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May 26, 2009

Dr. Suzette Kimball, Acting Director
U.S. Geological Survey
12201 Sunrise Valley Drive
Reston, Virginia 20192

Dear Dr. Kimball,

On behalf of the National Earthquake Prediction Evaluation Council (NEPEC), I am writing to provide you with the Council's perspective on the Collaboratory for the Study of Earthquake Predictability (CSEP). This international research collaboration was initiated by the Southern California Earthquake Center (SCEC), a consortium based at the University of Southern California that is jointly funded by the National Science Foundation and the U.S. Geological Survey (USGS). CSEP was created to foster rigorous application of the scientific method to the field of earthquake prediction research. CSEP testing centers provide resources to run earthquake prediction computer programs, to conduct prospective prediction experiments, and to evaluate the predictive strength of proposed methods. SCEC developed the first testing center with support from the Keck Foundation, and additional testing centers have been developed abroad.

At the request of the USGS Earthquake Hazards Program, NEPEC evaluated CSEP at a meeting held on September 10, 2008. Specifically, we were asked to comment on whether the CSEP approach is important and worthwhile, whether its current approach and capabilities are useful for NEPEC and USGS, what capabilities should be added to CSEP, and whether it would be appropriate for USGS to provide financial support to the SCEC testing center. We were briefed on CSEP's current capabilities and future plans by Tom Jordan, Director of SCEC, and Danijel Schorlemmer, CSEP's science lead at the SCEC testing center.

NEPEC's recommendations, provided in more detail below, are that CSEP is an important research activity that is relevant to your Stafford Act responsibility to provide Federal guidance on earthquake predictions, and that USGS should play a part in supporting the future operation of the CSEP testing center at USC.

Background

CSEP was created to address a need—well recognized in the earth science community—for a more rigorous approach to posing earthquake predictions and independent testing of predictions. Many predictions are posed vaguely, making them difficult or impossible to evaluate. And all too often a researcher "goes public" with a prediction method that appears to be promising based on a small number of apparent successes, whereas it generally requires a substantial record of performance to establish that a method does better than educated guessing. To address this situation and make progress in earthquake research, CSEP provides standards and rules for both formulation and objective testing of earthquake prediction methods. Its testing centers provide software tools and services for the formal testing of prediction models. Staff are available to assist investigators in developing prediction methods in a form amenable for testing by CSEP. Prediction models submitted for testing are housed by CSEP and cannot be altered or influenced by the investigator once the test begins. Therefore, the results of the testing can be directly compared to model features, without ambiguities that have often plagued such attempts.

The initial testing center at USC was developed under the auspices of SCEC with a substantial grant from the Keck Foundation. Testing centers funded by the host countries have also been established in New Zealand, Japan and the European Union, and are being considered in China and elsewhere. Tests in certain "natural laboratories" (such as California), which have abundant data on faults and seismicity, are currently underway, and global tests are under development. Tests typically are five years in length, and predict the rate of earthquakes of magnitude 5 and larger. Tests for California begun under the earlier SCEC/USGS Regional Earthquake Likelihood Methods project have been running about three years. Additional five-year tests begun under CSEP have been running two and a half years. Additional tests of daily forecasts for magnitude-4 or greater earthquakes are also being conducted. The duration of these tests was chosen such that the likely number qualifying earthquakes is great enough to reveal contrasts between the performance of competing models.

CSEP currently accommodates only prediction methods based on observed seismicity catalogs, with predictions expressed as probabilities of occurrence at a grid of geographic locations. CSEP evaluates the predictions using sophisticated statistical testing methods, and compares the performance of various methods that use common input data (such as the catalog of earthquake times and locations).

Comments and recommendations

NEPEC finds the CSEP concept and approach to be very worthwhile. It establishes an unbiased framework to evaluate prediction methods, enforces strict adherence to the scientific method, motivates investigators to accurately and unambiguously express prediction hypotheses, and provides guidance and tools on formal testing of those hypotheses. These features should lead to progress in evaluating seismicity-based models. In fact, the very process of creating a testable prediction hypothesis can reveal shortcomings or incomplete features of the prediction method. By comparing different

forecasts that are computed from common data, contrasts in performance can be tied to specific features of the prediction method. Even for prediction methods that are not currently testable by CSEP, the collaboratory demonstrates a proper approach and illustrates the need for, and benefits of, rigor and patience. Additionally, CSEP is commended for taking leadership in organizing an international effort to address this important and difficult topic at the broadest scale possible.

