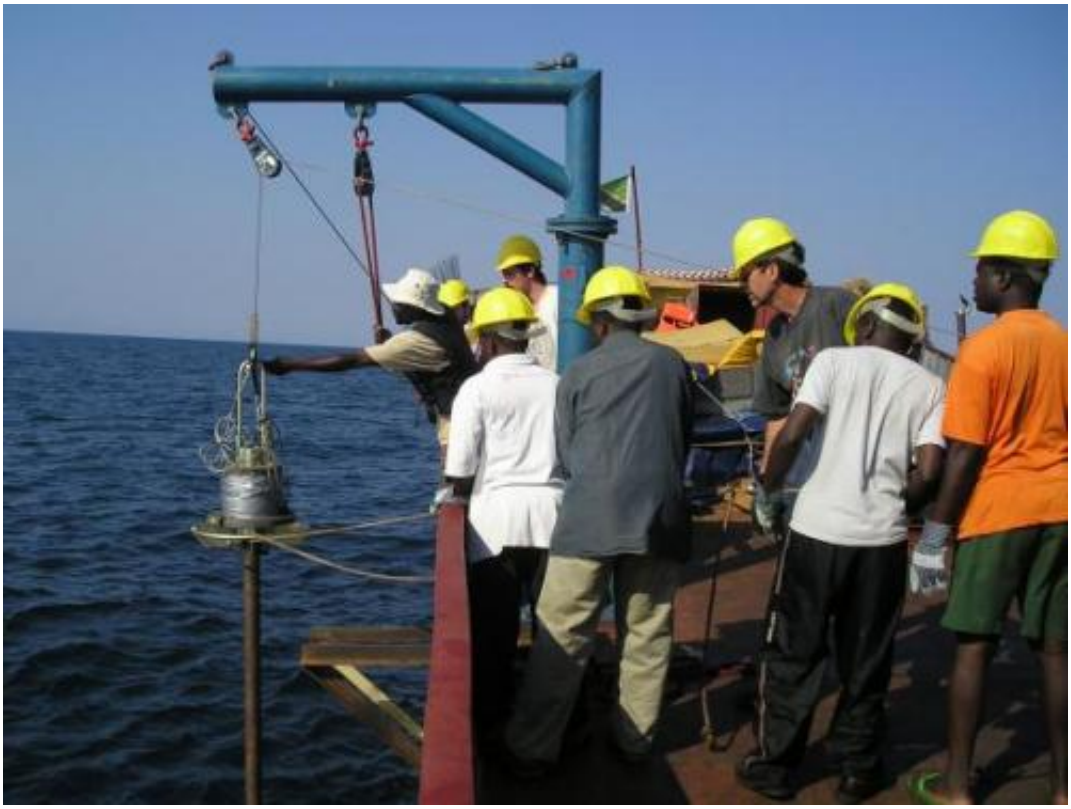
Reconstructing the African humid period

December 5 2014, by Kevin Stacey



Around 21,000 years ago, Lake Tanganyika was 300 meters lower than it is now, and Lake Victoria was completely dry. New research using a major U.S. climate model, pointed to an important role for greenhouse gases. James Russell (left of the blue post) and his team took core samples from Lake Tanganyika.

During the end of the last ice age, there were dramatic changes in rainfall across a vast swath of Africa. As the world's large ice sheets receded in northern and southern latitudes, rainfall in much of Africa

increased dramatically, marking the beginning of what is known as the African Humid Period.

In a study published in *Science*, researchers used a complex climate model to simulate that shift in rainfall and better understand the forces that drove it. The model simulations were compared to geological datasets that reconstruct past rainfall changes. The study showed that the model was able to simulate accurately the changes that occurred in the past. The findings are important not only for understanding the causes of the precipitation patterns in Africa, but also because they bolster confidence in the climate model used in the study.

James Russell, professor of Earth, environmental and planetary sciences at Brown, was a co-author of the paper. He discussed the findings and their implications with Kevin Stacey.

