

# Developing Tsunami Damage Estimation and Mitigation Technologies

## Tsunami Research Group G2

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Let us imagine again the tsunami disasters.



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# Objectives and goals

- To assess the **potential tsunami disaster** and its **impact** to the Peruvian coast
- To develop the **practical technologies** to mitigate tsunami risks in Peru
- To implement the **strategic plans** for disaster mitigation of Peruvian government
- To contribute the **Pacific tsunami disaster mitigation strategies**

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# Tsunami group member

- Dr. Shunichi Koshimura (Tohoku Univ., Tsunami engineering, Team Leader)
  - Dr. Gaku Shoji (Univ. of Tsukuba, Structural and earthquake engineering)
  - Dr. Yushiro Fujii (BRI, Seimology and Tsunami modeling)
  - Dr. Yuji Yagi (Univ. of Tsukuba, Seismology)
  - Dr. Hideaki Yanagisawa (TEPSCO, Tsunami modeling)
  - Msc. Julio Kuroiwa (Leader, CISMID)
  - Guillermo Hasembank (Contralminarte, DHN)
  - Gilberto Tacilla (Tec., DHN)
  - Mr. Cesar Jiménez (Tsunami simulation, DHN)
  - Carlos Marcos Villanneva (DHN)
  - Dr. Miguel Estrada (CISMID)
- by Prof. Carlos Alberto Zavala Tóledo  
at the kickoff tsunami meeting  
CISMID, Dec 20, 2009

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## Research plan - Scientific phase -

- Assessing historical tsunami events and its impact in Peru
  - Tsunami sources
  - Tsunami hazard (Tsunami generation, near-shore propagation and coastal inundation)
  - Damage (Casualties, structural damage)
- Identifying potential tsunamis and the worst case scenarios
  - Tectonic settings and tsunami source scenarios
  - Potential tsunami exposure (Exposed population)
  - Potential impact
- Mapping tsunami hazard and its impact
  - Inundation modeling
  - Damage estimation (Casualties, structural damage)
  - Hazard maps, Cartography

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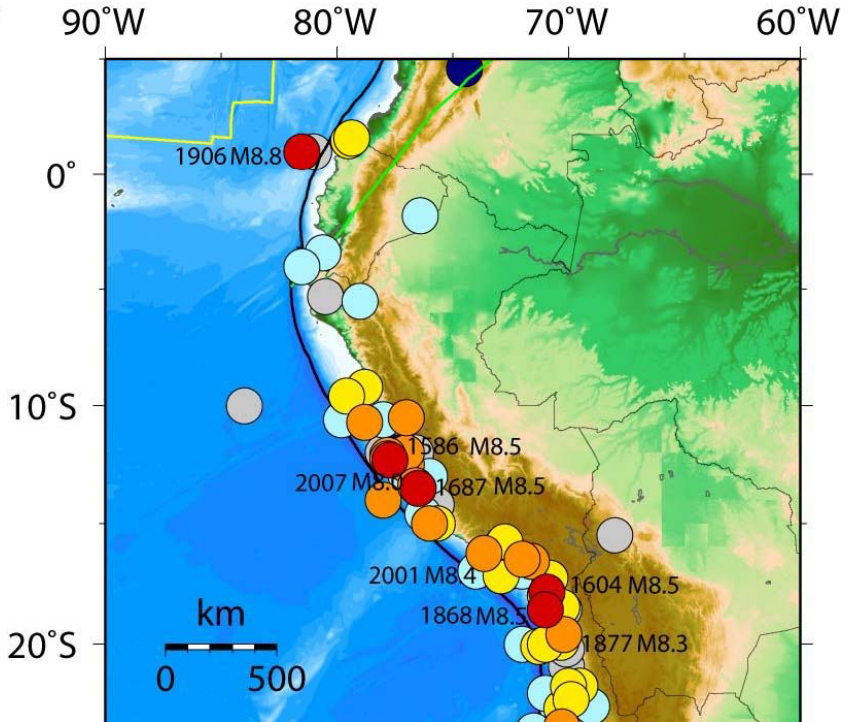
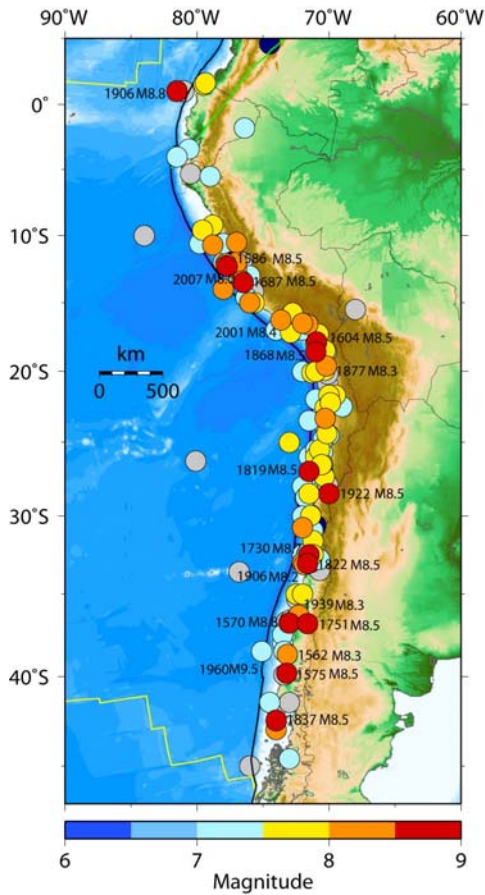
## Research plan - Implementation Phase -

