

We will not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time

T.S. Eliot (1888–1965)

NATURAL DISASTERS

Building a Tsunami Warning System

The 26 December 2004 tsunami that devastated coastal areas in Indonesia, Malaysia, Thailand, Myanmar, India, the Maldives, Sri Lanka, and Somalia was produced by a magnitude 9.0 earthquake 155 kilometers southwest of northern Sumatra. The tsunami inundated coasts with waves more than 30 feet high every 30–40 minutes for several hours. It killed more than 150,000 people and injured millions, making it one of the worst natural disasters the modern world has ever seen.

Could populations have been warned in advance? Not with the tsunami monitoring networks that exist in the affected area today, say officials with the National Oceanic and Atmospheric Administration (NOAA). Unlike the Pacific Ocean, which is wired for tsunami alerts by the United Nations Intergovernmental Oceanographic Commission, the Indian Ocean is largely devoid of comparable sensor technologies that detect earthquakes and issue tsunami warnings to affected countries. According to NOAA officials, future warnings could be enhanced by the creation of an Indian Ocean tsunami warning center that would deploy coastal tide gauges to measure

the amplitude of waves near tsunami source areas such as fault zones and volcanoes, and would establish a communications infrastructure to send and receive alerts.

Tsunami buoys also would be useful in an early warning system, NOAA officials say. At present, a network of six buoys is deployed by NOAA off the Aleutian Islands



The tragedy of hindsight. Similar disasters may be mitigated in the future by better warning systems.

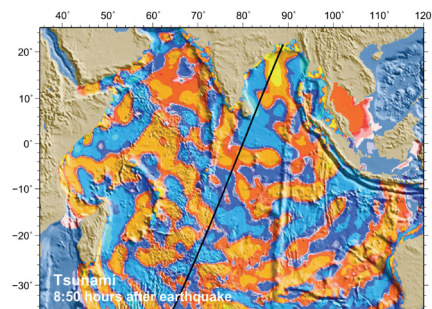
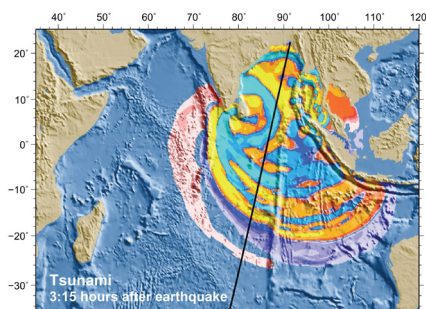
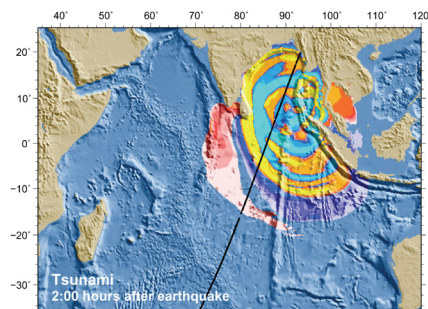
in the Pacific Ocean. This network, called Deep Assessment and Reporting of Tsunamis, is composed of two parts: a sea floor sensor and a buoy that relays tsunami information to warning centers on the ground by satellite communication. NOAA estimates that about 50 such buoys are needed to adequately cover the world's oceans. On 6 January 2005 Senator Joe Lieberman (D-CT) proposed a \$30 million package to develop these additional buoys, which the

U.S. Congress is currently considering. Australian scientists are also designing an Indian Ocean tsunami alert system that is expected to cost US\$20 million.

Still more help could come from the sky. On 10 January 2005, NOAA announced that its scientists had measured the height of the December 26 tsunami using data from four Earth-orbiting satellites passing over the affected area at the time. NOAA geophysicist Walter H.F. Smith said in an agency press release that the best application of satellite data to improve tsunami hazard forecasts may be in helping to map the ocean floor from space.

To be truly effective, any tsunami warning system will need to be part of an overall disaster reduction strategy, says Helen Wood, senior advisor for systems and services in NOAA's National Environmental Satellite, Data, and Information Service. "You don't want a separate system that segregates tsunamis from earthquakes or cyclones, because populations on the coast are at risk from any and all of those things," she says.

