CONCERT-Japan RAPSODI
Risk Assessment and design of Prevention Structures fOr enhanced tsunami DIsaster resilience

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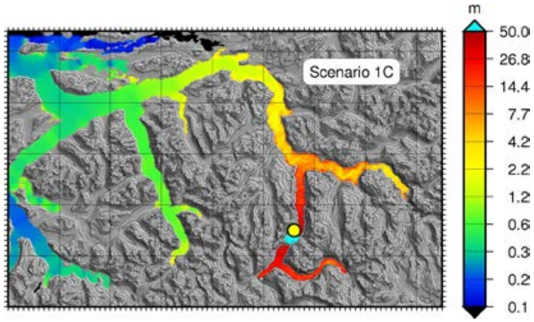
CONCERT-Japan Joint Workshop on

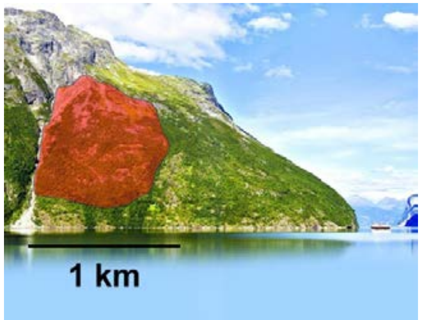
Resilience Against Disasters

JST Tokyo 25th November 2014

Consortium of four partners

- 1. NGI – Norwegian Geotechnical Institute, Norway





NGI

- 2. PARI – Port and Airport Research Institute, Japan

PARI

Consortium of four partners

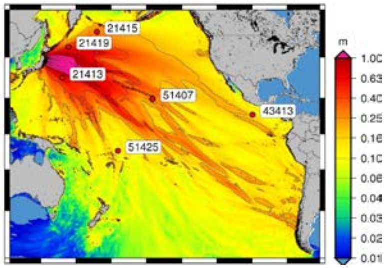
- 3. METU – Middle East Technical University, Turkey

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

- 4. TU-BS – TU Braunschweig, Leichtweiss – Institute for Hydraulic Engineering and Water Resources, Germany

Technische Universität Braunschweig

Complementary background

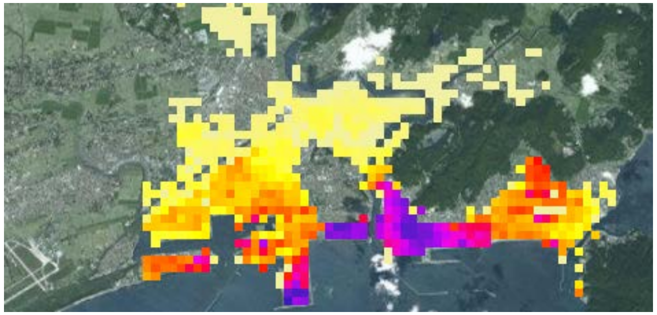


- All partners do physical and numerical tsunami modelling
- All partners have experience with
  coastal management and mitigation structures

- PARI: data and expertise on <u>earthquake</u> tsunami impact
- NGI: experience on vulnerability and
  risk analysis; <u>landslide</u> tsunamis
- METU: expertise on mitigation strategies,
  socio-economic impact analysis,
  structural and social resilience
- TU-BS: laboratory facilities and expertise on coastal engineering, flood risk, and structural behaviour

Research idea - Main objectives

1. Cooperation and exchange of knowledge
2. Design of novel mitigation measures
3. Quantitative tsunami risk analysis;



Potential for further development based on data from the 2011 Tohoku tsunami

1. Cooperation and exchange

- Complementary expertise
  - Learn from each other
  - Produce results that we could not achieve alone
- Exchange
  - Experience, knowledge, results, staff
  - Smaller meetings, workshops, research visits
  - Joint deliverables and publications
- Dissemination
  - Documents for end-users and stakeholders on the web http://www.ngi.no/en/Project-pages/RAPSODI/
  - Guidelines for design of structures and risk management strategies
- Establish a platform for further Euro-Japan collaboration within tsunami science

Joint research activities

Exchange of personnel for laboratory experiment campaigns

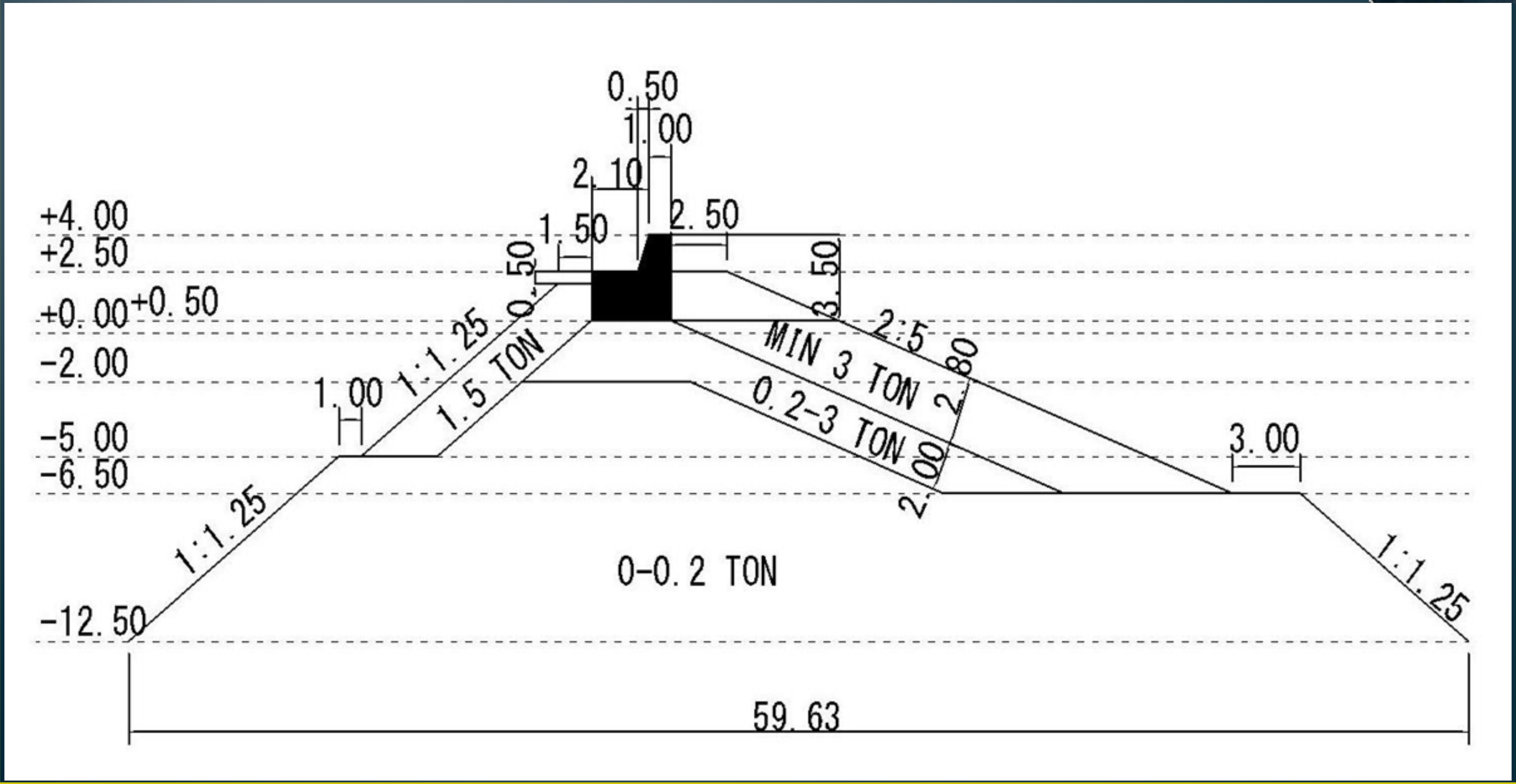
Mutually contribute to joint Deliverables

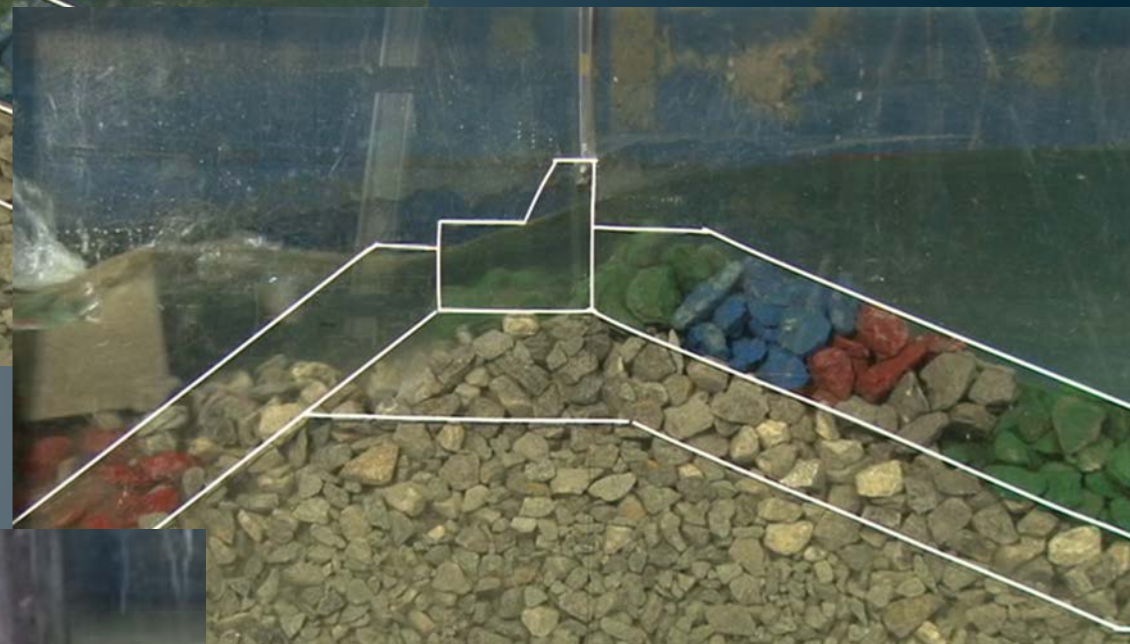
Quality control of «others'» Deliverables

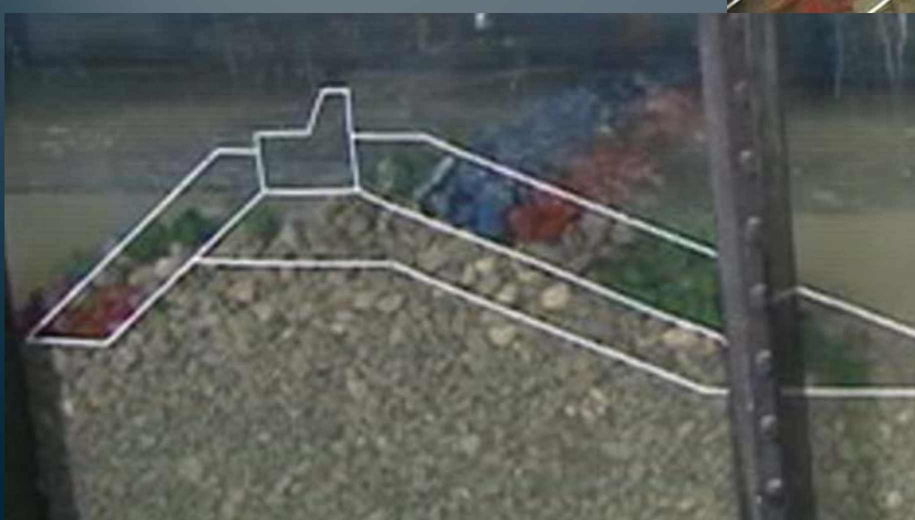
- Integration of partners
- Exchange of knowlegde

