

## EDITORIAL

# CHIKUNGUNYA FEVER RESURGENCE AND GLOBAL WARMING

PAUL R. EPSTEIN\*

*Center for Health and the Global Environment, Harvard Medical School, Boston, Massachusetts*

Chikungunya (CHIK) is not a household word in most parts of the world. However, in 2004, CHIK fever carried by mosquitoes re-emerged with a vengeance in nations cresting an overheated Indian Ocean. For Africa, climate change portends more such surprises.

Chikungunya fever, first described in 1952 in southern Tanzania (formerly Tanganyika) along its border with Mozambique, draws its name from the Makonde people, who are famous for their intricate ebony sculpture, and connotes the contortions of those who contract this dengue-like disease. Like Rift Valley fever,<sup>1</sup> CHIK fever usually follows heavy rains.<sup>2</sup> Now Chretien and others in this issue of the journal describe how water stored in open containers during droughts creates ideal breeding sites for *Aedes aegypti* mosquitoes, the primary carrier.<sup>3</sup> In 2004, CHIK fever afflicted nearly 500,000 in Africa, and since then nearly 200 tourists have returned home with this illness. For sub-Saharan Africa, already burdened with disease, debt and terms of trade so detrimental to development, its nations and people face a sere, inhospitable future.

The story of changing ecologic conditions in Africa begins, as do all stories, in the world's ocean, and, over the past half century, the ocean has accumulated 22 times the amount of heat as has the atmosphere.<sup>4</sup> This fundamental change in the earth's heat budget is accelerating the global hydrologic cycle: water is warming, ice is melting, and water vapor is rising. Enhanced evapotranspiration over warming land surfaces deepens droughts, and higher humidity condenses into heavier downpours. The resulting wide swings in weather can be devastating: in the fall of 2006 east Africa's drought yielded to heavy rains and the flooding killed many, displaced more, and provoked outbreaks of Rift Valley fever, malaria, and cholera across the Horn of Africa.

In 2001, the United Nation's Intergovernmental Panel on Climate Change,<sup>5</sup> in an unprecedented, exhaustive assessment, concluded: 1) climate is changing, 2) human activities are contributing to this change, 3) weather has become more extreme, and 4) biologic systems on all continents and in the seas are shifting as the earth warms. Since 2001, we've learned a great deal more: 1) the pace of warming is increasing, 2) the rate of the Greenland ice sheet melt has doubled, 3) circumpolar winds have sped up, and 4) carbon dioxide uptake has begun to acidify the ocean. Warming of the deep ocean and ocean surfaces appear to be altering the natural cycles that help stabilize climate over decades to millennia.

The Pacific Ocean alternates between hot and cold phases of the El Niño/Southern Oscillation. Since 1976, the pattern has differed from any period since modern record keeping began in the 1880s. (In 2006, El Niño reappeared and sent

strong westerly winds that deflected Atlantic hurricanes away from American shores.) El Niños tend to bring extremes to specific regions of the globe, and this information can help generate early warnings of conditions conducive to fires, famine, and disease.<sup>6,7</sup>

The Arctic Oscillation in the Atlantic Ocean alternates between strong and weak phases. However, because Greenland outlet glaciers are hurtling toward the sea (14 km/year) and freshening the North Atlantic, the over-turning pump of the ocean conveyor belt is slowing.<sup>8</sup> Shifting temperatures and pressures are altering weather patterns in Europe and the Northeast United States

Warming of the Indian Ocean and the Indian sub-continent is intensifying the monsoon cycle and could alter the winds that blow south in austral summer, winds that once spirited 12th century Arab traders down the chain of islands along the east coast of Africa.

This brings us to the region where CHIK fever re-emerged in 2004. After several years of consecutive drought, which left soils caked and strewn with animal carcasses, CHIK fever escaped from its sylvan reservoir to surge in the Kenyan coastal towns of Lamu and Mombassa, the Seychelles, Comoros, and Reunion. It later appeared in Asian nations bordering the Indian Ocean, and then in The Philippines.

