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GREENHOUSE GASES LINKED TO PAST AFRICAN RAINFALL

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BOULDER — New research demonstrates for the first time that an increase in greenhouse gas concentrations thousands of years ago was a key factor in causing substantially more rainfall in two major regions of Africa. The finding provides new evidence that the current increase in greenhouse gases will have an important impact on Africa's future climate.

The study, led by the National Center for Atmospheric Research (NCAR), is being published this week in Science.

"The future impact of greenhouse gases on rainfall in Africa is a critical socioeconomic issue," said NCAR scientist Bette Otto-Bliesner, the lead author. "Africa's climate seems destined to change, with far-reaching implications for water resources and agriculture."

The research drew on advanced computer simulations and analyses of sediments and other records of past climate. It was funded by the National Science Foundation, which is NCAR's sponsor, and the Department of Energy Office of Science.

A MYSTERIOUS PERIOD OF RAIN

Otto-Bliesner and her co-authors in the United States and China set out to understand the reasons behind dramatic climate shifts that took place in Africa thousands of years ago.

Lakes and other water features, such as the Ubari Oasis in southern Libya, were more prevalent across now-dry parts of Africa during past periods of more-plentiful precipitation. (Wikimedia Commons photo by Sfivat.)

As the ice sheets that had covered large parts of North America and northern Europe started retreating from their maximum extent around 21,000 years ago, Africa's climate responded in a way that has puzzled scientists. Following a long dry spell during the glacial maximum, the amount of rainfall in Africa abruptly increased, starting around 14,700 years ago and continuing until around 5,000 years ago. So intense was the cumulative rainfall, turning desert into grasslands and savannas, that scientists named the span the African Humid Period (AHP).

The puzzling part was why the same precipitation phenomenon occurred simultaneously in two well-separated regions, one north of the equator and one to the south. Previous studies had suggested that, in northern Africa, the AHP was triggered by a ~20,000-year cyclic wobble in Earth's orbit that resulted in increased summertime heating north of the equator. (In contrast, the northern hemisphere today is closest to the Sun in winter rather than summer.) That summertime heating would have warmed the land in such a way as to strengthen the monsoon winds from the ocean and enhance rainfall.

But Otto-Bliesner said the orbital pattern alone would not explain the simultaneous onset of the AHP in southeastern equatorial Africa, south of the equator, since the wobble in Earth's orbit led to less summertime heating there rather than more. Instead, the study revealed the role of two other factors: a change in Atlantic Ocean circulation that rapidly boosted rainfall in the region, and a rise in greenhouse gas concentrations that helped enhance rainfall across a wide swath of Africa.

TRACING MULTIPLE CAUSES OF A WETTER AFRICA

As Earth emerged from the last Ice Age, greenhouse gases, especially carbon dioxide and methane, increased significantly—reaching almost to pre-industrial levels by 11,000 years ago—for reasons that are not yet fully understood. It was, the authors note, the most recent time during which natural global warming was associated with increases in greenhouse gas concentrations. (Because of feedbacks between the two, greenhouse gas concentrations and global temperature often rise and fall together across climate history.)

The end of the last Ice Age also triggered an influx of fresh water into the ocean from melting ice sheets in North America and

Scandinavia about 17,000 years ago. The fresh water interfered with a critical circulation pattern that transports heat and salinity northward through the Atlantic Ocean, much like a conveyer belt. The weakened circulation led to African precipitation shifting toward southernmost Africa, with rainfall suppressed in northern, equatorial, and east Africa.

When the ice sheets stopped melting, the circulation became stronger again, bringing precipitation back into southeastern equatorial and northern Africa. This change, coupled with the orbital shift and the warming by the increasing greenhouse gases, is what triggered the AHP.

To piece together the puzzle, the researchers drew on fossil pollen, evidence of former lake levels, and other proxy records indicating past moisture conditions. They focused their work on northern Africa (the present day Sahel region encompassing Niger, Chad, and also northern Nigeria) and southeastern equatorial Africa (the largely forested area of today's eastern Democratic Republic of Congo, Rwanda, Burundi, and much of Tanzania and Kenya).

In addition to the proxy records, they simulated past climate with the NCAR-based Community Climate System Model, a powerful global climate model developed by a broad community of researchers and funded by the National Science Foundation and Department of Energy, and using supercomputers at the Oak Ridge National Laboratory.

By comparing the proxy records with the computer simulations, the study demonstrated that the climate model got the AHP right. This helps to validate its role in predicting how rising greenhouse gas concentrations might change rainfall patterns in a highly populated and vulnerable part of the world.

"Normally climate simulations cover perhaps a century or take a snapshot of past conditions," Otto-Bliesner said. "A study like this one, dissecting why the climate evolved as it did over this intriguing 10,000-year period, was more than I thought I would ever see in my career."

ABOUT THE ARTICLE

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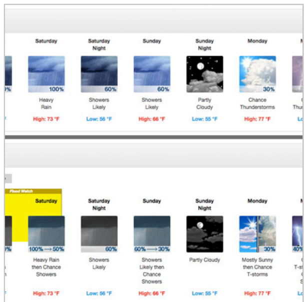

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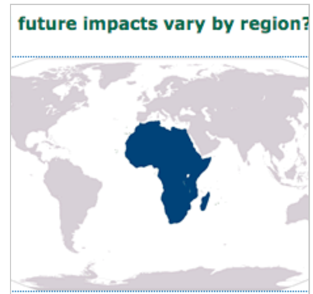

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