Today I Learned About Geoengineering

"The volcano erupts and lots of gases and rocks and dust and everything else escape, including so-called sulfur aerosols that reflect sunlight back into space and cool the temperature of the Earth. And in fact, after a major volcanic eruption like … Mount Pinatubo in the Philippines, the world could measure that the global temperature went down by about a half a degree."

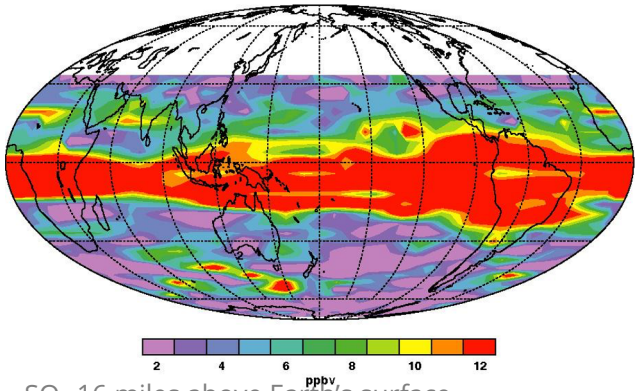
Janos Pasztor, Carnegie Climate Governance Initiative

TILclimate podcast: Today I Learned About Geoengineering

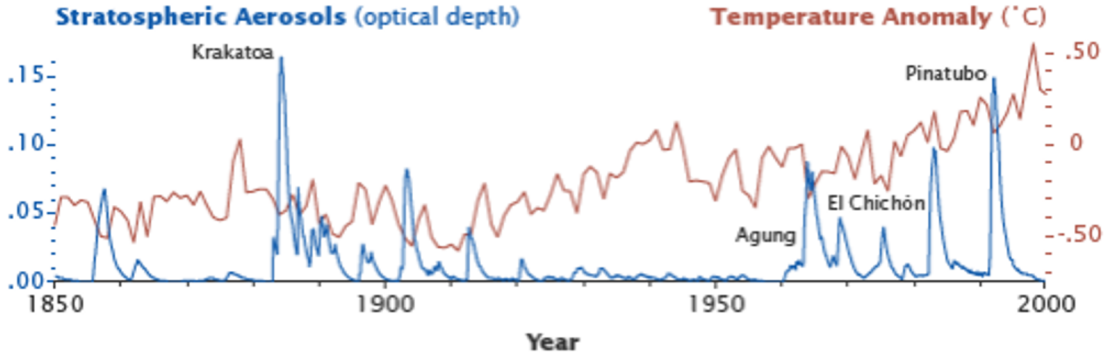
Volcanoes and a Cooling Earth

On June 15, 1991, a volcano in the Philippines called Mt. Pinatubo erupted. Over the next few days, the volcano spewed more than 20 million tons of sulfur dioxide (SO_2) into the atmosphere, along with millions of tons of ash, smoke, and other materials. In the atmosphere, SO_2 reacts to produce sulfate aerosols. Aerosols are extremely small particles that stay in the air. Sulfate aerosols have the effect of reflecting the sun's rays back into space, cooling Earth.

The sulfate aerosols from Mt Pinatubo spread around the globe, especially at the equator. Global temperatures dropped by 0.6°C (1.1°F) for the next two years, and then continued to rise on the same path they had been rising on before 1991. Looking back, climatologists could see a similar pattern after eruptions at El Chichón (Mexico, 1982) and Mt Agung (Indonesia, 1963.) The 1883 eruption of Krakatoa lowered global temperatures by 0.4°C (0.7°F) and may have caused record rainfall in southern California, over 9,000 miles away.



SO_2 16 miles above Earth's surface
September 21, 1991
NASA Upper Atmosphere Research Satellite[1]



Aerosols in the high atmosphere from large volcanic eruptions align with drops in temperature.
https://earthobservatory.nasa.gov/features/Aerosols/page3.php