Field trip to the Norwegian rockslide tsunami warning center

2. Haydarpasa Breakwater Cross Section

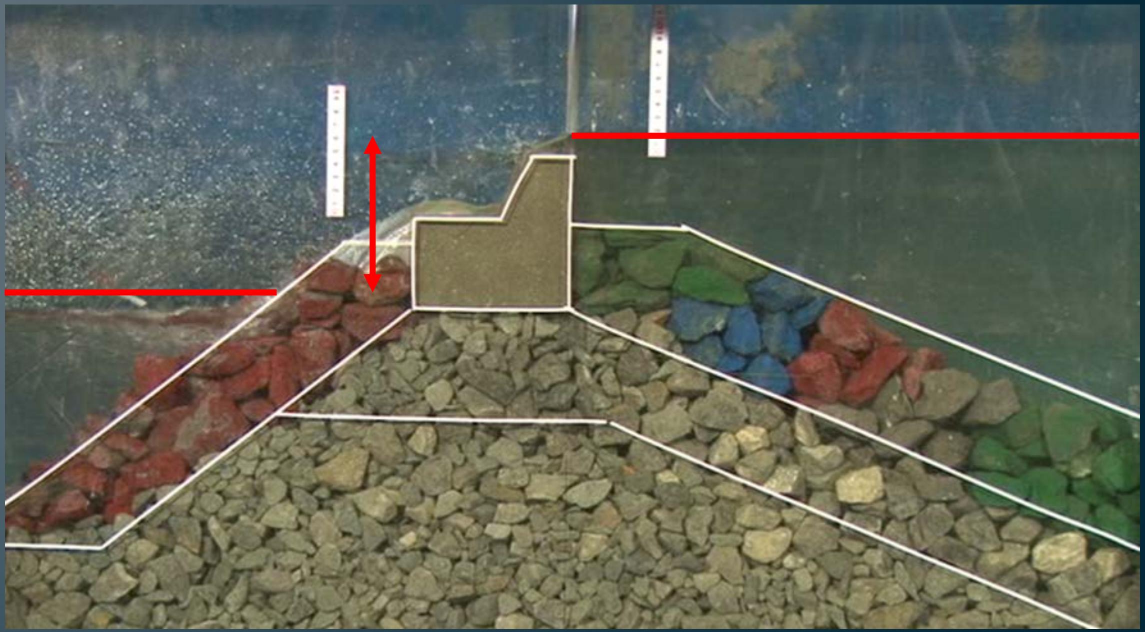






Failure Mechanism

- Both type of experiments showed that the main failure mechanism of these types of breakwaters is sliding of crown walls.
- Sliding is mainly caused of difference in water level between sea side and the harbour side of the breakwater.



- Driving Forces
  - Pressure forces
  - Buoyancy Force
- Supporting Forces
  - Weight of crown wall
  - Stones in the harbour side armour layer

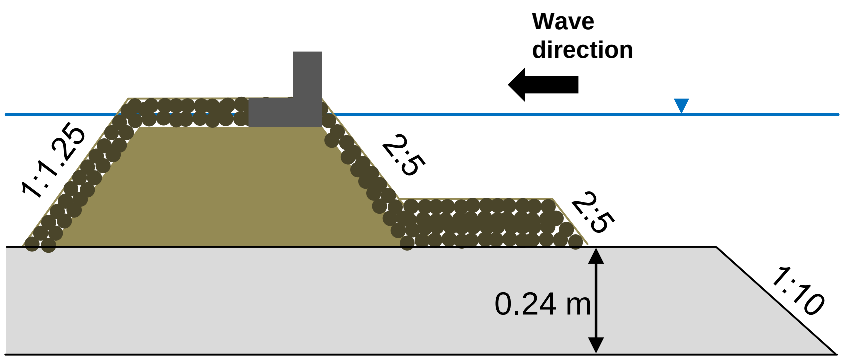
2. Laboratory experiments at TUBS - overview

- Selection of the structure to be tested based on failure analysis of structures in Japan (METU) → roubble mound breakwater
- Breakwater geometry → simplified geometry of the breakwater at Haydarpasa Port, Turkey (tested by METU and PARI)
- Investigation of structure damage and exerted forces by tsunami (solitary waves and tsunami bores)
- Model scale1:30

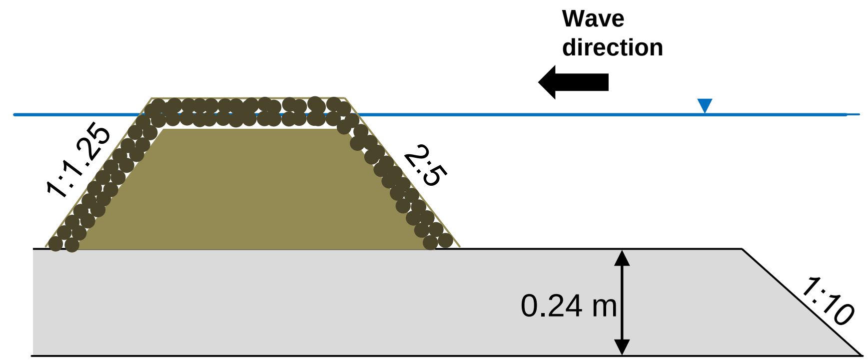
- Improvement of knowledge on structure failure under tsunami impact
- Development of innovative protective structures against tsunami
- Comparison with PARI experiments and their extension

Tested breakwater configurations (1)

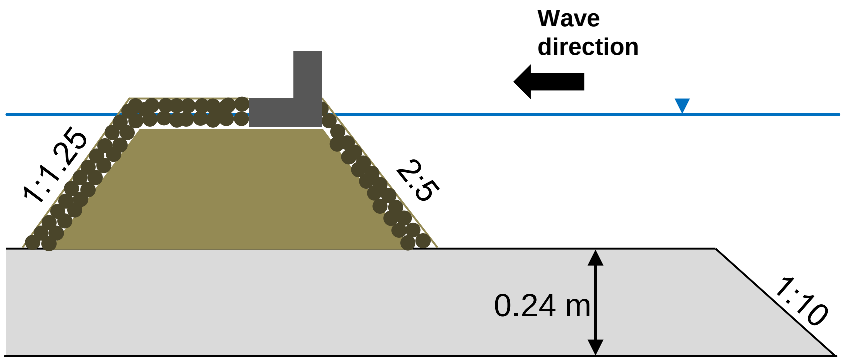
Configuration 1 (crown wall and berm)



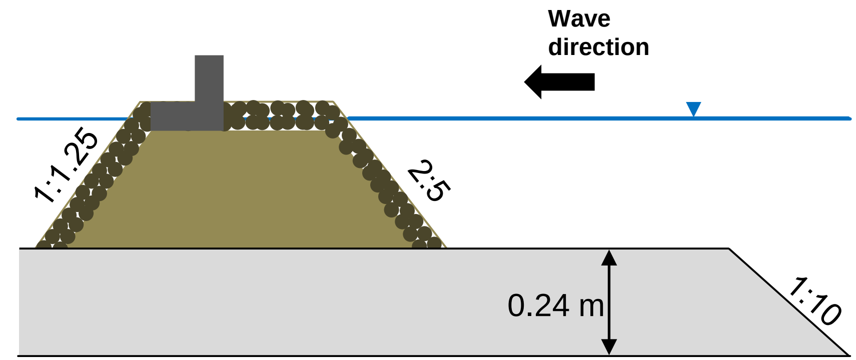
Configuration 2 (without crown wall)



Configuration 3 (crown wall)

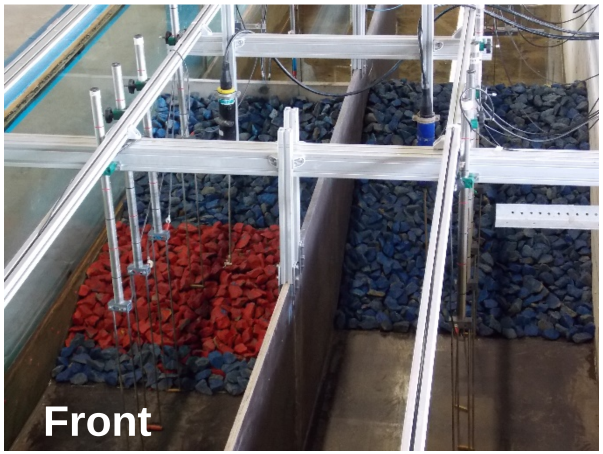


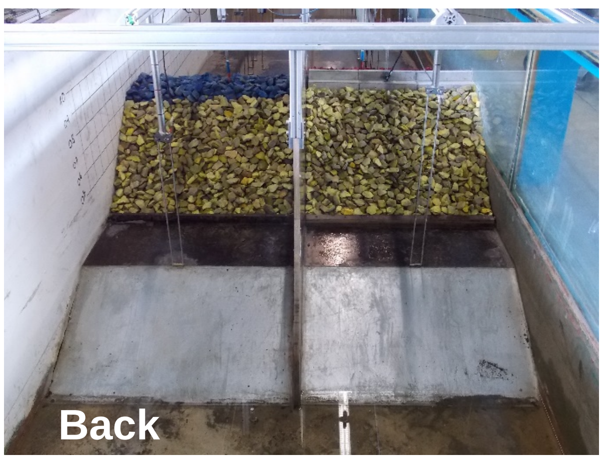
Configuration 4 (shifted crown wall)



Tested breakwater configurations (2)

