

Seismic Risk & Vulnerability in the Caribbean

CCRIF Technical Workshop

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Global Context & Loss

- Earthquakes are among the most deadly and devastating natural hazards.
- They occur without warning and many seismic zones coincide with areas of high population density.
- Large earthquakes can be catastrophic with overwhelming impacts to the economy and considerable loss of lives.
- Earthquake magnitude is not the only factor to consider.
- Approximately 500,000 earthquakes worldwide annually.



Historical Earthquakes

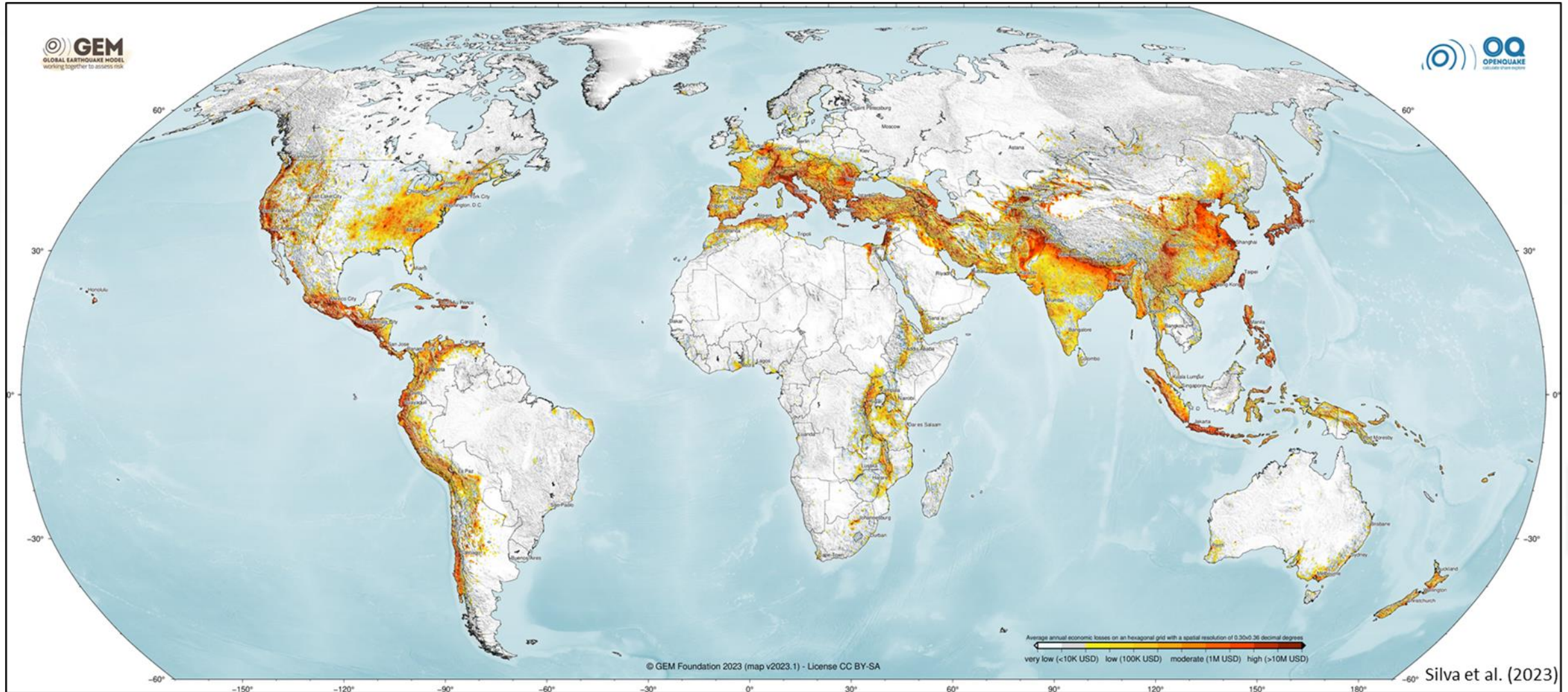
- 1989 Australia: Magnitude 5.6 | 13 Fatalities | \$1.2 Billion
- 2017 Mexico: Magnitude 7.1 | 361 Fatalities | \$4 Billion
- 1985 Mexico: Magnitude 8.0 | 5000 Fatalities | \$5 Billion
- 2010 New Zealand: Magnitude 7.0 | 2 Fatalities | \$6.5 Billion
- 1989 USA: Magnitude 6.9 | 63 Fatalities | \$10 Billion
- 2004 Indian Ocean: Magnitude 9.1 | 227898 Fatalities | \$10 Billion
- 2015 Nepal: Magnitude 7.8 | 8964 Fatalities | \$10 Billion
- 1999 Taiwan: Magnitude 7.3 | 2400 Fatalities | \$14 Billion
- 2004 Japan: Magnitude 6.6 | 33 Fatalities | \$28 Billion