Wood heads the secretariat for the Global Earth Observation System of Systems, an emerging international coalition that has set disaster reduction as one of nine priority areas [see "Terra Cognita: Using Earth Observing Systems to Understand Our World," p. A98 this issue]. "We had already identified tsunami and related instrumentation as a necessity," Wood says. "Now there's a sense of urgency. [The December 26 tsunami] was a catalyst for action. It's sad, but disaster often mobilizes people at all levels to take action." —Charles W. Schmidt



Waves of destruction. Composite satellite images created by NOAA measure the tsunami's height as it spread from the quake epicenter. The ability to make depth surveys from space may lead to improvements in models that forecast the hazardous effects of tsunamis.

Photos: Philip A. McDaniel/US Navy; maps: NOAA

GLOBAL WARMING

Arctic Climate: The Heat Is On

In November 2004, the Arctic Council, a coordinating body of the eight Arctic nations (Canada, Denmark, Iceland, Sweden, Norway, Finland, Russia, and the United States) released its *Arctic Climate Impact Assessment: Impacts of a Warming Arctic* (ACIA). Emerging from the work of hundreds of scientists and incorporating indigenous knowledge about conditions in the Arctic, the ACIA paints a sobering picture of the effect of present and expected global warming on Arctic peoples and ecosystems.

Although a few Arctic areas have cooled over recent decades, overall average surface air temperatures have risen almost twice as much as global averages. In Alaska and western Canada, temperatures have risen 3–4°C since 1954. For the whole Arctic, the ACIA projects additional warming of 4–7°C over the next century. These projections are not a worst-case scenario; they are based on low-to-middle projections from the United Nations Intergovernmental Panel on Climate Change.

The focus of the ACIA was not temperatures, though, but the ecological, cultural, and economic impacts of warming. A few impacts could be positive: marine transportation should improve as ice retreats from shorelines, and vegetation growth may also accelerate in warmer conditions, perhaps increasing food production. But land transportation has already become more difficult due to melting of permafrost; ice highways used to transport industrial and mining equipment are now available for shorter periods each winter. Ice-free oceans, combined with melting permafrost, have already resulted in severe erosion and coastal destruction in Alaska.

In terms of ecology, the impacts are largely negative. Over the past few decades, the amount of boreal forest that burned each year has doubled, and the ACIA says forest insect outbreaks and forest fires are “very likely” to intensify. As ice continues to retreat from the Arctic Ocean, animals that live on or hunt under the ice, including polar bears and several seal species, could grow scarcer or even go extinct.

Caribou in the giant Porcupine River herd in northwest Canada and Alaska are drowning as they cross rivers that normally are still ice when the animals migrate. Warming has also interfered with caribou feeding, says Craig Fleener, a wildlife biologist for the Gwich'in Council International,

an indigenous group for whom the Porcupine River herd provides a material and cultural foundation. Repeated freezing and thawing, he says, creates a very hard, crusty layer on the ground that makes it hard for the caribou to reach the lichen that is their major food source.

“What is really happening is rapid climate and environmental change that goes beyond our capability of adapting quickly enough,” says Fleener. “If the change happens over a long period, we can find new methods, a new place to live or harvest, but when you have rapid change, it is much more difficult [to adapt].”

Hunters are also being affected more directly, says Sheila Watt-Cloutier, chair of the Inuit Circumpolar Conference, one of six indigenous organizations that contributed to the report. “As a result of warming,” she says, “Inuit hunters are falling through the thinning ice.” Hunting is the basis of Inuit culture, she stresses, and an economic necessity because imported food prices reflect high transportation costs. The Inuit include 155,000 Arctic natives living in eastern Siberia, North America, and Greenland.

The report is a wake-up call, says Jonathan Foley, director of the Center for Sustainability and the Global Environment at the University of Wisconsin–Madison, but not just for Arctic residents. Polar snow and ice reflect solar radiation out to space, he points out. As the snow and ice retreat, the Earth’s surface gets darker and absorbs more heat, warming the whole planet in a dangerous feedback loop where warming causes melting and melting causes warming.

Watt-Cloutier observes that Arctic peoples already face the threat of high levels of organic pollutants such as dioxin and polychlorinated biphenyls that have drifted north through the atmosphere and now contaminate animal fat and human breast milk. With the prospect of greenhouse gases produced further south causing disproportionate warming in the Arctic, the region is once again “being poisoned from afar,” she says.