- Developing a fundamental procedure for mapping tsunami hazard
  - Training program (Tsunami modeling and mapping)
  - Warning, guidance and public awareness
- Strategic planning to mitigate tsunami risks and damage
  - Tsunami disaster mitigation program for Peruvian government
  - Tsunami countermeasures
  - Design for tsunami evacuation facilities
  - Tsunami evacuation strategies

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# Past events in Peru

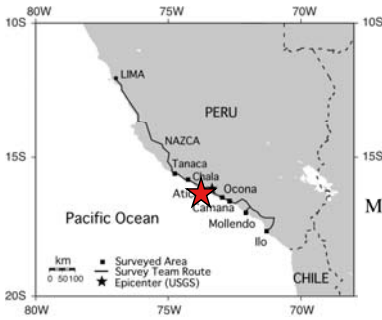


NGDC Tsunami Database  
[http://www.ngdc.noaa.gov/hazard/tsu\\_db.shtml](http://www.ngdc.noaa.gov/hazard/tsu_db.shtml)

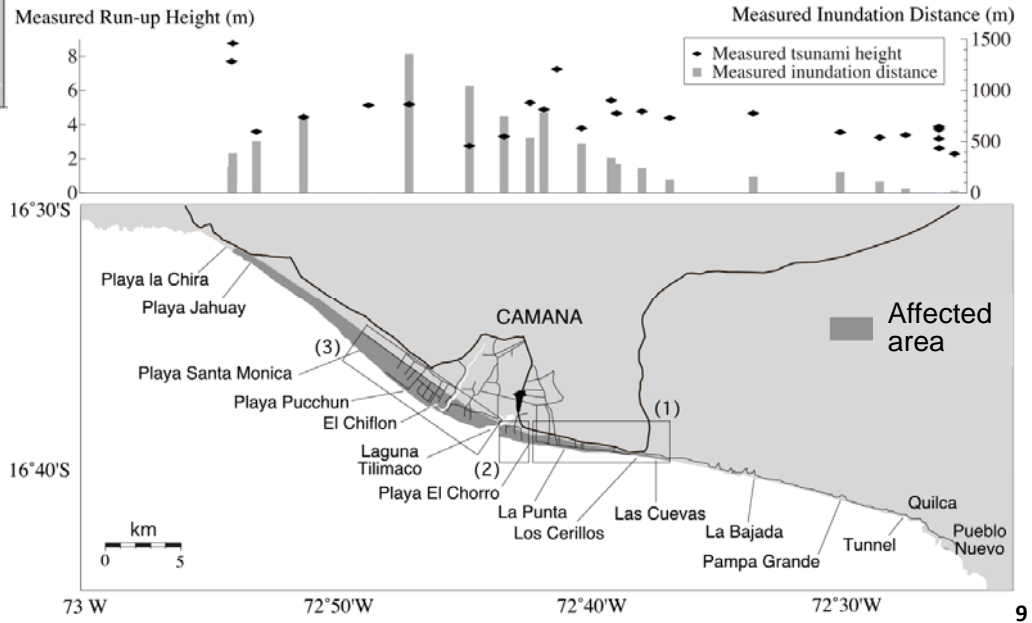
# Damage at Camana



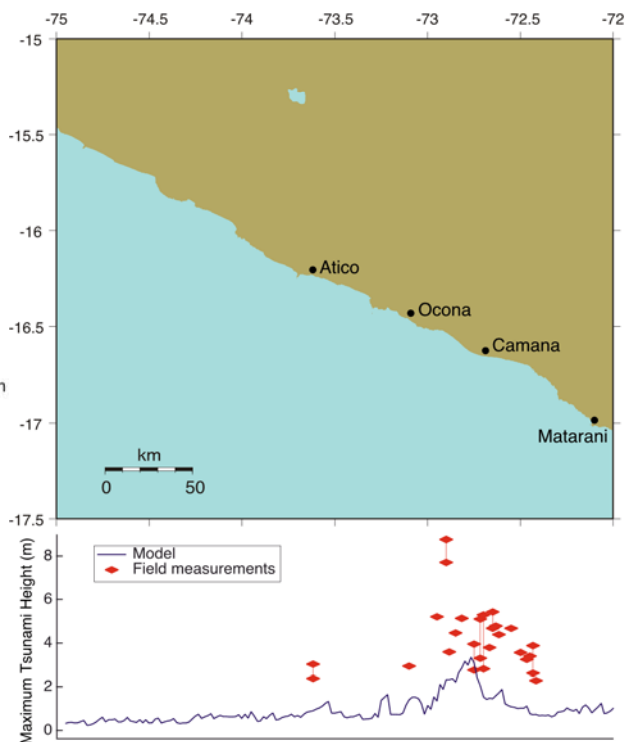
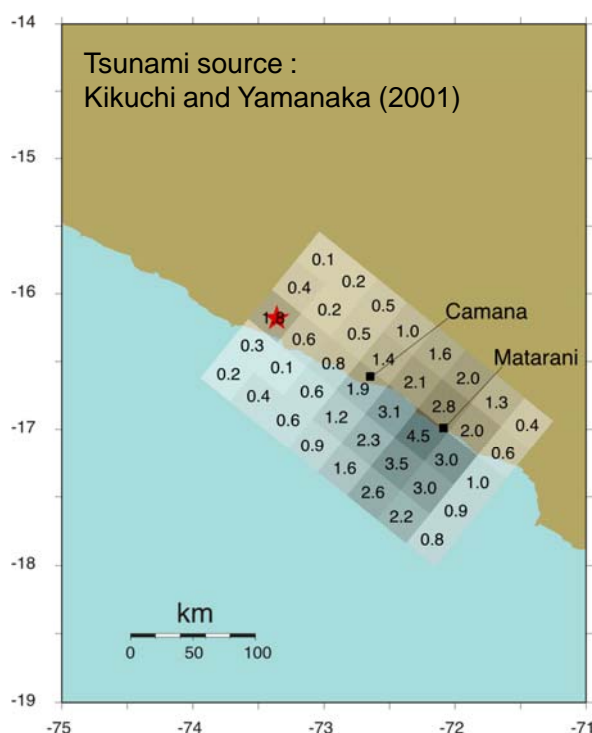
# 2001 Tsunami - Camana, Peru -



Casualty			House damage	
Dead	Missing	Injury	Major/Minor	Collapsed
24	62	41	760	2915

