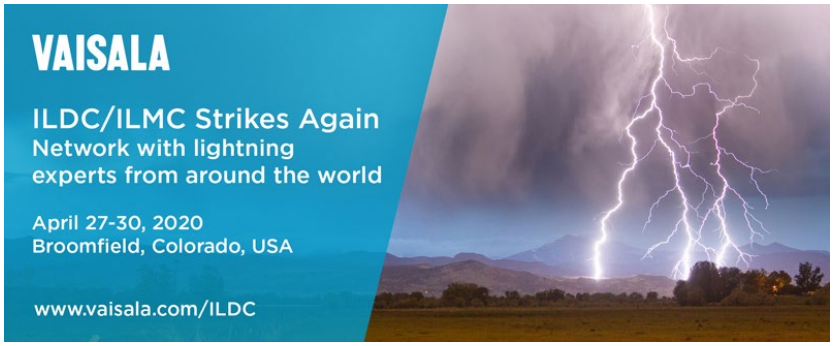

Using volcanic lightning to monitor eruption plume development during explosive volcanic eruptions

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Abstract

Explosive volcanic eruptions generate ash-bearing eruption plumes that can rise tens of kilometers into the atmosphere. These eruption plumes are hazardous to aviation, with previous ash-aircraft encounters leading to jet engine malfunction or failure. Rapid detection and characterization of these ash plumes for aviation safety is a main objective for volcano observatories. Volcanic lightning commonly occurs in volcanic eruption plumes and has been reported in a wide range of eruptions.[i] It has been recorded on both locally deployed lightning mapping arrays and global detection networks such as the GLD360. Previous work on globally detected volcanic lightning has indicated that lightning stroke-rates correlate to factors such as plume height and the freezing level of the atmosphere.[ii],[iii],[iv] Previous work has shown that the locations of volcanic lightning may be useful in tracking the direction of plume movement during an eruption response effort.[v] However, detailed relationships between globally detected volcanic lightning and key parameters are still lacking. There is a need for a comprehensive spatial and temporal analysis of globally detected lightning with satellite analysis of eruption source parameters such as plume height, umbrella cloud expansion, and atmospheric properties.

In this study we will explore these potential relationships through a spatial and temporal analysis of five recent eruptions that produced lightning detected by the GLD360. Bogoslof in the Aleutian Arc (Alaska) had a series of explosive eruptions from Dec 2016 to Aug 2017 with >4,000 lightning strokes recorded across the nine-month eruption. Anak Krakatau, Indonesia, began erupting on 22-Dec-2018, and generated a flank collapse that caused a local tsunami. Over the six-day eruption the GLD360 recorded >346,000 lightning strokes within 100 km of the volcano. Then, within one week in June 2019 Raikoke (Kurile Islands), Ulawun (Papua New Guinea), and Manam (Papua New Guinea), erupted with 845, 1,522, and 1,392 strokes, respectively. We will use these five eruptions to explore the spatial distribution of volcanic lightning within the eruption plumes to consider the effects of (i) atmospheric temperature gradient, (ii) wind profiles, and (iii) plume heights and mass eruption rates. Increasing our understanding of the timing and spatial distribution of volcanic lightning, across a range of different volcanoes, will improve the value of volcanic lightning as a near-real-time monitoring resource for the detection and characterization of ash-bearing volcanic plumes.

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Topic Areas

Applications of Lightning Data: Community events, Advanced Warnings, Aviation and Other Unique Uses of Lightning Data

Submission Format

No preference