Energy & Environment

Climate Numerology

Trying to find a “safe” level for atmospheric carbon dioxide

BY DAVID BIELLO

Last December world leaders met in Copenhagen to add more hot air to the climate debate. That is because although the impacts humanity would like to avoid—fire, flood and drought, for starters—are pretty clear, the right strategy to halt global warming is not. Despite decades of effort, scientists do not know what “number”—in terms of temperature or concentrations of greenhouse gases in the atmosphere—constitutes a danger.

When it comes to defining the climate’s sensitivity to forcings such as rising atmospheric carbon dioxide levels, “we don’t know much more than we did in 1975,” says climatologist Stephen Schneider of Stanford University, who first defined the term “climate sensitivity” in the 1970s. “What we know is if you add watts per square meter to the system, it’s going to warm up.”

Greenhouse gases add those watts by acting as a blanket, trapping the sun’s heat. They have warmed the earth by roughly 0.75 degree Celsius over the past century. Scientists can measure how much energy greenhouse gases now add (roughly three watts per square meter), but what eludes precise definition is how much other factors play a role—the response of clouds to warming, the cooling role of aerosols, the heat and gas absorbed by oceans, human transformation of the landscape, even the natural variability of solar strength. “We may have to wait 20 or 30 years before the data set in the 21st century is good enough to pin down sensitivity,” says climate modeler Gavin Schmidt of the NASA Goddard Institute for Space Studies.

Despite all these variables, scientists have noted for more than a century that doubling preindustrial concentrations of CO₂ in the atmosphere from 280 parts per million (ppm) would likely result in global average temperatures roughly three degrees C warmer.

But how much heating and added CO₂ are safe for human civilization remains a judgment call. European politicians have agreed that global average temperatures should not rise more than two degrees C above preindustrial levels by 2100, which equals a greenhouse gas concentration of roughly 450 ppm. “We’re at 387 now, and we’re going up at 2 ppm per year,” says geochemist Wallace Broecker of Columbia University. “That means 450 is only 30 years away. We’d be lucky if we could stop at 550.”

Goddard’s James Hansen argues that atmospheric concentrations must be brought back to 350 ppm or lower—quickly. “Two degrees Celsius [of warming] is a guaranteed disaster,” he says, noting the accelerating impacts that have manifested in recent years. “If you want some of these things to stop changing—for example, the melting of Arctic sea ice—what you would need to do is restore the planet’s energy balance.”

Other scientists, such as physicist Myles Allen of the University of Oxford, examine the problem from the opposite side: How much more CO₂ can the atmosphere safely hold? To keep warming below two degrees C, humanity can afford to put one trillion metric tons of CO₂ in the atmosphere by 2050, according to Allen and his team—and humans have already emitted half that. Put another way, only one quarter of remaining known coal, oil and natural gas deposits can be burned. “To solve the problem, we need to eliminate net emissions of CO₂ entirely,” Allen says. “Emissions need to fall by 2 to 2.5 percent per year from now on.”

Climate scientist Jon Foley of the University of Minnesota, who is part of a team that defined safe limits for 10 planetary systems, including climate, argues for erring on the side of caution. He observes that “conservation of mass tells us if we only want the bathtub so high either we turn down the faucet a lot or make sure the drain is bigger. An 80 percent reduction [in CO₂ by 2050] is about the only path we go down to achieve that kind of stabilization.”

The National Academy of Sciences, for its part, has convened an expert panel to deliver a verdict on the appropriate “stabilization targets” for the nation, a report expected to be delivered later this year. Of course, perspectives on what constitutes a danger may vary depending on whether one resides in Florida or Minnesota, let alone the U.S. or the Maldives.

Keeping atmospheric concentrations of greenhouse gases below 550 ppm, let alone going back to 350 ppm or less, will require not only a massive shift in society—from industry to diet—but, most likely, new technologies, such as capturing CO₂ directly from the air. “Air capture can close the gap,” argues physicist Klaus Lackner, also at Columbia, who is looking for funds to build such a device.
Closing that gap is crucial because the best data—observations over the past century or so—show that the climate is sensitive to human activity. “Thresholds of irreversible change are out there—we don’t know where,” Schneider notes. “What we do know is the more warming that’s out there, the more dangerous it gets.”

**Medicine & Health**

**Renewed Hope**

Despite questions, AIDS vaccine trial in Thailand spreads optimism  **BY KATHERINE HARMON**

The long search for an AIDS vaccine has produced countless false starts and repeated failed trials, casting once bright hopes into shadows of disenchantment. The now familiar swings appeared in high relief last fall, with news of the most recent, phase III trial in Thailand. Initial fanfare for a protective swing appeared in high relief last fall, with news of the most recently, phase III trial in Thailand. Initial fanfare for a protective effect gave way to disappointment after reanalysis showed that the protection could be attributed only to chance. But rather than dashing all hopes for an AIDS vaccine, the trial has heartened some researchers, who see new clues in the battle against the fatal illness.

Costing $105 million and enrolling more than 16,000 subjects, the Thai clinical trial was the largest AIDS vaccine test to date. It began in 2003, and early results released last September showed a slim but statistically sound benefit from the vaccine (a series of inoculations with drugs known as ALVAC-HIV and AIDSVAX B/E). But in October the full report, with various statistical analyses, was released in a Paris meeting to greater skepticism. Specifically, 74 people who had received the placebo became infected with HIV in the trial period, compared with the 51 people who became infected after receiving the vaccine, which makes for a protective effect of 31.2 percent. By including, however, the seven people who turned out to have had HIV at the start of the trial (two in the placebo group and five in the vaccine group), the effectiveness drops to 26.4 percent.

“There are still a huge number of uncertainties surrounding this trial,” says Dennis Burton, an immunologist at the Scripps Research Institute in La Jolla, Calif. The subjects were in low- and moderate-risk groups, such as heterosexuals in monogamous relationships, rather than higher-risk groups such as intravenous drug users. “The numbers involved are small,” he adds, noting that statistically the protective effects could be the result of mere chance.

---

EcoBoost™ engine technology is at the very heart of the effort by Ford to bring smarter, greener power to the people. Thanks to direct injection and twin turbocharging, our EcoBoost V6 engine delivers V8 power with V6 fuel efficiency.* It’s remarkable.

**How EcoBoost is powering an entire company.**

Best of all, it’s available right now. EcoBoost technology. Just one of the ways Ford is delivering smaller, more fuel-efficient engines. And making vehicles that really make a difference. Drive one.

---

*EPA-estimated 17 city/25 hwy mpg, EcoBoost AWD.

---

**THE FORD STORY**

For more information, visit thefordstory.com/green.

© 2009 SCIENTIFIC AMERICAN, INC.