GEM FOUNDATION

FOR A SAFER and
EARTHQUAKE RESILIENT FUTURE.

Global Earthquake Model

GEM

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VISION & MISSION

Assisted by an initiative of the OECD's Global Science Forum, GEM was formed in 2009 as a non-profit foundation in Pavia, Italy, funded through a public-private sponsorship with the vision to create **a world that is resilient to earthquakes**. GEM's mission is to become one of the world's most complete sources of risk resources & a globally accepted standard for seismic risk assessment; and to ensure that its products are applied in earthquake risk management worldwide.

A world
that is
resilient to
earthquakes

Leadership

John Schneider
Secretary General

Mauro Dolce - DPC Italy
Governing Board Chairperson

WHO WE ARE

GEM Team and Partners

GEM is comprised of collaborators from public, private, academic and non-government organizations worldwide. These partners work together to advance the state-of-the-art for disaster risk reduction by developing data, tools and information and conducting hazard and risk assessments for improving our understanding of earthquake hazard and risk globally. (https://www.globalquakemodel.org/about-us)

GEM Secretariat staff with the Governing Board members, December 2017

2009-2018 Sponsors

Private sponsors

Munich RE | ZURICH | AIR WORLDWIDE | EUCENTRE European Centre for Training and Research in Earthquake Engineering | hannover re | FM Global | PartnerRe

suramericana | ARUP | OYO | Nephila | General Insurance Rating Organization of Japan | Renaissance Re RISK SCIENCES FOUNDATION, INC. | Willis

Public sponsors

Australian Government Geoscience Australia	Natural Resources Canada / Ressources naturelles Canada — Canada	CIGIDEN	SERVICIO GEOLÓGICO COLOMBIANO	CAMICON	GFZ Helmholtz Centre Potsdam	PROTEZIONE CIVILE Presidenza del Consiglio dei Ministri Dipartimento della Protezione Civile	NIED	NSET
Australia	Canada	Chile	Colombia	Ecuador	Germany	Italy	Japan	Nepal

GNS SCIENCE TE PŪ AO	The Research Council of Norway	NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE	Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra	TAIWAN Earthquake Model	AFET SIGORTALARI KURUMU	NATURAL ENVIRONMENT RESEARCH COUNCIL	USAID FROM THE AMERICAN PEOPLE	funvisis Fundación Venezolana de Investigaciones Sismológicas
New Zealand	Norway	Singapore	Switzerland	Taiwan	Turkey	United Kingdom	United States of America	Venezuela

