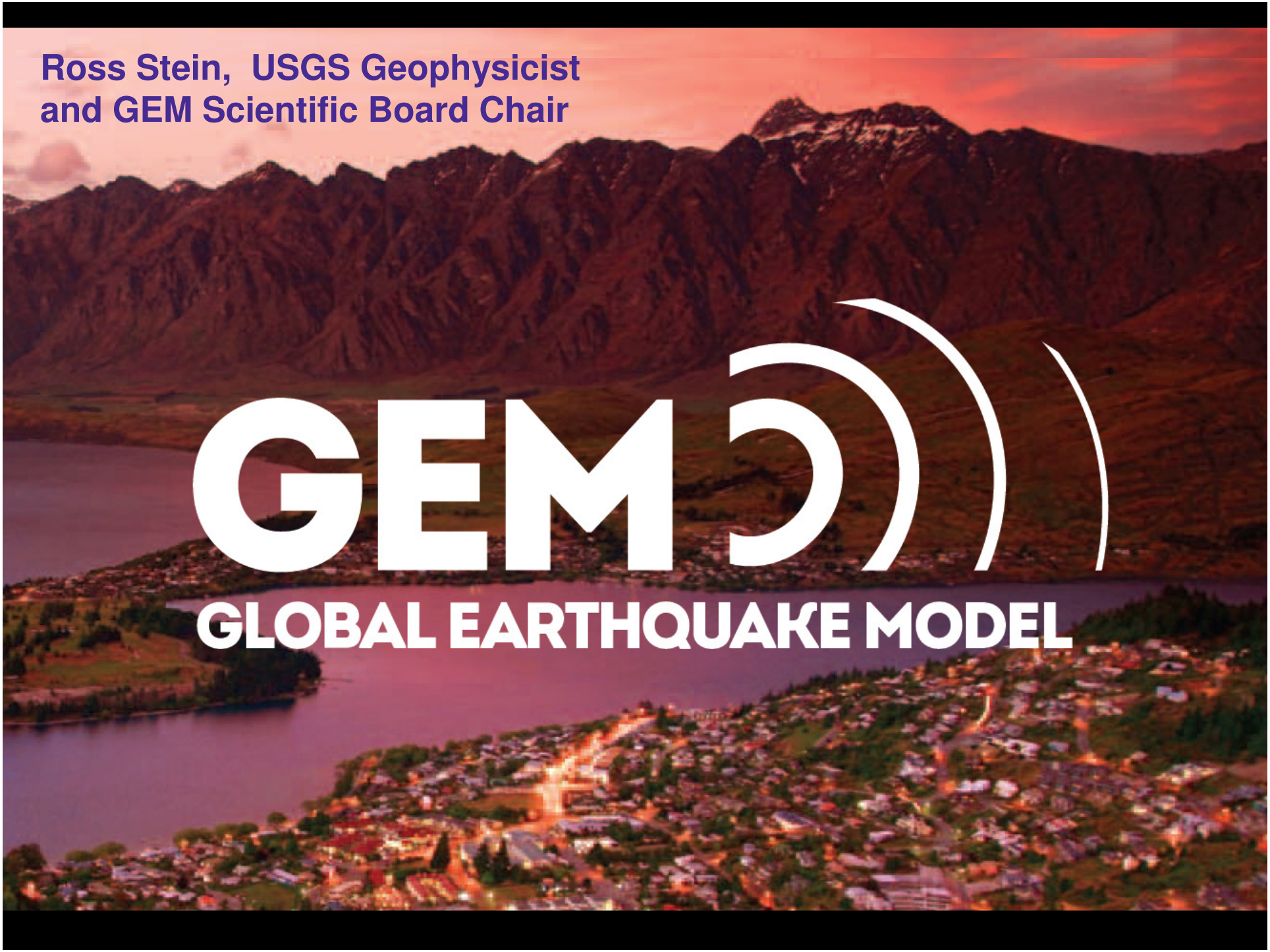
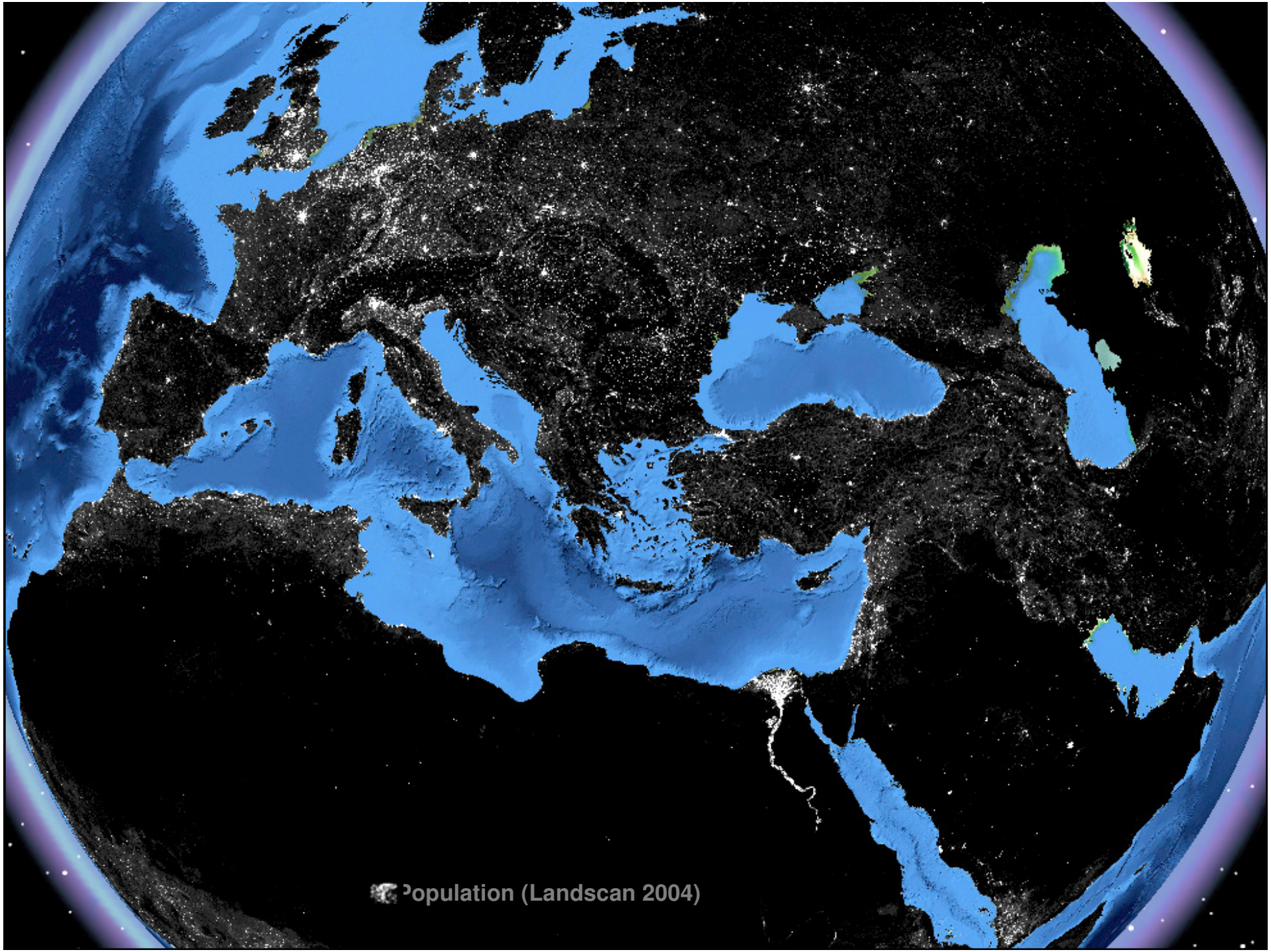
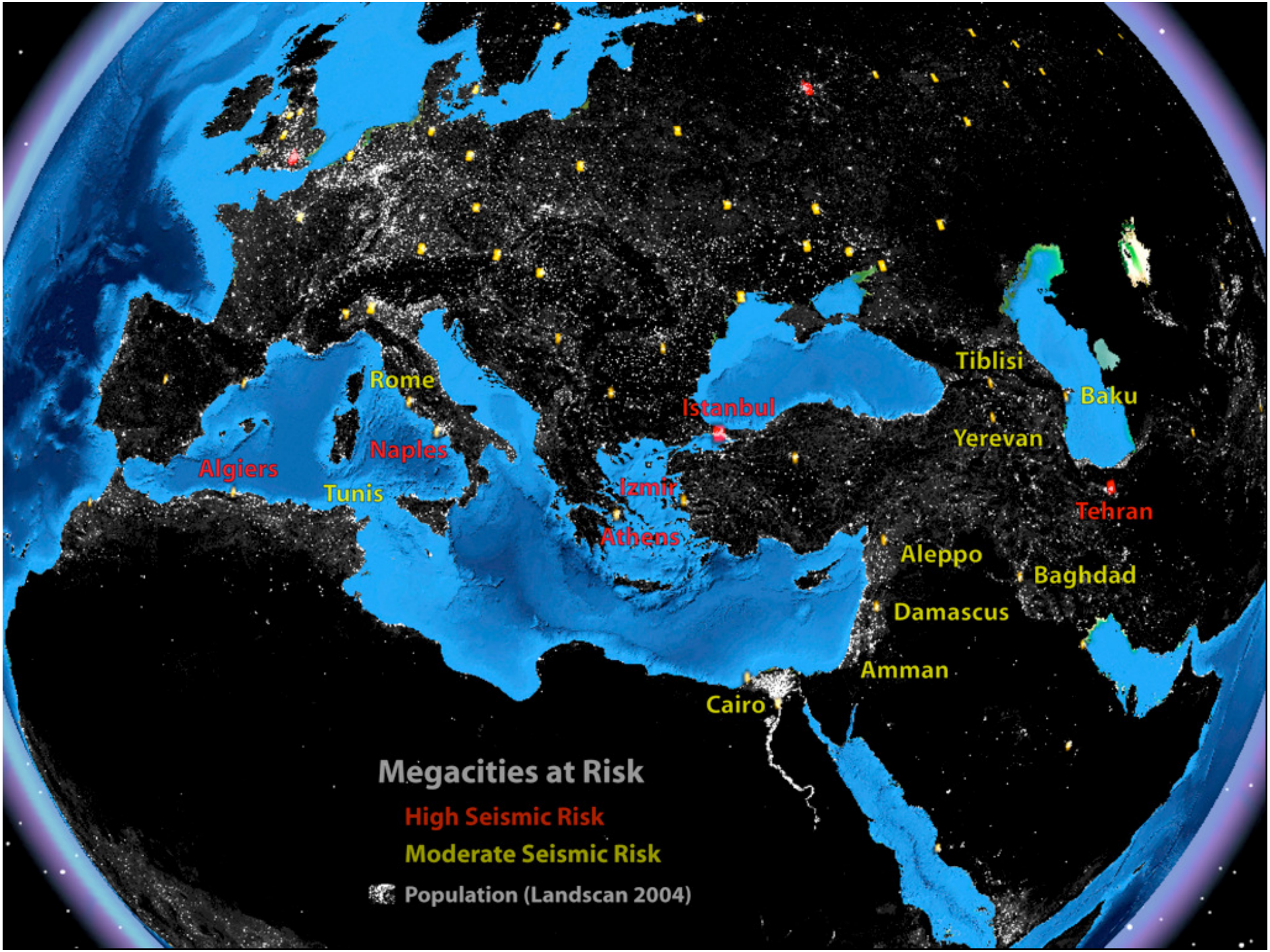
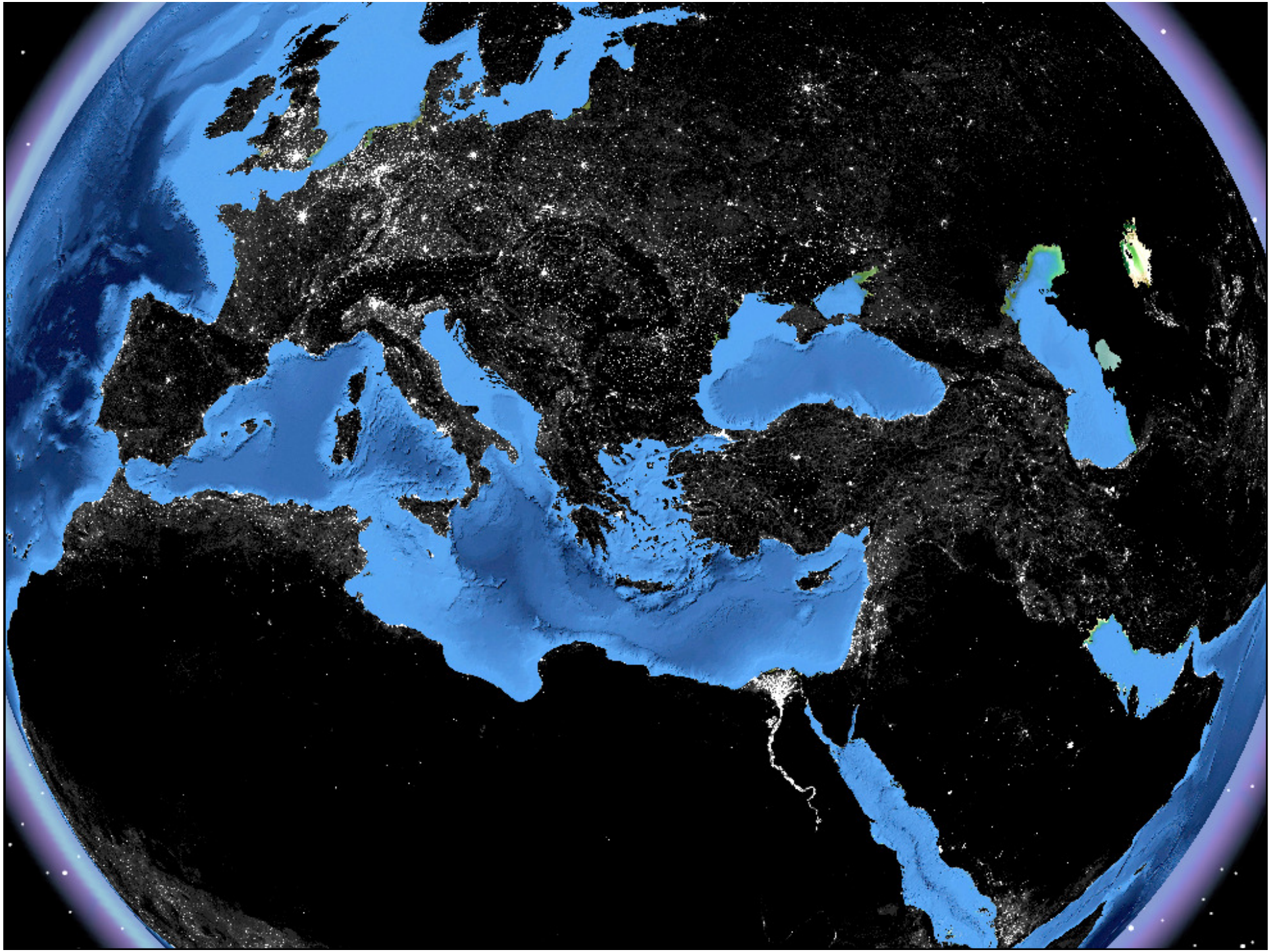
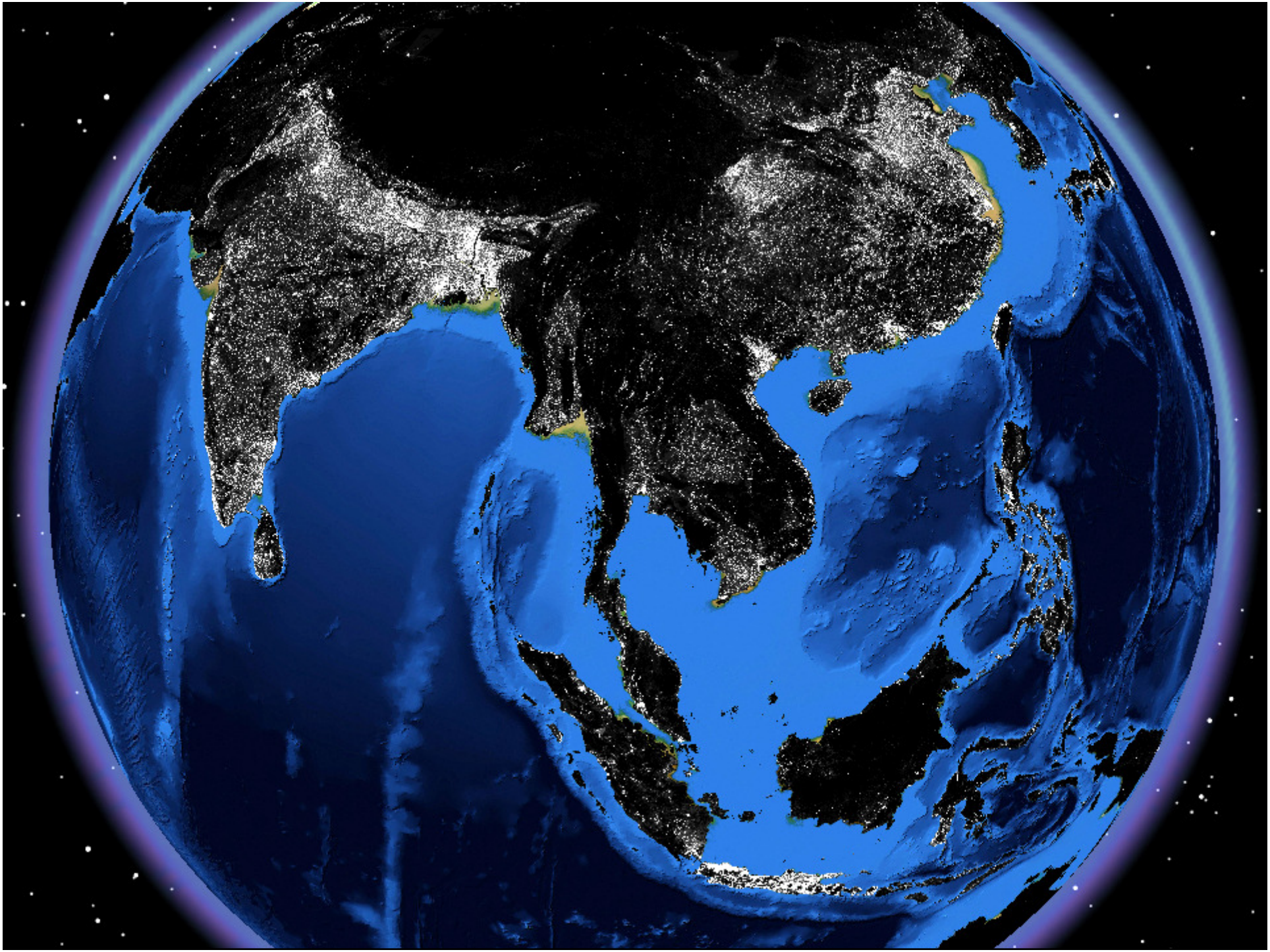
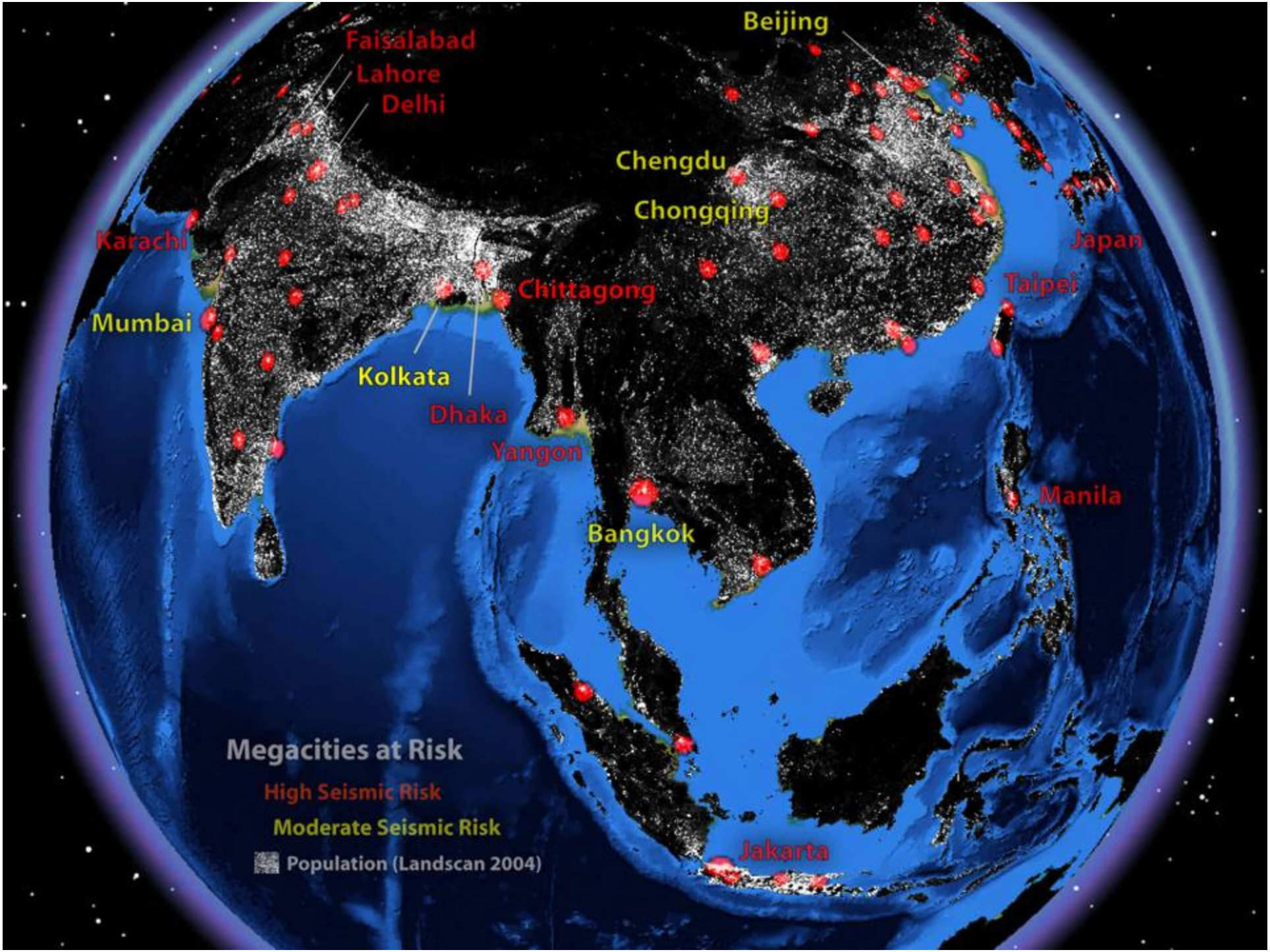