Configuration 1 and 2

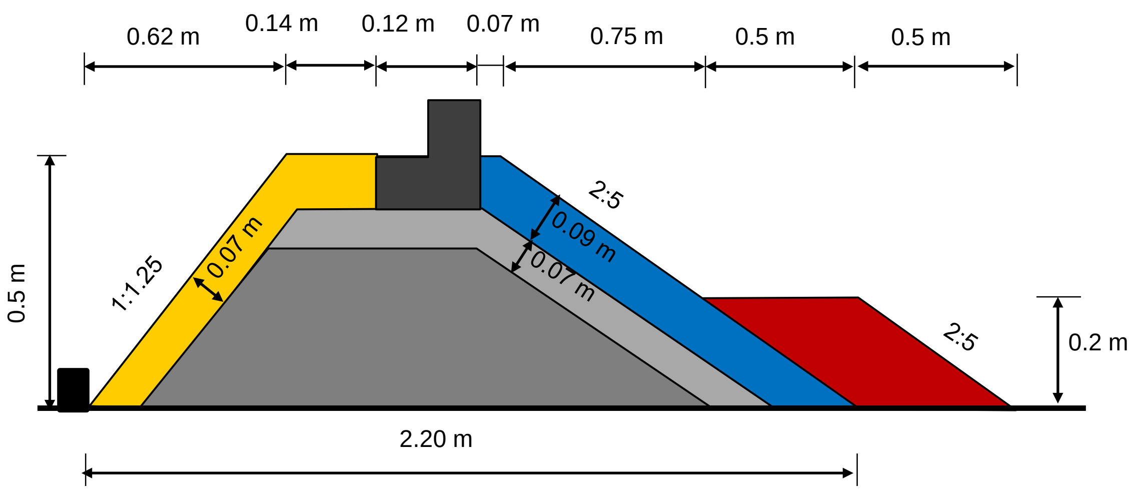




Configuration 3 and 4

Breakwater geometry

Configuration 1



- Armour layer on the seaside (100 – 150 g)
- Armour layer on the harbour side (50 – 100 g)
- Berm (100 – 150 g)
- Filter layer (50 – 100 g)
- Core layer (0 – 10 g)
- Concrete crown wall

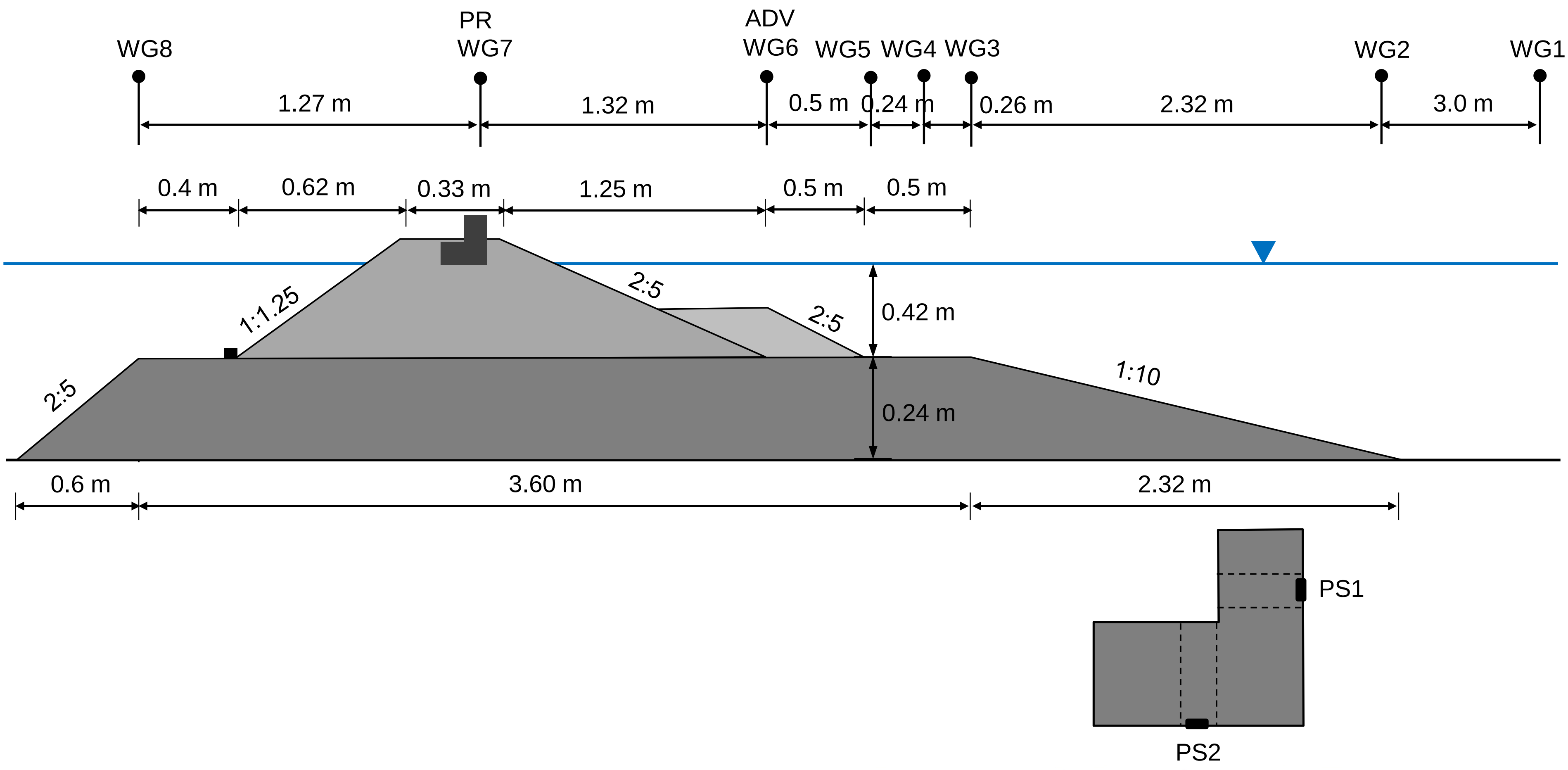
Core layer (0-10 g)

Filter layer (50-100 g)
Harbour side armour

Seaside armour (100-150 g)
Berm layer

Measuring instrumentation

Configuration 1



Experimental programme

Test no.	Configuration		Wave type	Wave height	Water depth	
	Left part of wave flume [No.]	Right part of wave flume [No.]		[m]	In front of bore gate [m]	Behind bore gate [m]
20140721_01 20140721_02 20140721_03	3	4	Tsunami bore	-	0.200	0.750 0.800 0.850
20140723_01 20140723_02	1	2	Tsunami bore	-	0.200	0.750 0.800
20140725_01 20140725_02	1	2	Solitary wave	0.050 0.075	0.680 0.680	
20140807_01 20140807_02 20140807_03	1	2	Solitary wave	0.100 0.125 0.150	0.670	

Configuration 1: crown wall and berm Configuration 2: without crown wall	Configuration 3: crown wall Configuration 4: shifted crown wall

Analysis of experimental data

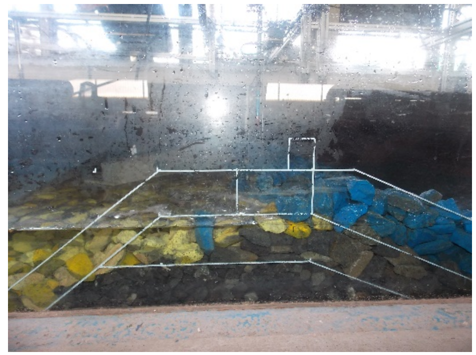
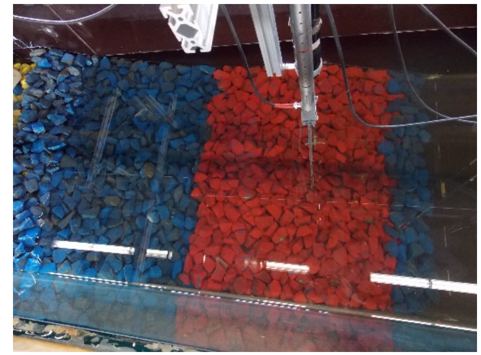
- Identification of occurring processes
- Determination of duration of wave impact
- Determination of structure damage (classification of the damage, analysis of damage breakwater profiles)
- Analysis of evolution of wave profiles, determination of max. wave height/max. flow depth
- Determination of flow velocity
- Determination of wave-induced pressure and corresponding forces

Observed processes and structure damage

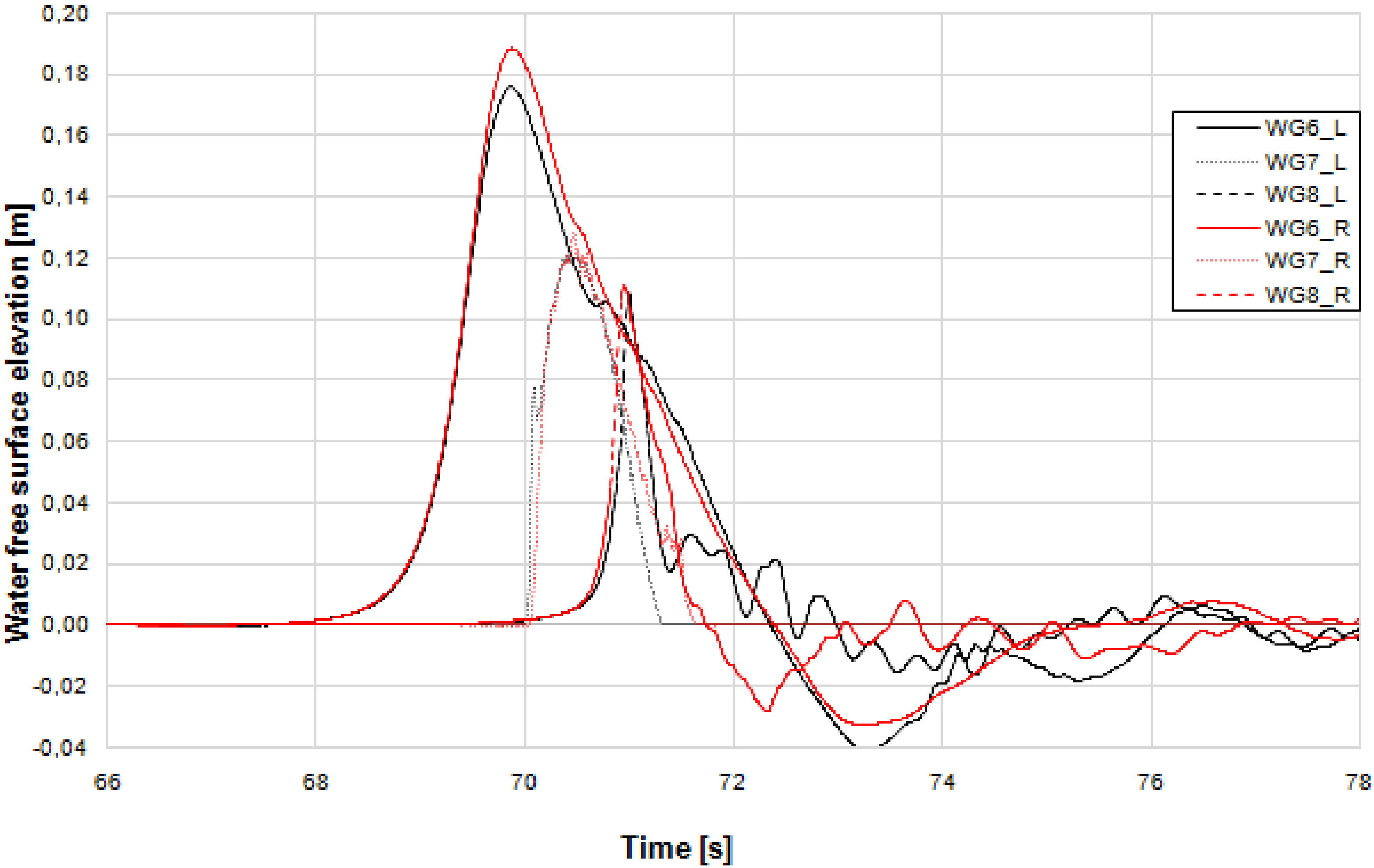
Test no.	Config.	Wave type	Observations
20140721_01 20140721_02 20140721_03	3 and 4	Bore: 0.2, 0.75m Bore: 0.2, 0.80m Bore: 0.2, 0.85m	No overflow, ftb, no damage Weak overflow (C3), ftb, minor damage Overflow, ftb, total failure
20140723_01 20140723_02	1 and 2	Bore: 0.2, 0.75m Bore: 0.2, 0.80m	No overflow, ftb, minor damage Overflow, ftb, major damage
20140725_01 20140725_02 20140807_01 20140807_02 20140807_03	1 and 2	Solitary: 0.050m Solitary: 0.075m Solitary: 0.100m Solitary: 0.125m Solitary: 0.150m	No overflow, no damage Overflow, almost no damage Overflow, minor damage Overflow, minor damage Overflow, major damage