Associates

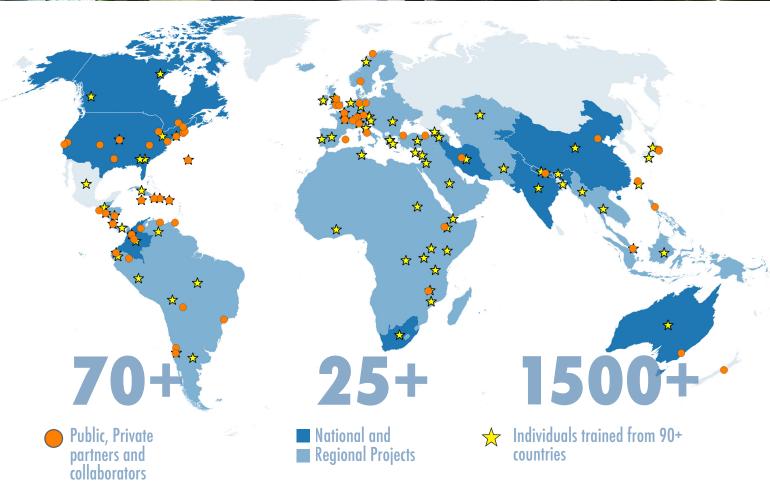| CSSC	EERI	IAEE	IASPEI	IRDR/ICSU	ISE	OECD	UNESCO	UNISDR	WB-GFDRR	100RC

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WHO WE ARE

GEM works with international network of experts, regional collaborations and global projects to ensure that GEM tools, models and datasets that support the creation of earthquake risk reduction strategies are promoted and utilized by local and international communities. GEM is a unique organization due to its open, collaborative approach, global coverage, and commitment to scientific credibility.
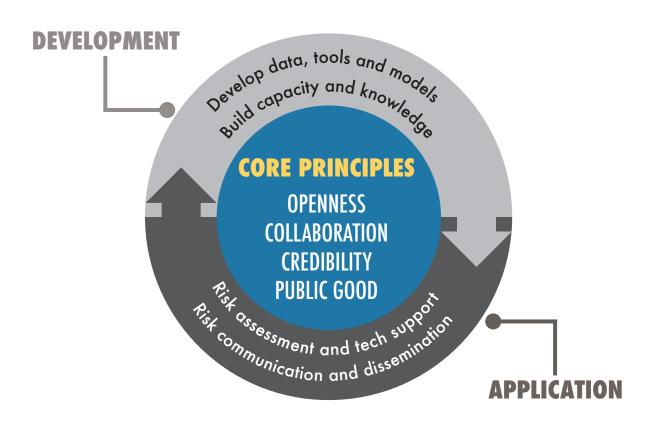

70+
25+
1500+

- ● **Public, Private partners and collaborators**
- ■ **National and Regional Projects**
- ★ **Individuals trained from 90+ countries**

FRAMEWORK
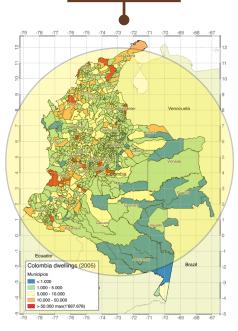
GEM builds capacity to assess and manage risk through open, transparent and collaborative seismic risk assessment at local, national, regional and global scales. Using state-of-the-art tools, GEM is committed to share and advocate open, reliable earthquake risk information to support sound disaster risk-reduction planning at various levels.

DEVELOPMENT

Develop data, tools and models
Build capacity and knowledge

CORE PRINCIPLES

OPENNESS
COLLABORATION
CREDIBILITY
PUBLIC GOOD

Risk assessment and tech support
Risk communication and dissemination

APPLICATION

A snapshot of building exposure in Colombia helps risk reduction planners in analyzing the density of the built environment that could be affected by a seismic event.

GEM builds the capacity of a wide range of stakeholders in seismic risk analysis using GEM open data, tools and models through training.

Colombia dwellings (2005)
Municipios
< 1.000
1.000 - 5.000
5.000 - 10.000
10.000 - 50.000
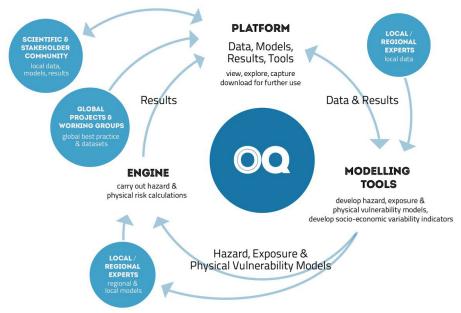> 50.000 max(1'697.678)

GEM collaborators in Lima, Peru creating a building inventory with GEM's Android and Windows apps. The activity was part of the South America Risk Assessment project in 2015.

OUR WORK

OpenQuake (OQ) - comprised of the engine, platform and tools - caters to a variety of users, from modellers and researchers to emergency planners - every user will find OpenQuake useful for a wide range of purposes for disaster risk reduction and management. The OQ engine (https://bit.ly/2MLbwR9) - a state-of-the-art, open-source software collaboratively developed for the assessment of earthquake hazard and risk - is complemented by an array of tools, information and the OpenQuake Platform.

