Global Earthquake Model:

Uniform and Open Standards to Calculate and Communicate Earthquake Risk

Rui Pinho | Secretary General, GEM Foundation
“A collaborative effort devised and launched by OECD’s Global Science Forum, aimed at engaging the global community in the design, development and deployment of state-of-the-art models and tools for earthquake risk assessment worldwide”
Seismic risk mitigation requires accurate, consensual and uniform risk estimates.

Since strong earthquakes know no political boundaries and occur relatively rarely, a global knowledge-sharing approach is required, which should lead also to the development of socio-economic impact assessment tools, including cost-benefit analysis, involving both the public and the private sectors, as well as international organisations, professionals associations and the wider community.
PUBLIC-PRIVATE PARTNERSHIP

9 countries have adhered so far

7 private organisations have partnered up with GEM so far

they contribute 13.6 M Euro

discussions and negotiations are ongoing with 15+ others

the OECD, WorldBank, UNESCO, UN/ISDR, IAEE and IASPEI are associative participants
PRIVATE PARTICIPANTS

Founders:

Munich RE 5 Mill. €
ZURICH 3 Mill. €

Sponsors:

AIR WORLDWIDE 1 Mill. €
Willis 1 Mill. €
EUCENTRE 1.6 Mill. €

FM Global 1 Mill. €
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Interaction between the OpenQuake calculation software, the OpenGEM risk assessment platform, the Regional Programmes and Global Components for the development of the GEM model between 2011 and 2013.
GLOBAL COMPONENTS

For and from the community..

- **scientific modules** of GEM that are developed at a global scale to provide standards, methods and tools for global datasets
- addressed by **international consortia** that respond to Requests for Proposals (RfPs) released periodically by the Scientific Board
- before consortia are selected there is a thorough process of **expert elicitation, community feedback, and peer review**
- provide the **global framework** for the model which will be reviewed and further developed by the Regional Programmes to ensure they are adequate for regional needs and characteristics
GLOBAL COMPONENTS MAIN MODULES

Seismic Risk

Seismic Hazard
- Probability
- Intensity
- Location

Exposure
- Buildings
- People

Vulnerability
- Physical
- Social

Socio-Economic Impact
- Relief/Recovery/Mitigation
  - Local/Regional/National
Global Earthquake History

Objective is to build up a Global Earthquake History, based on existing regional initiatives and to support regional capacities, considering mainly earthquakes with $M \geq 7.0$, in the time window 1000 to 1903.

In particular, will produce a common set of definitions, strategies, standards, quality criteria and formats for the compilation of historical earthquake data.

INGV, BGS and a number of international experts and collaborators. More than 50% of the resources are set aside for will be executed with local collaborators from various regions.
Global Instrumental Earthquake Catalogue

A global instrumental catalogue covering the period 1900-2009 in a database that includes: 110 years of relocated earthquake hypocenters; recomputed Ms values for relocated events; Mw values based on seismic moment where possible (mainly 1980-2009) and proxy values in other cases using appropriate empirical relationships; scanned historical bulletin pages.

ISC, IASPEI, IES Jaume Almera, Colorado University, GFZ and SISMOS
Global Active Fault and Seismic Source Database

- Compilation of a global database of active faults by:
  - developing a commonly accepted flexible database standard for faults and seismic sources;
  - creating an accurate and uniform inventory of the world’s faults;
  - creating a database of active faults and seismic sources;
  - studying more closely faults near mega-cities;
  - creating easy-to-use tools and assist in uploading of data to the database.

- GNS Science, Earth Observatory of Singapore (EOS), Universidad Nacional de San Luis
Global Ground-Motion Prediction Equations

Development of a harmonized suite of ground-motion prediction equations (GMPEs) following the definition of a consistent strategy for modelling ground motion. Regional experts involved in the project will subsequently compare observed data in their regions to those predicted by the shortlisted GMPEs to account for possible regional variances.

Pacific Earthquake Engineering Research Center (PEER), 27 experts from all regions of the world.
Global Geodetic Strain Rate Model

- Creation of a comprehensive and uniform model for geodetic strain rates by means of critically reviewing all global and regional studies since 1994, leading to a significant update of the Global Strain Rate Model of 2004. Furthermore, a uniform global GPS velocity database will also be delivered.