ftb – flow through breakwater

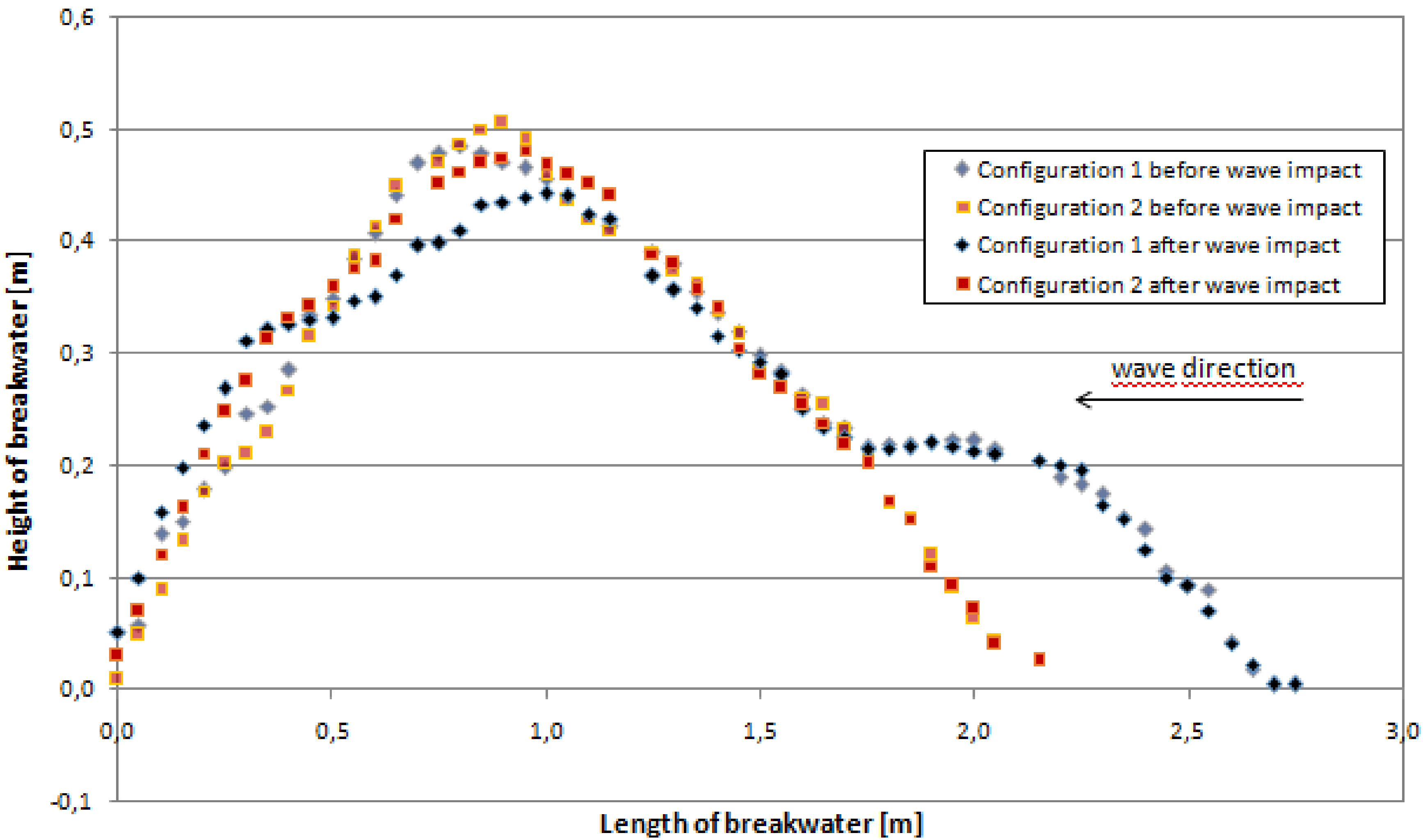
Test with solitary wave of H=0.15 m (1)

	Configuration 1 and 2
Test 20140807_03	    

Test with solitary wave of H=0.15 m (2)



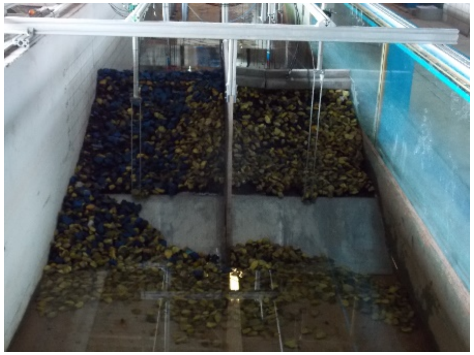
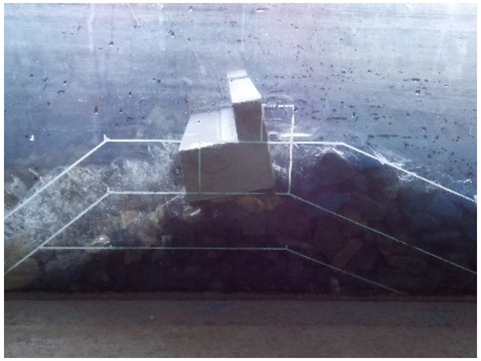
Test with solitary wave of H=0.15 m (3)



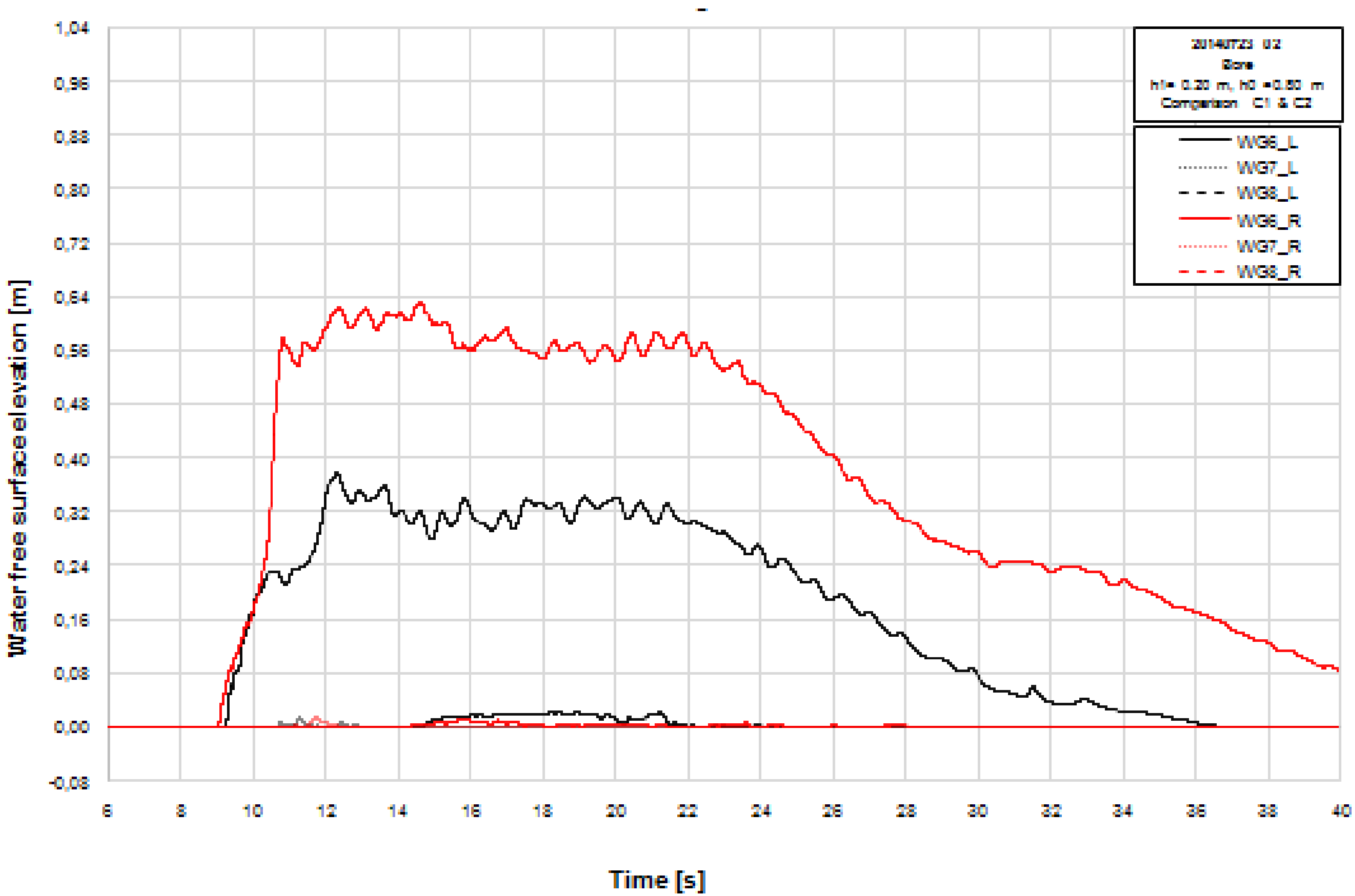
Tests with bore 0.2 m, 0.8 m (1)

