1st Joint Coordinating Committee
Developing Tsunami Damage Estimation and Mitigation Technologies
G2: Tsunami

- Dr. Shunichi Koshimura (Tohoku Univ., Tsunami engineering)
- **Mr. Erick Mas** (Tohoku Univ., Tsunami engineering)
- **Mr. Cesar Jimenez** (DHN, San Marcos Univ., Seismology and tsunami modeling)
- **Mr. Bruno Adriano** (CISMID, Tsunami modeling)
- **Ms. Sheila Yauri** (IGP, Seismology)
- **Dr. Miguel Estrada** (CISMID, Earthquake engineering)
- Dr. Gaku Shoji, Mr. Yu Hiraki, Mr. Yoshiyuki Ezura (Tsukuba Univ., Structural and earthquake engineering)
- Dr. Yuji Yagi (Tsukuba Univ., Seismology)
- Dr. Yushiro Fujii (BRI, Seismology and Tsunami modeling)
- Dr. Hideaki Yanagisawa (TEPSCO, Tsunami modeling)

Project Plan

Research Topic (Organization)	Period (2010-2014)					
	2009 (10 Months)	2010	2011	2012	2013	2014 (12Months)
G2: Tsunami 【Tohoku, BRI, Tsukuba, TEPSCO DHN, CISMID】 1) Tsunami Propagation and Impacts 2) Tsunami Hazard Mapping 3) Tsunami Damage Mitigation Technology	Tsunami Simulation — Inundation and Impact; Data Collection — Damage Assessment Method — Tsunami Damage Analysis; Historical Tsunami Data — Tsunami Damage Mitigation technology					

Objectives and Goals

- To assess the **potential tsunami disaster** and its impact to the Peruvian coast.
- To develop **practical technologies** to mitigate tsunami risks in Peru.
- Implementation to the **strategic plans** for disaster mitigation of Peruvian government.
- Contributions to **Pacific** tsunami disaster mitigation strategies.
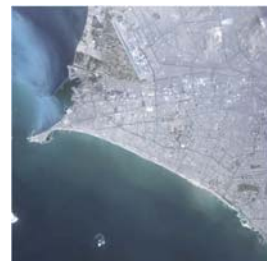
Tsunami modeling technology

Tsunami Modeling techniques (TUNAMI-code to simulate tsunami generation, off-shore/near-shore propagation and coastal inundation)

Equipments donated by JICA

| Year	Items	Quantity	Price
2010	Desktop workstation for tsunami modeling	3	$8,897.82
2010	Mobile workstation for survey and analysis	1	$2,002.77
2010	Software for data analysis (Arc GIS and extensions)	3lic.	$10,535.72
2010	High-resolution satellite image data	1set	¥1,519,105

What we have done so far

- Transfer of tsunami numerical modeling technique

- Post-tsunami field survey in Chile (2010 event)

- Tsunami field survey in Camana, Peru (2001 event)

- Verification of tsunami numerical model and tsunami source study (The 2001 Camana tsunami)

