



Developing Tsunami Damage Estimation and Mitigation Technologies towards Tsunami-Resilient Community

G2: Tsunami

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- Mr. Bruno Adriano (CISMID, Tsunami modeling)
- Ms. Sheila Yauri (IGP, Seismology)
- Dr. Miguel Estrada (CISMID, Earthquake engineering)
- Dr. Gaku Shoji, 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, TEPCO DHN, CISMID】 1) Tsunami Propagation and Impacts 2) Tsunami Hazard Mapping 3) Tsunami Damage Mitigation Technology						
	<p> Tsunami Simulation Inundation and Impact Data Collection Damage Assessment Method Tsunami Damage Analysis Historical Tsunami Data Tsunami Damage Mitigation technology </p>					

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)



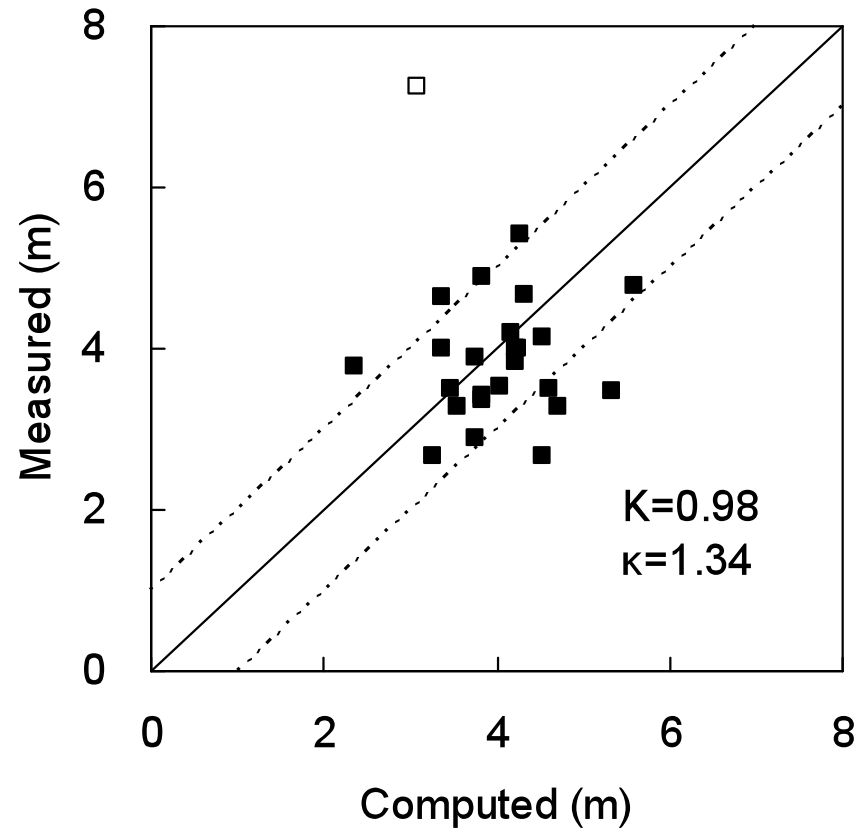
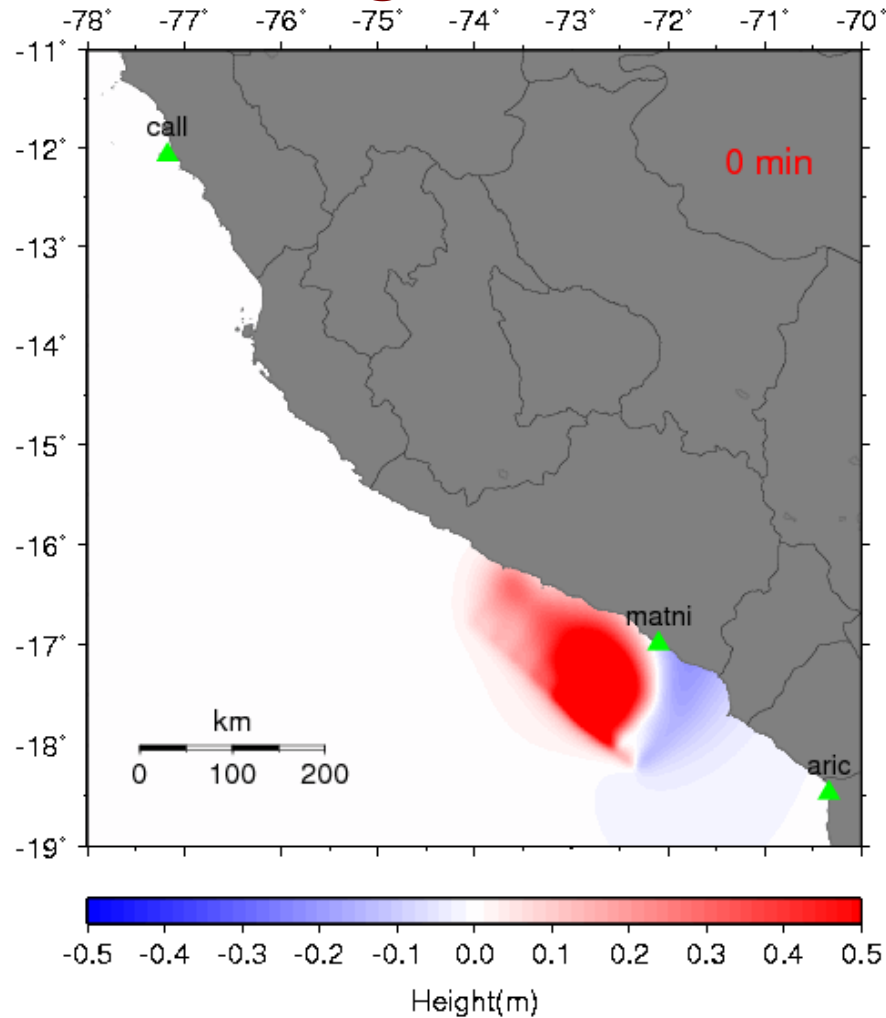
What we have done so far

- 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

Progress

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

Bruno Adriano@CISMID



Why velocity information is important ?

- A key information to identify the tsunami force actually acting on structures.
- How tsunami penetrates on land and how urban development patterns reduces the tsunami flow are still unknown.
- Important for verifying tsunami inundation modeling.