Ross Stein, USGS Geophysicist
and GEM Scientific Board Chair
GEM
GLOBAL EARTHQUAKE MODEL

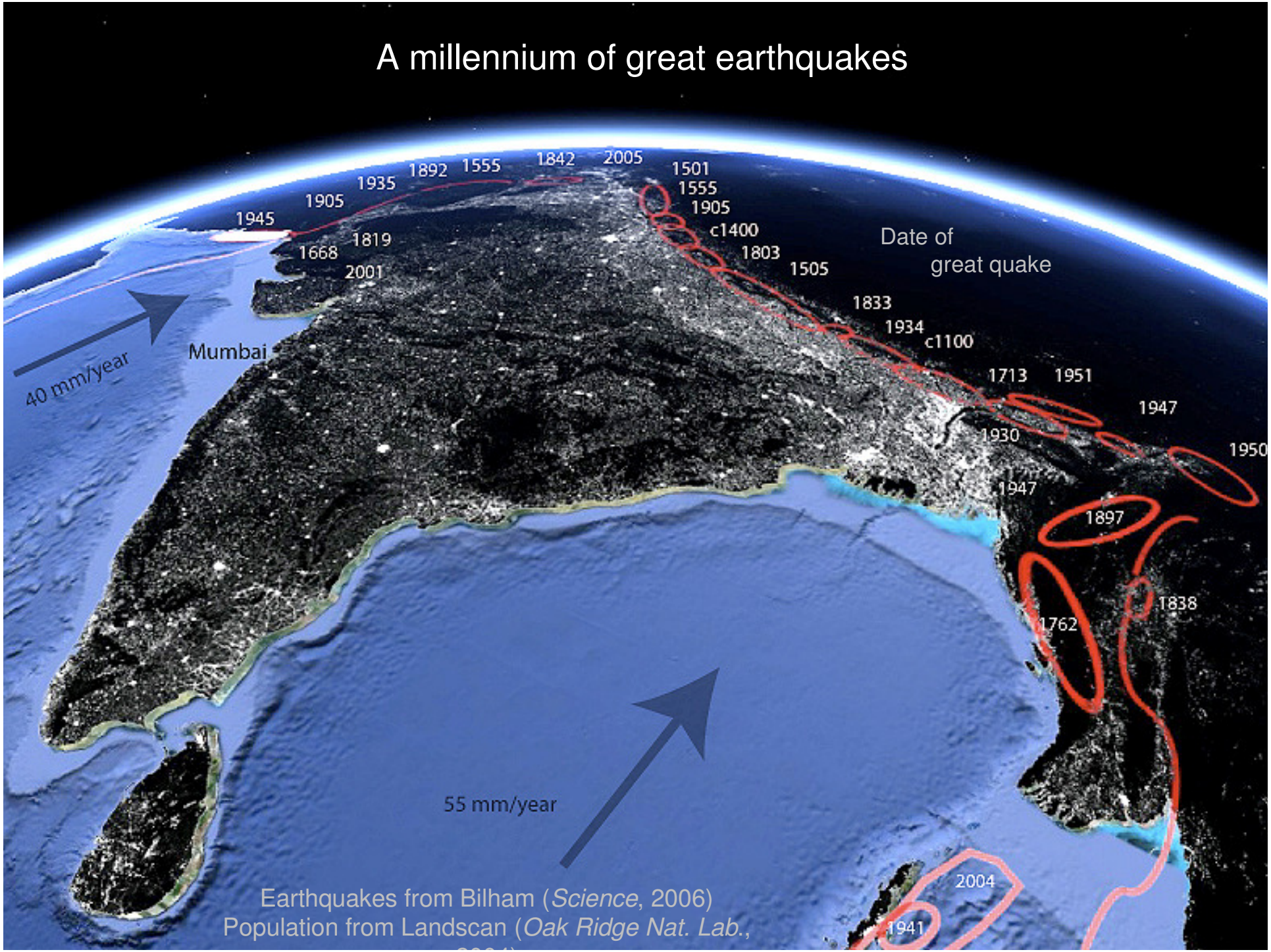

Population (Landscan 2004)


Rome
Istanbul
Tiblisi
Baku
Yerevan
Naples
Algiers
Tunis
Izmir
Athens
Tehran
Aleppo
Baghdad
Damascus
Amman
Cairo
Megacities at Risk
High Seismic Risk
Moderate Seismic Risk
Population (Landscan 2004)

