GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

Hedging against irrigation costs by means of index-based weather insurance

SCC-76 Annual Meeting

Pensacola, 30 March - 01 April 2017

Matthias Buchholz & Oliver Musshoff

Department of Agricultural Economics and Rural Development
University of Goettingen

Outline




Irrigation as risk management tool

- Droughts during cropping season as major driver for yield uncertainty
- Irrigation can be considered as a straightforward on-farm instrument for hedging risks associated with the absence of precipitation (Buchholz & Musshoff 2014; Finger 2013; Garrido et al. 2006)
- Irrigation also involves high costs for farmers that are uncertain and vary substantially depending on the weather conditions

➡ General purpose: Using index-based weather insurance to hedge against operating costs of irrigation in dry years?

Background on index based-weather insurance

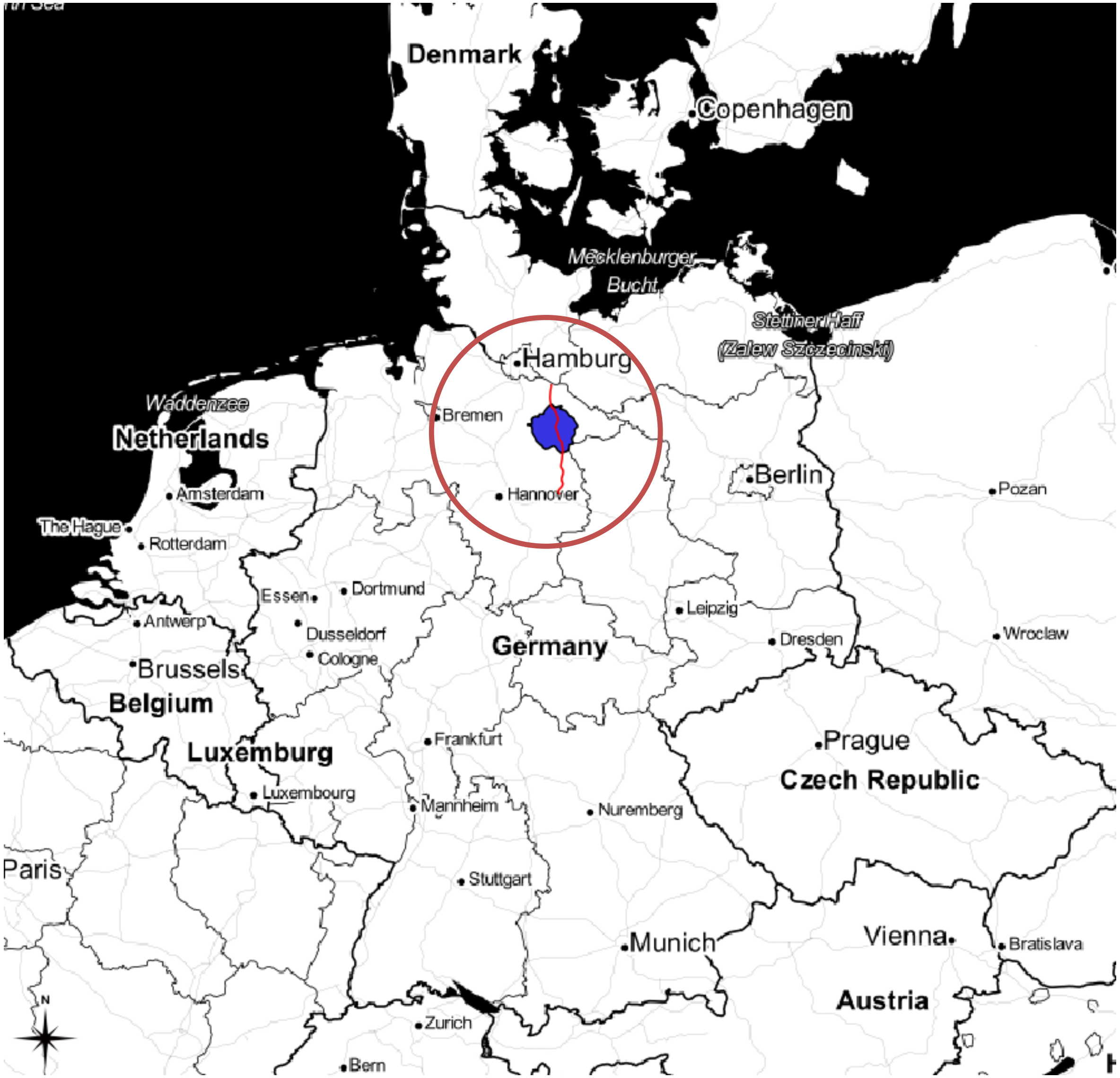
- For agricultural insurance: Primary focus on hedging yield risks (e.g. Richards et al. 2004, Turvey 2001, Vedenov & Barnett 2004, Woodard & Garcia 2008)
- Studies that focus on hedging against volatile costs of agricultural inputs (irrigation) are rare (e.g. Mafoua & Turvey 2003)
- Major drawbacks of index insurance:
  - Geographical basis risk → Gridded weather data
  - Need for a valid underlying → Climatic water balance

