Supplementary material

Stratospheric turbidity in the period 1600–1800 CE derived from lunar eclipse brightness and colour, and inferences for global volcanism

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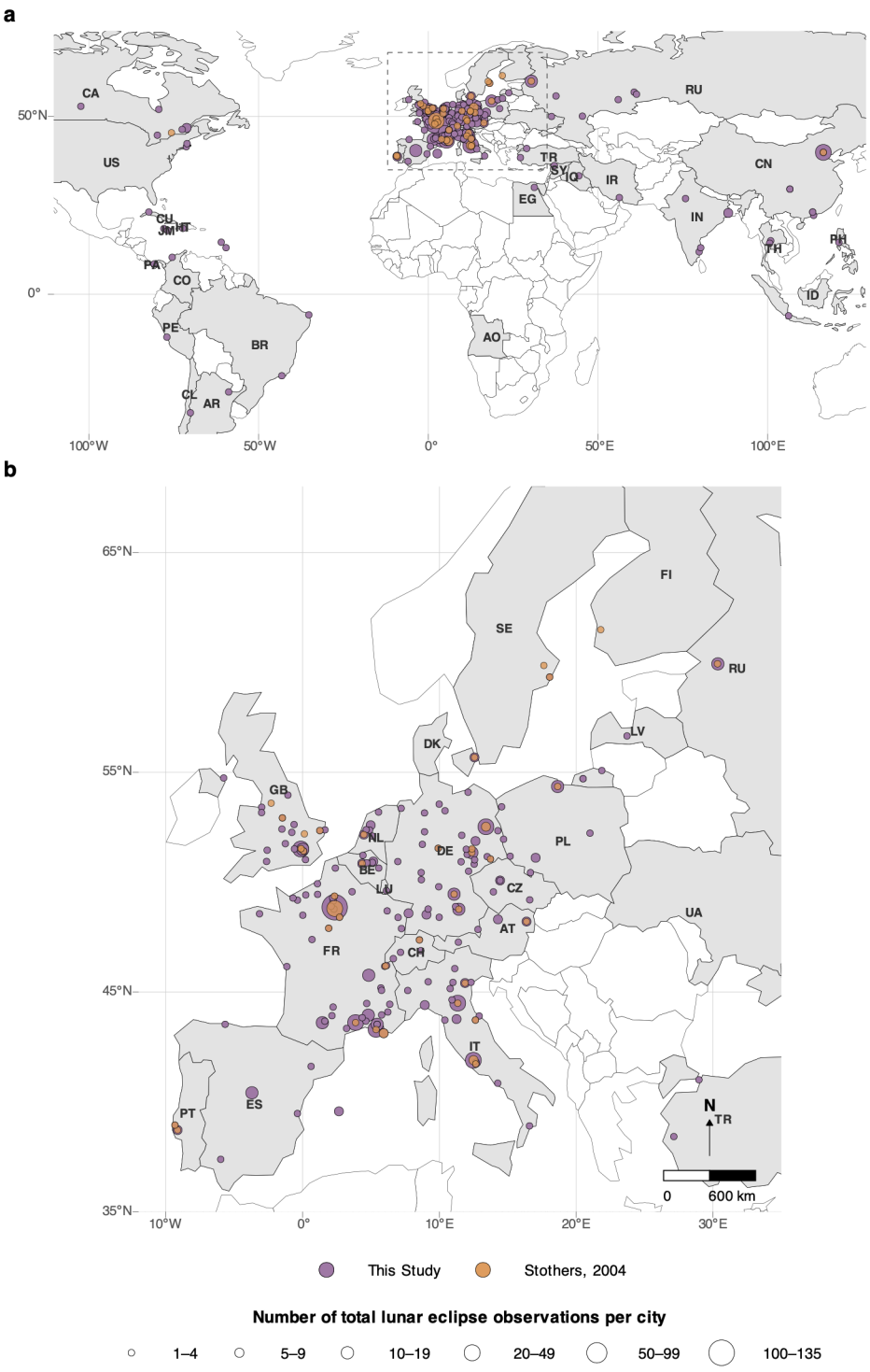


Figure S1

Comparison between the historical eclipse dataset compiled by Stothers (2004) and the expanded version presented in this study, (a) Number of total lunar eclipses with at least one observation, globally, **(b)** Same as **(a)**, restricted to Europe.