- Tsunami risk assessment along the Peruvian coast

- Mapping tsunami inundation in Callao, Lima

- Tsunami risk perception and evacuation in Callao, Lima

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Progress Report (Tsunami Propagation and Impacts)
Verification of tsunami numerical model and tsunami source study (2001 Camana tsunami)
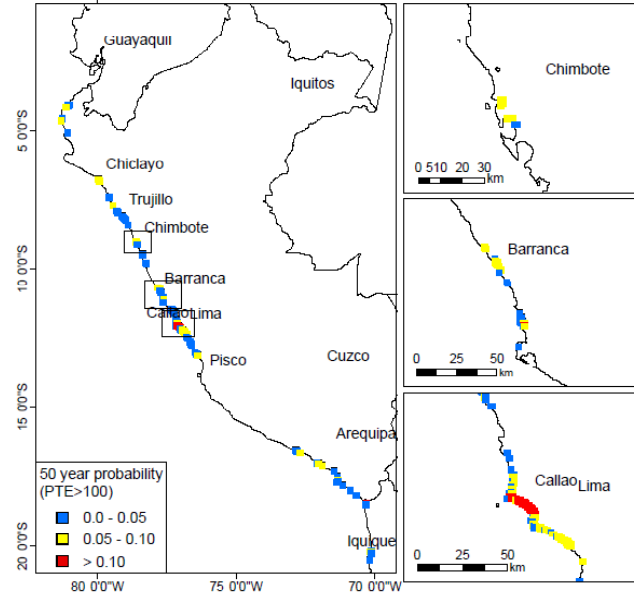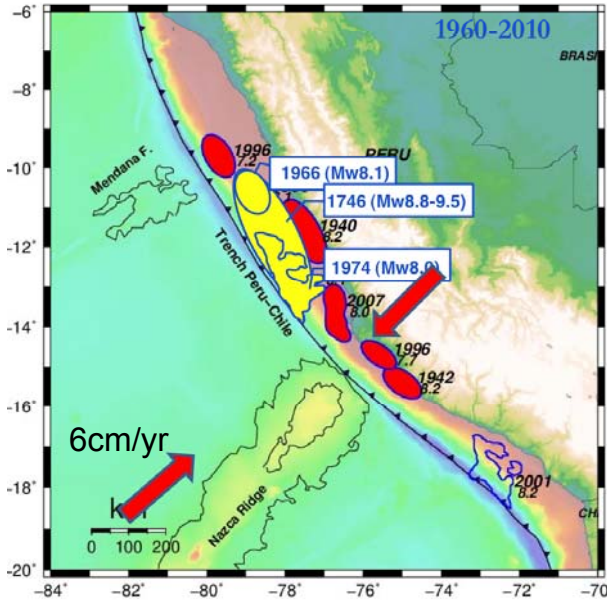
Bruno Adriano@CISMID

K=0.98
κ=1.34
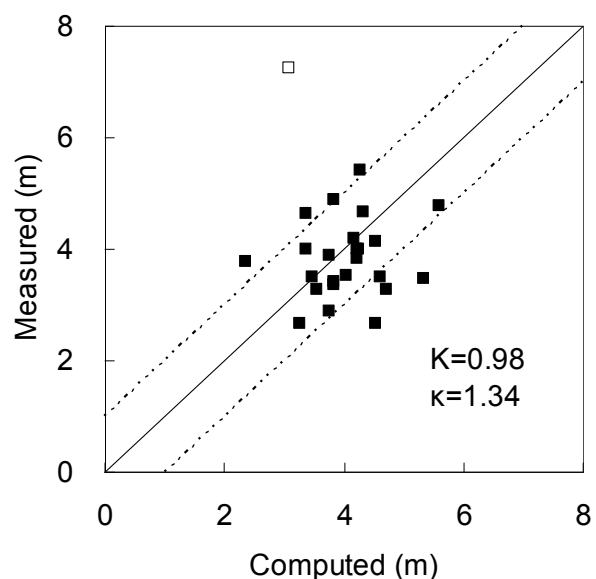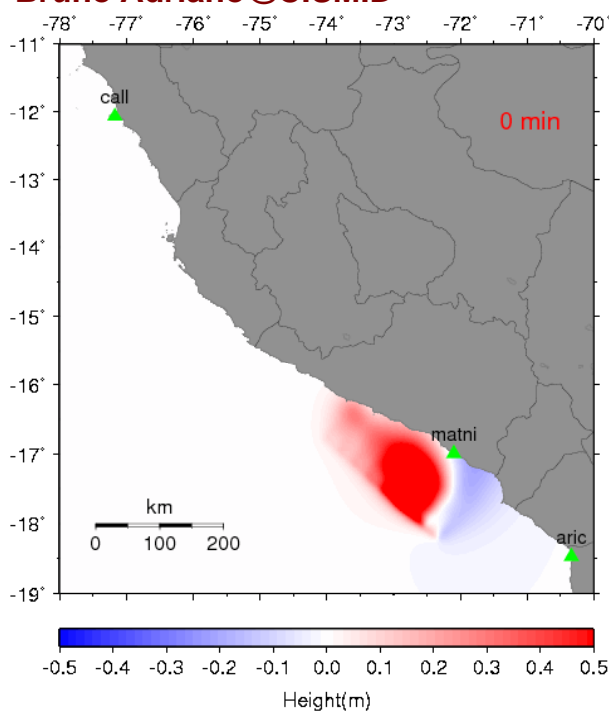
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Progress Report
Tsunami Propagation and Impacts
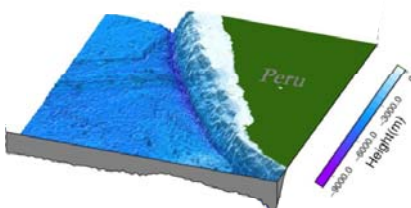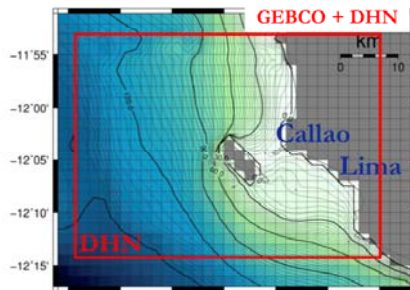### Review of historical earthquakes (1513 - 1959) and risk analysis