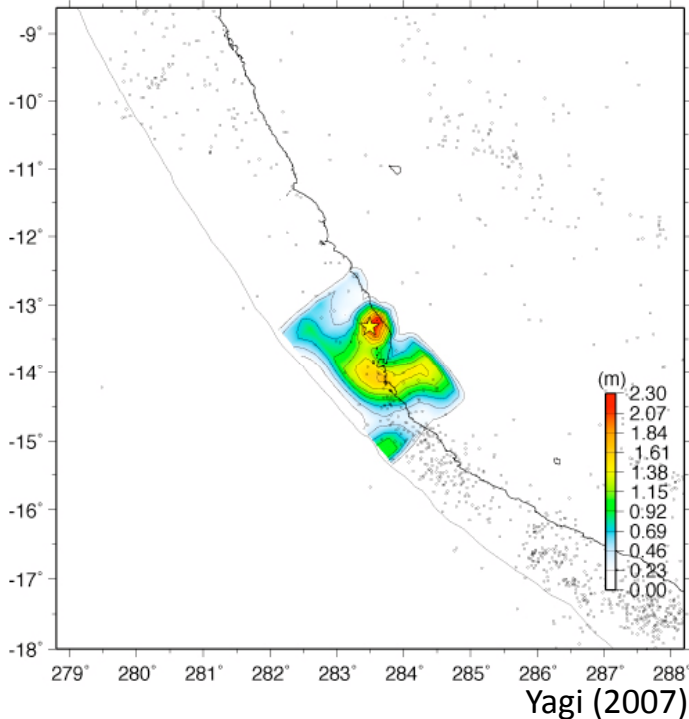


# Modeling the 2001 Peruvian tsunami



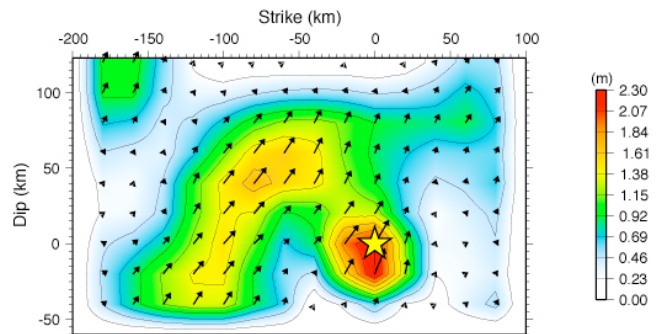
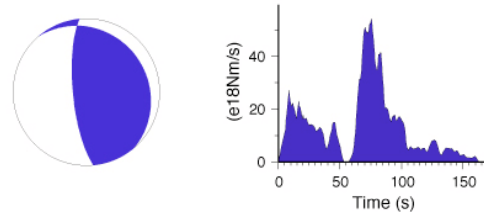
# Source process of 2007 Peru earthquake by inversion of tele-seismic body wave

Slip distribution (Map view)