Improve performance?

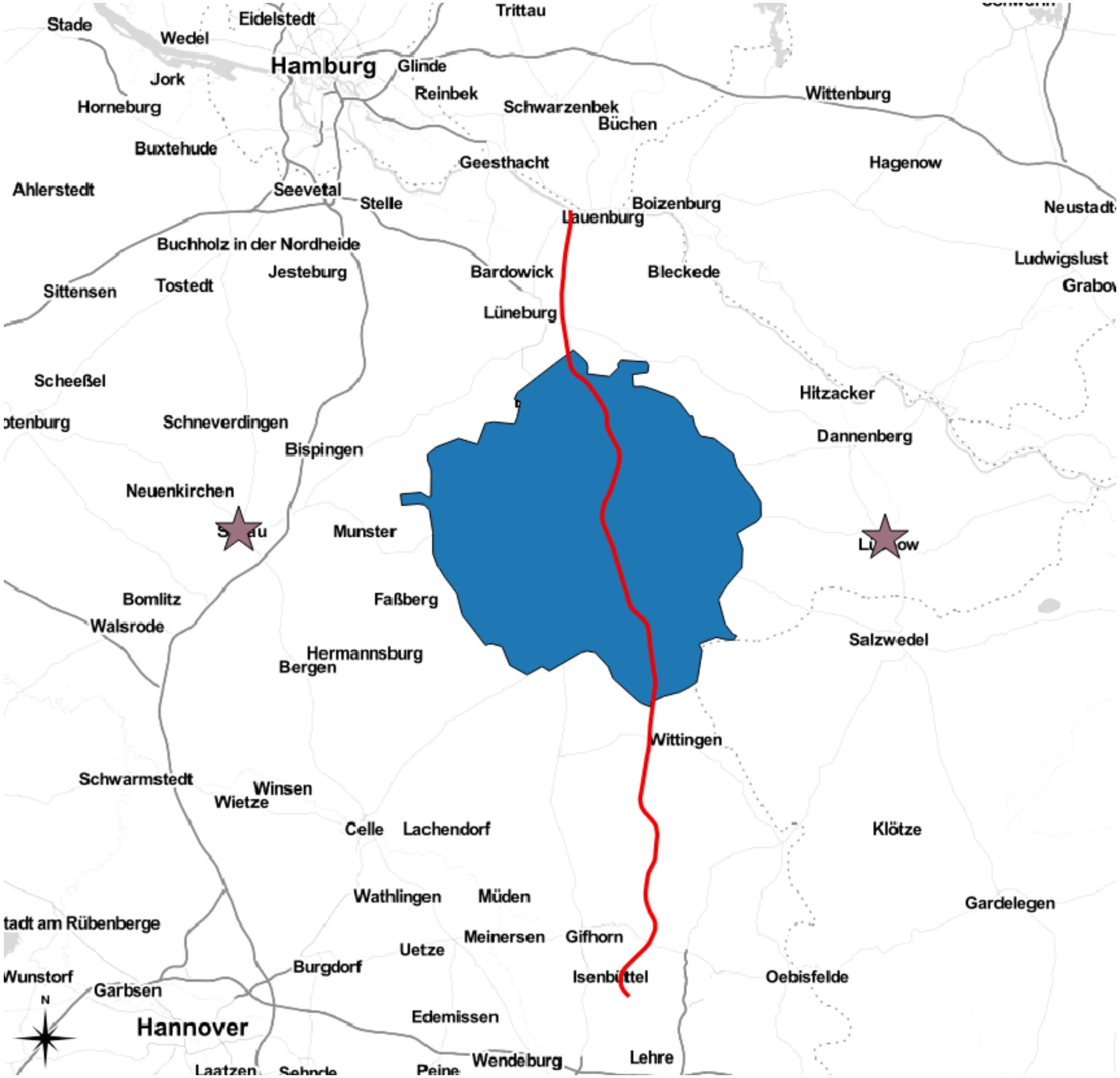
Case study area: Lower Saxony (northern Germany)

