Impact of heat stress, drought and wetness on crop yield anomalies in Germany

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Introduction

- In well managed environments, with sufficient nutrient supply and control of pests, diseases and weeds, crop yield anomalies are often caused by unsuitable weather conditions during the growing period which are likely to increase in the future.
- Here we analyze the impact of three stressors (heat, drought and wetness) on yield anomalies of four crops (winter wheat, winter rapeseed, sugar beet and silage maize) grown in Germany between 1950 and 2010.

Data and methods

- Observed crop yields averaged over the whole of Germany (Figure 1) and over the German federal states were derived from annual statistical yearbooks.
- Crop yield anomalies were calculated as deviation from the 11-year moving average crop yields in both, absolute (t ha⁻¹) and relative (% terms).
- Ranking of years according to largest negative crop yield anomalies.

Results

- Heat stress was computed as accumulated temperature sum of daily maximum temperatures above 30 °C (°Cd) in period 1950 – 2010 averaged over cropland in Germany or German federal states.
- Three precipitation anomaly indicators were calculated for periods between 1 and 5 months based on deviations from long-term mean precipitation (Figure 3): (i) accumulated relative monthly precipitation deficit [mm], (ii) accumulated relative monthly precipitation surplus [mm], and (iii) deviation of precipitation sum [mm].
- A correlation coefficient between heat stress and crop yield anomalies was analyzed to detect crop specific sensitivity of yields to heat stress.
- Combined effects of heat and drought on crop yields were analyzed by comparing regression coefficients of single or multivariate (heat + drought) regressions.

Spatial patterns in crop yield anomalies

- Distinct spatial pattern in crop yield anomalies; differences among crops and years; even in years with the largest negative crop yield anomalies yields in some federal states were less or even not affected (Figure 4).

Impact of the stressors heat, drought and wetness

- Positive precipitation anomalies (wetness) resulted in negative yield anomalies of winter crops in western Germany (Figure 5).
- Negative precipitation anomalies (drought) resulted in negative yield anomalies of summer crops in almost all federal states (Figure 5).
- Negative correlation between heat stress and crop yield anomalies in almost all federal states, but at different magnitudes depending on crop and state (Figure 6).

Interaction of heat and drought

- In most regions and for most crops drought (precipitation sum) explained the variability in crop yield anomalies much better than heat stress, even when the analysis was performed only for years with heat stress (Figure 7).
- High regression coefficients of heat stress and crop yield anomalies were only obtained in regions that were classified as to wet (Figures 5, 7).

Conclusion

Analyses of crop yield anomalies need to be crop specific, have to consider distinct spatial patterns even in small countries like Germany and have to account for interactions between different stressors.

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References


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