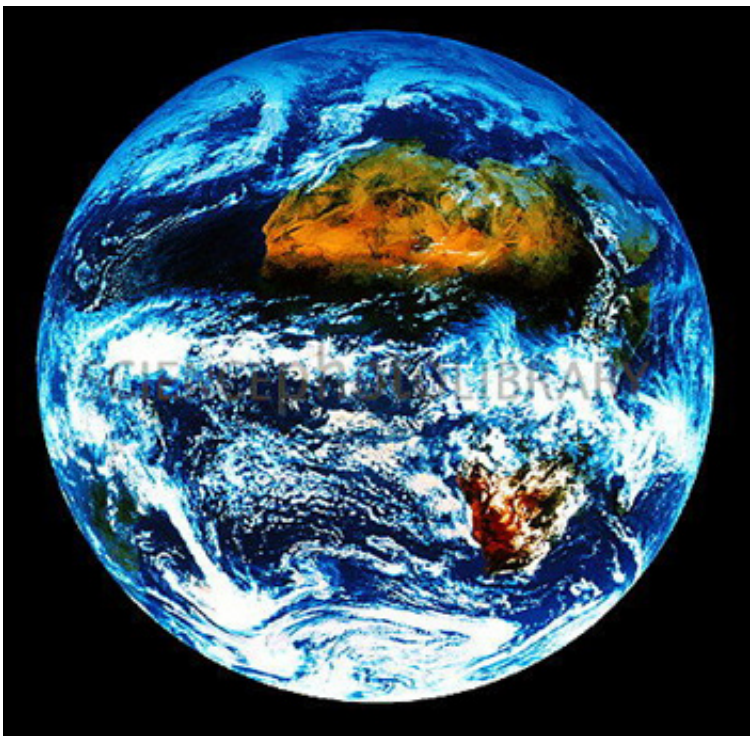
Rising temperature difference between hemispheres could dramatically shift rainfall patterns in tropics

April 2 2013, by Robert Sanders



The tropical rain band is clearly visible as an equatorial belt of clouds cutting just below the Sahara desert. Courtesy of GEOSPACE/SCIENCE photo library.

(Phys.org) —One often ignored consequence of global climate change is that the Northern Hemisphere is becoming warmer than the Southern Hemisphere, which could significantly alter tropical precipitation patterns, according to a new study by climatologists from the University

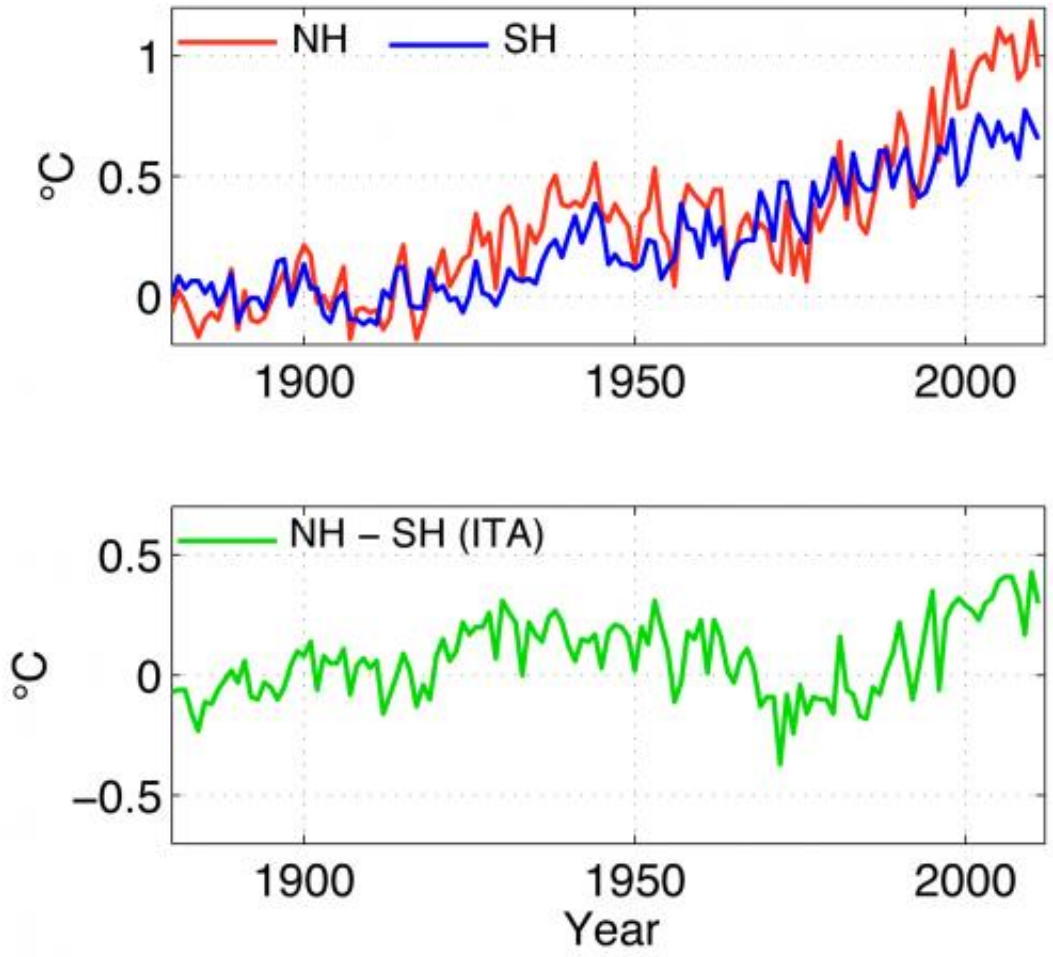
of California, Berkeley, and the University of Washington, Seattle.