Arctic people are resilient by necessity and tradition, says Watt-Cloutier, and they have come through enormous, sudden, tumultuous change in the last 50–60 years caused by the introduction of culture, technology, and foods from the temperate regions. But the Arctic way of life is wedded to a specific environment, and that environment is rapidly changing. While much of the press coverage of the ACIA report has focused on the possibility that polar bears could become extinct, she warns, “It’s not just about endangered species of animals. We ourselves are an endangered species.” —David J. Tenenbaum

NASA for Nature

In November 2004 the World Conservation Union (IUCN) and NASA announced the formation of a partnership to use NASA’s data, images, and remote sensing capabilities to help the IUCN in its efforts to conserve biodiversity around the world. NASA data will be used in support of several IUCN programs, including the Protected Areas Learning Network and the World Database on Protected Areas. Many protected areas are remote and in regions with few resources, and so are poorly mapped. But together with NASA, the IUCN will be able to generate satellite imagery and accurate maps to help create a protected area archive.



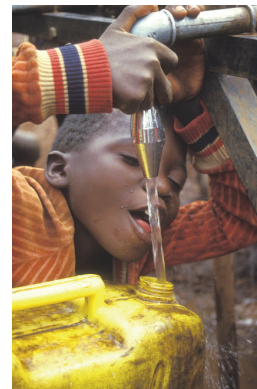
Amazon River

Global Warming On the Streets

The British government launched an advertising campaign in October 2004 to educate the public about the potential dangers of climate change. The £6 million campaign kicked off with the publication of a report detailing the effects that could result from higher temperatures. The ads themselves suggest ways the public can help curb global warming—for example, by turning down their thermostats, choosing cars that run on renewable energy, and properly insulating their homes. The advertisements will appear in the press, on billboards, and possibly on television. The British Energy Saving Trust estimates that Brits currently waste £5 billion worth of energy each year.

Millennium Development Progress Report

The United Nations has issued a progress report on the Millennium Development Goals, which were set in September 2000 in an attempt to halve world poverty by 2015. Most countries appear on track to halve the number of people without access to safe water (although 800 million would still be at risk), but progress toward meeting sanitation goals is slow or nonexistent in several regions. By 2015, about 2.4 billion people could still face disease and death due to poor sanitation, which contributes to the spread of cholera and diarrheal disease, killing a child every 21 seconds. Western and southern Asia, sub-Saharan Africa, and Oceania are among the regions showing the least progress; conditions are deteriorating in some developed countries such as the former Soviet republics.



SYSTEMS BIOLOGY

New Clue to Heat Stress

The human body cools itself by increasing blood flow to surface areas and by sweating. When these cooling responses fail, the result may be heat-related injuries such as heat stroke or even death. Although the consequences of impaired heat loss are known, the complex networks that increase skin blood flow during heat stress are not well understood. Now, however, a new study identifies one type of histamine receptor as a key regulator of body temperature.

Some people are particularly prone to heat illnesses, including the elderly and those with diabetes, heart disease, and cystic fibrosis. No one knows if global warming will bring more catastrophic heat waves, but the number of at-risk people will increase as the population ages. In order to protect at-risk individuals during heat waves, researchers must identify all the steps involved in skin blood flow. "Right now, we don't fully understand all the interactions that control skin blood flow during heat stress in healthy young people," says study coauthor Brett Wong, a doctoral student in the Department of Human Physiology at the University of Oregon in Eugene.

Wong and his colleagues put 11 healthy volunteers in specially designed suits fitted with tubing that circulates hot water and quickly warms the body. Once the participants' core body temperatures reached about 100°F, they were dermally dosed with either the

antihistamine pyrilamine, which acts through the H1 receptor; the antihistamine cimetidine, which acts through the H2 receptor; or nitro-L-arginine-methyl ester (L-NAME), which blocks nitric oxide. It's well documented that nitric oxide raises skin blood flow when the body heats up, and that L-NAME blocks blood flow. All three chemicals act locally in the skin and do not circulate in the body.

The team used noninvasive laser-Doppler flowmetry to measure how these agents affected skin blood flow during heat stress. As expected, L-NAME blocked skin blood flow. Cimetidine's blockage of the H2 receptor showed no effect. But when pyrilamine blocked the H1 receptor, blood flow to the skin was dramatically reduced. The report appears in the November 2004 issue of the *Journal of Physiology*.

