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The Value, Protocols, and Scientific Ethics of Earthquake Forecasting

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Earthquakes are different from other common natural hazards because precursory signals diagnostic of the magnitude, location, and time of impending seismic events have not yet been found. Consequently, the short-term, localized prediction of large earthquakes at high probabilities with low error rates (false alarms and failures-to-predict) is not yet feasible. An alternative is short-term probabilistic forecasting based on empirical statistical models of seismic clustering. During periods of high seismic activity, short-term earthquake forecasts can attain prospective probability gains up to 1000 relative to long-term forecasts. The value of such information is by no means clear, however, because even with hundredfold increases, the probabilities of large earthquakes typically remain small, rarely exceeding a few percent over forecasting intervals of days or weeks. Civil protection agencies have been understandably cautious in implementing operational forecasting protocols in this sort of "low-probability environment."

This paper will explore the complex interrelations among the valuation of low-probability earthquake forecasting, which must account for social intangibles; the protocols of operational forecasting, which must factor in large uncertainties; and the ethics that guide scientists as participants in the forecasting process, who must honor scientific principles without doing harm.

Earthquake forecasts possess no intrinsic societal value; rather, they acquire value through their ability to influence decisions made by users seeking to mitigate seismic risk and improve community resilience to earthquake disasters. According to the recommendations of the International Commission on Earthquake Forecasting (www.annalsofgeophysics.eu/index.php/annals/article/view/5350), operational forecasting systems should appropriately separate the hazard-estimation role of scientists from the decision-making role of civil protection authorities and individuals. They should provide public sources of information on short-term probabilities that are authoritative, scientific, open, and timely. Alert procedures should be negotiated with end-users to facilitate decisions at different levels of society, based in part on objective analysis of costs and benefits but also on less tangible aspects of value-of-information, such as gains in psychological preparedness and resilience.

Unfortunately, in most countries, operational forecasting systems do not conform to such high standards, and earthquake scientists are often called upon to advise the public in roles that exceed their civic authority, expertise in risk communication, and situational knowledge. Certain ethical principles are well established; e.g., announcing unreliable predictions in public forums should be avoided, because bad information can be dangerous. But what are the professional responsibilities of earthquake scientists during seismic crises, especially when the public information through official channels is thought to be inadequate or incorrect? How much should these responsibilities be discounted in the face of personal liability? How should scientists contend with highly uncertain forecasts? To what degree should the public be involved in controversies about forecasting results? No simple answers to these questions can be offered, but the need for answers can be reduced by improving operational forecasting systems. This will require more substantial, and more trustful, collaborations between scientists, civil authorities, and public stakeholders.