- Germany’s major irrigation area
- Highly specialized cash crop farming despite poor soils
- Focus: Water user association with about 11,000 hectares of arable land
- Water withdrawals from the local channel ‘Elbe-Seitenkanal’
- Aggregated water applications from 1980-2011 (Dachverband Elbe-Seitenkanal 2015)
- Irrigation systems are already installed
- Actual irrigation costs comprising pumping, labor and maintenance (not including overhead costs) amount to 0.2 €/m^3

Case study area: Lower Saxony (northern Germany)



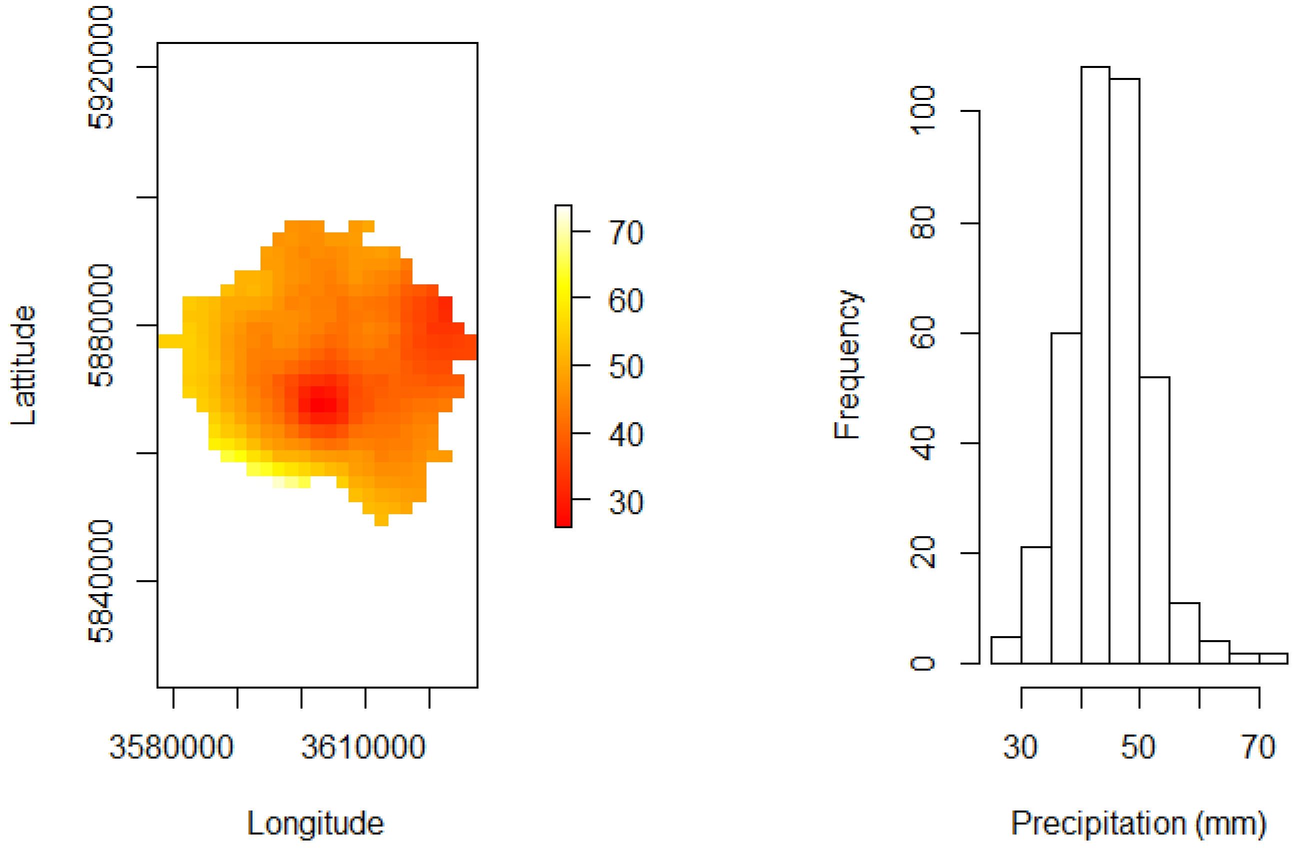
Station-based vs. regionalized gridded weather data



