Volcanoes and climate change

Volcanic fallout reveals secrets of past eruptions

IMPORTANT INFORMATION about a past volcanic eruption's impact on climate is provided by determining the height of the eruption.

Eruptions that reach higher, up to the stratosphere, have a greater influence on climate compared with the case when volcanic material only reaches the lower atmosphere wherein the effects are relatively local and short term because the material is washed out by rain.

A method to determine the influence of past volcanic eruptions on climate and the chemistry of the upper atmosphere, and significantly reduce uncertainty in models of future climate change, has been developed by a team of American and French scientists.

To distinguish eruptions that made it to the stratosphere from those that did not, the researchers examined the isotopes of sulphur in fallout preserved in the ice in Antarctica.

Chemical fingerprint

In the January 5 issue of the journal *Science*, the researchers from the University of California, San Diego, the National Center for Scientific Research (CNRS) and the University of Grenoble in France report that the chemical fingerprint of fallout from past eruptions reveals how high the volcanic material reached, and what chemical reactions occurred while it was in the atmosphere.

"In predictions about global warming, the greatest amount of error is associated with atmospheric aerosols," explained Mark Thiemens, Dean of UCSD's Division of Physical Sciences and professor of chemistry and biochemistry in whose laboratory the method, which is based on the measurement of isotopes — or forms of sulphur — was developed.

"Now for the first time, we can account for all of the chemistry involving sulphates, which removes uncertainties in how these particles are made and transported. "

Sulphuric acid droplets

"In the stratosphere, sulphur dioxide that was originally in the magma gets oxidized and forms droplets of sulphuric acid," said Joël Savarino, a researcher at the CNRS and the University of Grenoble.

Acts as a blanket

"This layer of acid can stay for years in the stratosphere because no liquid water is present in this part of the atmosphere.

The layer thus acts as a blanket, reflecting the sunlight and therefore reducing the temperature at ground level."

Sulphur that rises as high as the stratosphere, above the ozone layer, is exposed to short wavelength ultraviolet light. UV exposure creates a unique ratio of sulphur isotopes. Therefore the sulphur isotope signature in fallout reveals whether or not an eruption was stratospheric.

To develop the method, the team focused on two volcanic eruptions, according to a UCSD press release. Both eruptions, one in 1963 and the other in 1991, were stratospheric according to the isotope measurements.

Modern intruments

"Young volcanoes have the advantage of having been documented by modern instruments, such as satellites or aircraft," said Savarino.

"We could therefore compare our measurements on volcanic fallout stored in snow with atmospheric observations."

Not only did their isotope measurements match the atmospheric observations, they were also able to distinguish the Pinatubo eruption from the eruption of Cerro Hudson that occurred the same year.

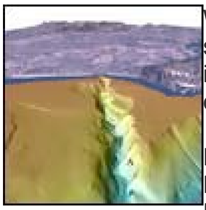
Cerro Hudson did not send material as high as the stratosphere and the fallout had a different sulphur isotope fingerprint than the fallout from Pinatubo.

Chemical reactions

Data from eruptions in the recent past revealed what chemical reactions of sulphates occur in the upper atmosphere.

Sulphates can cause warming or cooling depending on how they are made. They are usually white particles, which tend to reflect sunlight, but if they are made on dark particles like soot, they can absorb heat and worsen warming

Scientists find link between ancient eruptions and climate change



Washington, Jan 07: A team of American and French scientists have found that remnants of volcanic ice locked up in Antarctic ice provided a strong link between ancient eruptions and climate changes.

Researchers from the University of California, San Diego, the National Center for Scientific Research (CNRS) and the University of Grenoble in France report in the January 5 issue of Science how volcanic materials from past eruptions reached the upper reaches of the atmosphere and what chemical reactions they induced in the atmosphere.

According to Mark Thiemens, Dean of UCSD's Division of Physical Sciences and professor of chemistry and biochemistry, their work is particularly relevant because the effect of atmospheric particles, or aerosols, is a large uncertainty in models of climate.

"In predictions about global warming, the greatest amount of error is associated with atmospheric aerosols. Now for the first time, we can account for all of the chemistry involving sulphates, which removes uncertainties in how these particles are made and transported. That's a big deal with climate change," said Thiemens, in whose laboratory the method based on the measurement of isotopes—or forms of sulphur—was developed.

According to him, determining the height of a past volcanic eruption provides important information about its impact on climate.

If volcanic material only reaches the lower atmosphere, the effects are relatively local and short term because the material is washed out by rain. On the other hand, eruptions that reach higher, up to the stratosphere, have a greater influence on climate.

"In the stratosphere, sulphur dioxide that was originally in the magma gets oxidized and forms droplets of sulphuric acid. This layer of acid can stay for years in the stratosphere because no liquid water is present in this part of the atmosphere. The layer thus acts as a blanket, reflecting the sunlight and therefore reducing the temperature at ground level, significantly and for many years," said Joël Savarino, a researcher at the CNRS and the University of Grenoble, who led the study.

For distinguishing eruptions that made it to the stratosphere from those that did not, the researchers examined the isotopes of sulphur in fallout preserved in the ice in Antarctica.

The researchers travelled to Antarctica and recovered the samples by digging snow pits near the South Pole and Dome C, the new French/Italian inland station.

Generally, sulphur that rises as high as the stratosphere, above the ozone layer, is exposed to short wavelength ultraviolet light. UV exposure creates a unique ratio of sulphur isotopes. Therefore the sulphur isotope signature in fallout reveals whether or not an eruption was stratospheric.