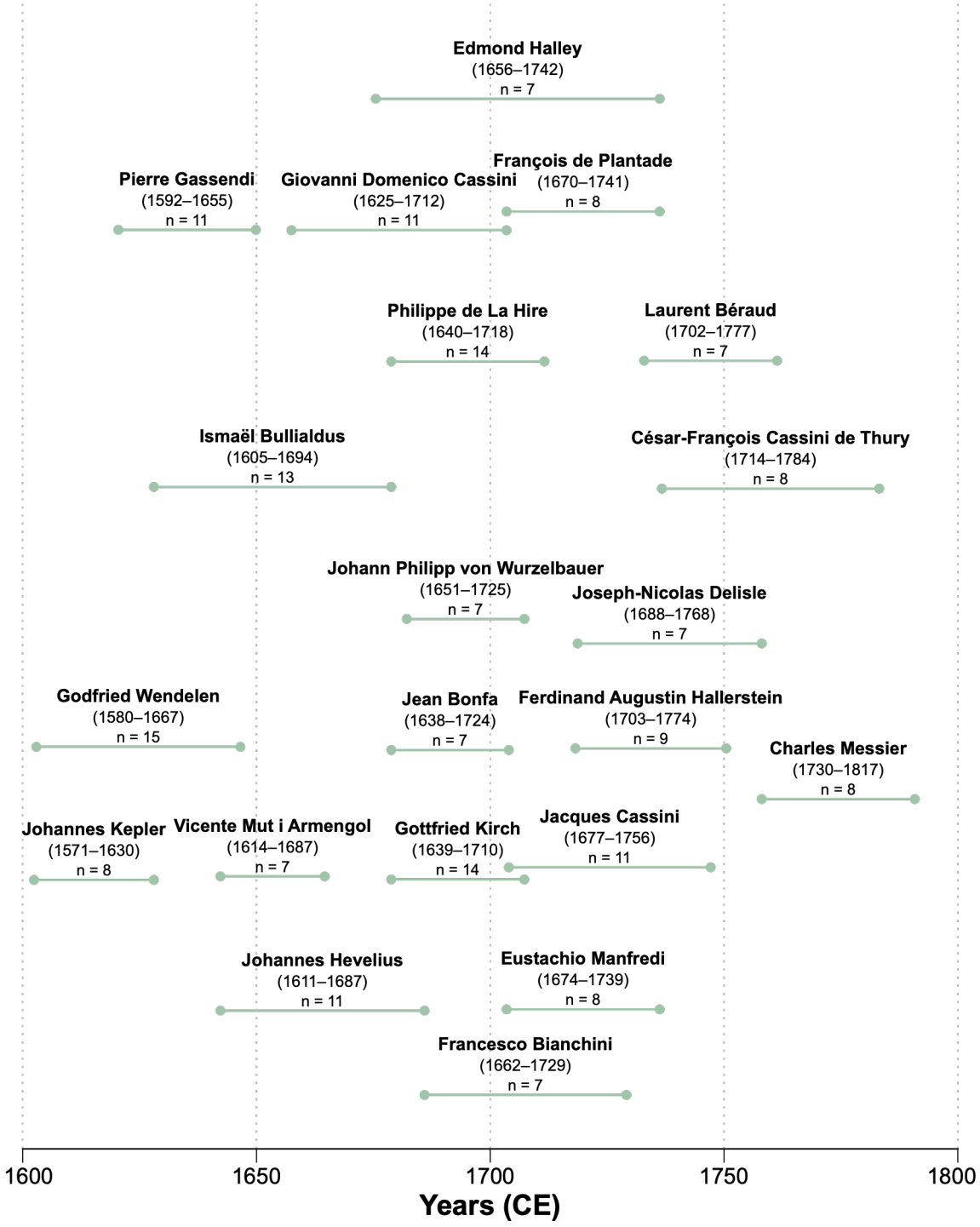


Figure S2

Distribution of astronomers who observed seven or more total lunar eclipses between 1600 and 1800 CE, underscoring the observational continuity of certain individuals. For each observer, the horizontal line extends from the first to the last total lunar eclipse recorded in the database, and the large dots mark these first and last observed eclipses.

Full citation S1

Ismaël Bullialdus (1605-1694), for the total lunar eclipse of 20 December 1638 observed in Paris

(L = 2), wrote:

"The colour of this eclipse was red when the Moon was fully immersed in darkness. The wind, which had been quite strong before, completely died down, but at the emergence, as the Moon came out of the shadow, the intensity of the darkness grew stronger."

Jacques Cassini (1677-1756) in Paris, describing the eclipse of 9 September 1718, (L=3) noted:

"During the time of total immersion, the Moon appeared a fiery red, and even the main spots could be seen; the western edge, which had just been eclipsed, was more vividly coloured than the eastern edge. This light successively followed the Moon as the shadow advanced, so that a little before emersion, the western edge became more vividly coloured than the western."

