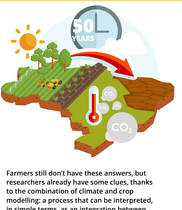
VIEWpoint

HOW WILL CLIMATE CHANGE AFFECT THE FUTURE OF AGRICULTURE OVER THE NEXT DECADES?

NUMERICAL MODELS ALLOW SIMULATION OF THE IMPACTS OF GRADUAL CHANGES AND EXTREME CLIMATE EVENTS ACROSS THE MAIN BRAZILIAN CROPS, SUCH AS SOYBEAN, MAIZE AND SUGARCANE

What would happen to the main Brazilian crops if the average temperature and concentration of carbon dioxide in the atmosphere increased and soil water availability decreased over the next fifty years?



CLIMATE MODELLING + CROP MODELLING

Farmers still don't have these answers, but researchers already have some clues, thanks to the combination of climate and crop modelling: a process that can be interpreted, in simple terms, as an integration between mathematics, physics, biology and computing.

WHAT IS THIS MODELLING?

Modelling is in fact a way to forecast the future based on present and past information. It's as if scientists had their own model of Earth and could mathematically change some climate variables, such as temperature, rainfall, and carbon dioxide concentration, to see how the planet reacts to these changes.

That allows them to simulate the impacts of climate on a certain area of the globe and make more assertive predictions.

For example, scientists of the Intergovernmental Panel on Climate Change (IPCC) write their reports based on this model.

With the goal of predicting the impacts of gradual changes and extreme climate events in Brazilian agriculture, a group of researchers gathered to improve and implement an existing ecosystem modelling tool: the JULES model (Joint UK Land Environment Simulator).

The platform is the result of the research project titled "Monitoring and Projecting Climate Impacts on Agriculture" led by Brazilian researcher Marcelo Galdos (University of Leeds), with the participation of Marcelo Zeri and Ana Cunha (Cemaden), Fabio Marin (ESALQ-USP) and Murilo Vianna (University of Leeds), among several British researchers. The project is part of the "Climate Science for Service Partnership' (CSSP-Brazil) – a partnership between Met Office of the UK and the Brazilian institutions National Institute for Space Research (INPE), National Institute of Amazonian Research (INPA) and National Center for Monitoring and Alerting of Natural Disasters (Cemaden).

WHAT IS JULES?

The JULES model simulates the flow of water, carbon and nutrients between vegetation and the atmosphere, to more accurately predict the impact of future climate changes in the Earth's surface.

This model can also be used to simulate the effects of climate on major agricultural regions of Brazil. However, to improve the quality and accuracy of simulations, the model must be calibrated and evaluated based on data collected on the field.

Find out how the researchers adapted the model to the reality of the main Brazilian crops:

1 Soil moisture simulations provided by JULES were compared to data from field experiments and sensors.

2 The model was then adapted and evaluated for some of the main Brazilian crops, such as sugarcane and corn.

3 Initial evaluations were performed, for example, such as the system's ability to predict sugarcane yield variation in different environments and production conditions.

4 The researchers identified that the data simulated by the JULES model after calibration and evaluation (i.e. comparison with field experiments) were compatible with actual crop yield data, such as the data from IBGE for the historical series of 1980 to 2010.

This is an important step before putting the model into practice, in order to understand its strengths and limitations, and it showed that the calibrated JULES reached satisfactory results when simulating the main climate effects on these crops.

5 In the future, the researchers expect to incorporate remote sensoring and machine learning techniques to make predictions even more assertive.

WHAT KINDS OF PREDICTIONS CAN JULES OFFER TO FARMERS?

The modelling process allows simulating climate impacts on crops, anticipating the potential impacts of future climate conditions, and outlining crop adaptation strategies based on this new reality.

Predictions cover a future period between 2030 and 2100 for two greenhouse gas (GHG) emission scenarios: pessimistic (high emissions and lower adoption of sustainable practices) and optimistic (low emissions and greater adoption of sustainable practices).

Hypothetical scenario: the year is 2070 and the carbon emission trends remain the same as today (pessimistic). The temperature in Brazil rose 2 to 5 degrees Celsius on average, while CO2 concentration rose from 410 ppm to 740 ppm.

Question: In this scenario, what would happen to sugarcane production in Brazil?

Modelling answer: in areas where temperatures remain below 35 degrees, production would increase. However, researchers still don't how these temperatures would impact the incidence of new pests and diseases, which could undermine the positive impacts of such productivity increase in this scenario. Above 35 degrees, however, a sharp drop in productivity is expected. That is because the plant absorbs less carbon, which impacts production if the crop is not properly adapted.

Relevance for agricultural planning: this type of information could help develop crops that are more resistant to drought and heat or make changes in plantation areas. For example: it could help managers move plantations to areas of the country that are more suitable for a certain crop, considering future climate conditions.

PREDICTION OF DOUBLE IMPACT

Another feature of JULES is that it allows investigating not only climate impacts on agriculture, but also the impacts of agriculture and different land uses on the climate. For example: if soybean plantation areas increase in a certain area, replacing the previous land use, how would that impact the climate?

This information is particularly important not only to plan and establish climate agreements, but also to improve the climate models adopted (e.g. by entities such as the IPCC).

This showcases the importance of Brazilian investments to improve international climate models, with clear practical applications.

HOW CAN I LEARN MORE ABOUT THE JULES MODEL?

The JULES model can be accessed through this link, where you can find more information and find out how to use it.

WHERE CAN I LEARN MORE ABOUT THIS SUBJECT?

The project's results are also available in the form of scientific publications, showing each step of the calibration and evaluation processes, as well as the parameters to apply this model to Brazil's specific conditions. Check out the publications below:

- **Article evaluating the Jules model**
- **About the Jules model**
- **How to use Jules for modeling**

A Python programming language pack was also developed in this project to facilitate the interface with the JULES model at:
https://github.com/Murilodsv/py-jules

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