Derivation of gridded weather data

- Provided by German meteorological service (DWD 2015)
- Spatial resolution of 1 km x 1 km
- Gridded fields of weather variables are interpolated from station data
- Use of different multiple linear regression approaches depending on the specific weather variable and temporal resolution (Kaspar et al. 2013; Rauthe et al. 2013)
  - Estimation of background fields
  - Consideration of orographic parameters
  - Inverse distance weighting
  - Triangulation
  - Plausibility checks / Quality control

Example: Gridded accumulated precipitation June 2016 (in mm)



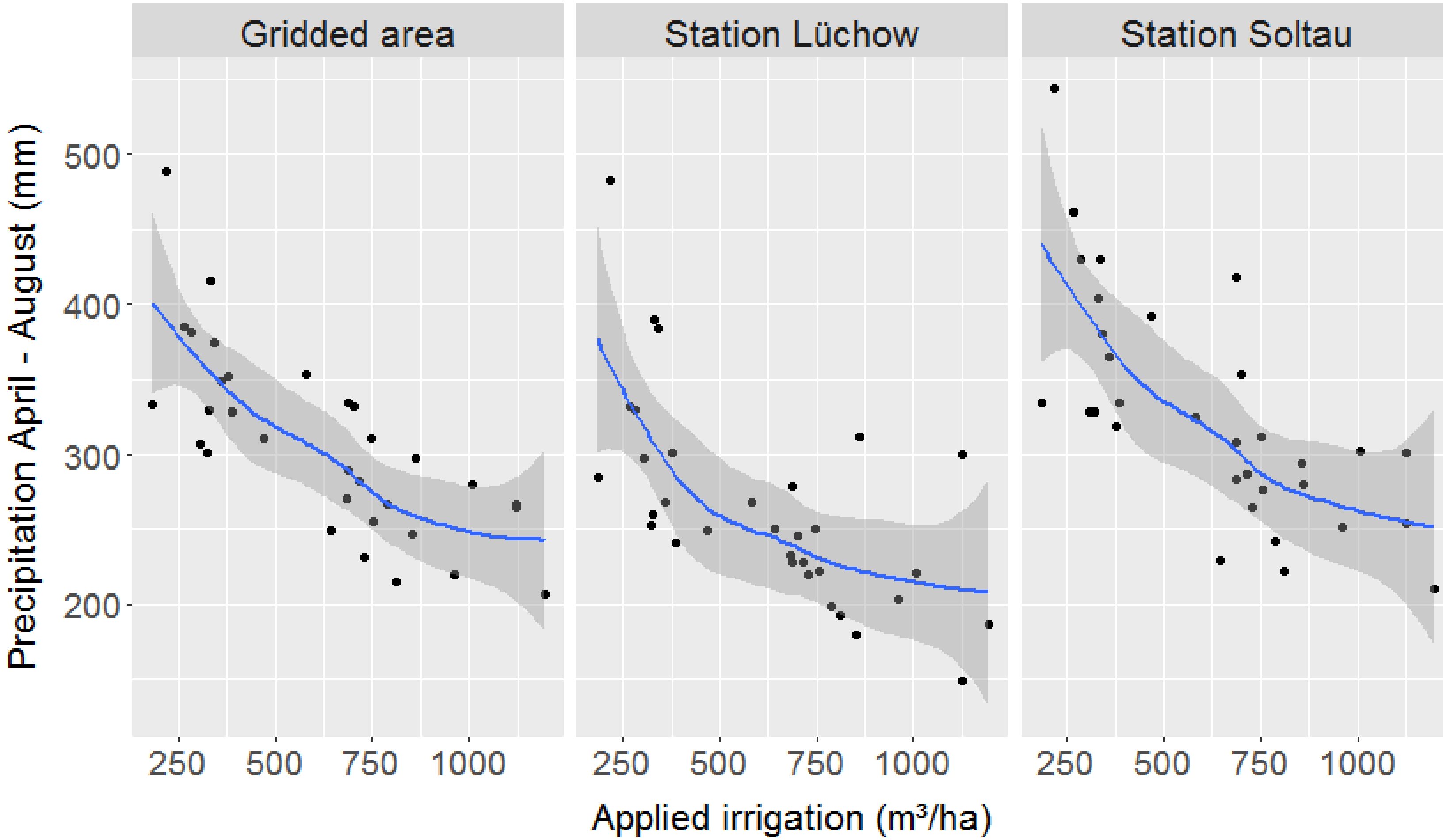
Climatic water balance (WB) as innovative underlying

