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**2009 SCEC Report 09137:**

Global and Regional Earthquake Forecasts

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We constructed long- and short-term earthquake forecasts for CSEP (Collaboratory for the Study of Earthquake Predictability) natural labs including New Zealand, Japan, the Mediterranean area, and the whole globe. Our ultimate goal is to develop forecasting and testing methods to validate or falsify common assumptions regarding earthquake potential. Our immediate purpose is to extend the forecasts we made in 1999 for the northwest and southwest Pacific to include somewhat smaller earthquakes, adapt the methods to apply in other areas, and test the resulting forecasts against others. The previous forecasts used the CMT earthquake catalog to forecast magnitude 5.8 and larger earthquakes. Like our previous forecasts, the new ones here are based on smoothed maps of past seismicity and assume spatial clustering. Our short-term forecasts also assume temporal clustering. We expanded our forecast based on the CMT catalog to the whole world. The application of the present methodology to other subduction zones does not present any fundamental difficulty, and these subduction earthquakes constitute a major part of the global seismicity. So far we have relied on tensor focal mechanism solutions to forecast both the locations and focal mechanism of future earthquakes. We developed CMT-based forecasts for all natural labs, but we also introduced a new approach that circumvents the need for focal mechanisms. This permits use of earthquake catalogs that reliably report many smaller quakes but no such mechanism estimates. The result is that we forecast earthquakes at higher spatial resolution and down to a magnitude threshold of 5.0 and perhaps as low as 4.7. The new forecasts can be tested much more quickly because smaller events are much more frequent. We developed two global forecast based on two catalogs – the CMT and PDE. Figs. 1-3 display examples of our forecasts and their testing.

Below we list publications (with appropriate SCEC publication numbers) and abstracts, related

to the topic of this proposal and finished during the proposal duration.

PUBLICATIONS:


1. Kagan, Y. Y., 2009. On the geometric complexity of earthquake focal zone and fault systems: A statistical study, *Phys. Earth Planet. Inter.*, **173**(3-4), 254-268, DOI: 10.1016/j.pepi.2009.01.006, SCEC #1256.
2. Kagan, Y. Y., 2009. Testing long-term earthquake forecasts: likelihood methods and error diagrams, *Geophys. J. Int.*, **177**(2), 532-542, SCEC #1252.
3. Bird, P., Y. Y. Kagan, D. D. Jackson, F. P. Schoenberg, and M. J. Werner, 2009. Linear and nonlinear relations between relative plate velocity and seismicity, *Bull. Seismol. Soc. Amer.*, **99**(6), 3097-3113 (plus electronic supplement), SCEC #1264.
4. Kagan, Y. Y., 2010. Statistical distributions of earthquake numbers: consequence of branching process, *Geophys. J. Int.*, **180**(3), 1313-1328. doi: 10.1111/j.1365-246X.2009.04487.x, SCEC #1304.
5. Kagan, Y. Y., P. Bird, and D. D. Jackson, 2010. Earthquake Patterns in Diverse Tectonic Zones of the Globe, *Pure Appl. Geoph.* (*The Frank Evison Volume*), **167**(6/7), in press, DOI: 10.1007/s00024-010-0075-3, SCEC #1244.
6. Kagan, Y. Y. and D. D. Jackson, 2010. Earthquake forecasting in diverse tectonic zones of the Globe, *Pure Appl. Geoph.* (*The Frank Evison Volume*), **167**(6/7), in press, DOI: 10.1007/s00024-010-0074-4, SCEC #1245.
7. Kagan, Y. Y. and D. D. Jackson, 2010. Short- and long-term earthquake forecasts for California and Nevada, *Pure Appl. Geoph.* (*The Frank Evison Volume*), **167**(6/7), in press, DOI: 10.1007/s00024-010-0073-5, SCEC #1246.
8. Console, R., D. D. Jackson and Y. Y. Kagan, 2010. Using the ETAS model for catalog declustering and seismic background assessment, *Pure Appl. Geoph.* (*The Frank Evison Volume*), **167**(6/7), in press, DOI: 10.1007/s00024-010-0065-5, SCEC #1257.
9. Kagan, Y. Y., 2010. Earthquake size distribution: power-law with exponent $\beta \equiv \frac{1}{2}$ ?, *Tectonophysics*, in press, DOI: 10.1016/j.tecto.2010.04.034, SCEC #1418.
10. Werner, M.J., A. Helmstetter, D.D. Jackson, and Y.Y. Kagan, 2010. High resolution long- and short-term earthquake forecasts for California, BSSA, in review.

11. Werner, M.J., A. Helmstetter, D.D. Jackson, Y.Y. Kagan, and S. Wiemer, 2010. Adaptively smoothed seismicity earthquake forecasts for Italy, submitted to CSEP-Italy special issue in *Annals of Geophysics*, in review.

