

CHALLENGES TO FOOD PRODUCTION



A new study finds that climate extremes, like heatwaves and droughts, are impacting the food we get from crops. By understanding these effects we can better plan for climate change

Australia has just experienced its [hottest summer on record](#) as well as a succession of climate extremes. Currently, a vast area of New South Wales is [drought-affected](#). Floods have devastated vast sections of Queensland while [bushfires](#) and [cyclones](#) wreaked havoc across the country.

And bearing the brunt of these extremes are many of Australia's farmers. In fact, last year's national farm production [was down on 2016 results](#).



Extreme weather can cause harvest losses, risking farmer's livelihoods as well as food security. Picture: Getty Images

Droughts, heatwaves, cold extremes or floods can all cause severe harvest losses and pose great risks to the livelihoods of farmers, as well as the food security of communities around the world who rely on agriculture.

If we go back to the Millennium Drought in Australia which began in 1997 and ran through until 2009, agricultural production fell from [2.9 per cent to 2.4 per cent of Gross Domestic Product](#), with drought playing a significant role.

Between 2002 & 2009, rice production in [South-East Australia](#) dropped by [99 per cent](#), while wheat yields declined by [12 per cent](#) compared to pre-drought levels.

Due to climate change, the frequency and severity of climate extremes is predicted to further increase in most regions worldwide. It means that our global crop yield – the measurement of the amount of agricultural production harvested per unit of land area – will be affected.

It also means that there's work to be done to plan for, and improve the resilience of our food production systems. But in order to do this, it's important to understand several things: how climate extremes interact with agricultural yields, to what extent crop yields are influenced by climate extremes and how these interactions differ between agricultural regions.

CRUNCHING THE CLIMATE NUMBERS

Our new study, published in [Environmental Research Letters](#), investigated the effects of climate conditions on yield during the growing season, using climate and climate extremes datasets with near-global coverage and a high-resolution agricultural database.

CHALLENGES TO FOOD PRODUCTION



Between 2002 and 2009, rice production in South-East Australia dropped by 99 per cent. Picture: Getty Images

This database contains regional crop yield data for the four major crops – maize, rice, soybeans and wheat.

By applying a machine learning algorithm, called **Random Forest**, we can then investigate the relationship between the year-to-year climate variations and the crop yield fluctuations.

Random Forests is a statistical tool that uses a large number of decision trees (hence the name) that are used to identify patterns in the data and create statistical models. The benefit of Random Forests is that they can capture very complex, non-linear relationships between variables.

Using Random Forests, we looked at the effect of the growing season's mean climate (that is, temperature and precipitation) and a number of climate extremes indicators (like hot and cold temperature extremes, drought and heavy precipitation events) on yield anomalies.

Overall, changing climate conditions during the growing season explain 20 to 49 per cent of the variance of yield anomalies of all crops we investigated, at the global scale.

This indicates that year-to-year changes in temperature and precipitation, including the growing season mean and extreme events, account for a considerable fraction of year-to-year yield fluctuations.

And these explained variances are especially high for maize: with values between 45 and 55 per cent for all continents, except South America and Oceania.



But how large is the impact of climate extremes?

THE EFFECT OF CLIMATE EXTREMES ON CROP YIELDS

We compared our results with the outputs of a second statistical model, which only uses the mean growing season temperature and precipitation as predictors for any yield variations. This means we can quantify how much the explained variance drops when climate extremes are excluded from the model.

As a result, we found that climate extremes indicators explain about 18 to 43 per cent of the variance of year-to-year all crop yield anomalies. For maize, soybeans and rice, this represents more than half of the explained variance, emphasising that climate extremes play a very significant role in understanding and predicting yield variations in these crops.

Interestingly, temperature-related variables – both the mean growing season temperature and temperature extremes – play a more significant role in predicting yield fluctuations than precipitation-related variables, such as total growing season precipitation, drought or heavy rain.

It also indicates that a meteorological drought (i.e. below-average rainfall) alone can't accurately predict yields, but that soil moisture drought – which is affected not only by rainfall, but also other factors, like temperature, solar radiation, water vapour pressure deficit, and the properties of soil and vegetation – could be potentially better predictors of yield anomalies.

IDENTIFYING THE HOTSPOTS

So, what does this all mean for global agricultural production?

We have identified hotspot regions that are critical for global production, as they are contributing a large fraction of the world's food, but are also particularly susceptible to the effects of climate extremes.

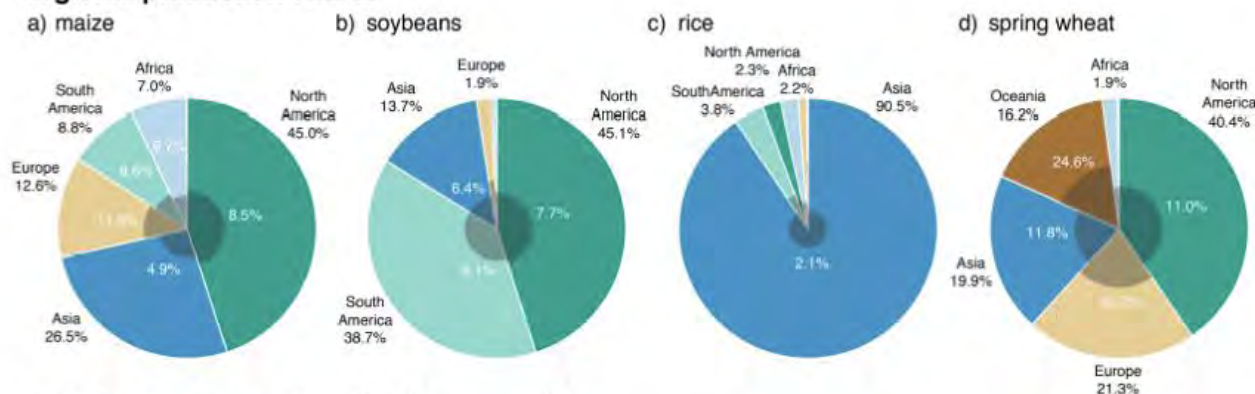
These regions are: North America for maize, spring wheat and soy production, Asia for maize and rice production, and Europe for spring wheat production.