Numerical Modeling in Sendai



Velocity measurement using aerial video

NHK Aerial video

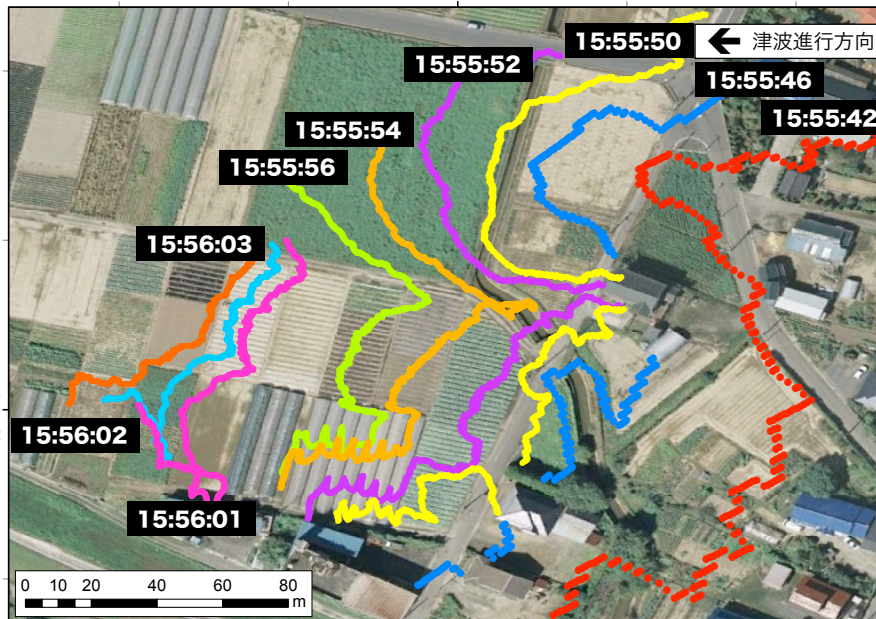
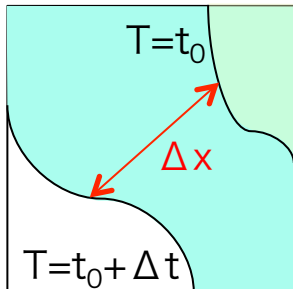


Projective transformation



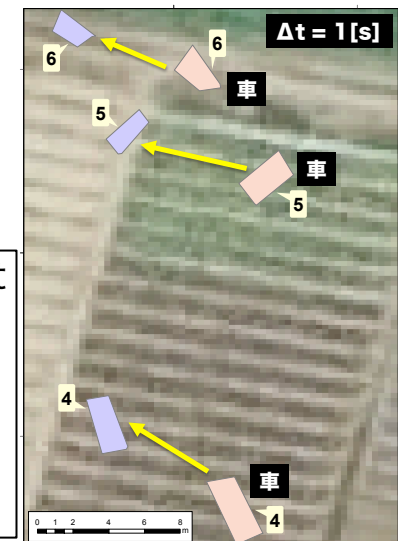
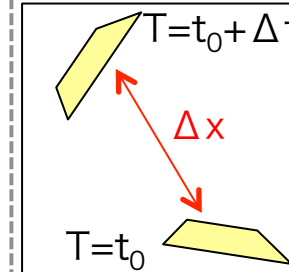
Measuring tsunami front velocity

$$v_p = \frac{\Delta x}{\Delta t}$$

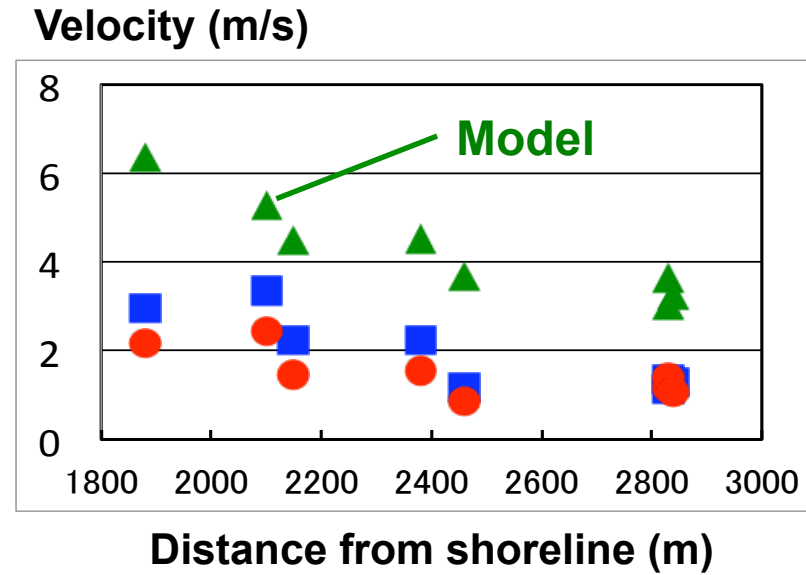
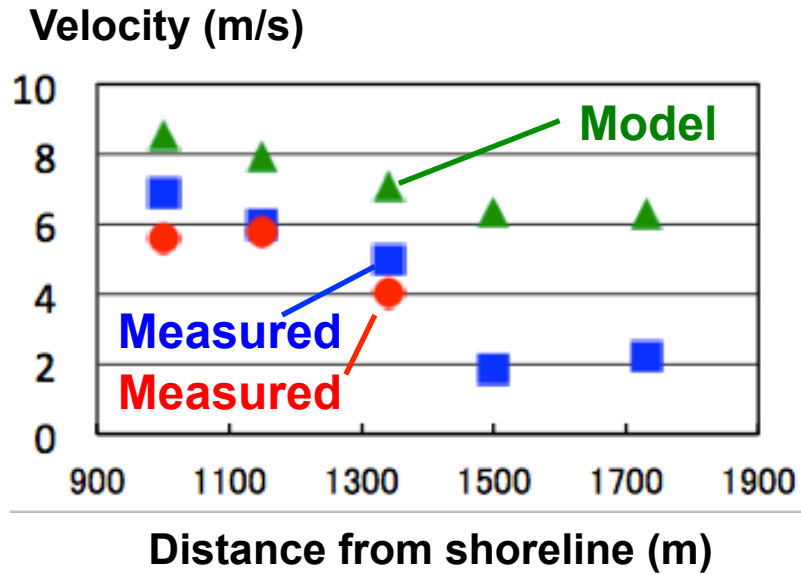