OpenQuake engine

The functionality to analyze hazard and risks at specific site, city, country or regional level make the OpenQuake engine a powerful and dynamic tool for assessing the potential impacts of earthquakes at any location in the world.
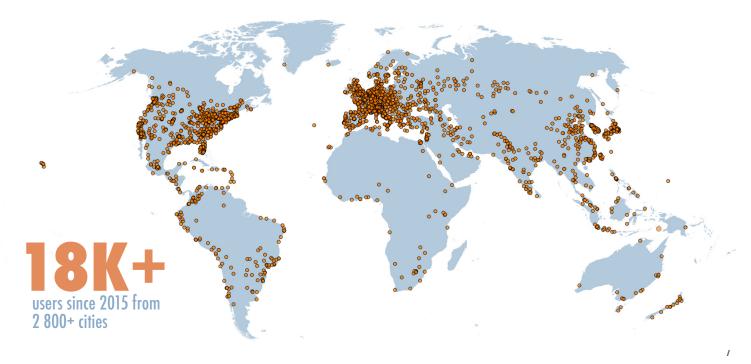

"

OpenQuake is a huge effort from GEM. It is recognized as one of the most advanced tools in the world. Because of its transparent nature, you can trace the outputs of your work giving modellers access to how it works – it's not a 'black box'.

Jack Baker
Stanford University, USA

OpenQuake platform

The OpenQuake Platform (https://platform.openquake.org) is a web-based application that allows the community to explore, manipulate and visualize the datasets and models and to use tools that GEM produces. The platform also allows users to contribute, share and discuss new findings and results with the GEM community.

18K+
users since 2015 from
2 800+ cities

OUR WORK

GEM successfully implemented risk assessment projects with regional, national and local collaborators covering more than **150 countries** in the following areas: Europe, Middle East, South America, Central America, North America, Sub-Saharan Africa, Asia and the Pacific. (https://www.globalquakemodel.org/projects)

650+ participants

country risk profiles

90+ collaborators

South America Risk Assessment (SARA)

▪ Period: 2013-2015   ▪ Countries: Argentina, Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela

Description: The objective of the project was to develop an open and uniform seismic hazard model covering the entire continent, and seismic risk profiling for the Andean countries.
Funding partner: Swiss Re Foundation
Collaborators: Geological groups & associations, universities, scientists, engineers, international agencies, municipalities and government agencies

500+ participants

country risk profiles

20+ collaborators

Sub-Saharan Africa Hazard and Risk Assessment (SSAHARA)

▪ Period: 2014-2016   ▪ Countries: Burundi, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda

Description: GEM led a program in East Sub-Saharan Africa to develop the first uniform and open earthquake hazard and risk model.
Funding partner: United States Agency for International Development (USAID)
Collaborators: African Union, AfricaArray FEPRA – Ethiopia, University of Pennsylvania, Addis Ababa City Government, UNDP Regional Office, international agencies, municipalities and government agencies

320+ participants

country risk profiles

20+ collaborators

Assessing and Mitigating Earthquake Risk in the Caribbean and Central America (CCARA)

▪ Period: 2016-2018   ▪ Countries: all Central American and Caribbean countries (except Cuba and Mexico)

Description: GEM developed the capacity in the region for earthquake risk assessment using GEM tools and resources to bridge the gap between risk assessment and disaster risk reduction.
Funding partner: United States Agency for International Development (USAID)
Collaborators: Municipality of San José (Costa Rica), National Commission of Emergencies (CNE), University of Costa Rica (UCR) - Laboratorio Nacional de Materiales y Estructuras (LANAMME), Open Street Maps, ineter, ONESVIE, ODPEM, ONEV, BRGM, Bureau des Mines, VT, Geologica UPR Mayaquez, UNI, SRC and UMG

Assessing and Mitigating Earthquake Risk in the Caribbean and Central America training in Pavia, Italy (2017)

South America Risk Assessment training in Lima, Peru (2015)

