

THE YEAR IN SCIENCE

Discover

SCIENCE FOR THE CURIOUS

January/February 2015

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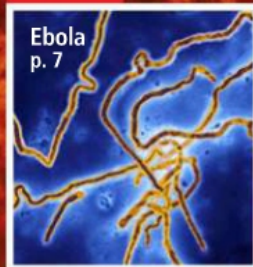
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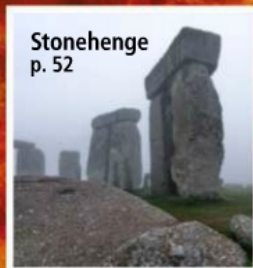
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chapman.edu

Dr. Erik Linstead

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of Electrical and Electronics Engineers

Data Scientist

Assistant Professor, Computer Science
and Software Engineering

Director of Computer Science,
Chapman University

FOCUS

on what matters

Meet Dr. Erik Linstead. His focus? Improving life for those with autism spectrum disorder via innovative research using data mining and machine learning. Dr. Linstead contributes to the advancement of care and treatment through the development of the Autism Management Platform, a mobile and web-based technology solution focused on data collection, communication and the effective management of autism spectrum treatment. By sharing his research and challenging his students to think differently, Dr. Linstead brings the exploration of life-changing impact into focus.

 **CHAPMAN
UNIVERSITY**

THE YEAR IN SCIENCE

JANUARY/FEBRUARY 2015

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One of the deadliest viral outbreaks in recent history caught the world off guard, sending health experts and scientists scrambling to find a solution.

BY KARI LYDERSEN

Editor's Note

Welcome to our Year in Science edition, an issue so jam-packed with great stories that I have maybe 75 words to tell you about it. But I don't need more than that: These top 100 science stories from 2014 (plus bonus content, such as our New Species spotlights, peppered throughout the following pages) speak for themselves. Enjoy the issue, and don't forget to vote for your own top science stories at DiscoverMagazine.com/YearInScience.



Stephen C. George, EDITOR IN CHIEF

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A microscopic view of the highly infectious Ebola virus.

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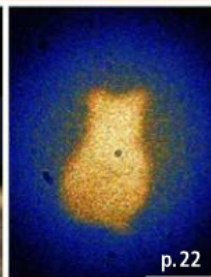
Scientists trumpeted proof of signals originating from the Big Bang, putting them a massive step closer to figuring out our cosmic creation. But were they right?

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King Solomon's Secret Treasure: FOUND

Ancient beauty trapped in mines for centuries is finally released and available to the public!

King Solomon was one of the wealthiest rulers of the ancient world. His vast empire included hoards of gold, priceless gemstones and rare works of art. For centuries, fortune hunters and historians dedicated their lives to the search for his fabled mines and lost treasure. But as it turns out, those mines hid a prize more beautiful and exotic than any precious metal: chrysocolla.

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William Cho (landscape); Mike Reynolds (eclipse)

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100 TOP Stories *of* 2014

no. 1

THE EBOLA EXPLOSION

BY KARI LYDERSEN
PHOTOS BY KIERAN KESNER

A burial team member removes the body of a woman who died the night before. She had been awaiting treatment in an Ebola holding center in Monrovia, Liberia, in August.



→ It started quietly, deep in the forest of southern Guinea.

In Meliandou, a village in the prefecture of Guéckédou, a 2-year-old boy contracted the virus, possibly from a fruit bat. The child's flu-like symptoms at first would have caused little alarm. But before long he began vomiting, and his stool was black with blood.

The young boy died on Dec. 6, 2013. By New Year's Day, his mother, sister and grandmother were dead. A month later, so were two mourners who had attended the grandmother's funeral, a local nurse and the village midwife. Before they died, the two mourners and the midwife carried the virus to nearby villages and to the region's hospital, infecting others.

Thus began the worst Ebola outbreak the world has ever seen.

