The relationship between extreme weather and low crop yields

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Background

Around 1/3 of global crop yield variation is explained by weather (Ray et al. 2015, Vogel et al. 2019)

Large regional differences in weather impacts

-> Idea is to explore the climatological drivers and differences in different regions

-> Here, climatological variations are described through soil moisture and temperature
Data

Daily minimum and maximum temperature: AgMerra (Ruane et al. 2015)

Daily soil moisture data from GLEAM (Martens et al. 2017)

Include data only for growing season based on planting and harvesting dates from AgMIP (Müller et al. 2017)

Rasterized maize yield data from Deepak Ray, University of Minnesota

Maize-specific regional climate classification (100 regions based on average growing degree days and soil moisture conditions, Mueller et al. 2012)

Timespan 1980-2010, due to climate data availability
Methods

Sinusodial interpolation of daily temperatures, based on minimum and maximum

Growing season weather cube
- Allocate growing season weather to bins
- Unit is days per bin

Statistical analyses with Random Forest regression
- Explain maize yield anomalies with soil moisture and temperature variability
- Splitting data to training (75%) and testing (25%) sets
Cool and wet regions most susceptible to soil moisture and temperature variability

Increasing soil moisture

Increasing average growing degree days

Maize yield variance explained

R² per climate region

Maize yield variance explained
Most susceptible areas are also those with largest production

![Graph showing production per climate region with increasing soil moisture and average growing degree days.](image)

- Increasing soil moisture
- Increasing average growing degree days

Maize production (10M tonnes)

R2 per climate region (see previous slide)
At least in cool and wet climate regions, high temperatures and low soil moisture seem to reduce crop yields especially when occurring together.

Maize yield anomaly as a function of very hot and dry days (above 90th percentile) during the growing season.
Final notes

Analyses and results are still preliminary

Next ideas: run the analyses for early and late growing seasons separately and for different crop types

Compare impacts irrigated and rainfed areas

Inspect the importance of the explanatory variables (wet, cold, dry, hot, etc.) in different areas