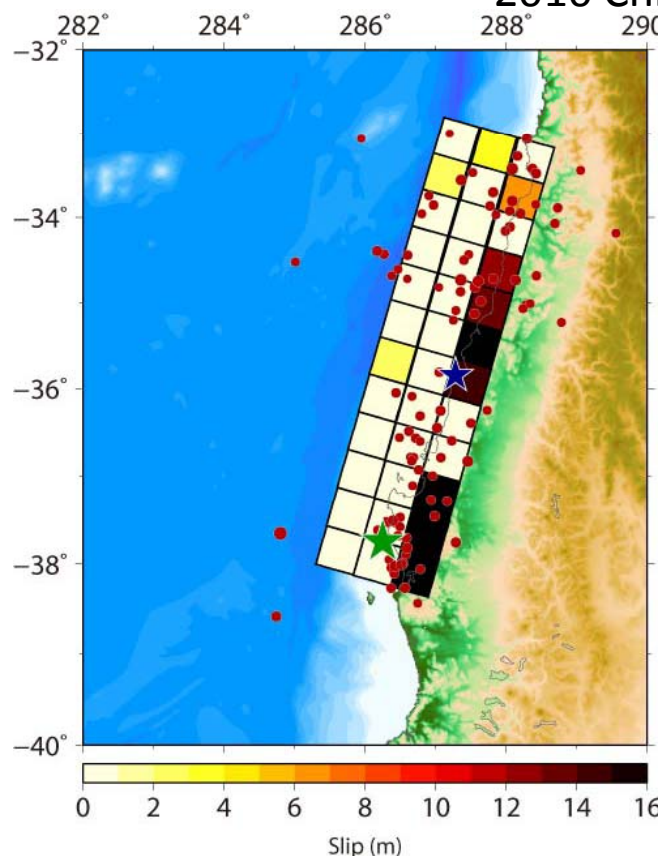


Focal mechanism, Source time fun.,  
 Slip distribution on fault plane

(Strike,Dip,Slip) = (320.0, 18.0, 56.8)  
 Moment = 0.1998E+22(Nm); Mw = 8.1  
 Variance = 0.20129  
 Depth = 40.00(km) ; Vrmax = 1.75(km/sec)



# Tsunami Waveform Inversion Result 2010 Chile earthquake



Length: 50 km  
 Width: 50 km  
 for each subfault



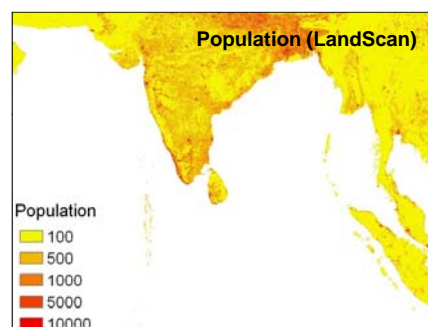
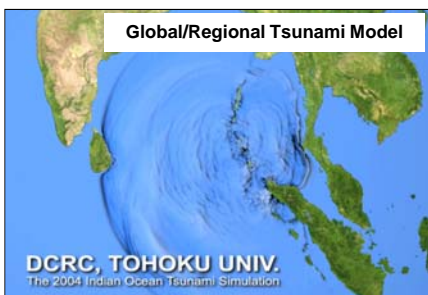
# Tsunami modeling technology

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

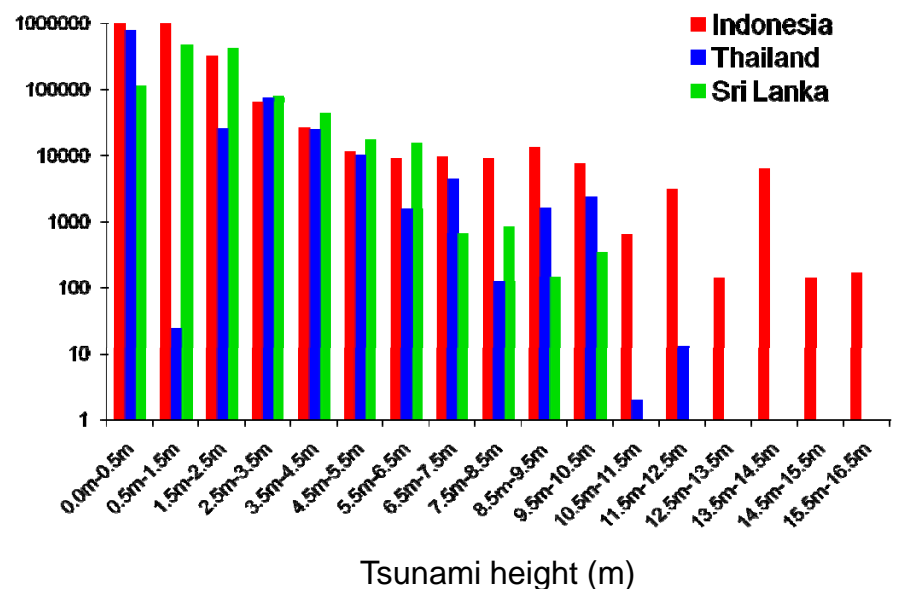


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# Potential tsunami exposure