- University of Nevada, the Ecole Normale Supérieure, the Chinese Earthquake Administration, University of California and UNAVCO
HAZARD GLOBAL COMPONENTS

Interaction between Hazard Global Components

- Global Active Fault Database
  - e.g. zones of weakness delineation
  - e.g. tools and data (for instance, fault geometries and geology derived strain rates)

- Global Geodetic Strain Rate Model
  - e.g. tools and data

- Global Instrumental Seismic Catalogue
  - e.g. tools and data (for instance, low magnitude seismicity rates)

- Global Ground Motion Prediction Equations
  - e.g. tools and data (for instance, tectonic region dependent GMPEs)

- Global Historical Earthquake Catalogue
  - e.g. EQ parameters determination from macroseismic data
  - e.g. tools and data (for instance, lower bound Mmax)

PSHA Input Model Building Tools
RISK GLOBAL COMPONENTS

GEM Ontology and Taxonomy

Technical communications and coordination programme to support exchange of knowledge and opinions between various GEM collaborators, that can be sustained into the future.

Definition of the concepts used in GEM and the relationship between them: GEM Ontology.

GEM Taxonomy: a classification of things in an ordered system that reflects their relationship.

AGORA, DPRI, PEER, WHE-EERI + a number of experts
Global Vulnerability Estimation Methods

- Provide standards for vulnerability estimation (i.e. the estimation of building damage, both structural and non-structural, and associated social and economic loss) using a number of different methods (empirical, analytical, expert opinion) and a range of measures of ground-motion intensity.

- University of Colorado, University of Chile, Geoscience Australia, EERI, Stanford University, UCL, University of Bath, USGS and Willis
Global Earthquake Consequences Database

Create an infrastructure to assemble and store earthquake consequences data in a web-accessible way. Building damage, damage to lifelines and other infrastructure, ground failure, human casualties, social disruption, and financial and economic loss.

Information on past events, useful for benchmarking analytical loss models and developing empirical loss models. Interface and protocol for collecting future loss information.

CAR Ltd, CRED, ERN-AL, GNS, KOERI, Kyoto University, Munich Re, SPA Risk and USGS
Global Exposure Database

Create the first open database of global building stock and population distribution containing the spatial, structural, and occupancy-related information necessary for damage, loss and human casualty (estimation) models.

University of Pavia, CIESIN-Colombia-Univ., IES-CEA, IGP-CEA, ImageCat, JRC, UN-HABITAT and USGS
Inventory Data Capture Tools

Provide tools that will enable the capture and transfer of high-resolution inventory or damage data into the GED and/or GECD, and develop tools to merge data collected using Remote Sensing with data acquired from Direct Observation.

ImageCat, BGS, CAR, CEDIM, DLR, OpenGeo, University of Nottingham, University of Pavia, SPA Risk, Stanford University and WAPMERR
Interaction between Risk Global Components

1. **GEM Ontology and Taxonomy**: E.g. building typologies, damage and loss scales, building typologies.

2. **Global Exposure Database**: E.g. tools and data.

3. **Inventory Data Capture Tools**: E.g. building typologies, e.g. tools and data.

4. **Global Vulnerability Estimation Methods**: E.g. tools and data, e.g. calibration and comparison.

5. **Global Earthquake Consequences Database**:
Crowdsourcing

“Crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call.” Jeff Howe, June 2006
Socio-Economic Impact

The main objective is to provide the community with a set of methods for assessing, estimating and communicating impacts of earthquakes on variables that are deemed as representative of the social and economic system. The choice of methods to include and of principles on how to organise them, will be defined together with the community, under a participatory framework.

Three proposals received and currently under peer review.
Feeding and feedbacking global models..

central-america  africa  middle-east  caribbean  europe
north-america  south-asia  south-america  north-east-asia
south-east-asia &pacific
Regular regional workshops to aid regional and global coordination, typically featuring:

- Discussion of status-quo of regional activities in seismic risk, identifying gaps in knowledge and data
- Presentation of global activities, databases, methods, standards
- Sessions dedicated to technology transfer (software and tools)
Global Vulnerability Standards

- Structural type, material, age, empirical, analytical, performance...
- African RP
- Latin American RP
- European RP
First Products

What is OpenQuake?

