‘Arctic Armageddon’ Needs More Science, Less Hype

Researchers agree that global warming will unleash methane stored at high latitudes, further increasing the greenhouse effect. But their concerns fall far short of the apocalyptic headlines.

“MASSIVE METHANE RELEASE SPARKS global warming fears,” blared the online news headline. “Arctic seabed methane stores destabilizing,” warned a University of Alaska, Fairbanks (UAF), press release. Even the U.S. National Science Foundation, in another press release, found Arctic methane to be leaking off Siberian shores at “an alarming rate.”

Alarm might well be warranted. Methane, chemical formula CH$_4$, is a powerful greenhouse gas 25 times more potent than carbon dioxide, and the ongoing global warming driven by carbon dioxide will inevitably force it out of its frozen reservoirs and into the atmosphere to amplify the warming. Such an amplifying feedback may have operated in the past, with devastating effects. If the modern version is anything like past episodes, two scientists warned in a Perspective in Science (24 April 2009, p. 477), it could mean that “far from the Arctic, crops could fail and nations crumble.”

Yet, with bubbles of methane streaming from the warming Arctic sea floor and deteriorating permafrost, many scientists are trying to send a more balanced message. The threat of global warming amplifying itself by triggering massive methane releases is real and may already be under way, providing plenty of fodder for scary headlines. But what researchers understand about the threat points to a less malevolent, more protracted process. “It will aggravate the global change problem,” says geochemist Martin Heimann of the Max Planck Institute for Biogeochemistry in Jena, Germany, “but it’s not a catastrophe.”

Sure looks scary

There’s certainly plenty of methane out there. Beneath the sea floor, methane produced by the microbes in the sediment can become trapped in the crystalline cages of water ice to form methane hydrate, “ice that burns.” No one is sure how much submarine hydrate exists worldwide, but it is on the order of several thousand petagrams (Pg) of carbon. (A petagram is $10^{15}$ grams, or a billion metric tons.) That’s easily 1000 times the amount of methane presently in the atmosphere.

If hydrates are warmed, especially those under relatively low pressure beneath the shallow sea floor, they will melt, releasing their methane. “If you gave the planet a shake,” says geochemist David Archer of the University of Chicago in Illinois, the gas “would all come out, and it would be a global catastrophe.”

The other precarious source of methane is permafrost. Permanently frozen soil and sediment contains organic matter that microbes can convert to methane if the permafrost thaws and remains free of oxygen. That happens, for example, in the bottoms of the numerous arctic lakes that form in thawing permafrost. The top 3 meters of arctic permafrost are thought to hold about 1000 Pg of carbon as organic matter that could be converted to methane that would equal 300 times the methane in the atmosphere.

Here it comes?

This past March, oceanographer Natalia Shakhova of UAF and colleagues reported what sounded to some like the first methane gusher of many to come. The group took exhaustive samples over the East Siberian Arctic Shelf and found pervasive methane-rich waters, as they reported in the 5 March issue of Science (p. 1246). The methane was coming from the sea floor. The group calculated that as much

Going, going, … In a model, a methane hydrate deposit (orange) recedes as ocean warmth penetrates, much as happened off Svalbard (opposite page).
methane was escaping from the water into the atmosphere as had been estimated to be escaping from the entire world ocean.

Alarm gripped at least some quarters of the media. But reporters failed to note—and scientists did not emphasize—one important detail: The methane was coming from permafrost thawing under the relatively warm waters that had inundated the Siberian shelf as sea level rose after the last ice age. With only 5 years of sampling, no one could tell whether the leak had started under global warming or had been going on for millennia. Many scientists lean toward millennia in this case.

A far stronger case for incipient hydrate destabilization appeared last year with less fanfare. In a paper in the 6 August 2009 issue of Geophysical Research Letters, marine geophysicist Graham Westbrook of the University of Birmingham in the United Kingdom and colleagues described how they used sonar to probe the shallow waters just west of Norway’s Svalbard archipelago—halfway between mainland Norway and the North Pole. There, bottom waters had in fact warmed by a considerable 1°C during the previous 30 years, possibly because of global warming.

