Research activities in PARI
and future planning for RAPSODI

Port and Airport Research Institute, Japan
Yoshiyuki Nakamura

Current activities

- Discussions with METU during ITS on Sept.

PARI will accept students from METU for three months supported by another project.

- Visit NGI on Oct 7-8

As central members of the PARI tsunami team will face difficulties to attend the kick-off meeting, a separate RAPSODI discussion between PARI and NGI was arranged.

Drs. Arikawa, Harano, Kubota, & Sassa attended from PARI.

Both NGI and PARI presented their ongoing tsunami studies, with focus on the activities relevant for RAPSODI.

- Kickoff meeting on Oct. 25
- Visit TU-BS in December?

Main contributions of PARI for RAPSODI

- • PARI will perform

  large scale experiments on breakwater resilience against tsunami attack, and

  centrifugal experiments on submarine landslide tsunamis.
- PARI will further provide data and knowledge on tsunami damage and fatalities for further joint development of tsunami vulnerability models and prevention structures.

Members

- Yoshiyuki NAKAMURA, Leader of PARI
- Taro ARIKAWA, Senior Researcher, Maritime Structure Group
- Ken'ichiro SHIMOSAKO, Head of Maritime Structure Group
- Seiji HIRANO, Maritime Structure Group
- Koichiro KUBOTA, Maritime Structure Group

and

- Shinji SASSA, Head of Soil Dynamics Group

Contributions of PARI in Stage 1

STAGE 1 Evaluation of existing knowledge and comparisons of mitigation strategies

WP 1: Evaluation of existing tools, data, and mitigation strategies (**WP leader: METU**)

- \- Review and evaluation of tools available for the numerical modelling, and the assessment of impact loads on structures, failure modes, and vulnerability
- \- Comparison of coastal structures and mitigation strategies in Europe and Japan
- \- Implementation of a database including data from post-tsunami field surveys (run up, flow depth, flow velocities, fluxes), damage data, and number of fatalities data
- \- Evaluation of the performance of structural and societal mitigation strategies from the 2011 event

Contributions of PARI in Stage 2

STAGE 2 Numerical and experimental studies

WP 2: Numerical modelling of tsunamis (**WP leader: METU**)

- - Numerical modelling of spatial and temporal changes of tsunami parameters in high resolution geometries including structures for the assessment of damage (impact, scour, erosion) and flow conditions
- - Computation of coastal zone flow pattern due to different characteristics (direction, shape) of incident tsunami
- - Applications to selected coastal areas in Japan (e.g. Kamaishi, Oarai, Yamada) and a selected port in Europe (e.g. Haydarpasa port)
- - Recommendations on types/design of harbours and coastal structures for mitigation of tsunami impact

WP 3: Laboratory experiments on tsunami impact on structures (**WP leader: TU-BS**)

- - Model tests to understand failures of structures and buildings
- - Quantification of tsunami-induced loading on assets and calibration by prototype data
- - Development of improved guidance on vulnerability of structures and buildings

Contributions of PARI in Stage 3

STAGE 3 Methodology for tsunami vulnerability assessment and risk management

WP 4: Development of a risk assessment model (**WP leader: NGI**)

- - Development of vulnerability criteria to determine structural, socio-economic and ecological vulnerability based on literature, as well as on data and experiences from the 2011 Tohoku tsunami
- - Development of a framework for a quantitative risk assessment model
- - Development of a GIS-based software to quantify tsunami risk

WP 5: Development of mitigation strategies (risk management) (**WP leader: PARI**)

- - Preparation of strategies to improve preparedness in the communities
- - Development of new innovative mitigation measures, which are tested in model tests
- - Development of guidelines for the design of structures as well as an overall tsunami risk management including the strengthening of preparedness in coastal communities

Contributions of PARI in Stage 3 (Continued)

WP 6: Networking and dissemination (**WP leader: NGI**)

- \- Workshops and seminars (see details above)
- \- Dissemination to stakeholders, decision-makers, and professionals
- \- Preparation of easily accessible documents, focused on the end-user and stakeholders

Agreements on Oct.8 meeting

- For RAPSODI WP1, PARI will summarize existing knowledge on tsunami defense structures and foundations. Special attention should be paid to impact loads and failure modes of structures as input to a matrix for different types of structures and buildings with their potential failure modes.
NGI will summarize its work on local tsunami risk assessment. Both summaries will be contributions to deliverables D1, D3 & D8.

- For RAPSODI WP2, the PARI numerical models will be applied to study impact and loads on tsunami defense structures with varying characteristics of the incident tsunami (e.g. representative for earthquake and landslide tsunamis; contributions to deliverables D5 & D6).

- For all deliverables, journal papers are preferred, documents should anyhow be devoted to RAPSODI.

- PARI will suggest a location where data exist so that the NGI and PARI together can improve the GIS tsunami vulnerability and risk model, e.g. by including the distribution of people, economical values, and/or the influence of protective measures in the risk assessment.

Agreements on Oct.8 meeting

- All presentations and documents discussed in the meeting should be exchanged, preferably uploaded at the RAPSODI home page at ftp://ftp.ngi.no/RAPSODI/ (11 October)

- PARI interested to see the 2011 Tohoku earthquake source applied by NGI (already uploaded at ftp).

- The need to focus our attention on the tasks relevant for the RAPSODI project was emphasized by both parts.

- PARI kindly offers students from NGI to visit PARI and study their numerical codes and laboratory facilities for up to 3 months.

- Intention to meet at forthcoming conferences, e.g. AGU 2013, EGU 27 April 2 - 2 May 2014 Vienna, IAEG 15-19 Sep 2014 Torino (see links in presentation by CH)

Agreements continued

- The following additions are noted:

  - PARI has a desire to collaborate also on landslide tsunamis. NGI is obviously positive to do so under our MoU, and also as part of the networking that is the main intention of the CONCERT-Japan call. Submarine landslides are admittedly not a target for RAPSODI, but PARI employees are certainly welcome to visit NGI to work also on this issue.

  - PARI expressed a desire to visit the unstable rock slopes along the fjords in western Norway. We should try to keep this in mind for a later meeting in Norway. Summer time with warmer and longer days is a must.

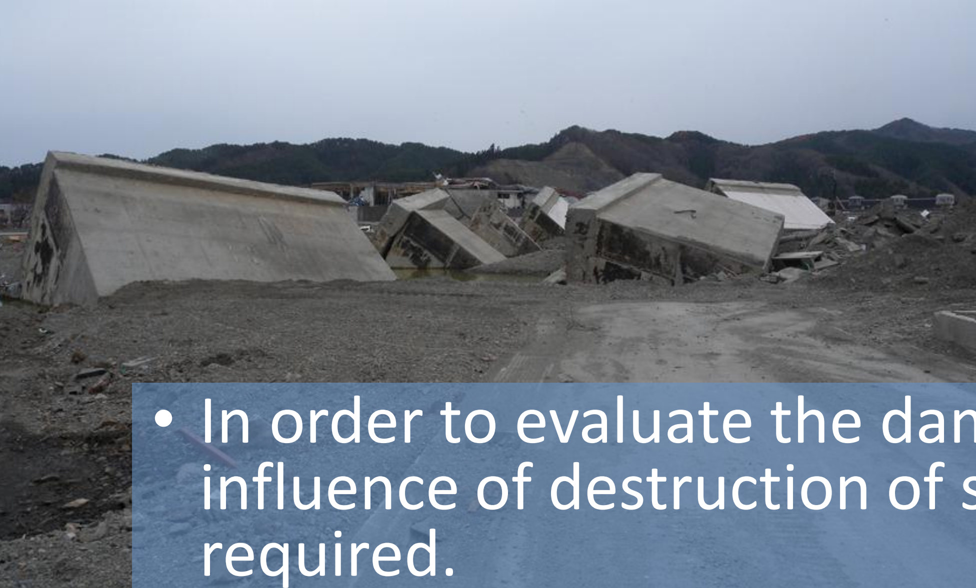
  Finally, PARI is kindly asked to provide logo and link for their national funding organization for RAPSODI (see front page of RAPSODI home page http://www.ngi.no/no/Prosjektnett/RAPSODI/)