Measuring tsunami flow velocity

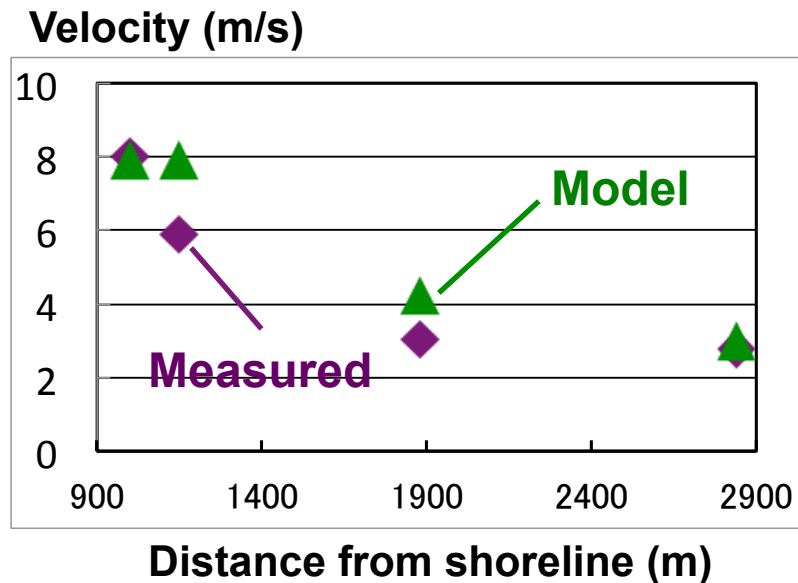
$$v_f = \frac{\Delta x}{\Delta t}$$



Tsunami front velocity



Tsunami flow velocity

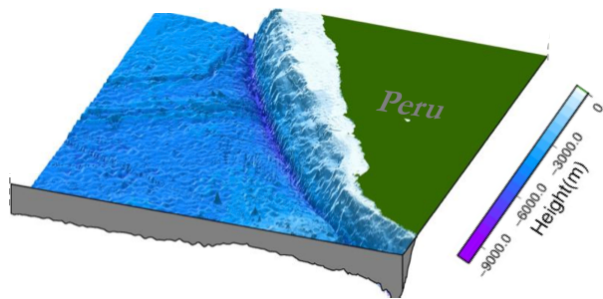
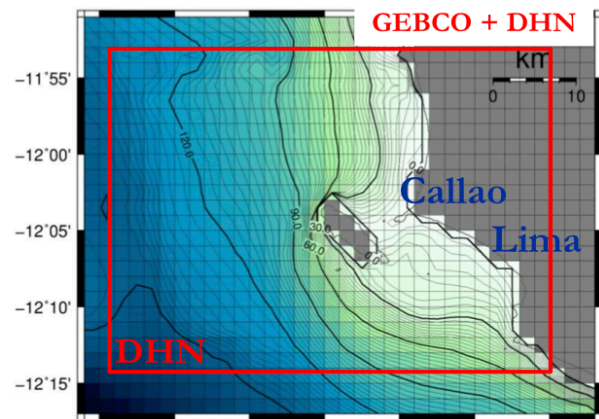


