NOTES AND CORRESPONDENCE

Comments on "Major Volcanic Eruptions and Climate: A Critical Evaluation"

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Mass and Portman (1989, referred to hereafter as MP) claim that actinometric observations of total solar radiation following major volcanic eruptions show a higher percentage of depletion in the polar regions than at lower latitudes. MP use their cited observations to suggest that a 2% solar reduction, with a half-life of 1 year, following major volcanic eruptions is hemispherically representative and when introduced into a climate model produces results that are consistent with observed global temperature variations. Although their initial claim is consistent with the modeling results of Harshvardhan (1979) for a volcanic aerosol uniformly spread over a hemisphere, MP omit several references (given later) reporting observations at lower latitudes that show sustained volcanically induced solar depletions as large as any reported for polar regions. Also, MP do not account for the time evolution of the nonuniformity in the latitudinal distribution of the aerosol.

Mass and Portman cite polar observations reported by Wendler (1984) and Viebrock and Flowers (1968) following the eruptions of El Chichón and Agung, respectively and lower latitude observations by Dyer and Hicks (1965) following the eruption of Agung. The polar observations cited by MP showed a 5%–7% decrease in total solar flux following the eruptions whereas the lower latitude observations showed no significant decrease because of the level of noise in the record. MP do not make any reference to many lower latitude observations following the eruption of El Chichón, although even Wendler (1984) notes a 7% depletion in Hawaii. Nor do MP refer to a reanalysis of the Dyer and Hicks data by DeLuisi and Herman (1977), who show that the clear-sky solar depletion at 38°S following the eruption of Agung was at least 5%.

It should be noted that, for proper analysis of total solar irradiance measurements relative to depletion by a stratospheric aerosol, the local effects of clouds and tropospheric aerosols should be removed, the resulting indicated solar depletions being typical of the loss of solar irradiance to the entire troposphere as well as to the surface for some representative latitude band. Several references (discussed next) show that the observed volcanically induced percentage reduction in total solar irradiance under clear-sky conditions at lower and middle latitudes was sustained for months by an amount three to four times more than that assumed in MP's representative scenario.

DeLuisi et al. (1983) show that two months after the April 1982 eruption of El Chichón and after the eruption cloud had circled the earth at least twice, there was a representative ~7.5% daily depletion in total solar radiation at Mauna Loa (19°N), relative to a year prior. The Mauna Loa loss of total solar energy was represented by a daily integral rather than by observations at solar noon, the depletion being 2%–3% greater for the entire day than at just noon. The extensive Mauna Loa dataset given by Dutton et al. (1987) shows that the monthly average solar depletion remained at 5%–6.5% for five months after the eruption (during maximum seasonal solar heating), dropped to 3%–4% for three months, and then quickly became undetectable even though the detectability limit was 1%–1.5%. The Mauna Loa lidar and optical depth record shows a very sudden decrease in volcanic aerosol during late November 1982. The maximum depletions at middle and polar latitude locations were recorded after that time.

Hay and Darby (1984) and Rao and Bradley (1983) also show relatively large solar depletion outside the polar regions. Hay and Darby show a reduction at Vancouver, British Columbia, of 5%–6% for three months, December 1982–February 1983. Rao and Bradley show a depletion at Oregon of 11% immediately after detection of El Chichón effects in late November 1982. The Rao and Bradley value was the highest reported, but when their best estimate and standard deviation statistics are considered, a minimum depletion of 8% is indicated.

There are numerous other lower latitude observations reported after the eruption El Chichón that show direct solar beam reductions of 20%–30% and aerosol optical depths of 0.15–0.25. These magnitudes of direct beam depletions and optical depths are consistent with

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a reduction substantially greater than an initial 2% reduction in total solar irradiance as deduced by MP. Additionally, none of the aforementioned observational time series indicate a 1 year (or even constant) half-life for the volcanic aerosol or its effects.

The modeling results of Harshvardhan (1979) cited by MP correctly show that the planetary albedo increases toward the poles for an aerosol spread uniformly over the hemisphere. This would be expected as a result of multiple scatter and solar zenith angle path length geometry. Additionally, the model results of Harvey and Schneider (1985), which include infrared aerosol effects, were used by MP to show that a 2% reduction in solar radiation, uniformly spread over the eruption hemisphere, yields results consistent with their conclusions concerning observed global temperature change related to volcanic eruptions. However, that uniform aerosol distribution was not the case following the eruption of El Chichón (Dutton and DeLuisi 1983; Spinhirne 1983; and others). Also, the lower latitude observations referenced here do not show a smaller depletion than the high latitude ones, quite possibly because the cloud aged considerably at the low latitudes before spreading to the poles. Therefore, it appears that MP have mistakenly substantiated Harshvardhan's model and have assumed much too small a solar depletion, with an inappropriate time dependence, over large latitude bands in determining an expected temperature response.

The following question is then raised: If the observed reduction of solar radiation following major volcanic eruptions is substantially greater than that considered by MP, but the actual temperature change is as small as they show, how then does the earth ocean/atmosphere system compensate for the difference? Although speculation on the answer is not the topic of this comment, it should be noted that MP do search for a volcanic signal in pressure and precipitation patterns. They use extensive spatial averaging consistent with a hemispherically uniform forcing, however, and therefore the effects of the strong latitudinal gradients in the aerosol and the longitudinal differences in the land/ocean surface heat budget responses would not be detected.

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