

OECD Global Science Forum

Workshop on Earthquake Science and its Contribution to Society and Follow up Expert Meeting

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Chairman's preliminary report on findings and recommendations

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by the Delegation of Germany

Background

A proposal to organize a workshop on earthquake science was made by the German delegation at the Eleventh Meeting of the Global Science Forum. Following recommendations from GSF delegates, a Steering Committee was set up, comprising eleven members from nine countries (Australia, France, Germany, Italy, Japan, Norway, Switzerland, Turkey and the United States) and chaired by Prof. Jochen Zschau, to refine the scope and content of the workshop. As a result of this work, the Steering Committee proposed that the Global Science Forum convene a workshop to explore the opportunities for new and/or enhanced international co-operation in the field of earthquake sciences in connection to their contribution to society.

This workshop was held in Potsdam, Germany, on June 1-2, 2006. The focus was on major advances in fundamental understanding of the complexity of earthquakes (not only of the source problem but of the full seismic cycle), and on how best to exploit these advances for the benefit of society.

Principal topics discussed at the workshop

The workshop was divided into five sessions, each introduced by a keynote presentation. During a longer concluding discussion period at the end of the workshop, participants debated on possible recommendations on the broad scientific perspectives and generic issues of relevance to governments.

1. Earthquake process

This session addressed the following challenging question: why, where, when and how do earthquakes occur ? (prediction, generation, potential, mega-events, modelling...)

2. Hazard assessment

Recent advances in earthquake science are used to predict the ground shaking during earthquakes and assess seismic hazard in exposed regions. This session was focused on the needs to compute hazard maps, predict ground motion, calculate probabilities of earthquake occurrence and evaluate time-dependent hazard. (time-dependence, forecasting, probabilities, aftershocks...)

3. Data issues

Earthquake data come from a network of observatories around the globe. Current and future challenges were discussed regarding increasing availability and demand for data, long-term infrastructure for open access to data, real-time access, lack of information from ocean bottom. (access, distribution, instrumentation, target in critical areas, ocean floors...)

4. Rapid earthquake information

The objective of this session was to discuss how the seismological community can serve the demand from the civil community during and immediately after an earthquake. Questions addressed the need for early warning systems, the extent of data coverage required, the level of detailed information required, alerting procedures, and primary audience for rapid earthquake information (scenarios, early warning, shake maps, alert procedure, response measures...).

5. From science to application

Society tends to be poorly prepared to deal with extreme natural events. The issues raised during this last session dealt with the transfer of information and knowledge from earthquake science to the policy and civil communities to tackle prevention and mitigation aspects of earthquakes (technology transfer, risk assessment, education and training, mitigation...).

Findings and recommendations

Each session of the workshop produced a set of findings and recommendations, respectively, which are summarized below. They address the present society-oriented research demands being most important in the field of earthquake science, and may serve as guidelines for policy and decision makers. In the concluding discussion at the end of the workshop an attempt was made to prioritize the recommendations with regard to their impact on society. As a result the participants of the workshop agreed to one principal recommendation that underlines the need for and feasibility of internationally co-ordinated *global earthquake risk mapping and monitoring* as a basis for effective and economically justified risk mitigation measures.

1. Earthquake Process

Findings

- Better understanding of the earthquake process is considered an absolutely necessary precondition for
 - making progress in earthquake prediction research,
 - improving earthquake hazard information, assessment and methodology as well as long-term forecasting, and for
 - predicting realistic earthquakes scenarios as basis for decisions on the appropriate prevention strategy to follow.
- Frictional properties at plate interfaces for interplate earthquakes and at active fault planes for intraplate earthquakes as well as their relation to asperities and other coupling mechanisms are considered key parameters for understanding the earthquake generation process.

Recommendations

- Our basic understanding of the whole earthquake generation cycle should be improved by combining field observations with laboratory experiments, modelling and computer simulations.
- The coupling mechanisms and frictional properties at active faults including the influences of pore pressure and asperities should be a major focus of research related to earthquake process understanding.

2. Hazard Assessment

Findings

- Present probabilistic seismic hazard approaches (PSHA) widely used in the earthquake engineering community, still have large epistemic and aleatory uncertainties.
- A robust and shared validation of the available numerical procedures for assessing seismic hazard, computing earthquake probabilities and calculating ground shaking scenarios is still lacking.
- The next generation of seismic hazard assessment is emerging and will represent a paradigm shift from purely statistical and time-independent towards more realistic, time-dependent and physics-based approaches.
- The probability of loss of life in seismic events is highest for developing countries. Despite this, the present transfer of disaster prevention knowledge (including hazard assessment methodology) to the developing world is far from sufficient.