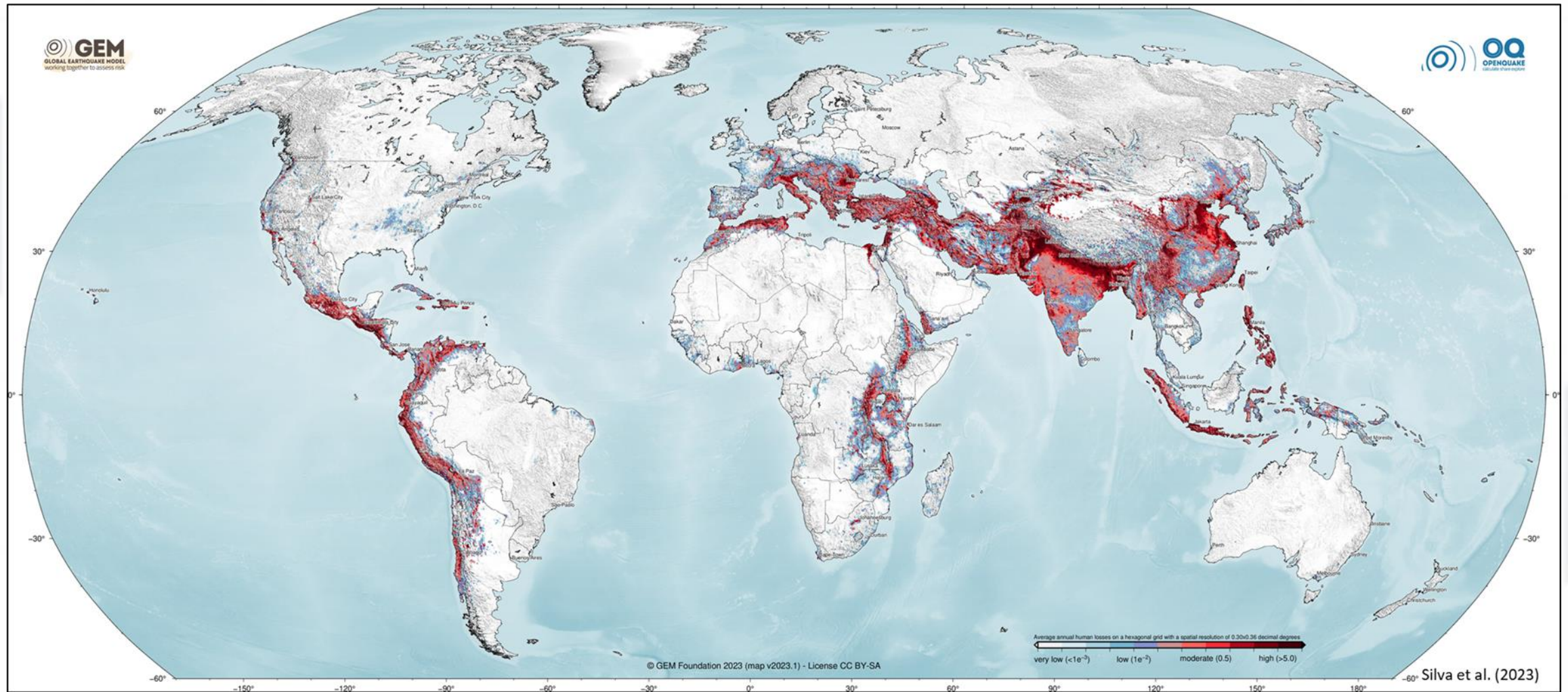
- 1995 Japan: Magnitude 6.9 | 6434 Fatalities | \$197 Billion
- 2008 China: Magnitude 8.0 | 69000 Fatalities | \$148 Billion
- 2010 Haiti: Magnitude 7.0 | 220000 Fatalities | \$14 Billion
- 2023 Turkey: Magnitude 7.8 | 56000 Fatalities | \$34 Billion
- 2023 Morocco: Magnitude 6.8 | 2900 Fatalities | \$10.7 Billion
- 2010 Chile: Magnitude 8.8 | 521 Fatalities | \$30 Billion
- 2011 New Zealand: Magnitude 7.1 | 166 Fatalities | \$20 Billion
- 1994 USA: Magnitude 6.4 | 60 Fatalities | \$44 Billion
- 2011 Japan: Magnitude 9.1 | 15000 Fatalities | \$360 Billion