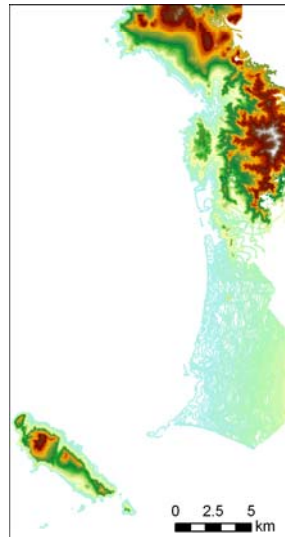**Sheila Yauri@IGP**
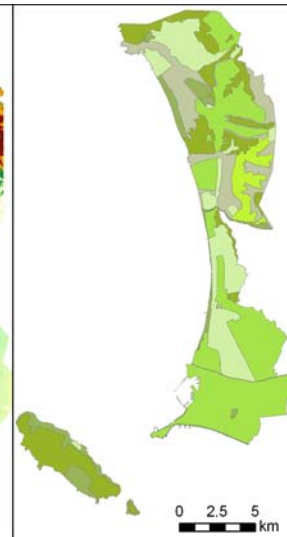

Progress Report
Tsunami Hazard Mapping
Data Collection

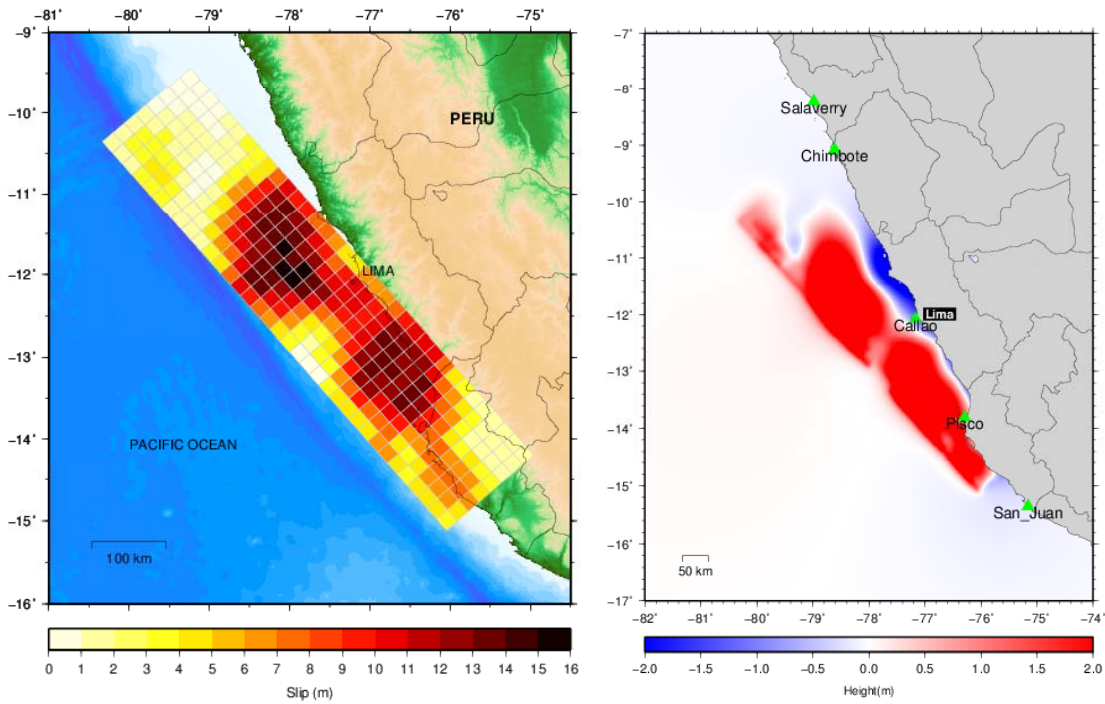**Bathymetry** **Topography** **Landuse** **Street & Evacuation zone**

