Volcanic Aerosol Optical Depths during the post-Pinatubo era, 1996-2018

Global values from Lunar Eclipse observations

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About once per year on average, a Lunar Eclipse occurs when the Moon passes through the Earth's shadow. At these times we can measure the effect of volcanoes on Earth's climate.

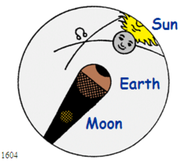
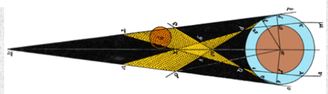


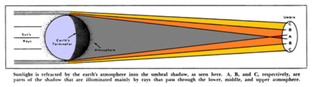
Diagram: Kepler, 1604

Sun light (coming from the right) is refracted (like a lens) into the Earth's umbra and onto the Moon during a lunar eclipse.
From J. Kepler, "Astronomiae pars Optica" (1604)



Kepler wrote that sunlight is reddened & dimmed as it passes through "mists and smoke" in the Earth's atmosphere (mostly stratosphere, we now know), causing the eclipsed moon to appear orange, red, or darker.

Most of the sunlight that illuminates the moon during an eclipse passes through the stratosphere 15-40 km altitude



... which is where volcanic aerosols concentrate and persist for years after an eruption.

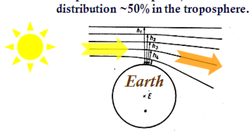
Put "dirt" in the stratospheric light path, and the eclipse becomes darker.

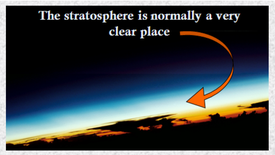
Observe the actual brightness, then calculate the amount of volcanic stuff from the difference.

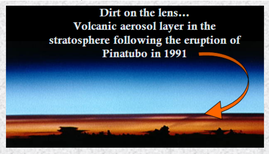
Lunar Eclipse: Calculate a "predicted" brightness for a clear atmosphere.

First, calculate the bending and attenuation of sunlight passing at different altitudes, to predict the amount of light reaching various parts of the umbra.

Include refraction, scattering, and absorption by clear air in the stratosphere & mesosphere, and an assumed cloud distribution ~50% in the troposphere.

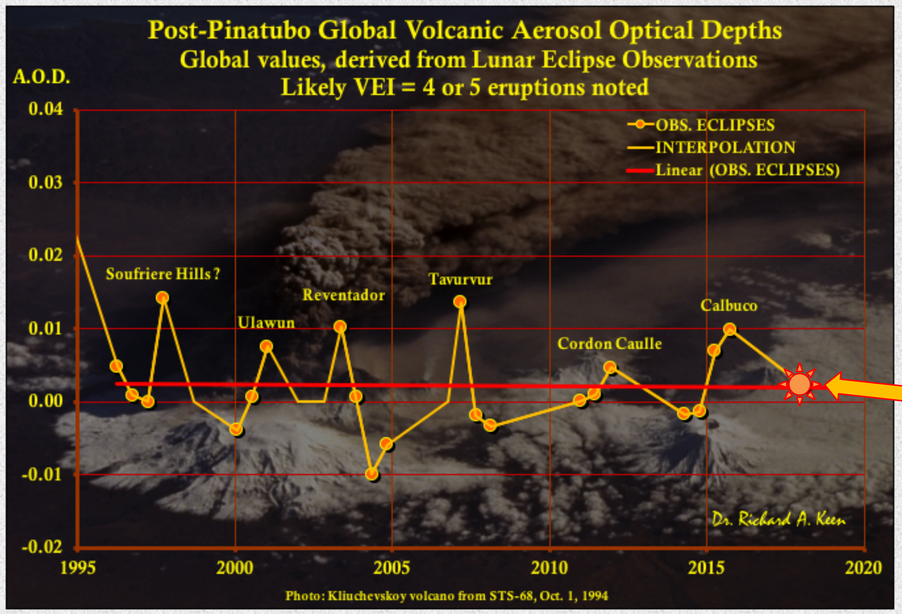






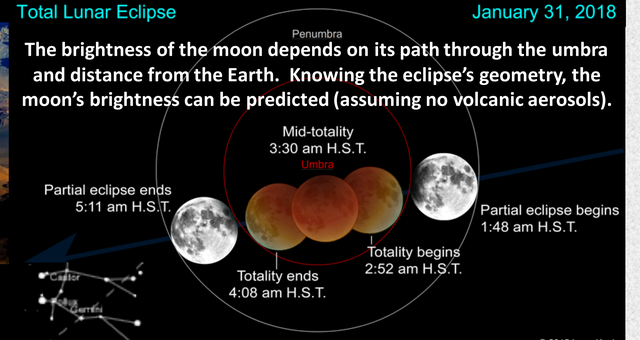
About once per year, on average, the moon is totally eclipsed; the moon is then illuminated by sunlight refracted into the umbra, primarily by the stratosphere. Stratospheric aerosols can affect the brightness of the eclipsed moon, and climatically significant, visible-band, global aerosol optical depth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