Economic Loss

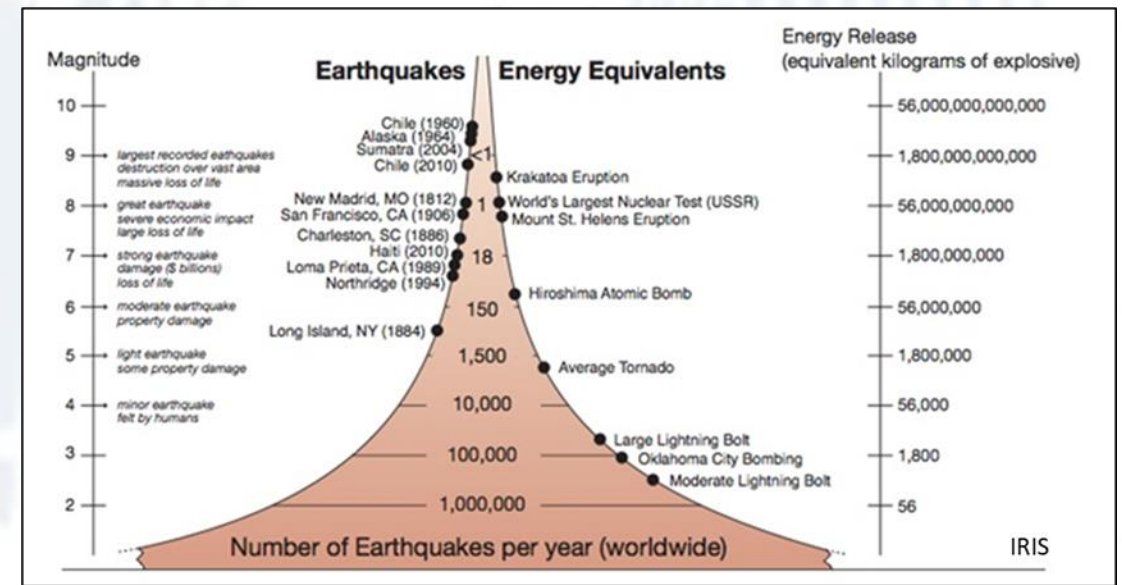
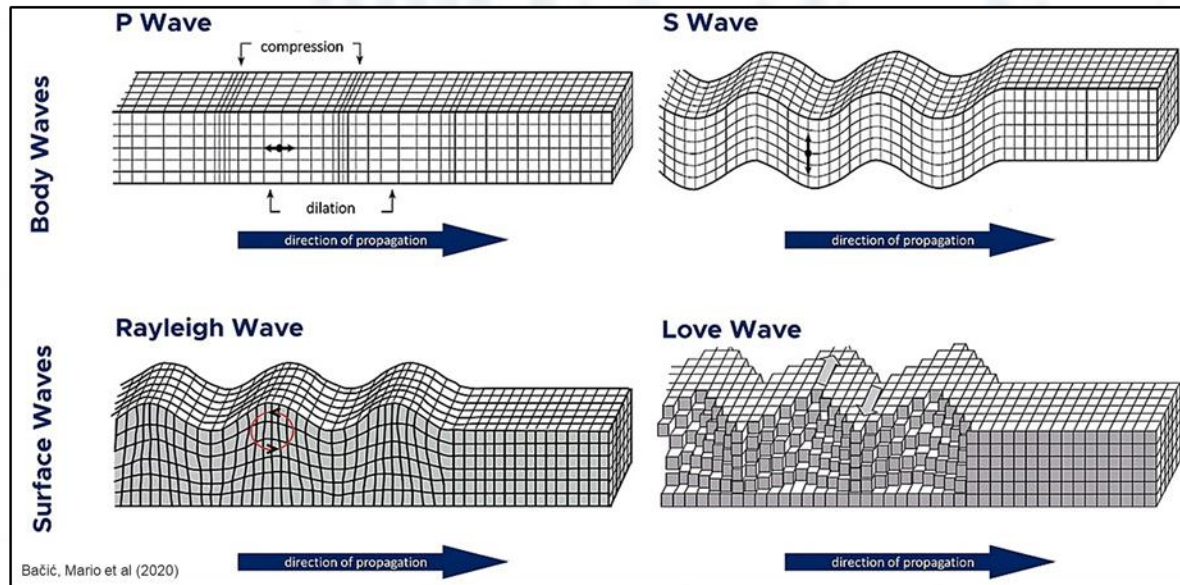
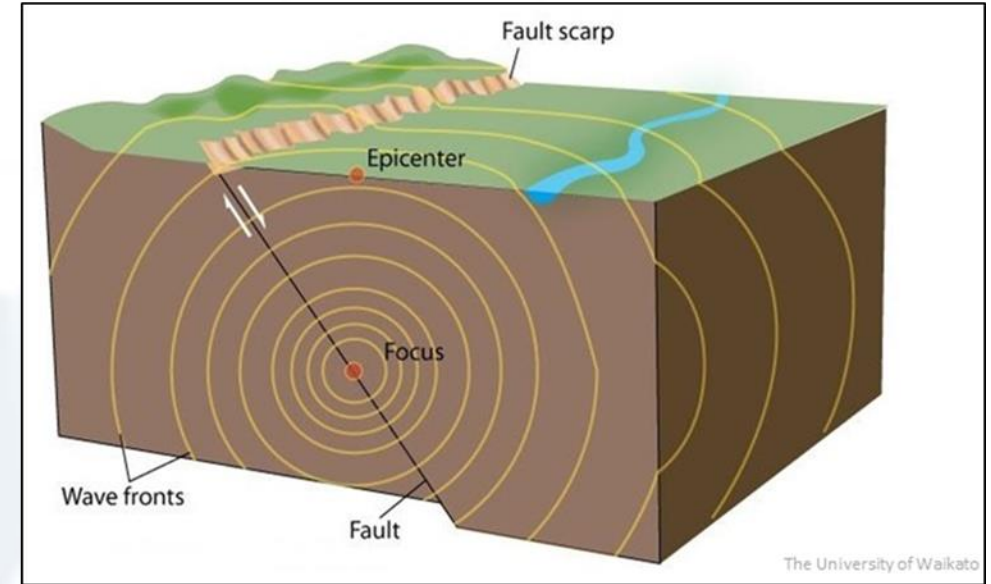