Progress Report
Tsunami Hazard Mapping
Potential tsunami source scenario [Pulido et al., 2011](G1)
Bruno Adriano@CISMID, Cesar Jimenez@DHN, Sheila Yauri@IGP

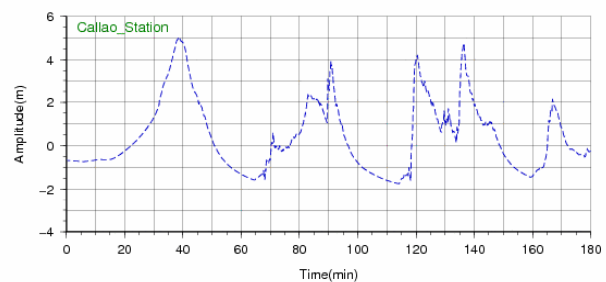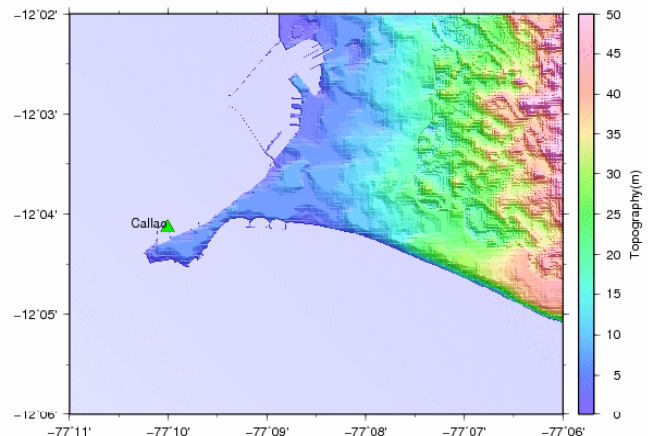
1746 Peru Earthquake   0 min

Progress Report
Tsunami Hazard Mapping

Bruno Adriano@CISMID, Cesar Jimenez@DHN

Source Model (Pulido et al., 2011)

Lima – Callao   0 min

Bruno Adriano@CISMID

TSUNAMI INUNDATION MAP (1746 PERU EARTHQUAKE)
Seismic Source Model - Pulido 2011

Inundation Height (m)
- 0.00 - 0.50
- 0.50 - 1.50
- 1.50 - 2.50
- 2.50 - 3.50
- 3.50 - 6.00

1:15,000

0 125 250   500 Meters

By Bruno ADRIANO
Japan-Peru Center for Earthquake Engineering and Disaster Mitigation