Full citation S2

A particularly detailed account of solar dimming in 1601–1602 is provided by Renward Cysat (1545–1613), a city clerk and natural philosopher from Lucerne, in central Switzerland, in his Collectanea pro Chronica Lucernensi et Helvetiae, where he notes that:

"The sun, until June, did not display its usual brightness or radiance at sunrise, but instead appeared either red or pale, resembling the rising moon, and only its disk could be seen. Even at its highest point, it remained dim and cast no clear reflection on the mountains as it normally would. This continued until the 23rd of July, when it regained its proper, regular brightness, which had not been seen this year up to that day, nor at all in the entire year of 1601."

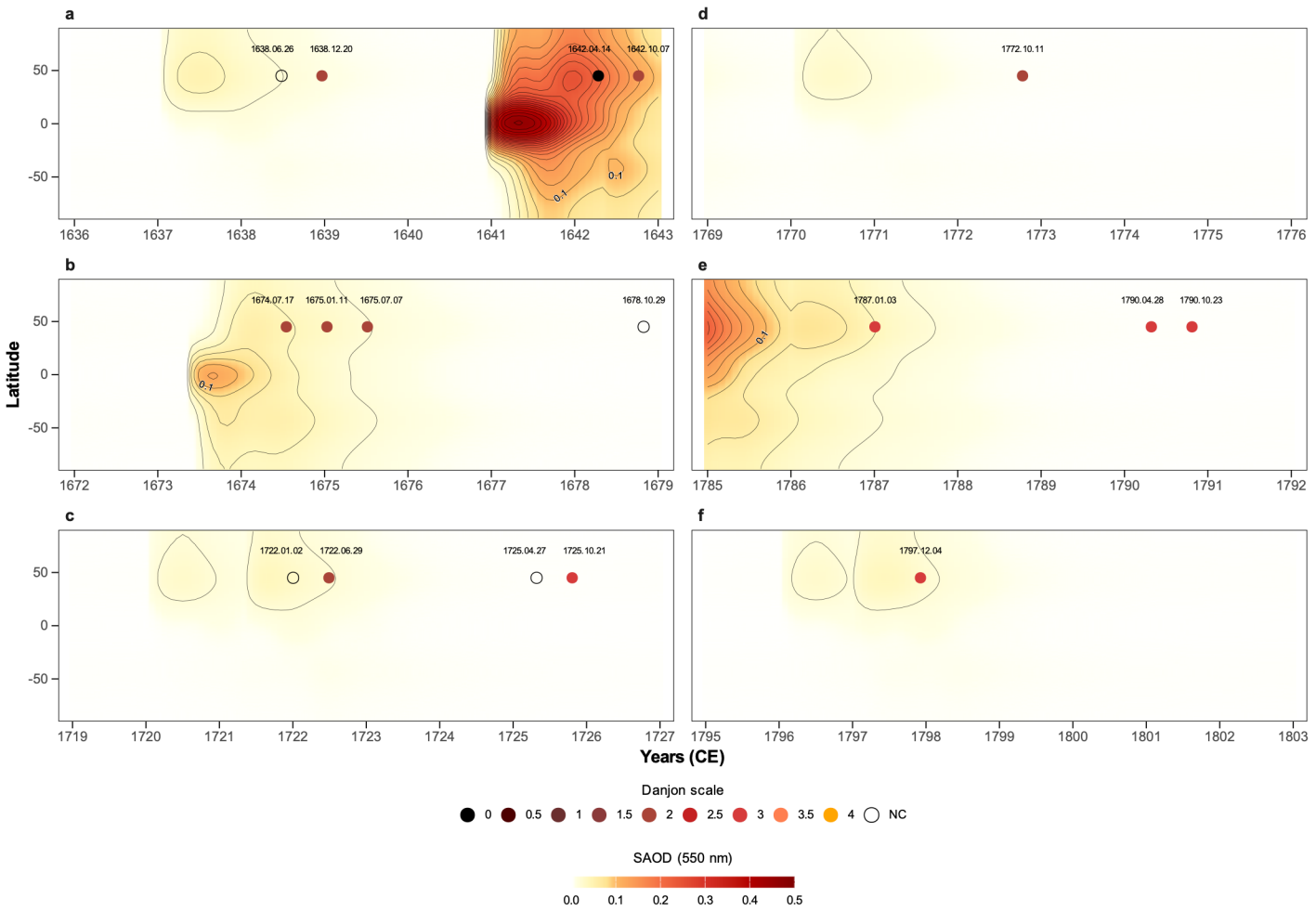


Figure S3