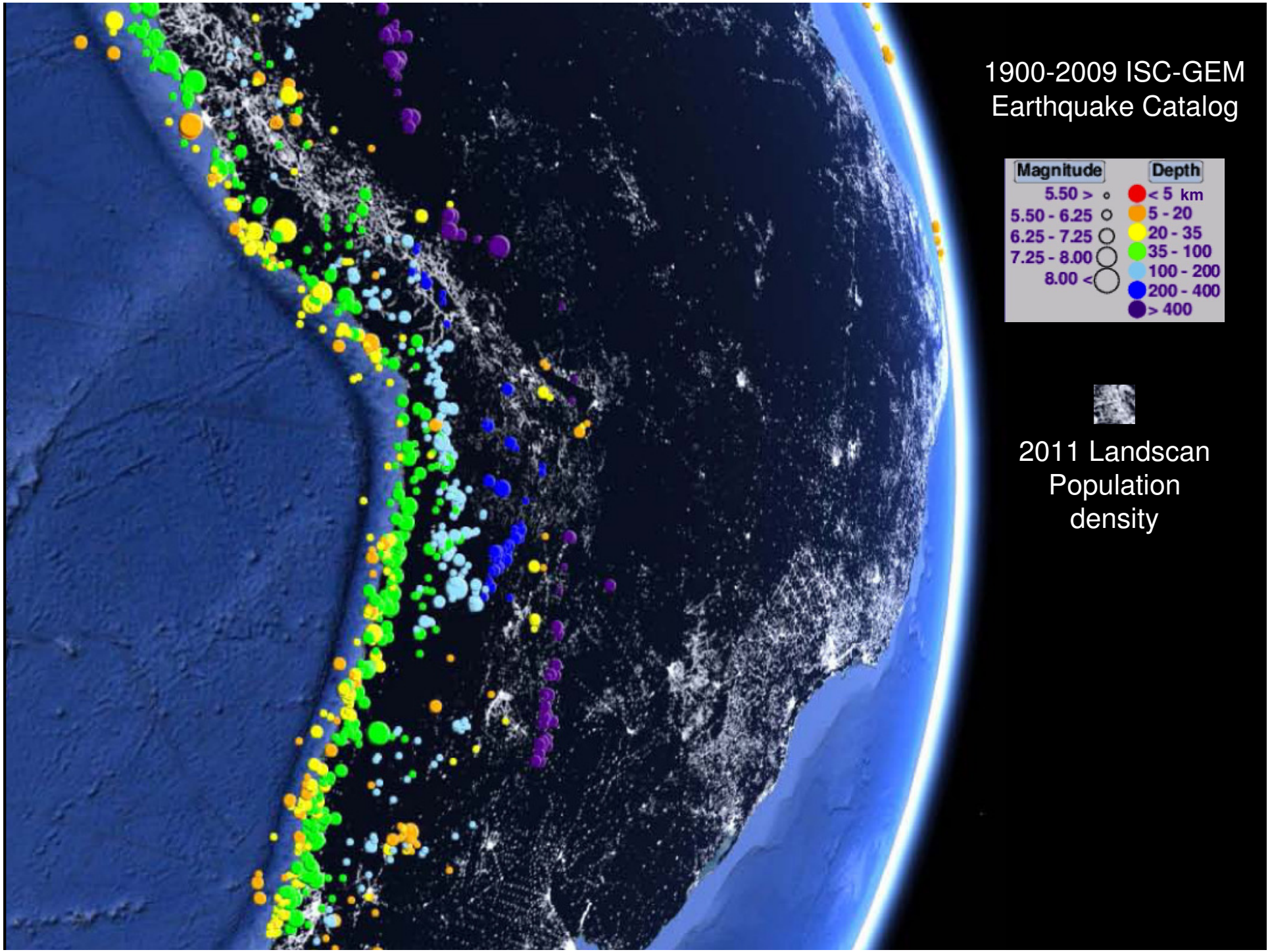


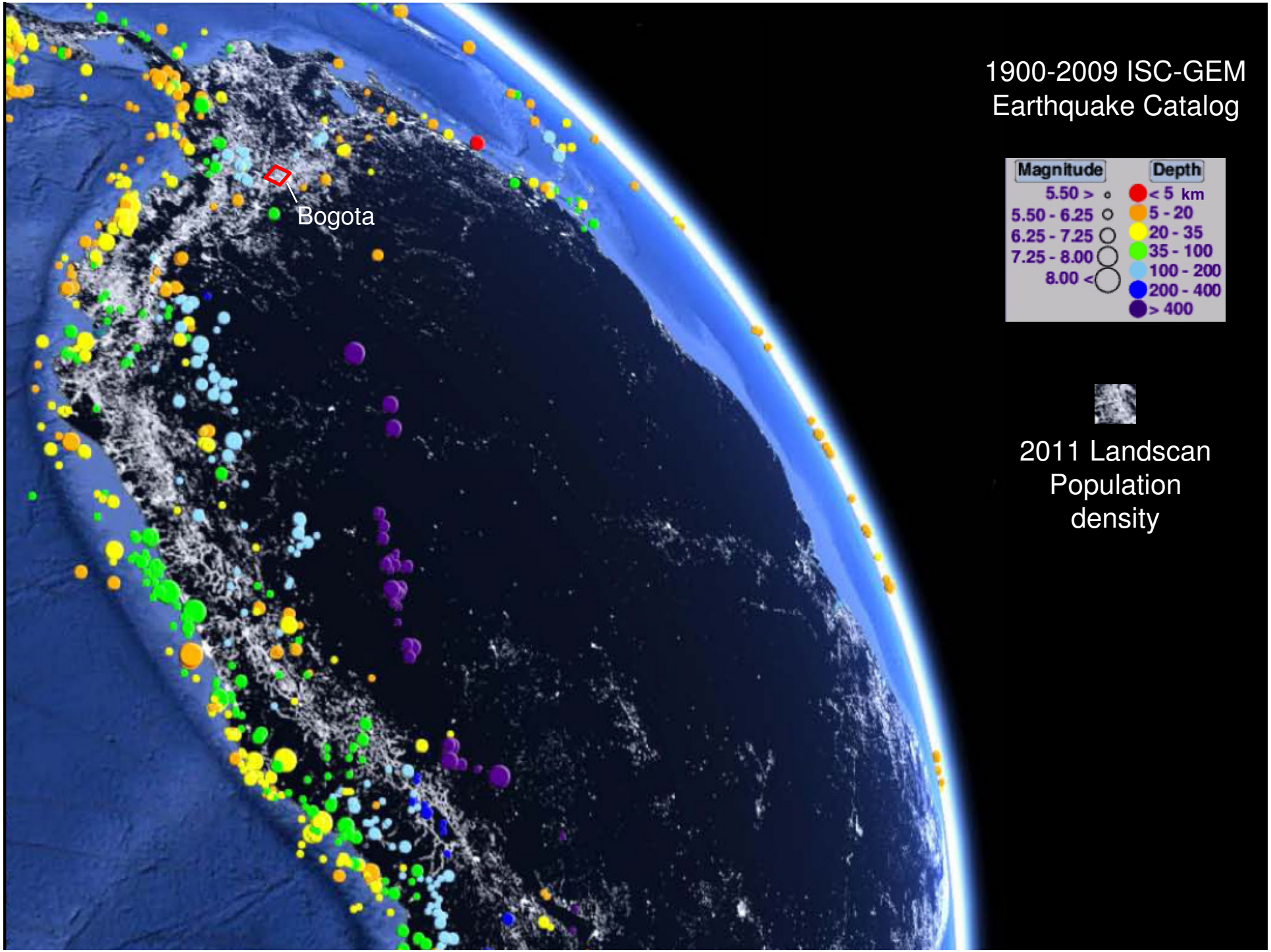


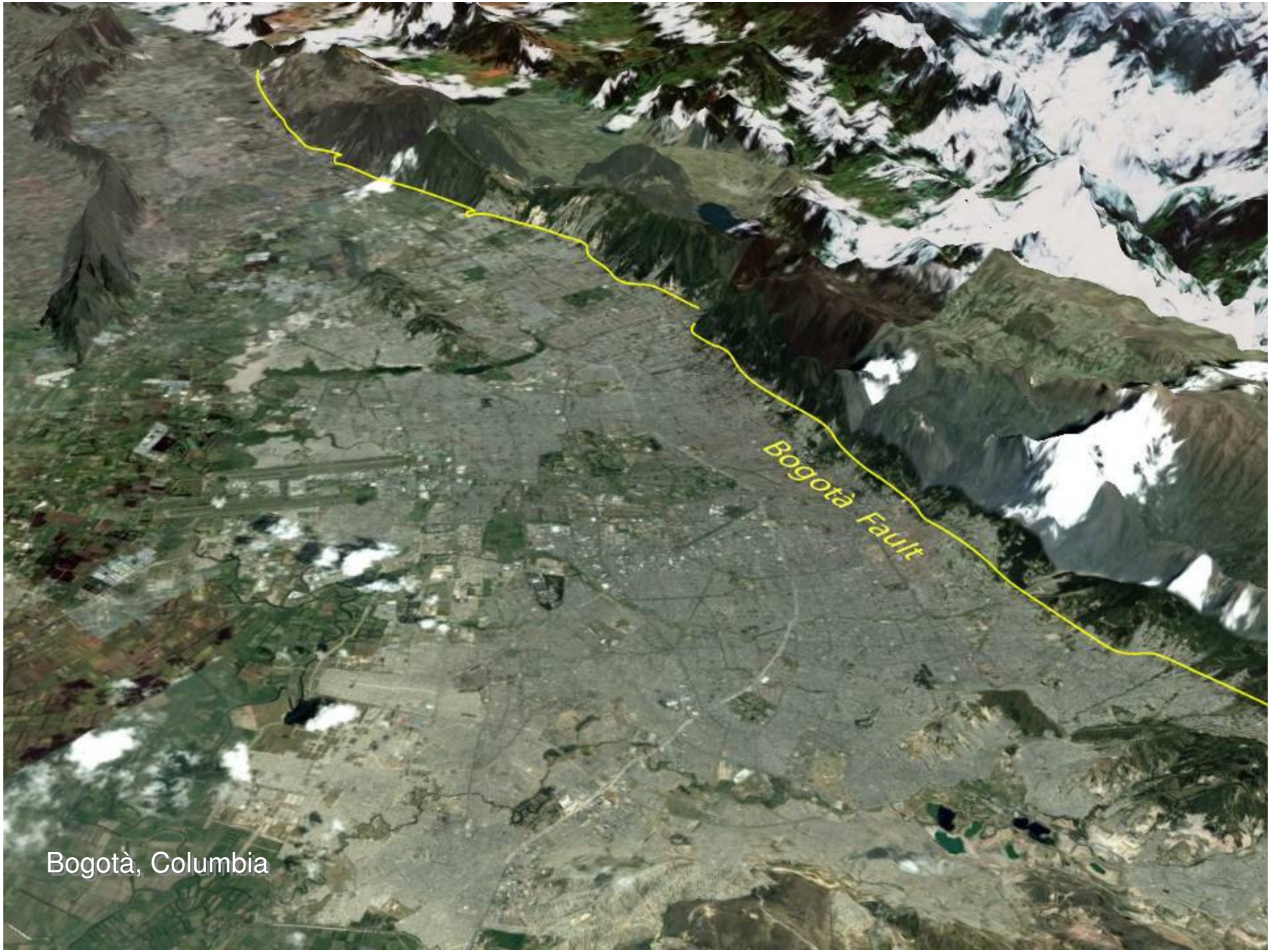

Beijing
Faisalabad
Lahore
Delhi
Chengdu
Chongqing
Karachi
Japan
Taipei
Chittagong
Mumbai
Kolkata
Dhaka
Yangon
Manila
Bangkok
Megacities at Risk
High Seismic Risk
Moderate Seismic Risk
Population (Landscan 2004)
Jakarta


A millennium of great earthquakes
Date of great quake
1945
1905
1935
1892
1555
1842
2005
1668
1819
2001
1501
1555
1905
c1400
1803
1505
1833
1934
c1100
1713
1951
1947
1930
1950
1947
1897
1838
1762
1941
2004
Mumbai
40 mm/year
55 mm/year
Earthquakes from Bilham (*Science*, 2006)
Population from Landscan (*Oak Ridge Nat. Lab.*,


2005 M=7.6 Kashmir, Pakistan, earthquake (80,00 deaths)


1900-2009 ISC-GEM
Earthquake Catalog
Magnitude
5.50 >
5.50 - 6.25
6.25 - 7.25
7.25 - 8.00
8.00 <
Depth
< 5 km
5 - 20
20 - 35
35 - 100
100 - 200
200 - 400
> 400
2011 Landscan
Population
density


Bogota
1900-2009 ISC-GEM
Earthquake Catalog
Magnitude
5.50 >
5.50 - 6.25
6.25 - 7.25
7.25 - 8.00
8.00 <
Depth
< 5 km
5 - 20
20 - 35
35 - 100
100 - 200
200 - 400
> 400
2011 Landscan
Population
density


Bogotà Fault
Bogotà, Columbia

GEM
GLOBAL EARTHQUAKE MODEL
working together to assess risk

GEM's GLOBAL COMMUNITY

Founding meeting, Zürich Development Centre, 2008

5 Meetings (~120 people): Zurich, 2008; Munich, 2009; Washington, 2010; Beijing, 2011; Taipei & Pavia, 2012

25 Workshops (~30 people): Pavia, London, Nairobi, Windhoek, Algiers, Santiago, Madrid, Canberra, Menlo Park, Manila, Cape Town, Brisbane, Ft. Collins, Lisbon, Quito, Caracas, Bangkok, Trinidad, Tobago, Rabat, Singapore, Kathmandu

GEM PRINCIPLES

Humanitarian

Raise risk awareness; promote preparedness, building codes, and financial risk transfer

Scientific

Only through open exchange and global model testing can seismic risk assessment be rapidly improved

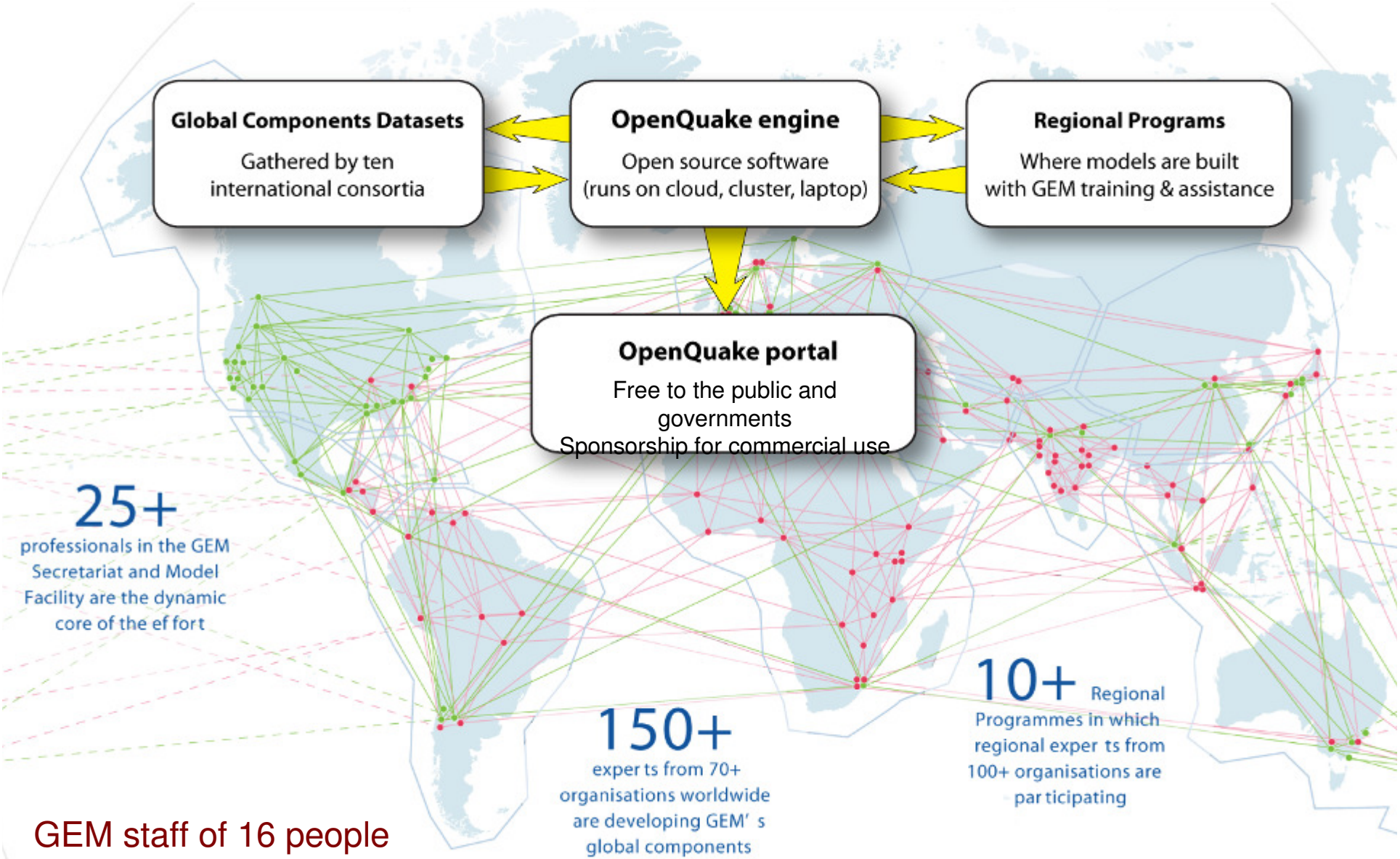
Credible

Clear and accessible risk information, in which we tell users what we know and what we don't know

Independent

A worldwide, non-governmental, non-commercial community of scientists, model builders and users

GEM ELEMENTS



GEM staff of 16 people
Annual budget of $5M

GEM PUBLIC-PRIVATE PARTNERSHIP

Founders

Munich RE

AIR WORLDWIDE

ZURICH

Willis

EUCENTRE
European Centre for Training and Research in Earthquake Engineering

Sponsors

FM Global

hannover re

Nephila

RenaissanceRe

Non-Life Insurance Rating Organization of Japan

Australia

Belgium

Ecuador

Germany

Italy

New Zealand

Norway

Singapore

Switzerland

Turkey

TEM

United Kingdom

United States

Chile

Japan

Associate Participants

OECD

WORLD BANK

UN-ISDR

UNESCO

IASPEI

IAEE

IStrucE

California Seismic Safety Commission

Willis Re MANAGING EXTREMES

View from Willis on the value of GEM

Rowan Douglas, Chairman, Willis Research Network

- Make quake insurance affordable by greater penetration
- More competition in risk taking & more financial solutions
- Bring models and thus insurance to emerging markets
- Foster public-private partnerships and insurance pools
- Make mitigation measurable and hence applicable
- Foster influx of capital, allow trading and cat bonds
- Increase market reputation, educate regulators

OpenQuake 'Models create and consume capital'

Matthew Jones, Head of Catastrophe Modeling, Zurich Insurance Group

What Zurich—a founding Sponsor—sees in GEM

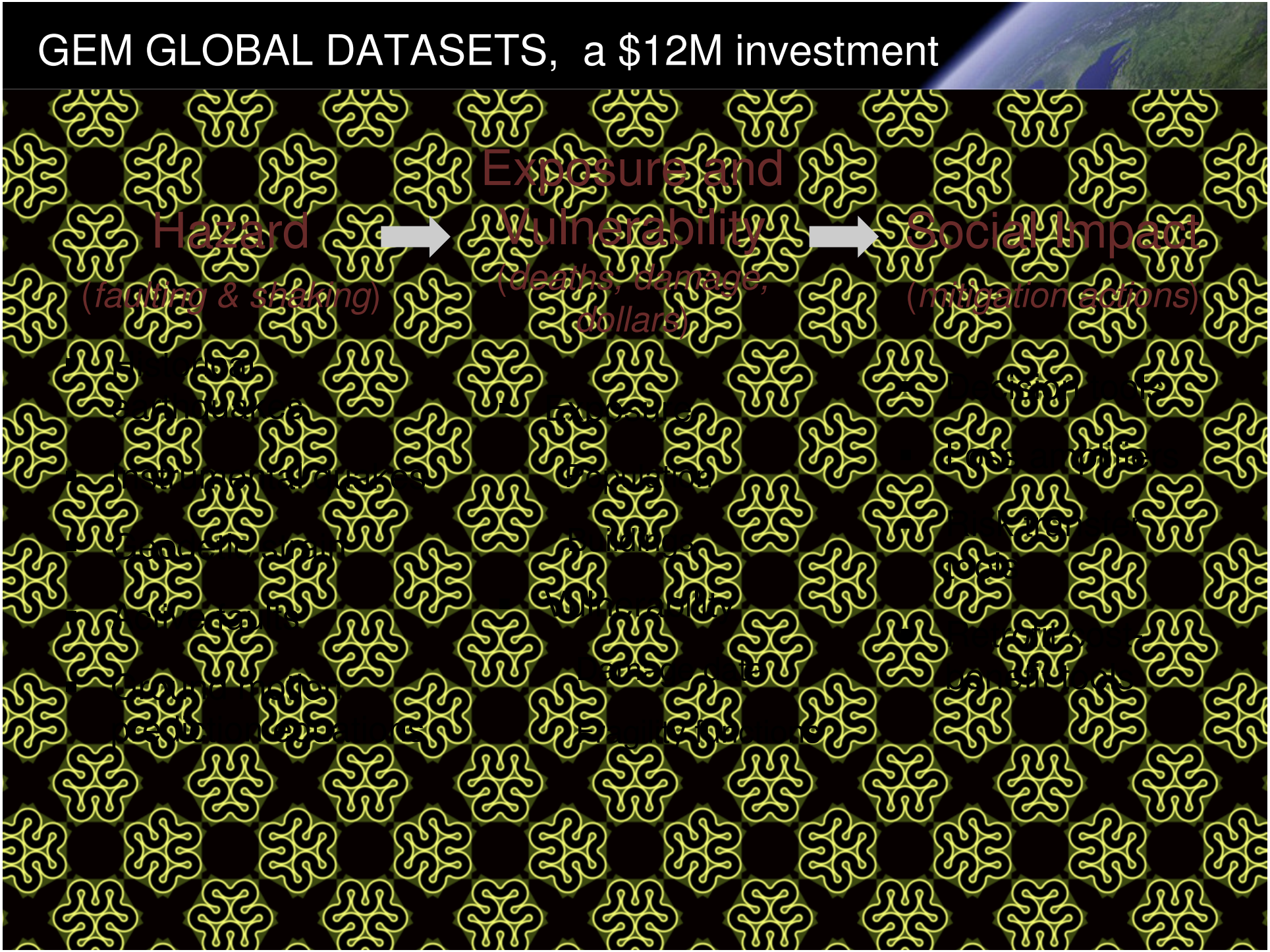
ZURICH

1. **Truly alternative / independent / unbiased view of risk**
   - No point replicating what current Cat model vendors do
   - Model should include / focus on areas that have not been properly tackled yet, or where there is disagreement
   - Model should attempt to get best estimate of risk free of political influences
2. **Transparent model**
   - Need full access to hazard maps, vulnerability curves, and its methodologies
   - Needs to be well documented
   - Needs ability to sensitivity-test assumptions
3. **Sharing claims data can ensure a model is not too far from reality**
4. **Providing user requirements / needs up front will help ensure the model is useful and provides value**