Progress

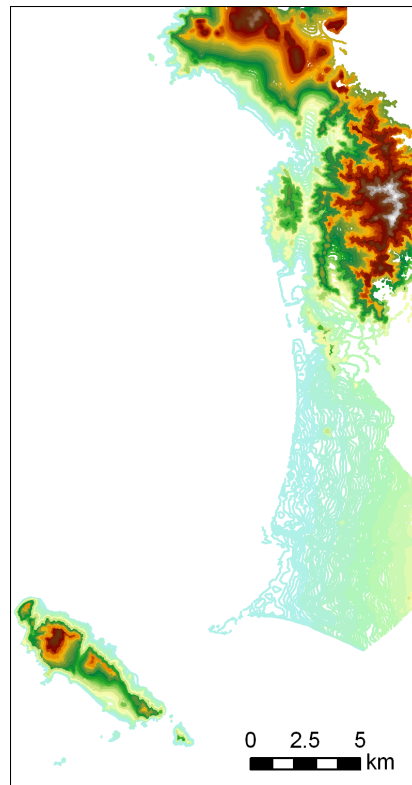
Tsunami Hazard Mapping

Data Collection

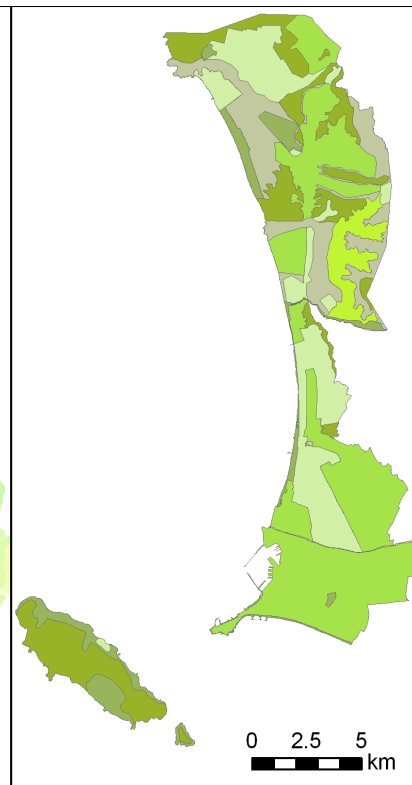
Bathymetry



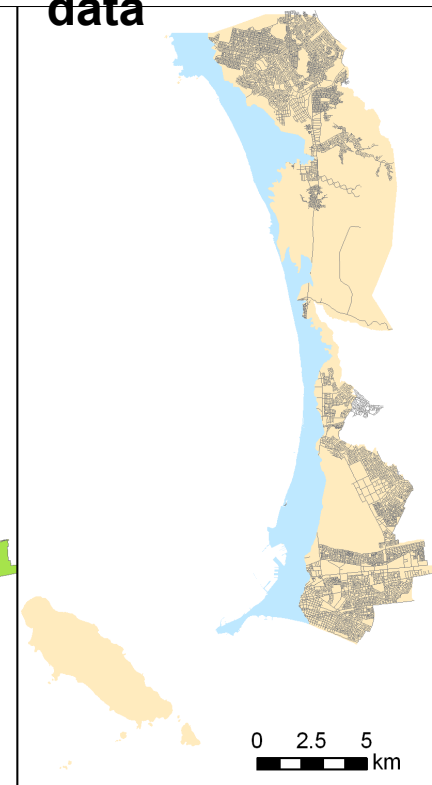
Topography



Landuse



Street,
Evacuation
zone, Census
data



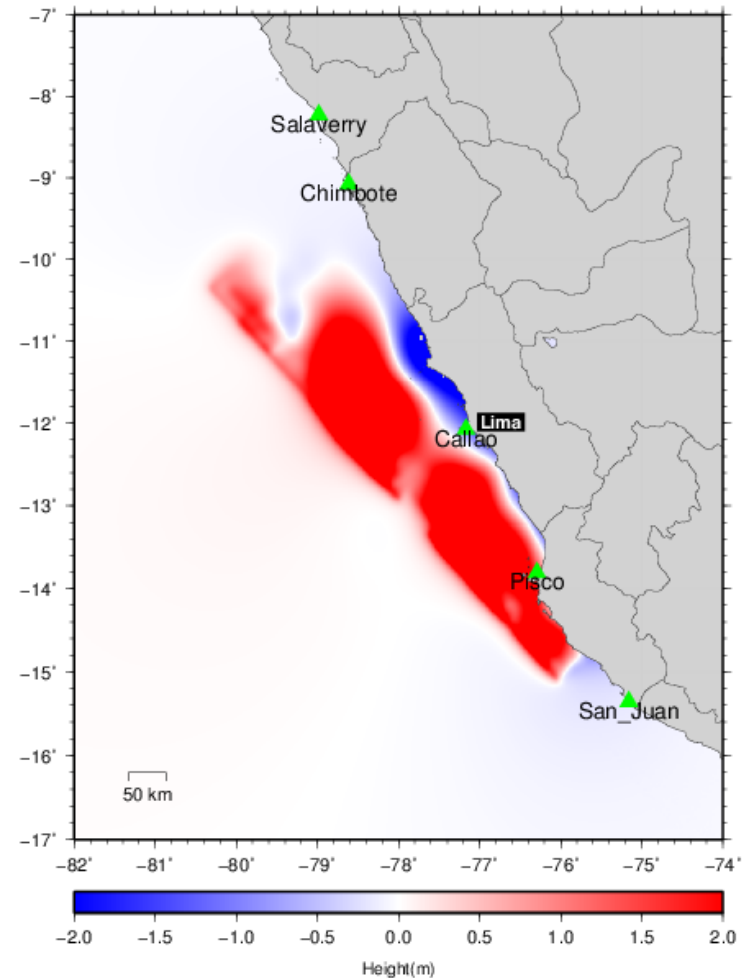
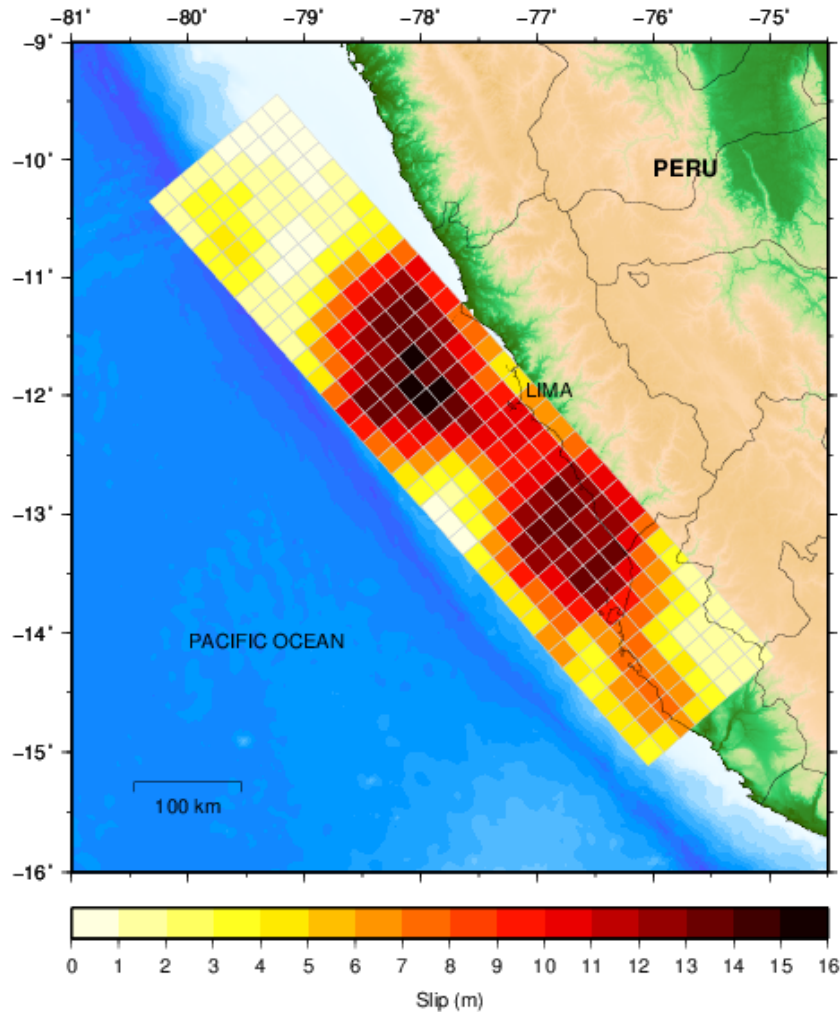
Progress

Tsunami Hazard Mapping

Potential tsunami source scenario [Pulido et al., 2011](G1)