By last summer, people across Guinea, Sierra Leone and Liberia had retreated to their homes, unwilling or unable to get to clinics where they'd seen their friends and relatives go, never to return. Health care workers labored in sweltering facilities. More than 200 succumbed to the virus, and frightened staff fled their positions, forcing clinics to turn patients away.

Since the Ebola virus first emerged in 1976 in the Democratic Republic of Congo (then Zaire), flare-ups had occurred mostly in isolated Central African forest villages. News of Ebola's lethality and its horrific symptoms — vomiting, diarrhea, and sometimes bleeding from the eyes, nose and other orifices — bred morbid curiosity and fear, and the gripping story of its emergence inspired the best-selling book *The Hot Zone*.

Despite Ebola's ferocity, previous outbreaks infected a few hundred people at most. Ebola is highly infectious — just a few particles of the virus in a drop of sweat or blood can cause disease — and health workers must don personal protective suits and quarantine patients in isolation units.

But the virus is not especially contagious. It's transmitted only via close contact with a patient's bodily fluids, excretions, soiled clothing or bedding. And patients are contagious only when they are palpably and visibly ill, making carriers easy to spot. All this helped health workers corral past outbreaks, and before long the virus would retreat into the forest.

Not this time. Why, in 2014, did Ebola spread sickness and death through West Africa and beyond — and how can science help stop it?

A PERFECT STORM

Robert Garry knew early on that trouble was brewing. He was working at Kenema Government Hospital in Sierra Leone last March when he heard reports of Ebola in neighboring Guinea. He was there studying Lassa fever, a cousin of Ebola. At the time, 112 people had been infected and 70 had died from Ebola, but the World Health Organization (WHO) said Guinea's outbreak was "relatively small still," and Guinean officials said it was under control.

Garry, a virologist from Tulane University in New Orleans, knew a thing or two about how outbreaks of Lassa, Ebola and related viruses play out. "Lassa simmers," he says. "Ebola explodes."

And as the international community dozed, an outbreak detonated. Through the spring and summer of 2014, Ebola swept through Guinea and into its neighbors, Sierra Leone and Liberia.

The 2014 Ebola epidemic, the first in West Africa, was driven by a confluence of factors: poverty and lack of health care infrastructure; traditional burial practices that helped spread the disease; deep-seated mistrust of Westerners, health care workers and authorities; and the region's growing mobility.

In May, women from Sierra Leone attended the funeral of

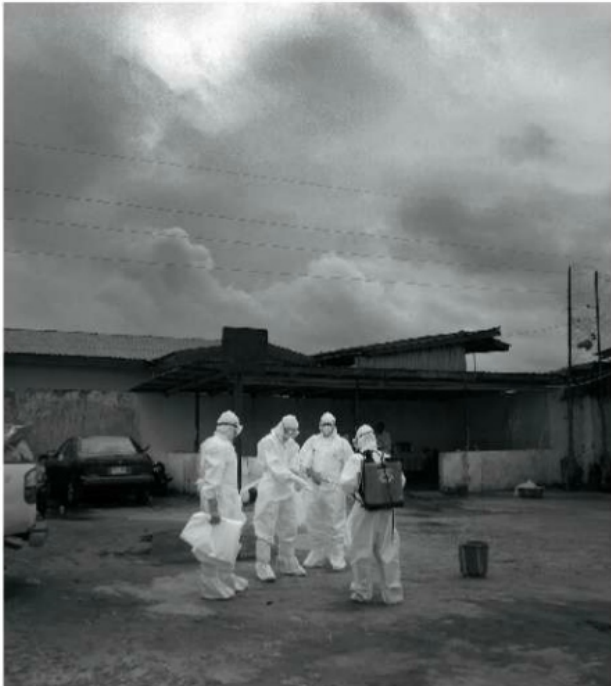


A boy cries outside an Ebola clinic in Monrovia's impoverished West Point district, where riots broke out and food ran short in August.

a traditional healer who had treated Ebola patients across the border in Guinea. One of the mourners, a young pregnant woman, showed up at Kenema Government Hospital, where she miscarried and was diagnosed with Ebola. In all, 14 of the mourners were infected and spread the virus to their contacts in Sierra Leone, stoking that country's epidemic, according to a DNA-sequencing study that Garry, renowned Sierra Leonean virologist and doctor Sheik Humarr Khan, Harvard virologist Stephen Gire and 55 colleagues later published in *Science*.

