Researchers use supercomputing to assess the impact of climate change on the country's growing season

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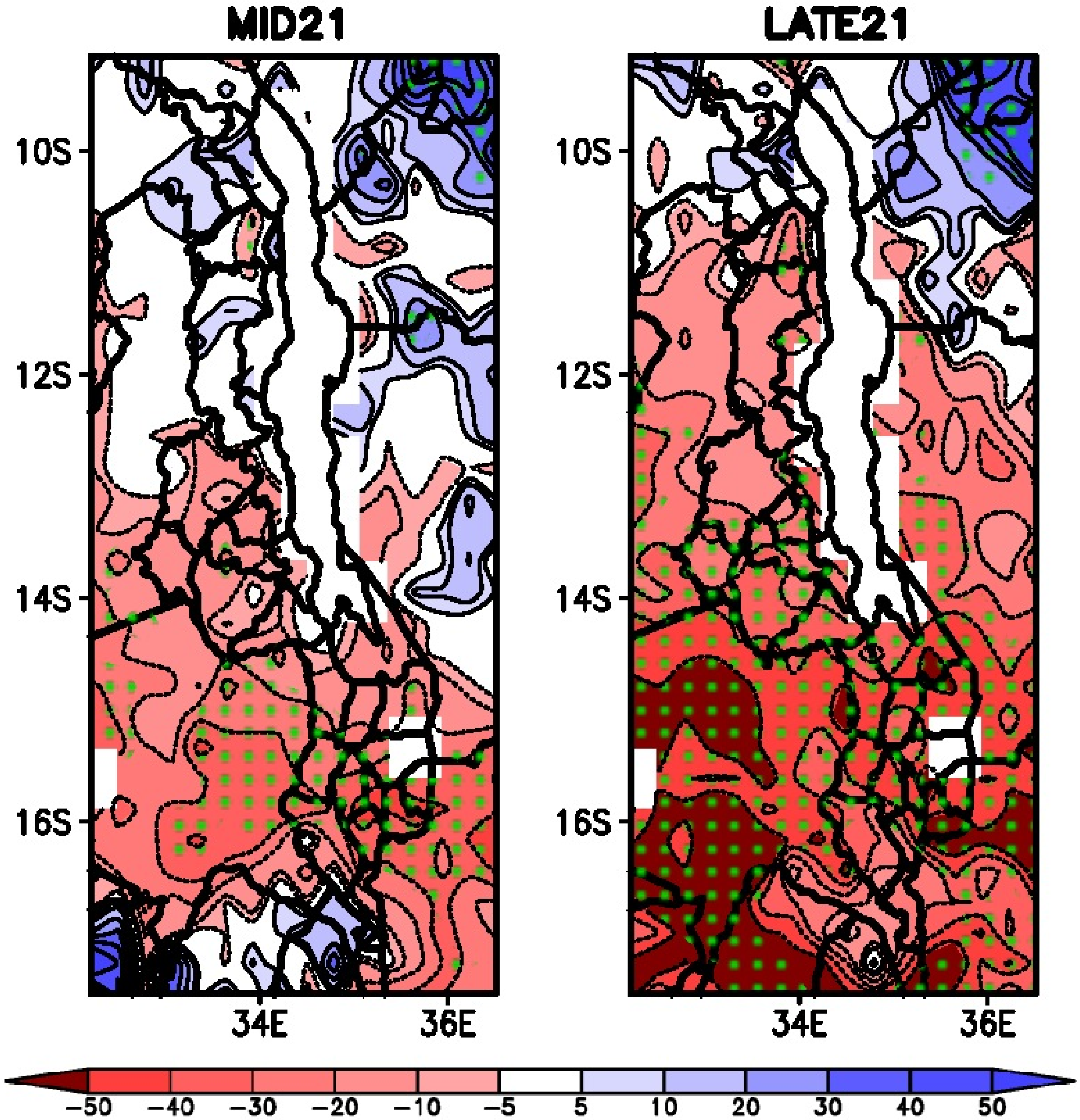

Projected (left) mid-21st century and (right) late-21st century changes in growing season length expressed as a percent change from the present day.

