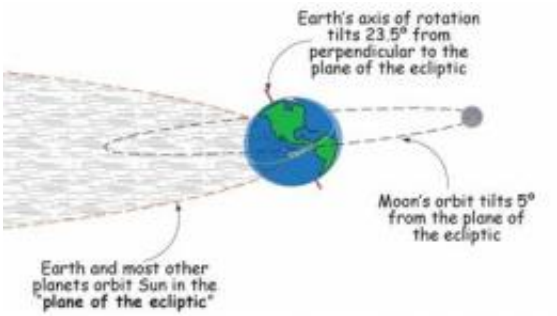
How Earth's orbital shift shaped the Sahara

December 21 2010, By Anuradha K. Herath



Changes in the Earth's tilt cause changes in weather patterns. Such a change is believed to have made the "Green Sahara" go dry. Image credit: NASA

A change in the Earth's orbit, many scientists believe, transformed the "Green Sahara" into what is now the largest desert on the planet. While scientists are still trying to find out if the slow shift in orbit had rapid or gradual environmental consequences, they say Earth's orbit will continue to change today and into the future.

The Sahara, the world's largest desert, was once fertile grassland. This fact has been common knowledge in the scientific community for some time, but scientists are still grappling with historic data to determine whether that transition took place abruptly or gradually.

At the European Geosciences Union General Assembly held in Vienna, Austria earlier this year, researchers presented new evidence showing that the eastern region of the Sahara desert, particularly the area near

Lake Yoa in Chad, dried up slowly and progressively since the mid-Holocene period.

“The findings of this study are that the sedimentological and geochemical properties of the lake sediments confirm that the Sahara has been drying slowly from six thousand years ago to reach the present day conditions around 1,100 years ago,” said lead author Pierre Francus, professor at the National Institute of Scientific Research in Quebec, Canada.

In this latest study, researchers analyzed the sedimentation in Lake Yoa on a yearly basis and dated it to determine when and how the Sahara region dried-up. Other studies have used climate modeling to determine the time period that the Sahara went dry and the prevailing climate conditions at that time.

The Cave of Swimmers, located in southwest Egypt, depicts a time when the Sahara was wetter. Image credit: *Science*

The widely-held belief is that the Sahara dried up due to a change in the Earth's orbit, which affects solar insolation, or the amount of electromagnetic energy the Earth receives from the Sun. In simpler terms, insolation refers to the amount of sunlight shining down on a particular area at a certain time, and depends on factors such as the geographic location, time of day, season, landscape and local weather.

Climate scientist Gavin Schmidt, of NASA's Goddard Institute for Space Studies, explained that around 8,000 years ago, the Earth's orbit was slightly different to how it is today. The tilt changed from around 24.1 degrees to the present-day 23.5 degrees.

"Additionally, the Earth had its closest approach to the Sun in the northern hemisphere (with) summer in August," Schmidt said. "Today, that closest approach is in January. So, summertime in the north was warmer back then than it is now."

The changes in the Earth's orbital tilt and precession (or the wobbling motion) occur because of gravitational forces emanating from other bodies in the solar system. To understand exactly what happens, picture a spinning top when it is slightly disturbed. Just like a top, the Earth too wobbles slightly about its rotational axis. This tilt changes between roughly 22 and 25 degrees about every 41,000 years, while the precession varies on about a 26,000-year period. These cycles have been determined by astronomers and validated by geologists studying ocean sediment records.

"If you get a long enough time series that can be well dated, you should be able to see frequencies in the data that correspond to the periods predicted by theory," Schmidt explained.

For a long time, the belief was that the Earth's tilt would change only insignificantly in the next century. However, recent research is suggesting that the effects of global warming—particularly the oceans—could cause a change in the Earth's axial tilt. Scientists from NASA's Jet Propulsion Laboratory say that the current melting of ice in Greenland is already causing the tilt to change at a rate of approximately 2.6 centimeters each year. They predict that his change could increase in the years ahead.

The changes in insolation caused by shifts in axial tilt have an impact on atmospheric weather patterns such as monsoons. Thousands of years ago when the northern hemisphere received more sunlight, it also intensified the monsoons. After the Earth’s tilt changed, the monsoons decreased and the vegetation began to disappear. When there were no plants to retain water and release it back into the atmosphere, the rain progressively decreased. The resulting feedback loop between plant life and climate eventually created the current desert conditions.