Sub-Saharan Africa Hazard and Risk Assessment conference in Addis Ababa, Ethiopia (2014)
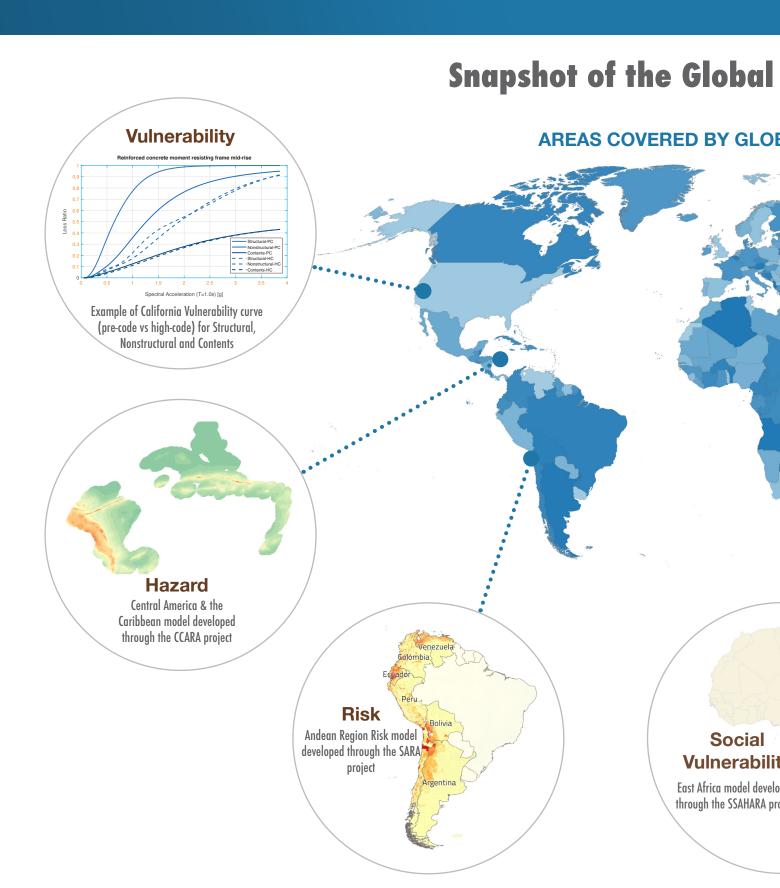
OUR WORK

Key Projects - 2015 and Beyond

GEM collaborates with its partners and stakeholders to build the foundation of better informed disaster risk management through projects that provide technical support and training on the use and application of GEM's tools and methodologies.

Below is GEM's most recent projects implemented in various parts of the world.