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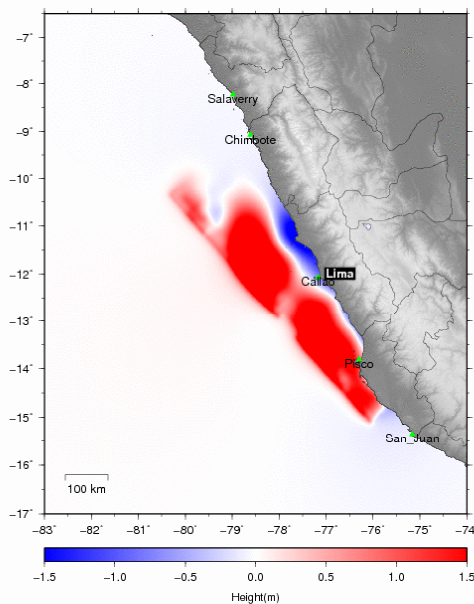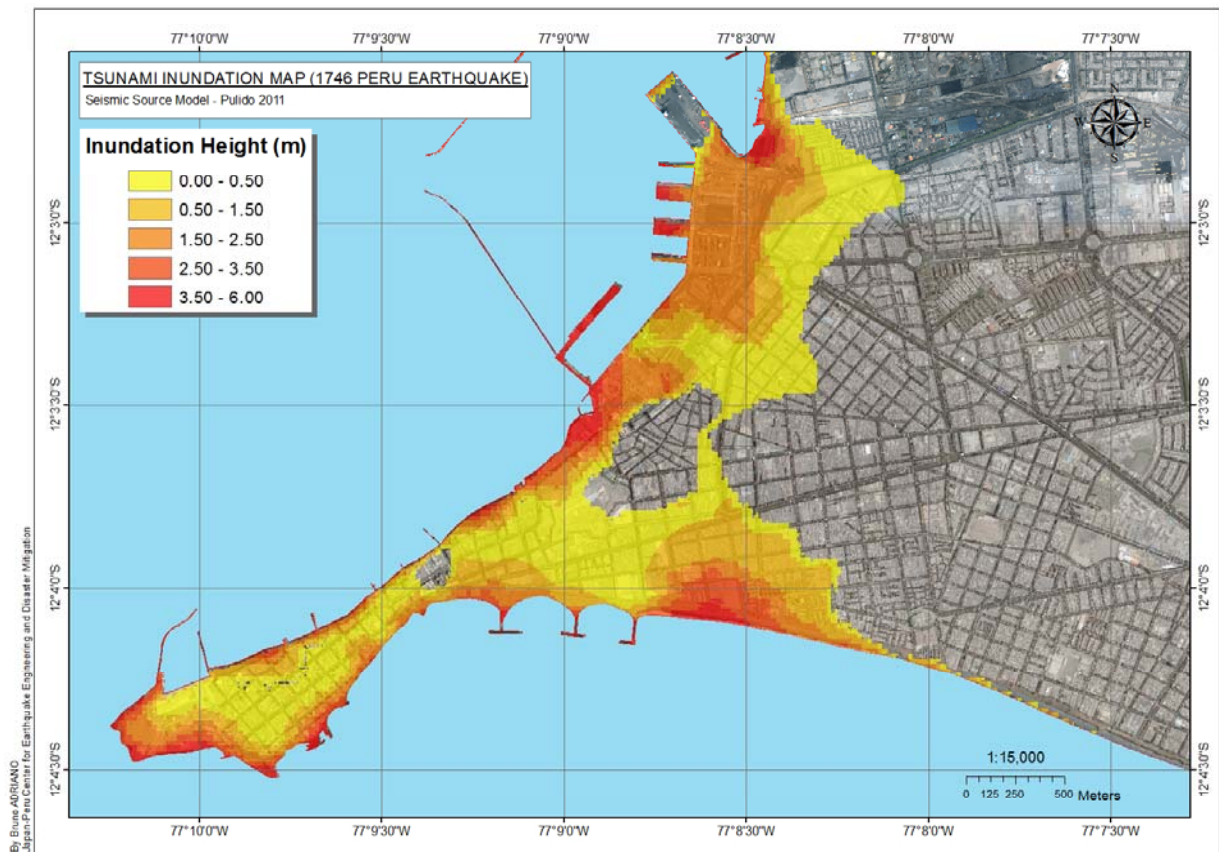
Progress Report
Tsunami Damage Mitigation Technology
Multi-agent simulation

Erick Mas@Tohoku Univ.

- **Tsunami evacuation activities and strategic planning**
- **Requirement of tsunami evacuation building**
- **Casualty estimation**
- **Public education**

Human Resources Development
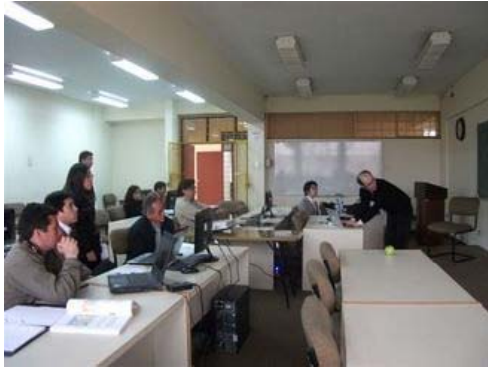
Tsunami Training Course

Field Survey in Chile

Technical Discussion

Group Meeting

Coming Schedule for 2011-2012

Tsunami Propagation/Inundation Mapping

Date	Topic	Organization
2011	Complete review of historical tsunami events and determine potential tsunami source scenarios for Callao, Lima	G1 IGP, DHN, Tohoku Univ., BRI
2011-2012	Developing archives of historical tsunami data, propagation simulation, inundation mapping.	IGP, DHN, CISMID, Tohoku Univ., BRI

Tsunami Damage/Loss Estimation

Date	Topic	Organization
2011	Developing house/building inventory, census data for Callao, Lima	G1, CISMID, Tohoku Univ.
2011-2012	Developing tsunami fragility curves and conducting damage/loss estimation for Callao, Lima.	DHN, CISMID, Tohoku Univ. Tsukuba Univ.