Spatio-temporal evolution of stratospheric aerosol optical depth (SAOD at 550 nm) and lunar eclipse brightness observations for five volcanic eruptions. Panels show latitude–time cross-sections of SAOD derived from the eVolv2k_v3 dataset (Toohey and Sigl, 2017) for the eruptions of **(a)** 1637, **(b)** 1673, **(c)** 1720 and 1721, **(d)** 1770, **(e)** 1786, and **(f)** 1796 and 1797. Color shading (cream to dark red) reflects SAOD levels. Superimposed filled circles indicate historically documented lunar eclipse brightness estimates on the Danjon scale (0 = very dark; 4 = bright copper-red), with open circles (NC) denoting eclipses for which data on brightness estimate could be retrieved.

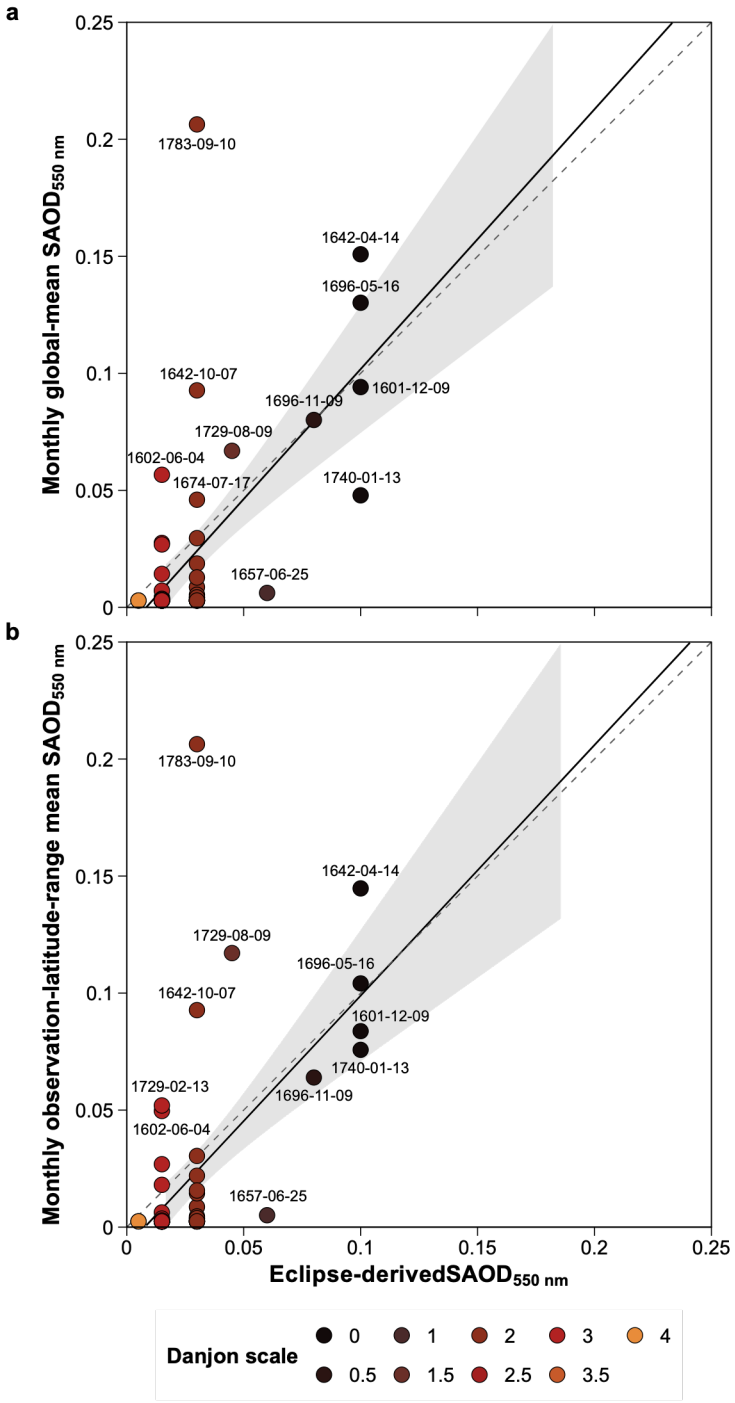


Figure S4

Lunar eclipse-derived SAOD versus monthly eVolv2k SAOD, (a) Monthly global-mean eVolv2k SAOD at the time of each eclipse, **(b)** Monthly eVolv2k SAOD averaged between the minimum and maximum latitudes of the historical observations used for each eclipse