Man-Made Volcanic Effect?

A Nobel prize winning scientist suggests injecting sulfur into the atmosphere to produce volcanic like cooling

Nobel laureate Paul Crutzen from the Max Planck Institute for Chemistry in Germany and the Scripps Institution of Oceanography, University of California at San Diego has proposed one way to curb global warming (natural and/or man-made) is to purposely shoot sulfur into the atmosphere, in much the same way that major volcanic eruptions do. Injecting sulfur into the stratosphere would reflect more sunlight back to space and offset greenhouse gas warming, according to Crutzen. Crutzen suggests carrying sulfur into the atmosphere via balloons and using artillery guns to release it, where the particles would stay for up to two years. The results could be seen in six months.

HOW VOLCANISM AFFECTS CLIMATE

Climatologists may disagree on how much the recent global warming is natural or man-made but there is general agreement that volcanism constitutes a wildcard in climate, producing significant global scale cooling for at least a few years following a major eruption.

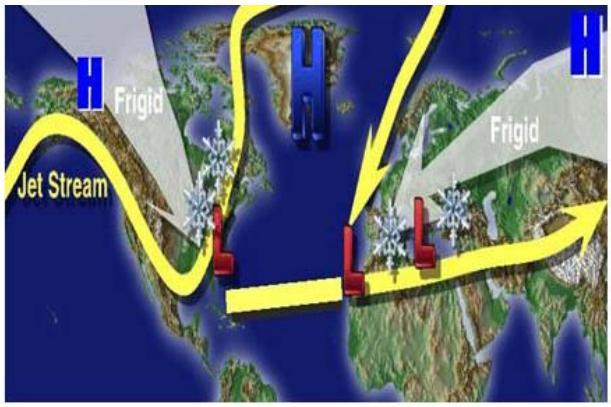
Volcanic activity is constantly ongoing around the globe with a half-dozen or more volcanoes active at any given moment. Most of these are smaller eruptions, however, and their effects are minor, short lived and confined to the lower atmosphere near the volcano.

Major eruptions are much rarer. They can eject both ash and gases like sulfur dioxide high into the atmosphere -- 80,000 feet or more. Although much of the ash may fall out within 6 months to a year, sulfur dioxide quickly gets converted to sulfate aerosols, which can reside for two or more years in the stable high atmosphere. These then block some of the incoming solar radiation. The net result is a global cooling. An average cooling of 0.2 to 0.5C over a 2 to 3 year period can occur for a major eruption (de Silva, Robock, others) and has been documented by both surface and satellite observations after major eruptions like El Chichon (Mexico in 1982) and Pinatubo (Indonesia in 1991).

It should be noted that Robock (2003) and others have shown that though major volcanic eruptions seem to have their greatest cooling effect in the summer months, the location of the volcano determines whether the winters are colder or warmer over large parts of North America and Eurasia.

According to Robock, tropical region volcanoes like El Chichon and Pinatubo actually produce a warming in winter due to a tendency for a more positive North Atlantic Oscillation (NAO) and Arctic Oscillation (AO) (below left). In the positive phase of these large scale pressure oscillations, low pressure and cold air is trapped in high latitudes and the resulting more westerly jet stream winds drives milder maritime air into the continents.

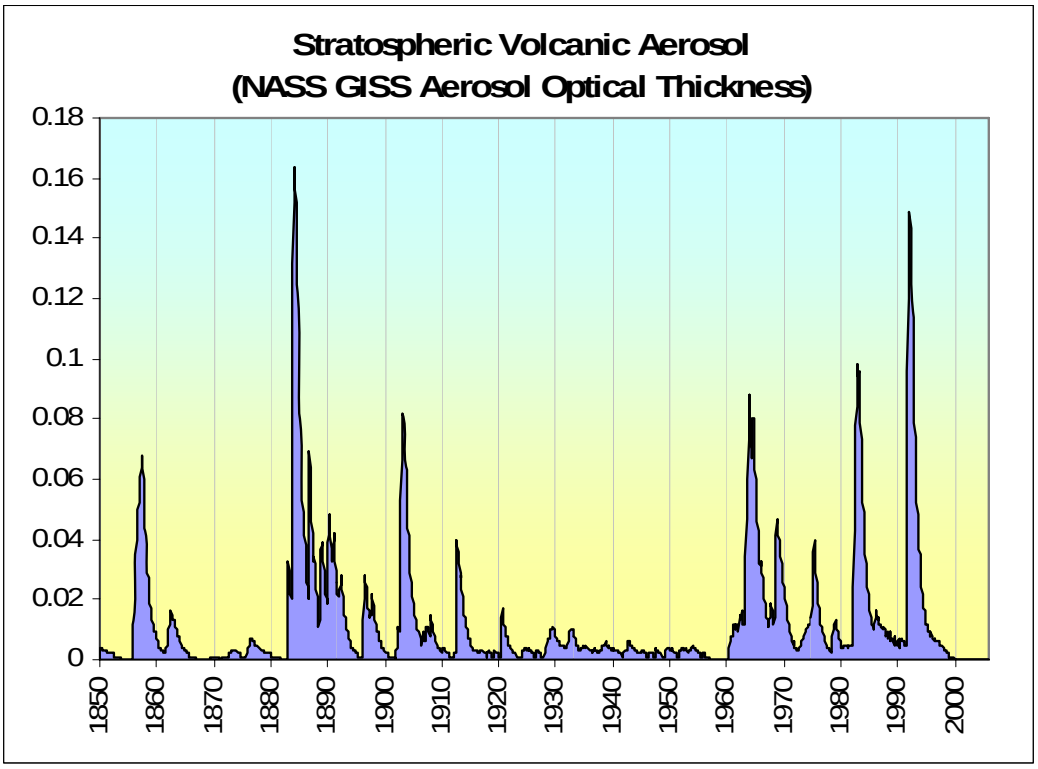
Robock found high latitude volcanoes like Katmai (Alaska in 1912,) instead favored the negative phase of the Arctic and North Atlantic Oscillations and cold winters (below right). In the negative phase, the jet stream winds buckled and forced cold air south from Canada into the eastern United States and west from Siberia into Europe. Despite the regional differences in winter, globally on an annual basis, volcanic eruptions lead to a net cooling regardless as to the volcano's latitude.



