Global crop yields are strongly affected by extreme climate conditions

Key Points

- **The ARC Centre of Excellence for Climate Extremes has contributed to a new scientific study that reveals that extremely hot and cold temperatures, drought and heavy rainfall strongly affect the year-to-year variation in the total global yield of four important crops - maize, soybeans, rice and spring wheat.**

- **The study identifies North America, Asia and Europe as regions of the world "that are critical for global production and particularly susceptible to the effects of climate extremes". Harvest failures in these regions could disrupt global trade in agricultural products and increase food prices in other parts of the world.**

- **The study highlights that climate extremes must be accounted for when making predictions of future crop yields and in planning for climate change. Work by the ARC Centre of Excellence for Climate Extremes to improve the ability of climate models to simulate extremes is facilitating this.**

Why is the link between extreme climate conditions and crop yields important?

Climate extremes can cause harvests to fail and threaten the livelihoods of farmers and the food security of communities. For example, a drought and heat wave in the summer of 2018 caused widespread harvest failures and a shortage of cattle fodder in Europe. The effects are often not limited to regions in which the harvests fail. Global trade in agricultural products can be disrupted and food prices increased in other parts of the world as a result. Reducing the local and global effects of climate extremes requires us to have a better understanding of the links between the climate and crop yields. This is becoming more and more important as climate change increases the intensity and frequency of some types of climate extremes[1].

How is the ARC Centre of Excellence for Climate Extremes helping to understand this link?

The ARC Centre of Excellence for Climate Extremes has contributed to a new analysis of the impacts of the climate on yields from four important crops - maize, soybeans, rice and spring wheat, including the impacts of extremely hot and cold temperatures, drought and heavy rainfall[2]. For the first time, the study has assessed these impacts on total global yields by analysing detailed records of crop yields at the scale of regions within countries[3]. Many previous global studies have relied on records of yields for entire countries, and it is possible that these have under-estimated the effect of climate extremes on crop yields[a]. This study has used regional yield data in combination with climate data to isolate the effects of different aspects of the climate.

How important are extreme climate conditions to global crop yields?

The study shows that year-to-year variations in the climate are responsible for 20 to 49% of the year-to-year variation in the total global yield, depending on the crop. Extreme climate conditions account for almost 40% of this climate effect in the case of spring wheat and over 80% in the cases of maize, soybeans and rice. Extreme temperatures have a particularly strong effect on yields, though the effects of extreme heat can be reduced by irrigation.

What are the implications for global crop production?

Global crop production is dependent on limited areas of high agricultural productivity and is vulnerable if harvests fail in these regions. The study identifies regions of the world “that are critical for global production and 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. The study highlights the importance of taking account of climate extremes in these regions when making predictions of, and maintaining, global crop production in the face of climate change.

What are the implications for the climate science community?

The importance of climate extremes means that assessing the impact of future climate change on crop production poses a challenge to the climate science community. The computer models used to generate projections of future climate conditions are currently unable to represent extremes in enough detail for us to rely on them to infer impacts on specific crops being grown in specific geographical locations. Models of the global climate system can't represent variations in the climate over distances of less than about 100km. They are also unable to represent processes by which cropping itself could affect the severity of climate extremes (e.g. through irrigated crops releasing additional water into the atmosphere). Improving the ability of the models to simulate climate extremes is a key objective of the research being undertaking by the ARC Centre of Excellence for Climate Extremes. Efforts to use Australia's most powerful computers to run global simulations that can represent variations in the climate over distances of around 20km are a national priority.

Explainers

a. Previous assessments of the effects of the climate on global crop production have sourced national crop production data from the United Nations Food and Agriculture Organisation (FAO)[4]. However, climate conditions can vary significantly within countries, especially large countries, such as Russia, China and the US. This means that in national crop production data the effect of climate conditions on yields in one part of a country could be "washed out", or even offset, by climate conditions in another part. For example, the effect of a heatwave on wheat yields in one part of US may be moderated in national crop production data due to near-average yields from parts of the country not affected by the heatwave. For this reason, the new study has used a recently-developed global data base containing crop production data for 13,500 sub-national administrative regions[3]. This was compiled from information from a large number of public sources, statistical bureaus and agricultural agencies. For example, for Australia, in addition to the FAO, data sources included the Australian Natural Resources Atlas, the Australian Bureau of Statistics and the Australian Oilseeds Federation.

References

[1] IPCC (2013) Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.
https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_SPM_FINAL.pdf

[2] Vogel, Donat, Alexander, Meinshausen, Ray, Karoly, Meinshausen and Frieler (2019) The effects of climate extremes on global agricultural yields. *Environmental Research Letters.*
https://doi.org/10.1088/1748-9326/ab154b

[3] Ray, Ramankutty, Mueller, West and Foley (2012) Recent patterns of crop yield growth and stagnation. *Nature Communications.* https://doi.org/10.1038/ncomms2296

[4] FAO (2019) FAOSTAT. http://www.fao.org/faostat/en/#data/QC

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https://climateextremes.org.au.