Fatalities



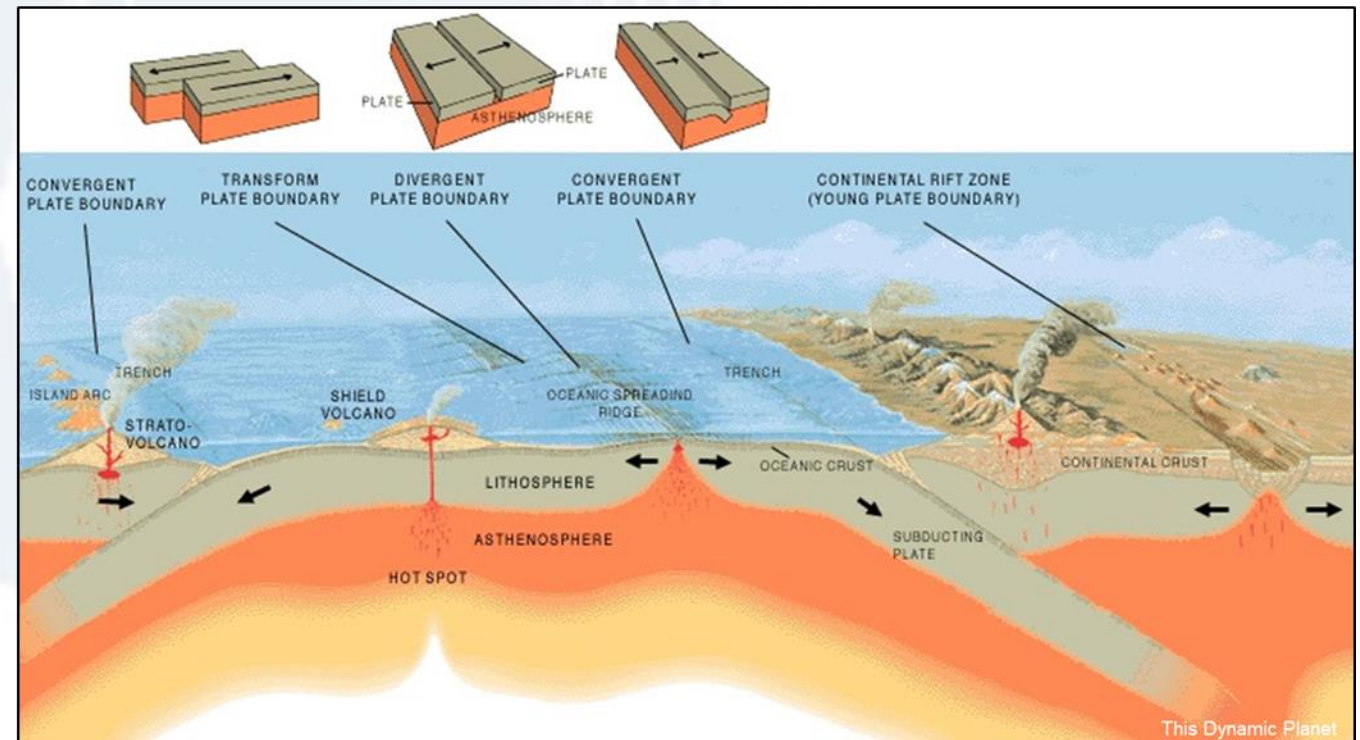
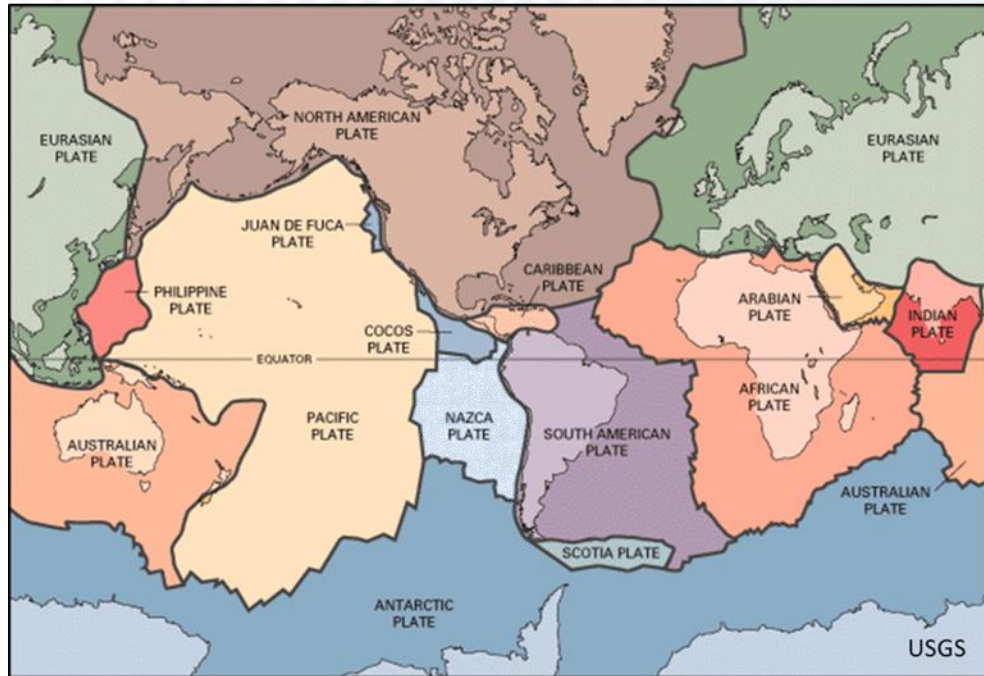
Earthquakes

- Sudden release of strain energy in the Earth's crust, resulting in waves of shaking that radiate outwards from the earthquake source (*BGS*).
- Types of earthquakes: tectonic, volcanic, collapse and explosion.
- Epicentre and focus
- Magnitude and intensity
- Aftershocks and foreshock



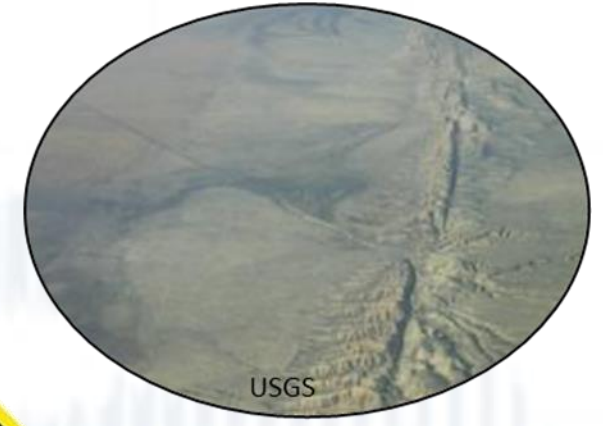
Tectonics & Faults

- Fracture or zone of fractures between two blocks of rock
- Movement along faults may occur rapidly (earthquakes) or slowly (creep)
- Types of faults: normal, reverse, strike-slip faults, hybrid