- Depends on specific crop
- Usually based on precipitation (R) and potential evapotranspiration over grass (ETp):
- Definition: WB = R - ETp
- ETp derived from agrometeorological model AMBAV (Friesland & Löppmeier 2007)
- Appears to be more meaningful than traditional weather variables
- Not subject of irrigation actually applied in the field!

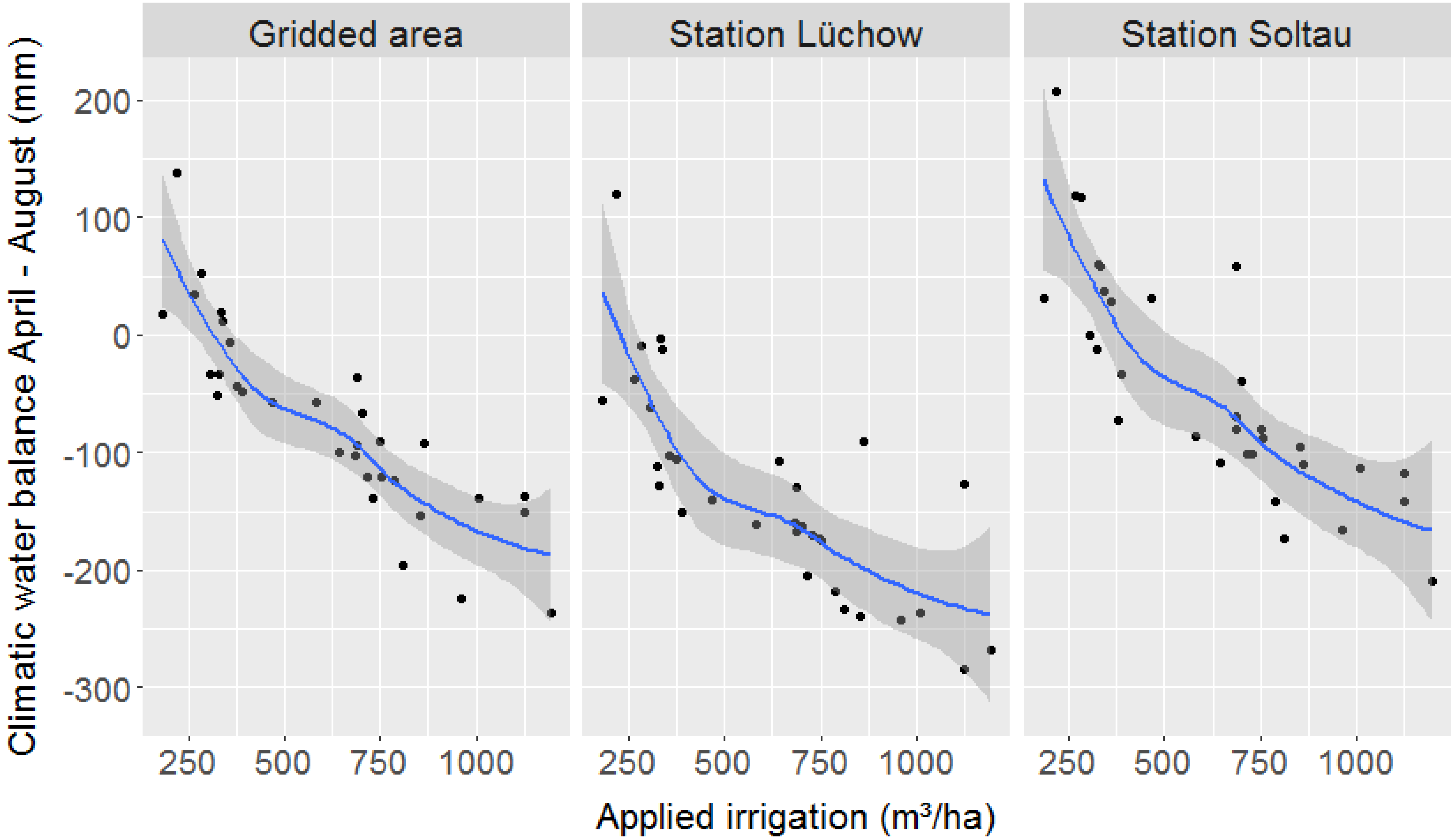
Design & pricing of index insurance – Burn rate method