Garry and some colleagues, including Khan, readied the Kenema Government Hospital for Ebola patients. Soon he returned to the U.S., where he contacted federal officials to express his fears about a brewing epidemic. He received only "polite responses," he says.

Meanwhile, in Monrovia, Liberia's capital, physician and Christian missionary Kent Brantly began setting up that country's first Ebola isolation ward. Before long



A team in the West Point district prepares to enter a holding center to retrieve the bodies of Ebola victims.

the disease took hold in Monrovia's dense slums, filling Brantly's ward to overflowing.

"The disease was spiraling out of control, and it was clear we were not equipped to fight it effectively on our own," Brantly testified later to the U.S. Senate. He said he and his colleagues "began to call for more international assistance, but our pleas seemed to fall on deaf ears."

On Aug. 8, WHO finally declared the epidemic a public health emergency of international concern. "No one was really imagining we would get to this situation," WHO spokesman Tarik Jasarevic says. Within weeks, Liberia had surpassed Sierra Leone as the outbreak's epicenter. By then, more than 2,400 had been infected and 1,346 had died.

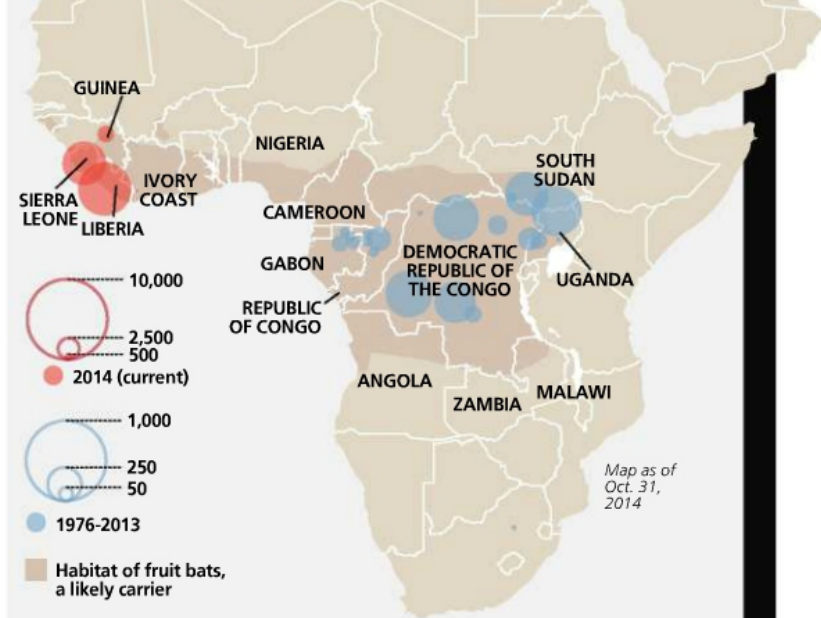
SCIENTISTS SCRAMBLE

Ebola's spread caught many scientists off guard at first. They knew that shortly after infection, the Ebola virus commandeers or kills immune cells, weakening the body's defenses and letting the virus run wild. They also knew that the virus interferes with blood clotting, which leads to bleeding and, in many cases, multiple organ failure.

But no proven therapy or vaccine existed at first, in part because of long-standing funding shortfalls for diseases that mostly affect the developing world. By summer, however, researchers worldwide were racing to the lab to combat the epidemic.