Country	End year	Title	Funder	Partners
Global	2021	Modelling Exposure Through Earth Observation Routines (METEOR)	UK Space Agency	BGS, HOT, ImageCat, NSET, DMD Tanzania
Europe	2020	Risk Modelling Framework for Europe - Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe (SERA)	European Centre for Training and Research in Earthquake Engineering (Eucentre)	
Global	2019	Collaborative Risk Assessment for Volcanoes and Earthquakes (CRAVE)	USAID	BGS, EOS, Univ. of Edinburgh, VDAP-USGS, SGC, PhiVolcs, Badan Geologi
Global	2018	GFDRR-DFID – Challenge Funds	GFDRR-DFID	HOT, ImageCat, BGS, UCL, CIMA, Norwegian Geotechnical Institute
Colombia	2018	National seismic hazard model for Colombia	Colombian Geological Survey	
Armenia	2018	Improving Post-Disaster Damage Data Collection to inform Decision Making	World Bank	JBA Consulting, CIMA Foundation, Geocom Ltd. (Armenia)
Latin America	2018	Hazard, Exposure and Vulnerability Model for Latin America	Suramericana	
Armenia	2017	Probabilistic Seismic Hazard Assessment for the Republic of Armenia	World Bank	AIR Worldwide, GeoRisk
USA	2017	"Beyond Button Pushing": Probabilistic loss assessment in California	California Seismic Safety Commission	UCLA
USA	2017	"Back to Normal": Earthquake Recovery Modelling	California Seismic Safety Commission	
Global	2017	Open Risk Data Dashboard	GFDRR	CIMA Foundation, Deltares
Kyrgyzstan Republic	2017	Measuring seismic risk in the Kyrgyz Republic	World Bank-GFDRR	Arup, GFZ Potsdam, Central Asian Institute for Applied Geosciences (CAIAG)
Iran	2016	Development of an Earthquake Loss Model for Iran	Aon Benfield	International Institute for Earthquake Engineering & Seismology
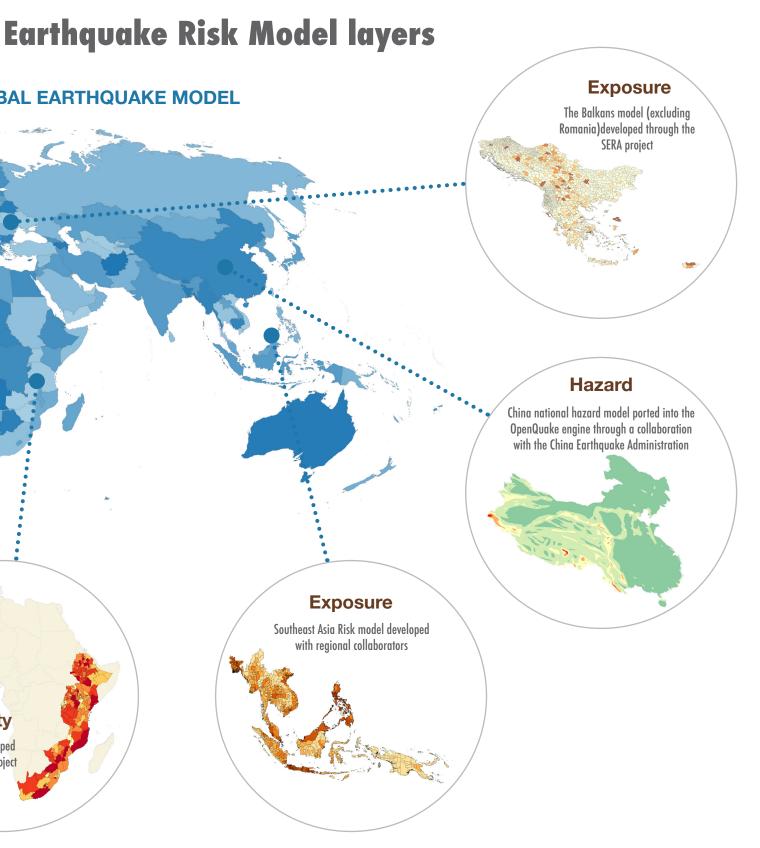
Global Earthquake Risk Model 2018

The development of the Global Earthquake Hazard and Risk Model is a key priority of GEM under its 2014-2018 Work Program. The objective is to collaboratively develop a complete set of earthquake data & models, and to deliver a comprehensive global assessment of earthquake risk.

Snapshot of the Global

AREAS COVERED BY GLOB

Vulnerability

Reinforced concrete moment resisting frame mid-rise

Example of California Vulnerability curve (pre-code vs high-code) for Structural, Nonstructural and Contents

Hazard

Central America & the Caribbean model developed through the CCARA project

Risk

Andean Region Risk model developed through the SARA project

Social Vulnerabilit

East Africa model develo through the SSAHARA pro

The resulting information from this project will support a wide range of disaster risk management decision-making, including (re)insurance pricing & risk transfer, and emergency response, recovery and planning in support of the Sendai Framework for DRR at subnational, national and regional scales.

This initiative is funded by GEM public and private sponsors with contributions from local, national and government agencies, universities, scientific groups, non-government organizations, and international institutions and aid agencies. The map will be released on 5th December 2018.

