CLIMATOLOGY

Volcanoes May Warm Locally While Cooling Globally

The debris thrown into the stratosphere by the June 1991 eruption of Mt. Pinatubo was supposed to give the world a break from the record-shattering global warmth of the 1980s. But throughout North America and much of northern Eurasia those expectations were confounded as the following winter proved unusually mild. Normally frigid Minneapolis, for example, had its third warmest winter ever, with temperatures averaging a relatively sultry 4.3°C above normal.

So the obvious question is, what might have temporarily counteracted Pinatubo's chilling effects on the northern continents? The stratospheric haze created by Mt. Pinatubo did, as expected, screen out some sunlight and cool the globe as a whole. But recent evidence also suggests that it may have had the counter-intuitive effect of raising winter temperatures in large regions of North America and northern Eurasia by altering the weather patterns in those areas.

The idea that volcanoes can warm locally while chilling globally has not yet gained wide acceptance, for good reason. Temperature patterns can vary wildly from one year to the next for no obvious cause, leading climate researchers to require numerous case studies before making a link between volcanic eruptions and a particular weather pattern. Indeed, only recently were they able to pick out the overall global cooling effects of volcanoes from the natural ups and downs of the global temperature record (*Science*, 14 July 1989, p. 127), in part because there are barely enough big eruptions to build a statistically sound case. Regional effects are even harder to identify. So in the controversial field of volcano-climate relations, it's a fairly positive appraisal when climatologist Thomas Karl of the National Climatic Data Center (NCDC) in Asheville, North Carolina, describes the new evidence suggesting volcano-induced shifts in weather patterns as "certainly intriguing" and having "a lot more credibility than some things we've heard in the past."

Part of the evidence that's winning this modicum of respect comes from a climate study performed by longtime volcano-climate researcher Alan Robock of the University of Maryland and his graduate student Jianping Mao. Beginning with Krakatau in 1883 and ending with Mt. Pinatubo, they surveyed temperatures at sites throughout the Northern Hemisphere during the winters immediately following what they estimated were the 12 largest volcanic eruptions since usable hemispheric records have been kept. After correcting for the climate effects of El Niño's warm Pacific waters, Robock and Mao found that the winter after each eruption was unusually warm across northern Eurasia. Most winters were warmer than normal over central North America, too. The average increase for Eurasia was greater than 2°C, and in some cases the increase exceeded 3°C.

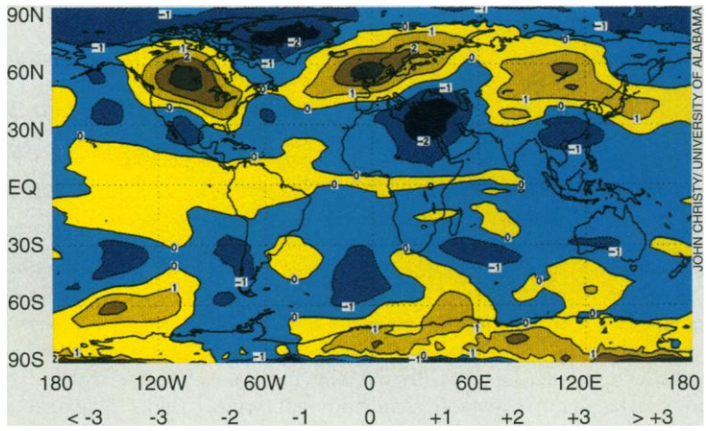
A single analysis of the climate record would not by itself get much attention from a steadfastly skeptical scientific community, but Robock and Mao's detection of a possible volcanic warming is getting some support from more geographically limited studies. In a *Geophysical Research Letters* paper last year, Pavel Groisman, who is at the State Hydrological Institute in St. Petersburg, Russia, but is visiting the NCDC, pointed out that in the mid-1980s he and his Soviet colleagues reported—in the Russian literature—an average winter warming of 2°C in Central Russia following the nine largest eruptions of the past two centuries. Central Russia falls in Robock's Eurasian warming. And on this side of the globe, David Portman of Atmospheric and Environmental Research Inc. in Cambridge, Massachusetts, who helped give global volcanic cooling its credibility, in collaboration with David Gutzler of the National Oceanic and Atmospheric Administration (NOAA) in Boulder, found a post-eruption winter warming in the mid- and high-latitudes of the continental United States after five large eruptions in this century.

These observations are winning some support from computer climate modeling. Working with Robock, Hans Graf and his colleagues at the Max Planck Institute for Meteorology in Hamburg inserted volcanic debris into his model's stratosphere in quantities typical of those injected by Mexico's El Chichón in 1982. With the model running in its January mode, addition of the stratospheric aerosol caused surface temperatures in North America and northern Eurasia to increase by as much as 2°C, a change similar to that seen by Robock after El Chichón. The model also showed extreme cooling over Greenland, in accord with actual temperatures measured by satellite.

In the model, the stratospheric aerosol altered surface weather patterns through a chain of physical processes. First it absorbed solar radiation over the tropics, where sunshine is abundant even in winter, and warmed the tropical stratosphere. That intensified the stratospheric temperature difference between the tropics and the polar region and thus strengthened the winds blowing around the polar vortex, which in turn redirected the great waves in the winds below the stratosphere that guide storms. The result: a surge of warm air north into North America and northern Eurasia and of cold air down over Greenland.

Skeptics remain to be convinced, however. "There's a thousand ways you can get the right answer for the wrong reasons," says Chester Ropelewski of NOAA's Climate Analysis Center in Camp Springs, Maryland. He points out that some northern winters have been abnormally warm even in years without major eruptions, raising the possibility that the association of eruptions and warmings is simply a coincidence despite the basic statistical tests that say the warmings are significant. Nevertheless, if further modeling and climate analyses support these early studies, Minneapolis' neighbor St. Paul might be able to make alternative plans the next time its winter carnival falls during a post-eruption winter warming.

–Richard A. Kerr



Refuges from the chill. While chilling most of the globe, Mt. Pinatubo's eruption indirectly gave some northern lands a break from the depths of the 1991-92 winter. (Bars give temperature anomalies in °C.)

Additional Reading

D. A. Portman and D. S. Gutzler, "Volcanic Eruptions, ENSO, and United States Temperature Variability," *Proceedings of the 17th Annual Climate Diagnostics Workshop* **341** (GPO, Washington, D.C., 1993).

A. Robock and J. Mao, "Winter Warming From Large Volcanic Eruptions," *Geophys. Res. Letts.* **19**, 2405 (1992).