Use of Bayesian event trees in semi-quantitative volcano eruption forecasting and hazard analysis

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Use of Bayesian event trees to forecast eruptive activity during volcano crises is an increasingly common practice for the USGS-USAID Volcano Disaster Assistance Program (VDAP) in collaboration with foreign counterparts. This semi-quantitative approach combines conceptual models of volcanic processes with current monitoring data and patterns of occurrence to reach consensus probabilities. This approach allows a response team to draw upon global datasets, local observations, and expert judgment, where the relative influence of these data depends upon the availability and quality of monitoring data and the degree to which the volcanic history is known. The construction of such event trees additionally relies upon existence and use of relevant global databases and documented past periods of unrest. Because relevant global databases may be underpopulated or nonexistent, uncertainty in probability estimations may be large. Our 'hybrid' approach of combining local and global monitoring data and expert judgment facilitates discussion and constructive debate between disciplines: including seismology, gas geochemistry, geodesy, petrology, physical volcanology and technology/engineering, where difference in opinion between response team members contributes to definition of the uncertainty in the probability estimations.

In collaboration with foreign colleagues, we have created event trees for numerous areas experiencing volcanic unrest. Event trees are created for a specified time frame and are updated, revised, or replaced as the crisis proceeds. Creation of an initial tree is often prompted by a change in monitoring data, such that rapid assessment of probability is needed. These trees are intended as a vehicle for discussion and a way to document relevant data and models, where the target audience is the scientists themselves. However, the probabilities derived through the event-tree analysis can also be used to help inform communications with emergency managers and the public. VDAP trees evaluate probabilities of: magmatic intrusion, likelihood of eruption, magnitude of eruption, and types of associated hazardous events and their extents. In a few cases, trees have been extended to also assess and communicate vulnerability and relative risk.