While these hot spot regions are mostly in industrialised, high-input crop producing areas, climate extremes are also critical in other regions, where the contribution to global production might be small, but the reliance of communities on subsistence farming is high.

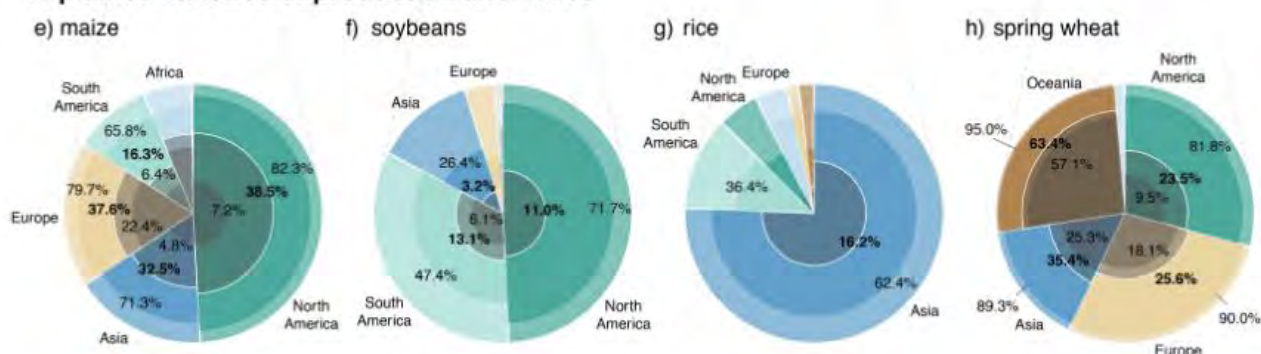
There are hotspot regions that are critical for global production. Picture: Getty Images

CHALLENGES TO FOOD PRODUCTION

Regional production shares



Explained variance of production anomalies



Top row (a-d) shows mean production shares for each continent, with the inner circle showing the standard deviation of production anomalies. The bottom row (e-h) shows the share of production anomalies for each continent. The three inner circles represent (from outside to inside): i) the fraction of variance of production anomalies that can be explained by yield anomalies; ii) the fraction of variance of production anomalies explained by mean climate conditions plus extreme indicators; iii) the fraction of variance of production anomalies explained by mean climate conditions. Picture: Supplied

Overall, our study highlights the importance of considering climate extremes for understanding and predicting the yield we can expect from our crops.

It may be used to support the development and improvement of global and regional seasonal forecasting systems for agriculture – identifying key climate factors and estimating their contribution to yield fluctuations, for each region and crop individually.

LINKS TO RELATED MEDIA REPORTS

1. Can we have urbanisation and enough to eat
<https://pursuit.unimelb.edu.au/articles/we-can-have-urbanisation-and-enough-to-eat>
2. The grand challenge of feeding 9 billion people
<https://pursuit.unimelb.edu.au/podcasts/the-grand-challenge-of-feeding-9-billion-people>
3. Farming the future
<https://pursuit.unimelb.edu.au/articles/editing-farming-the-future>

Featured



Elisabeth Vogel
Honorary Research Fellow, Australian-German Climate & Energy College, University of Melbourne



Dr Markus G Donat
Research Fellow, Climate Change Research Centre, University of New South Wales



Associate Professor Lisa V Alexander
Senior researcher, Climate Change Research Centre, University of New South Wales



Dr Malte Meinshausen
Senior Research Fellow, School of Earth Sciences, Faculty of Science; Australian German Climate and Energy College, University of Melbourne



Dr Deepak K Ray
Senior Scientist, Institute on the Environment, University of Minnesota



Professor David Karoly
School of Earth Sciences, ARC Centre of Excellence for Climate System Science, University of Melbourne



Dr Nicolai Meinshausen
Seminar for Statistics, Swiss Federal Institute of Technology



Dr Katja Frieler
Deputy Chair, Research Domain II on Climate Impacts and Vulnerabilities, Potsdam Institute for Climate Impact Research

REPUBLISH THIS ARTICLE



We believe in the free flow of information. This work is licensed under a [Creative Commons Attribution-No Derivatives 3.0 Australia \(CC BY-ND 3.0 AU\)](https://creativecommons.org/licenses/by-nd/3.0/), so you can republish our articles for free, online or in print.

All republished articles must be attributed in the following way and contain links to both the site and original article:
"This article was first published on [Pursuit](https://pursuit.unimelb.edu.au). Read the [original article](#)

FIELDWORK OPPORTUNITIES



Zhangjiajie National Forest Park

China Geography Tour

9 Days Sydney / Changsha / Zhangjiajie / Shanghai / Sydney



Shanghai



Grand Canyon Glass Bridge



Selective Tours

Tailor-made Journeys