Recommendations

- Seismological communities should be encouraged to improve probabilistic seismic hazard assessments by combining statistical with deterministic approaches and moving towards time-dependent hazard assessments from a local to a global scale.
- The creation of international validation centres for seismic hazard assessment and for the forecasting of seismicity evaluation should be promoted.
- Closer communication between the seismological and engineering communities should be encouraged for the proper translation of seismic hazard information into engineering and emergency decision-making.
- To foster outreach and preparedness activities, hazard assessment methods and their evaluations should be diffused with the help of special training and education programmes, particularly in the developing world.

3. Data Issues

Findings

- International cooperation in the collection and exchange of seismic waveforms, coordinated under the FDSN, allowed creating a mosaic of regional and national networks complemented by a global backbone of data centers. The role of global projects (GSN, GEOFON, GEOSCOPE) in building the global backbone is recognized.
- Seismology and seismological organizations are not operating under the umbrella of an inter-governmental organization (i.e. UNESCO or WMO), and existing international seismological structures are based on voluntary contributions by countries and associations, with the consequence that (i) in many countries the need for continued, long-term support for local monitoring and hazard assessment is not adequately recognized and supported, and (ii) no global coordination exists in seismic alerting for damaging earthquakes.
- Research activities and applications in earthquake monitoring and more generally in earthquake risk assessment and mitigation, display a high variability between more developed and developing countries.
- 70% of the Earth is covered by oceans, and many disastrous earthquakes and related natural disasters (i.e. tsunamis) originate under water. Monitoring of earthquake phenomena requires a multi-disciplinary approach.

Recommendations

- The coverage and activities of the FDSN should be extended to all countries of the world, increasing access to more seismic networks and eliminating the still existing barriers to the free distribution of data and products, with particular regard to real-time access to data required for the protection of populations and society in case of earthquakes.
- Countries should evaluate with their national seismological agencies the present international structure of seismology, and initiate a discussion on possible future structural changes within their own country.
- Technology transfer and capacity building are required.
- OBS networks and multi-parameter monitoring should be enhanced.

4. *Rapid Earthquake Information*

Findings

- Rapid earthquake information represents a core societal service that earthquake science can provide, particularly for high-hazard urban areas. The value of the information depends on the extent to which it is integrated into emergency response at the local, regional and national level.
- The benefits of rapid EQ information systems have been demonstrated, enabling a focused deployment of limited emergency response resources after an EQ and cutting through the information fog. Cost-benefit analyses, particularly for EEW, are lacking.
- The utility of real-time information depends on other types of datasets (soil, structures, geology) that must be acquired and interfaced well ahead of an event in order to generate accurate estimates.
- Because the epicenter is not synonymous with the region of highest shaking, ShakeMap is a critical tool for local emergency response and situational awareness for lifeline utilities.

Recommendations

- Rapid earthquake information should be a major focus of government investment for high-hazard urban areas. Delivery requires investment in strong-motion seismic networks and robust and redundant communications and data processing systems.
- Any rapid earthquake information or EEW system should be developed in close coordination with potential users in order to ensure that it meets recipient needs.
- Specific research needs?
 - Develop cheap sensor technology to get past cost obstacle
 - Develop better methods for reliably deducing near real-time information on fundamental earthquake parameters of large events within seconds to minutes
 - Carry out cost-benefit analyses for EEW

5. *From science to application*

Findings

- There is a mismatch between the effort and resources that must be devoted to recovering from an earthquake and the effort and resources devoted to preparation and preventing damage before it occurs.
- Overall economic development is, in general, a powerful way to protect society. That is, for natural catastrophes, wealthy countries suffer less than poor ones.

- There is a far-reaching consensus of the scientific community that our understanding of the earthquake process is not yet sufficient to realize short-term earthquake prediction in the foreseeable future. The question of short-term earthquake predictability is still a domain of basic research.
- There is a need to do more to apply the insight, knowledge, expertise and technologies that have been developed through cutting edge research (mostly in industrialised countries) to actually reducing the impact of earthquakes, especially in developing countries.

