Volcanic winter

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A **volcanic winter** is a reduction in global temperatures caused by volcanic ash and droplets of sulfuric acid obscuring the Sun and raising Earth's albedo (increasing the reflection of solar radiation) after a large particularly explosive volcanic eruption. Long-term cooling effects are primarily dependent upon injection of sulfide compounds in aerosol form into the upper atmosphere—the stratosphere—the highest, least active levels of the lower atmosphere where little precipitation occurs, thus requiring a long time to wash the aerosols out of the region. Stratospheric aerosols cool the surface and troposphere by reflecting solar radiation, warm the stratosphere by absorbing terrestrial radiation, and when combined with anthropogenic chlorine in the stratosphere, destroy ozone which moderates the effect of lower stratospheric warming. The variations in atmospheric warming and cooling results in changes in tropospheric and stratospheric circulation.[1]

Contents

Historic examples

The effects of volcanic eruptions on recent winters are modest in scale, but historically have been significant.

Pinatubo early eruption, 1991

Most recently, the 1991 explosion of Mount Pinatubo, a stratovolcano in the Philippines, cooled global temperatures for about 2–3 years.[2]

In 1883, the explosion of Krakatoa (Krakatau) created volcanic winter-like conditions. The four years following the explosion were unusually cold, and the winter of 1887-1888 included powerful blizzards.[3] Record snowfalls were recorded worldwide.

The 1815 eruption of Mount Tambora, a stratovolcano in Indonesia, occasioned mid-summer frosts in New York State and June snowfalls in New England and Newfoundland and Labrador in what came to be known as the "Year Without a Summer" of 1816.

A paper written by Benjamin Franklin in 1783[4] blamed the unusually cool summer of 1783 on volcanic dust coming from Iceland, where the eruption of Laki volcano had released enormous amounts of sulfur dioxide, resulting in the death of much of the island's livestock and a catastrophic famine which killed a quarter of the Icelandic population. Northern hemisphere temperatures dropped by about 1 °C in the year following the Laki eruption. However Franklin's proposal has been questioned.[5]

In 1600, the Huaynaputina in Peru erupted. Tree ring studies show that 1601 was cold. Russia had its worst famine in 1601-1603. From 1600 to 1602, Switzerland, Latvia and Estonia had exceptionally cold winters. The wine harvest was late in 1601 in France, and in Peru and Germany, wine production collapsed. Peach trees bloomed late in China, and Lake Suwa in Japan froze early.[6]

In 1452 or 1453, a cataclysmic eruption of the submarine volcano Kuwae caused worldwide disruptions.

The Great Famine of 1315–1317 in Europe may have been precipitated by a volcanic event,[7] perhaps that of Mount Tarawera, New Zealand, lasting about five years.[8]

The extreme weather events of 535–536 are most likely linked to a volcanic eruption. The latest theorised explanation is the Tierra Blanca Joven (TBJ) eruption of the Ilopango caldera in central El Salvador.[9]

One proposed volcanic winter occurred around 71,000–73,000 years ago following the supereruption of Lake Toba on Sumatra island in Indonesia. In the following 6 years there was the highest amount of volcanic sulphur deposited in the last 110,000 years, possibly causing significant deforestation in Southeast Asia and the cooling of global temperatures by 1 °C.[10] Some scientists hypothesize that the eruption caused an immediate return to a glacial climate by accelerating an ongoing continental glaciation, causing massive population reduction among animals and human beings. Others argue that the climatic effects of the eruption were too weak and brief to impact early human populations to the degree proposed.[10]

This, combined with the abrupt occurrence of most human differentiations in that same period, is a probable case of bottleneck linked to volcanic winters (see Toba catastrophe theory). On average, super-eruptions with total eruptive masses of at least 10^{15} kg (Toba eruptive mass = 6.9×10^{15} kg) occur every 1 million years.[11]

However, archaeologists who in 2013 found a microscopic layer of glassy volcanic ash in sediments of Lake Malawi, and definitively linked the ash to the 75,000-year-old Toba super-eruption, went on to note a complete absence of the change in fossil type close to the ash layer that would be expected following a severe volcanic winter. This result led the archaeologists to conclude that the largest known volcanic eruption in the history of the human species did not significantly alter the climate of East Africa.[12][13]

Effects on life

The causes of the population bottleneck— a sharp decrease in a species' population, immediately followed by a period of great genetic divergence (differentiation) among survivors—is attributed to volcanic winters by some researchers. Such events may diminish populations to "levels low enough for evolutionary changes, which occur much faster in small populations, to produce rapid population differentiation".[14] With the Toba bottleneck, many species show massive effects of narrowing of the gene pool, and Toba reduced the human population to between 15,000 and 40,000 or even fewer.[14]

The supervolcano Caldera Lake Toba

See also

- Global dimming
- Impact winter
- Nuclear winter
- Supervolcano

- Timeline of volcanism on Earth
- Year Without a Summer

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