matthew.jones@uk.zurich.com

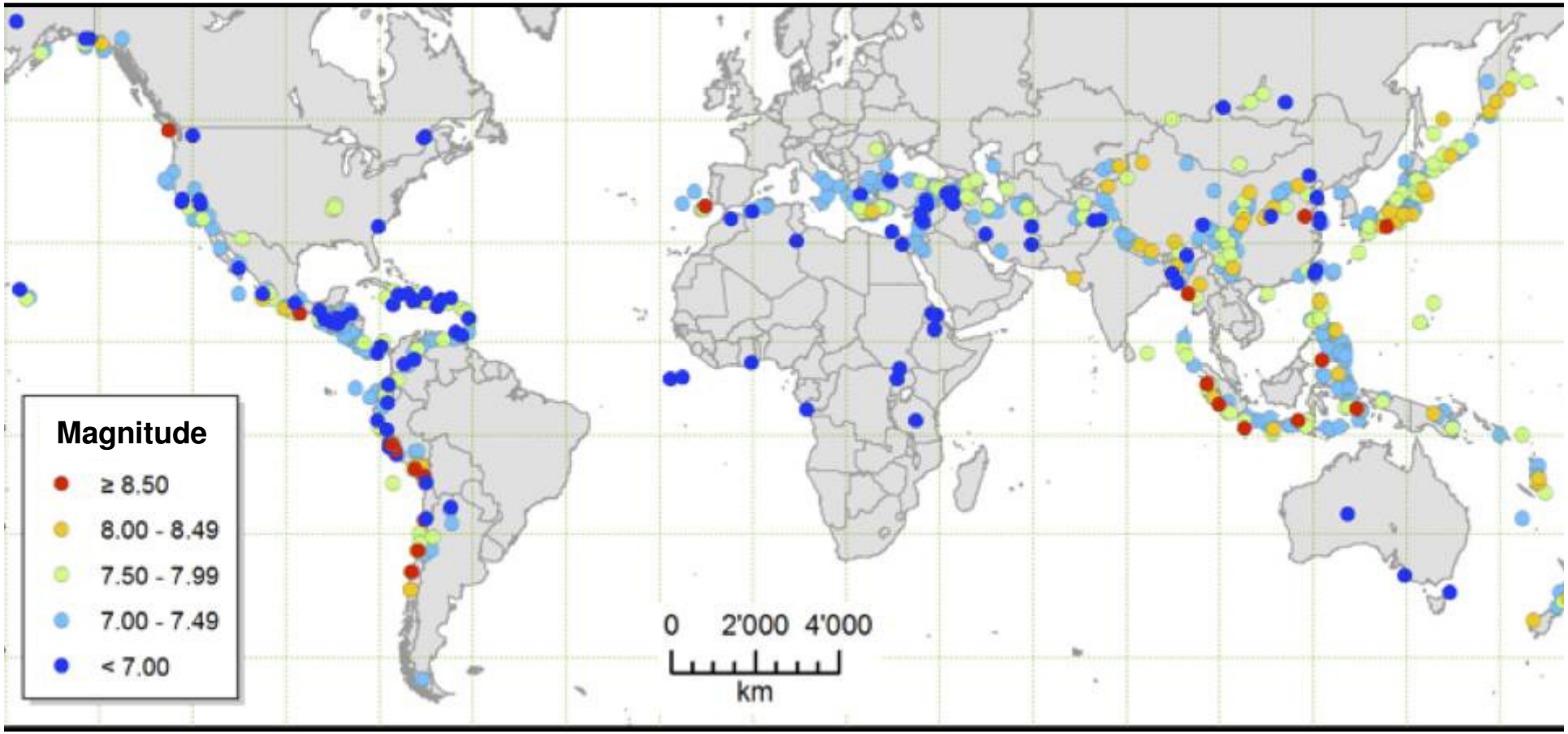
Zurich HelpPoint

GEM GLOBAL DATASETS, a $12M investment



Earthquake potential from millennial, century, and decade record

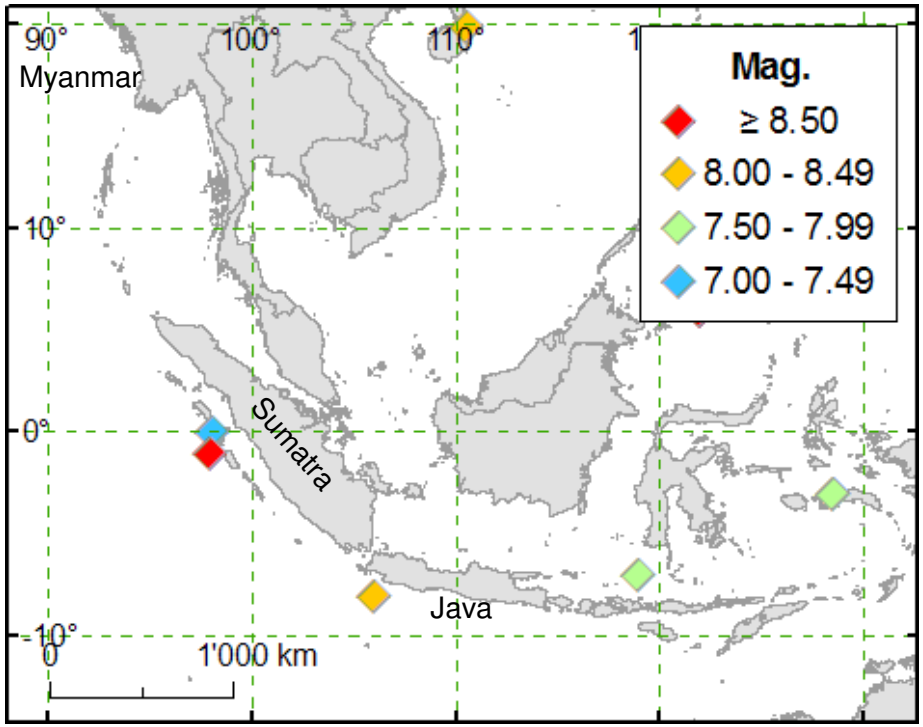
GEM Large Historical Earthquake Catalog: 832 M≥7 quakes during AD 1000-1900



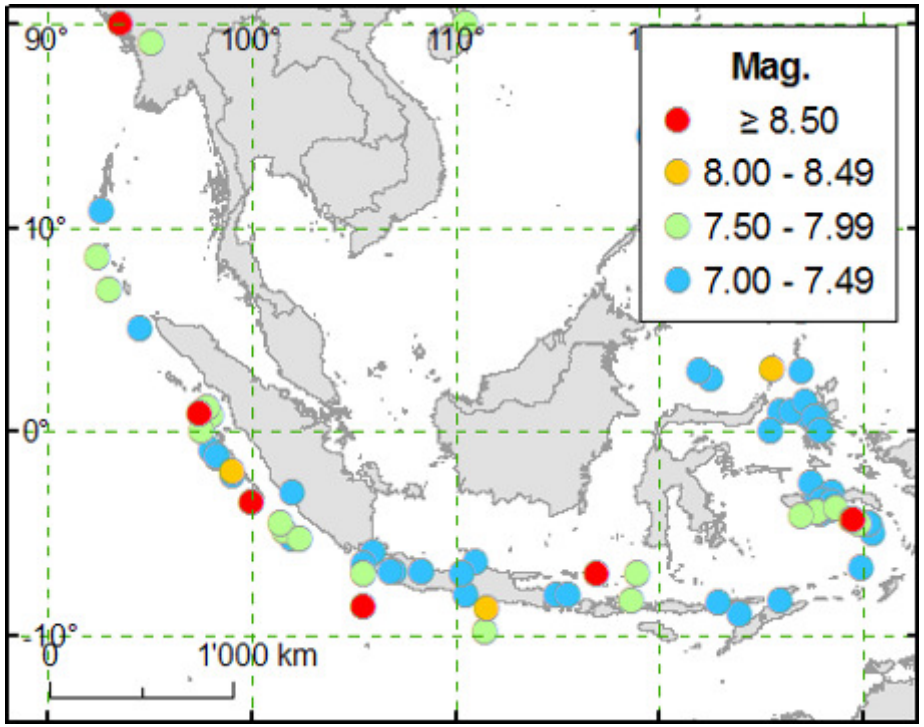
Paola Albini (INGV Milan) and Roger Musson (British Geological Survey), Principal Investigators

Indonesia: GEM Catalog has 12 times more quakes than NOAA

NOAA Catalog: **6** earthquakes

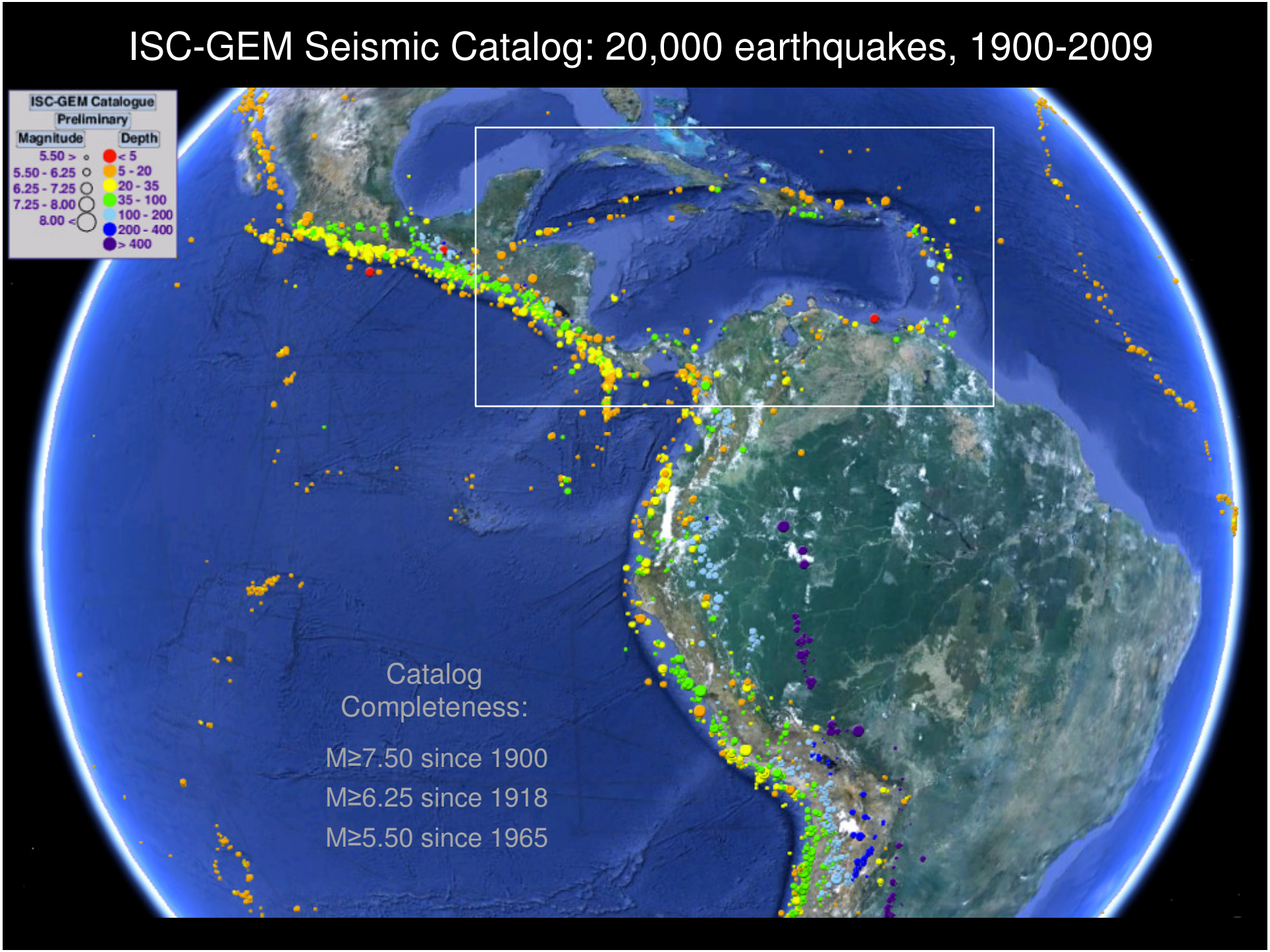


GEM Catalog: **75** earthquakes

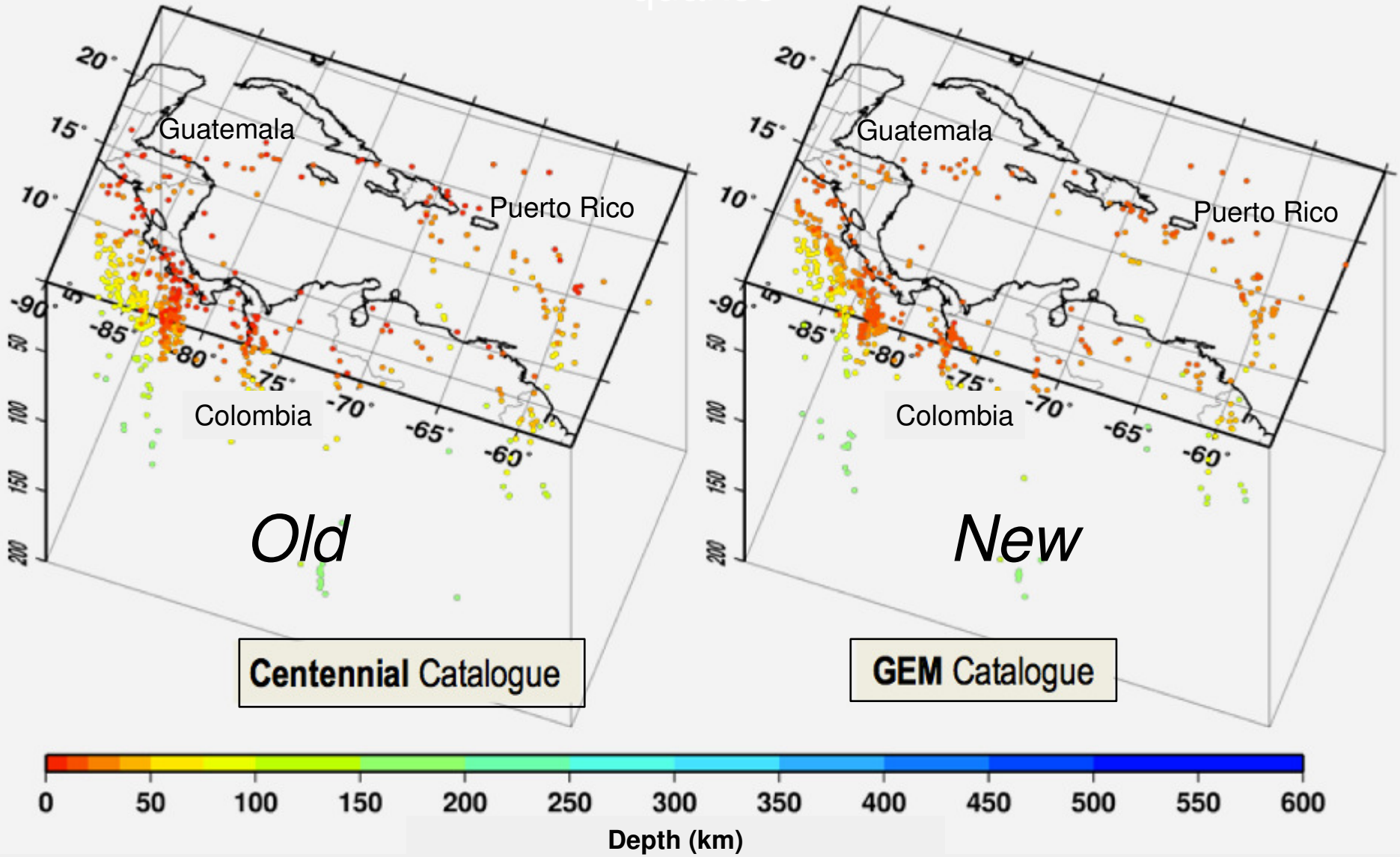


NOAA Catalog = National Geophysical Data Center/ World Data Service Significant Earthquake Database