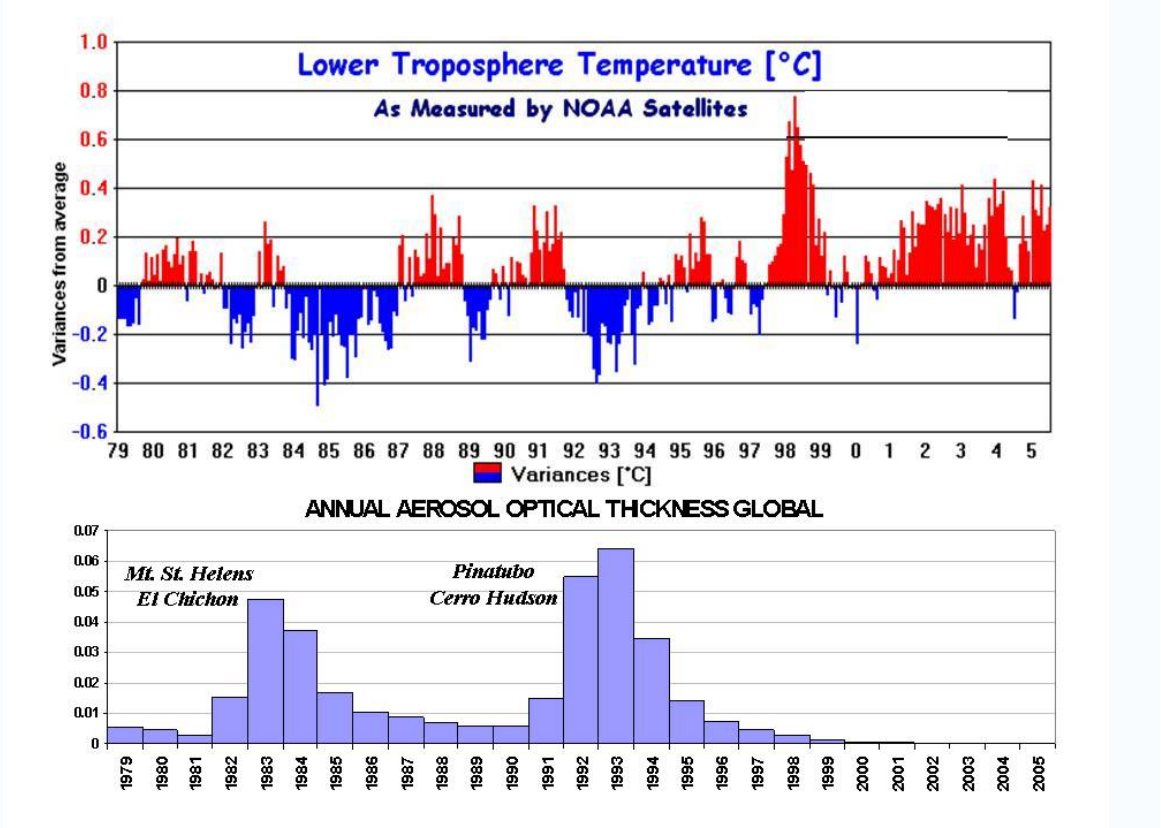
Major eruptions are relatively rare events and seem to occur in clusters as the chart (stratospheric aerosol as measured by NASA GISS Aerosol Optical Thickness) below shows. The late 1800s to the early 1900s was a very active period with Krakatoa (Indonesia between Java and Sumatra in 1883) as the major event. With a quiet sun, it is no surprise this era was very cold. A quiet sun is associated with lower solar irradiance (energy emission) and less heat input into our atmosphere.

The 1920s to the 1940s was a period of very little volcanic activity that coincided with a rapid increase in solar irradiance and multi-decadal warming in both oceans with a resulting warming of global temperatures. The sun and oceans are believed to be the primary drivers but lack of volcanic ash may have augmented the warming.

