

PAGE 324

Droughts threaten Bornean rainforests

At 130 million years old, the rainforests of Southeast Asia are the oldest in the world and home to thousands of species of plants and animals, some endemic to these forests. The rainforests also play important roles in modulating regional rainfall and in the global carbon cycle.

However, since the 1960s, increased warming in the Indian Ocean and frequent El Niño events have reduced rainfall in the region by approximately 1.0% per decade. Furthermore, the Intergovernmental Panel for Climate Change predicts that over the 21st century, Southeast Asia will experience higher land temperatures, more droughts, and increased seasonality; that is, wet seasons during the fall will get wetter, and dry seasons during the spring will get drier. However, few studies in the past have investigated how trees in the southeastern Asian rainforests respond to droughts and climate change.

In a new study, *Kumagai and Porporato* combine extensive field observations, historical records, and global climate models to investigate the potential impact of rainfall shifts and droughts on tree mortality in the Bornean rainforests of Southeast Asia. They found that as El Niño events become more frequent in the future in response to warming in the tropical oceans, even the species of trees that can adapt to drought conditions will be at increased risk of dying off. The small number of species that cannot adapt well to drought conditions will be at even greater risk of dying off.

Their study has implications for predictions of ecological changes, regional rainfall patterns, and global climate as well as direct applications for policies aimed at reducing additional human impacts on these ecosystems, which not only are vulnerable to climate change but also have the highest rates of deforestation in the world. (*Journal*



T. Kumagai

Tropical rainforest in Lambir Hills National Park, Sarawak, Malaysia.

Atmospheric moisture residence time affects rainwater isotope ratios

The water cycle is expected to respond to rising air temperature, which redistributes moisture in the lowest part of the atmosphere, known as the boundary layer. To understand how boundary layer processes redistribute rainfall across different climate settings, climatologists use stable isotope ratios of oxygen and hydrogen in rainwater. A process known as Rayleigh fractionation—which depends on air temperature and amount of rainfall among other factors—controls the stable isotope makeup of rainwater. For example, in the tropics the isotope ratio depends on the amount of rainfall, whereas in high-latitude continents it depends on the air temperature.

The ratio, however, does not always follow the Rayleigh model, particularly in regions receiving moderate to heavy rainfall, suggesting that scientists still do not fully understand the complex atmospheric processes that distribute moisture in the boundary layer. Poor understanding of boundary layer processes also makes it

difficult to interpret oxygen isotope ratios in paleorecords, such as ice cores and cave deposits, as proxies of past response of water cycle to climate change.

In a new study, *Aggarwal et al.* present a model linking oxygen isotope ratios in rainwater to a single atmospheric parameter, the residence time of moisture in the atmosphere, which is the ratio of the amount of moisture in a column of the atmosphere (available from satellite observations) to the amount of precipitation in the region underlying that column.

Their model holds across all climate settings and explains why stable isotope ratios in rainwater should reflect regional dependences on different parameters. The new model not only helps explain boundary layer processes and past responses of the water cycle but also could help societies to better prepare for the future as rainfall patterns respond to rising air temperatures. (*Geophysical Research Letters*, doi:10.1029/2012GL051937, 2012) —AB

of *Geophysical Research-Biogeosciences*, doi:10.1029/2011JG001835, 2012) —AB

Section of thermohaline circulation driven by transient current rings

The southward branch of the Atlantic Meridional Overturning Circulation (AMOC), the stretch that carries deep, cold water from the North Atlantic to the Southern Ocean, predominantly flows along the eastern shoreline of the Americas. This deep water transport, known as the Deep Western Boundary Current, hits a fork in the flow at 25°S, off the coast of Brazil. Here the current splits in two, with the majority continuing its southbound journey and a smaller ribbon veering to the east. This eastbound water travels at depth across the South Atlantic, eventually passing around Africa's southern coast. In its path from Brazil to Africa the water crosses lines of consistent vorticity—essentially traveling uphill. Though researchers have known of this current for decades, little is known of what drives it.

Using an ocean circulation model fed with data recorded from 1980 to 2006, *van Sebille et al.* found that the eastward flow is driven by Agulhas rings, a transient feature off the South African shoreline. The Agulhas current flows southbound along Africa's eastern shore. Where the Agulhas current meets the Southern Ocean most of the warm Agulhas water retroreflects and turns back into the Indian Ocean. This sharp

about-face causes the Agulhas current to shed counterclockwise rotating warm water eddies. These eddies travel westward along the African coast and break down in the South Atlantic.

The authors used simulated floats to track three-dimensional ocean circulation, finding that the eastward deep water current traveled directly beneath the Agulhas rings. Further, they found that the Agulhas rings actually drive the eastward flow. They note that their finding implies a transitory nature for the eastward branch of AMOC deep water transport, as a break in Agulhas ring occurrence would stymie the flow. (*Journal of Geophysical Research-Oceans*, doi:10.1029/2011JC007684, 2012) —CS

Remote sensing of hydrological connectivity

The subsurface flow of water within a watershed is traditionally thought to depend solely on topographic or physical influences, such as slope, soil permeability, and channel density. Though often overlooked, some researchers propose that the role of vegetation and its feedback on subsurface flow could be just as important in some cases. Plants tend to increase subsurface flow by increasing soil conductivity and preferential flow paths. They can also cause it to decline, as plants use subsurface water and nutrients to fuel their growth, drawing it out of the system

through evapotranspiration. Both sets of feedbacks affect the downslope availability of water. To capitalize on this idea, *Hwang et al.* devised a system called the hydrological vegetation gradient (HVG).

HVG represents how vegetation density patterns develop along hydrological flow paths within a watershed. The authors' system draws on two values: the normalized difference vegetation index and the topographic wetness index, which can be derived through remote sensing and digital terrain analysis. The authors suggest

that their HVG system could be used to understand the role of subsurface lateral water transfer within a watershed without needing to conduct intensive field work.

To test their system, the authors used data collected in the Coweeta Hydrological Laboratory, a 5400-acre series of headwater catchments in North Carolina. They used rain gauge measurements, topographic information, and a distributed ecohydrological model to chart how water flows through each of the eight different watersheds. They compared

their HVG values with established hydrologic, geomorphic, and topoclimate variables to assess how well HVG serves as a proxy for subsurface flow and hydrological connectivity. The authors suggest that the work provides evidence for the coevolution of forest ecosystem patterns with hydrologic and geomorphic systems. (*Water Resources Research*, doi:10.1029/2011WR011301, 2012) —CS

—ATREYEE BHATTACHARYA and COLIN SCHULTZ,
Writers