1 NASA Upper Atmosphere Research Satellite https://uars.gsfc.nasa.gov/uars-science/BrochurePage1.html

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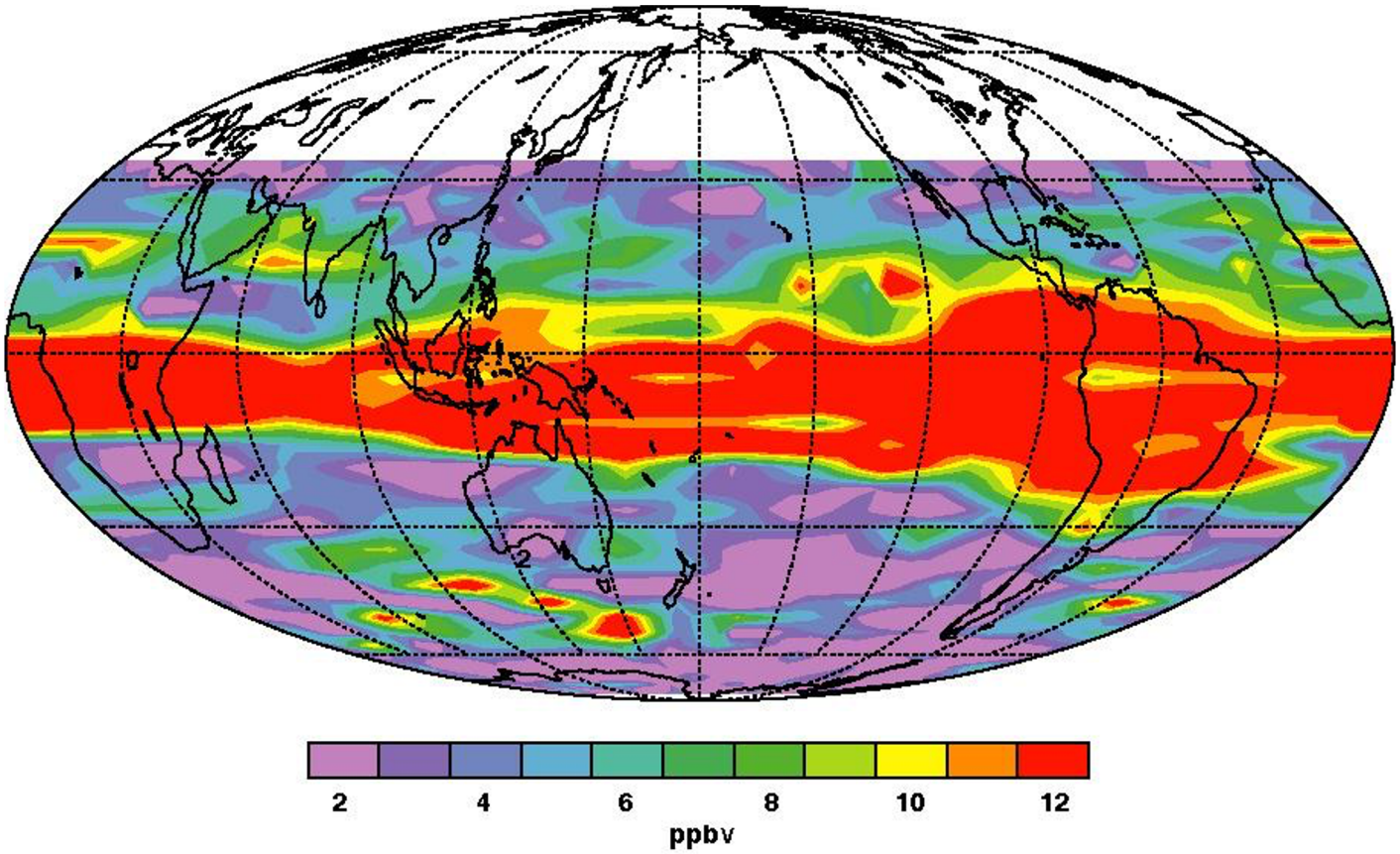

SO_2 from Mt Pinatubo 16 miles above Earth's surface, September 21, 1991
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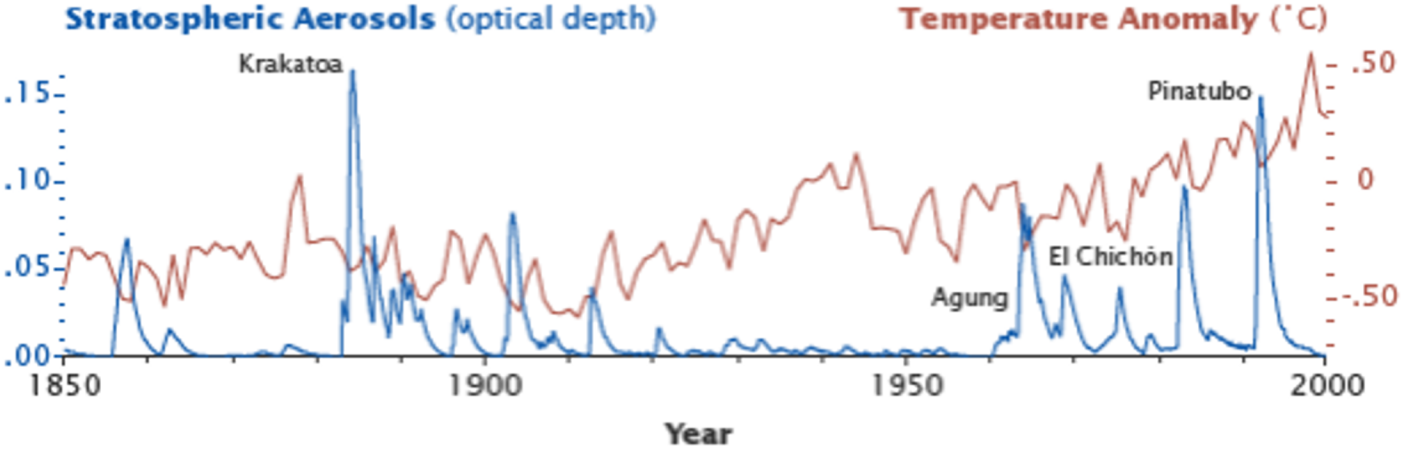

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"This technology also has impacts. First of all, it reduces sunlight that comes in to reach the Earth and that will have an impact on agriculture, on forests, on ecosystems. It will also change the weather patterns and we don't quite know how much but we need to find out before we take any decisions."