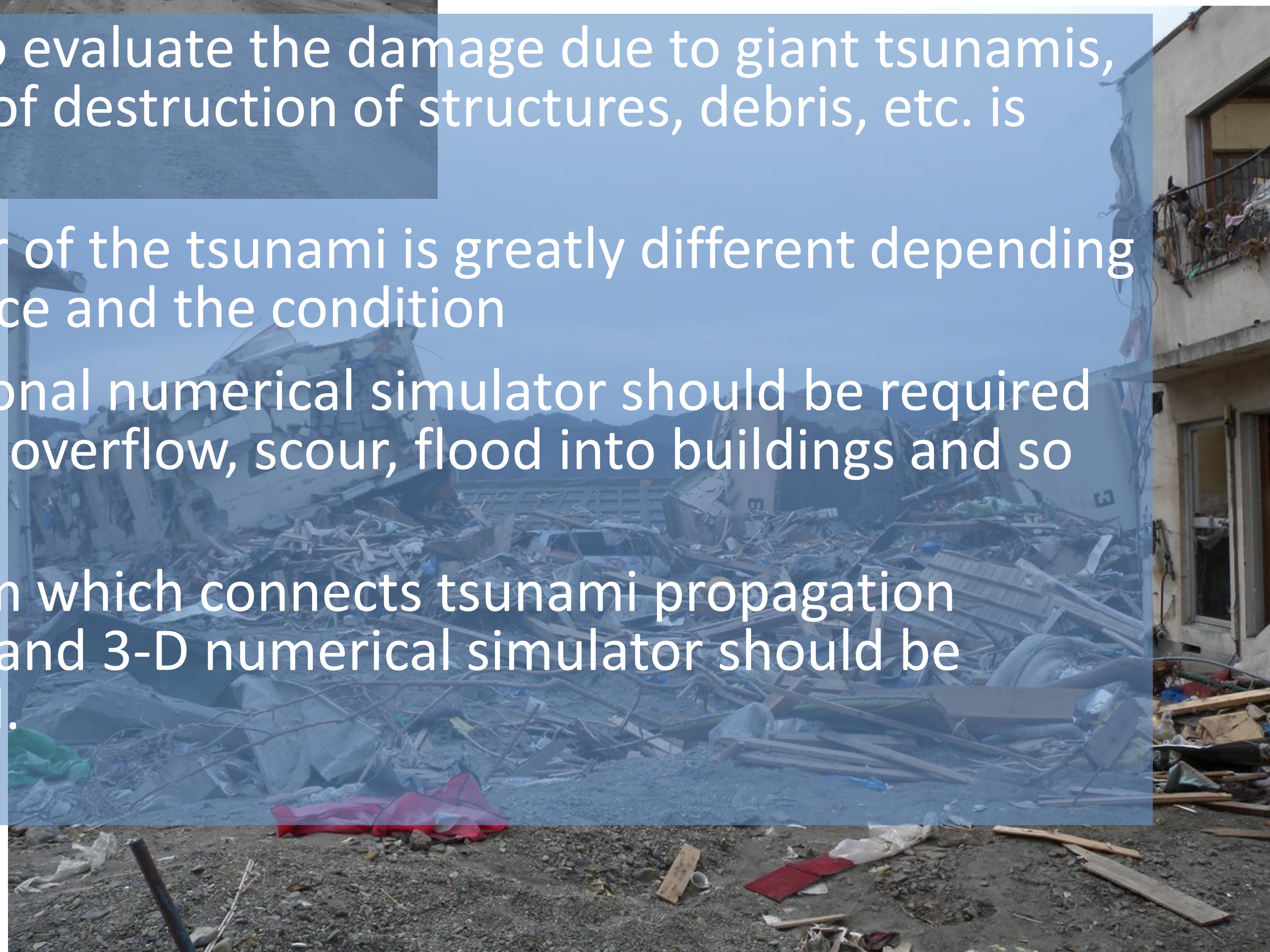
Development of high refining tsunami inundation simulator

Taro ARIKAWA, Port and Airport Research Institute, Japan

Takashi TOMITA, Port and Airport Research Institute, Japan

Objective of Research





- In order to evaluate the damage due to giant tsunamis, influence of destruction of structures, debris, etc. is required.
- The power of the tsunami is greatly different depending on the place and the condition
- 3 dimensional numerical simulator should be required to analyze overflow, scour, flood into buildings and so on.
- The system which connects tsunami propagation simulator and 3-D numerical simulator should be developed.

Outline of Research

- Outline of System
  - Methodology
  - Applicability using the local topography of Kamaishi
- Program's execution performance
  - Applicability using the local topography of Kamaishi
- Accuracy
  - Applicability using the local topography of Onagawa
- On going project

Outline of System

Methodology and Applicability using the local topography of Kamaishi

The STOC-CADMAS system

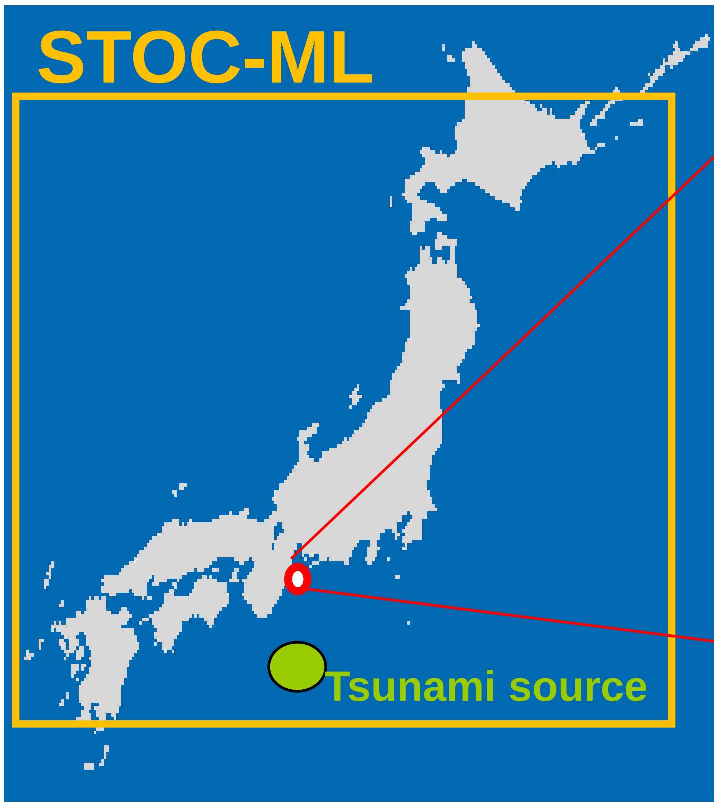
Quasi-3D model (multi-level model)

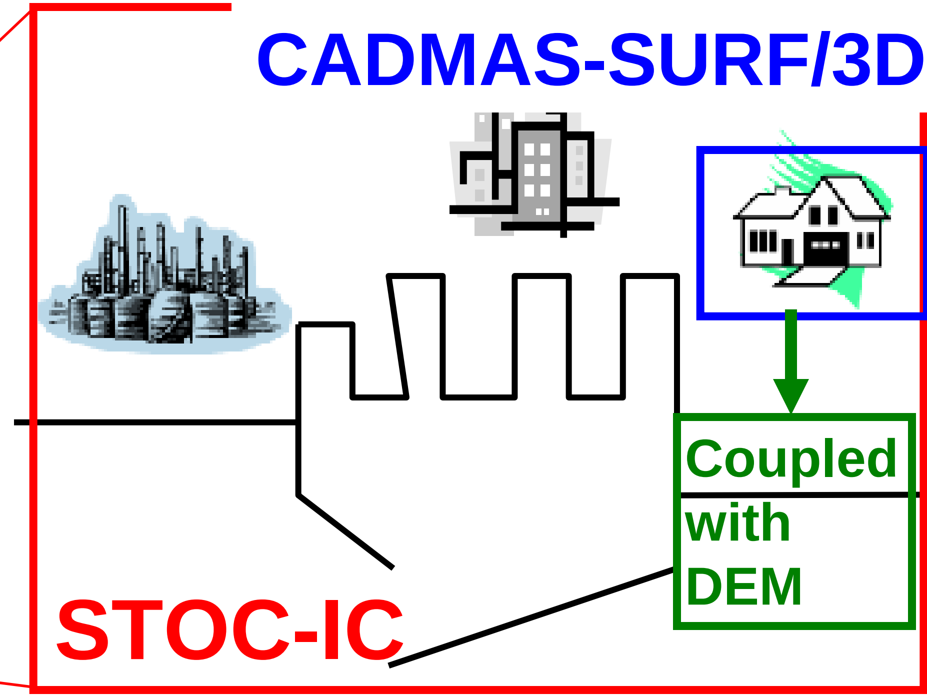
Assumes hydrostatic pressures at each level

Computation load: light

3D model Estimates the free water surface with the VOF method

Computation load: heavy



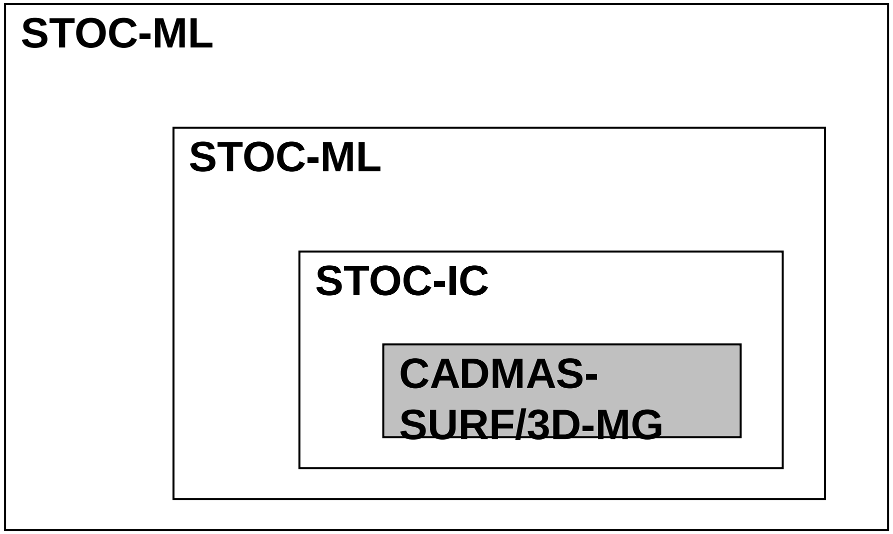


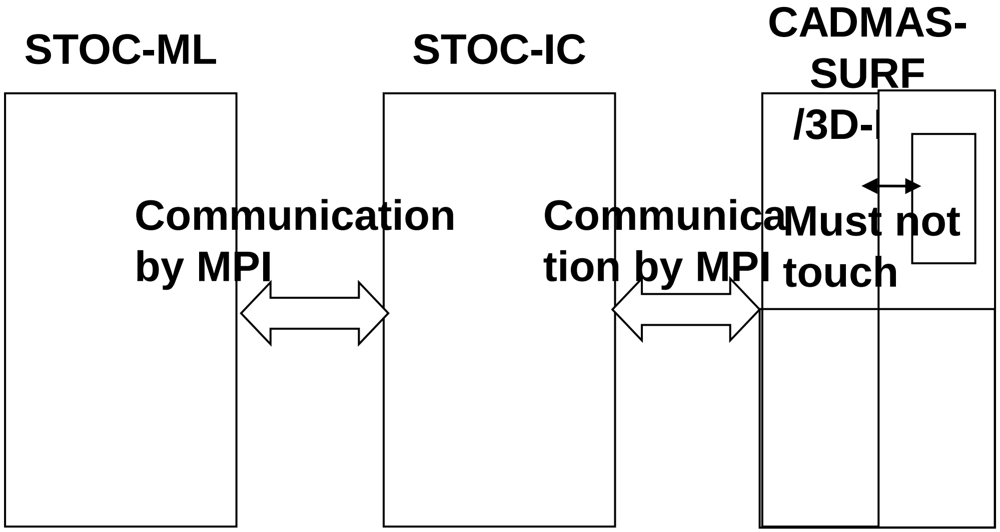
3D model Calculates the free water surface with a vertically integrated continuity equation

Computation load: moderate

STOC system (Tomita et. al., 2005)
CADMAS system (Arikawa et. al., 2005)

Connections between simulator calculations





All connections are made using MPI communications.