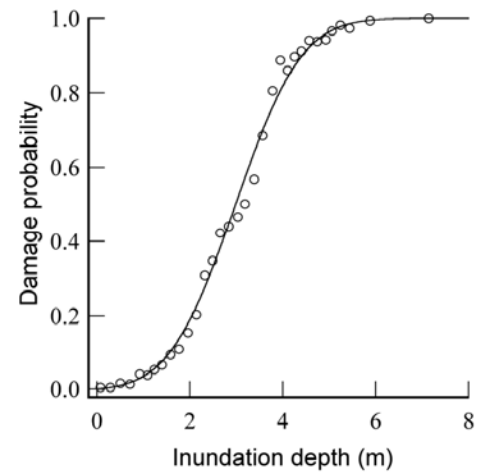
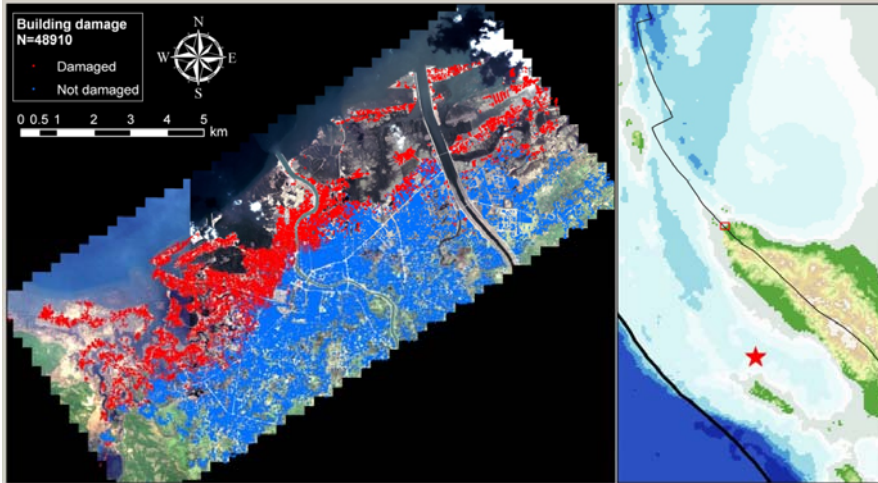
Population



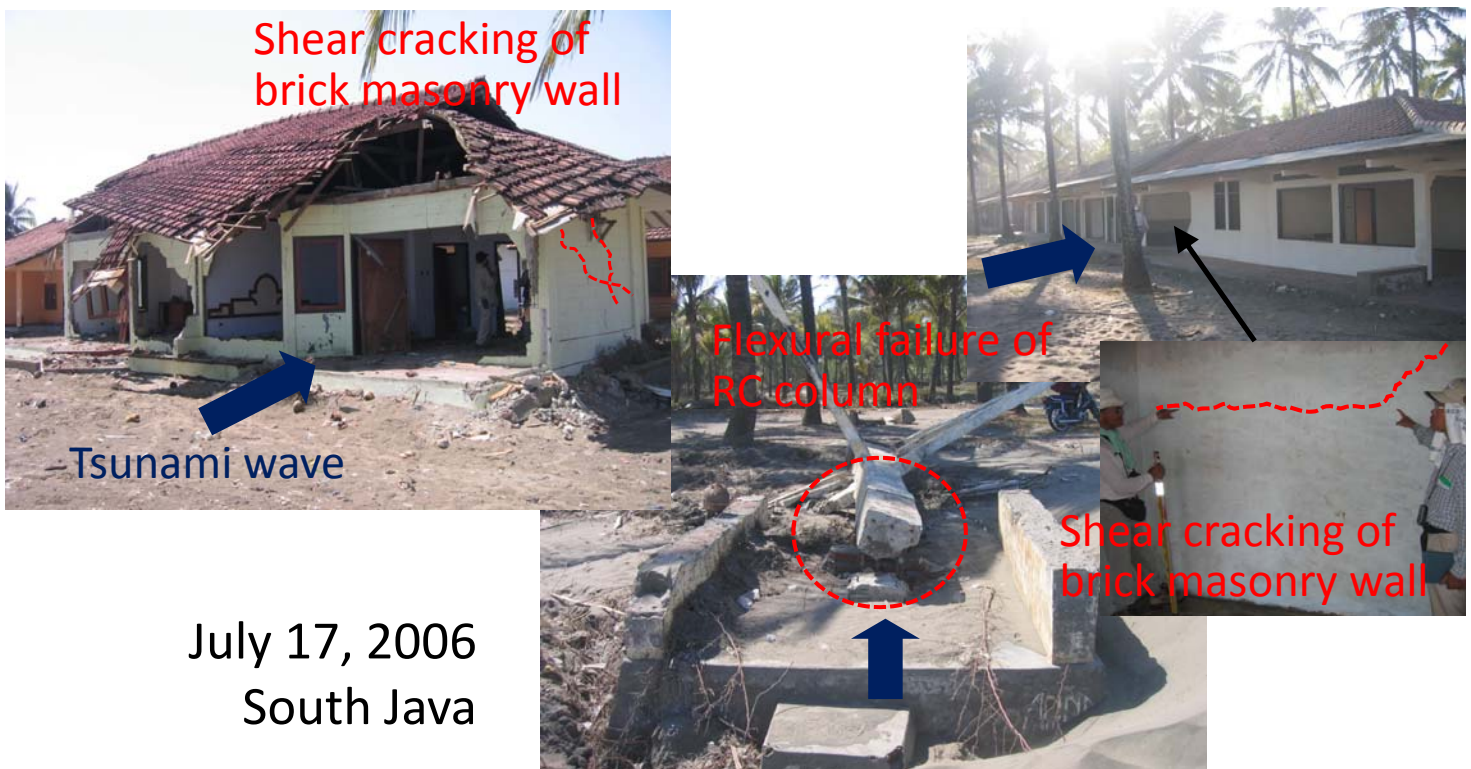
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# Tsunami fragility curves