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1746 Peru Earthquake 0 min

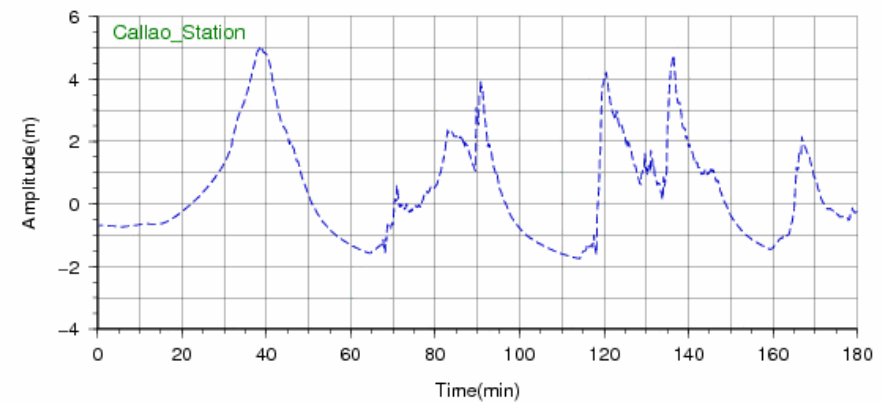
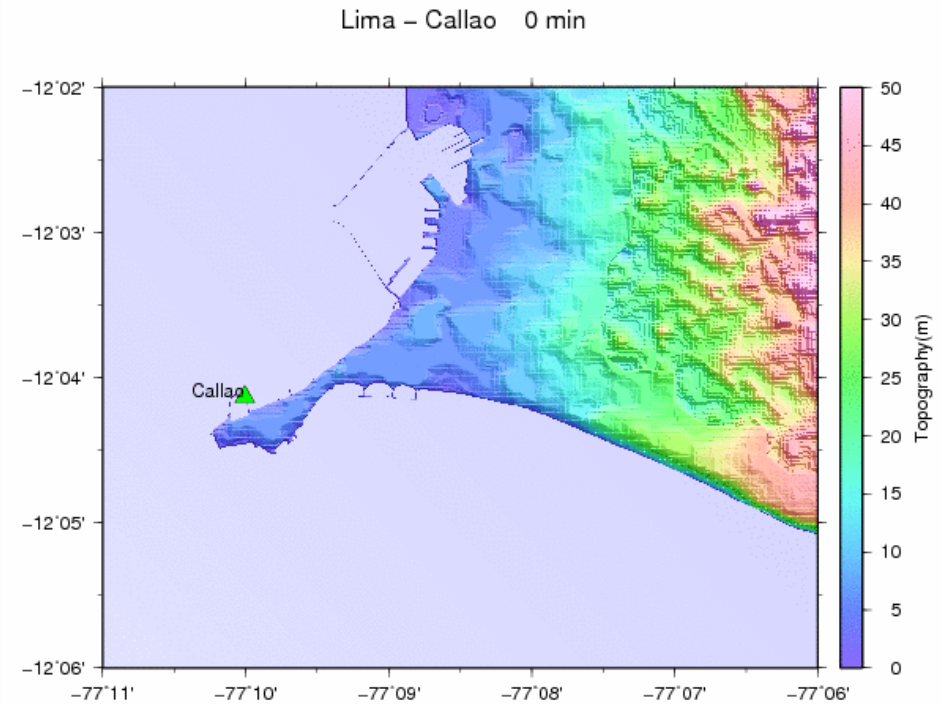
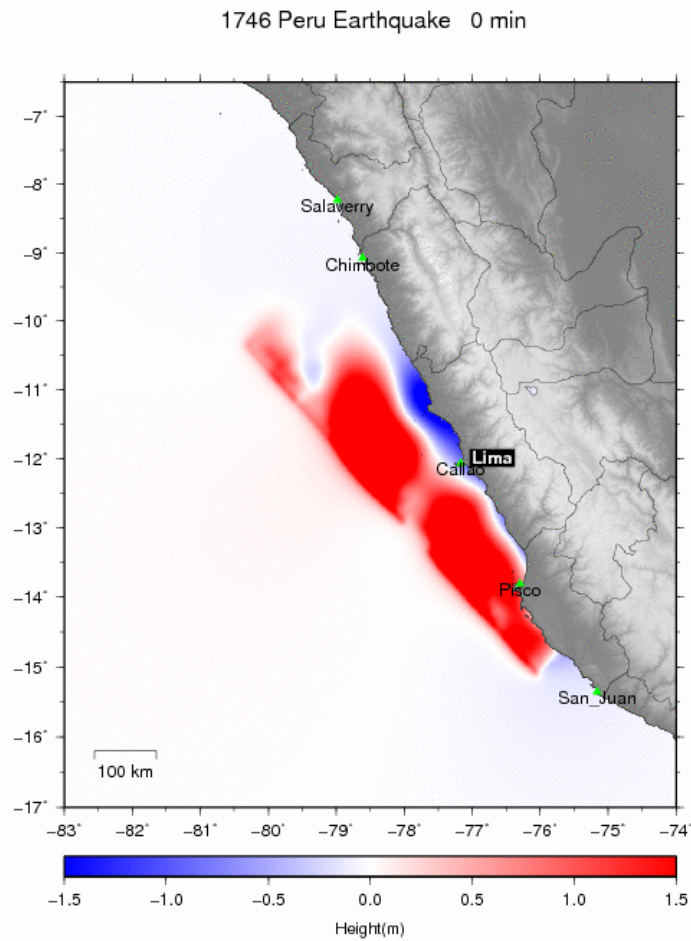