Although pyrilamine is an over-the-counter antihistamine, it's premature to say that people taking antihistamines for allergies may have trouble regulating their body temperature in heat stress, Wong cautions. Future studies will look at oral antihistamines, heat stress, and skin blood flow.

Studies like Wong's "are slowly putting the pieces of the puzzle together," says Michael J. Joyner, vice chair of the Department of Physiology at the Mayo Clinic. Once the basic biology is laid out, researchers can test what drugs help or hinder skin blood flow. In the future, "we may be able to warn at-risk people to either avoid or take certain drugs during heat waves," says Joyner. Outdoor workers or athletes who compete in hot climates will also benefit from such advice. —Carol Potera

ENVIRONMENTAL TOBACCO SMOKE

The Colic Connection

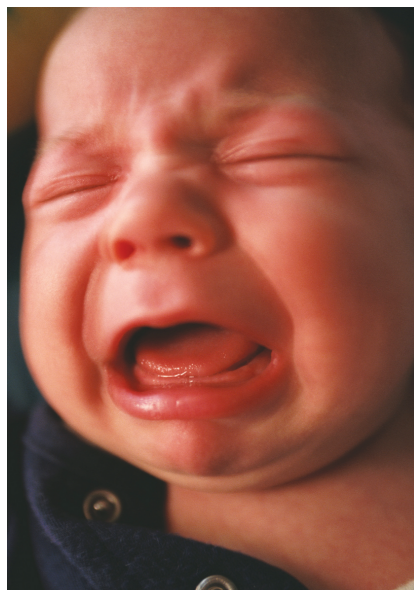
The ancient Greeks were the first to describe infant colic, a condition of inconsolable crying that may afflict as many as 28% of U.S. infants, yet the root causes of this malady remain a mystery. Among the theoretical risks are milk and soy allergies, infant temperament, and problems with the infant-caregiver interaction. Researchers now speculate that maternal smoking during or after pregnancy may result in gastrointestinal (GI) dysregulation and thus increase the risk of infant colic.

This hypothesis, proposed by Brown University epidemiologist Edmond Shenassa and Mary Jean Brown, an adjunct assistant professor of society, human development, and health at Harvard, is based on a review of more than 80 papers in different fields. As reported in the October 2004 issue of *Pediatrics*, the focus of the researchers' attention was the gut protein motilin. Infants with colic have higher motilin levels independent of how they are fed, suggesting this protein may play an important physiologic role in colic and other GI-related disorders among babies.

Three distinct lines of evidence were used to construct the hypothesis. First, mothers who smoke are twice as likely to have infants with colic. Second, exposure to nicotine and other tobacco smoke metabolites causes

higher-than-average blood motilin concentrations. Finally, pediatric studies suggest that high motilin levels may predispose infants to colic.

Each year, more than 500,000 U.S. infants are born having already been exposed to secondhand smoke metabolites *in utero*. Many more are exposed in the first few years after birth. Exposure through breast milk may be just as serious as exposure *in utero*,



A factor in fussiness. A literature review suggests that maternal smoking may lead to colic.

because nicotine concentrations in breast milk may be up to three times higher than maternal blood levels.

Further, says Brown, "Even if mothers don't smoke, the impact of [their own exposure to] secondhand smoke may be substantial." However, she says, there are no studies in which maternal exposure to environmental tobacco smoke has been directly quantified and linked to risk for colic.

It also remains to be seen whether smoking interacts with other GI reactivity factors, such as milk allergy. "Given the available data, we can't really speculate about possible interactions," says Brown, "nor do we know what underlying mechanisms might cause interactions between risk factors."

Shenassa is presently conducting a prospective population-based study, recruiting pregnant mothers and following them for about eight weeks after birth. This will be the first study to carefully consider the effects of both smoking and motilin on infant colic.

"It is significant that colic might have an environmental basis," says S. Katharine Hammond, a professor of environmental health sciences at the University of California, Berkeley. "Unlike the costs of controlling many environmental hazards, *in utero* exposures to environmental tobacco smoke can be minimized with little cost through education and restricting smoking in workplaces and public places." —M. Nathaniel Mead

ehpnet

The Earth Observing System

In 1991, the National Aeronautics and Space Administration (NASA) embarked upon the extensive and comprehensive Earth Science Enterprise, a program to help us better understand what is happening on the Earth's surface. The centerpiece of the Earth Science Enterprise is known as The Earth Observing System (EOS). The EOS website, located at <http://eosps.gsfc.nasa.gov/>, is designed to keep scientists, educators, and the news media informed about the system and its activities.

