 2.0 to 2.5 and up to 4.5 t/ha

SFA results for soy

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-27.91	5.76	-4.85	0.00	***
log(Mean_Prec_mpss)	0.39	0.13	3.07	0.00	**
log(Mean_Rad_mpss)	1.54	0.36	4.33	0.00	***
log(Mean_Temp_so)	0.51	0.08	6.72	0.00	***
Z_ESU	-0.02	0.00	-3.85	0.00	***
Z_PROTEC	-0.01	0.00	-3.43	0.00	***
sigmaSq	1.00	0.15	6.89	0.00	***
gamma	0.99	0.00	406.32	< 2.22e-16	***

summary of findings

- **mean efficiency: 0.69**
  - low compared to wheat: 0.80 → scope for management
- **meteorological effects**
  - rain matters
  - temperature matters
  - global radiance matters
- **farm specific effects**
  - farm size matters
  - model without fertilizer because accumulated by plant
  - expenditures for crop protection substances

discussion

- **yield gap analysis is a daunting task**
- **what can be learned**
  - economics matters: prices of crop and other crops
  - land expansion: more land becoming more marginal
  - management matters a lot but – not directly observable in data
  - significant knowledge gaps still there
- **way forward:**
  - look at other crops
  - explore options to improve management

acknowledgements

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