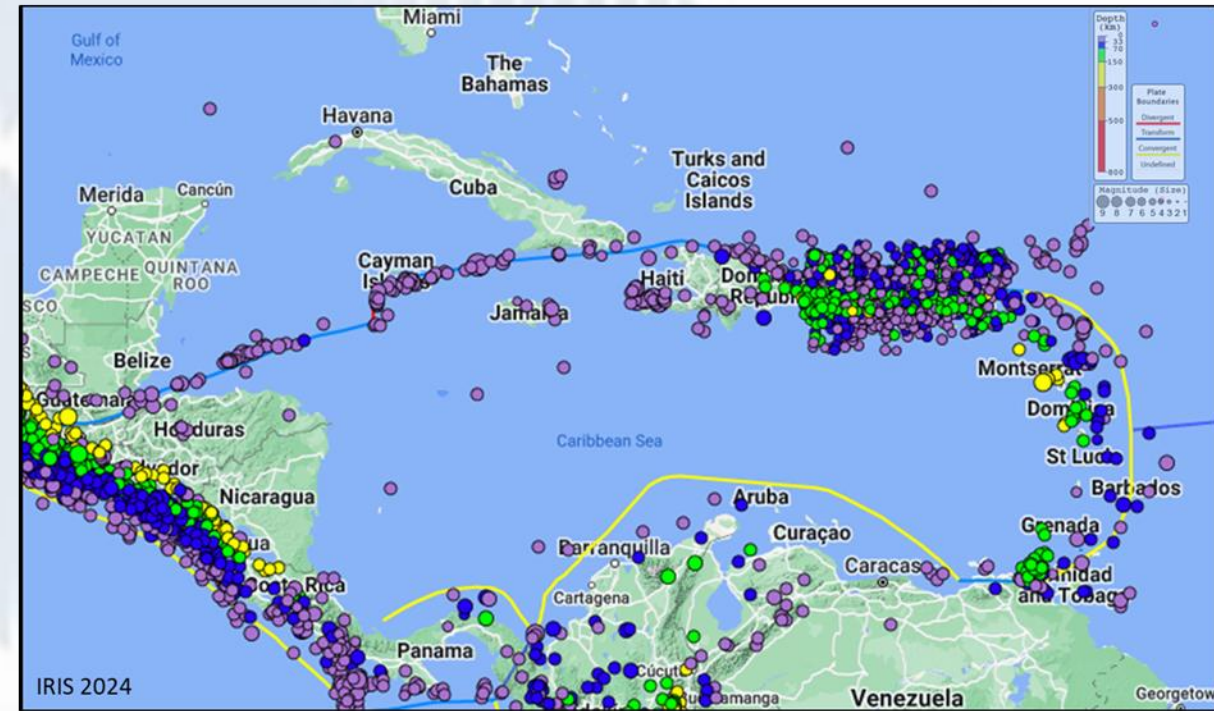
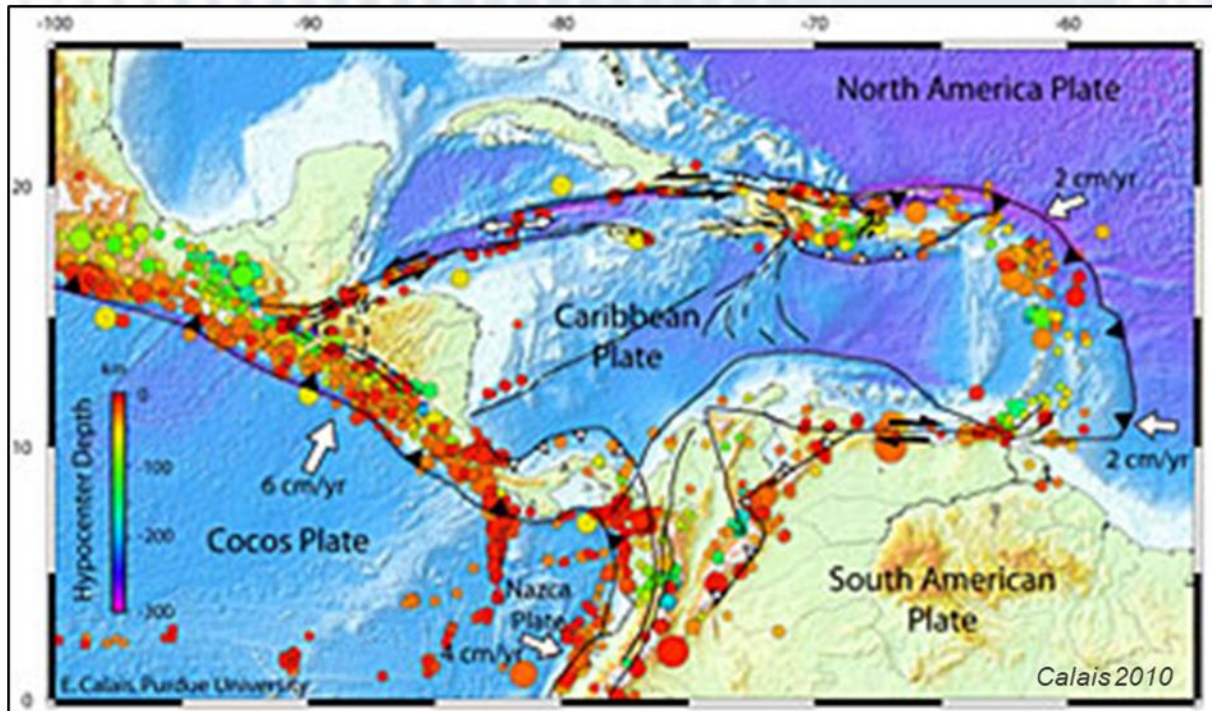
Seismic Hazards