Test 20140723_02

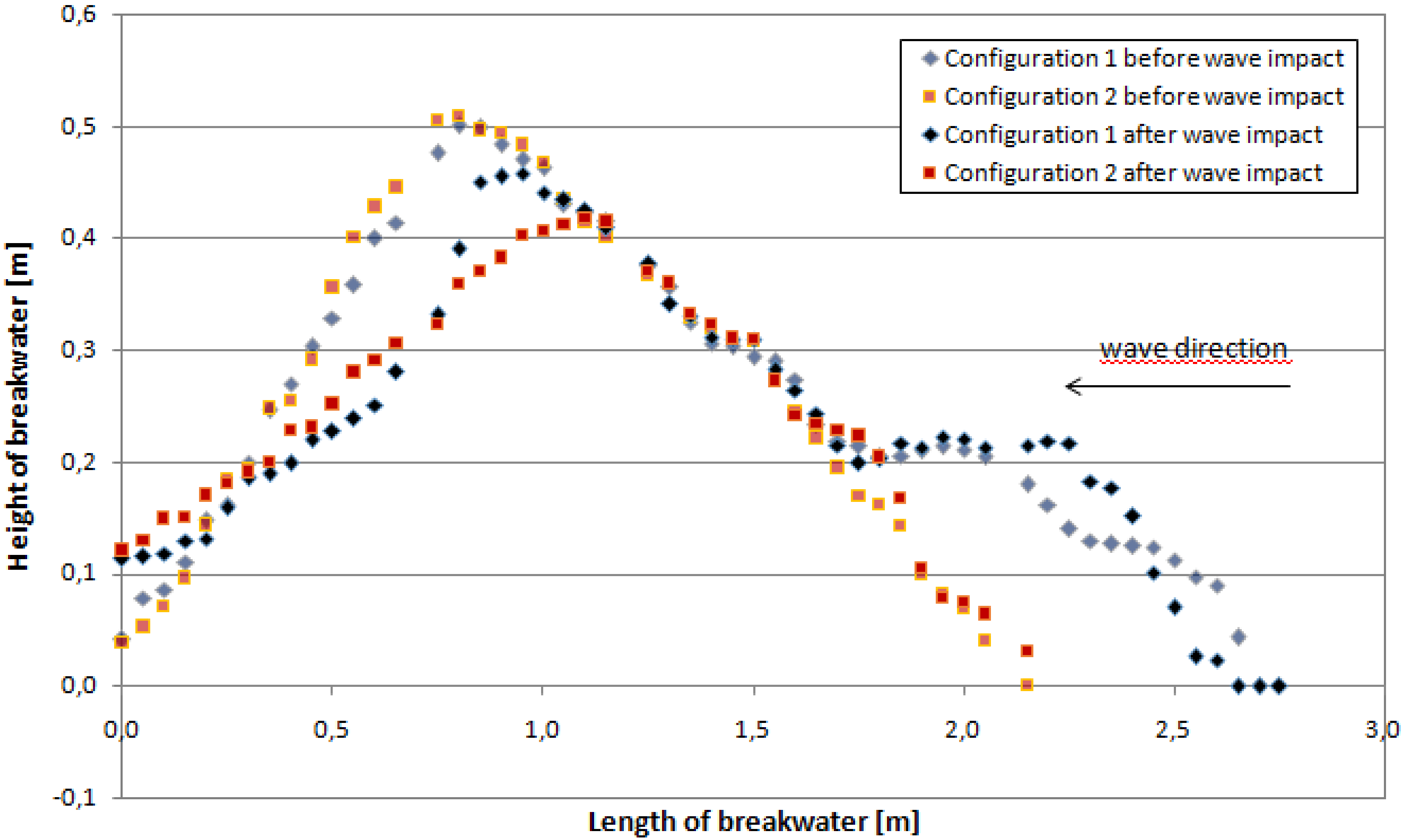
Configuration 1 and 2

Tests with bore 0.2 m, 0.8 m (2)



Tests with bore 0.2 m, 0.8 m (3)



Preliminary conclusions

- Breakwater damage under bore impact due to pressure difference on seaside and harbour side → flow through porous media dominant, effect of overflow negligible → layers washed away
- No significant difference in degree of damage observed for configurations tested under bore impact → no preferable solution
- Breakwater damage under solitary wave impact due to overflow → flow through porous media negligible → roubbles moved rather than washed away
- Incomplete overview of structure performance under solitary wave impact → tests with configurations 3 and 4 to be performed

3. Tsunami vulnerability and risk assessment

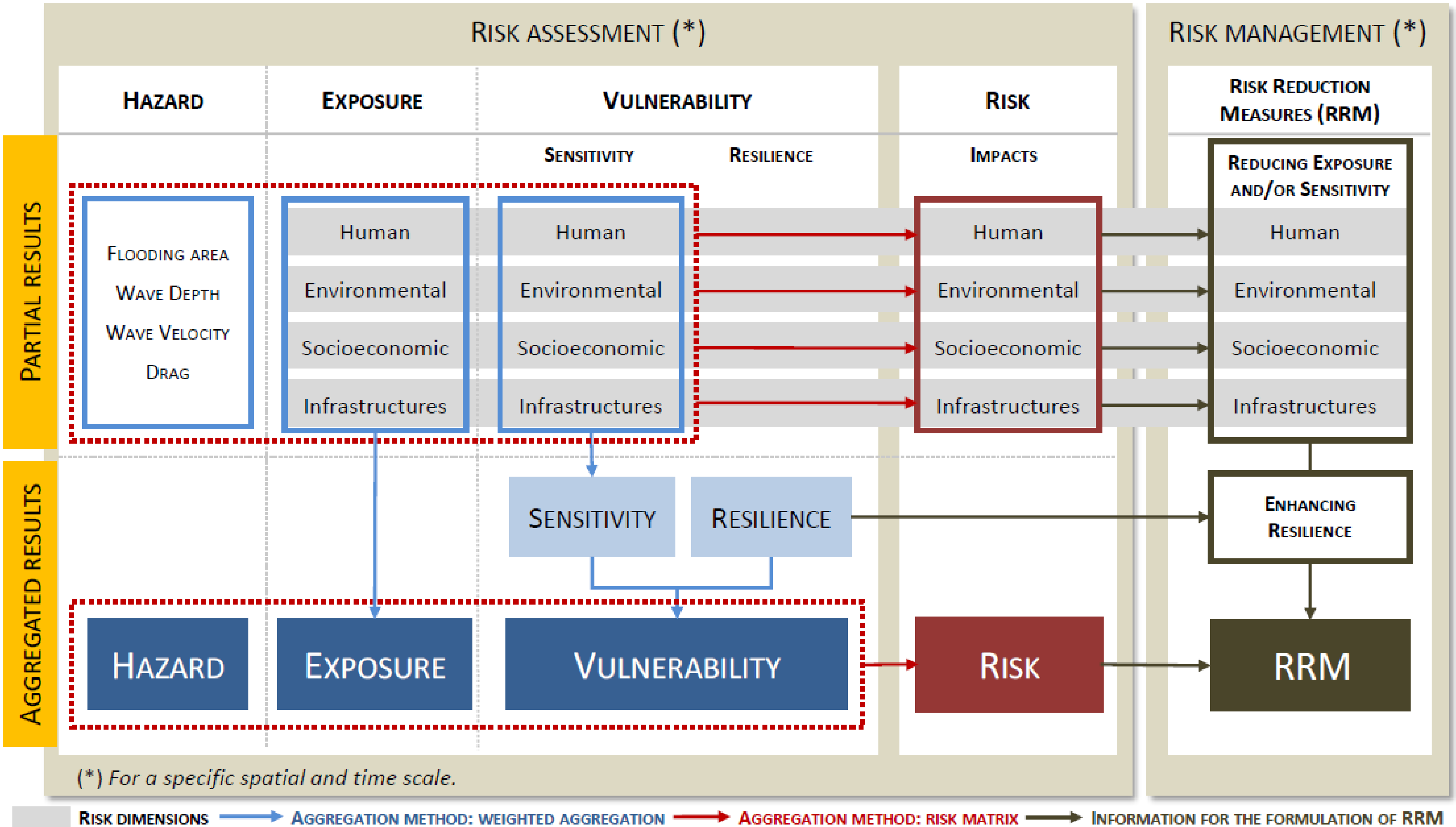
Today's quantitative models for tsunami risk assessment have clear limitations, in particular for the vulnerability

Idea:

- Hindcast of the 2011 Tohoku tsunami
- Combine information on tsunami vulnerability
  - mortality rates and damages as function of tsunami flow depth and current velocities, buildings and other infrastructure, population capabilities and exposure, mitigation structures, etc.
- with existing models for tsunami risk analysis

→ Validation and further development

From hazard analysis to risk management



González-Riancho, P. et al.
doi:10.5194/nhess-14-1223-2014

Risk parameters

GENERAL

Risk = Hazard * Consequence

Hazard = maximum tsunami flow depth related to a certain probability of occurrence

Consequence described by *exposure* and *mortality*

SITE DEPENDENT

Exposure; density of population

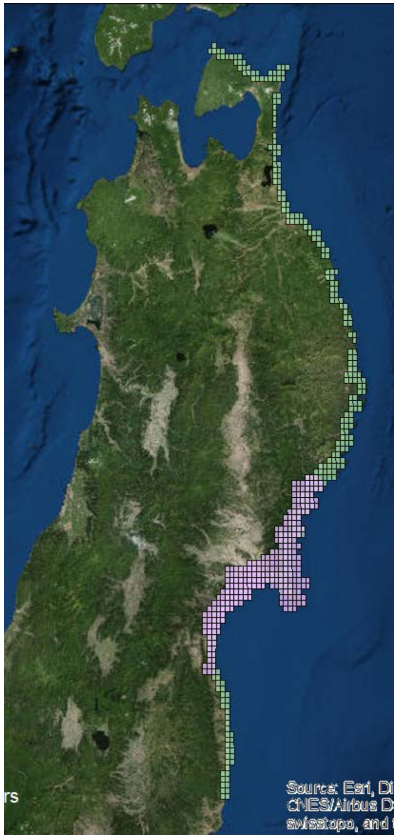
Mortality; function of flow depth and building vulnerability

→ 4 factors describing the buildings:

