

Two Centuries of Volcanic Aerosols Derived from Lunar Eclipse Records, 1805–2019

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About once per year, on average, the moon is totally eclipsed; the moon is then illuminated by sunlight refracted into the umbra, primarily by the stratosphere. Stratospheric aerosols can affect the brightness of the eclipsed moon, and climatically significant, visible-band, global aerosol optical depth (AOD) can be directly measured from the difference between observed and predicted brightness.

In 2004, Hofmann et al. summarized five decades of stratospheric aerosol observations, “Surface-Based Observations of Volcanic Emissions to the Stratosphere”, in *Volcanism and the Earth’s Atmosphere*, Geophysical Monograph 139, American Geophysical Union. Among the records were lunar eclipse AOD, updated at the 2018 and earlier NOAA Global Monitoring Annual Conferences (GMAC):

https://www.esrl.noaa.gov/gmd/publications/annual_meetings/2018/abstracts/22-180320-A.pdf and

https://www.esrl.noaa.gov/gmd/publications/annual_meetings/2018/posters/P-40.pdf

Hofmann concluded that a 200-year record of eclipse-based AOD was a “goal worth pursuing”.

Using records of 147 lunar eclipses published in the recent and historic literature, observations communicated directly from observers around the globe, and 31 eclipses observed by the author, the AOD time series now extends from 1805 to 2019. Some climatically-significant implications of the AOD record:

1. There was more volcanic effect on the climate during 1915–1962, and less from 1820–1882, than previously determined by Dust Veil and Volcanic Explosivity Indices and other estimates. The largest DVI event, Cosigiina in 1835, is demoted to a minor event in the eclipse AOD record.
2. There have been no climatically significant volcanic eruptions since Pinatubo, 27 years ago. This is the longest period without a major climatically significant volcano in the past two centuries.
3. A continuum of smaller volcanic eruptions since Pinatubo has maintained a steady activity level, with no detectable trend in stratospheric AOD. The most recent, Ambae in 2018, produced an AOD of just 0.01.
4. The average volcanic AOD for 1996–2018 is 0.002, compared to 0.041 for the previous 14 years. According to Hansen et al. (2002), this corresponds to an increase of forcing of +0.82 W/m. For comparison, forcing increase due to CO₂ and other GHG during the same interval is less, at +0.62 W/m².

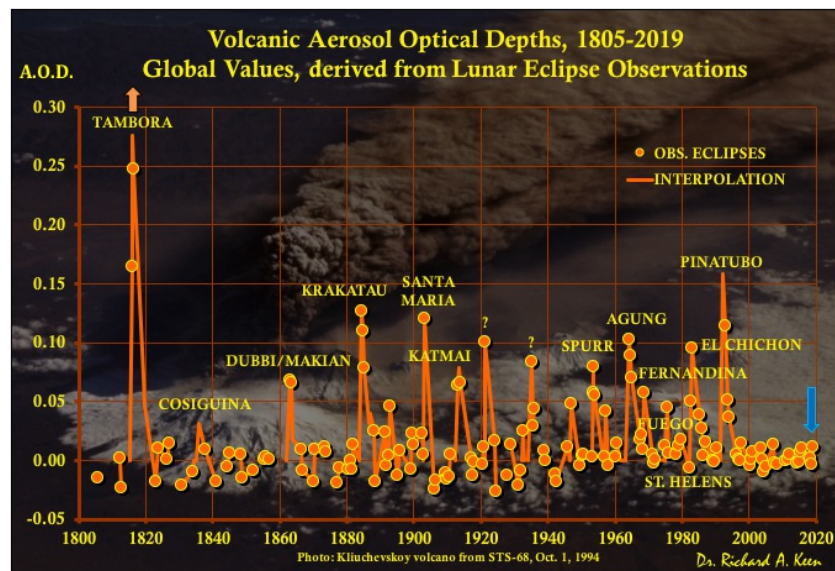


Figure 1. Global volcanic aerosol optical depth from lunar eclipse observations, 1805–2019.