ISC-GEM Seismic Catalog: 20,000 earthquakes, 1900-2009

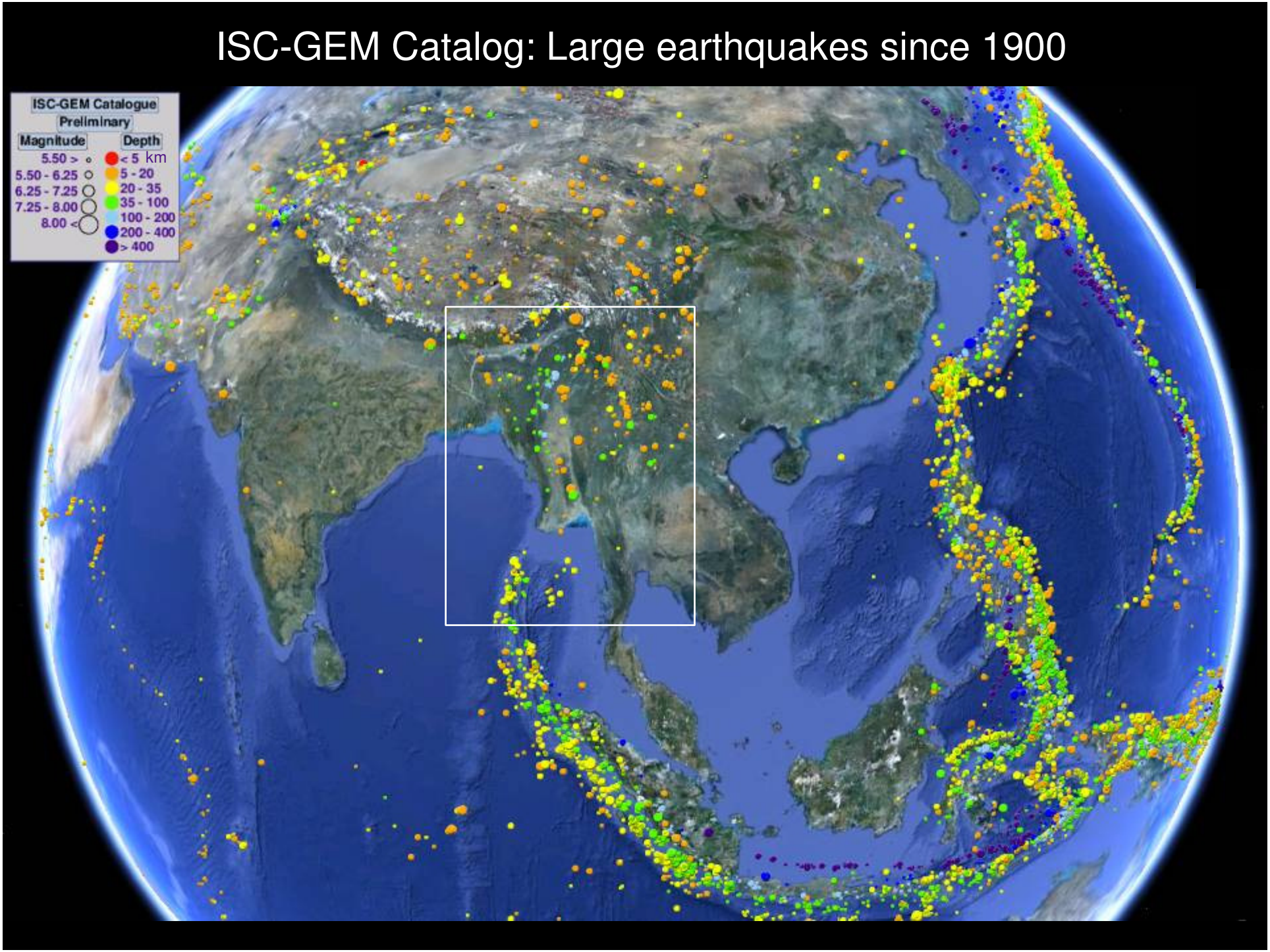


ISC-GEM Catalog: New magnitudes, locations, and depths for all quakes



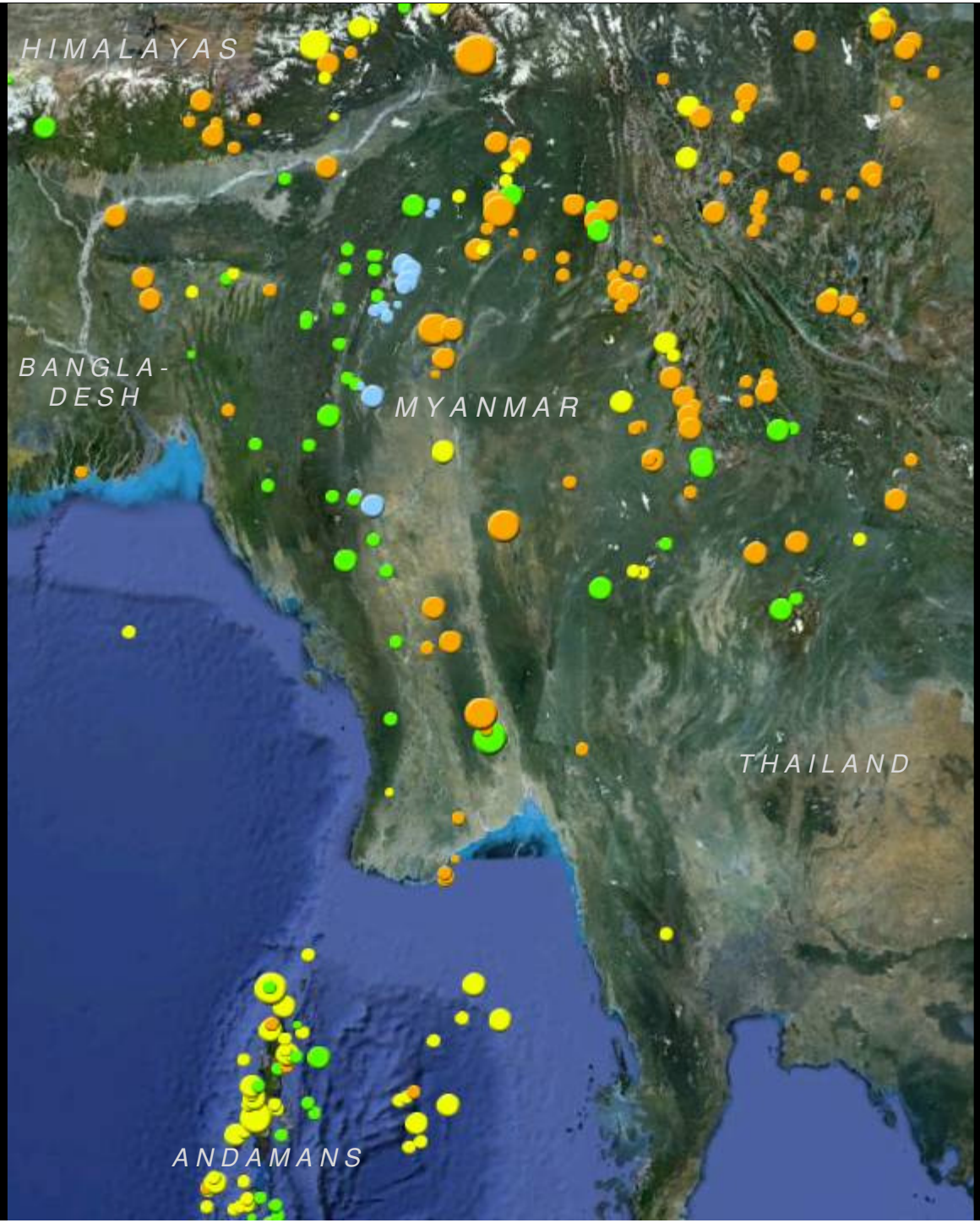
Dmitry Storchak (International Seismological Centre), Principal Investigator

ISC-GEM Catalog: Large earthquakes since 1900



GEM Faulted Earth

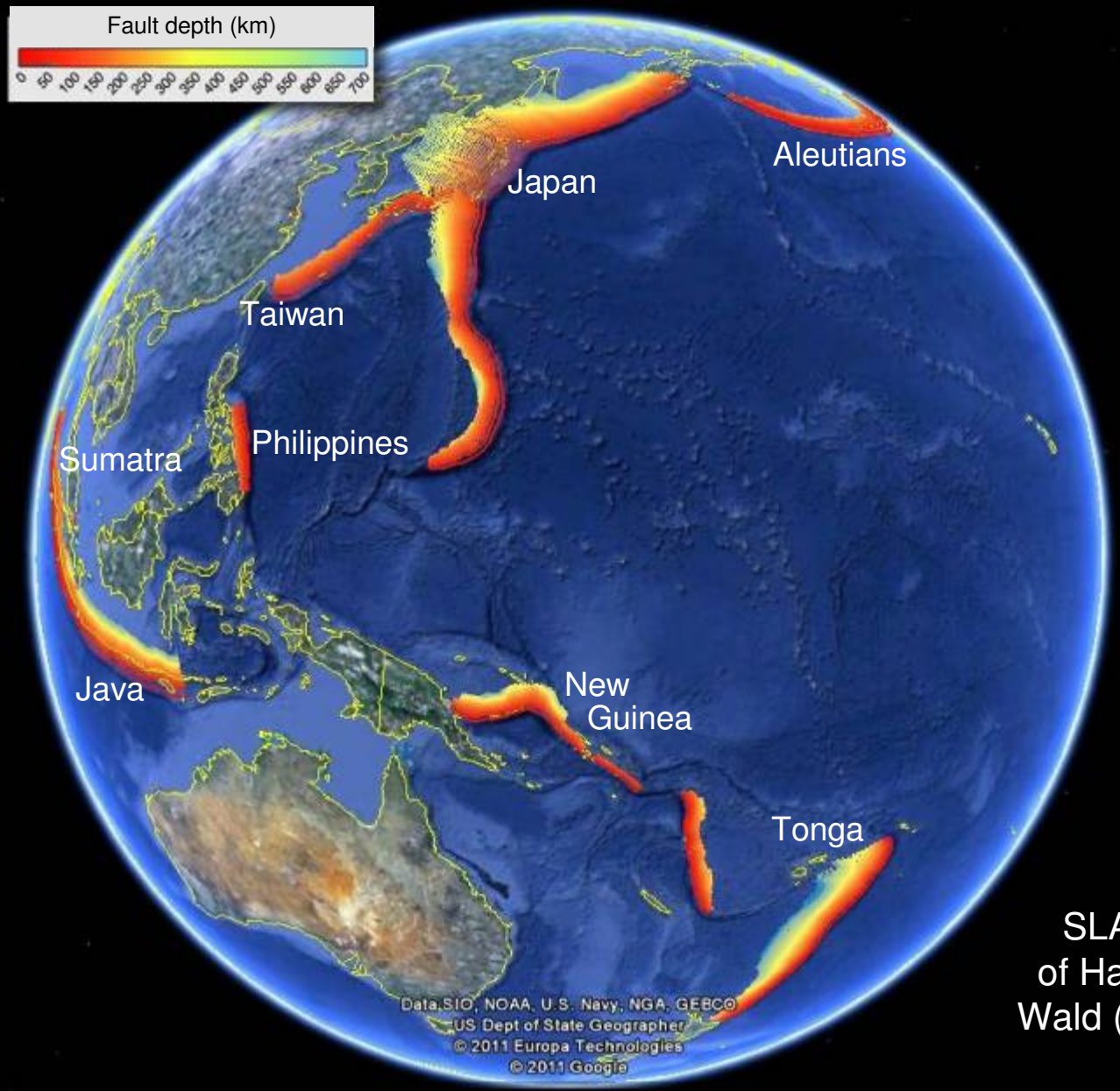
Kelvin Berryman (*GNS Science*) Principal Investigator



ISC-GEM Seismic Catalog

(orange quakes are shallow, blue are deep)

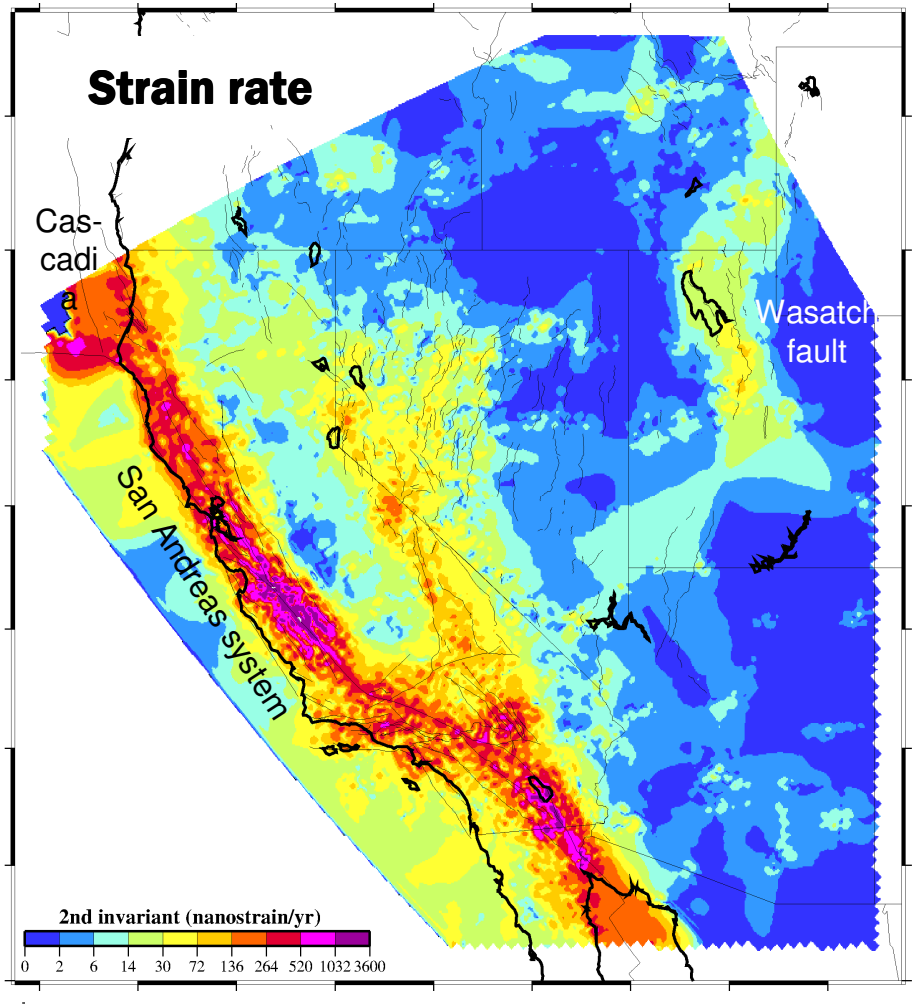
GEM Faulted Earth includes 40,000 km of subduction zones



SLAB 1.0 of Hayes & Wald (2010)

Why geodetic strain rates for hazard assessment?