Recommendations

- A cost-benefit approach to earthquake protection should be encouraged.
- To bridge the gap between science and application will require moving from understanding the hazard to reducing the risk. In particular, this means that earthquake scientists need to obtain and incorporate knowledge about local vulnerability, develop earthquake scenarios (for effectively communicating risk to non-scientists) and foster close interactions between earthquake scientists and many diverse stakeholder communities.
- Risk assessment and improved public outreach should be promoted especially in less developed countries through:
 - (1) Basic and applied science (physics of earthquakes, hazard assessment, data and rapid response)
 - (2) Education and outreach (training, publications, the media and internet)
 - (3) Infrastructure changes (international, national and local), and
 - (4) Emergency response preparedness (damage scenarios, evacuation measures and response to disruption of vital services).

Proposal for a Global Earthquake Risk Map

The principal recommendation from the Potsdam Workshop was to invite interested countries to begin working on a new international project for the creation of a “Global Earthquake Risk Map”. At the last meeting of the Global Science Forum in Helsinki, delegates requested that workshop participants explore further the substance and the practical aspects of this recommendation. At the invitation of the Turkish delegation, an experts meeting (13 experts from China, Germany, Italy, Japan, Norway, Switzerland, Turkey and the United States), took place in Gebze (Turkey) at a Tübitak research centre on 25-26 January 2007, to address these issues.

During this meeting, the goals, content and methodologies of a follow-on activity were agreed upon.

The goal of the initiative is to create a global earthquake risk analysis information resource, using internationally agreed standards. Its activities would be focused on:

- elaborating a probabilistic model for global change of earthquake risk
- monitoring and forecasting the emerging risk of earthquake disasters globally
- comparing the earthquake risk between regions worldwide
- running characteristic loss/damage scenarios for seismic hotspots on a global scale

The information provided would be useful for global risk monitoring, global risk comparison, policy and decision making, risk management, etc.

This resource would provide a model, not just a map. This model would be continuously updated and adapted to the dynamic changes in vulnerability (for example, using new satellite remote sensing techniques for monitoring). This would need to be taken into account in the organizational structure. Models would be built sequentially (in different phases) to provide information on seismic hazard, ground shaking, potential damages to dwellings and potential loss of lives, property and infrastructure. In the future, it could also provide additional information on environmental and social damage. The model should be able to provide probabilistic maps as well as deterministic scenarios.

A technically consistent model is proposed, rather than a model built by consensus. The meeting participants agreed that, in order to ensure a global homogeneity of the information, the needed standards and methodologies should be defined by an international expert group, rather than be the result of just aggregating information from individual national models. They should cover the whole risk chain, including seismic hazard, local site effects, vulnerability assessment and risk assessment. Although the first phases (concerning hazard assessments) will be mostly of a purely scientific nature, close interactions with engineers should be ensured during the subsequent damage assessments phases. For the hazard assessment component, the model will not rely exclusively on an improved Global Seismic Hazard Assessment map (GSHAP map) but should take into account new approaches to hazard estimation.

The spatial resolution at which information can be provided should be at least at community level. It will depend on existing data and future national, regional and international efforts aimed at acquiring and compiling such data, but the agreed objective is to provide hazard and risk information at a 10-20 km scale, with zooming capacities on hot spots and major cities (a “Google Earth-like” system). The end-product should be a transparent internet-based tool, offering easily accessible information not only to expert user groups but also to non-specialists.

Damage assessment information should be provided using both macro-seismic (empirical) and analytical approaches (based on intensity and ground displacement, respectively). Damage assessment using ground displacement information may be more accurate when good data are available, but problems in defining and calibrating damages arise when such data are not available.

Expected use and impact for such a resource includes:

- Possibilities for global risk monitoring, global risk comparison and future risk prediction
- Contributing to raising earthquake risk awareness and enabling populations (especially in developing countries) to confront such a hazard
- Providing useful frameworks for stimulating the cat bond (catastrophe bond) and derivative market (and hence providing affected governments with immediate cash for recovery), policy and decision making, and earthquake risk management

Action item

Several key questions regarding this proposal remain to be addressed: defining an organisational model (national or international umbrella?), a business plan (potential stakeholders, contributors), solutions for the continual updating of the information and long-term funding of the platform, solutions for data access, interoperability, etc.

The proposal to the GSF is to endorse such a follow-on activity, and to agree to establish a Working Group with interested governments and other potential stakeholders to move this initiative forward.