The current CSEP activities focus on comparative testing of prediction methods based on seismicity and fault information that provide probabilistic predictions of moderate-magnitude earthquakes on a geographic grid. This approach is optimized to achieve useful statistics in a short time and to advance the research field by providing insights into the predictability of earthquakes. It supports the research of those who choose to participate in the collaboratory; however, it is currently of limited direct use to NEPEC and the USGS because earthquakes that pose a risk to the nation are larger, and because predictions are often posed in a variety of ways that cannot currently be evaluated by CSEP. The NEPEC is most likely to be called upon to advise USGS on persistent, visible hypotheses such as the M8/MSc predictions for global earthquakes, the "reverse detection of precursors" method, or the "RIPI" method, each of which analyze temporal and spatial variations in seismicity, or methods based on other observable quantities such as electromagnetic field, ground temperature, gaseous emissions, geodetic deformation, or changes in seismic wave speed. Many of the most visible and influential earthquake predictions are posed as "alarms" or "times of increased probability" (TIPs) within some specified region rather than as probabilities on a grid of points. NEPEC may also be asked to evaluate emerging situations such as earthquake swarms, the likelihood of damaging aftershocks or triggered earthquakes following major quakes, or the likelihood of re-rupture of a fault following a major earthquake. The usefulness of CSEP to USGS would be significantly increased with the added capability to evaluate alarm-based predictions for larger earthquake magnitudes. This might involve comparisons of earthquake occurrence within TIP space/time windows against probabilities based on one or more simple null models of seismicity.

Prediction methods currently being tested by CSEP include many that are complex and hard to explain to non-specialists. The existing statistical tests are similarly complex. It would be useful for CSEP to test some very basic prediction methods, such as spatially uniform probability, to serve as null hypotheses and points of reference. It would then be straightforward, for example, to demonstrate that even modestly complex methods, such as the USGS Short-Term Earthquake Probabilities (STEP) model that underlies the 24-Hour Aftershock Forecast Map for California posted on the USGS website, do better than the simpler methods. Likewise, a broader suite of statistical tests, spanning the range from straightforward to sophisticated, would allow some prediction methods to be easily disproven in a way that's clear to researchers, the media and the public, while providing the rigorous analysis required for comparative testing. These should include statistical tests applicable to alarm-based prediction methods.

Often, USGS is faced with the need to quickly comment on a prediction or emerging situation, without the time or ability to gain insight from a prolonged prospective test.

There is a continuing unmet need to develop a suite of basic tools and reference models to rapidly establish a framework to put earthquake predictions into context. Although the USGS Earthquake Hazards Team has staff with the expertise to develop and test such tools, those scientists are already heavily committed. This need could be addressed by CSEP and logically falls under its mission.

CSEP has developed procedures and safeguards that protect the intellectual property of investigators. There are issues of ownership and availability of results, and publication of findings, that deserve continued discussion so that prediction researchers have the knowledge and comfort to submit their prediction methods for testing by CSEP.
The Keck Foundation grant funded the development of CSEP through a philanthropic grant. That grant is expiring within months, and SCEC plans to request a substantial amount of USGS support to continue to operate the CSEP testing center. NEPEC believes that it appropriate that USGS play a part in supporting CSEP. Given the highly constrained budget of the USGS Earthquake Hazards Program, it is unlikely that the USGS can provide sole support at the level needed to sustain this effort. SCEC should consider additional sources as well; for example, NASA vigorously supports earthquake prediction research, so support from that agency would be appropriate and should be pursued. Lastly, USGS researchers interested in earthquake occurrence, statistics, forecasting and prediction should be encouraged to collaborate with CSEP.

Sincerely,

{signed}

James H. Dieterich
Chair, National Earthquake Prediction Evaluation Council