Evaluating the performance of models for rates of pre-eruptive seismicity

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Volcanic eruptions are commonly preceded by elevated rates of seismicity. Various models have been proposed to explain apparently systematic trends in pre-eruptive earthquake rate and potentially promise quantitative forecasts of the timing of future eruptions. However, these models, and their forecasting power, remain largely untested. Here we evaluate the performance of models based on the exponential and power-law forms of Voight's relation. Drawing on examples of pre-eruptive seismicity from volcanoes including Mount St Helens, Mt Etna, and Pinatubo, we use statistical techniques for model preference, estimating parameter uncertainty, and constraining forecast convergence rates. A comparison between the observed behaviour and that for idealized synthetic data finds reasonably good agreement. However, unsurprisingly, there is evidence for pre-eruptive processes not captured in these simple models, including episodes of relative quiescence immediately prior to the onset of eruption that may be indicative of magma migration. These results suggest that the uncertainty in eruption forecasts based on such models is even larger than the inherent model-based uncertainty, and highlight the necessity for improved understanding and quantitative models for pre-eruptive processes.