Although all three models are capable of segmenting their respective areas of interest, when different calculation methods are used in the same area (for example, STOC-IC calculations are used in an STOC-ML area), the parent area containing the different calculation methods is regulated to prevent segmentation.

Consequently, when a CS3D area is made sufficiently large, the STOC-IC area that contains it ultimately becomes larger as well, as a single area.

Accuracy

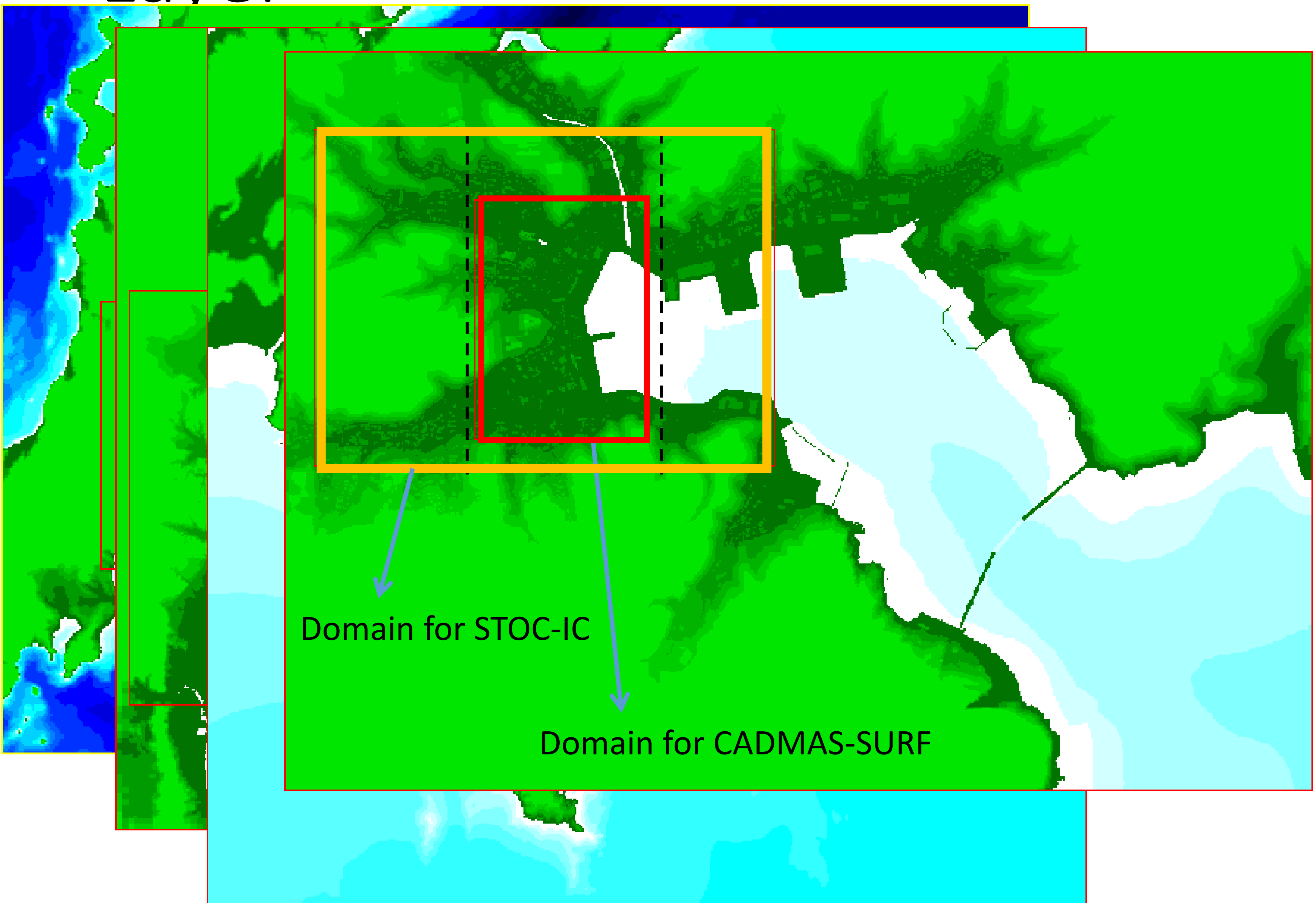
Applicability using the local topography of Onagawa

Calculation Domain for Onagawa Area

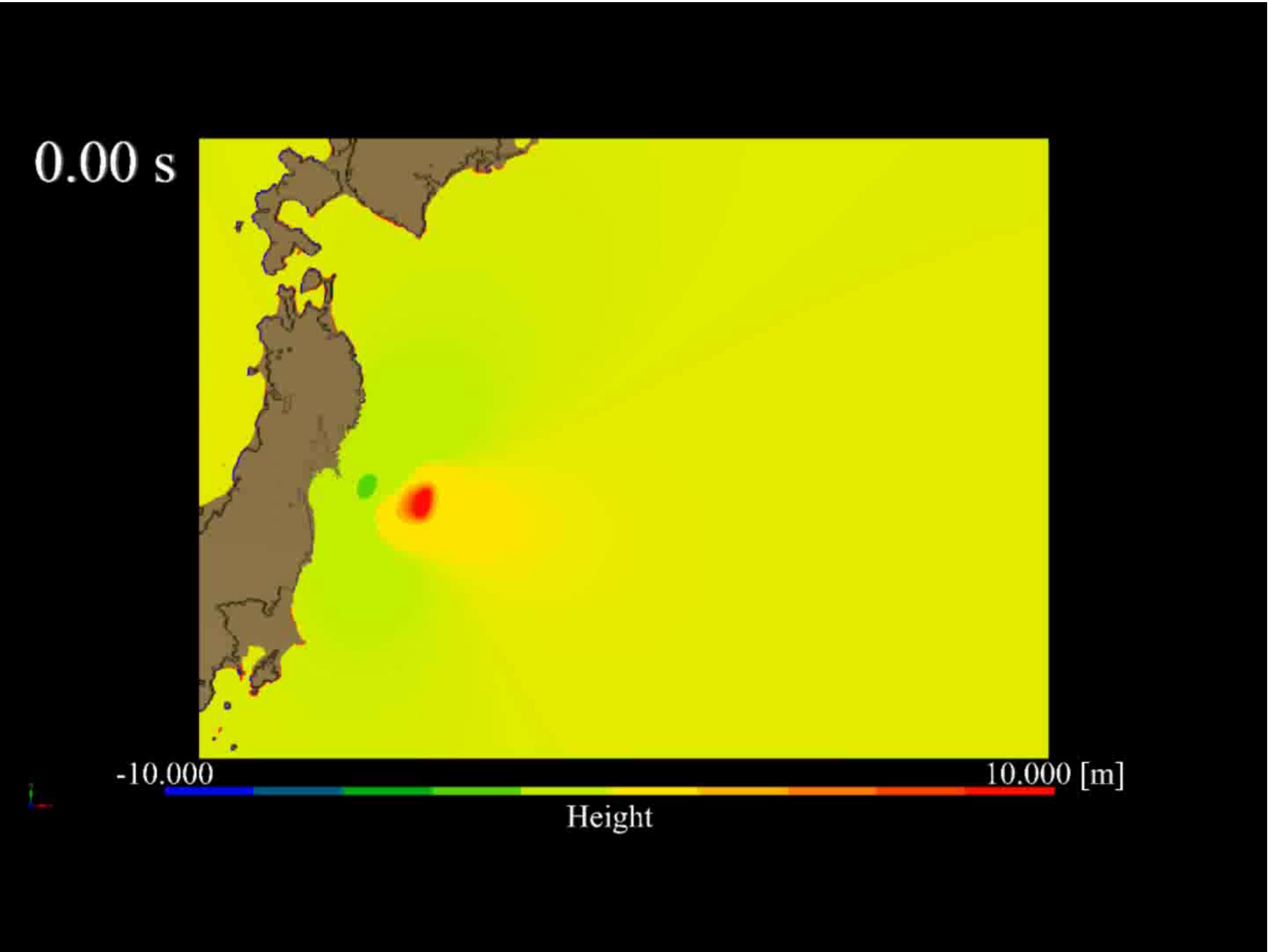
No. Layer	Grid Size(m)	Ratio of Grid size	Number of grid (X)	Number of grid (Y)	Number of grid (Z)	Number of grid	Code Name	Number of Core
1	2,916.0	—	500	365	1	182,500	STOC-ML	1
2	972.0	3	510	390	1	198,900	STOC-ML	1
3	324.0	3	405	387	1	156,735	STOC-ML	1
4	108.0	3	900	600	1	540,000	STOC-ML	1
5	36.0	3	930	930	1	864,900	STOC-ML	1
6	12.0	3	1,020	780	1	795,600	STOC-ML	1
7	4.0	3	870	627	1	545,490	STOC-ML	1
8	4.0	1	390	285	13	1,444,950	STOC-IC	3
9	1.0	4	600	800	32	15,360,000	CADMAS-SURF/3D	32

Tsunami Source: Fujii-Satake ver. 4.0 model with scaling adjustments to match the tsunami waveform obtained with GPS wave sensors off the southern Iwate coast.