Tsunami Damage Mitigation Technology

Date	Topic	Organization
2011-2012	Complete hazard map for Callao, Lima	CISMID, INDECI, Tohoku Univ.
2011-2012	Strategic planning for tsunami evacuation by multi-agent simulation	CISMID, INDECI, Tohoku Univ.

Towards a new tsunami warning system in Peru & Latin American countries

❖**How the seismic source information is acquired (IGP)**
   ➢**Depth**
   ➢**Location**
   ➢**Magnitude**
❖**How tsunami forecasting is performed (DHN)**
   ➢**Numerical model & Database (Travel time, height)**
   ➢**Bathymetry**
   ➢**Monitoring system**
❖**How the information is delivered to the public**
   ➢**Strategic plan for evacuation (INDECI)**
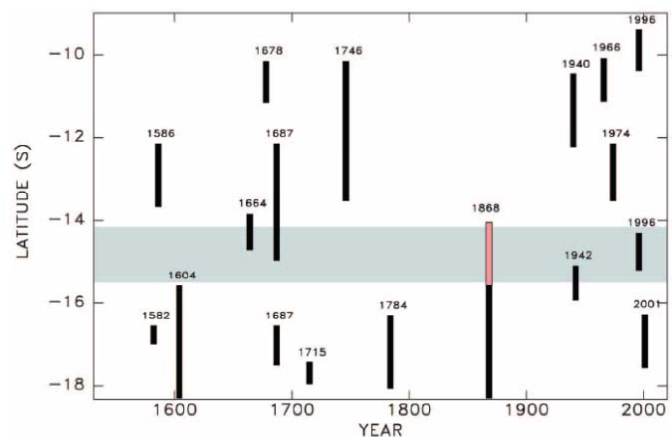   ➢**Public education (INDECI, CISMID)**

IGP
DHN
CISMID   INDECI
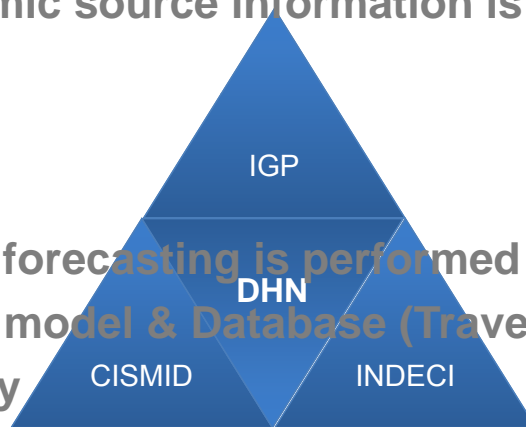
Historical earthquakes

TABLE 3
HISTORICAL EARTHQUAKES IN PERU: ESTIMATES OF MAGNITUDE

Year	L (km)	H_r (m)	$[M_w]$	$[M_t]$	M (Silgado)
1582	80	1–2	7.5	7.7–8.0	7.9
1586	175	5	8.1	8.5	8.1
1604	450	10–15	8.7	8.8–9.0	8.4
1619	100–150		7.7–8.0		7.8
1664	75		7.5		7.8
1678	100–150	5 (?)	7.7–8.0	8.5	
1687	300	5–10	8.4	8.5–8.8	8.2
1687	150 (?)		8.0		
1715	75		7.5		
1725	75		7.5		
1746	350	15–20	8.6	9.0–9.2	8.4
1784	300	2–4	8.4	8.0–8.4	8.0
1833	50–100		7.2–7.7		
1868	500	14	8.8	8.9	8.6
1940	180	3	8.1	8.2	
1942	200	3	8.2	8.2	
1966	100	2.6	7.7	8.2	
1974	140	1.6	7.9	7.9	