Janos Pasztor, Carnegie Climate Governance Initiative

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How Do We Decide? Who Decides?

Geoengineering – especially *solar radiation management* and/or *stratospheric aerosol injection* (see glossary, page 4) – has the potential to counteract decades of trapped heat in Earth's atmosphere. As we burn fossil fuels like coal, oil, and natural gas and cut down forests, we release carbon dioxide (CO_2) into the atmosphere. This CO_2 acts like a blanket, trapping heat from the sun – and this is warming our Earth, air, and ocean. Some people suggest that we should inject reflective particles called *aerosols* into the atmosphere to reflect the sun's heat back out into space.

But who is "we," and what, exactly, would that look like?

In small groups, each person or pair of people should read one of the following articles:

Earth's Energy Budget, NASA, https://science-edu.larc.nasa.gov/wp-content/uploads/sites/141/2021/08/ERB-Litho-Edits-2020.pdf

What is stratospheric aerosol injection, and why do we need to govern it? Carnegie Climate Governance Initiative https://www.c2g2.net/project/infographic-what-is-stratospheric-aerosol-injection-and-why-do-we-need-to-govern-it/

Simulated geoengineering evaluation: cooler planet, but with side effects, NOAA, https://research.noaa.gov/article/ArtMID/587/ArticleID/2756/Simulated-geoengineering-evaluation-cooler-planet-but-with-side-effects

As You Read

- What are three core takeaways from this article that you want someone else to know?
- What do you find confusing or hard to understand?
- What questions do you still have?
- Does this article seem to encourage or discourage geoengineering as a solution?

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Each One, Teach One

After each person or pair has finished reading and discussing their article, share with the members of your group in the order that the articles were listed.

- What are three core takeaways that other people need to understand?
- What questions do you still have?

After each person or pair has shared, discuss:

- Can anyone answer any of the questions other people had, based on what they read?
- What new questions do you have? How might you answer these questions?
- What are some of the possible benefits of geoengineering?
- What are some of the concerns with geoengineering?
- Some people have suggested that discussing and researching solar radiation management could slow down progress on reducing CO_2 emissions. What do you think?
- If the science became clear that solar radiation management was possible, who should decide whether to do it?

Share Your Learning

Geoengineering is challenging to communicate about – it includes complex science, tough questions, and many unknowns. How could you explain one or two core ideas to a friend or family member? Consider the medium: a podcast episode, comic strip, story, song, video? Who needs to know about the possibilities and challenges of geoengineering?

Today I Learned About Geoengineering

Glossary

- **Geoengineering** is an umbrella term for a host of interventions that could reduce the amount of warming that Earth is experiencing due to heat-trapping gases in the atmosphere. There are two large categories of geoengineering: *Carbon Dioxide Removal* and *Solar Radiation Management*.

- **Carbon Dioxide Removal** is any technology, practice, or process that seeks to absorb carbon dioxide out of the atmosphere, reducing the amount of heat the atmosphere can trap. This includes:

  - **Forestation**, including *afforestation* (planting new forests) and *reforestation* (restoring and preserving existing forests). Trees absorb and store CO_2 as part of growth. Grasslands and other ecosystems also absorb CO_2.

  - **Carbon Capture and Storage (CCS) technology**, including *CCS from fossil fuels* (capturing CO_2 from power plants and factories) and *CCS from air* (capturing CO_2 directly out of the air).

  - **Ocean Iron Fertilization** introduces iron into low-iron areas of the ocean, which causes *phytoplankton* (plant-like plankton) to grow. Phytoplankton absorb CO_2 as part of growth and store that CO_2 in the deep ocean when they die.

- **Solar Radiation Management** is any technology or process that seeks to reflect more of the sun's rays back out into space, reducing the amount of heat that enters Earth. These proposals range from technologies that are well-understood to ideas that still need significant research. This includes:

  - **Increased Albedo**, which makes roads, roofs, and other surfaces brighter to reflect more of the sun's rays.

  - **Cloud Seeding** would spray particles into low cloud areas (especially over oceans) to increase their brightness and reflect sunlight back into space.

  - **Cirrus Thinning** would break up high cirrus clouds, which otherwise tend to trap more heat on Earth.

  - **Stratospheric Aerosol Injection** would spray particles into the upper atmosphere, above the clouds, to reflect sunlight back into space.

  - **Space Mirrors** would orbit Earth and reflect the sun's rays.

Images from The Noun Project by Design Circle, Dooder, Lars Meiertoberens, Vichanon Chaimsuk, asianson.design, Gilad Sotil, and Michele Ficeli