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Assessing the likelihood of an impending eruption using the distal VT model and the catalog of Alaskan volcanic eruptions

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For many years, the USGS Volcano Disaster Assistance Program (VDAP) has employed the distal volcano-tectonic (VT) earthquake model for eruption forecasting around the world (White and McCausland, 2016). In this model, VTs occur as a secondary response to crustal strain induced by magmatic intrusion in the shallow crust surrounding closed system volcanoes. Although useful as a conceptual model, direct, quantitative use of the VTs for hazard assessment is more difficult. Observations of distal VTs preceding eruptions are widespread, but the timing and location of these swarms with respect to the eventual eruption varies widely. In addition, distal VTs are expected to precede large explosive eruptions at long dormant volcanoes but are sometimes also observed preceding smaller more passive eruptions at open system volcanoes. Furthermore, in regions with significant background seismicity, difficulties arise in trying to distinguish distal VT swarms from crustal tectonic seismicity unrelated to volcanism. To address these issues and apply the concepts of the distal VT model more formally for eruption forecasting, we statistically analyze seismicity preceding eruptions monitored by the Alaska Volcano Observatory (AVO), which has responded to 63 eruptions from 20 volcanoes since 1988. The AVO data provide a well-monitored set of eruptions of various styles and sizes from which to form statistics of distal VT swarms preceding eruptions. We quantify the likelihood of eruption given various sets of input criteria with the goal of obtaining eruption probabilities following future distal VT swarms at analogous volcanoes. The results confirm that closed-system stratovolcanoes with longer repose times have a high probability of eruption within a few months of the onset of distal VTs that clearly diverge from 'background' seismicity. In contrast, caldera systems and open system volcanoes have much lower probabilities of eruption following such swarms. These results should better inform future probabilistic hazard assessments.