POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

PIK

Extreme Weather Events and Agriculture

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How much of the changes in historic agricultural production (1961-2010) in major producing regions can be attributed to the occurence of extreme events?

MOTIVATION

Record-breaking extreme events cause large economic losses, endanger local food security and affect millions of people.

Estimating the impact of extreme events on agricultural production requires separating climate effects from technology and management trends.

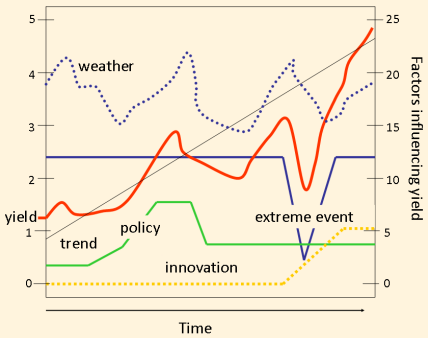
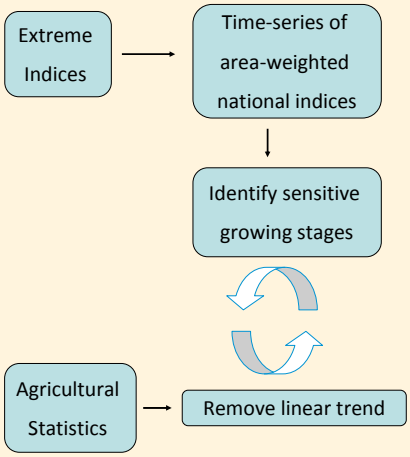


Fig 1 *Factors affecting agricultural yields, according to Gommes et al. 1998*

METHODS - OVERVIEW

Droughts and Heat Waves in Australia, India and the United States are among the Top 10 most important events since 1900 regarding the economic damage and people affected (EM-DAT 2013).

We focus on the wheat, maize and rice yields in these three countries which together produce ~ 1/3 of the worldwide production.



METHODS – DETAILS

1) Extreme indices

ID	Indicator Name (unit)
DTR	Diurnal temperature range (°C)
TNn	Coldest night (°C)
TXn	Coldest day (°C)
TNx	Warmest night (°C)
TXx	Hottest day (°C)
TR	Tropical nights (°C)
WSDL	Warm spell duration index (day)
TN90p	Warm nights (%)
TX90p	Warm days (%)
GSL	Growing season length (day)
PRCPTOT	Annual total precipitation (mm)
Rx5day	Max 5 day precipitation (mm)
Rx1day	Max 1 day precipitation (mm)
CDD	Consecutive dry days (day)
SDII	Simple daily intensity index (mm/day)

Table 1 *Indices indicating dryness/drought or extreme temperatures (Donat et al. 2013)*

2) Identify the sensitive growing stages

Wheat: Heading to Filling in January/February (India), May (USA), September/October (Australia)

Rice: Heading in August (India)

Maize: Silk emergence in July (USA)

3) Remove linear long-term trend from crop yield statistics

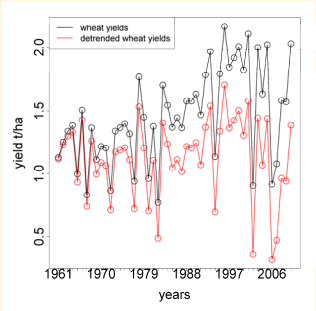


Fig 2 *Wheat yields in Australia 1961-2010 (FAO 2013)*

4) Empirial relationship between extreme indices and crop yields

RESULTS

There is a significant correlation between CDD (R2=-0.58), DTR (R2=-0.64), Rx1day and Rx5day in October (R2=0.57) and wheat yields in Australia (Fig 3), PRCPTOT and rice yield in India (R2=0.61) and TXx and maize yields in the United States (R2=-0.42).

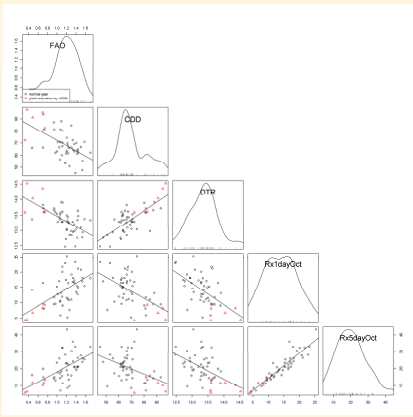


Fig 3 *Scatterplot matrix of correlation coefficients for four extreme indices and wheat production in Australia*

While 10 out of 15 extreme indices are significantly correlated with wheat yields in Australia only few extreme indices correlate with maize, wheat and rice yields in India and the United States. The largest yield reductions in Australia are associated with droughts and heat waves (Table 2).

Year	Yield reduction	**Damage** (EM-DAT, 2013)
1982	56%	Drought affecting 80.000 people, 6000 million US$ damage
1994	55%	Heat Wave affecting > 1 million people
2002	77%	Drought, 2000 million US$ damage
2006	77%	Drought

Table 2 *Yield reduction, estimated economic damage and people affected from droughts and heat waves.*

References

Donat, M.G., Alexander, L.V. et al. 2013. Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset. Journal of Geophysical Research: Atmospheres. 118, 2098-2118.

Gommes, R., 1998. Climate-related risk in agriculture. IPCC Expert Meeting on Risk Management Methods, Toronto, AES, Environment Canada.

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