- Property of an earthquake that can cause damage or loss.
- Include phenomenon associated with an earthquake that may produce adverse effects on human activities.
- Primary seismic hazards:
 - ✓ Ground shaking
 - ✓ Liquefaction
 - ✓ Landslides
 - ✓ Surface rupture
- Secondary seismic hazards:
 - ✓ Tsunami
 - ✓ Fire
 - ✓ Seiche
 - ✓ Flooding



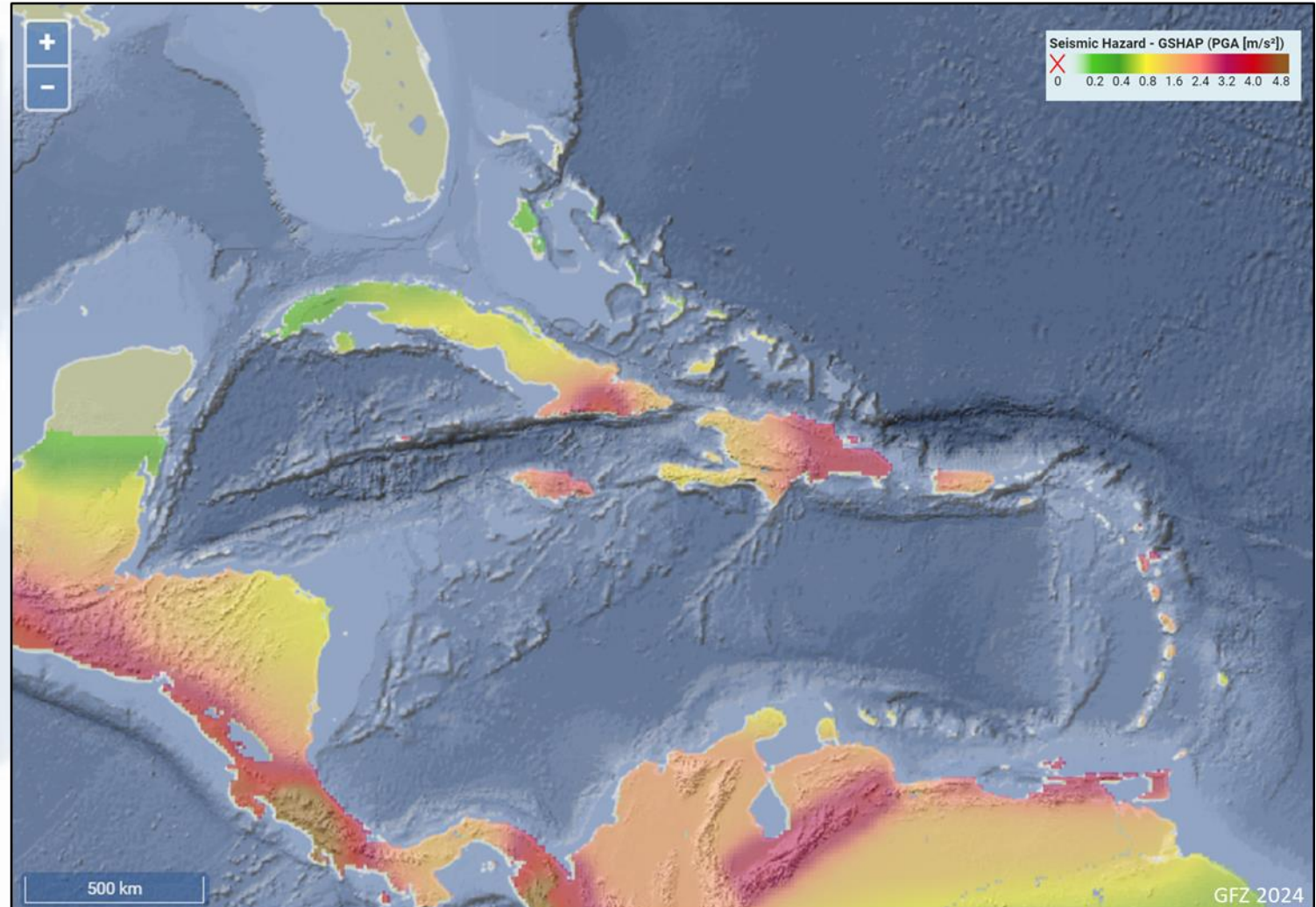
Earthquakes in the Caribbean

- The Caribbean region is located within a seismically active zone.
- Seismotectonics of the Caribbean Plate: delineated by earthquakes and reflects tectonic plate movement.
- The region has a well documented earthquake history and records significant seismic activity every year.
- Several of these earthquakes are felt.



