SCIENCE UPDATE

Solar Geoengineering: Going Volcanic on Climate Change

Reducing the amount of carbon dioxide (CO_2) in the atmosphere has proven elusive, and cutting CO_2 emissions now does not affect what already exists in the atmosphere. One course of action garnering serious consideration is solar geoengineering. The premise is simple: If you can't control the amount of insulation in the blanket, turn down the heat.

Solar geoengineering would spread particles into the atmosphere to reflect or refract the sun's rays, reducing the greenhouse gas effect and cooling the planet. Governments, ethicists, scientists and citizens are somewhat resistant to this, however. The scale of the manipulation lends itself to nonlinearities and serendipitous discoveries, some of which could be damaging to ecology and society. A precedent to this globe-altering step exists, however: volcanoes. Volcanoes have ejected particulates into the atmosphere on numerous occasions in recorded history. A 2015 study found that 15 of the 16 coldest summers recorded between 500 B.C. and A.D. 1,000 followed large volcanic eruptions.[1]

One event that resembles a global-scale manipulation was the Tambora eruption of 1815. On April 5, 1815, the Indonesian volcano exploded in one of the most significant volcanic events in recorded history, with the highest explosive index in 500 years.[2] The resulting spread of sulfate aerosols around the world contributed to extreme weather, ecological disruption and geopolitical upheaval. The effects of the eruption lasted for 1.5 years and included global temperature decreases of 1° to 1.5°C. Unseasonably cold conditions were accompanied by drought and floods, particularly in the Northern Hemisphere.[3]

> SOLAR GEOENGINEERING WOULD...REFLECT OR REFRACT THE SUN'S RAYS, REDUCING THE GREENHOUSE GAS EFFECT.

In retrospect, the Tambora eruption highlighted the tight connections between human and natural systems by showing how one event could create a global cascade of localized events that changed how humans interact with their environment and each other. Events in the northeastern United States and Canada highlight the upheaval connected to Tambora. The spring and summer of 1816, "the year without a summer," was punctuated by monthly killing frosts during the growing season and poor snow and rainfall from the Hudson Bay to Virginia. Migratory fish that were staples for European Americans and Native Americans in the northeast found conditions too cold to support successful spawning and likely decimated future fish populations.[2] The fish that did return were overfished to supply needed protein to the surviving populace. In northeastern cities, the death rate tripled.[2] The year of 1816 also was called the "mackerel year," as mackerel was one of the few available protein sources. Mass emigration from the northeast, particularly in 1817 as the spring shaped up to

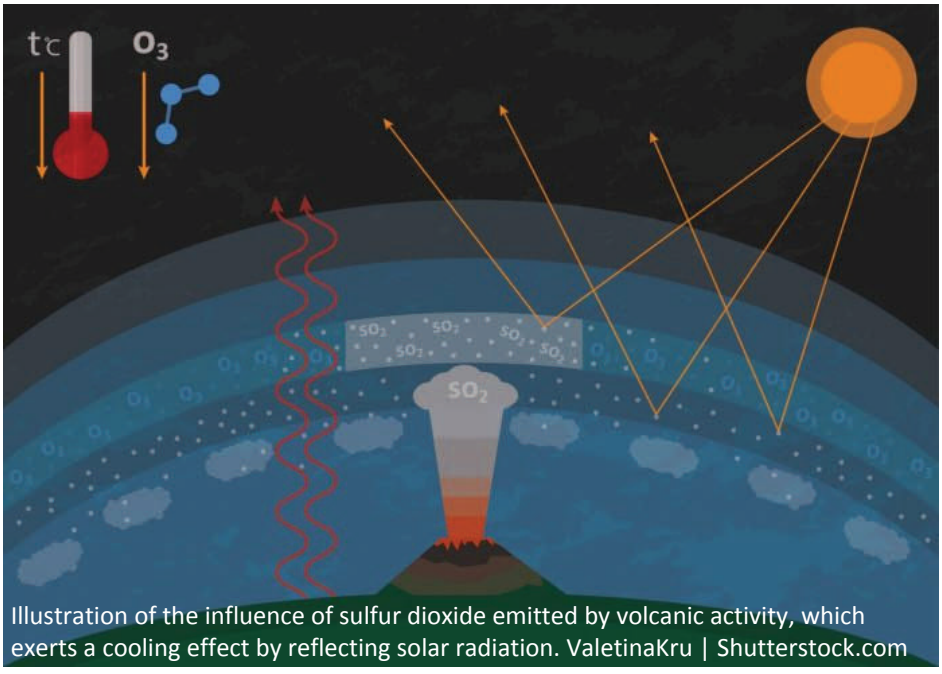

Illustration of the influence of sulfur dioxide emitted by volcanic activity, which exerts a cooling effect by reflecting solar radiation. ValetinaKru | Shutterstock.com

SCIENCE UPDATE

Solar Geoengineering (continued)

Aerial view of the crater of Mount Tambora, formed during the 1815 eruption. learnodo-newtonic.com/mount-tambora-facts

be like the previous devastating year, resulted in a shift of population to industrial cities and the Midwest where conditions were better.[4]

Native Americans found themselves with low food stores and less freedom to fan out across their lands to weather the calamity. A number of tribes in the northeast signed treaties between 1816 and 1818 that traded vast tracts of land for payment and supplies. The Penobscot Nation agreed to a treaty with Massachusetts in 1818 that surrendered most of the tribe's land on either side of the Penobscot River, excepting about 25 square miles of parcels and the islands above Old Town Falls. In exchange, the Penobscot received large quantities of corn, flour, pork, molasses, cloth, blankets, gunpowder, shot, tobacco, chocolate and $50 in silver annually.[5] The Onondaga Nation traded 4,320 acres in 1817 for $430 a year and large quantities of salt.[6] Also in 1817, the Ottawa, Chippewa, Shawnee, Wyandot and Potawatomi ceded large areas of tribal land to the federal government, continuing a process of clearing the Ohio Valley for settlement by New Englanders moving west.[7] The lens of history is never so clear as to draw a straight line between events, but the location and size of the treaty exchanges and conflicts certainly bear an air of desperation easily associated with the food shortages of 1816 and 1817.

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The Obama administration did not seriously consider solar geoengineering. The Trump administration is revisiting this policy. Solar geoengineering may be a temporary and short-term fix for climate change, but the effects on the environment, human systems and their interconnection should be seriously considered. The Tambora eruption arguably impoverished thousands of Native Americans for centuries to come for want of necessities to survive following the dramatic cooling that followed the eruption.

[1] allnewspipeline.com/Volcanoes_Poverty_And_Global_Famine.php. Accessed 4-7-2017.

[2] Alexander KE, Leavenworth WB, Willis TV, Hall C, Mattocks S, Bittner SM, Klein E, Staudinger M, Bryan A, Rosset J, Carr BH, and Jordaan A. 2017. Tambora and the mackerel year: Phenology and fisheries during an extreme climate event. *Science Advances* 3:1 doi:10.1126/sciadv.1601635.

[3] www.scientificamerican.com/article/1816-the-year-without-summer-excerpt.Accessed 4-7-2017.

[4] regencyredingote.wordpress.com/2015/04/10/regency-bicentennial-mount-tambora-erupts. Accessed 4-7-2017.

[5] cprr.org/Museum/BMLRR/Penobscot.html. Accessed 4-7-2017.

[6] www.dyarrow.org/indigenous/landclaim.htm. Accessed 4-7-2017.

[7] nativeamericannetroots.net/diary/2263. Accessed 4-7-2017. ❍