Towards a Volcanic Climate Index

Volcanic eruptions have had major and sporadic impacts on the climate system, reducing temperatures, changing circulation patterns and affecting stratospheric chemistry; but the magnitude of this impact varies widely between eruptions. Effects depend not only on the amount of ash and sulfur injected into the stratosphere, but also the timing and placement of the eruption relative to the atmospheric state. Eruptions at higher latitudes reach the stratosphere more easily, while the phase of the QBO affects the confinement of aerosol in the tropics to name just two. While countless eruptions have occurred in the past decades and centuries, only a small fraction of these have had substantial climate effects. Quantifying what eruptions have an impact and their relative magnitude is a complex problem and one that has been approached from different directions in the past.

In 1982 Newhall and Self introduced the Volcanic Explosivity Index (VEI) to help evaluate records of past volcanic eruptions. Based largely on the volume of tephra emitted by the eruption, VEI has been calculated for most modern and many of the larger past eruptions, making for a long term and up-to-date database for comparison. In the climate community, this metric is often used as a proxy to indicate eruptions with marked impact on global temperatures. However, the correlation between climate variables such as temperature and VEI are poor, as it does not directly incorporate sulfur emissions, residence time in the atmosphere, or indirect effects. Since VEI, other metrics have emerged to address these concerns, such as the Volcanic Sulfur Dioxide Index (VSI) which is based on the total sulfur emitted to the stratosphere. While more direct than VEI, these improvements still leave possibly important effects unaccounted for, and the metrics have not been widely adopted.

This work seeks an improved metric that better describes a volcanic eruptions’ impact on climate by answering the following questions:

* What variables best define “climate impact?” Temperature, radiative forcing, circulation changes, etc.
* What metric can be quickly and easily determined after an eruption that captures these variables?
* What metric can be applied to both past and present eruptions with vastly different observational data?

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