	Precipitation (R)	Climatic water balance (WB)
Accumulation period	April - August for station/area i	
Weather index	$R_{a,i} = \sum_{m=4}^{8} R_m^{a,i}$	$WB_{a,i} = \sum_{m=4}^{8} WB_m^{a,i}$
Payoff P	$P_{a,i}^{R} = max\left(R_{a,i} - S_i^R, 0\right) \cdot V_i^R$	$P_{a,i}^{WB} = max\left(WB_{a,i} - S_i^{WB}, 0\right) \cdot V_i^R$
Strike S & Tick-Size V	Adjusted to maximize risk reduction potential (using OptQuest routine)	
Loading	20 % load of the fair premium	

Results: Accumulated precipitation plotted against applied irrigation



Results: Climatic water balance plotted against applied irrigation



Results: Relationship between weather indices and applied irrigation

Estimates of a rank-order correlation analysis (according to Spearman):

Weather station / gridded area	Weather indices	
	Accumulated precipitation April-August	Climatic water balance April-August
Station Lüchow	-0.71***	-0.82***
Station Soltau	-0.78***	-0.88***
Gridded area	-0.78***	-0.91***

Note: *** p-value ≤ 0.001

Results: Risk reduction potential of considered insurance schemes

Estimates reveal the % reduction in the standard deviation (SD) and upside semi-standard deviation (Semi-SD) of irrigation costs:

Weather station / gridded area	Weather indices			
	Accumulated precipitation April-August		Climatic water balance April-August	
	SD	Semi-SD	SD	Semi-SD
Station Lüchow	-28.51%	-22.42%	-41.82%	-35.31%
Station Soltau	-32.91%	-31.42%	-51.05%	-47.73%
Gridded area	-37.46%	-35.51%	-55.33%	-52.55%

Conclusive remarks

- Index-based weather insurance has the potential to hedge against volatile irrigation costs
  - Aggregation level: Single farm vs. water user association?
  - Policy instrument?
- Weather indices based on the climatic water balance appears to increase hedging efficiency
- Regionalized gridded data may increase performance of index insurance:
  - Computational burden?
  - Data availability?
  - Use of remote sensing data?
- Adverse ecological effects on input demand: Substitute or compliment?

Limitations & future research

- Need for further empirical evidence (e.g. Dahlhaus & Finger 2016)
- Collect more data:
  - Effect of aggregation level?
- Make proper use of the whole ‘tool box’:
  - Temporal basis risk?
  - Choice of more sophisticated methods?
  - Look at extreme events (CVAR)
- Estimation of actual insurance demand

Thank you for your attention!

"Climate is what we expect,

weather is what we get."

(Mark Twain)

Contact:
Dr. Matthias Buchholz
Department of Agricultural Economics and Rural Development
University of Goettingen, Germany
mbuchho@gwdg.de

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Appendix: Single farm efficiency of index insurance schemes

Estimates reveal % reduction in the standard deviation (SD) and upside semi-standard deviation (Semi-SD) of irrigation costs:

Weather station / gridded area	Weather / climate indices			
	Accumulated precipitation April-August		Climatic water balance April-August	
	SD	Semi-SD	SD	Semi-SD
Station Lüchow	-	-	-48.43%	-46.76%
Station Soltau	-	-	-44.42%	-47.19%
Gridded area	-	-	-56.24%	-63.67%
Farm site	-	-	-53.70%	-60.66%

Appendix: Histogram of applied irrigation from 1980-2011