Caribbean Seismic Profile

- Seismic hazard
- Risk vs vulnerability
- Ground acceleration and other parameters should be considered
- Primary and associated secondary hazards
- Teleseismic events and impacts



Historical Earthquakes in the Caribbean Region

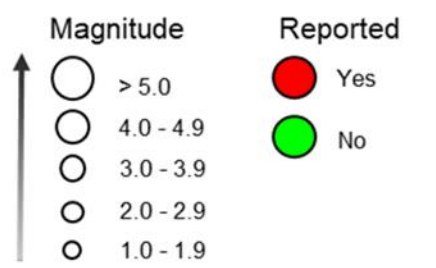
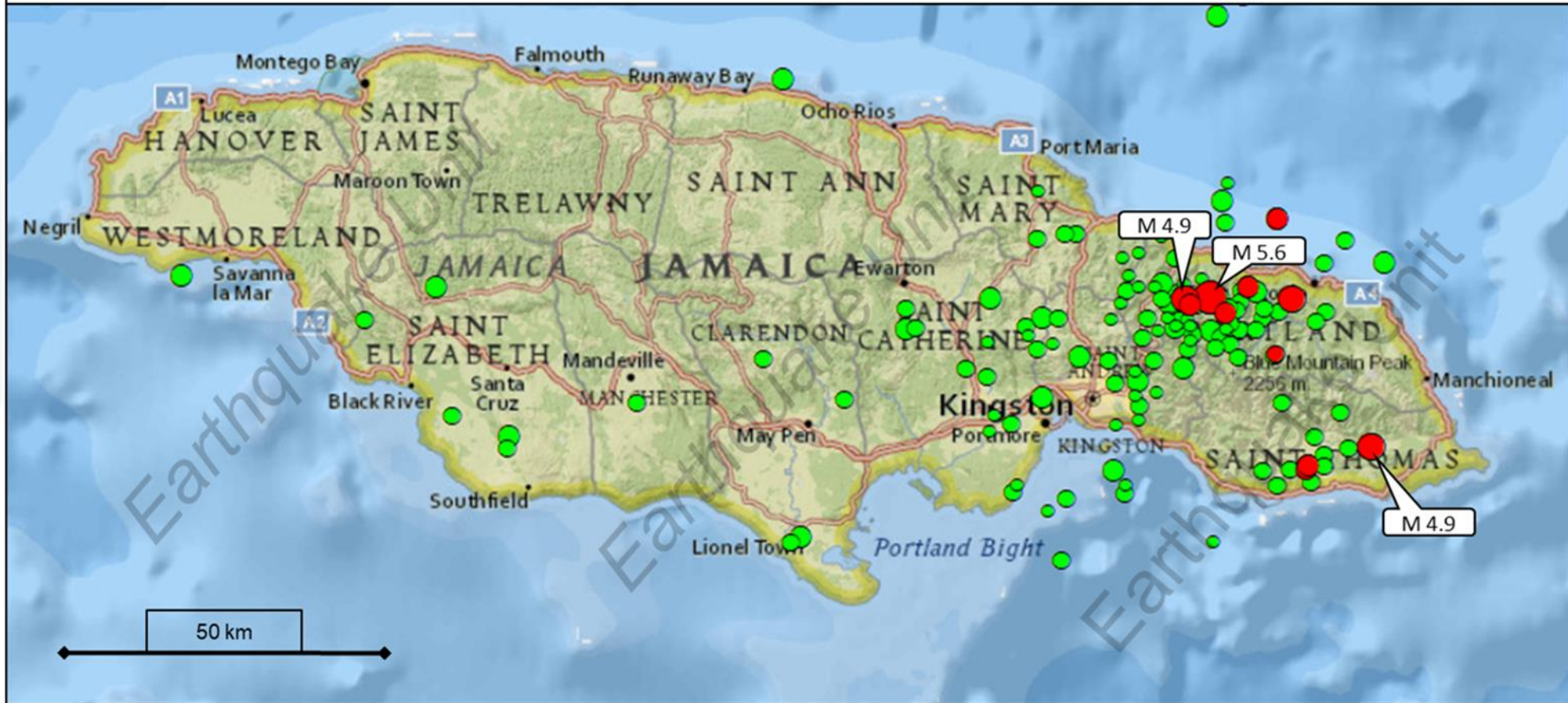
- Historical records over the past 500 years indicate frequent seismic activity

Event	Mag.	Fatalities	Impacts
2023 Jamaica 2023	5.6		Minor damage, landslides subsea cable damage, landslides
2021 Haiti	7.2	2248	Severe damage
2020 Cayman Islands	7.7		Tsunami
2020 Puerto Rico	6.4	4	
2018 Haiti	5.9	18	
2018 Trinidad, Venezuela	7.3	5	Ground failure
2010 Haiti	7.0	220000	Extreme damage and minor tsunami
2007 Martinique	7.3	6	
2005 Jamaica	5.1		Damage
2004 Grand Cayman	6.8		Several holes developed
2004 Guadeloupe, Dominica	6.3	1	Tsunami
2003 Dominican Republic	6.4	3	
1997 Trinidad and Tobago	6.7		Damage
1993 Jamaica	5.5	1	Damage

Event	Mag.	Fatalities	Impacts
1984 Dominican Republic	6.7	5	Damage and tsunami
1974 Antigua, Barbuda	6.9		
1946 Dominican Republic	8.1	2550	Destructive tsunami
1954 Trinidad	6.5		
1943 Puerto Rico	7.7		Moderate damage
1918 Puerto Rico	7.1	76–116	Tsunami
1918 Trinidad	6.5		Damage, most masonry buildings destroyed in POS
1907 Jamaica	6.2	800–1000	Tsunami, fires, landslides
1906 St. Lucia	>7		Severe damage in St. Lucia & Martinique
1867 Virgin Islands	7.2	24	Destructive tsunami
1843 Antigua & Guadeloupe	8-8.5	2000	Extreme damage
1842 Haiti	8.1	5300	Severe damage and destructive tsunami
1839 Martinique	6.5	400	Severe damage, felt from Saba to Dominica
1787 Puerto Rico	8.0 - 8.2		Tsunami
1766 Venezuela, Trinidad	7.5 – 8.0		Severe, total destruction of masonry structures
1701 Haiti	6.6		
1692 Jamaica	7.5	5,000	Tsunami, liquefaction
1690 Antigua, St. Kitts and Nevis	8.0		Destructive tsunami




Seismicity in Jamaica 2023



Basemap Source: Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, National Geographic
 Seismic Data: Jamaica Seismograph Network, Earthquake Unit.
 Date created: 8th November, 2023
 Created by: K. Tankoo (2023)

Note: Data included in this map is subject to change. Permission is required for the reproduction or use of this map and associated earthquake information.