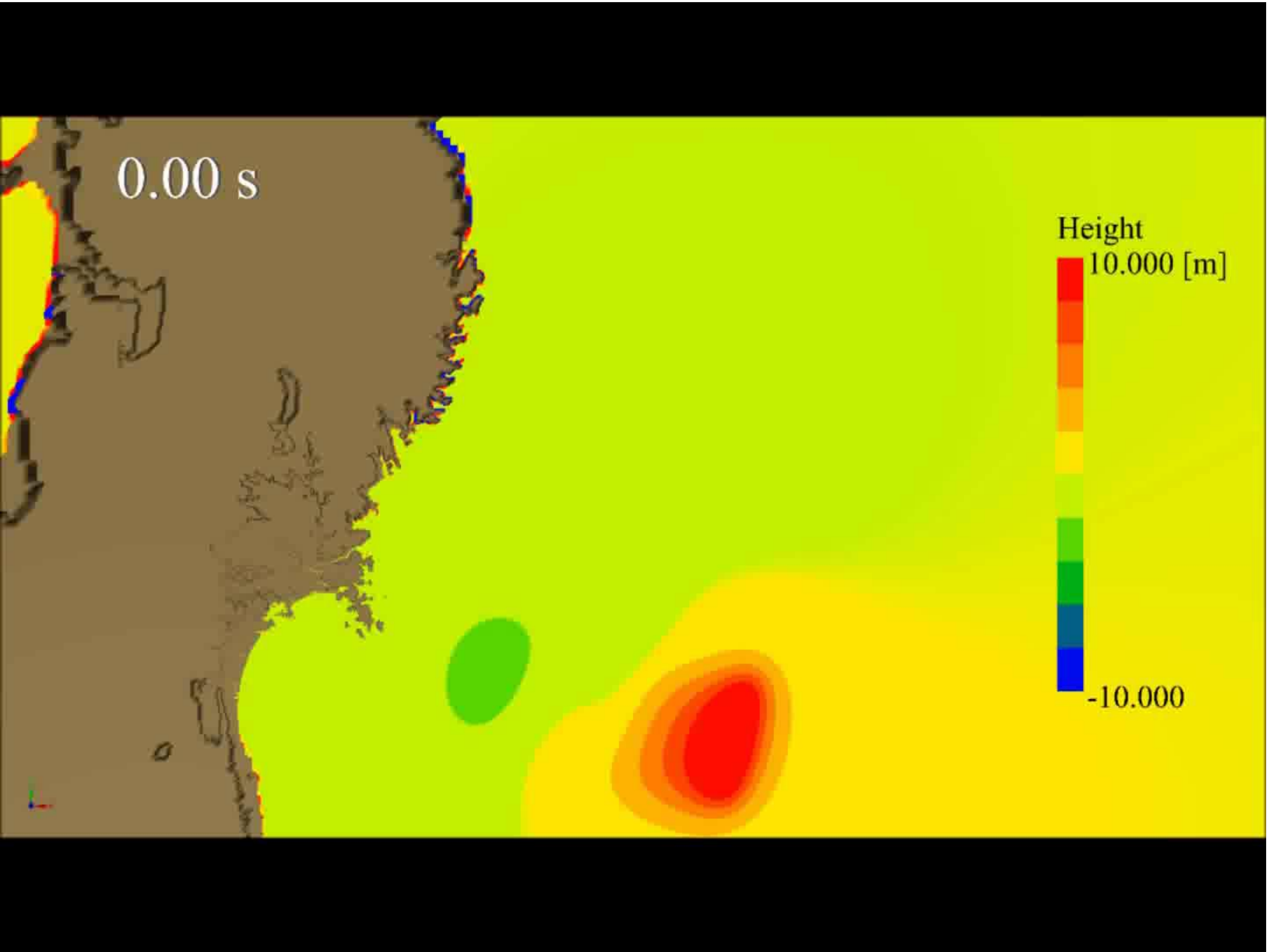
Layer



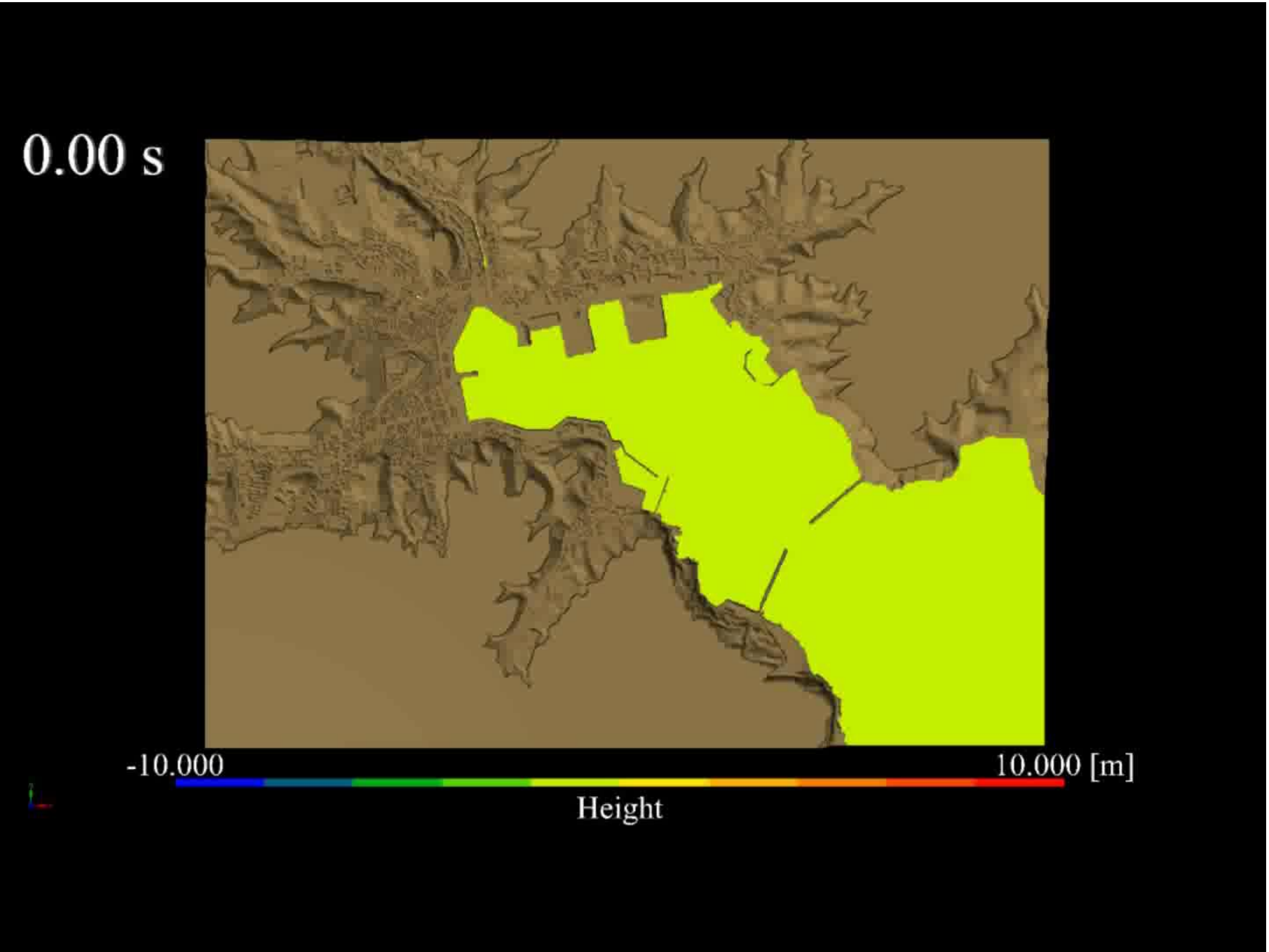
STOC-ML



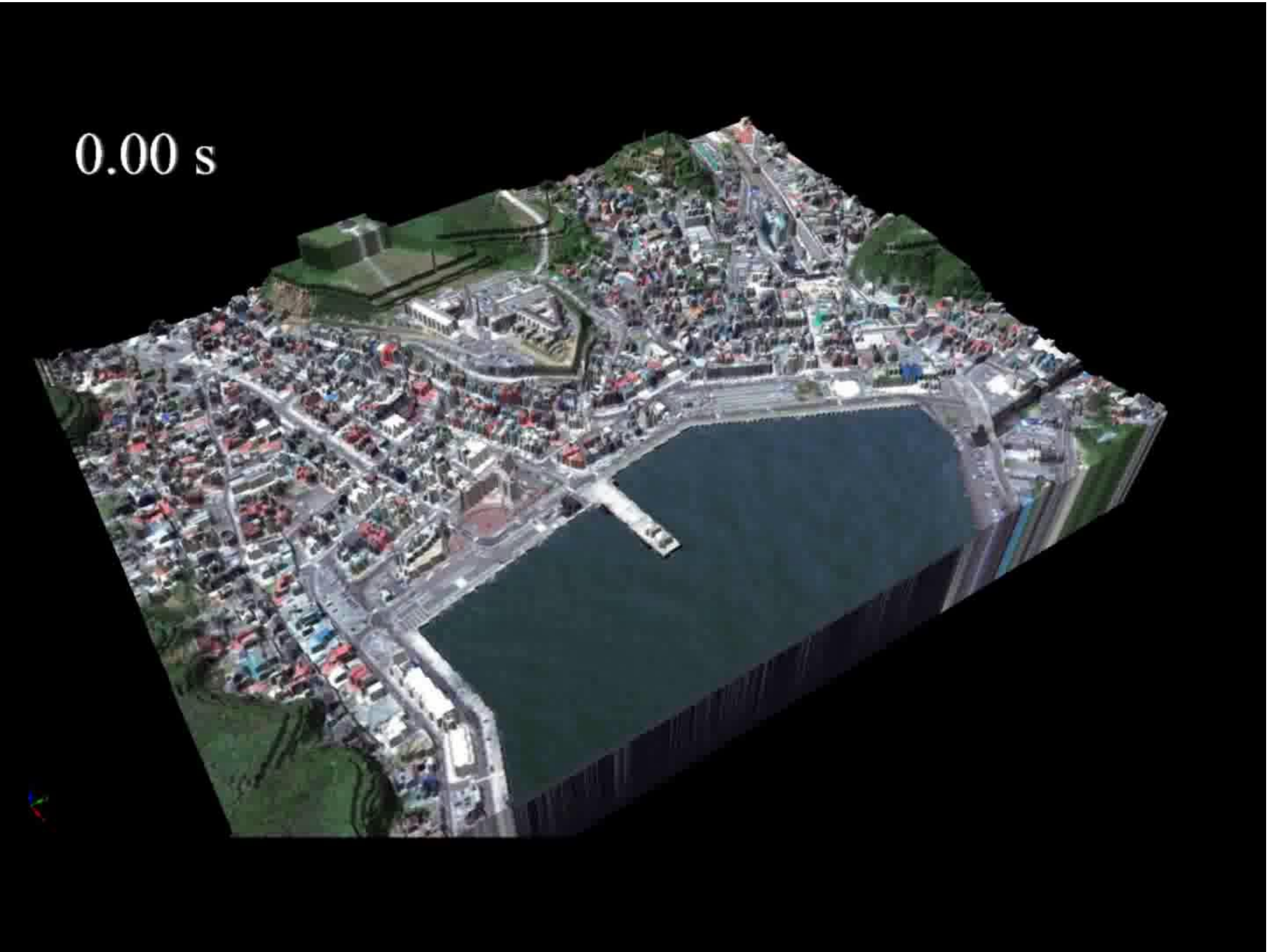
STOC-ML to IC



STOC-IC to CADMAS-SURF/3D