height – material – barrier – use

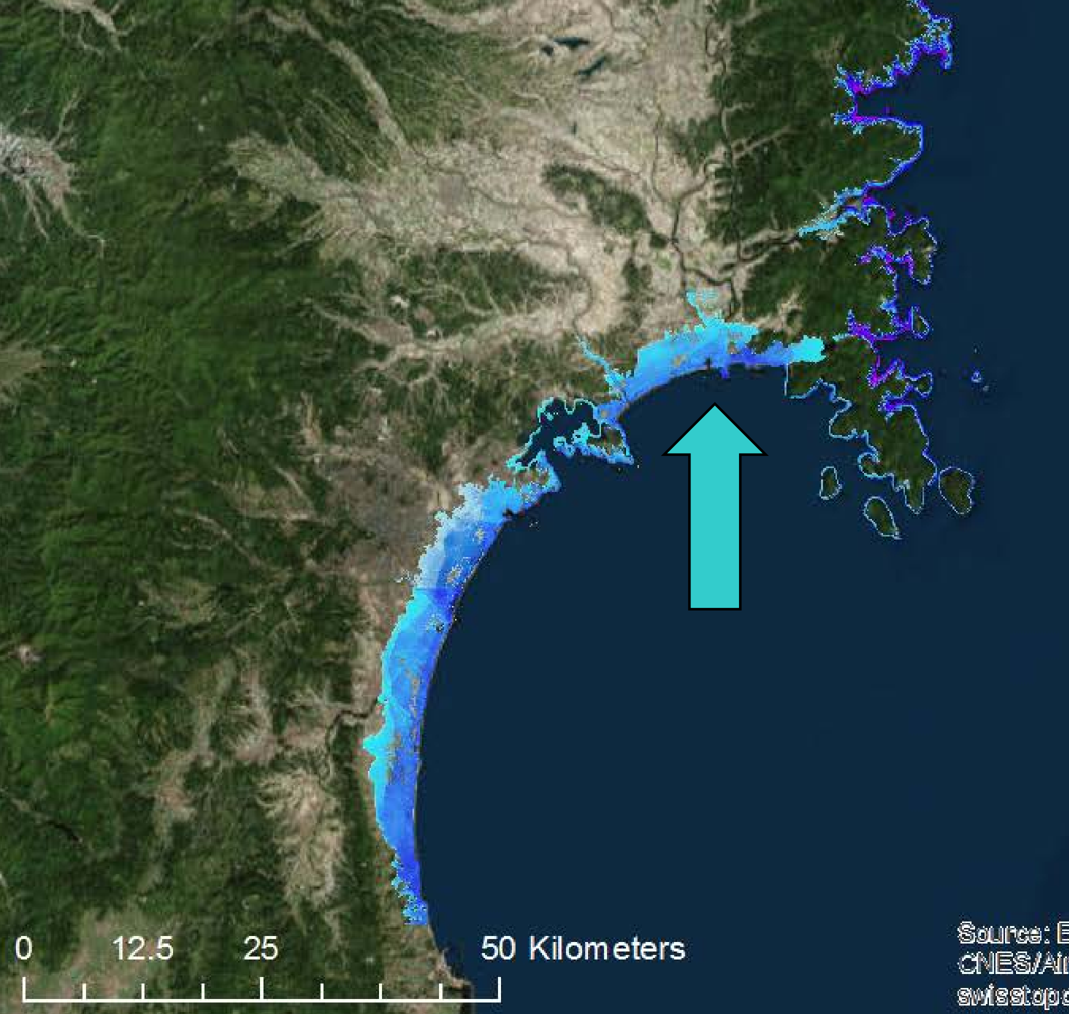
Data

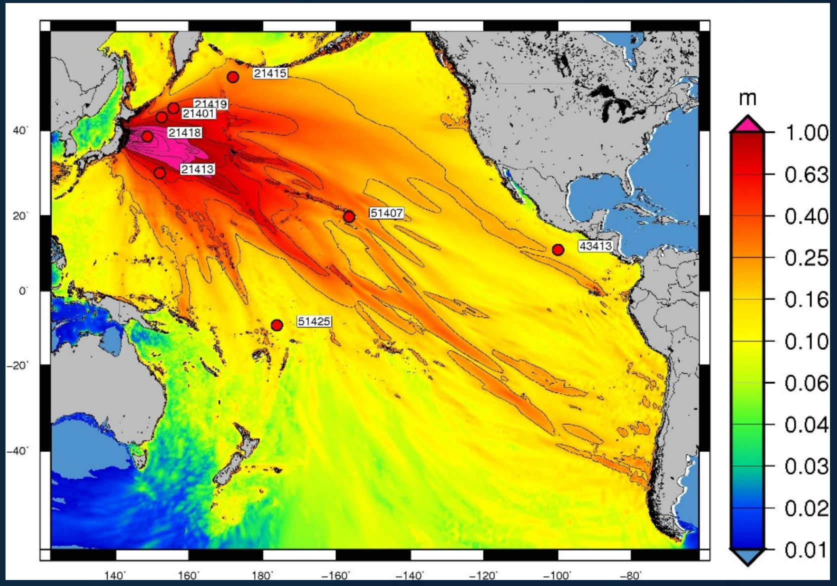
- Very high resolution digital elevation model
  - received from PARI
- Post-tsunami field data
  - water mark measurements, structural building vulnerability, etc. available on http://fukkou.csis.u-tokyo.ac.jp/
- Census data
  - aggregated by geographical units from the Portal Site of Official Statistics of Japan: http://www.e-stat.go.jp/SG1/estat/eStatTopPortal.do



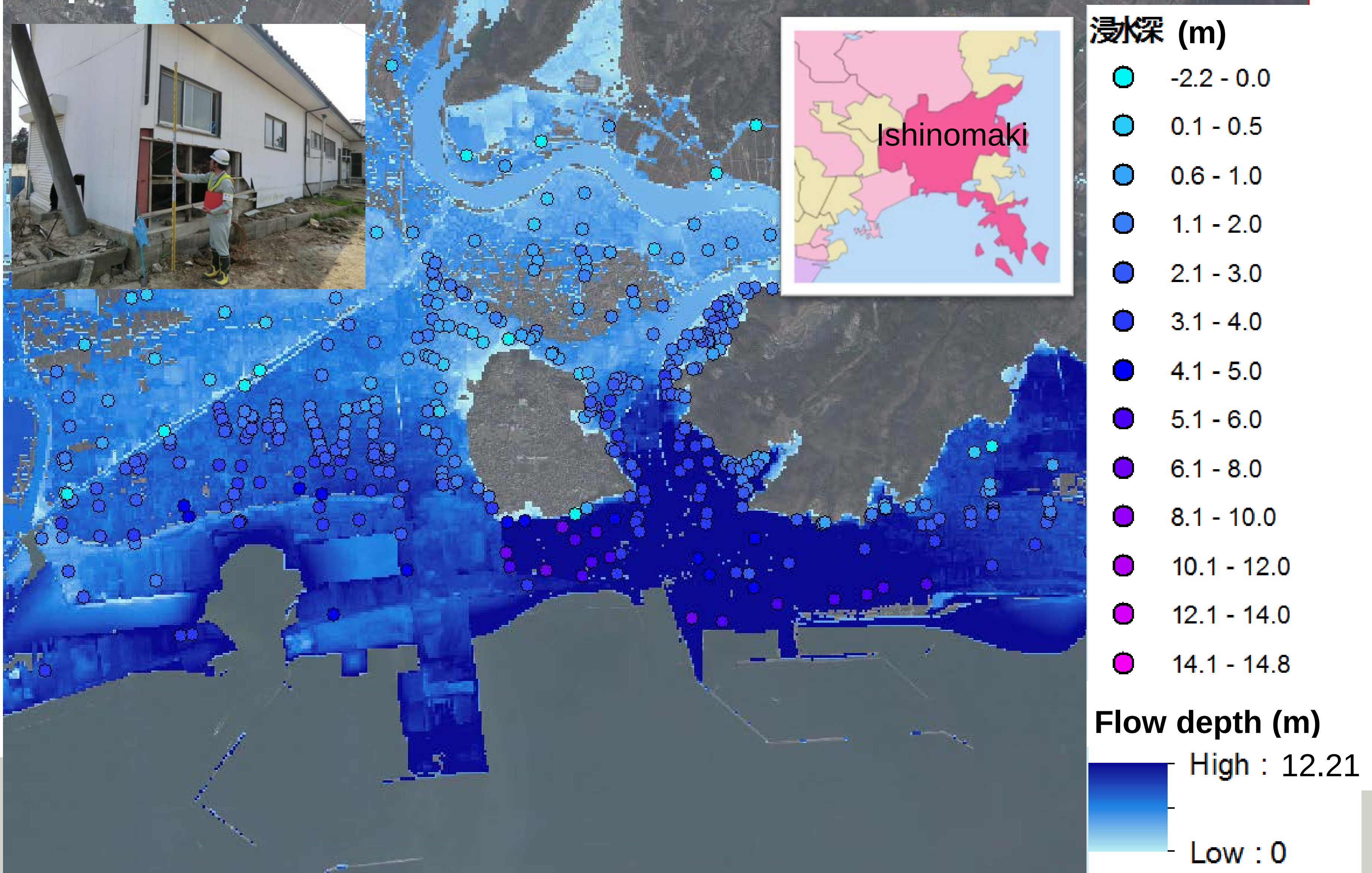
Maruyama, Y., Tanaka, H., 2014. Evaluation of building damage and human casuality after the 2011 off the Pacific coast of Tohoku earthquake based on the population exposure. International Conference on Urban Disaster Reduction, Sept. 28.-Oct.1, 2014, Boulder, Colorado, US.

- Back-calculating the 2011 Tohoku earthquake and tsunami
- Tsunami inundation modelling with VHR DEM