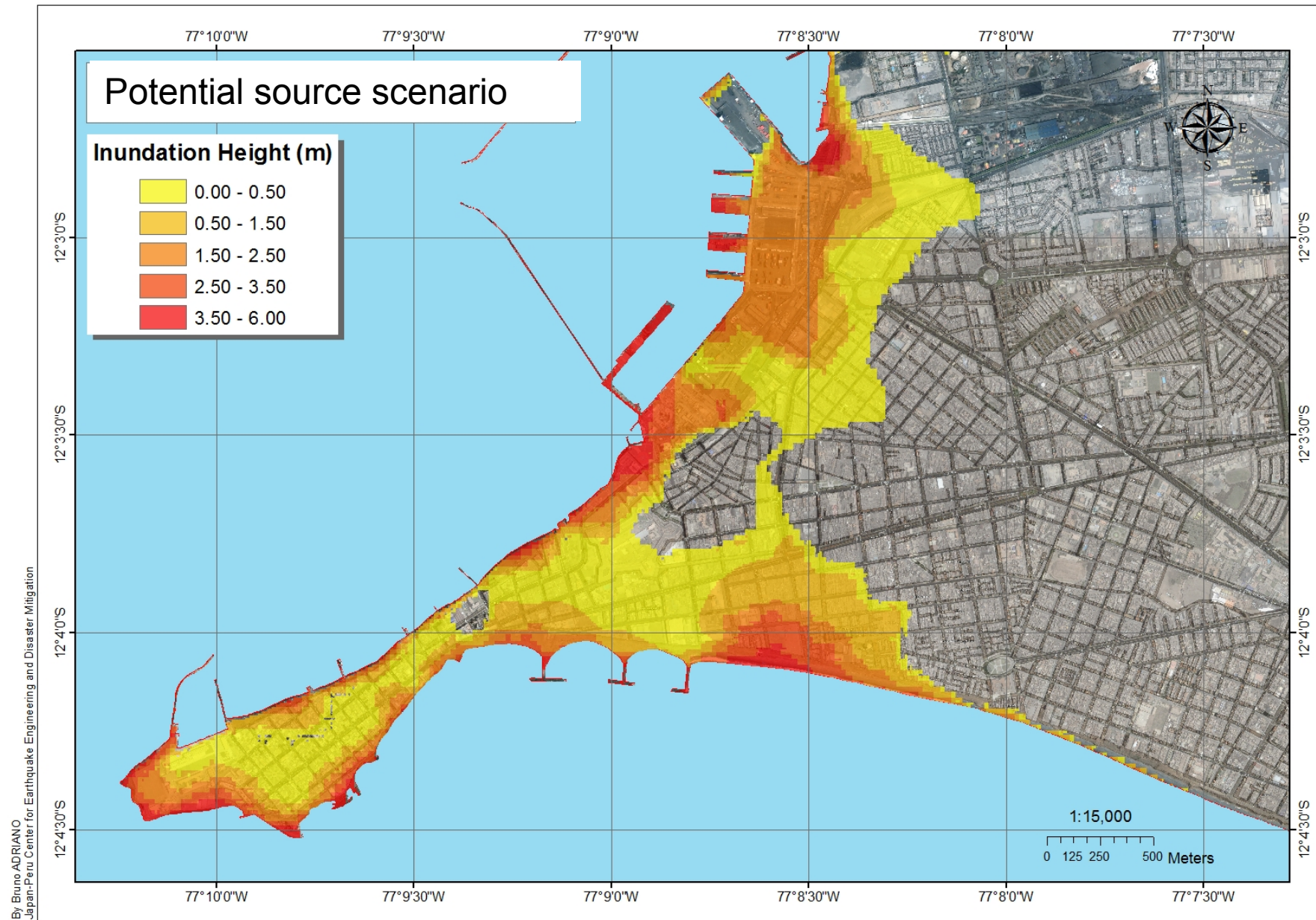
Progress

Tsunami Hazard Mapping

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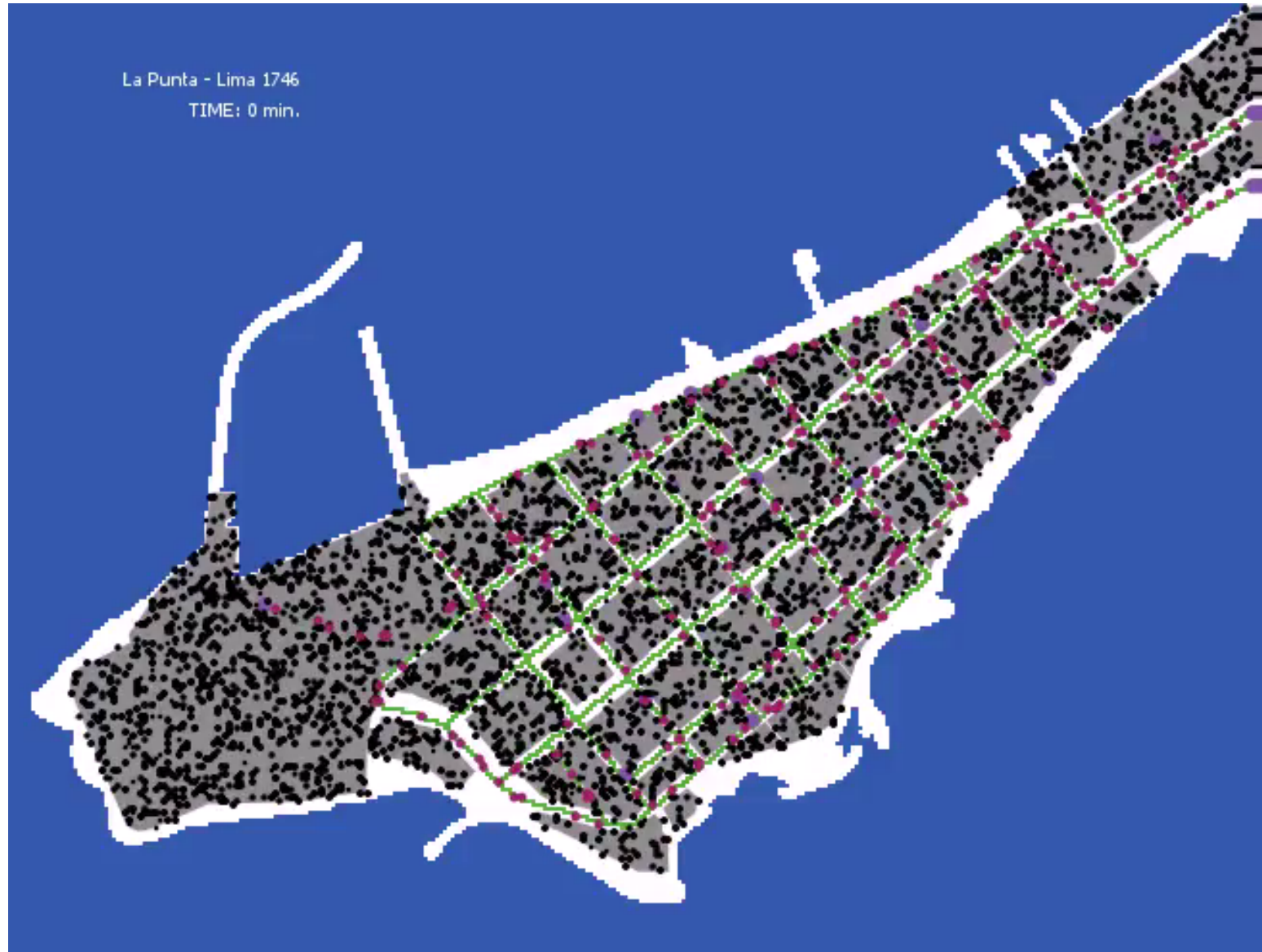
Source Model (Pulido et al., 2011)

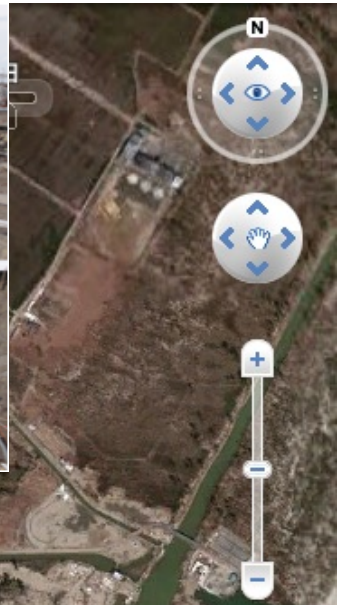
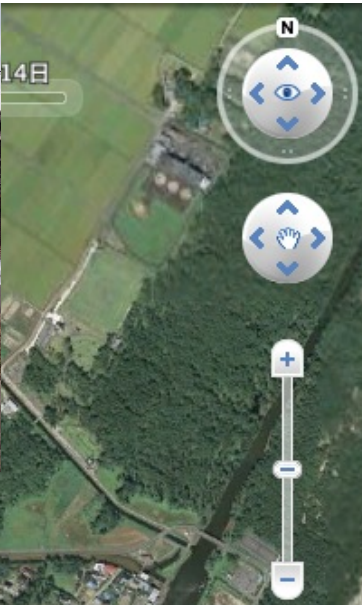




Modeling Social Response

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Progress

Multi-agent simulation (Arahama, Sendai)