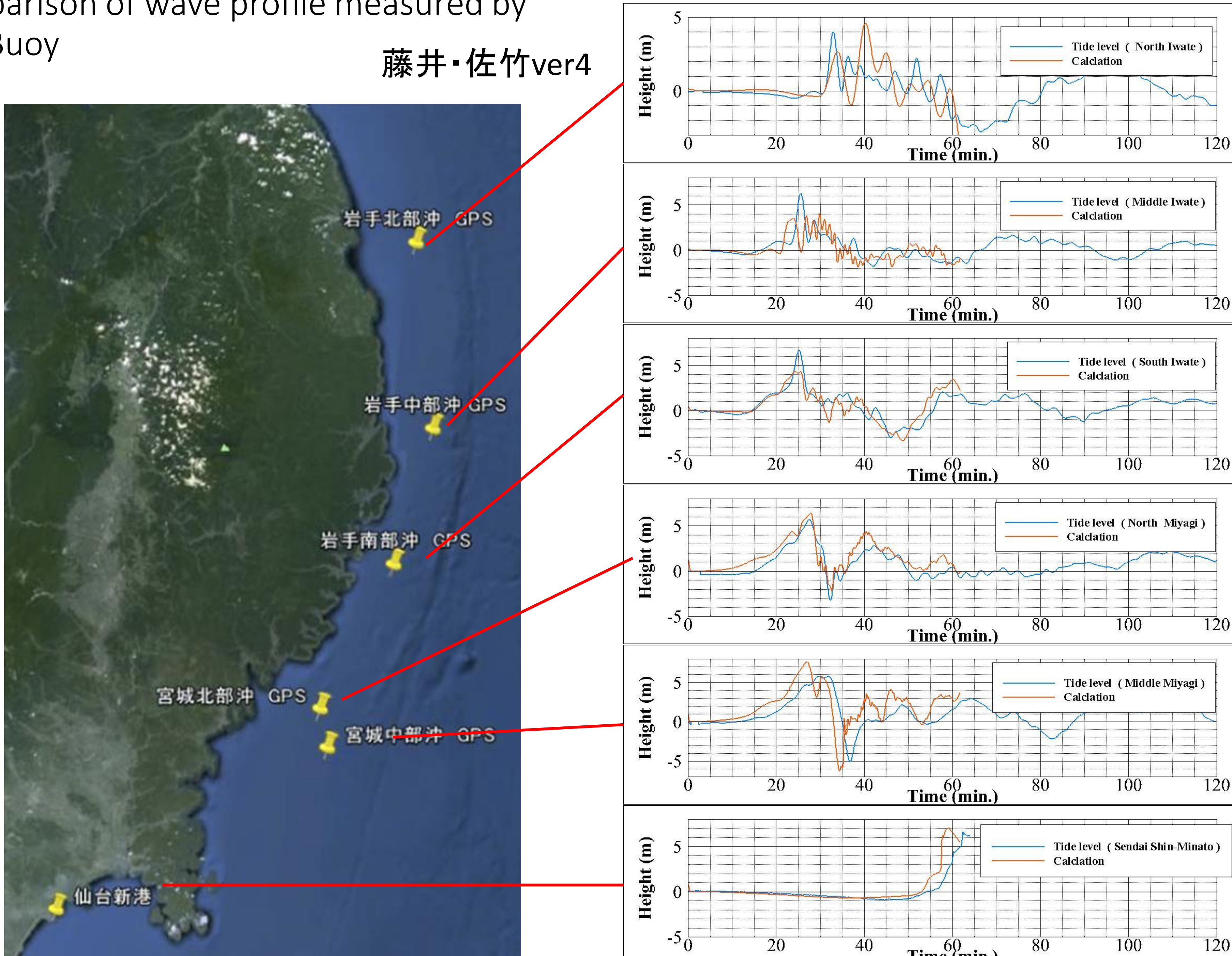


CADMAS-SURF/3D

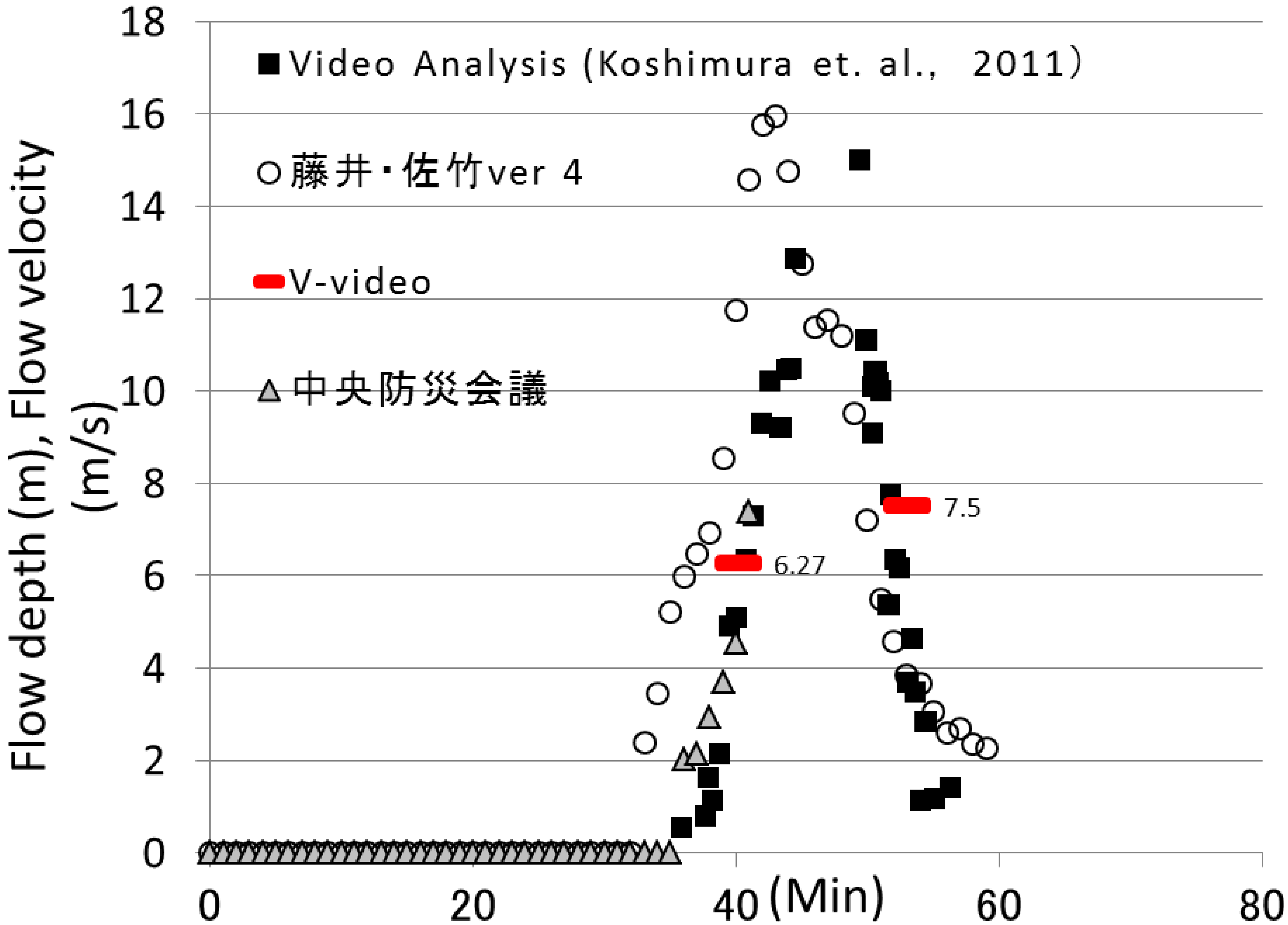


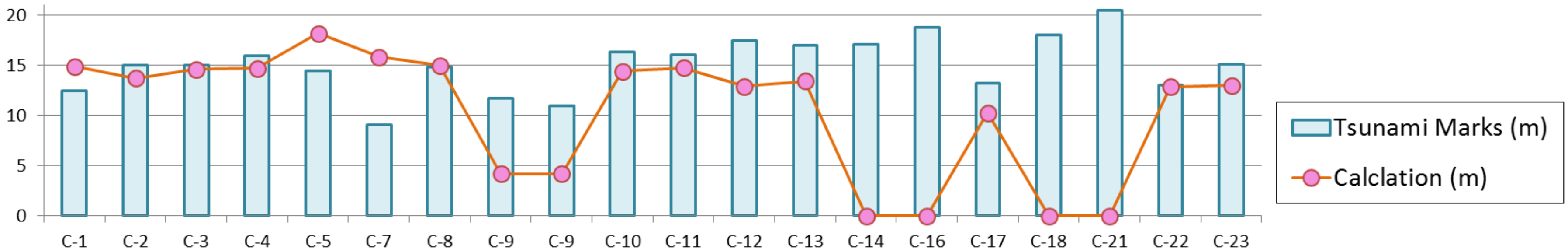
Comparison of wave profile measured by GPS Buoy