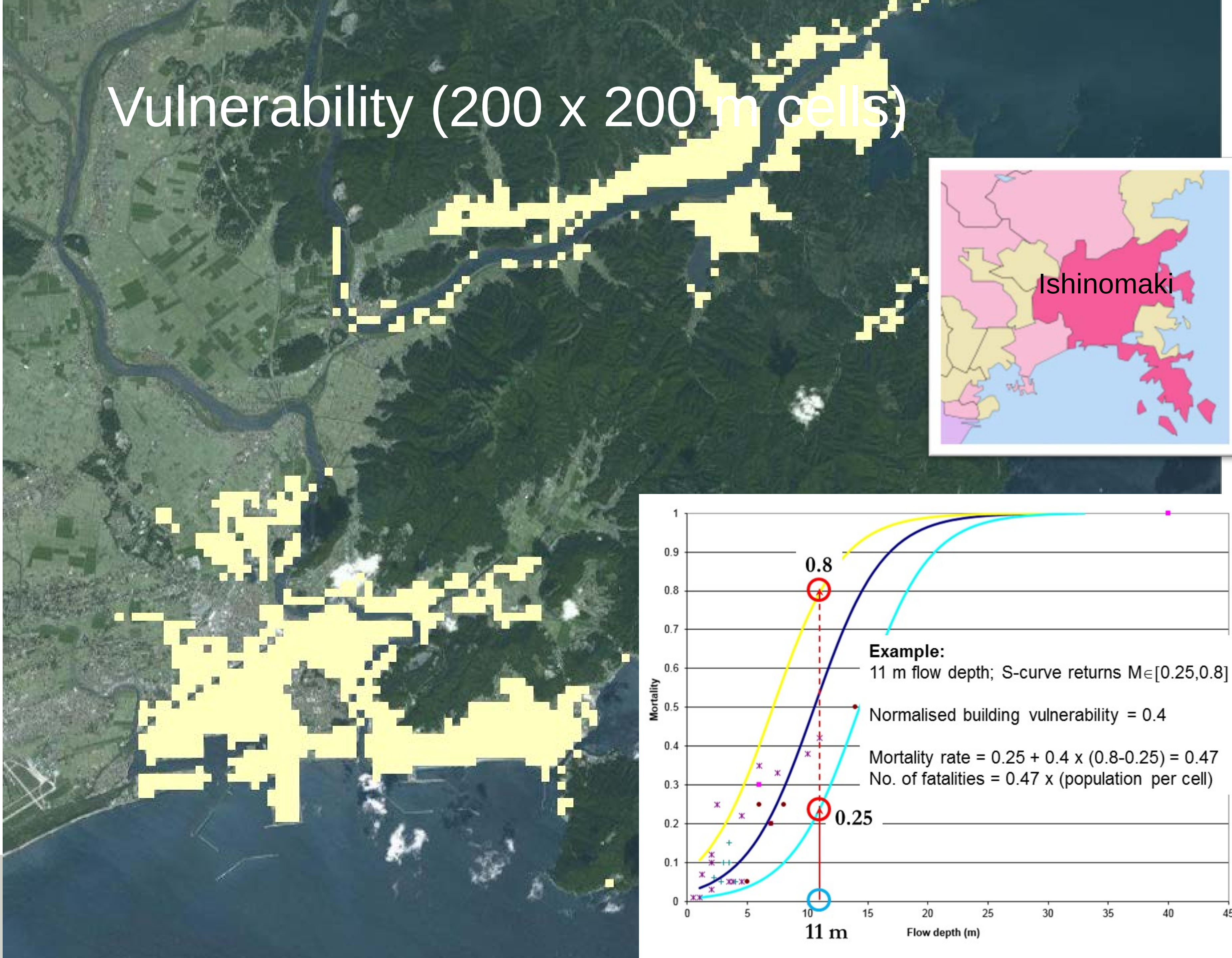




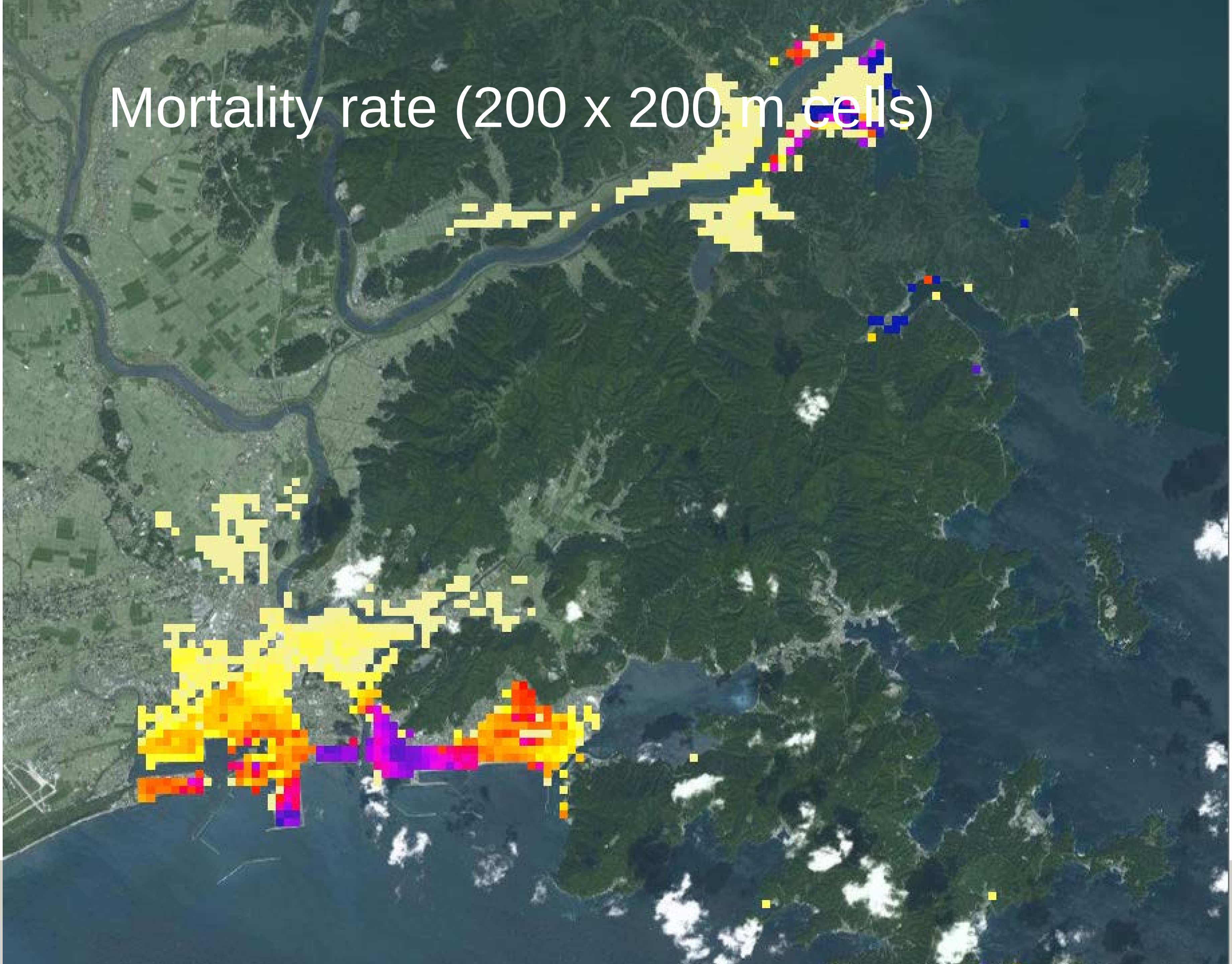
Comparison of numerical simulation with post-tsunami «water mark» data



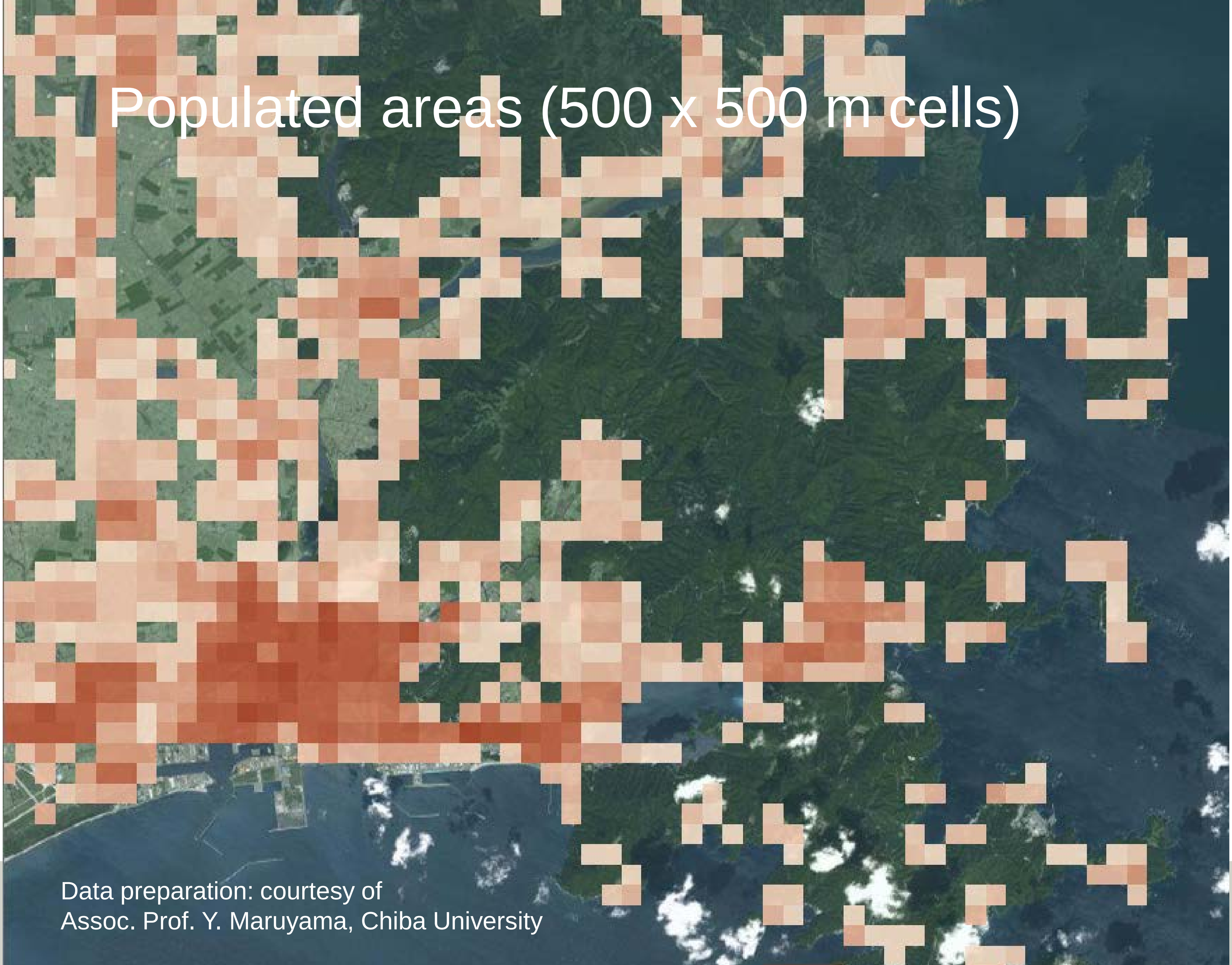
Vulnerability (200 x 200 m cells)



Mortality rate (200 x 200 m cells)

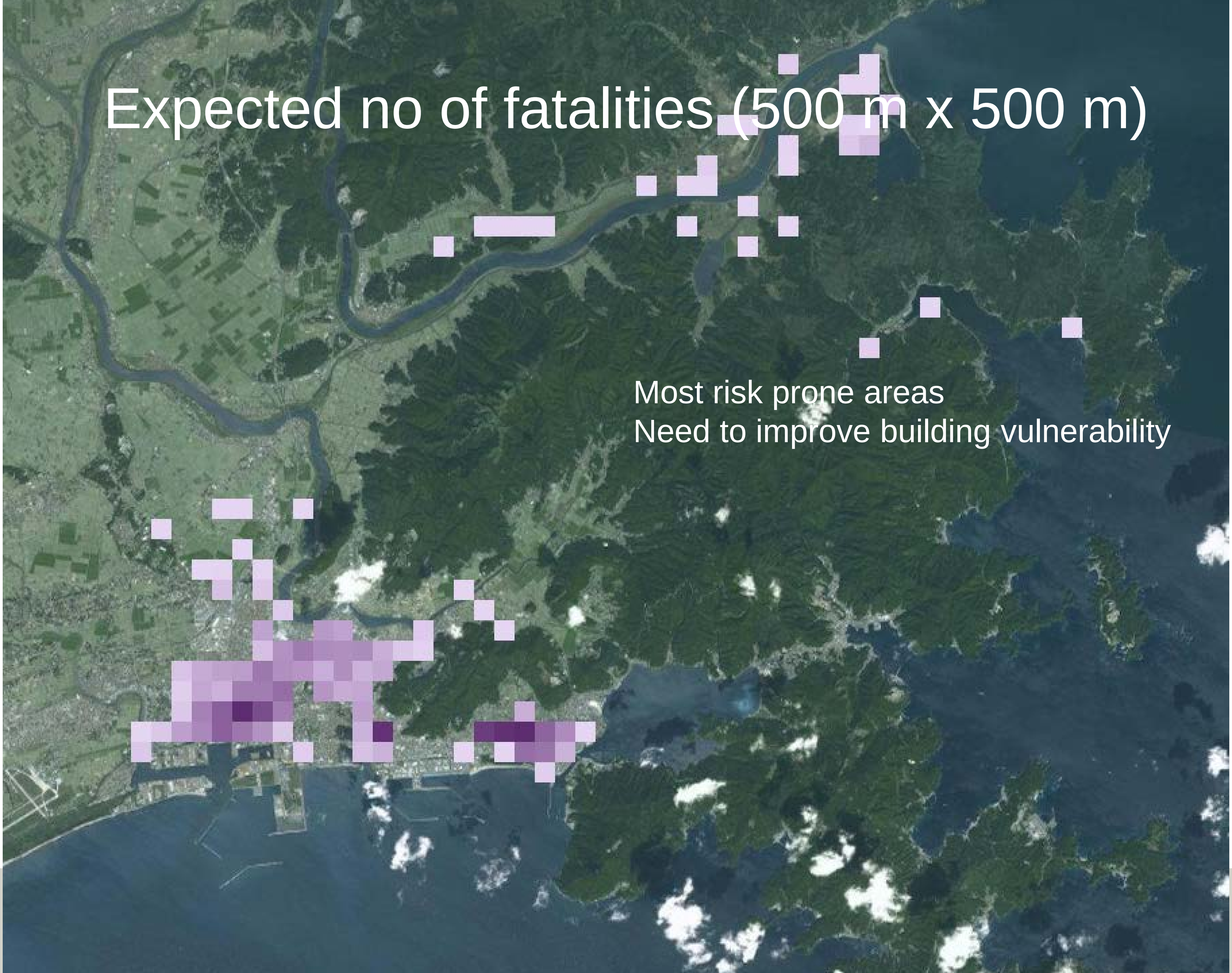


Populated areas (500 x 500 m cells)