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- Evacuation decision

Stage 0



- Shelter decision

Stage 1



- Path finding

Stage 2



- Evacuate

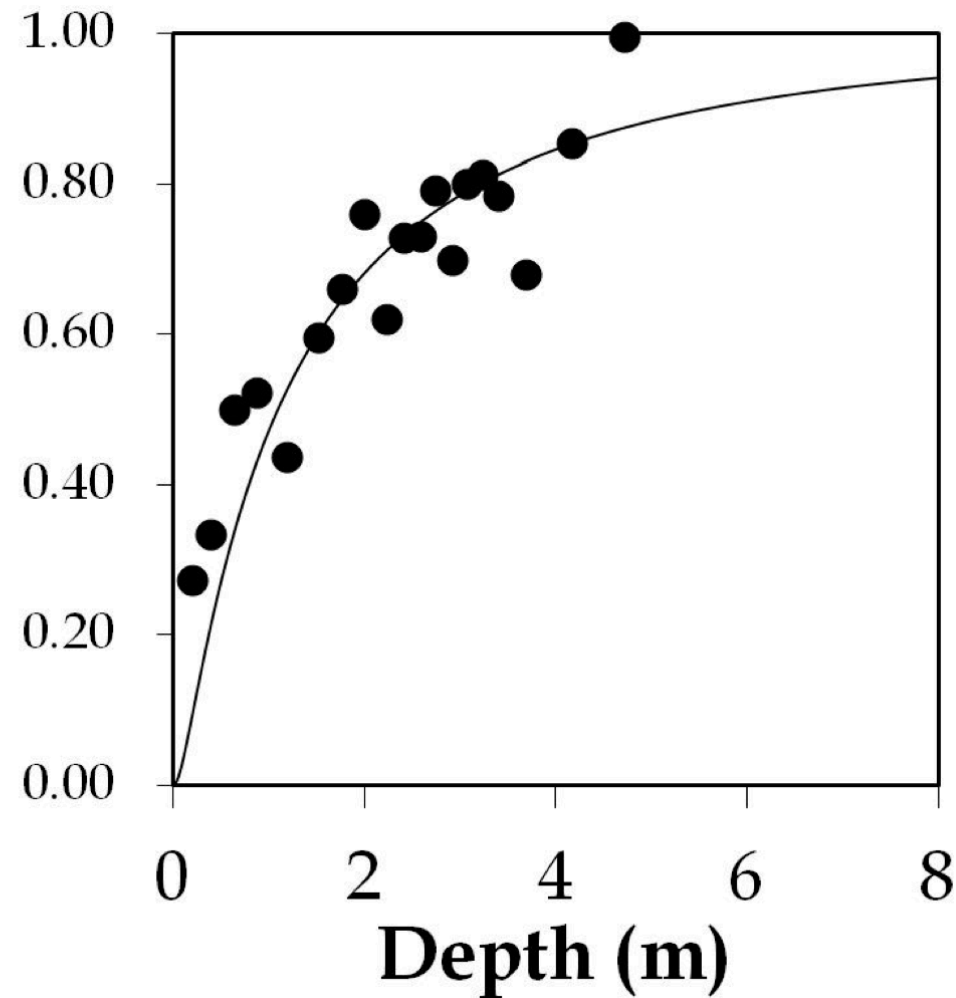
Stage 3



Structural damage estimation tool from Dichato, Chile



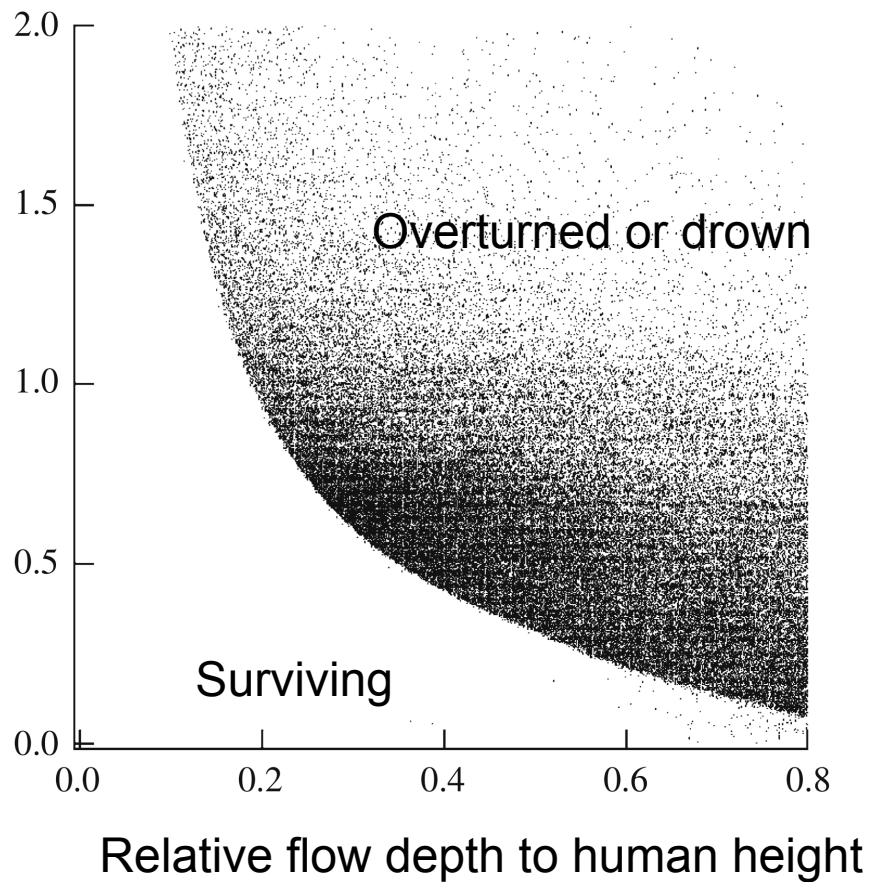
Damage probability



Loss estimation tools

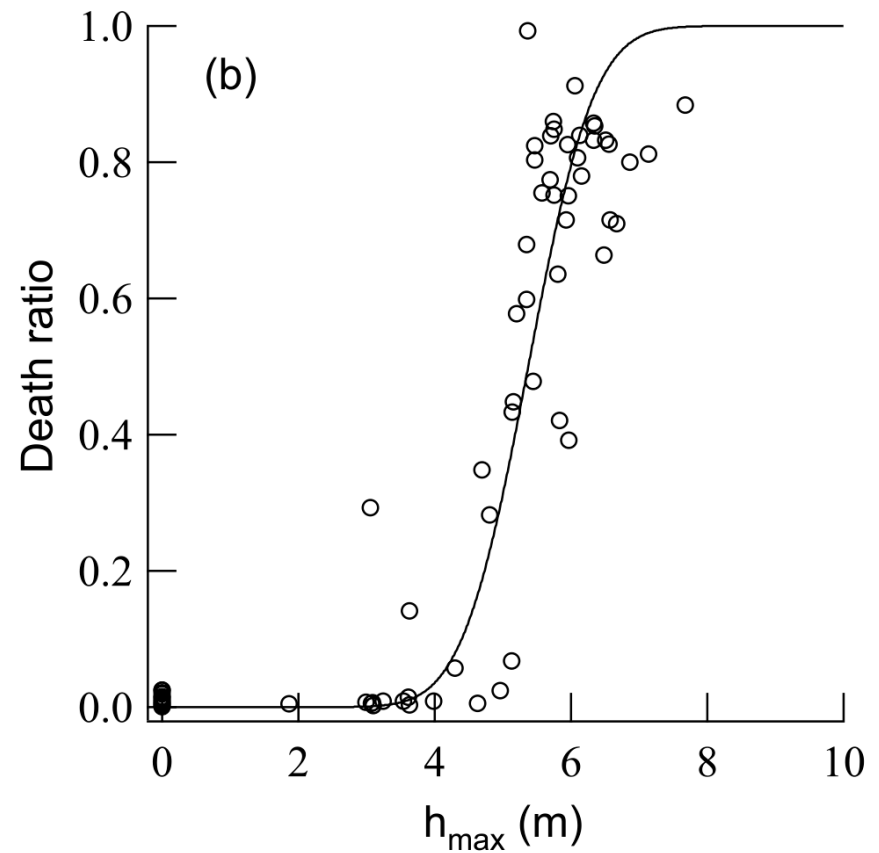
$$\frac{u}{\sqrt{gd}}$$

Surviving possibility of human body



Koshimura et al., 2006

Tsunami fragility curve for fatality



Koshimura et al., 2009

Publications (2011-2012)