The Sahara Desert extends eastward from the Atlantic Ocean some 3,000 miles to the Nile River and the Red Sea, and southward from the Atlas Mountains of Morocco and the Mediterranean shores more than 1,000 miles to the savannah called the Sahel. More than 16 times the size of France, the Sahara Desert blankets nearly all of Mauritania, Western Sahara, Algeria, Libya, Egypt and Niger; the southern half of Tunisia; and the northern parts of Mali, Chad and Sudan. Image credit: NASA's MODIS instrument (Moderate Resolution Imaging Spectroradiometer)

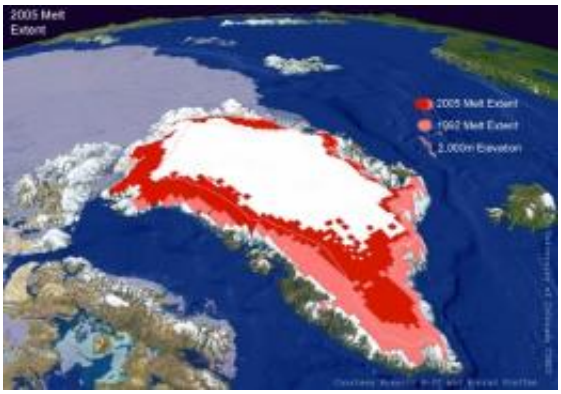
There is now considerable evidence to show that the Sahara used to have a grassland ecosystem and was a much wetter place than it is now. However, the debate about how that transition occurred continues. The disagreement among scientists is in part due to the lack of paleo-environmental records from the region. Therefore, scientists must often resort to climate modeling.

In 1999, German scientists used computer simulations to model the Earth's climate thousands of years ago. They concluded that the climatic transition of the Sahara took place abruptly, within a possible span of about 300 years.

Nearly ten years later, another group of scientists studied the environmental changes in the northern Chad area during the past 6,000 years and came to the conclusion that the Sahara underwent a more progressive drying-up process.

Schmidt belongs to the group of scientists who think there is evidence for sudden changes in the Sahara.

"Given the very strong dependence of vegetation on water availability, the end of the 'Green Sahara' came about quite suddenly around 5,500 years ago," Schmidt said. "Thus, a very slow change in the orbit (led) to an abrupt collapse in that ecosystem."



Scientists from NASA's Jet Propulsion Laboratory say that the current melting of ice in Greenland is causing Earth's axial tilt to change at a rate of approximately 2.6 centimeters each year. Image credit: University of Colorado at Boulder/CIRES

Since the Sahara spans a massive area—covering nearly a third of the African continent—it is quite possible that parts of it dried up abruptly while it took other regions a longer period of time to transform into a desert.

"It seems that drying was progressive in our area, but it does not automatically mean that it was the case in other areas such as Western Sahara," said Francus. "We cannot rule out completely the possibility of abrupt drying. Understanding the regional differences in climate change is the next challenge for climate scientists."

Francus explained that abrupt climate changes have been documented in many places on Earth at various times in the past. One example he cited is the Younger Dryas, one of the most famous examples of abrupt climate change that occurred between (approximately) 12,800 and 11,500 years ago. According to the National Oceanic and Atmospheric Administration, the end of this period was particularly abrupt when, for example, in Greenland, temperatures increased 18 degrees Fahrenheit in

about a decade.

“Many scientists think that abrupt climate changes are possible in the future, but the nature, direction and intensity of these changes will most probably be region-dependent,” Francus said.

Francus also noted that there are some models that cannot predict an abrupt climate shift at all. Some scientists feel that there is not enough knowledge to understand the processes driving these changes primarily because it is difficult to model the soil moisture and cover.

Regardless of whether the Saraha dried up gradually or suddenly, most scientists agree that it is important to understand how the climate changed in the past and what kinds of natural forces affected those changes. That will help climate researchers determine the precise role human behavior plays on current climate change.

“The models that are used to predict future climate need to be tested, and using information from the past is one way to achieve this goal,” Francus said.

Source: Astrobio.net