Such a shift could increase or decrease seasonal rainfall in areas such as the Amazon, sub-Saharan Africa or East Asia, leaving some areas wetter and some drier than today.

"A key finding is a tendency to shift tropical rainfall northward, which could mean increases in monsoon weather systems in Asia or shifts of the wet season from south to north in Africa and South America," said UC Berkeley graduate student Andrew R. Friedman, who led the analysis.

"Tropical rainfall likes the warmer hemisphere," summed up John Chiang, UC Berkeley associate professor of geography and a member of the Berkeley Atmospheric Sciences Center. "As a result, tropical rainfall cares a lot about the temperature difference between the two hemispheres."

Chiang and Friedman, along with University of Washington colleagues Dargan M. W. Frierson and graduate student Yen-Ting Hwang, report their findings in a paper now accepted by the *Journal of Climate*, a publication of the American Meteorological Society. It will appear in an upcoming issue.



The top chart shows the steady rise in Northern and Southern Hemisphere temperature since the beginning of the 20th century. The second chart shows little change in the interhemispheric temperature asymmetry (ITA) until the 1980s, when the effect of sulfate aerosols declined as a result of the Clean Air Act. Credit: Andrew Friedman, UC Berkeley

Generally, rainfall patterns fall into bands at specific latitudes, such as the Intertropical Convergence Zone. The researchers say that a warmer northern hemisphere causes atmospheric overturning to weaken in the north and strengthen in the south, shifting rain bands northward.

The regions most affected by this shift are likely to be on the bands'

north and south edges, Frierson said.

"It really is these borderline regions that will be most affected, which, not coincidentally, are some of the most vulnerable places: areas like the Sahel where rainfall is variable from year to year and the people tend to be dependent on subsistence agriculture," said Frierson, associate professor of atmospheric sciences. "We are making major climate changes to the planet and to expect that rainfall patterns would stay the same is very naïve."

20th century rainfall patterns

Many discussions of climate change focus on long-term trends in the average global temperature. The UC Berkeley and University of Washington researchers went a step further to determine how the temperature difference between the two hemispheres changed over the last century and how that may have affected tropical rainfall patterns.

Using more than 100 years of data and model simulations, they compared the yearly average temperature difference between the Northern and Southern hemispheres with rainfall throughout the 20th century and noticed that abrupt changes coincided with rainfall disruptions in the equatorial tropics.

The largest was a drop of about one-quarter degree Celsius (about one-half degree Fahrenheit) in the temperature difference in the late 1960s, which coincided with a 30-year drought in the African Sahel that caused famines and increased desertification across North Africa, as well as decreases in the monsoons in East Asia and India.

"If what we see in the last century is true, even small changes in the temperature difference between the Northern and Southern hemispheres could cause measureable changes in tropical rainfall," Chiang said.

This bodes ill for the future, he said. The team found that most computer models simulating past and future climate predict a steadily rising interhemispheric temperature difference through the end of the century. Even if humans begin to lower their greenhouse gas emissions, the models predict about a 1 degree Celsius (2° F) increase in this difference by 2099.

Impact of the Clean Air Act

While the average temperature of the Earth is increasing as a result of dramatic increases in atmospheric greenhouse gases, primarily carbon dioxide, the Earth is not warming uniformly. In particular, the greater amount of land mass in the north warms up faster than the ocean-dominated south, Chiang said. Yet, even though greenhouse gas warming of Earth has been going up since the 19th century, his team found no significant overall upward or downward trend in interhemispheric temperature differences last century until a steady increase beginning in the 1980s.

The researchers attribute this to human emissions of aerosols, in particular sulfates – from coal-burning power plants, for example – which cooled the Northern Hemisphere and apparently counteracted the warming effect of rising greenhouse gases until the 1970 U.S. Clean Air Act led to a downward trend in sulfur emissions. The act reduced pollution and saved more than 200,000 lives and prevented some 700,000 cases of chronic bronchitis, according to 2010 figures from the Environmental Protection Agency.

"Greenhouse gases and aerosols act in opposite directions, so for much of the 20th century they essentially canceled one another out in the Northern Hemisphere," Chiang said. "When we started cleaning up aerosols we essentially leveled off the aerosol influence and allowed the greenhouse gases to express themselves."

Chiang and his colleagues argue that climate scientists should not only focus on the rising global mean temperature, but also the regional patterns of global warming. As their study shows, the interhemispheric temperature difference has an apparent impact on atmospheric circulation and rainfall in the tropics.

"Global mean temperature is great for detecting climate change, but it is not terribly useful if you want to know what is happening to rainfall over California, for example," Chiang said. "We think this simple index, interhemispheric temperature, is very relevant on a hemispheric and perhaps regional level. It provides a different perspective on climate change and also highlights the effect of aerosols on weather patterns."

More information: Interhemispheric temperature asymmetry over the 20th century and in future projections, *Journal of Climate* journals.ametsoc.org/doi/abs/1 … 75/JCLI-D-12-00525.1

Provided by University of California - Berkeley