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# Global volcanic $CO_2$ fluxes have been underestimated due to neglect of light scattering processes

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Volcanic gas emissions reveal magma dynamics and affect climate. Recent estimates for global volcanic subaerial $CO_2$ flux range from 0.1 PgC/yr to 0.15 PgC/yr, or ∼1-2% of anthropogenic emissions, extrapolated from combined measurements of volcanic $CO_2/SO_2$ ratios and scattered sunlight UV measurements of $SO_2$ flux. The latter are affected by light scattering into the UV spectrometer from below the volcanic plume, diluting the $SO_2$ signal. Whilst the 'light dilution' effect was initially recognised, and has recently been placed on a sound theoretical basis, it has not yet been widely addressed in volcanic $SO_2$ flux measurements, due to a lack of a suitable retrieval procedure. Here, we report a practical new $SO_2$ retrieval process that addresses light dilution, and apply it to plume measurements on six volcanoes, including a year of data from Mt. Etna, Italy. We find light dilution-corrected $SO_2$ fluxes are typically 2-4 times and occasionally 13 times greater than uncorrected fluxes. Light dilution produces a systematic bias, consistently underestimating the true flux when not corrected. The magnitude of this correction is a function of plume distance, plume aerosol optical depth, atmospheric aerosol load and $SO_2$ abundance. We estimate conservative correction factors for all measured volcanic $CO_2$ fluxes, and produce a new global volcanic $CO_2$ flux of 0.5 PgC/yr, or 5% of anthropogenic emissions. This corrected volcanic $CO_2$ source flux implies a larger land and ocean $CO_2$ sink than previously thought, and hence a shorter atmospheric lifetime of $CO_2$. These revised volcanic fluxes may significantly alter our understanding of the climate response to anthropogenic $CO_2$ emissions. Our results demonstrate that the standard methodologies used in volcanic $SO_2$ flux measurement can significantly underestimate the true flux, calling into question the 35 year old empirical foundation upon which much of our understanding of magmatic degassing is based.