VOLCANIC DUST VEILS AND CLIMATE: HOW CLEAR IS THE CONNECTION? – AN EDITORIAL

There is in Iceland a chain of mountains with lyrical names – Laki, Hekla, and Askja. They are underlain by a fissure in the earth's crust, a rift through which gases and molten rock come. In June 1783, Mount Laki injected sulfur-rich gases into the troposphere and stratosphere, casting a pall over Europe. The Parisian sun was dimmed and temperatures were believed to be colder than usual that winter. It was Benjamin Franklin, serving in France as an envoy, who suggested there could be a connection between the three events. In May 1784 Franklin wrote of the summer of 1783 and the following winter:

> During several of the summer months of the year 1783, when the effect of the sun's rays to heat the earth in these northern regions should have been greatest, there existed a constant fog over all Europe, and great part of North America. . .

Franklin speculated on several possible causes of the 'constant fog', including 'the vast quantity of smoke' from volcanoes in Iceland which 'might be spread by various winds over the northern part of the world' [1]

Although the effect of Laki may have been concentrated into the northern half of the Northern Hemisphere over a six month period, the reach of Mount Tambora some thirty years later was apparently more global. Over two days in April 1815, this Indonesian volcano produced a dust veil that shrouded the earth, and created a vivid 'Turner sunset' for at least a year – that is, a colorful sunset like those that were immortalized in paintings by the British artist Joseph Mallord William Turner.

In England, the following year temperatures dropped some 1.5 to 2.5 °C. In eastern North America and in Western Europe, the summer of 1816 was reported in places to be 1 to 2.5 °C colder than the previous years; New Englanders, complaining of untimely frosts, called it 'the year without a summer'. It was, in fact, the coldest summer in New Haven during the whole period of record from 1780 to 1968. Henry and Elizabeth Stommel, who reviewed historical documents of the time, reported:

> In New England the loss of most of the staple crop of Indian corn and the great reduction of the hay crop caused so much hardship in isolated subsistence farms that the year became enshrined in folklore as 'Eighteen Hundred and Froze to Death'. The calamity of 1816 is an interesting case history of the far-reaching and subtle effects a catastrophe can have on human affairs. [2]

Whether Tambora caused these events or was merely a component of them – or even a coincidence – is still debated. For example, even if the eruption caused a 3 °C drop in average summer temperatures in New England, such a large cooling isn't enough by itself to create mid-summer frosts. It would take many times that few degree cooling to drop July temperatures to freezing. However, if the jet stream also dipped down unusually far to the south over New England at the same time the hemisphere cooled a few degrees, then perhaps the combination of the two factors could have created the few frosty days in the summer of 1816. Evidence for such a southward dip of the midlatitude westerlies in the summer of 1816 is given in this issue of *Climatic Change*.

A. J. W. Catchpole and Marcia-Anne Faurer surveyed ships' logs for evidence of wind

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direction and sea ice anomalies in the Hudson Strait from 1751–1870. [3] They argue that "a detailed study of the westward passage of the Hudson's Bay Company Ships through the Strait in 1816 has revealed evidence of patterns of ice distribution and behavior which are indicative of northerly and north westerly air flow over the region". As to the simultaneous occurrence of anomalous cold conditions that year in western Europe, Catchpole and Faurer suggest that "the frequent development of strongly meridional atmospheric circulation" allowed Arctic air to penetrate abnormally far south that summer, a conclusion consistent with Hubert Lamb's earlier reconstructions of July 1816 surface pressure patterns for the North Atlantic. To verify such a hypothesis of blocking in the westerlies that summer, we would need to examine temperature records from other regions, in particular those that should have been abnormally warm a half wavelength away from the persistent troughs centered over northeastern North America and Western Europe. [4] Unfortunately, the latter two regions are where most of the historical or meteorological records are.

Even if these hypothesized simultaneous events (regional blocking and hemispheric cooling from the Tambora dust veil) did happen, it is still conjecture whether they were chance occurrences rather than a volcanic dust caused jet stream anomaly. We need more than one eruption and its potential global climatic response to verify a volcanic dust climate connection, particularly in any one region.

Tambora was followed decades later by other lesser volcanic eruptions that have also been linked to hemispheric-scale climatic coolings of several tenths of a degree Celsius, lasting up to several years after the eruptions. Unfortunately, as Landsberg and Albert [5] suggested and Mass and Schneider [6] later showed, many of the short-term cooling dips seen in the temperature history of the past few centuries for nonvolcanic years were roughly of the same size as dips occurring just after major volcanic eruption years. We concluded, therefore, that one could not automatically assume any single eruption created a subsequent temperature dip, since similar dips have taken place at times when no major eruptions had occurred. In order to help distinguish volcanic-induced dips from random, short-term cooling periods, Mass and Schneider used superposed epoch analysis to combine a large number of volcanic eruptions with a large number of temperature dips that followed each eruption. This averaging or compositing process reduces the 'noise' of interannual climatic fluctuations, and showed a fairly clear volcanic signal. The strength of the signal was several tenths of a degree Celcius cooling lasting a year or two following major eruptions. Such cooling effect has been subsequently corroborated by theoretical studies and by the semi-empirical modeling studies of Gilliland, Hansen, and others. [7, 8]

Finally, in the spring of 1982 El Chichon in Mexico erupted, creating a large sulfate aerosol loading in the stratosphere. The amount of ejecta made climatologists excited that at last we had a test case eruption that would not be marred by the lack of precise data that has so confused the cause-and-effect interpretations between previous eruptions and their alleged climatic responses. Although very dense, this dust veil unfortunately stayed concentrated in the 0 to 30° N latitude belt for nearly 6 months. Thus, it was not, initially at least, a global perturbation. Moreover, a large El Niño type event caused unprecedented warming of the central and eastern equatorial Pacific oceanic surface waters in late 1982 and early 1983. These complications have, so far, made an interpretation of El Chichon's climatic effects far from obvious.

However, by mid-1983 the Pacific waters appear to be becoming more normal and the El Chichon dust veil seems to be spreading globally. We may yet have a natural experiment with which to further verify modeling and observational inferences about the climatic effects of volcanic dust veils derived from previous eruptions. This time, at least, lack of data will be less of a problem and clearer inferences may thus be possible.

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References

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