Earthquake Risk Model layers

BAL EARTHQUAKE MODEL

Exposure
The Balkans model (excluding Romania)developed through the SERA project

Hazard
China national hazard model ported into the OpenQuake engine through a collaboration with the China Earthquake Administration

Exposure
Southeast Asia Risk model developed with regional collaborators

GEM IMPACT

From Knowledge to Application

GEM strives to deliver lasting effects on the ground in the form of reduced earthquake risk and improved earthquake risk management at local and national levels. GEM believes that high quality, open, transparent and accessible earthquake risk tools and models combined with collaborative capacity development is key to achieving a world that is resilient to earthquakes.

18K+ OpenQuake platform users from **156** countries since 2015

> " OpenQuake and the ISC-GEM catalog were used in countless presentations at the 2017 Fall AGU meeting in New Orleans. Really fantastic impact on the research community, raising the bar on seismic risk assessment; it was great.
>
> **Ross Stein**
> CEO & Cofounder, Temblor, Inc. USA

- OpenQuake engine, supporting tools and web platform
- Databases for earthquakes, exposure, faultlines
- Seismic risk models at various scales
- Global earthquake risk model

Global Earthquake Risk Model

covering **240+** countries

10+ global seismic risk databases

1000+ fragility curves

80+ publications

Outputs & Products

Technical Activities

- Seismic risk assessment tools development
- Seismic risk data collection and standardization
- Seismic risk model development at local, national, regional and global scales

20+ open computational tools and global databases for earthquake hazard, vulnerability and exposure highlighted by the **OpenQuake (OQ)** analysis engine.

> " In ARUP, we really value sharing and collaboration, so for us, GEM is a natural fit. ARUP supports GEM's mission - to share information and promote the use of open tools more widely through collaboration.
>
> **Katherine Coates**
> ARUP, UK

> " GEM has been highly successful in mobilising support and cooperation for achieving its goal of producing a global map of seismic hazard and risk. At the time of writing, no other special interest group has been anything like as successful in producing global hazard and risk maps.
>
> **Edmund Booth**
> The Institution of Structural Engineers

Delivery Mechanisms

- Capacity development through OpenQuake tools training, technical support and assistance

1500+ trained in seismic risk assessment using OpenQuake in **90+** countries since 2014

- Local, national, regional and global seismic risk projects implementation

25+ local, national, regional and global seismic risk assessment projects covering **150+** countries

- Data and information sharing through the OpenQuake web platform and GEM website

30K+ website and platform users from **150+** countries since 2015

> *We are particularly impressed by GEM's collaborative, interactive approach in working with its stakeholders, and are proud to support GEM in their goal of worldwide earthquake resilience.*

Paul Della Marta
PartnerRe, Head of Catastrophe Research

🏛 National government agencies
🏦 Municipalities and cities
🏠 Insurance & reinsurance companies
〰 CAT modellers
👥 Engineering companies
🏅 Universities
🤝 International agencies
💡 Energy companies

20+
Government agencies using OQ and GEM resources to develop or revise national hazard maps

20+
Insurance and reinsurance companies using OQ, GEM resources and technical services to enhance in-house capabilities in seismic risk assessment

Global earthquake resilience.

Safer communities.

IMPACT

Immediate Beneficiaries

> *GEM has successfully developed a 21st century seismic risk assessment software – OpenQuake, and addressed the challenges of global data-base standards for risk assessment.*

Kelvin Berryman
GNS Science, New Zealand

> *GEM's earthquake resilience performance scorecard methodology has been used in Lalitpur as inputs for the building code process. We are keen to move forward and to further use the scorecard method in the future.*

Surya Shrestha
National Society for Earthquake Technology, Nepal

Outcomes

Enhanced global understanding of earthquake risk

Improved, standardized and more accessible information for disaster management

Improved information for insurance pricing

Improved skills in scientific seismic risk assessment

> *GEM is a groundbreaking initiative. From the scientific perspective, it has completely blown me away with the extent and level of development of the tools such as the OpenQuake, and how GEM has managed to grow over the years.*