12. Chu, A., Schoenberg, F.P., Bird, P., Jackson, D.D., Kagan Y.Y., 2010. Comparison of ETAS parameter estimates across different global tectonic zones, *Bull. Seismol. Soc. Amer.*, submitted, in review.

ABSTRACTS

13. Werner, M. J., D. D. Jackson and Y. Y. Kagan, 2009. 24h High-Resolution Earthquake Forecasts for California IASPEI, abstract, see http://www.iaspei.org/downloads/Abstracts_2009/E3.pdf

14. David D. Jackson, Yan Y. Kagan, and Danijel Schorlemmer, 2009. Global earthquake forecasts and how to test them, IASPEI, abstract, see http://www.iaspei.org/downloads/Abstracts_2009/E3.pdf

15. Maximilian Werner (ETH Zurich), Agnes Helmstetter (LGIT, Univ. Grenoble), David Jackson (UCLA), Yan Kagan (UCLA), 2009. HIGH RESOLUTION LONG- AND SHORT-TERM EARTHQUAKE FORECASTS FOR CALIFORNIA, International Symposium on Earthquake Seismology and Earthquake Predictability, Beijing, 8 July 2009, http://www.cea-igp.ac.cn/English/Symposium/Slides

16. Werner, M. J., A. Helmstetter, D. D. Jackson and Y. Y. Kagan, 2009. High-Resolution Long-Term Earthquake Forecasts for California and Italy, EGU, EGU2009-12045, abstract.

17. Kagan, Y. Y. and Jackson, D. D., 2009. Global earthquake forecasts, SSA 09-144, *Seismol. Res. Lett.*, (SRL), **80**(2), abstract, pp. 376-7.

18. Jackson. D. D., Y. Y. Kagan, D. Schorlemmer, J. D. Zechar, Q. Wang, K. Wong, 2009. Prospective testing of Coulomb short-term earthquake forecasts, AGU Fall Meeting, Abstract S22C-01.

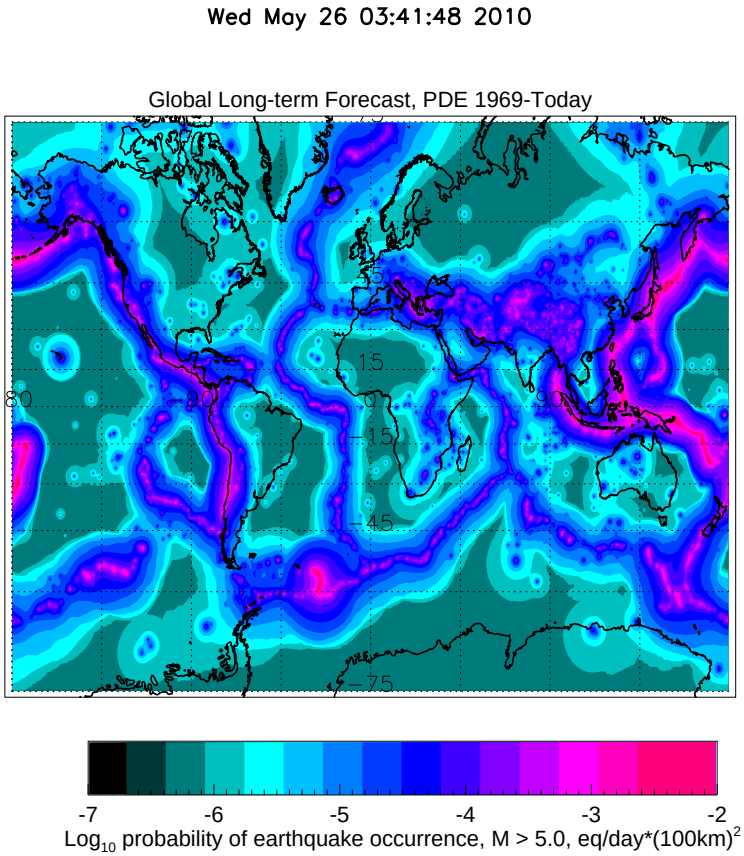


Figure 1:

Global earthquake long-term potential based on smoothed seismicity. Earthquakes ($M \geq 5.0$) from the PDE catalog since 1969 are used. Earthquake occurrence is modelled by a time-independent (Poisson) process. Colors show the long-term probability of earthquake occurrence.

