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Using Bayesian Belief Networks To Assess Volcano State from Multiple Monitoring Timeseries And Other Evidence

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When volcanoes exhibit unrest or become eruptively active, science-based decision support invariably is sought by civil authorities. Evidence available to scientists about a volcano's internal state is usually indirect, secondary or very nebulous.Advancement of volcano monitoring technology in recent decades has increased the variety and resolution of multi-parameter timeseries data recorded at volcanoes. Monitoring timeseries may be interpreted in real time by observatory staff and are often later subjected to further analytic scrutiny by the research community at large. With increasing variety and resolution of data, interpreting these multiple strands of parallel, partial evidence has become increasingly complex. In practice, interpretation of many timeseries involves familiarity with the idiosyncracies of the volcano, the monitoring techniques, the configuration of the recording instrumentation, observations from other datasets, and so on. Assimilation of this knowledge is necessary in order to select and apply the appropriate statistical techniques required to extract the required information.

Bayesian Belief Networks (BBNs) use probability theory to treat and evaluate uncertainties in a rational and auditable scientific manner, but only to the extent warranted by the strength of the available evidence. The concept is a suitable framework for marshalling multiple observations, model results and interpretations – and associated uncertainties - in a methodical manner. The formulation is usually implemented in graphical form and could be developed as a tool for near real-time, ongoing use in a volcano observatory, for example. We explore the application of BBNs in analysing volcanic timeseries, the certainty with which inferences may be drawn, and how they can be updated dynamically. Such approaches provide a route to developing analytical interface(s) between volcano monitoring analyses and probabilistic hazard analysis. We discuss the use of BBNs in hazard analysis as a tractable and traceable tool for the rational assimilation of complex, multi-parameter data sets in the context of volcanic crisis decision support.