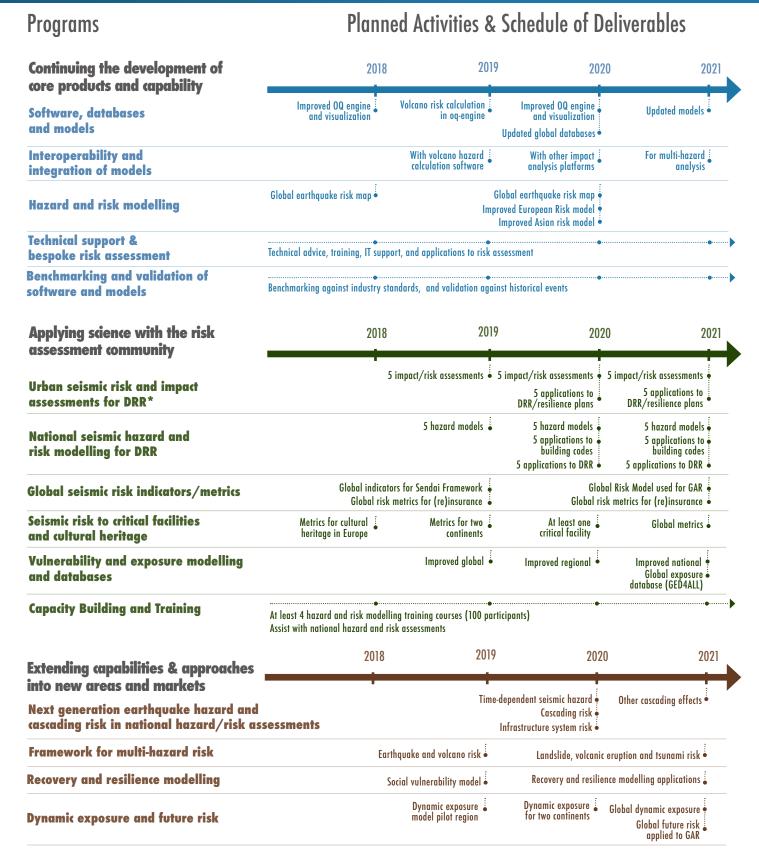**Rosa Sobradelo**
Willis Towers Watson, UK

> *Our partnership with GEM expanded in-house expertise on earthquake risk and strengthened our overall internal and external risk management processes. We hope to continue this productive collaboration in the years to come.*

Jörg Steffensen
Hannover Re - Group Risk Management Modelling

FUTURE WORK

GEM will continue to focus on the development of models and tools for earthquake risk assessment, and on their application at global, regional, national and local levels. Key activities will include improving the OpenQuake engine and its supporting tools and databases, and strengthening our capacity building and user support program. GEM will also extend its program of work to address more complex risk issues, and will collaborate more extensively with other hazard communities to make OpenQuake tools and models applicable to multi-hazard risk assessment.

Programs — Planned Activities & Schedule of Deliverables

Continuing the development of core products and capability

Program	2018	2019	2020	2021
Software, databases and models	Improved OQ engine and visualization	Volcano risk calculation in oq-engine	Improved OQ engine and visualization / Updated global databases	Updated models
Interoperability and integration of models		With volcano hazard calculation software	With other impact analysis platforms	For multi-hazard analysis
Hazard and risk modelling	Global earthquake risk map		Global earthquake risk map / Improved European Risk model / Improved Asian risk model	
Technical support & bespoke risk assessment	Technical advice, training, IT support, and applications to risk assessment			
Benchmarking and validation of software and models	Benchmarking against industry standards, and validation against historical events			