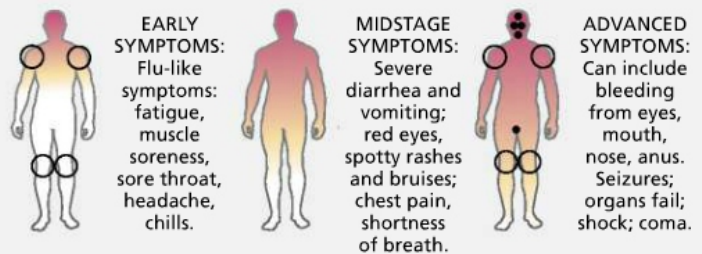
At least four experimental Ebola drugs were in early stages of development. The first human →

AN OUTBREAK LIKE NO OTHER



WORSENING SYMPTOMS

INFECTION: Ebola virus enters through eyes, mucus membranes or tiny cuts or scrapes. Symptoms typically appear four to 10 days later.



EBOLA INVADES

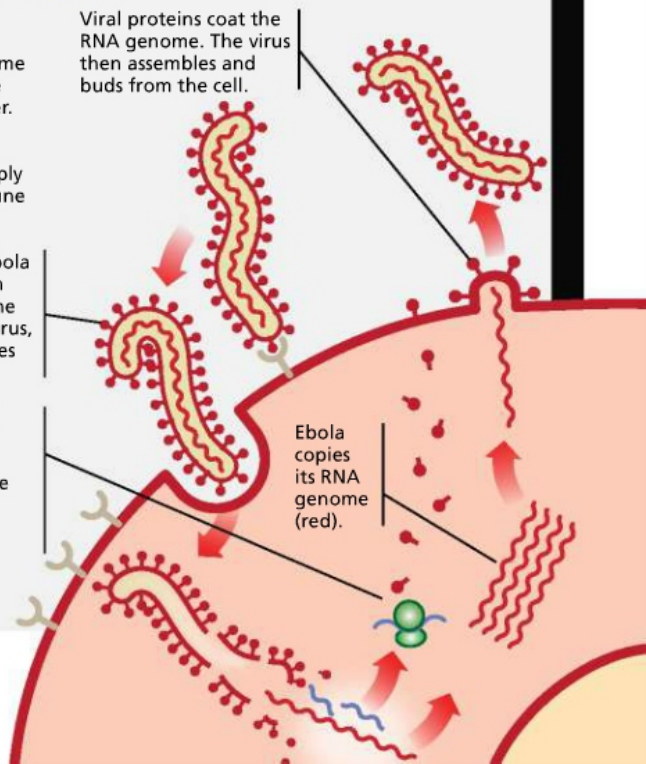
Like many other filoviruses, Ebola has an RNA genome and causes severe hemorrhagic fever. It hijacks the cell, making proteins that help it multiply and disable immune defenses.

Viral proteins coat the RNA genome. The virus then assembles and buds from the cell.

To enter a cell, Ebola binds to a protein on the surface. The cell engulfs the virus, which disassembles inside the cell.

Ebola makes viral messenger RNA (blue) and uses the cell's ribosome (green) to make its proteins (red lollipop).

Ebola copies its RNA genome (red).



safety trial on an Ebola drug began in January 2014 for TKM-Ebola, which contains snippets of RNA produced by Tekmira Pharmaceuticals that target three genes essential to viral replication. But it was ZMapp that grabbed the headlines. This cocktail of three antibodies, from San Diego-based Mapp Biopharmaceutical, binds to Ebola, neutralizes it and alerts the immune system to the infection. As of last summer, it had not been tested in people.

In July, Khan contracted Ebola. Physicians with the nonprofit group Doctors Without Borders, which led early efforts to combat the epidemic, agonized about whether to treat him with ZMapp. They feared that he might die, spurring even more mistrust of health care workers, and they decided not to. In late July, Khan died in a Doctors Without Borders clinic in Kailahun, Sierra Leone. He was 39.

Just days earlier in Monrovia, Brantly and a fellow American missionary, aid worker Nancy Writebol, were also diagnosed. They received a few of the ZMapp doses available and were then flown to Emory University Hospital in Atlanta. After several harrowing weeks in intensive care, they recovered.

By September, the first reports had appeared showing that ZMapp effectively fights Ebola in monkeys, and the U.S. government pledged \$25 million to help Mapp Biopharmaceutical manufacture more of the drug, test it in clinical trials and get it approved for human use.