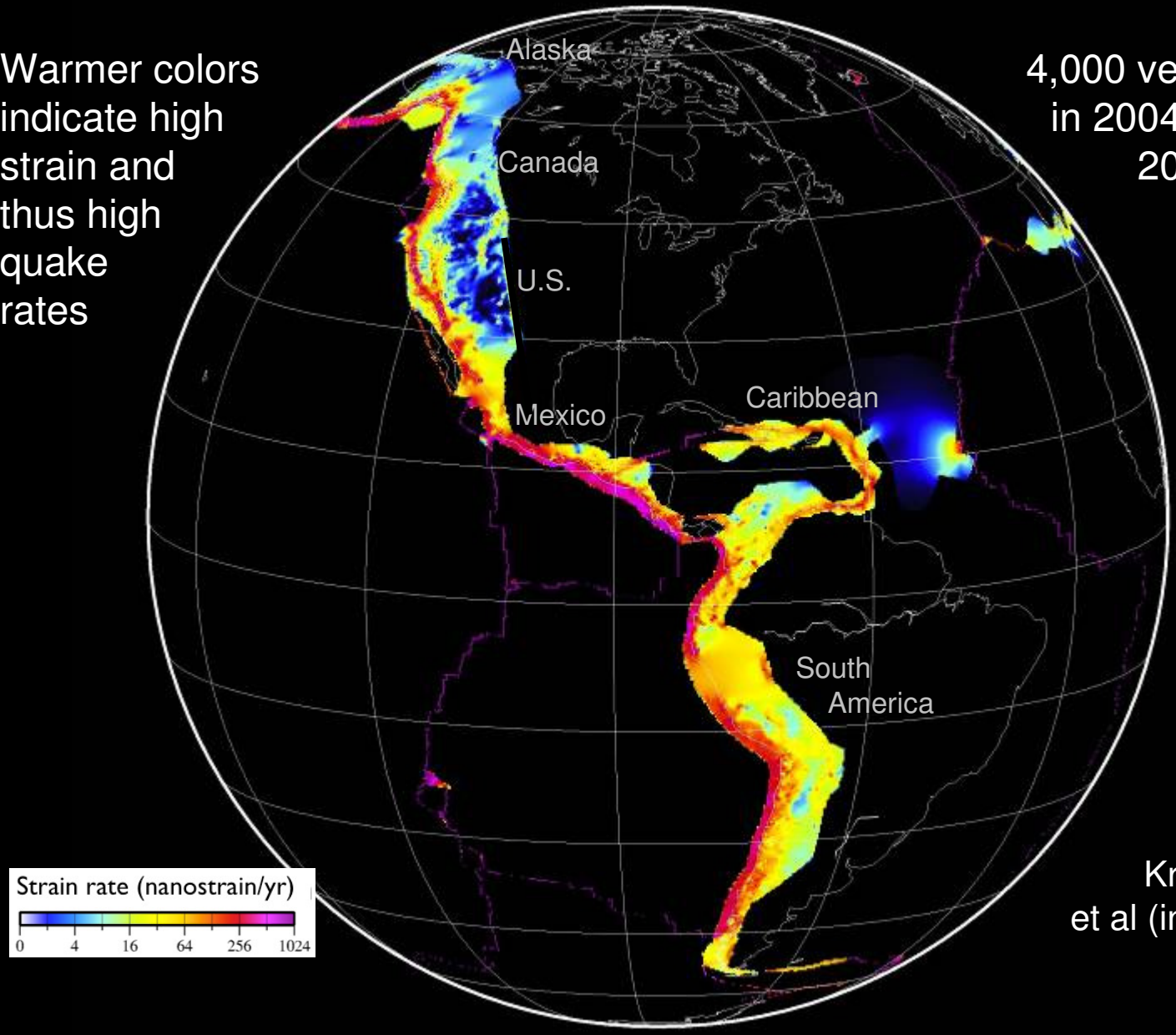
If all accumulating strain were released seismically, strain rate (*left panel*)



2000-2011 GPS velocities used by Kreemer et al
for the GEM Strain Rate Model

GEM Global Strain Rate Model reveals earthquake potential and active faults

Warmer colors indicate high strain and thus high quake rates

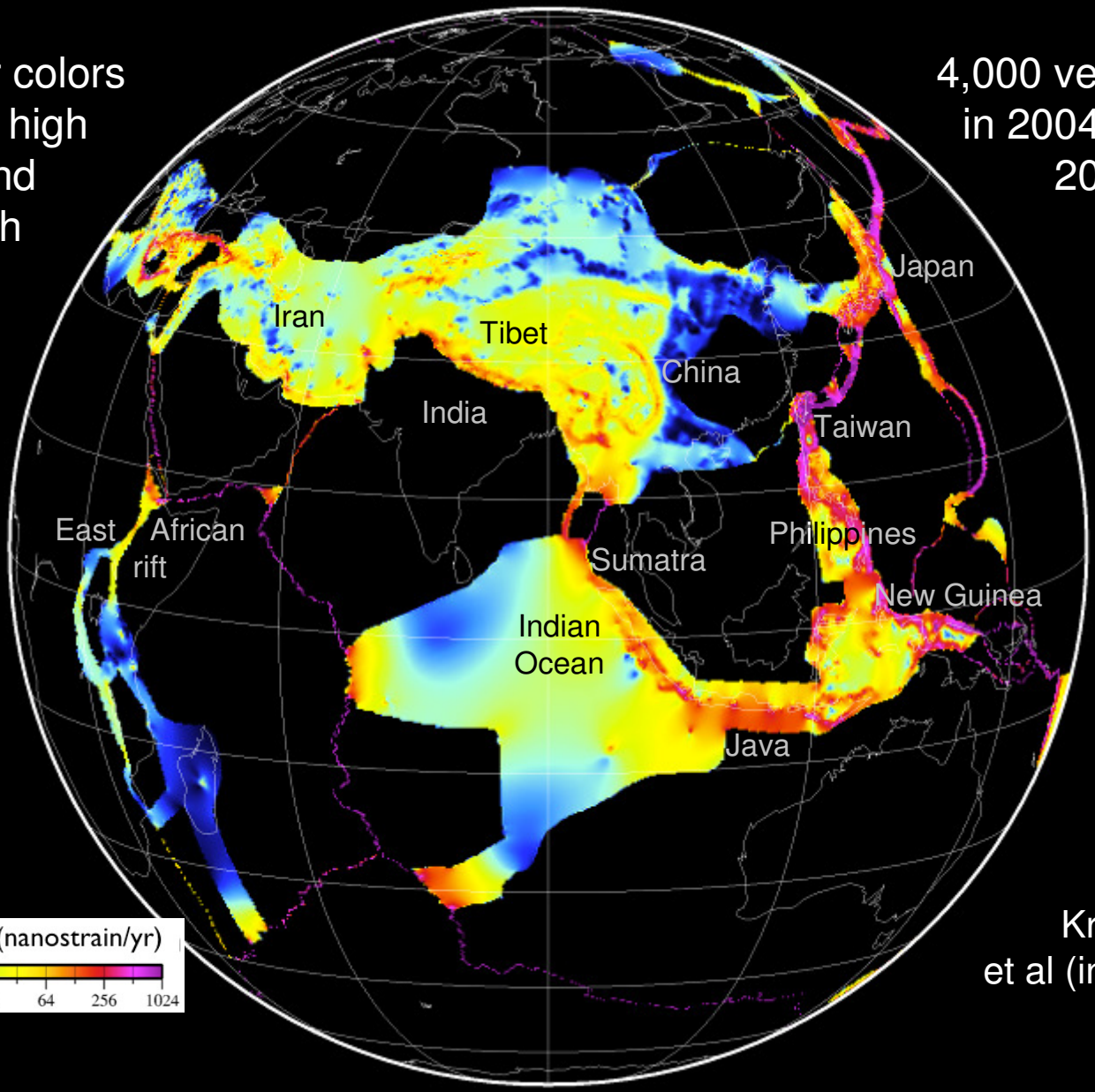


4,000 velocities in 2004 model 20,000 in GEM

Kreemer et al (in prep.)

GEM Global Strain Rate Model reveals earthquake potential and active faults

Warmer colors indicate high strain and thus high quake rates

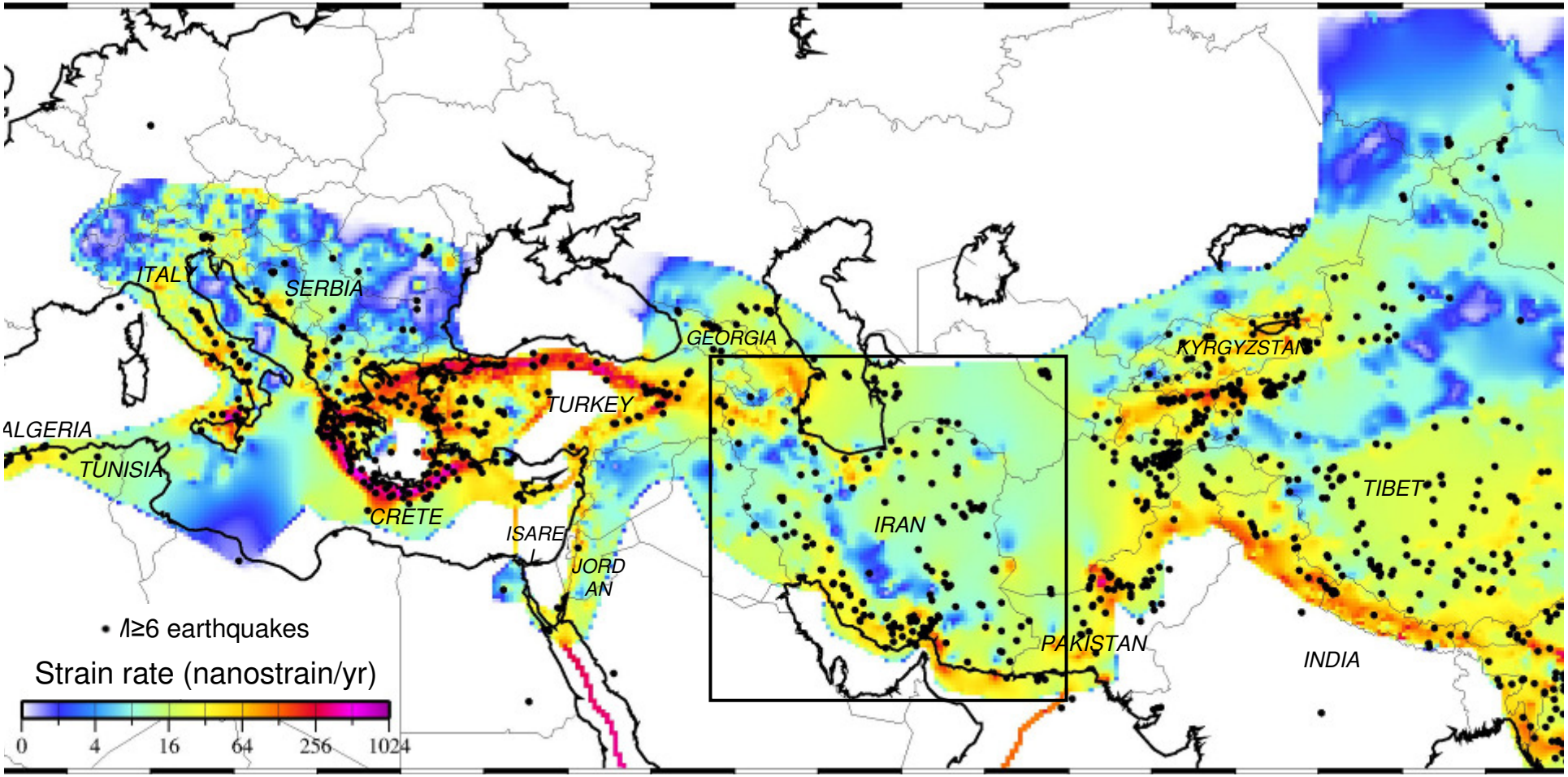


4,000 velocities in 2004 model 20,000 in GEM

Kreemer et al (in prep.)

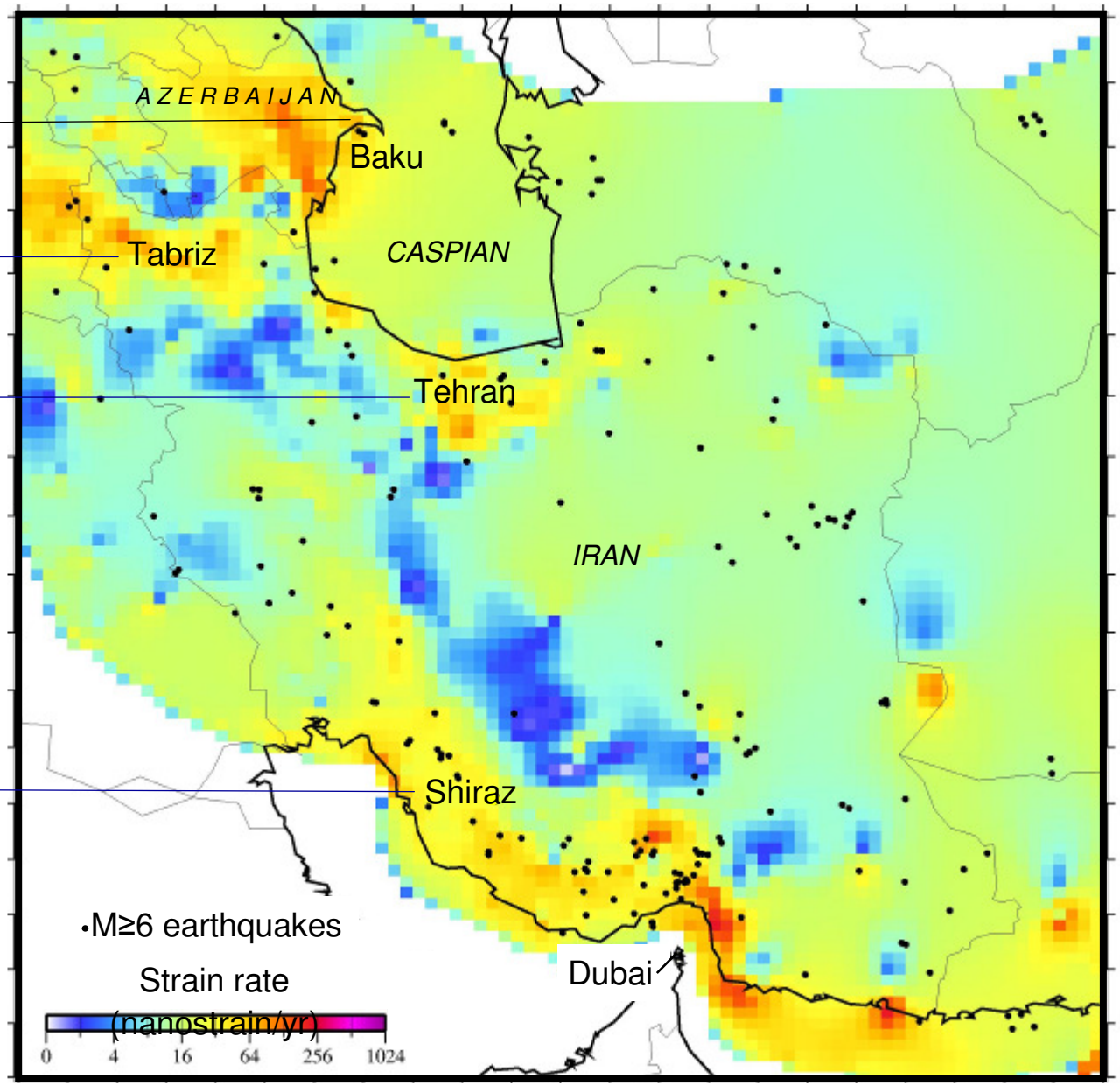
GEM Strain Rate Model and ISC-GEM Catalog across Eurasia