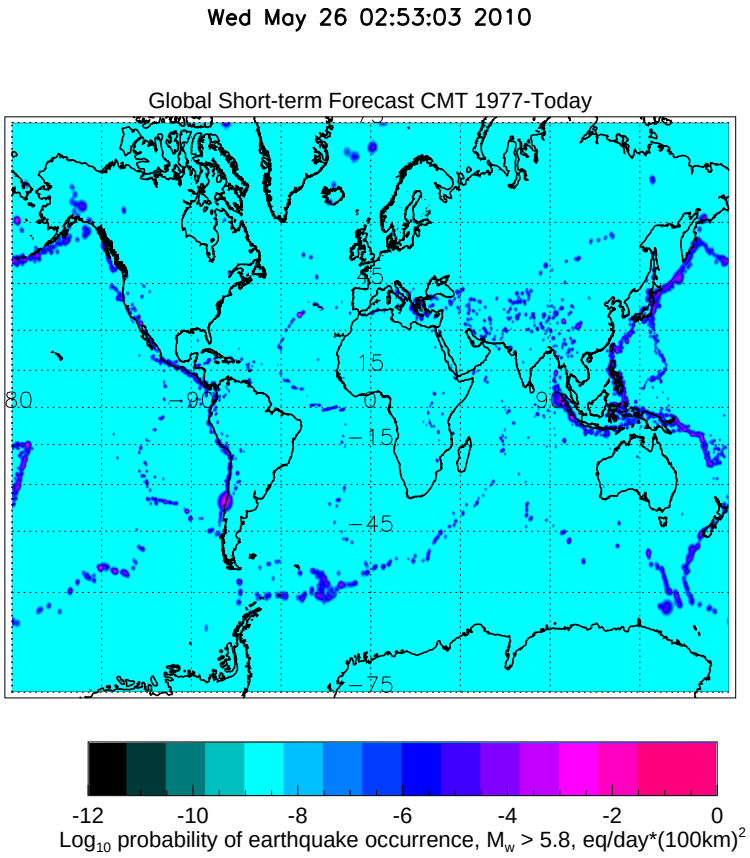


Figure 2:

Global earthquake short-term potential based on smoothed seismicity. Earthquakes ($M_W \geq 5.8$) from the CMT catalog since 1977 are used. Earthquake occurrence is modelled by a temporal process controlled by Omori's law type dependence. Colors show the long-term probability of earthquake occurrence.

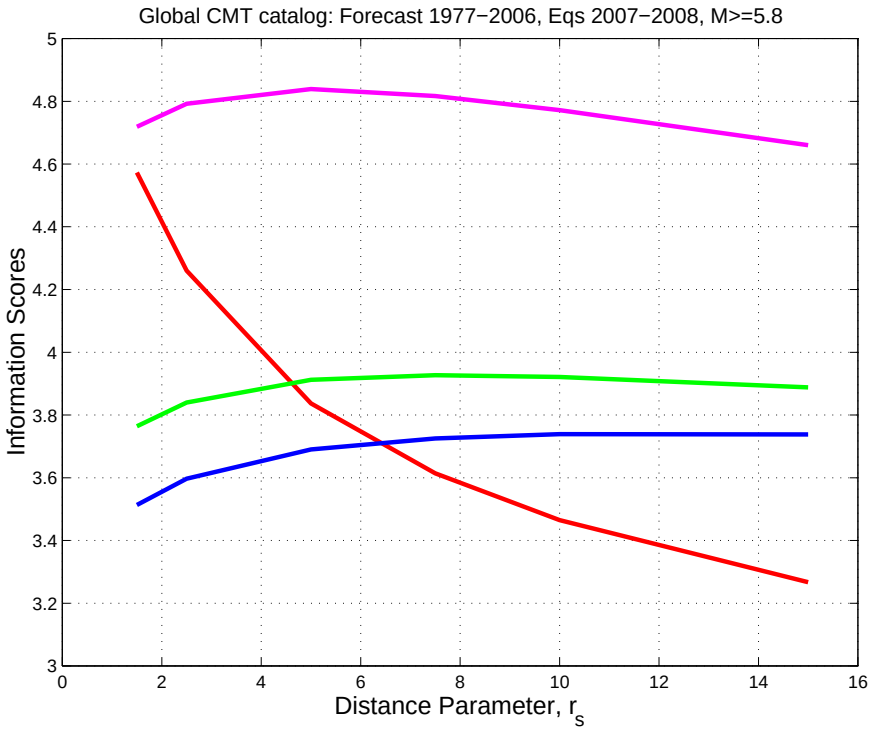


Figure 3:

Dependence of information scores on the smoothing scale parameter $r_s$ for the 2007-2008 forecast based on the CMT catalog for 1977-2006. Red line is $I_0$ score, blue – $I_1$, green – $I_2$, and magenta line is for $I_1'$ (Kagan, GJI, 2009, SCEC #1252).