To protect people from infection, researchers also developed two different vaccines, each with a key Ebola protein sewn into a harmless virus. One of the vaccines, developed by scientists at the pharmaceutical giant GlaxoSmithKline and the National Institute of Allergy and Infectious Disease (NIAID), helped protect monkeys from Ebola infection 10 months after vaccination. NIAID then launched a clinical trial to test the vaccine's safety, and GlaxoSmithKline committed to making 10,000 doses for health care workers by the end of 2014.

TOO LITTLE, TOO LATE

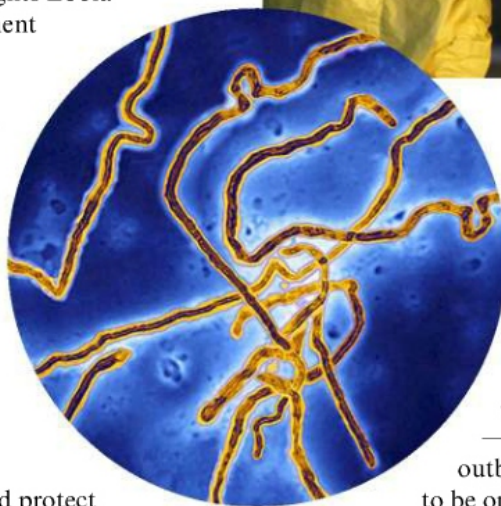
In September, the international community finally woke up to Ebola's threat. President Barack Obama promised to send 3,000 troops to Liberia and build 17 treatment centers with 100 beds each. But by then, about 7,200 people had been infected, more than 3,300 had died, and the casualties were skyrocketing. Researchers at

the Centers for Disease Control and Prevention built computer models, which predicted that, if a massive intervention failed to materialize, by January 2015 up to 1.4 million people could be infected.

The epidemic finally hit home for many Americans on Sept. 30, when Thomas Eric Duncan, a Liberian visiting Dallas, became the first person diagnosed on U.S. soil. He was isolated and treated intensively, but he succumbed just eight days later. Then two nurses who



It takes very little Ebola virus (left), to cause disease, so this Texas worker wore full protective gear while cleaning up outside the home of an infected health care worker.



treated Duncan at a Dallas hospital were diagnosed, becoming the first-ever cases of Ebola transmission on American soil, and a different epidemic — this one of anxiety — swept the nation. “As long as the outbreak continues in Africa, we need to be on our guard,” CDC director Tom Frieden told reporters.

It will be difficult to eliminate the virus entirely, since Ebola lurks in animals and periodically jumps to humans, Harvard's Gire says. But we can corral it by better diagnosing and treating infections, and by setting up labs on the ground to track emerging Ebola strains by sequencing their genomes. “Constant surveillance is the only way to be sure we know where the virus is going,” he says. “It’s imperative.”



Read the latest updates on the Ebola outbreak at DiscoverMagazine.com/Ebola

Climate in Crisis

West Antarctic Ice Sheet Collapses

→ Imagine you're canoeing the Niagara River when you notice mist ahead. You're still quite a distance from Niagara Falls, but the river's swift: There's no turning back.