Applying science with the risk assessment community

Program	2018	2019	2020	2021
Urban seismic risk and impact assessments for DRR*		5 impact/risk assessments	5 impact/risk assessments / 5 applications to DRR/resilience plans	5 impact/risk assessments / 5 applications to DRR/resilience plans
National seismic hazard and risk modelling for DRR		5 hazard models	5 hazard models / 5 applications to building codes / 5 applications to DRR	5 hazard models / 5 applications to building codes / 5 applications to DRR
Global seismic risk indicators/metrics		Global indicators for Sendai Framework / Global risk metrics for (re)insurance		Global Risk Model used for GAR / Global risk metrics for (re)insurance
Seismic risk to critical facilities and cultural heritage	Metrics for cultural heritage in Europe	Metrics for two continents	At least one critical facility	Global metrics
Vulnerability and exposure modelling and databases		Improved global	Improved regional	Improved national / Global exposure database (GED4ALL)
Capacity Building and Training	At least 4 hazard and risk modelling training courses (100 participants) / Assist with national hazard and risk assessments			

Extending capabilities & approaches into new areas and markets

Program	2018	2019	2020	2021
Next generation earthquake hazard and cascading risk in national hazard/risk assessments			Time-dependent seismic hazard / Cascading risk / Infrastructure system risk	Other cascading effects
Framework for multi-hazard risk		Earthquake and volcano risk		Landslide, volcanic eruption and tsunami risk
Recovery and resilience modelling		Social vulnerability model		Recovery and resilience modelling applications
Dynamic exposure and future risk		Dynamic exposure model pilot region	Dynamic exposure for two continents	Global dynamic exposure / Global future risk applied to GAR

*disaster risk reduction

HOW TO JOIN

GEM offers flexible mechanisms to enable potential partners to contribute to its ongoing and future work programs. Partners and collaborators can enter into sponsorships, project partnerships and service agreements, and can select the level of engagement based on their needs and requirements.

GEM's new sponsorship structure and fees has been designed to incentivize greater participation of public and private organizations. Private organizations may become Governor sponsors for less than half the previous annual fees and returning Governor sponsors may qualify for further reductions. New and returning Public Governors may propose to contribute directly to the work program via an in-kind project to offset the *GERD-based sponsorship contribution.

Sponsor Types and Contributions

2013-2018 program		2018 - onwards			
Sponsor Type	Minimum contribution (k EUR)	Sponsor Type	Minimum Contribution (k EUR)	Voting Rights	Attends GB Meetings & Events
Public Participant	Based on GERD	Public Governor	As 2013-2018 program	Yes	Yes
Governor (returning)	100	Returning Governor	60-80**	Yes	Yes
Governor (new)	250	New Governor	100	Yes	Yes
Advisor	60	Advisor	50	No	Yes
Patron	50	Patron	30	No	No

**80K EUR for those returning from either 2009-2013 program or 2013-2018 program; 60K if returning from both WP1 and WP2.

Contribution Levels based on GERD

*Gross Domestic Expenditure on Research and Development (GERD) (current PPP $)	Annual GEM contribution
GERD > $50,000 million	€275,000
$50,000 m > GERD > $25,000 m	€170,000
$25,000 m > GERD > $10,000 m	€100,000
$10,000 m > GERD > $2,000 m	€70,000
$2,000 m > GERD > $1,000 m	€30,000
GERD < $1,000 m	€15,000

*Public Participant minimum contribution levels based on GERD

For more information on how to join GEM, please contact us at join@globalquakemodel.org.

JOIN US

GEM has implemented a framework for building and sharing tools for collecting and analyzing data, and a collective ownership of the process, which has resulted in a common understanding of the risk and a will to act to value it.

Though material results from GEM are important and play an important role in risk reduction, they do not possess the power to further advance GEM's vision. That power lies in GEM's motivation and commitment to serve the public good in a collaborative, inclusive, credible and transparent way.

Join us now in promoting open data and tools and support risk information sharing on publicly accessible platforms.

GEM OpenQuake training in Medellin, Colombia (June 2017)