Malawi, a small landlocked country in southeast Africa, is home to 13 million people and is one of the least-developed countries in the world. As a nation that relies on subsistence farming, its security is highly dependent on rain-fed agriculture, including the crops maize, rice, and sweet potatoes. Changes in rainfall patterns associated with climate change can be devastating to people living in the country, leading to food crises, famines, and loss of life.

Two researchers at The University of Texas at Austin, Kerry Cook and Edward (Ned) Vizy, are dedicated to understanding how climate change and climate variability will impact Malawi and other regions throughout Africa. By running regional climate models, Cook and Vizy are examining Africa's diverse climate zones, ranging from the monsoon regions in West Africa and the Horn of Africa to the central tropics to the desert region in the north.

"Africa is particularly vulnerable to climate change," Cook said. "For instance, if the Sahel region experienced a drought like the current droughts in Texas and California, millions of people would die. And with global warming, we can expect more of these extreme events, like droughts and intense rainfall. Our hope is that with a better understanding through modeling, we can help improve prediction and planning."Cook and Vizy's findings on how climate change will impact Malawi's agricultural growing season were recently published in the journal *Climate Dynamics*. Using data from a report on future climate from the Intergovernmental Panel on Climate Change's Assessment Report 5 (IPCC AR5) to help drive their regional climate model simulations, the two researchers found that it is likely the growing season will be shorter, and there will be an earlier end of the growing season by the mid 21st century.

To develop a holistic view of how climate conditions affect the growing season, Cook and Vizy partnered with a team of social scientists and researchers at the University of Malawi. While the ground team worked to gather data from local farmers, Cook and Vizy ran climate models to examine changes to the growing season through the mid to late 21st century.

"First, we run a control simulation for the present day (1989-2008), so we can evaluate the model by checking it against actual data to assess the model's strengths and weaknesses," Vizy said. "Then we run the model for 20 year time slice periods, 2041-2060 and 2081-2100, to get an overview of how climate will change in the region."The researchers are long-time users of resources at the Texas Advanced Computing Center (TACC), which enables them to run their models and store data. Based on the laws of physics, the models calculate properties of the components that affect climate including heat energy, precipitation, and dynamics of the atmosphere.

"Our simulations are governed by seven differential equations that are solved simultaneously for each grid point at time steps of three to five minutes," Cook said. "We're also not just simulating at surface level conditions but 20 to 30 levels into the atmosphere. Then, we'll run the model for 20 to 30 years to look at climate—it's a very big calculation and why we need TACC."

TACC's Stampede supercomputer allowed the researchers to address a major challenge in climate science—obtaining higher resolutions with modeling. Climate models rely on grids of cells to provide a snapshot of the climate in a particular region. The closer the grid points, the more regional climate-related information the model is able to provide. For instance, many of the IPCC AR5 global climate models use spatial resolutions 100 kilometers or coarser. This distance does not allow the global models to adequately resolve regional topography or the physical processes involved in intense rainfall, as these convective systems mainly operate on spatial scales of less than 10 kilometers.

"TACC has enabled us to attain a much finer resolution—on some simulations the distance between grid points is only three kilometers," Cook said. "This allows us to better understand the physical processes that influence climate and helps us build confidence in our model projections."

If Cook and Vizy's projections on how climate change will impact Malawi's growing season are true, it could mean that current crop types may be unsustainable using rain-fed agricultural practices alone. It also suggests the need to begin adaptation planning to help mitigate the effect of global warming."TACC has enabled us to attain a much finer resolution—on some simulations the distance between grid points is only three kilometers. This allows us to better understand the physical processes that influence climate and helps us build confidence in our model projections." Kerry Cook, The University of Texas at Austin

With funding from NASA, the duo are also diving deeper into climate by pairing their regional model of the atmosphere with oceanic models. Understanding how ocean currents and the atmosphere interact have important implications for upwelling, a phenomenon where cold water draws up nutrients, attracting fish, and generating a massive fishing industry on the coast of west Africa and other places around the world.

Said Vizy: "We're taking our work to the next level to understand how the ocean responds to changes in the atmosphere to get a more complete understanding of how the planet's climate system is redistributing heat and energy."

Provided by University of Texas at Austin