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Revisiting the Krakatau 1883 Volcanic Aerosol Dispersal

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The 1883 Krakatau eruption is one of the most well-known historical volcanic eruptions due to its significant global climate impact as well as first recorded observations of various aerosol associated optical and physical phenomena. Although much work has been done on the former by comparison of global climate model predictions/ simulations with instrumental and proxy climate records, the latter has surprisingly not been studied in similar detail. In particular, there is a wealth of observations of vivid red sunsets, blue suns, and other similar features, that can be used to analyze the spatio-temporal dispersal of volcanic aerosols in summer to winter 1883. Thus, aerosol cloud dispersal after the Krakatau eruption can be estimated, bolstered by aerosol cloud behavior as monitored by satellite-based instrument observations after the 1991 Pinatubo eruption. This is one of a handful of large historic eruptions where this analysis can be done (using non-climate proxy methods). In this study, we model particle trajectories of the Krakatau eruption cloud using the Hysplit trajectory model and compare our results with our compiled observational dataset (principally using Verbeek 1884, the Royal Society report, and Kiessling 1884).

In particular, we explore the effect of different atmospheric states - the quasi-biennial oscillation (QBO) which impacts zonal movement of the stratospheric volcanic plume - to estimate the phase of the QBO in 1883 required for a fast-moving westward cloud. Since this alone is unable to match the observed latitudinal spread of the aerosols, we then explore the impact of an umbrella cloud (2000 km diameter) that almost certainly formed during such a large eruption. A large umbrella cloud, spreading over ~18 degrees within the duration of the climax of the eruption (6-8 hours), can lead to much quicker latitudinal spread than a point source (vent). We will discuss the results of the combined model (umbrella cloud and correct QBO phase) with historical accounts and observations, as well as previous work on the 1991 Pinatubo eruption. We also consider the likely impacts of water on aerosol concentrations and the relevance of this process for eruptions with possible significant seawater interactions, like Krakatau. We posit that the role of umbrella clouds is an under-appreciated, but significant, process for beginning to model the climatic impacts of large volcanic eruptions.