L = rupture length; H_r = local tsunami height; $[M_w]$ = estimate of moment derived magnitude; $[M_t]$ = estimate of tsunami magnitude.
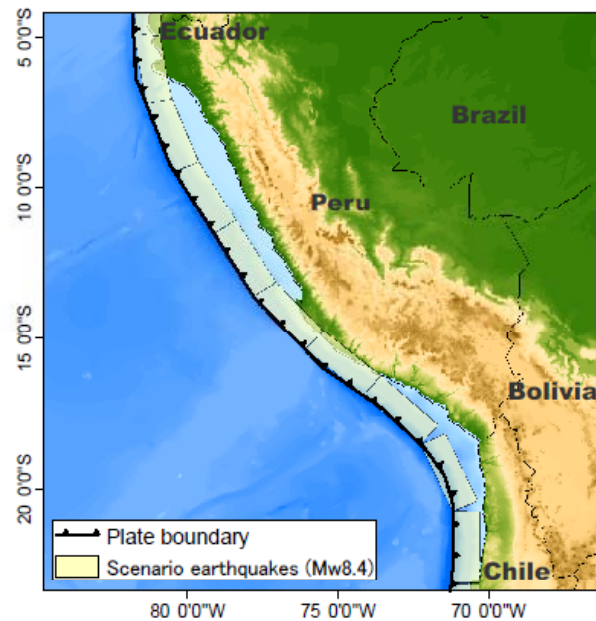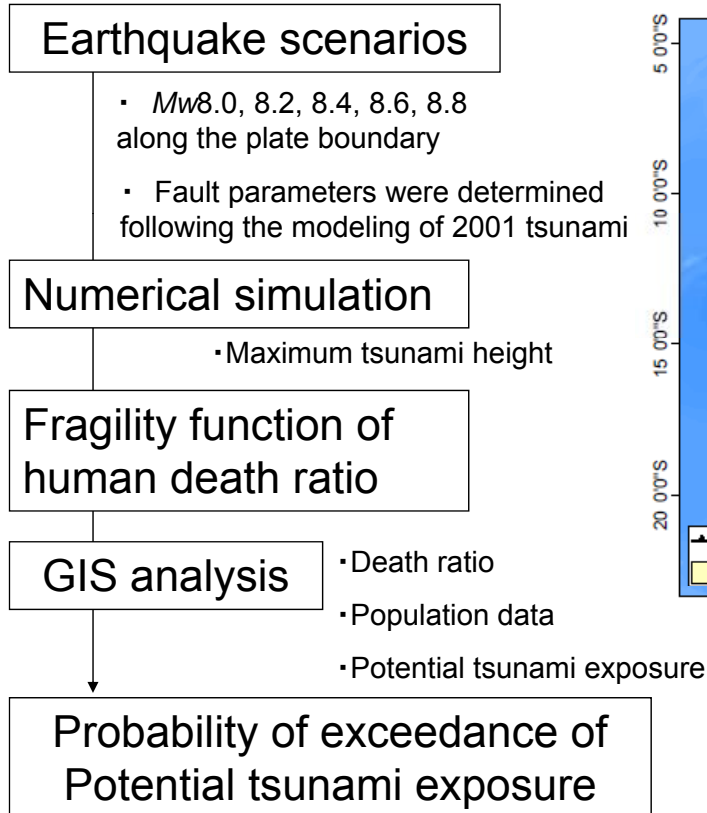
11 events (Mw>8) during 430

1877 Mw8.5 (Northan Chile), 2001 Mw8.4, 2007 Mw8.0

Tsunami vulnerability assessment

Earthquake scenarios

- *Mw*8.0, 8.2, 8.4, 8.6, 8.8 along the plate boundary
- Fault parameters were determined following the modeling of 2001 tsunami

Numerical simulation

- Maximum tsunami height

Fragility function of human death ratio

GIS analysis
- Death ratio
- Population data
- Potential tsunami exposure

Probability of exceedance of Potential tsunami exposure

Plate boundary
Scenario earthquakes (Mw8.4)

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3. Risk assessment using the index of Potential Tsunami Exposure

■ **Fragility function for death ratio (Koshimura et al.,2009)**

$$Fr(H) = \Phi\left[\frac{H - 5.37}{0.72}\right]$$

■ **Potential tsunami exposure**

$$PTE = Fr(H) \times Population$$

■ ***t* year probability of exceedance using Poisson process**

t year probability of exceedance that *PTE* exceeds *a* value

$$P[PTE \geq a; t] = 1 - \exp(-\lambda t)$$

λ is annual frequency of occurrence

$$\lambda = \sum_{m=1}^{n} \frac{N[PTE \geq a]}{N_m} \times \frac{1}{n} \times \frac{1}{T}$$

Population data (LandScan 2008)

Population
100
0