OpenQuake is an open source software application that allows users to compute seismic hazard and risk on any scale, developed as an open source project, available for download from http://openquake.org.
OpenQuake: Hazard Curves

Curves that give the probability of exceedance of a certain intensity measure level, within a given time span.
Distribution of the expected ground motion for a certain probability of exceedance with a given time span.
OpenQuake: Loss Curves

Curves that give the probability of exceedance of a certain loss, within a given time span.
Distribution of the expected losses for a certain probability of exceedance with a given time span
EXEMPLIFICATIVE RESULTS

OpenQuake: Ground-Motion Fields for Single Event

Distribution of the ground motion in a region for a single earthquake
A calculator capable of computing the economic and human losses for a single earthquake scenario
Disaggregation provides the contributions to the losses of discrete combinations of basic parameters considered in the calculations (e.g. magnitude, rupture-site distance, building typologies)
The Benefit-Cost Calculator will allow users to ascertain whether retrofitting the building stock is economically beneficial.
ONLINE PLATFORM FOR CALCULATING EQ RISK

Performing calculations and producing output using OpenQuake and (tested) data/models/tools that are available in OpenGEM.

SCENARIO 1

Browsing through pre-calculated GEM outputs and interacting with the global GEM community.

SCENARIO 2

Performing calculations and producing output, using OpenQuake, models/tools that are available in OpenGEM, but own (proprietary) data.

SCENARIO 3

Restricted Data

Open Data

OpenGEM at GEM Model Facility

OpenGEM
The models and tools are to meet the needs of a wide group of prospective users and beneficiaries and will need to include features that support the work of all those entities and individuals working and deciding on risk resilience and mitigation.

The models will, through their interfaces, allow for risk assessment at the community, national and international level and integration with many ongoing initiatives on disaster risk reduction.
GEM has carried out already a User Needs Assessment, and has now deployed a follow-up Beneficiaries Needs Assessment.

A project led by GeoHazards International will discover the needs of selected GEM beneficiaries in developing countries and describe how GEM could most effectively communicate its earthquake risk information to these beneficiaries to promote mitigating action.

10 target communities, 10 people to be interviewed in each: Padang and Bandung, Indonesia; Istanbul and Antakya, Turkey; Lima and Pisco, Peru; Thimphu, Bhutan; Guwahati, India; San Francisco, USA; and Christchurch, New Zealand.

Will provide recommendations on: what community leaders need to initiate risk management activities; which individuals or groups are most likely to use GEM’s tools; how GEM can best communicate its information in ways that are readily usable by its beneficiaries; and how a team of future advocates could be recruited, trained and financially supported to use GEM’s tools.
A comprehensive interactive model: Calculating and communicating hazard, risk (exposure and vulnerability) and impacts on the society and the economy

State-of-the-art: Latest developments in science and technology

Community based: Community involved in designing and implementing GEM procedures, software, tools, methods, collecting data etc.

Open access: Open source software, transparent tools and accessible global datasets

Global coverage: Global and regional coverage. Interaction with Regional Programmes

Serving Multitude of Users: Intuitive, customised interfaces and users needs assessments

Dynamic (“alive”): Updatable, modular, flexible models and tools

Public / Private Partnership: Combines strengths and objectives of public and private sectors

Application beyond GEM: Expandable to other perils
Adhesion of an ever growing number of States (hopefully including also those from the Caribbean region)

Sponsorship from new sectors (e.g. utilities, construction, IT..)

Ensure full regional coverage/engagement and cater for national adoption

Release of new Hazard RfPs on Site Effects and Macroseismic Intensity

Continue the community-based development of OpenQuake and OpenGEM

Continue to strengthen partnership and active engagement of the global scientific community, including India’s..

Introduce any necessary adaptations, following the recent events in New Zealand and Japan

Involve the general public (inc. facilitation of crowd-sourcing), and thus hopefully truly increase public awareness and pressure for risk mitigation.
**FURTHER INFORMATION**

**GEM Website**
- Most update source of information
- News, results, calls, …

**GEM Report 2009/2010**
- 36 pages
- Available from website and hard-copy

**GEM Brochure**
- Available from website and hard-copy

**Bi-monthly e-Newsletter**
- Sign-up at website
Aspects of “Priorities for Action” Addressed by GEM

**HFA1:** coordination of global and regional activities related to seismic risk, community participation and networking…

**HFA2:** advance knowledge of seismic hazard and vulnerability, produce hazard and risk maps and indicators and widely disseminate, develop and improve databases, promote open exchange of data and software, promote application of remote sensing, GIS, cost-benefit assessment, develop common methodologies for risk assessment…

**HFA3:** provide easily understandable information on seismic risk, improve dialogue between scientific communities and practitioners, offer training programmes, strengthen technical and scientific capacities…

**HFA4:** promote development of financial risk-sharing mechanisms, public-private initiative, promote financial instruments for addressing seismic risk, aid revision and development of building codes…

**HFA5:** coordinated regional programmes, working with earthquake risk mitigation programmes…