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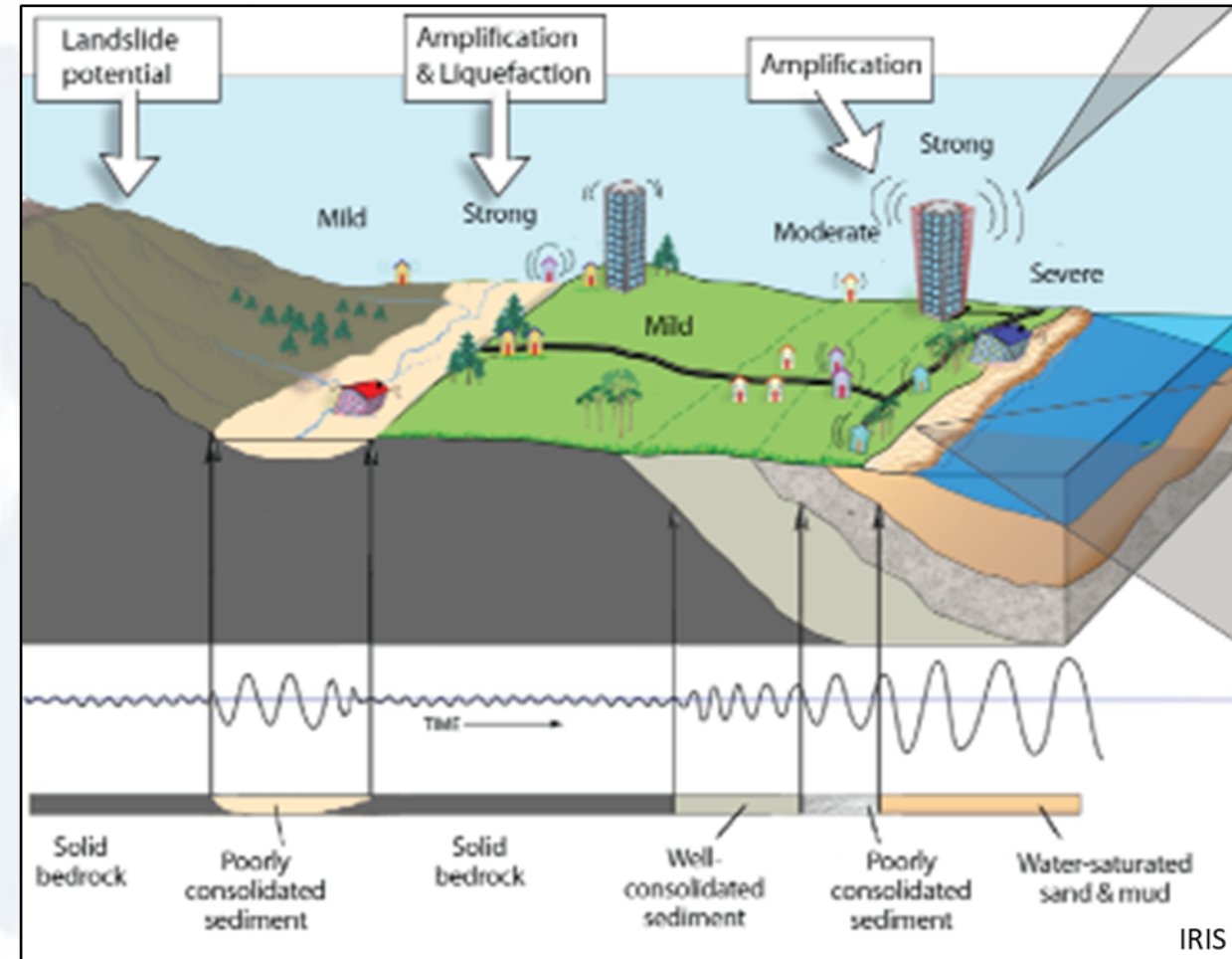
Earthquake Preparedness & Response

- DROP, COVER, HOLD ON!
- Update emergency plans
- Earthquake drills
- Education campaigns
- Monitoring network
- Alarm systems
- Logistics and coordination
- Communication network
- Rapid damage assessments
- Crisis decision-making



Earthquake Mitigation

- Seismic hazard assessments and risk modelling
- Hazards hunts
- Building/infrastructure assessments
- Structural measures
- Building codes and retrofiting
- Development plans
- Research
- Reduce impacts of hazards
- Critical facilities: safe hospitals, shelters?



Risk Transfer

- High seismic vs low seismic regions
- Management of the expected losses through financial risk transfer via earthquake insurance
- Epistemic uncertainty in hazard models
- Earthquake engineering solutions to manage the financial implications
- Speeding up recovery phase
- Governmental Level Action Plan





Thank You

Questions?

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