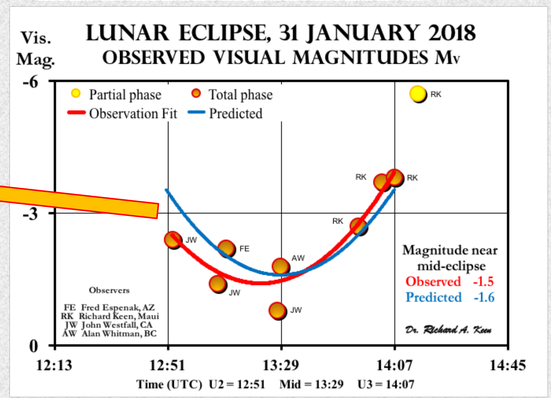
Successful observations of the total lunar eclipse of 31 January 2018 (the first eclipse in over two years) by the author and others reveal that the global volcanic AOD remains at very low levels. A 22+ year period of a relatively clear stratosphere therefore continues, and is the longest such stretch since 1837- 1862. The stratospheric impacts of several climatically insignificant volcanoes during 1996-2018 are identified. There is no trend in AOD over this period, ruling out volcanoes as a contributor to the stable global temperatures during 1998-2015. Compared to the volcanically active period 1980-1995 (el Chichon and Pinatubo), the clear stratosphere since 1995 has contributed an increase of radiative climate forcing equal to that due to increasing greenhouse gases.



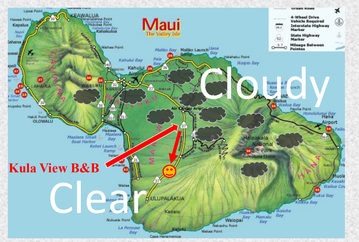
Total Lunar Eclipse — January 31, 2018

The brightness of the moon depends on its path through the umbra and distance from the Earth. Knowing the eclipse's geometry, the moon's brightness can be predicted (assuming no volcanic aerosols).



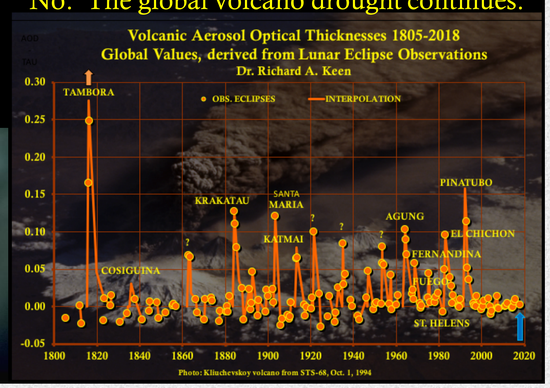


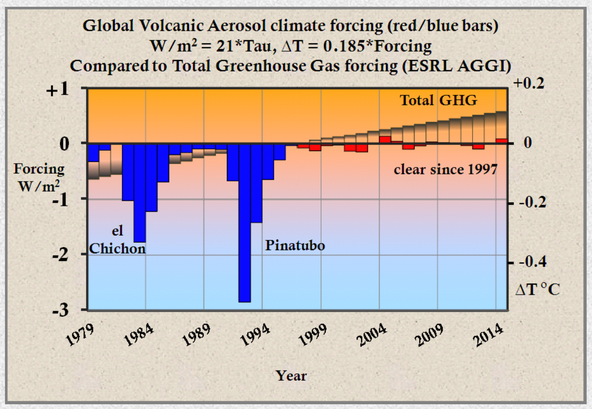
The 3 AM scramble for clear skies was worth it – I was able to get some good observations.



Did the recent eruptions of these three historical performers, Fuego, Agung and Mayon, actually perform?

No. The global volcano drought continues.





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References:

- Hofmann et al. (2004) "Surface-Based Observations of Volcanic Emissions to the Stratosphere", in Volcanism and the Earth's Atmosphere, Geophysical Monograph 139, American Geophysical Union.
- Keen (1983) "Volcanic Aerosols and Lunar Eclipses", Science, 2 December 1983: 1011-1013. [DOI:10.1126/science.222.4627.1011]

http://www.sciencemag.org/content/222/4627/1011.

Presentations at the 2015 and 2017 NOAA Global Monitoring Annual Conferences (GMAC):

- https://www.esrl.noaa.gov/gmd/publications/annual_meetings/2017/slides/7-Keen.pdf
- http://www.esrl.noaa.gov/gmd/publications/annual_meetings/2015/posters/P-48.pdf