藤井・佐竹ver4

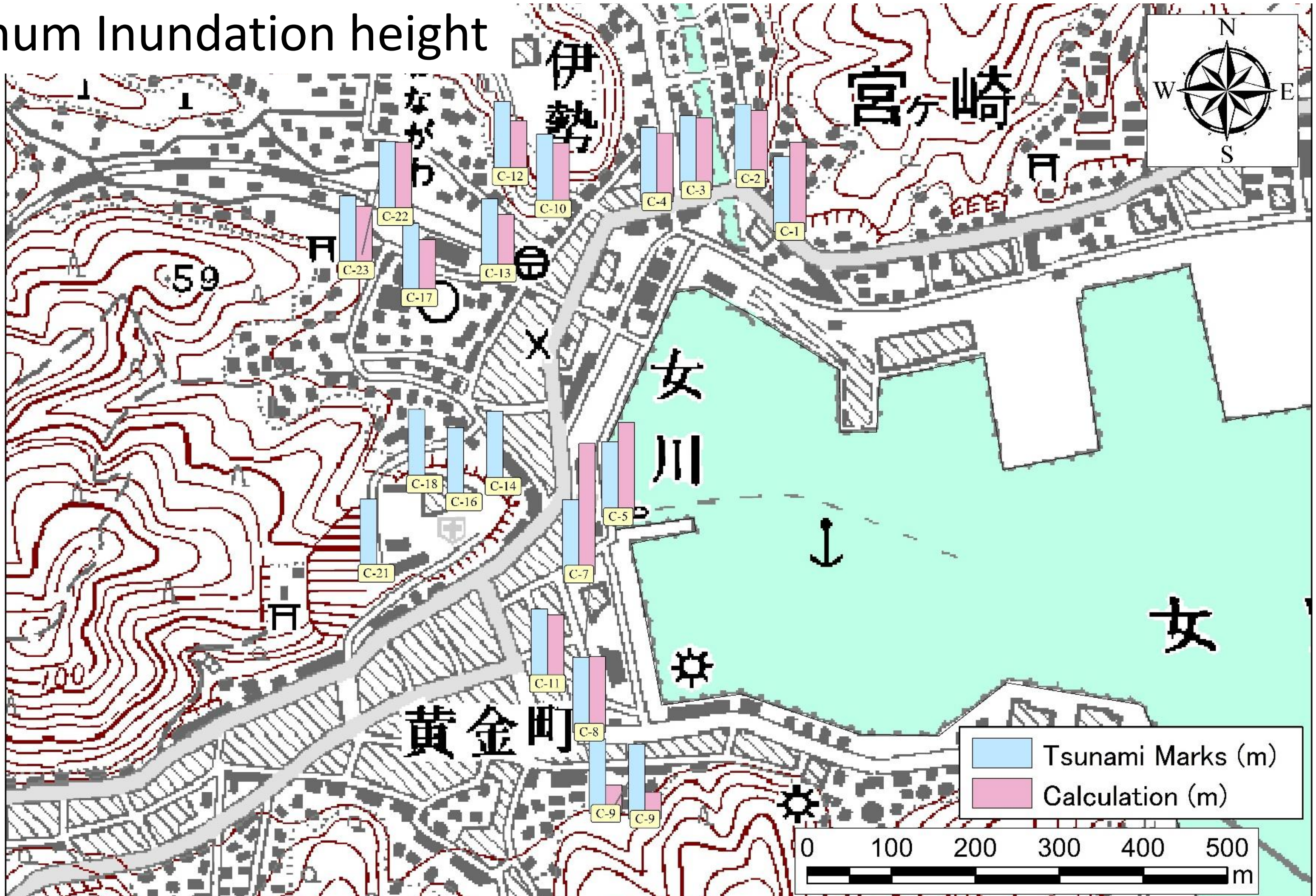


Comparison of Flow depth

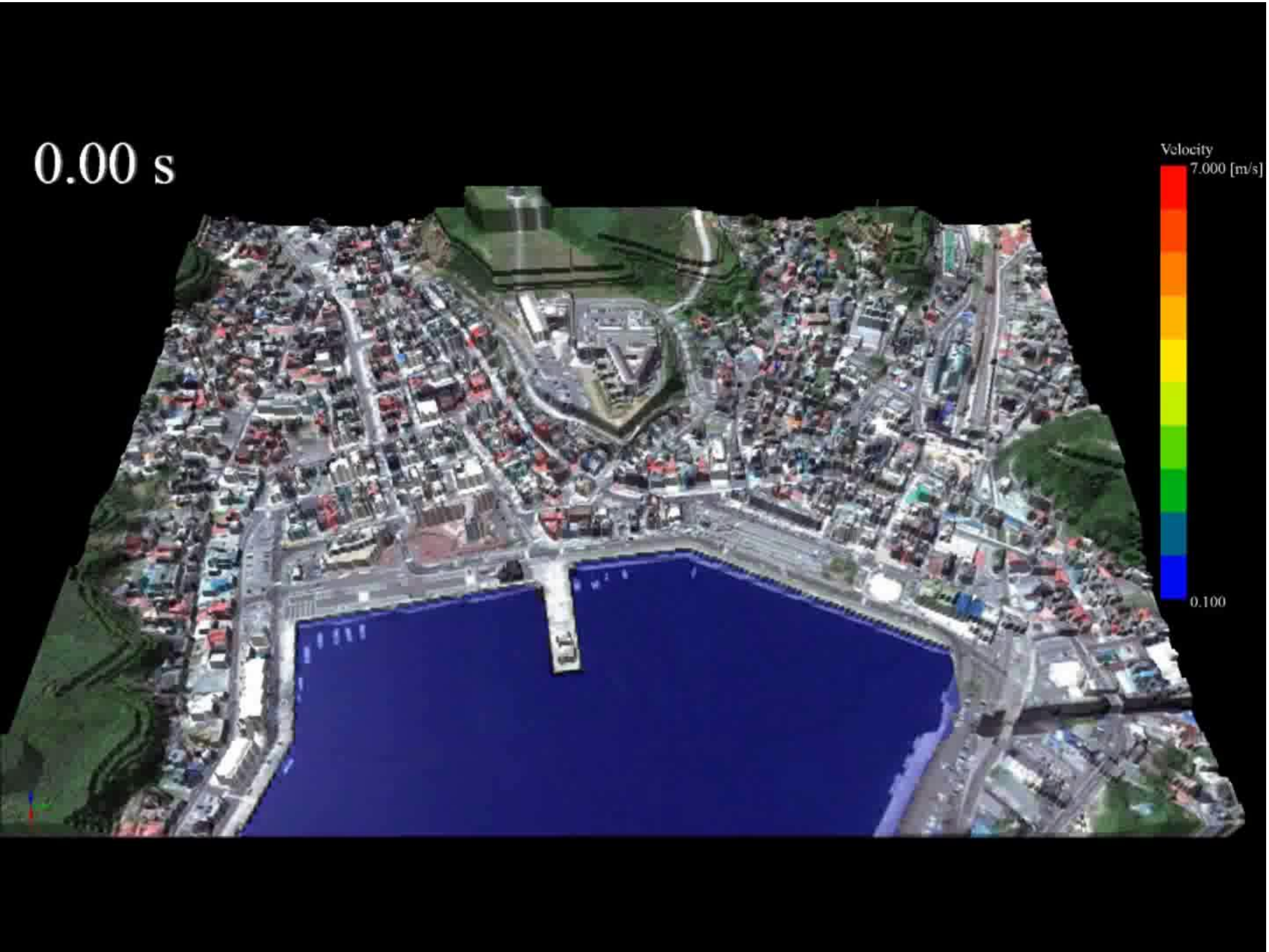




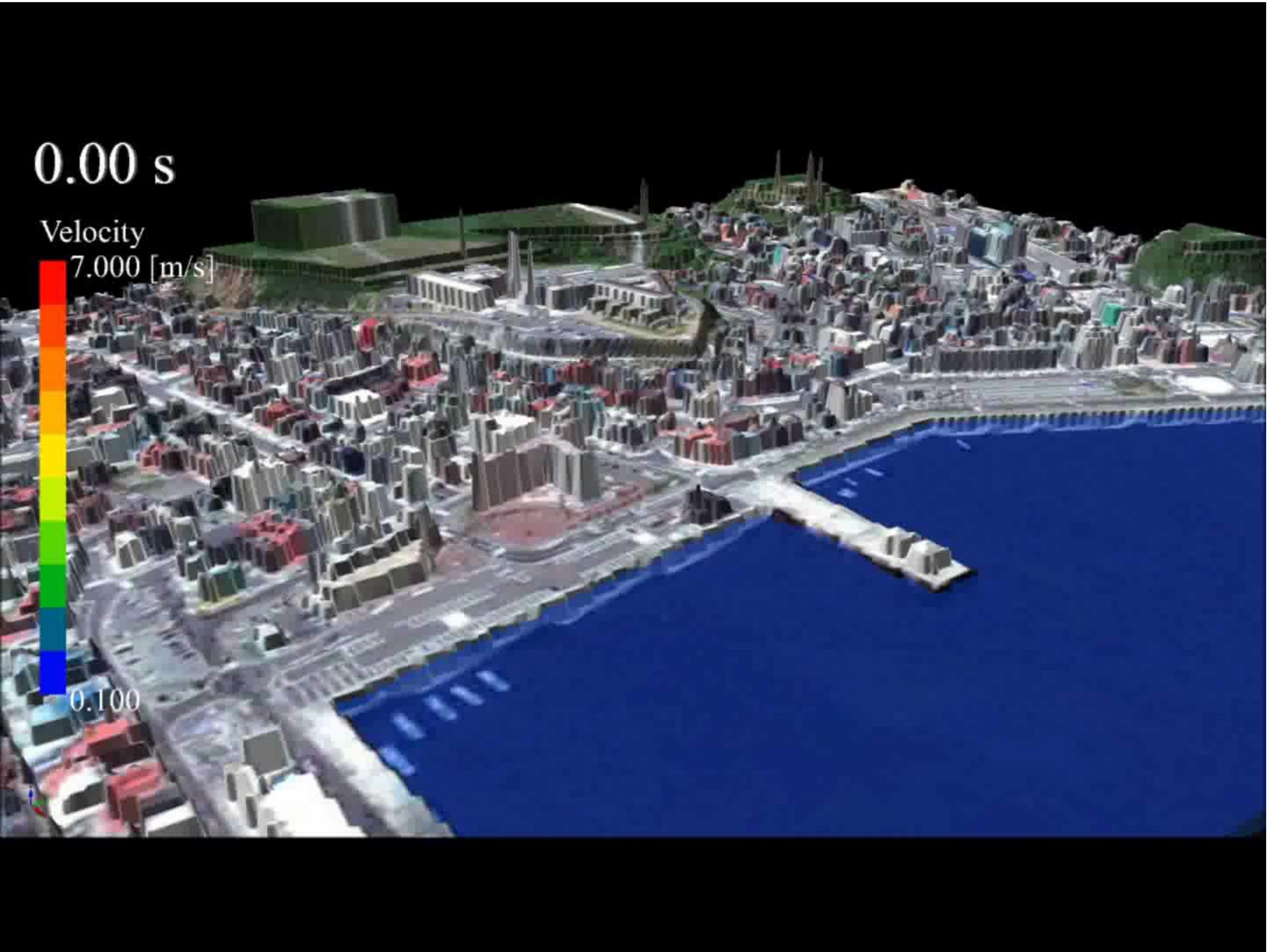
Maximum Inundation height



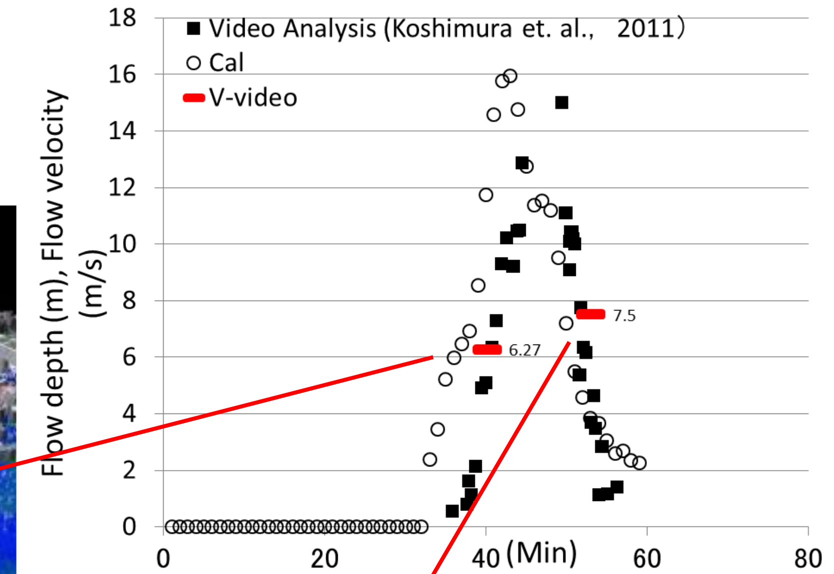
Velocity field

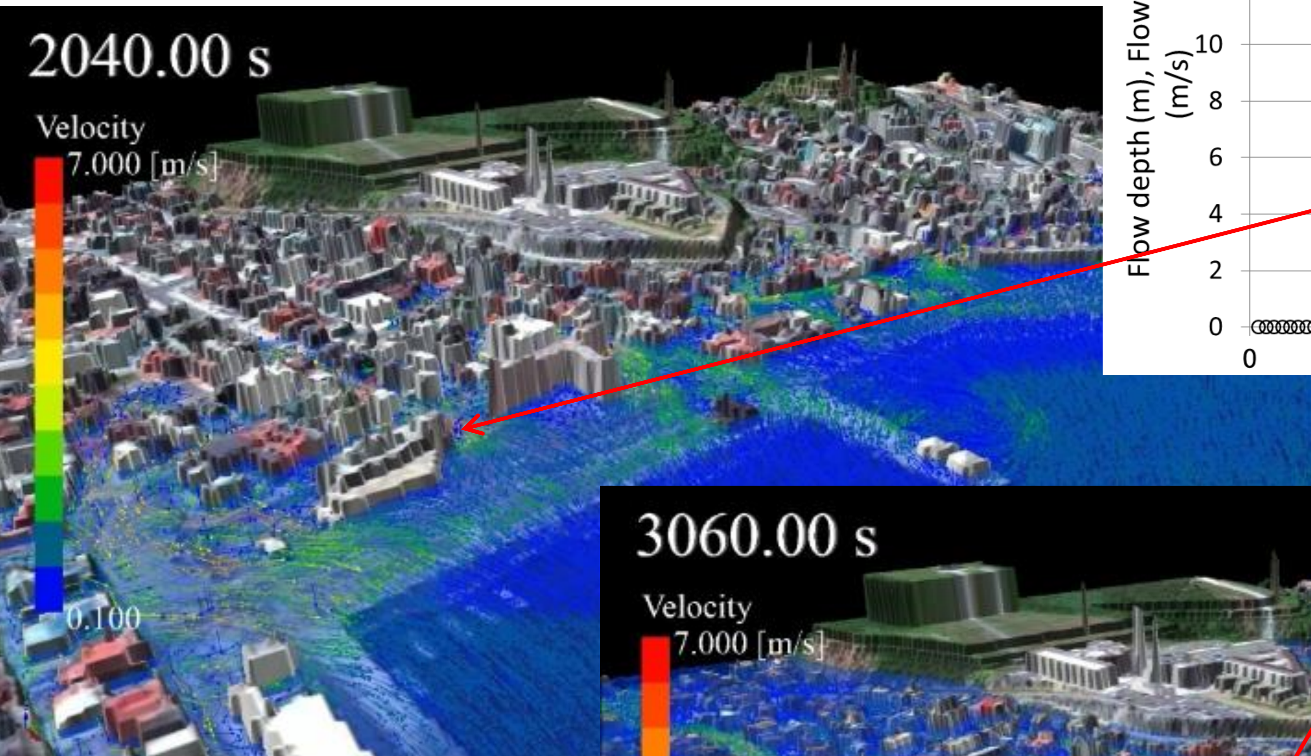


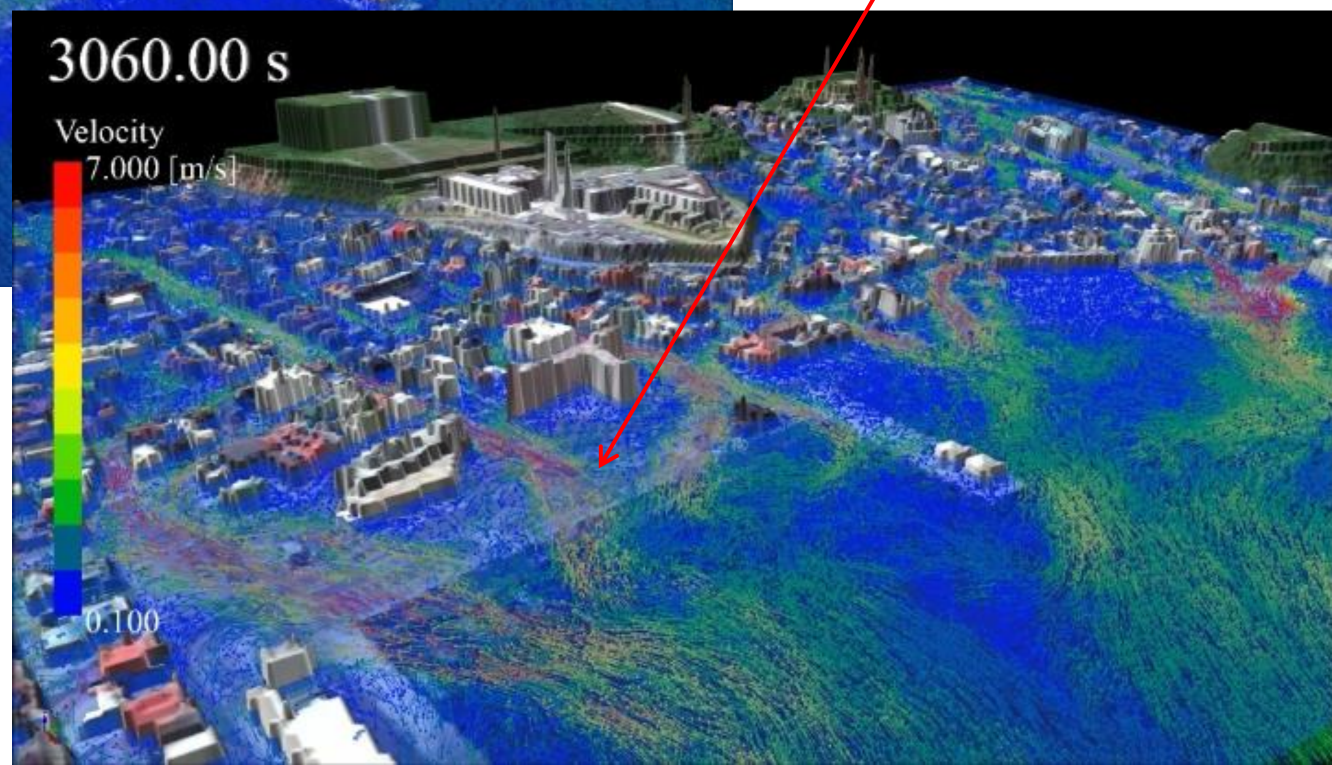
Velocity field



Comparison of Flow velocity





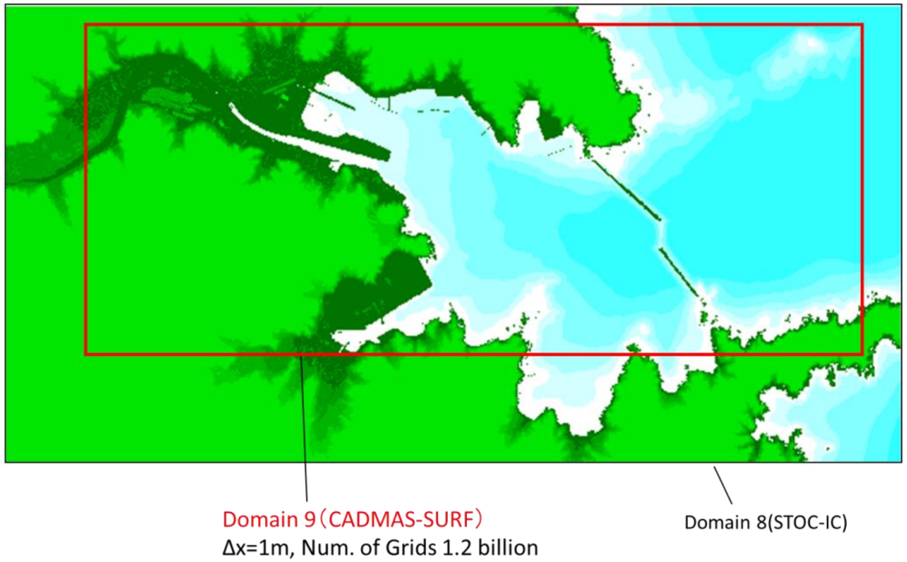


Summary