The 1960s became very active with Mt. Agung as the first of several significant eruptions that kept aerosols levels high much of the decade. This coincided with a quieter sun and cooler cycles in both the Atlantic and Pacific. That decade not surprisingly was the coldest of the last 50 years.



After 1979, even as temperatures began again to rise with an increasingly active sun and a warming in the Pacific (called the Great Pacific Climate Shift), cooler global temperatures followed the major eruptions of Mt. St. Helens (Washington State in 1981) and El Chichon (1982) and Pinatubo and Cerro Hudson (Chili in 1991),. This is clearly evident in graphic below which relates the stratospheric aerosol loading represented as aerosol optical thickness (Sato et al 1998) to the satellite derived lower tropospheric temperatures (Spencer and Christy 2006).



All the warm and cold periods on the satellite derived global temperature graph can be attributed to El Ninos or La Ninas and volcanic eruptions. El Ninos are events characterized by a warming of the east and central tropical Pacific Ocean. The warm water warms the atmosphere and that heat gets carried poleward by atmospheric circulations, resulting in a global rise in temperatures. La Ninas are characterized by colder than normal waters in the east and central tropical Pacific. They usually induce a global cooling.

Indeed most of the warm red spikes in the temperature (top curve) coincide with El Ninos and the cold blue dips from La Ninas. Volcanic eruptions can override El Nino warming. The volcanic cooling associated with the major eruptions in 1982 and 1991 were able to minimize and then offset the warming with the super El Nino of 1982/83 and the El Ninos of the early 1990s on a global basis.

LACK OF VOLCANISM CONTRIBUTING TO RECENT WARMTH?

The super El Nino of 1997/98 is clearly visible as the strongest event of the period. Though the El Nino of 2002/03 helped produce the warming in the early part of this decade, the warming has continued even as that El Nino faded.

As both aerosol graphics show, during the last six years, stratospheric aerosols are at an historic low levels (according to James Hansen's NASA GISS group, the level of

stratospheric aerosols is now at the very least at the lowest level since direct satellite measurements began in 1979). A cleaner atmosphere, with much below normal aerosol levels would allow more solar radiation to reach the earth's surface, which along with the warm multi-decadal modes in both Atlantic and Pacific may be driving the current continued warming even as the solar input appears to be starting a decline.

SO SHOULD WE PLAY VOLCANO?

Crutzen's idea would very likely induce a global cooling. But in this litigious society and age, you can imagine the potential lawsuits from all corners of the globe where people might blame drought, floods, unusual storms, extremes of temperature on our interfering with the natural climate.

There is some precedence for such human intentional human intervention and for the problems that can arise. Over half a century ago, the United States Weather Bureau, the US Army Signal Corps, the Office of Naval Research, and the US Air Force collaborated on an attempt to modify a hurricane called Project Cirrus. On October 13, 1947 an airplane flew along the rainbands of a hurricane that was heading west to east and out to sea, and dropped nearly 80 pounds of crushed dry ice into the clouds.

The hurricane changed its structure and direction and made landfall near Savannah, Georgia. The public blamed the seeding, and some scientists claimed that the reversal had been caused by human intervention. Project Cirrus was cancelled. Lawsuits were threatened. Only the fact that a system in the 1906 season had taken a similar path, as well as evidence showing that the storm had already begun to turn when seeding began, ended the litigation.

Another attempt by the United States military to modify hurricanes in the Atlantic basin using cloud seeding in the 1960s was called Project Stormfury. Only a few hurricanes were tested with cloud seeding because of the strict rules that were set by the scientists of the project. Little effect was observed and the overriding fear that cloud seeding could potentially change the course or power and even the course of hurricanes and negatively affect people in the storm's path stopped the project.

My guess is the same concerns will prevent us from playing volcano anytime soon.

References:

Fleming, J.R., Historical Perspectives on Climate Change, New York Oxford University Press, 1998 PDF file

Live Science Story: Scientist: Inject Sulfur into Air to Battle Global Warming (link)

Predictions of Climate following Volcanic Eruptions, Matthew Collins, Centre for Global Atmospheric Modelling, Department of Meteorology, University of Reading, Reading, RG6 6BB, UK. PDF file

Rampino, M.R., Self, S, Stothers, R.B., Volcanic Winters, Annual Review Earth Planet Sciences, 1988, 16: 73-99 PDF file

Robock, Alan, 2003: Volcanoes: Role in climate. in Encyclopedia of Atmospheric Sciences, J. Holton, J. A. Curry, and J. Pyle, Eds., (Academic Press, London), 10.1006/rwas.2002.0169, 2494-2500. (Invited paper) PDF file

Sato, M., J.E. Hansen, M.P. McCormick, and J.B. Pollack 1993. Stratospheric aerosol optical depth, 1850-1990. J. Geophys. Res. ***98**, 22987-22994. Data link.*

Spencer, R, and Christy, J. 2006 Globally Avergaed Tropospheric Temperatures, University of Alabama at Hunstville GHCC (link)

Volcanic eruptions and their impact on the earth's climate
Shanaka L. de Silva, Department of Space Studies, University of North Dakota, GrandForks, North Dakota, USA. Encyclopedia of Science (link)