Data preparation: courtesy of
Assoc. Prof. Y. Maruyama, Chiba University

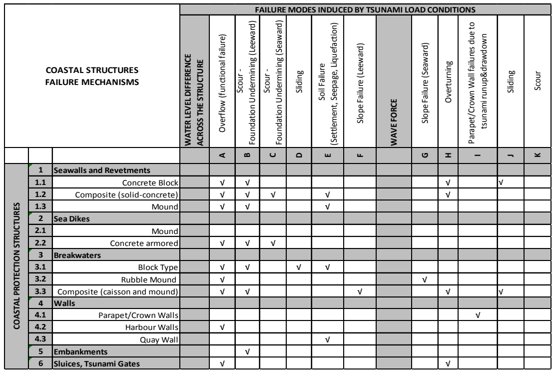
Expected no of fatalities (500 m x 500 m)



Most risk prone areas
Need to improve building vulnerability

Progress and results to date

- Reports on SoA in tsunami mitigation and risk analysis
  - Structural and non-structural measures
  - Approaches for modelling and risk analysis
  - Comparisons Europe – Japan
- Review of 2011 Tohoku post-tsunami field surveys
- Structure failure mode matrix
- Novel experiments on rubble mound breakwaters
- Tsunami risk analysis model
  - Tool to identify most critical areas
  - What factors contribute to the risk? (important for mitigation)



FAILURE MODES INDUCED BY TSUNAMI LOAD CONDITIONS

COASTAL STRUCTURES FAILURE MECHANISMS			WATER LEVEL DIFFERENCE ACROSS THE STRUCTURE	Overflow (functional failure)	Scour - Foundation Undermining (Leeward)	Scour - Foundation Undermining (Seaward)	Sliding	Soil Failure (Settlement, Seepage, Liquefaction)	Slope Failure (Leeward)	WAVE FORCE	Slope Failure (Seaward)	Overturning	Parapet/Crown Wall failures due to tsunami runup&drawdown	Sliding	Scour
				A	B	C	D	E	F		G	H	I	J	K
COASTAL PROTECTION STRUCTURES	1	Seawalls and Revetments													
	1.1	Concrete Block		√	√							√		√	
	1.2	Composite (solid-concrete)		√	√	√		√				√			
	1.3	Mound		√	√			√							
	2	Sea Dikes													
	2.1	Mound													
	2.2	Concrete armored		√	√	√									
	3	Breakwaters													
	3.1	Block Type		√	√		√	√							
	3.2	Rubble Mound		√							√				
	3.3	Composite (caisson and mound)		√	√				√			√		√	
	4	Walls													
	4.1	Parapet/Crown Walls											√		
	4.2	Harbour Walls		√											
	4.3	Quay Wall						√							
	5	Embankments			√										
	6	Sluices, Tsunami Gates		√								√			

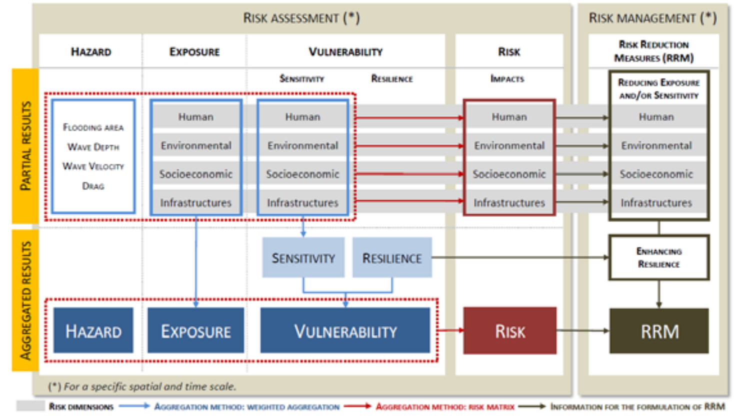
Expected impacts on society and/or academia

- Identifcation of research gaps
- Failure mode matrix – not previously presented
  - → innovative new design of protective structures
- Improved risk assessment
  - → improved risk management
- Exchange of expertise on large-scale lab experiments
- Platform for future Euro-Japan collaboration in tsunami science

Plans for the future

Hoping for a new call that enables further collaboration

- New generation of laboratory studies for further improvement of the foundations and tsunami mitigation structures
- Improved tsunami risk model including
  - other risks (beyond mortality)
  - other tsunami metrics for damage
  - more sophisticated numerical modellig and vulnerability analysis in urban areas



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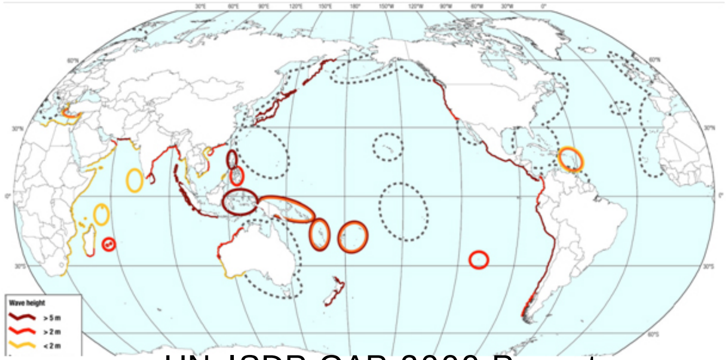
Challenges encountered – how overcome?

- Cultural and linguistic challenges
  - Different interpretation of the requirements stated in the proposal
  - Exchange and visits vs. scientific Deliverables
  - Different traditions for extent of Deliverables → delays
- Extensive communication
  - emails, skype, phone
- Seeking advice from Innovation Norway and the Royal Norwegian Embassy in Tokyo
- Joint field trip to the fjords of western Norway and the rockslide tsunami warning center

Other challenges

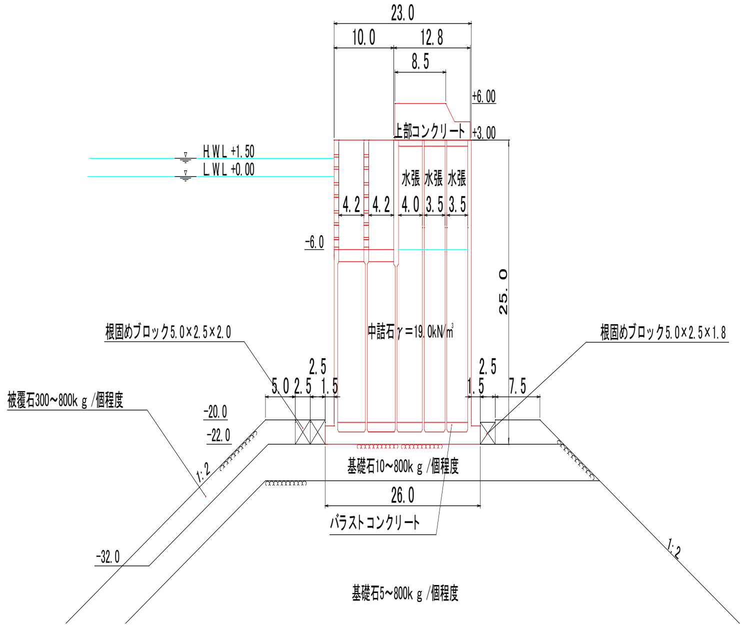
- Different funding schemes and separate national fundings made a joint start difficult
- Extremely high management efforts required for a small project → severe delays, funding issue still not solved
- Different technical backgrounds required more discussions and planning than expected
  - Approach, schedule, etc. for the joint laboratory experiments

Advantages of the CONCERT-Japan framework



UN-ISDR GAR 2009 Report

- Better exchange of research results, more «global» perspective
- From the Europen side:
  Better access to information on the 2011 Tohoku tsunami
  - including some help with translations
- From the Japanese side:
  Opportunity to gain experience in collaboration with foreign researchers



CONCERT-JAPAN
Connecting and Coordinating
European Research and Technology Development with Japan

Advantages of multilateral vs. bilateral cooperation

A multilateral cooperation is a definite plus

- Brings in various viewpoints and approaches
- A complementary and more complete consortium
  - tsunami science is very multi-disciplinary
  - earthquake source – wave – impact
  - numerical modelling – physical modelling – seismology –wave mechanics - statistics/likelihood – vulnerability and risk analysis
- Less chance of unresolved problems or deficient Deliverables

Opinion of joint call process

- Unclear funding schemes
- Good support prior to submission, weak support later
  - need for revised budgets, contracts, Consortium Agreement,…
  - much administrative effort needed

How could support within CONCERT-Japan have been improved?

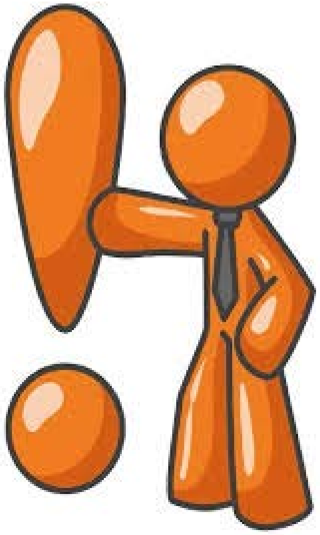
- More focus on the scientific issues
  - allow for more than 10% personnel funding
- More assistance with budgets, contracts, agreement,…
- Joint reporting, avoid
  - separate reports to the Secretariat and the national funding agencies
  - different deadlines
  - different languages

How could support within CONCERT-Japan have been improved?

- Why not accept journal papers as Deliverables?
  - more credit without duplicate work
- Include some financial support for translation Japanese → English
- The problems we reported were not followed up by the Secretariat or the national funding agencies. This was disappointing

Lessons learned

- Administrative efforts were clearly underestimated
- Expectations were highly different
- Such pre-projects are essential for later bi-(multi) lateral collaboration



Thank you!

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We acknowledge the financial support from the National Funding Organizations

The Research Council of Norway

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Bundesministerium für Bildung und Forschung

TÜBİTAK

www.concertjapan.eu
http://www.ngi.no/en/Project-pages/RAPSODI/