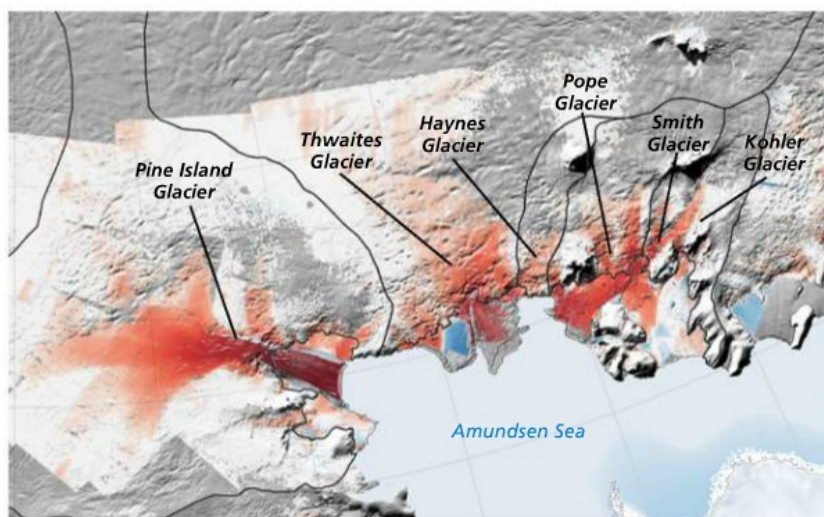
Two separate studies published last spring suggest that climate change has carried the West Antarctic Ice Sheet, or WAIS, across a similar threshold. The glaciers that flow off WAIS and dump ice into the sea already have contributed nearly 10 percent to the recent increase in global sea levels. Now, warming seawater intruding underneath has loosened the glaciers' grip on bedrock, speeding their flow toward the sea and causing increasing amounts of ice to break off into the ocean.

The research suggests that for a large portion of WAIS, this process "has passed the point of no return," says Eric Rignot of the University of California, Irvine, the lead author of

one of the studies. That means the ice sheet is now in irreversible retreat, and steps to slow global warming won't stop the ice sheet from raising the sea level 10 feet, swamping cities.

But there is a silver lining: Full collapse may take centuries, perhaps providing time to move populations at risk out of the way.

—TOM YULSMAN



These six massive glaciers of the West Antarctic Ice Sheet are picking up speed, shedding ice and raising sea levels. This map shows the pace of glacial flow between 1996 and 2008. Faster-moving areas are shown in red; slower-moving areas are in blue.



Climate Change Is Not in Hibernation

→ As brutal Arctic conditions gripped large parts of North America in the winter of 2014, it was tempting to think that global warming had vanished.

But along with the notorious polar vortex, the year also brought new evidence that human activities are altering the climate in ever more obvious ways — and that the risks of severe impacts rise with every ton of greenhouse gases emitted into the atmosphere.

"Climate change is real," says Gerald Meehl, a scientist with the National Center for Atmospheric Research (NCAR) in Boulder, Colo. "Humans are causing most of it, we can measure it better than before, we have good tools to measure it in the future, and it's going to be ongoing."

There's no denying 2014 got off to a weird start. The strong winds that normally corral a pocket of frigid air over the North Pole took a detour, allowing a giant blob of Arctic iciness to drop as far south as the Gulf Coast.

Some declared global warming dead. Others argued it

was cold *because* of global warming, pointing to inconclusive evidence that it had weakened polar vortex winds that normally keep Arctic air in the Arctic.

But while the "Arctic blanket" got all the attention, it didn't tell the whole story. Just ask a Californian, Alaskan or Finn. The same contortions of the polar vortex that blasted more than half of the U.S. allowed unusual warmth to spread north to Alaska, which was 14 degrees Fahrenheit warmer in January than the long-term average. In California, above-normal temperatures exacerbated a drought that reached historic proportions by summer. And in Finland, warm and wet conditions forced bears out of winter hibernation.

However unusual they may have been, the hot spells here and cold snaps there were examples of weather — the day-to-day variations in the state of the atmosphere. It's how those variations add up over several decades that gives you climate. And when you look at global averages over decades, it's clear that climate change has *not* gone →

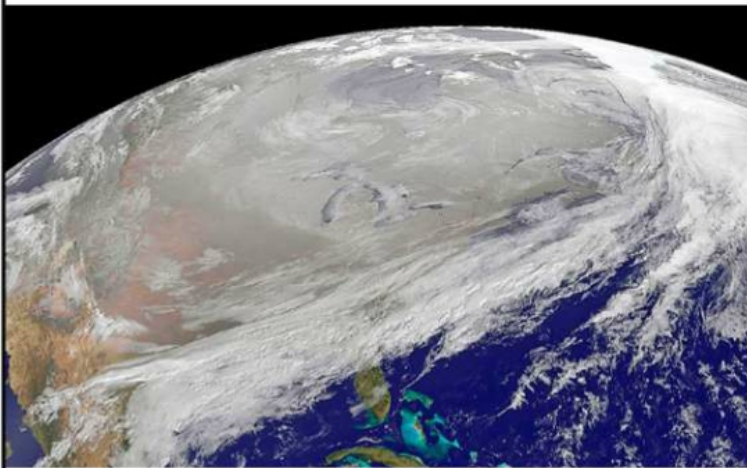
into hibernation. “Each one of the last three decades has been successively warmer at Earth’s surface than any preceding decade since 1860,” Meehl says.

