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Key Points:
- Revised estimate and uncertainty of post-2000 volcanic forcing and temperature
- Significant unaccounted volcanic aerosol between the tropopause and 15 km
- Novel use of AERONET to derive total stratospheric aerosol optical depth

Supporting Information:
- Readme
- Text S1, Tables S1 and S2, and Figures S1–S5

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Total volcanic stratospheric aerosol optical depths and implications for global climate change

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Abstract Understanding the cooling effect of recent volcanoes is of particular interest in the context of the post-2000 slowing of the rate of global warming. Satellite observations of aerosol optical depth above 15 km have demonstrated that small-magnitude volcanic eruptions substantially perturb incoming solar radiation. Here we use lidar, Aerosol Robotic Network, and balloon-borne observations to provide evidence that currently available satellite databases neglect substantial amounts of volcanic aerosol between the tropopause and 15 km at middle to high latitudes and therefore underestimate total radiative forcing resulting from the recent eruptions. Incorporating these estimates into a simple climate model, we determine the global volcanic aerosol forcing since 2000 to be $-0.19 \pm 0.09\,\mathrm{Wm}^{-2}$. This translates into an estimated global cooling of 0.05 to 0.12°C. We conclude that recent volcanic events are responsible for more post-2000 cooling than is implied by satellite databases that neglect volcanic aerosol effects below 15 km.

1. Introduction

Over about the past 15 years, globally averaged surface temperatures have increased more slowly than during the two previous decades (≈1980–2000), a phenomenon sometimes referred to as the "hiatus" or "pause" in global warming. Suggested mechanisms that may contribute to this behavior include (but are not limited to) increased heat uptake by the oceans, reduced solar output, and recent volcanic eruptions (see the brief review by *Schmidt et al.* [2014, and references therein]).

It has often been assumed that only very explosive volcanic eruptions have pronounced effects on stratospheric aerosol optical depth (SAOD) and that since Mount Pinatubo in 1991, no eruptions have contributed noticeably to stratospheric aerosol content. However, observations since about 2005 revealed significant increases in SAOD linked to a series of smaller eruptions [*Vernier et al.*, 2011; *Bourassa et al.*, 2012], with potentially important cooling effects on global climate [*Solomon et al.*, 2011; *Fyfe et al.*, 2013; *Haywood et al.*, 2014].