Where warmed currents brushed the Svalbard sea floor, the researchers found plumes of methane bubbles rising from the bottom. And in modeling reported in Geophysical Research Letters (GRL) on 15 December 2009 by hydrogeologists Matthew Reagan and George Moridis of Lawrence Berkeley National Laboratory in California, bottom-water warming melted the model’s hydrates and released methane along the edge of the deteriorating hydrate deposit, much as seen off Svalbard.

“That seems like the strongest argument for hydrates releasing methane” as they are warmed, says Archer.

And more-widespread warming could be big trouble. Last year in the 8 December issue of the Proceedings of the National Academy of Sciences, Archer and colleagues reported on their own modeling of methane hydrate behavior, this time on a global scale. In both of their models, a 3°C warming of the ocean melts fully half of the existing hydrates. And aquatic ecologists Katey Walter Anthony of UAF and Sergey Zimov of the Northeast Science Station in Cherskii, Russia, reported at last December’s meeting of the American Geophysical Union (AGU) that, according to “a very coarse estimate,” the dominant type of northern permafrost would yield 50 billion tons of methane if it should thaw—10 times the current methane content of the atmosphere.

Not so fast
So at least in one high-latitude location, hydrates seemed to be newly giving up their methane, while reports of thawing permafrost and bubbly arctic lakes streamed in as well. But what did all the bubbling—seen and presumably unseen—really amount to?

Atmospheric chemist Edward Dlugokencky of the National Oceanic and Atmospheric Administration’s Earth System Research Laboratory in Boulder, Colorado, and colleagues analyzed NOAA measurements of atmospheric methane made on samples collected weekly from 1983 to 2008 at 46 sites around the world. Atmospheric methane had been increasing until the late 1990s, when it leveled off. Then in 2007, its abundance bumped up.

Taking into consideration numerous factors—including latitudinal patterns of change in atmospheric methane and shifting regional climates—Dlugokencky and his colleagues concluded that the recent methane jump was not driven by melting hydrates and permafrost. Instead, it seemed to be due to some combination of the high northern-latitude warmth in 2007 that is accelerating emissions from wetlands there; biomass burning contributing methane in the tropics; and heavy rains in Indonesia and the eastern Amazon encouraging tropical wetlands emissions. But because methane stopped increasing in the polar Northern Hemisphere in 2008, “the Arctic has not yet reached a point of sustained increased CH4 emissions from melting permafrost and CH4 hydrates,” the group wrote in GRL. Dlugokencky summed up their conclusions at the AGU meeting: “Despite all the media hype, I don’t think we’re yet at an arctic tipping point.”

Tipping points for both methane hydrates and permafrost will come, Archer predicts—but they will probably happen slowly. It takes time, he notes, to get from an atmospheric warming driven by carbon dioxide to an amplifying warming driven by atmospheric methane. It takes time for the ocean to warm. It takes time for that warmth to penetrate into hydrates. And it takes quite a bit of that penetrating heat to melt hydrates.

Once freed, the methane has to reach the atmosphere through the obvious obstacle of the overlying sediment. The ocean presents an impediment of its own. Bubbles may never reach the surface. Methane leaks out of bubbles, reacts with air dissolved in sea water, and becomes oxidized to form carbon dioxide. Even methane that reaches the atmosphere intact gets oxidized within about 10 years.

Folding all of those processes into an admittedly still-crude model, Archer and his colleagues get a warming of about 0.5°C, whether the ultimate carbon dioxide warming is a very modest 2°C or an extreme 7°C. The catch is that once the methane is converted into long-lived carbon dioxide, it prolongs that added warming for thousands of years.

So to scientists, the methane threat looks less like a catastrophe than an aggravation of a problem that already scares them. But “media people are all the time trying to have a doomsday story” about methane, says Walter Anthony. Not that scientists are blameless. “Quite a few scientists have maybe exaggerated a bit,” Heimann acknowledges.

“Is now the time to get frightened?” Archer asked rhetorically on the blog Real Climate (www.realclimate.org) in March. His answer: “No. CO2 is plenty to be frightened about, but methane, says Walter Anthony. Not that scientists are blameless. “Quite a few scientists have maybe exaggerated a bit,” Heimann acknowledges.

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