- Structural damage probabilities in terms of flow depth, current velocity and hydrodynamic force



# Clarification of failure modes of a structural component by tsunamis



July 17, 2006  
 South Java



# Things to discuss are open based on the resolution at the kickoff tsunami meeting [1]

- Study area ...
  - One historical event for model verification/validation (Camana, Pisco)
  - Two potential scenarios (Callao, Chimbote, Pisco, Ilo harbor ; important ports industrial commercial places and exposures)
- Data we need
  - Merged bathymetry /topography grid in study areas (30 meter grid form North Pisco, South Pisco should be requested, Camana is already prepared)
  - Field survey results for model validation (Pisco, Camana)
  - Building polygon for structural damage estimation
  - Population data for fatality estimation

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# Things to discuss are open based on the resolution at the kickoff tsunami meeting [2]

- Human resources... who is going to work on tsunami modeling?  
Schedule?
- What we are going to do in 2010 is
  - Japan side
    - Tsunami propagation modeling to identify what the worst-case scenario is.
    - Tsunami damage assessment (Koshimura, Yanagisawa, Shoji)
    - Collecting field survey data (2001 Camana event)
  - Peru side
    - What has been done from Pisco and Camana.
    - Tsunami issues in Peru (San Marcos Univ. Prof. Ocola, DHN , Mr. Jiménez)

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# Field survey at Camana in Dec 21-22, 2009

▣ Non-engineered concrete block house



La Punta

▣ Engineered concrete block house



Inundation depth  
 2.60m



# Field survey at Callao in Dec 20, 2009



# Potential Tsunami Exposed-Death

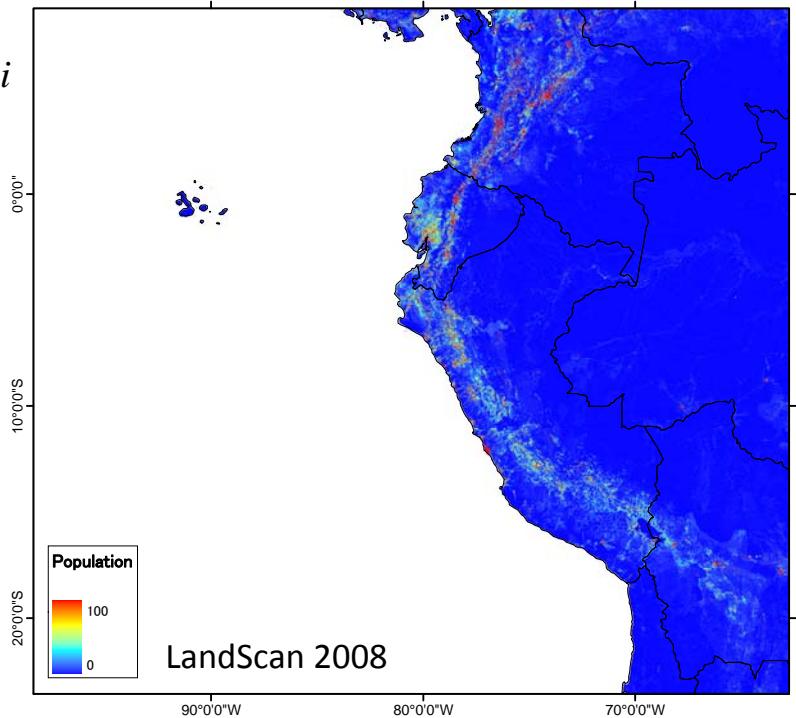
$$PTE = \sum_{i=1}^N (1/N) \times [Pop \times Fr(H)]_i$$

