Coupling 3D geophysical data to volcanic hazard assessments through Bayesian inference

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Modeling the long-term spatial behavior of volcanism is required in a volcanic country like Japan due to the potential impacts to nuclear facilities and future geological repositories (e.g., for high level radioactive waste, sequestration of CO2 etc).

Since volcanoes represent magma that has reached the surface, we developed a new probabilistic method that is the first to include both historic eruptions (e.g. over the last 1Ma), and the present day 3-D magma system (inferred form seismic tomographs) using the Tohoku region as a case study.

In the first instant, the spatial distributions of volcanoes are modeled using point process to create a continuous differentiable probability surface. This corresponds to an a priori 2-D probability distribution function (PDF) that can be used to give a probability estimate at any (x,y) location. The next stage is to modify this by using seismic tomographs of P wave velocity giving indirect information on the current location of melting regions in the lower crust and upper mantle. This is used to create another PDF (called a likelihood function) which is weighted on all depth levels from 10-100km. Finally Bayes' rule is employed to combine both the a priori PDF and the likelihood function to yield an a posteriori PDF.

These models are evaluated using pre-100 ka volcanic events to forecast locations of subsequent events that actually formed from 100 ka ago to present. Probabilities in Tohoku region range from 10-10 /yr between clusters and up to 9.8 x 10-6 /yr near the centers of clusters.