Strain rate and large 20th century earthquakes are correlated

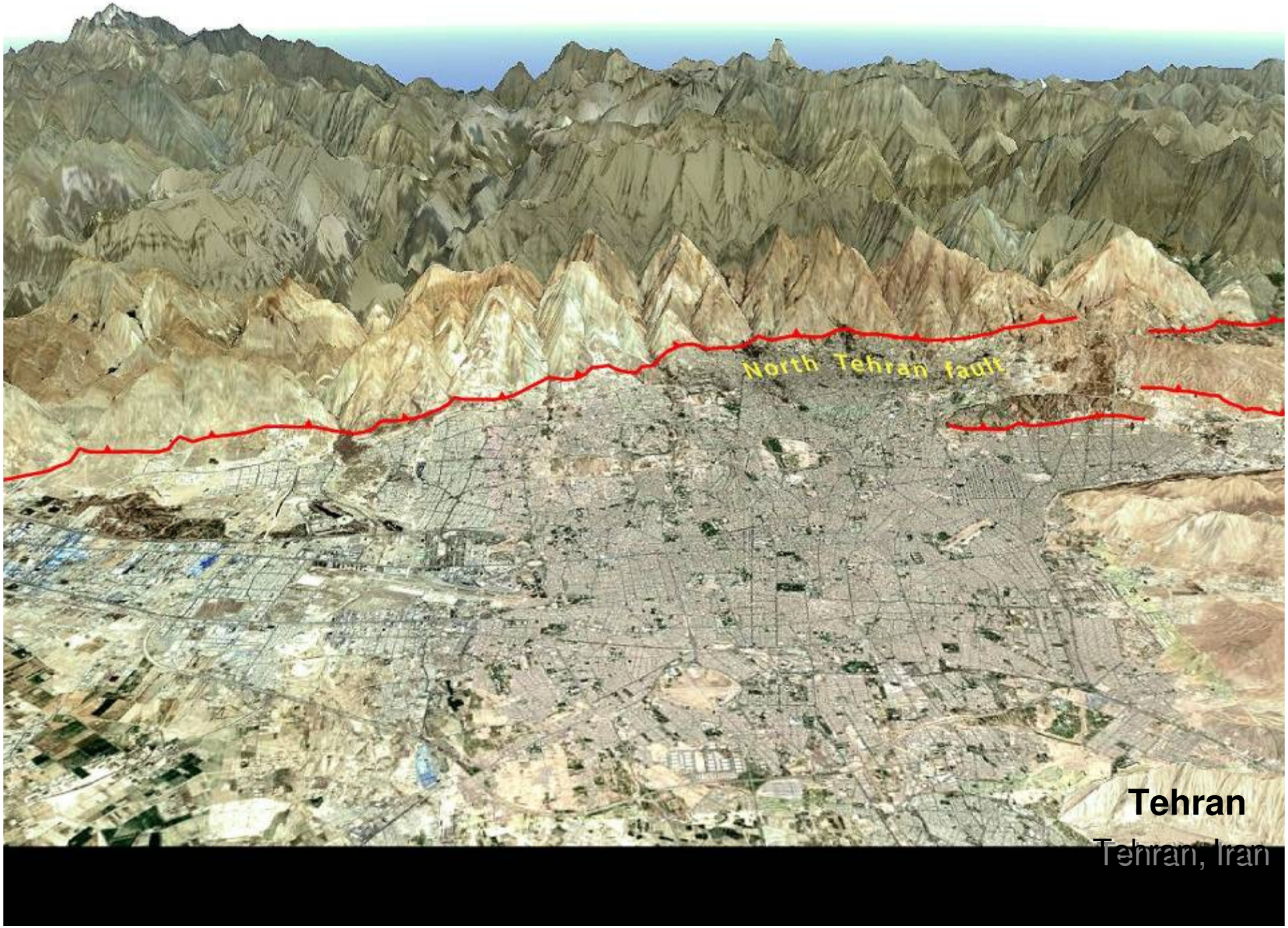


Warning Strain exceeds seismicity in Himalayas, Tehran, Baku, North Anatolian fault, Greece

Iran: GEM Strain Rate Model and ISC-GEM Seismic Catalog

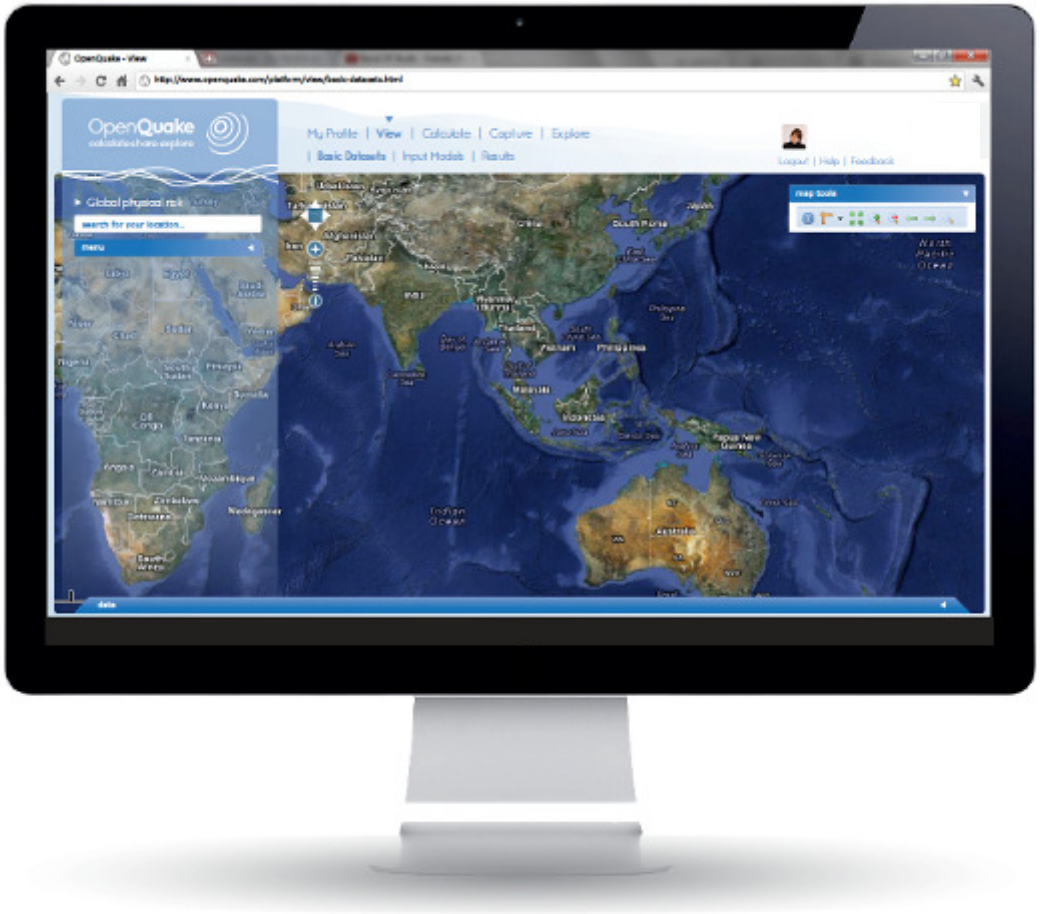


Kreemer
(in prep.)


North Tehran fault
Tehran
Tehran, Iran

GEM SOFTWARE: OPENQUAKE

My Profile | View | Calculate | Capture | Explore



Developed using many of the concepts and methods of OpenSHA (*Field et al.*, USGS & SCEC) and PAGER (*Wald et al.*, USGS)

Engine Open source calculation of hazard and risk on cluster or cloud

Data Preparation Tools For hazard, building exposure and vulnerability

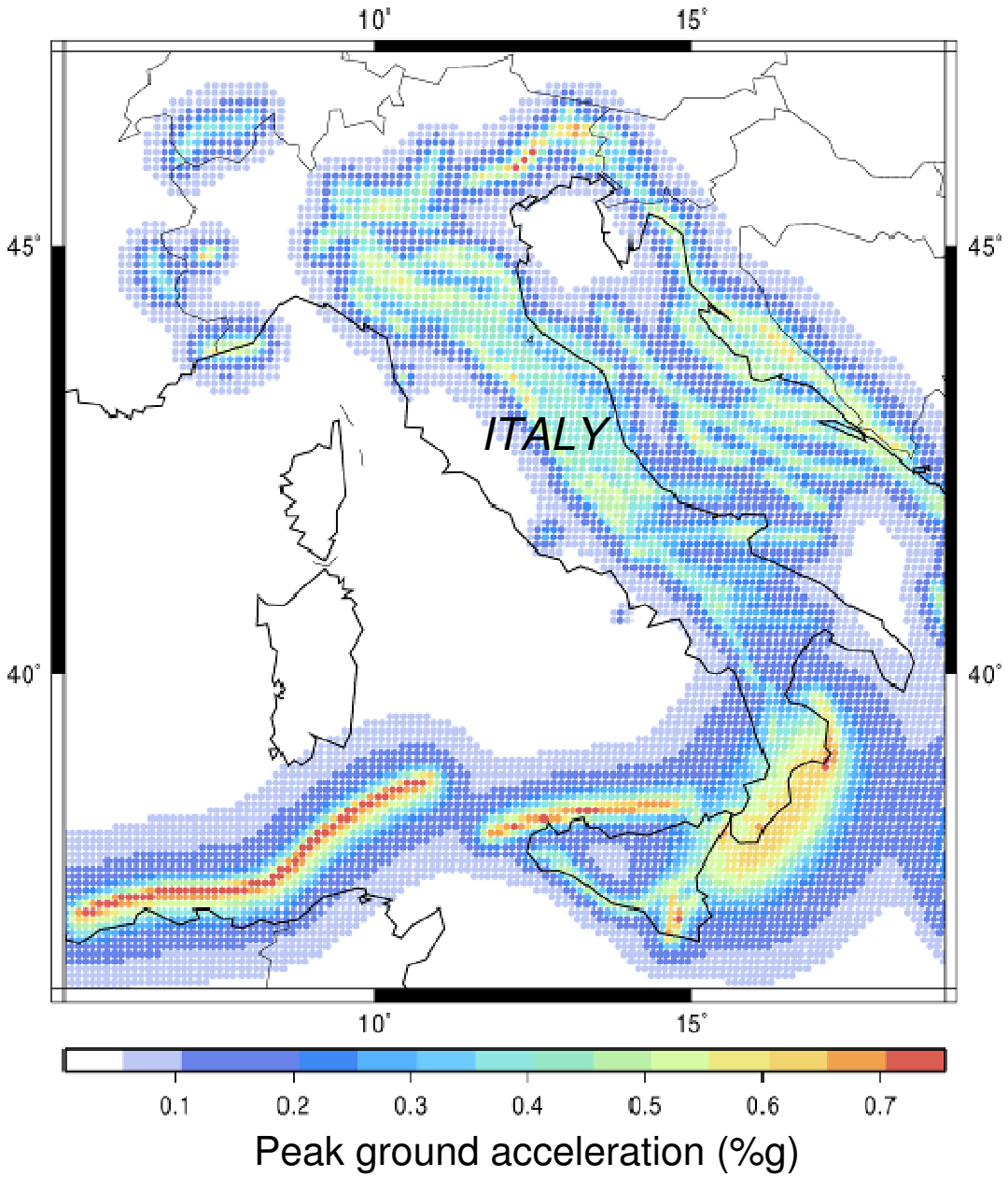
Capture Tools For remote sensing data and direct field observations

