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Using Volcanic Lightning to Monitor Explosive Eruptions

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With improvements in global detection of lightning comes the opportunity to use electrical signals to remotely track the development of explosive eruptions worldwide. In particular, the World Wide Lightning Location Network (WWLLN) can detect high-energy strokes from thousands of kilometers away. But what exactly can lightning tell us about the eruption source parameters (e.g., plume height, eruption rate) needed to model the dispersal of hazardous ash? Here, we discuss observations of WWLLN-detected lightning from three recent eruptions: Pavlof (Alaska) in 2016, Calbuco (Chile) in 2015, and Kelud (Indonesia) in 2014. These events span a range of durations (3–20+ hours) and eruption rates from 1e5–1e8 kg/s. Each case demonstrates a change in lightning that corresponds to measurable changes in eruption behavior. For example, during Calbuco and Kelud, the lightning stroke-rates and energies increased during the highest inferred eruption rates, and decreased as the eruption waned. This general pattern is valuable for estimating relative changes in eruptive intensity in near-real time. However, we still lack a quantitative relationship between lightning and eruption rate. In the case of the less voluminous eruption of Pavlof Volcano, lightning abruptly 'turned on' partway through the eruption, despite no significant change in eruption rate. We suspect that two factors were at play: (1) a shift to increased ash production (particles <2 mm), leading to an overall finer-grained eruptive mixture, and (2) increased atmospheric humidity, leading to more ice production near the top of the eruption plume. In this presentation, we will address the need to quantify the effects of these factors on lightning production to move forward with near-real time interpretation of electrical signals during volcanic crises.