Volcanic eruption durations: Forecasts and controls.

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During volcanic eruptions a question commonly asked is "How long will the eruption last?" To help answer this, we develop means of forecasting the eventual end of a volcanic eruption using statistical and physical approaches.

Ideally we would consider a period of continuous magma effusion as the basic building block of an eruption. Due to the nature of volcanic eruptions and the quality of historical records the start and/or end date of an eruption can be ambiguous, so some eruption durations carry an uncertainty of up to several days or weeks whereas others are known to a precision of less than one day. Short breaks in activity were dealt with by treating eruptive phases separated by periods of inactivity of less than 10 days as belonging to the same eruption.

Using this method we have critically assessed the literature and compiled datasets of historic eruption durations for Piton de la Fournaise (Indian Ocean), the flank eruptions of Mt Etna (Italy) and for 7 Icelandic volcanic systems. We present a statistical forecasting tool, which models the distribution of historic eruption durations within a dataset, and uses survival analysis to give the probability of a future eruption exceeding a specified duration. Such forecasts could be useful for emergency response planning prior to an eruption, providing insight into the likely time scale of the scenario being considered. The method also allows the probability of exceeding a specified duration to be calculated in cases where an eruption has already been occurring for a known amount of time. To assess the effect of duration uncertainty on the forecasted results the model has been run using maximum and minimum possible eruption durations with results showing an insignificant difference.

We also present a comparative study of the distribution of eruption durations for the datasets compiled. Results indicate a predominance of shorter eruptions at Piton de la Fournaise, and longer eruptions at Hekla (Iceland). For an individual eruption, the final duration can be considered to be a function of the volume of material available and the physical parameters controlling the rate at which this material is erupted i.e. magma viscosity, conduit radius, conduit height etc. The unique distribution of eruption durations at each volcano can then be interpreted to be a result of the range and distribution of the possible volumes and values for these parameters, which are specific to the volcano itself. Recognition of these leading controls on eruption duration could underpin the development of a physical model to forecast future eruption durations. Such a model could be refined throughout the early stages of an eruption, accounting for the physical properties that the eruption demonstrates, thus providing a forecasting tool that includes more information than the previously mentioned statistical model. Both approaches show great promise for their application in real life situations.