EOS is composed of a series of satellites conducting long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. The first EOS satellite, Terra, was launched into orbit in December 1999. NASA hopes the data gathered by the system, the first to provide integrated measurements of processes occurring on Earth, can be used to help better predict climate change, oversee conservation efforts, and improve forecasting to help farmers, fishers, and other weather-dependent tradespeople.

The For Scientists section of the website provides links to overviews of the field experiments that EOS conducts, and contains information on what sorts of measurements EOS takes and what types of instruments are used. Also within this section are links to brochures, reference books, data product catalogs, a bibliography of EOS-related publications, and a calendar of workshops and conference seminars conducted by EOS personnel.



Teachers looking for EOS-related resources can visit the For Educators section. The EOS Education Project, with a link located under the Educational Links subhead, has been developed for teachers and students at all levels to teach about topics including geographic information systems and remote sensing. The project offers outreach programs for teachers and Internet-based classes. This section also features a directory of other EOS-related teaching materials, including brochures, fact sheets, posters, lithographs, and lesson plans that can be downloaded or ordered for free. Also available are online tools for calculating when a satellite will pass overhead and tracking various satellites' current location in the sky. Links to other websites include the main NASA Earth Science Enterprise educational website and the homepages of related agencies such as the National Science Foundation.

News writers have their own section on the website. Available under For News Media is the Earth Observatory Newsroom, which contains press releases on the latest EOS research, NASA news announcements, and a list of newly published research. This section also features the EOS Global Change Media Directory 2001. This resource lists 343 scientists working in fields such as ozone chemistry, global warming, and ecosystems who have expressed interest in working with the media. Science writers' guides to individual spacecraft provide extensive background material and contact information.

The site's Data Services section provides links to the different types of data that the EOS and its partners provide. This section links to NASA's Global Change Master Directory website, which provides extensive data sets on 13 topics, including agriculture, human dimensions, oceans, and sun-Earth interactions. Subscribers can add to the data sets and participate in an online discussion list. —Erin E. Dooley

Machu Picchu Makeover

The World Bank announced a \$5 million loan in September 2004 to go toward protecting the area around Machu Picchu, one of Peru's main tourist and cultural areas and a World Heritage Site. The Peruvian government is contributing an additional \$3.2 million for the project, which will work to develop sustainable tourism initiatives, reduce pollution at the site, and improve environmental management in the Vilcanota Valley, where the site is located. The project will also improve the region's solid waste management system and allow for detailed environmental impact assessments to analyze the effect of urbanization of the area. The new water and sanitation developments may employ technologies such as solar aquatic systems and wastewater gardens. The local community has been consulted extensively in developing the project.



World Progress Up in Smoke?

Up in Smoke, released in October 2004 by the Working Group on Climate Change and Development, asserts that global warming could make it impossible to achieve the Millennium Development Goals set in 2000 by the United Nations, and could even reverse progress that has been made toward meeting the goals. The report states that the impacts of climate change will fall disproportionately on the poor in both developed and developing countries, and provides many scenarios to illustrate. For example, in developing regions where food security is already tenuous, increased flooding related to global warming could wipe out plant resources, stored food, and seed reserves. The report states that industrialized countries need to surpass Kyoto Protocol goals and cut greenhouse gas emissions by 60–80% below 1990 levels in order to stop climate change from "running out of control."

Green Guide for Health Care

The first-ever sustainable design guidebook for hospitals was released on 22 November 2004 by the Austin, Texas-based Center for Maximum Potential Building Systems. The product of a two-year multistakeholder development process, the guide is based on the U.S. Green Building Council's Leadership in Energy and Environmental Design rating system but has been modified to meet the specific needs of the hospital industry from start to finish. The program addresses topics including round-the-clock energy performance, chemical use, infection control requirements, and the elimination of toxic chemicals from building materials. Several major hospital systems, including Kaiser-Permanente, have agreed to pilot-test the guide over the next year.

