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Expectations of seismic hazard and risk, predictions, and actual aftermaths:

The 11 March 2011 Tohoku mega-earthquake case-history

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The 11 March 2011 mega-thrust off the Pacific coast of Tohoku region, Japan, and its consequences confirmed once again the evident problems of the conventional methodology to calculate the risks and losses from earthquakes and associated phenomena [1]. A systematic comparison of the conventional seismic hazard maps with the actual occurrence of strong earthquakes invalidates the existing false comfort expectations, as the result of probabilistic approach to seismic hazard assessment. The numbers of fatalities and people affected by recent large disastrous earthquakes were underestimated by approximately two orders of magnitude and more than three orders of magnitude for mega-earthquakes [2]. Deterministic and neo-deterministic methods should be used instead, in which approach, scenario computations of the possible losses, which consider the fragility of the local built environment and soil conditions, furnish far more informative risk assessments [3].

Moreover, a novel understanding the complexity of non-linear dynamics of hierarchically organized systems progresses to new approaches in assessing hazard and risk of the extreme catastrophic events. In particular, a series of studies of seismic process along with its non-stationary though self-organized behaviors, has led already to reproducible intermediate-term middle-range earthquake forecast/prediction technique that has passed rigid control in real-time applications during the last two decades [4]. Specifically, in the course of the ongoing since 1992 Global Test of the intermediate-term middle-range predictions by the M8 and MSc algorithms place and time of the mega-earthquakes of 27 February 2010 in Chile and 11 March 2011 in Japan were recognized as in state of increased probability of such events in advance their occurrences [5]. In conjunction with a retrospective analysis of seismic activity preceding the first of a series of mega earthquakes of the 21st century, i.e., 26 December 2004 in the Indian Ocean, these evidences give grounds for assuming that these algorithms of proven validated effectiveness in magnitude ranges M7.5+ and M8.0+ can be applied to the mega-earthquakes (M8.5+ and

M9.0+) as well.

In fact, there was a missed opportunity for implementing important disaster preparedness measures following an earthquake prediction that was diagnosed in mid-2001. This intermediate-term middle-range prediction was the initiation of a chain of alarms that eventually detected in the time, region, and magnitude range for the magnitude 9.0 Tohoku earthquake [6]. The prediction chains (Fig.1) could have been utilized to implement measures and improve earthquake preparedness in advance; unfortunately this was not done, in part due to the predictions' limited distribution and the lack of applying existing methods for using intermediate-term predictions to make decisions for taking action. Davis et al [6] show how the 2001 prediction may have been utilized to reduce significant damage, including damage to the Fukushima nuclear power plant. The case-history also (i) exemplifies that prudent cost-effective actions can be taken if the prediction certainty is known, but not necessarily high, and (ii) demonstrates how the prediction information can be strategically used to enhance disaster preparedness and reduce future impacts from the world's largest earthquakes.

References

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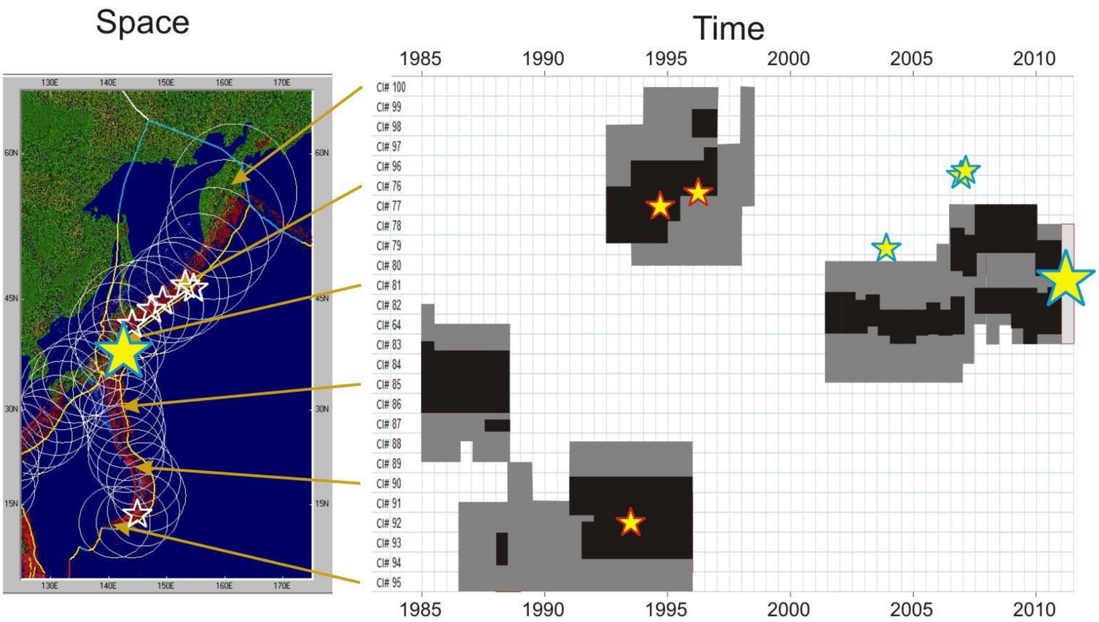

Fig. 1: Global testing of algorithms M8 and MSc aimed at magnitude range M ≥ 8.0: Space-time distribution of alarms from Kamchatka to the Marianas. Circles of Investigation (CI, white) are shown on the left; the space-time distribution of alarms from 1985-2011 is on the right (dark grey for M8 and black for MSc). The space coordinate is the distance along the belt (six arrows point to the centers of corresponding circles of investigation. Great earthquakes are marked by stars. The 2011 off the Pacific coast of Tohoku Earthquake is indicated by the big star.