For Africa, the climate prognosis is dire. A new United Nations report<sup>9</sup> projects continued drying of the continent, with increasing consequences for health, crop yields, livelihoods, refugees, and conflict. Sahel rainfall has already fallen 25% in the past 30 years, and wider epidemics of meningococcal meningitis can be expected. (Saharan dust storms traverse the Atlantic bringing fungi to fan coral and increasing asthma rates to the Caribbean isles.<sup>10</sup>)

By 2025, 480 million Africans are projected to face water scarcity or stress, 30% of Africa's coastal infrastructure could be inundated, and 80–90% of species' suitable habitats will shrink. Mountain biodiversity, where glaciers, plants, and mosquitoes are already migrating upward,<sup>11</sup> could be further degraded on peaks without room for species to shift. Wetlands will decrease as disappearing montane glaciers decrease runoff, and subsistence crops, such as sorghum, millet, maize, and groundnuts, are projected to suffer. Their loss will increase bushmeat hunting that will magnify environmental change and expose wider population to viral hemorrhagic fevers.

The explosive re-emergence of CHIK fever in 2004 is associated with intensifying weather extremes besetting Africa. Increased preparedness, where resources are available and systems are intact, can help manage climate-related disease spread. But, primary prevention is needed, and clean, distributed systems of energy for pumping water, cooking, lighting homes and health facilities, and powering computers and small machines, can improve public health, protect the environment, and help stabilize the climate, while providing a new engine of growth for the global economy.

\* Address correspondence to Paul R. Epstein, Center for Health and the Global Environment, Harvard Medical School, Boston, MA 02115. E-mail: paul\_epstein@hms.harvard.edu

Received December 26, 2006. Accepted for publication January 8, 2007.

Author's address: Paul R. Epstein, Center for Health and the Global Environment, Harvard Medical School, Boston, MA 02215, E-mail: paul\_epstein@hms.harvard.edu.

#### REFERENCES

1. Linthicum KJ, Anyamba A, Tucker CJ, Kelley PW, Myers MF, Peters CJ, 1999. Climate and satellite indicators to forecast Rift Valley fever epidemics in Kenya. *Science* 285: 397–400.
2. Jupp PG, Mcintosh BM, 1998. Chikungunya virus disease. Monath TP, ed. *The Arboviruses: Epidemiology and Ecology*. Boca Raton, FL: CRC Press, 137–157.
3. Chretien J-P, Anyamba A, Bedno SA, Breiman RF, Sang R, Seron K, Powers AM, Clayton CO, Small J, Tucker CJ, Linthicum KJ, 2007. Drought-associated Chikungunya emergence along coastal east Africa. *Am J Trop Med Hyg* 76: 405–407.
4. Levitus S, Antonov J, Boyer T, 2005. Warming of the world ocean, 1955–2003. *Geophys Res Lett* 32: L02604.
5. Houghton JT, Ding Y, Griggs DJ, Noguer N, van der Linden PJ, Xiasou D, eds., 2001. *Climate Change 2001: The Scientific Basis*. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge University Press.
6. Epstein PR, 2005. 2005. Climate change and human health. *N Engl J Med* 353: 1433–1436.
7. Epstein PR, Mills E, eds., 2005. *Climate Change Futures: Health, Ecological and Economic Dimensions*. Boston: Center for Health and the Global Environment, Harvard Medical School.
8. Bryden HL, Longworth HR, Cunningham SA, 2005. Slowing of the Atlantic meridional overturning circulation at 25°N. *Nature* 438: 655–657.
9. United Nations Framework Convention on Climate Change (UNFCCC), 2006. *Report on the African Regional Workshop on Adaptation*. Accra, Ghana, September 21–23, 2006. Available from [http://unfccc.int/adaptation/adverse\\_effects\\_and\\_response\\_measures\\_art\\_48/items/3743.php](http://unfccc.int/adaptation/adverse_effects_and_response_measures_art_48/items/3743.php)
10. Gyan K, Henry W, Lacaile S, Laloo A, Lamsee-Ebanks C, McKay S, Antoine RM, Monteil RM, 2005. African dust clouds are associated with increased paediatric asthma accident and emergency admissions on the Caribbean island of Trinidad. *International J Biometeorol* 49: 371–376.
11. Epstein PR, Diaz HF, Elias S, Grabherr G, Graham NE, Martens WJM, Mosley-Thompson E, Susskind J, 1998. Biological and physical signs of climate change: focus on mosquito-borne disease. *Bull Am Meteorol Soc* 78: 409–417.