$N$ : Number of Earthquake event  
 $Pop$ : Population per cell  
 $H$ : Maximum tsunami height  
 $Fr(x)$ : Fragility function of human damage

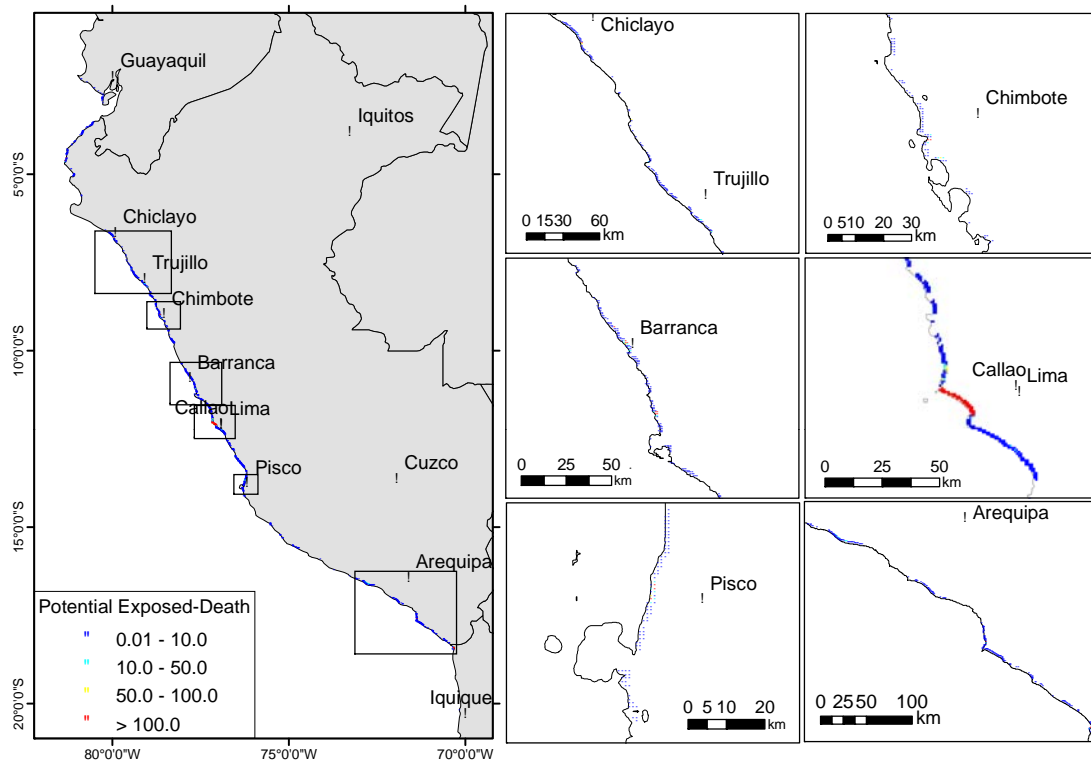
Koshimura et al.,(2009)

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

Here, the earthquake probability in Northern area ( $> 9S^{\circ}$ ) is assumed to be 100 %.



# The tsunami risk in the coast of Peru – Tentative version -





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