GLOBAL ‘SLOWDOWN’ EXPLAINED

Although decade by decade, Earth’s average surface temperature has risen, that trend has flattened over the past 10 years. In 2014, scientists started to figure out why. At least part of the answer may be that climate measurements are underestimating the amount of surface warming actually taking place.

It’s tricky to take Earth’s temperature because the poles have few weather stations, creating gaps in thermometer data. In a study published in February, scientists found that when satellite and other data are used to fill in the blanks for the Arctic — where glaciers and sea ice have been shrinking rapidly — a stronger global warming trend emerges.

“If you put the Arctic back in the picture, there’s much less of a slowdown in global average temperature, and nothing that looks like a plateau,” says Richard Alley, a climate scientist at Pennsylvania State University.



This satellite image from late January 2014 shows the extent of the polar vortex’s reach across the United States.

It also looks like nature is tucking a lot of heat away in the deep oceans. Research published in 2014 by Chinese and American scientists pointed to heat plunging into the Atlantic Ocean as a major factor in the leveling off of global surface temperatures.

Meanwhile, a study by NCAR senior scientist Kevin Trenberth and colleagues suggested that the Pacific Ocean is playing the most significant role, thanks to a phenomenon called the Pacific Decadal Oscillation. The oscillation is a pattern of climate variability akin to El Niño and La Niña — weather patterns caused by periodic warming and cooling of ocean temperatures in the Pacific — except it is longer-lived. It has been in a cool, La Niña-like phase for 10 years, causing heat to sink deep into the Pacific. The oscillation

also has triggered a chain of atmospheric waves — rippling out like a boat’s wake — ultimately making Eurasia in particular cooler than it otherwise would have been, Trenberth says.

Couldn’t this cool, La Niña-like state go on for a while? As 2014 progressed, there were hints that it might not. First, the opposite of La Niña — a warmer, El Niño condition — began to emerge in the Pacific early in the year. And that summer turned out to be the warmest on record, putting 2014 on track toward record global warmth.

WIDESPREAD IMPACTS

Whether or not Earth’s average temperature continues to rise in the coming year, this one factor won’t reveal the full picture of climate change, just as taking a person’s temperature doesn’t reveal the full picture of an illness. Fevers can fluctuate even as other symptoms intensify.

And symptoms of global climate change are already widespread — and growing. A report in 2014 from the National Oceanic and Atmospheric Administration pointed to human-caused climate change as a significant influence on some extreme weather events in 2013 — notably heat waves in Europe, Asia and Australia. And overall, climate change now affects agriculture, human health, ecosystems, water supplies and the livelihoods of people, according to a major 2014 report from the Intergovernmental Panel on Climate Change. “In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans,” the report notes.

Agricultural impacts are of particular concern, since the global population is expected to increase from more than 7.1 billion people to about 9.5 billion by 2050. To feed all those people, agricultural productivity will have to keep pace. But according to the IPCC, climate change already has slowed productivity for some crops. For example, global wheat production has dropped 2 percent per decade in the past 30 years.

Looking forward, research published in late July showed that expected climate change over the next 20 years substantially raises the risk that rising food production will fail to keep up with increasing demand.

“These kinds of studies should be a reminder that we are changing the climate enough to create consequences on things like our livelihoods and what we expect of food availability,” says Claudia Tebaldi of NCAR, a co-author of the study. “We are playing around with things that are important, and we should do something about slowing the pace of change, if not reversing it.” —TOM YULSMAN



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