Could you describe what was known about the rainfall transition in Africa during the last ice age?

We know that during the last glacial maximum, around 21,000 years ago, most of Africa was much dryer than the present. Some of the best evidence of that dryness comes from the equatorial lakes. Lake Victoria for instance, which today is about the size of Connecticut and Rhode Island combined, was completely dried out and converted into a vast, swampy plain. Some of the other great lakes in the region survived, but their water levels were much lower than today. Lake Tanganyika in central Africa, for example, was on the order of 300 meters below the present level.

We also know that starting about 15,000 years ago, the whole region got much wetter. The best example of that comes from North Africa. Today North Africa contains the Sahara desert, but in the early Holocene there

were big lakes in parts of the region, and savannahs replaced the deserts that existed during the glacial period. We see lake sediment deposits, where today there are no lakes, and there's cave art depicting giraffes and other animals that would have no business there in the present climate.

This has become known as Green Sahara Period or the African Humid Period, which lasted from about 11,000 to 5,000 years ago. Our fieldwork on the African great lakes has shown that the signal from that wet period extended south from the Sahara into equatorial and even southern equatorial Africa around the same time.

There's been a longstanding question about how that transition to a wetter climate happened. What caused it?

What light was the climate modeling able to shed on that?

We know that the African Humid Period in North Africa is mostly related to changes in the Earth's orbital cycle. Due to small wobbles in the Earth's rotation, summer sunlight in the Northern hemisphere 11,000 years ago was much stronger than today. This strong heating period warmed up the land surface, caused stronger winds to blow in from the ocean, and led to more rainfall.

But what the model helped to explain is how this wetter climate reached south into equatorial and southern equatorial Africa. The Earth's rotational wobbles actually cause changes in sunlight to be opposite between the hemispheres, such that extra heating in the north is cooling in the south. This means orbital forcing can't explain the wet, humid period that extends well into southern Africa. My collaborators were able to run experiments with the model using only orbital forcing, as well

as experiments using other factors that might cause rainfall to vary, such as greenhouse gas concentrations. By comparing these tests to a simulation in which every forcing changed simultaneously, we showed that an increase in greenhouse gases during the last deglaciation was largely responsible for the wetter conditions in equatorial and southeastern Africa.

That's important because most people don't necessarily think about greenhouse gases as a key driver of tropical rainfall during the last deglaciation. They think more about changes in the Earth's orbit or changes in the ice sheet. We believe this model result is robust, as the spatial and time evolution of rainfall changes simulated by the model matches the changes we can reconstruct from geological data.

What would you say are the big takeaways here?

There are two. First, the study suggests that changes in African rainfall, particularly in the equatorial regions, were quite sensitive to rising greenhouse gas concentrations. One thing I find especially impressive is that in spite of all of the factors that caused the Earth to warm during the last deglaciation, such as the Earth's orbital wobbles and the melting of the ice sheets, the primary factor causing equatorial and southeast African precipitation to change appears to be greenhouse gases. The sensitivity of equatorial African rainfall to greenhouse gases during the last deglaciation suggests important consequences of rising greenhouse gases for tropical Africa's future hydrology.

Second, this study lends confidence to this particular climate model's ability to predict future rainfall. The model used in this study was the Community Climate System Model, one of the big U.S.-based climate models, operated at the National Center for Atmospheric Research. This is one of the first times that a really detailed climate model has been run in transient mode, where we're looking at the time evolution of climate

during the deglaciation as opposed to a static map for some region during a particular time. Looking at the transition over time from 20,000 years ago to 10,000 year ago, the model has done a good job of capturing the dynamics of that transition. This provides more confidence in our understanding of how rainfall might change in tropical Africa in the future as greenhouse gas concentrations continue to rise.

More information: "Coherent changes of southeastern equatorial and northern African rainfall during the last deglaciation." *Science* 5 December 2014: Vol. 346 no. 6214 pp. 1223-1227 DOI: 10.1126/science.1259531

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