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Evaluating uncertainty and probabilistic forecast skill in volcanic hazard and risk assessments

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The Soufriere Hills volcano in Montserrat has been erupting, with time-varying levels of activity and intensity, for nearly 15 years. Since late 1997, a consistent risk estimation approach has been used in more than 21 successive biannual meetings, with risk calculated from probabilistic forecasts of event scenarios and population numbers. The outcomes of these forecasts are amenable to quantitative analysis, the first time such an appraisal has been undertaken for scientific advice during a volcanic crisis. The assessment cycle involves forecasts over the following 6 or 12 months. We cannot predict sensu stricto the exact timing, locations and magnitudes of dangerous volcanic events at the Soufriere Hills volcano, except in very exceptional circumstances, and certainly not for years ahead. Nevertheless the capabilities of the Montserrat Volcano Observatory have improved with effort and experience, and computer models of hazardous processes have advanced during the eruption. Confirming that these improvements have resulted in better forecasts is difficult because their effects cannot be separated easily from the temporal and intensity variations in activity and other changeable elements of the hazard/risk assessment process. Expert judgments concerning potential hazardous scenarios and their uncertainties are the main source of information that go into the risk assessment process, reflecting experience of similar eruptions elsewhere whilst conflating this in a Bayesian manner with the properties of the Montserrat volcano. Important scenarios for assigning risk relate to vulnerable populated areas, involving incursion of pyroclastic flows or directed lateral blasts; neither have happened to an unevacuated area, so these forecasts cannot be tested directly. However, 110 scenario probabilities can be examined against actual outcomes using the Brier Skill Score. Of these, 75 might be termed safety-critical had the areas been occupied, and for 83% of these a positive forecast skill score was achieved. Thus the experts have outperformed an "uninformed" baseline probabilistic forecast in the majority of cases, underlining the value for decision support for civil protection. This forecast skill can be expressed also in terms of an equivalent financial investment gain, which make the benefits of the scientists' forecast performance more readily understandable to decision makers, and the public generally.