Composite Indices Socio-economic vulnerability assessments and tools

Decision Support Tools Retrofitting, mitigation, insurance, preparation

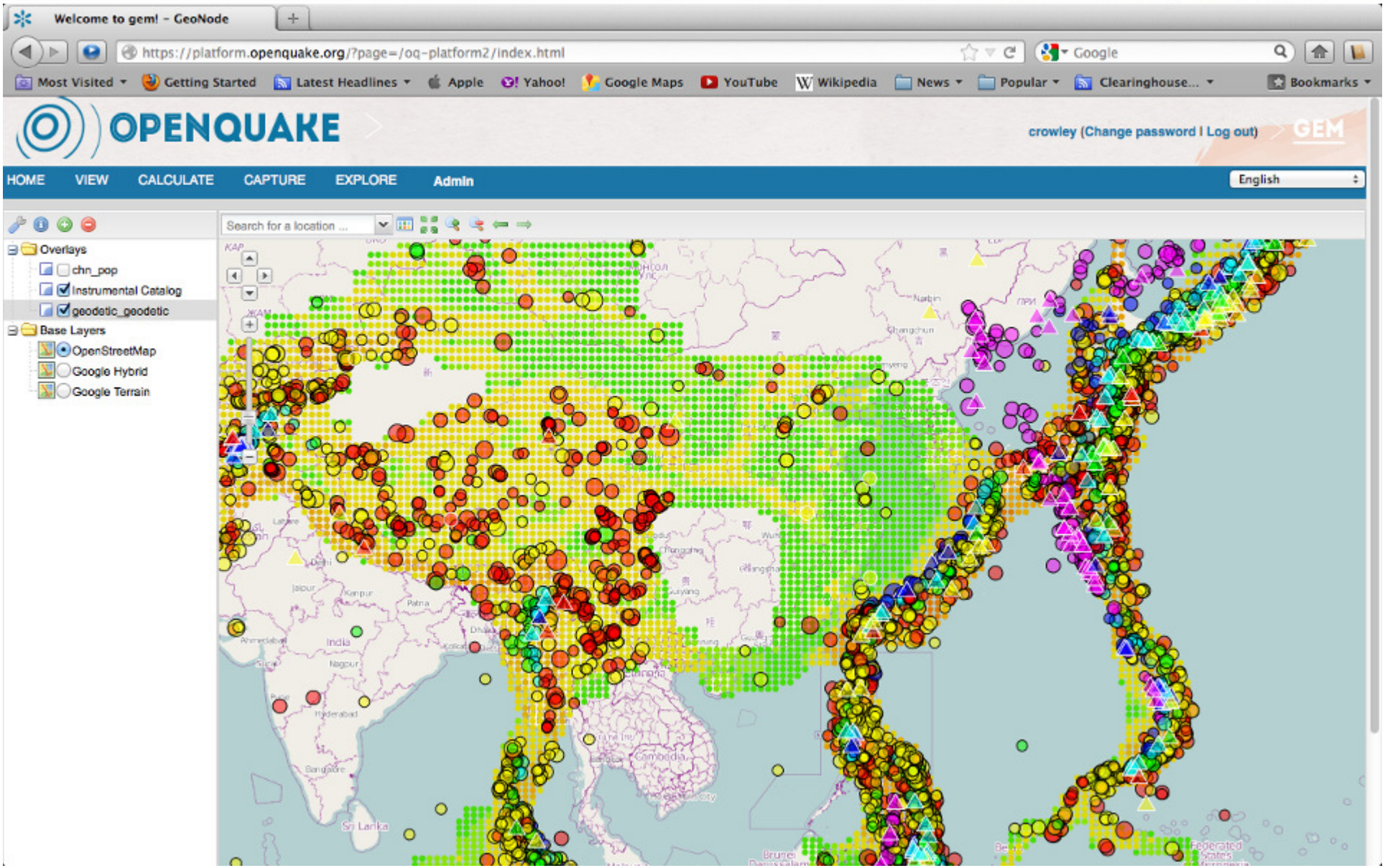
open source™

OpenQuake: Robust and efficient hazard calculations

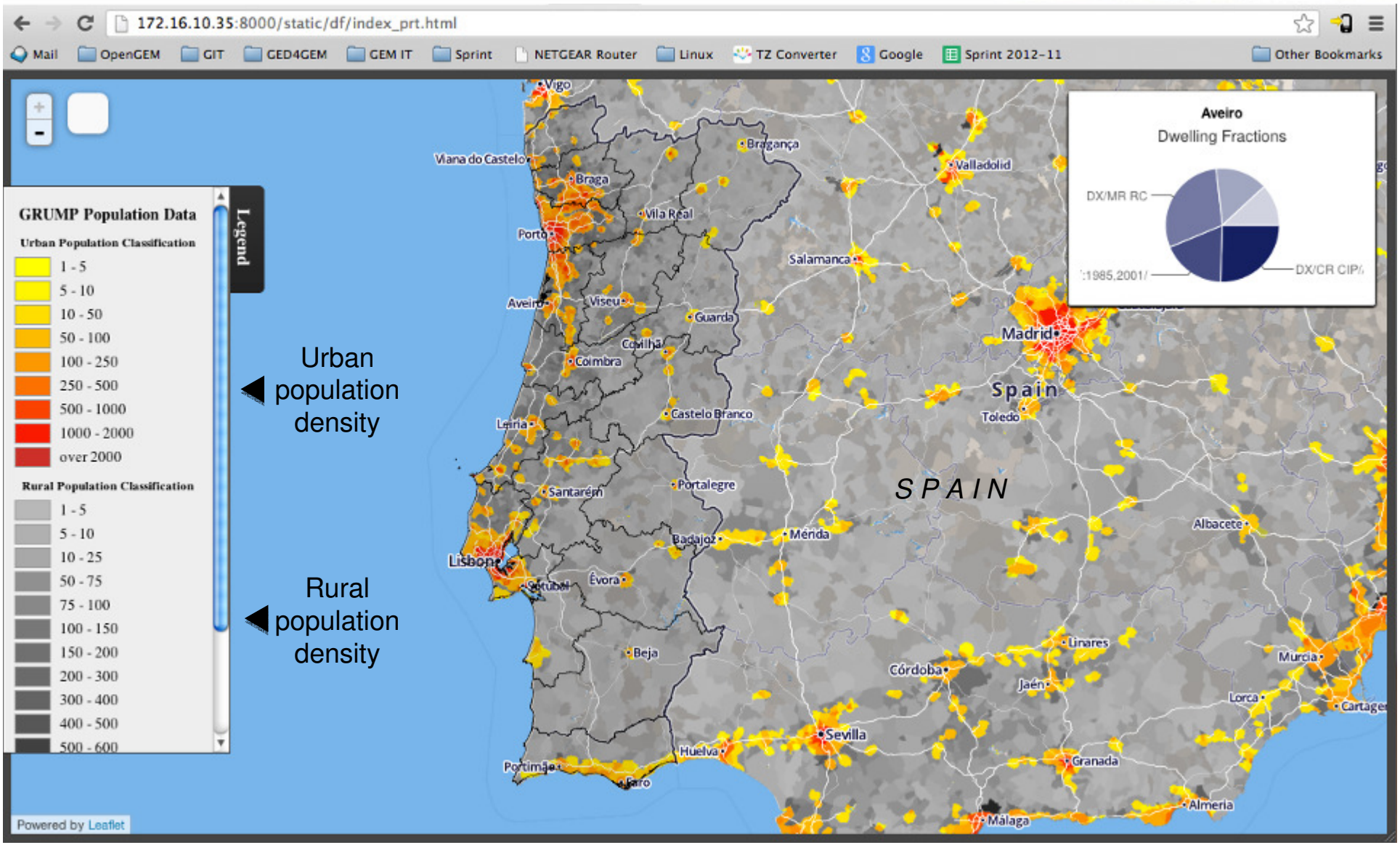


- 118 fault sources
- 1,000,000 ruptures
- Hazard curves for PGA (19 intensity levels)
- Ground Motion Pred. Eqn: *Chiou & Youngs* (2008)
- 14,000 calculation sites
- **Run time: 2h 40 m**

Intuitive data visualization: Quakes and Strain



Intuitive data visualization: Urban and rural



OPENQUAKE

SEISMIC HAZARD DEBATE

SSA PUBLICATIONS: SRL

OPINION

September/October 2011

Bad Assumptions or Bad Luck: Why Earthquake Hazard Maps Need Objective Testing

Seth Stein, Robert Geller, and Mian Liu

SSA PUBLICATIONS: SRL

OPINION

November/December 2012

Characteristic Earthquake Model, 1884–2011, R.I.P.

Yan Y. Kagan, David D. Jackson, and Robert J. Geller

SSA PUBLICATIONS: SRL

OPINION

March/April 2012

Earthquake Hazard Maps and Objective Testing: The Hazard Mapper's Point of View

Mark W. Stirling

SSA PUBLICATIONS: SRL

September/October 2012

Have Recent Earthquakes Exposed Flaws in or Misunderstandings of Probabilistic Seismic Hazard Analysis?

by Thomas C. Hanks, Gregory C. Beroza, and Shinji Toda

POWELL GROUPS: Harnessing the community

Bring warring parties together on a mountain top for 3 days to develop new strategies, and to agree on tests of seismic hazard assessment

USGS

GEM

POWELL GROUPS: Harnessing the community

USGS

GEM

Emerging Powell Projects

1. Test post-1996 ground motions against the 1996 US Natl Seismic Hazard Model

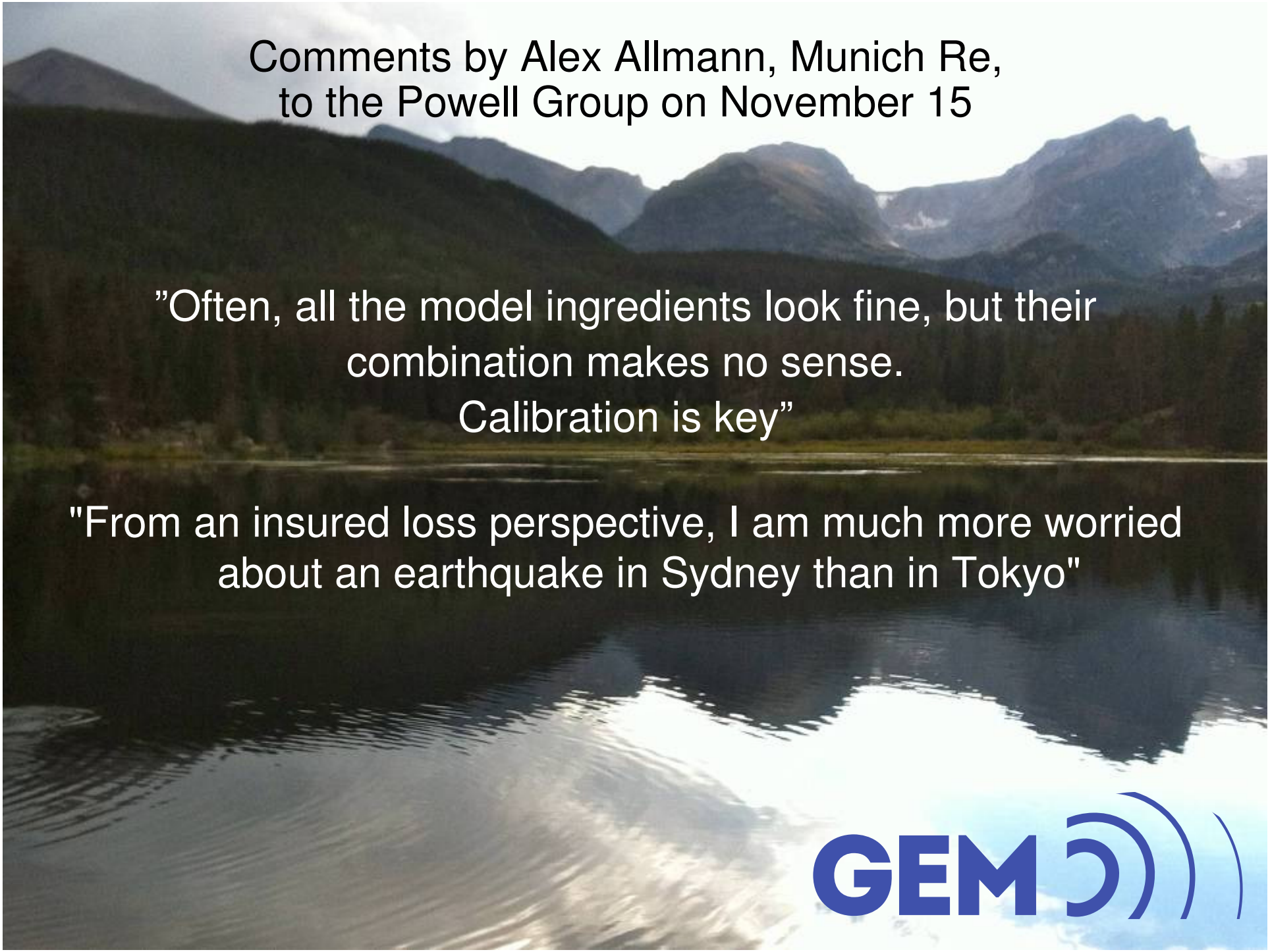
2. Build and test global earthquake rate model using smoothed seismicity and GEM strain rate

3. Abandon ‘maximum quake magnitude’ assignments for a scientifically sound alternative

4. Build OpenQuake Modelers Toolkit tests for ‘declustering’ (removing aftershocks from) seismic catalogs

USGS

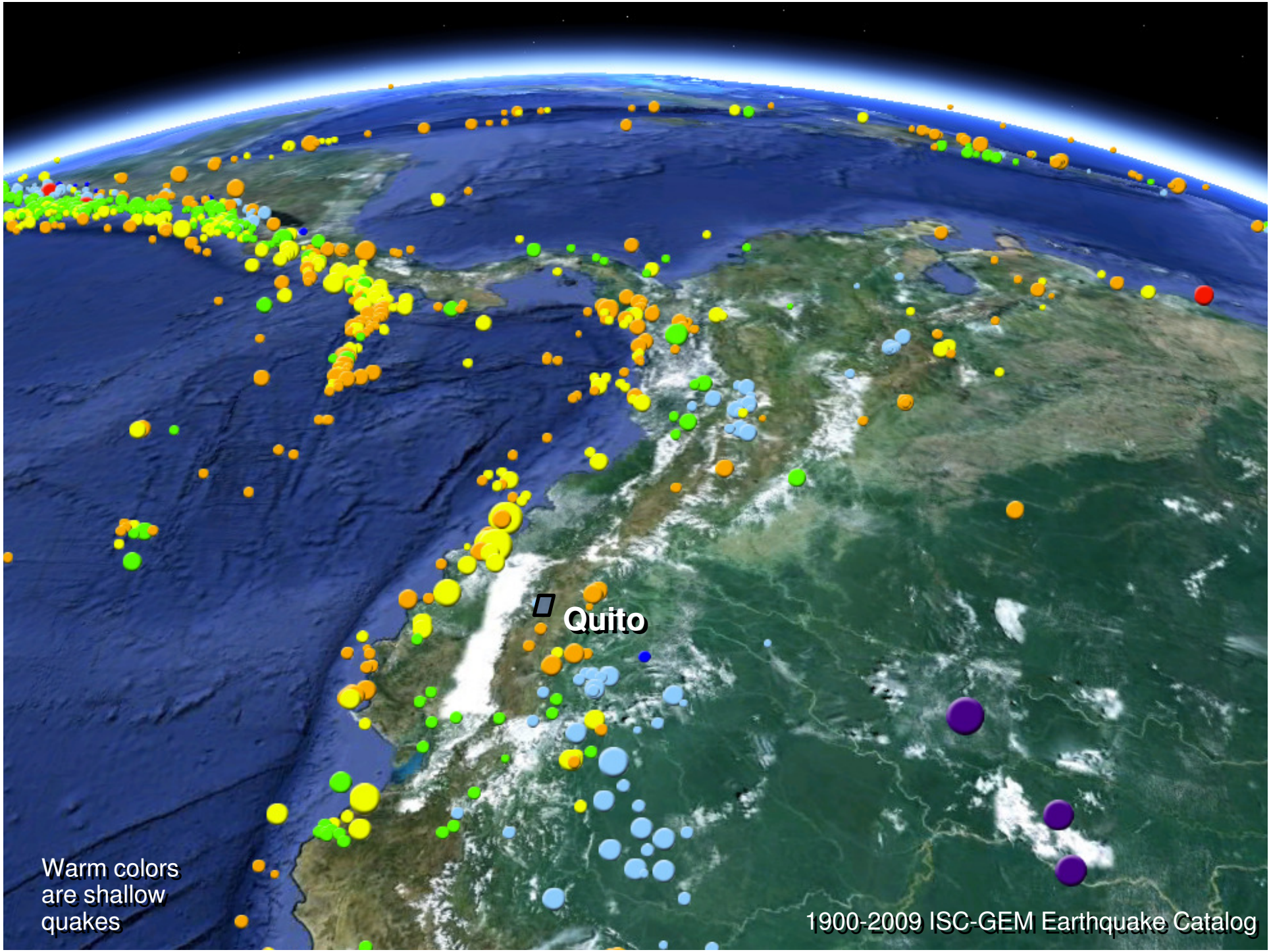
GEM

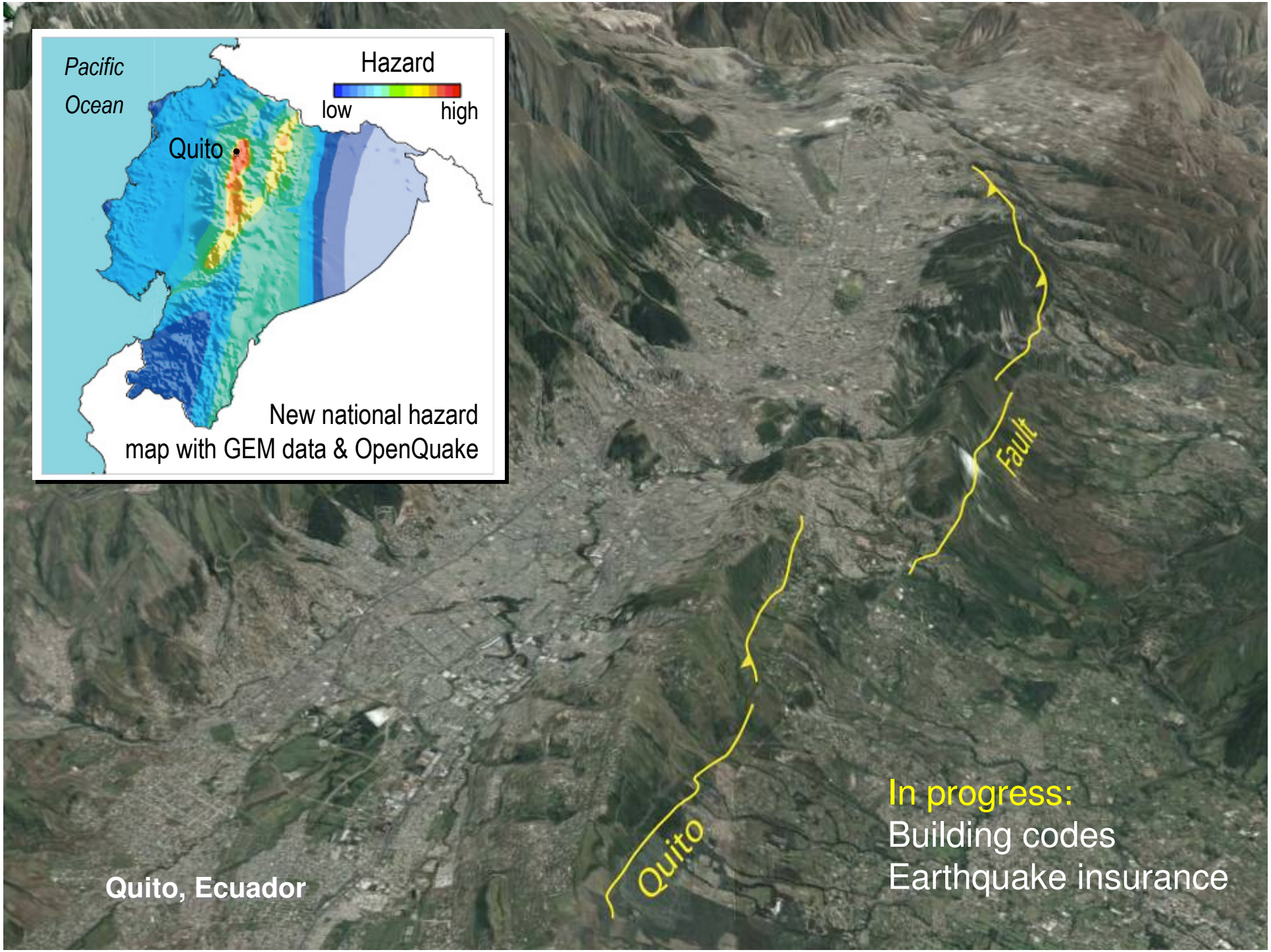


Comments by Alex Allmann, Munich Re,
to the Powell Group on November 15

”Often, all the model ingredients look fine, but their combination makes no sense.
Calibration is key”

"From an insured loss perspective, I am much more worried about an earthquake in Sydney than in Tokyo"


Quito
Warm colors
are shallow
quakes
1900-2009 ISC-GEM Earthquake Catalog


Pacific
Ocean
Hazard
low
high
Quito
New national hazard
map with GEM data & OpenQuake
Fault
Quito
Quito, Ecuador
In progress:
Building codes
Earthquake insurance

traditional bamboo house in
the Colombian Andes


GEM
Building a testable global model
will raise risk awareness,
advance the practice,
and open new
markets
www.globalquakemodel.org