To develop the method, the team, focused on two volcanic eruptions, the 1963 eruption of Mount Agung in Bali and the 1991 eruption of Mount Pinatubo in the Philippines, which were stratospheric according to the isotope measurements.

"Young volcanoes have the advantage of having been documented by modern instruments, such as satellites or aircraft. We could therefore compare our measurements on volcanic fallout stored in snow with atmospheric observations," said Savarino.

Findings revealed that not only did their isotope measurements match the atmospheric observations, the team was easily able to distinguish the Pinatubo eruption from the eruption of Cerro Hudson that occurred the same year.

"Cerro Hudson did not send material as high as the stratosphere and the fallout had a different sulfur isotope fingerprint than the fallout from Pinatubo," said Savarino.

"Volcanic material from more ancient eruptions is preserved in Antarctica, but the older, deeper seasonal layers of ice are extremely thin as a result of the pressure from the overlying ice. Therefore, it is not currently feasible to extract enough fallout from the ice to apply the isotope method to all past volcanoes. However, data from eruptions in the recent past reveal what chemical reactions of sulfates occur in the upper atmosphere," he added.

Bureau Report with ANI inputs

January 05, 2007

Scientific Nature: Researchers Use Volcanic Eruption as Climate Lab

When Mount Pinatubo erupted in 1991 it left a trail of evidence in the skies that is helping scientists decipher the workings of the global climate

By David Biello

Earth's climate cannot be replicated in a lab. So to understand how this critical component of the planet's heat regulation works, scientists must rely on "natural experiments." Such natural experiments take apocalyptic form, such as the eruption of Mount Pinatubo in the Philippines in June 1991 that sent 10 cubic kilometers of ash, gas and other materials sky high. By tracking how this eruption affected the global climate--and determining how to trace its footprint in other records--scientists have turned the catastrophe into a tool for comprehension. "The big problem with climate--and trying to study it--is you can't play with it in the lab," says atmospheric scientist Joanna Futyan of Columbia University. "We were trying to use this abrupt event as a natural experiment: something dramatic happened and you can look at how the atmosphere responds to it."

Image: USGS

ASHES TO CLIMATE: The eruption of Mount Pinatubo in 1991 provides a natural experiment for scientists to understand the complex workings of Earth's climate.

Futyan and physicist John Harries of Imperial College London analyzed how the atmosphere's humidity and temperature responded to the eruption as well as the overall radiative balance of the planet--in other words, the difference between the energy in sunlight absorbed by Earth versus the amount radiated back to space. The spectrum of this energy sent back into space from the surface (measured via satellite) has changed in the past 30 years as part of global warming, but the rate and magnitude of this change remain difficult to measure and rely on a variety of atmospheric processes, such as the amount of water vapor.

The atmospheric response to the Pinatubo eruption reveals that this system reacts rapidly, with sunlight-blocking sulfate aerosols ejected by the volcano cooling the planet within four months. By six months, the planet radiated 2.6 watts per square meter less heat to space than before the eruption. Humidity dropped as a result, but slowly, and by the end of 1992 the climate had once again reached equilibrium, the researchers write in the January 2 *Geophysical Research Letters.* "From the observations of Pinatubo, the net flux [of energy] brings itself back into balance quickly," Futyan says.

Pinatubo also left its mark on the weather. When the volcano erupted, it sent sulfur dioxide shooting into the atmosphere, where a wavelength of ultraviolet light transformed some of the sulfur molecules into a lighter isotope--a unique chemical sign of such stratospheric eruptions. Falling back to the surface, the sulfate bearing this specific isotopic ratio collected in undisturbed areas, such as the snow pack on Antarctica. Isotope chemist Mark Thiemens of the University of California, San Diego, and his team dug through 30 tons of snow in search of such an isotopic record, which has already been observed in the geologic strata of ancient Earth.

Both Pinatubo and its predecessor--the eruption of Mount Agung in 1963--left such traces in the snow, while lesser eruptions that did not blow as sky high left different marks, Thiemens and his team reveal in the January 5 *Science.* By understanding this chemistry, it may be possible to extend the volcanic record--and its influence on climate--back in time.

The effects of catastrophic eruptions like Pinatubo may be transitory, but their record both in the climate and its residue present a picture of how the climate may respond to other so-called forcings, such as human emissions of greenhouse gases. It also helps assess how this complex system might react to human attempts to tinker with it in order to avoid the potentially catastrophic effects of such climate change--such as injecting sulfate aerosols into the sky as proposed by atmospheric chemist and Nobel laureate Paul Crutzen. "It is a quantitative way to see how sensitive the stratosphere is to perturbations," Thiemens notes. "It gives you a feel for the chemistry because nature has run some of the experiments for you."

Perturbations to the radiative energy balance following the Mt. Pinatubo eruption

Natural aerosols are known to have a cooling effect on Earth's climate, because they scatter incoming solar radiation.

Volcanic eruptions provide a natural experiment to observe the time constants for the onset and decay of consequent radiative perturbations. Harries and Futyan studied atmospheric conditions following the 1991 eruption of Mt. Pinatubo in the Philippines. Using atmospheric records before and after the event, the authors analyzed the growth and decay of perturbations in atmospheric temperature, humidity, and radiative fields following the eruption. They were able to quantitatively distinguish between processes that respond quickly to the insertion of aerosols into the atmosphere, such as the shortwave and longwave fluxes at the top of the atmosphere, and those which evolve on slower timescales, such as changes in the humidity and temperature fields. The authors suggest that a valuable test of coupled climate models should be whether they correctly reproduce these response times after a volcanic eruption.

By American Geophysical Union