1. Koshimura et al., Post-tsunami field Survey of the 2010 Tsunami in Chile, Pure and Applied Geophysics, under review.
2. Yoshii et al., Residual chemicals in soil due to the 2010 Chile tsunami, Pure and Applied Geophysics, under review.
3. Mas et al., Tsunami fragility curves using remote sensing and survey data of the 2010 Chilean tsunami in Dichato, Natural Hazards and Earth System Sciences, under review.
4. Mas et al., An agent based model for the tsunami evacuation simulation. a case study of the 2011 great east Japan tsunami in Arahama town, Proceedings of 9th International Conference on Urban Earthquake Engineering/ 4th Asia Conference on Earthquake Engineering, pp.1957-1965.
5. Shoji and Shimizu, Evaluation of tsunami strengths of houses subjected to a tsunami wave load, Evaluation of tsunami strengths of houses subjected to a tsunami wave load, Proceedings of 9th International Conference on Urban Earthquake Engineering/ 4th Asia Conference on Earthquake Engineering, pp.1277-1283.
6. Shoji et al., Evaluation of tsunami fluid force acting on the bridge deck damaged by the 2011 off the Pacific coast of Tohoku earthquake tsunami, Proceedings of 9th International Conference on Urban Earthquake Engineering/ 4th Asia Conference on Earthquake Engineering, pp.2049-2054.
7. S. Koshimura, M. Matsuoka, M. Matsuyama, T. Yoshii, E. Mas, Cesar Jimenez, and Fumio Yamazaki, Field Survey of the 2010 Tsunami in Chile, Proceedings of the 8th International Conference on Urban Earthquake Engineering, Paper No. 18-108, Tokyo, 2011.3
8. C. Jimenez, B. Adriano, S. Koshimura, and Y. Fujii, The Tsunami of Camana, Proceedings of the 8th International Conference on Urban Earthquake Engineering, Paper No.18-140, Tokyo, 2011.3
9. H. Yanagisawa, K. Shunichi, Y. Yagi, Y. Fujii, G. Shoji, and C. Jimenez, The Tsunami Vulnerability Assessment in Peru using the Index of Potential Tsunami Exposure, Proceedings of the 8th International Conference on Urban Earthquake Engineering, Paper No. 18-12, Tokyo, 2011.3
10. Bruno ADRIANO, Shunichi KOSHIMURA, Yushiro FUJII, VALIDATION OF TSUNAMI INUNDATION MODELLING FOR THE JUNE 23, 2001 PERU EARTHQUAKE, Bulletin of BRI, 2010.
11. Sheila YAURI, Yushiro FUJII, Bun'ichiro SHIBAZAKI, TSUNAMI HAZARD ASSESSMENT FOR THE CENTRAL COAST OF PERU USING NUMERICAL SIMULATIONS FOR THE 1974, 1966 AND 1746 EARTHQUAKES, Bulletin of BRI, 2011.
12. Adriano et al., Validation of tsunami inundation modeling of 2001 Peruvian earthquake, prepared.
13. Adriano et al., Tsunami hazard assessment for Lima, Peru, prepared.
14. Jimenz et al., Tsunami source model of the 1746 earthquake in Peru, prepared
15. Jimenez et al., Tsunami waveform inversion for the 2010 Chilean earthquake, Journal of Earthquake and Tsunami, prepared.

Erick Mas was awarded at CUEE conference at Tokyo Tech.



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

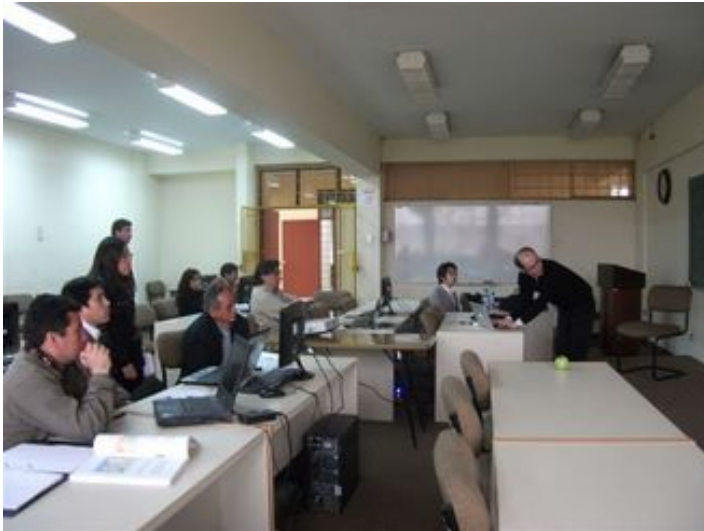
Tsunami Damage/Loss Estimation

Date	Topic	Organization
2011	Developing house/building inventory, census data for Callao, Lima	G4, CISMID, Tohoku Univ.
2011-2012	Developing tsunami fragility curves and 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 (needs more precise bathymetric survey)	CISMID, INDECI, Tohoku Univ.
2011-2012	Strategic planning for tsunami evacuation by multi-agent simulation	CISMID, INDECI, Tohoku Univ.

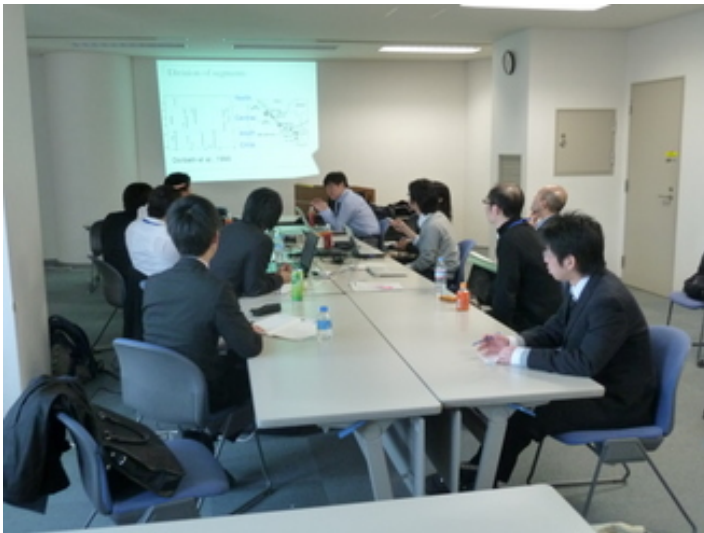
Human Resources Development



Tsunami Training Course



Field Survey in Chile



Technical Discussion



Group Meeting