- There are two problems of a coupling system. One is a boundary condition and another is aggravation of the computational efficiency depended on the waiting for a synchronization.
- A several times reduction in execution costs was obtained by using arranging the balance of computational load, and thread parallelization
- Accuracy of calculation is good agreement with field observation results. Better agreement would be obtained by improved tsunami source model

For the future

- The area of CADMAS-SURF/3D will be larger by using 1m grid size because of investigating the influence of breakwater destruction.
- Better way to prevent the disaster due to tsunami will be considered by using this simulation system

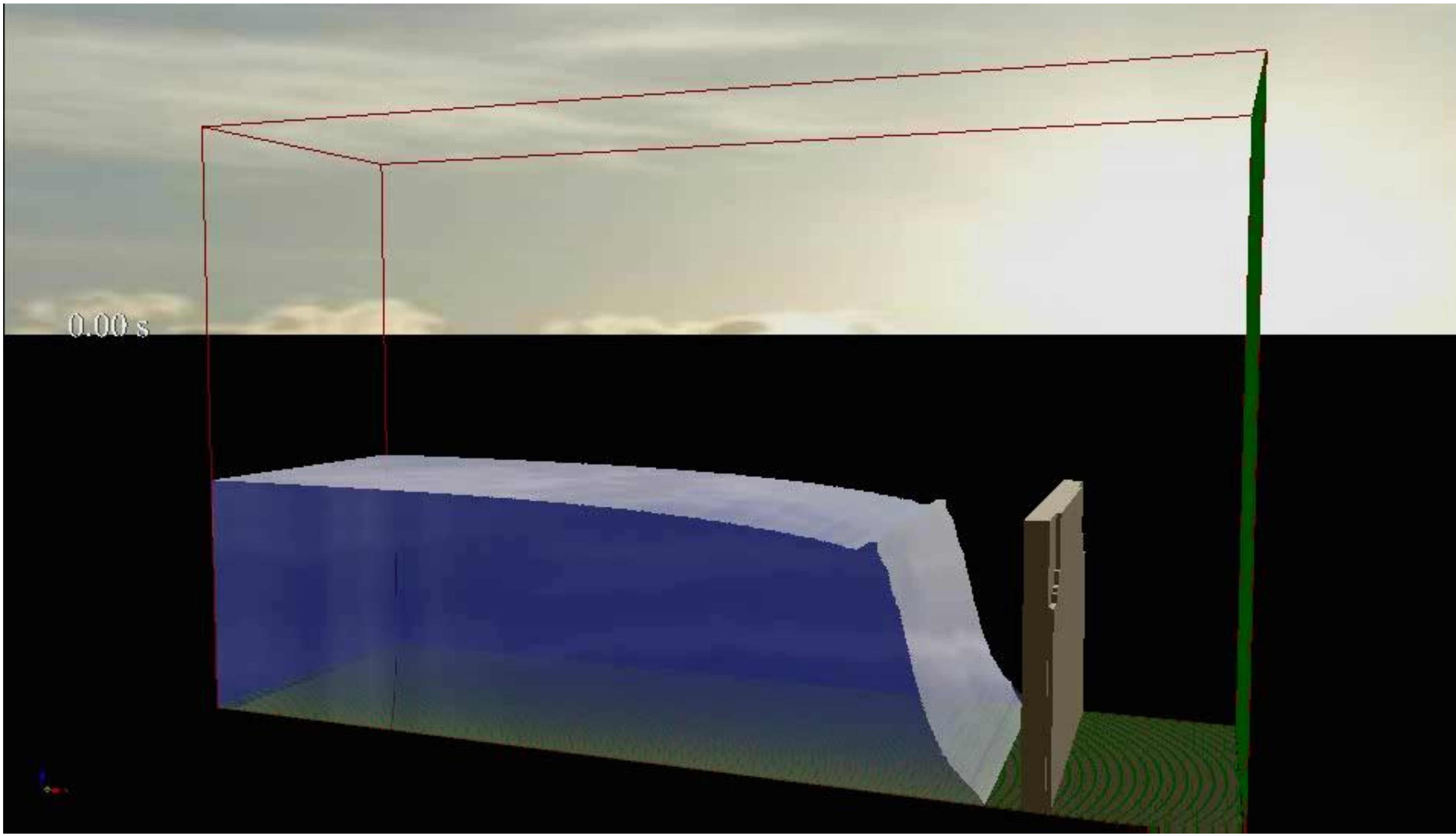


On going project

Concrete wall destruction due to Tsunami Bore

Tickness 60mm

CADMAS-DEM system



Development of CADMAS-AGENT

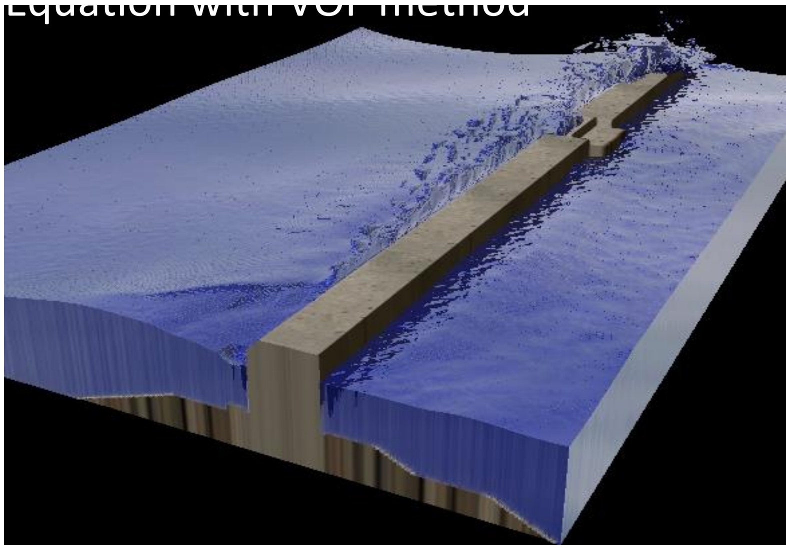
Taro Arikawa

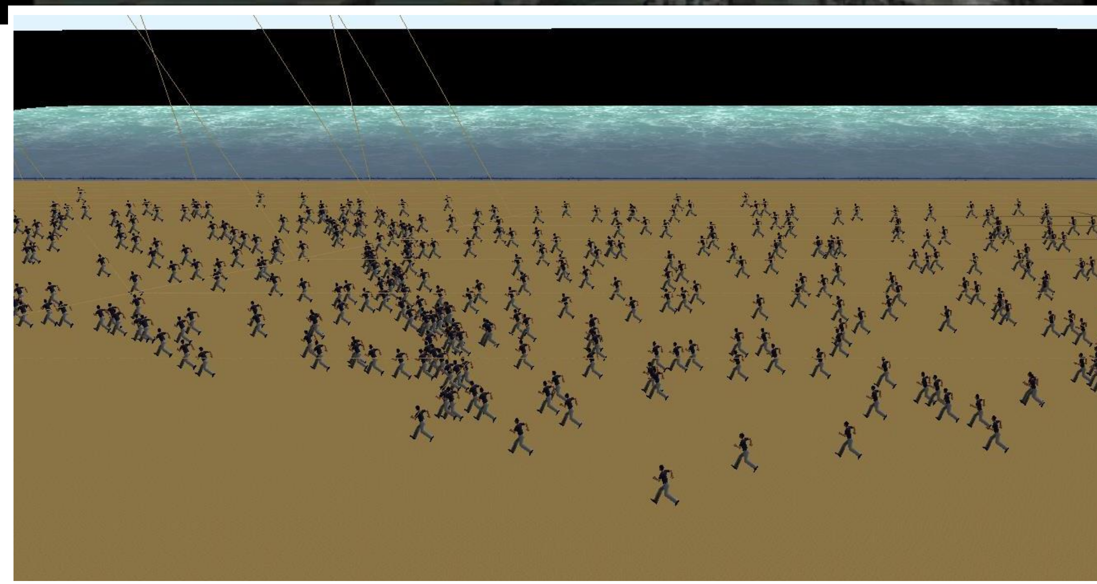
Port and Airport Research Institute

Coupling CADMAS-SURF/3D and PARI-AGENT

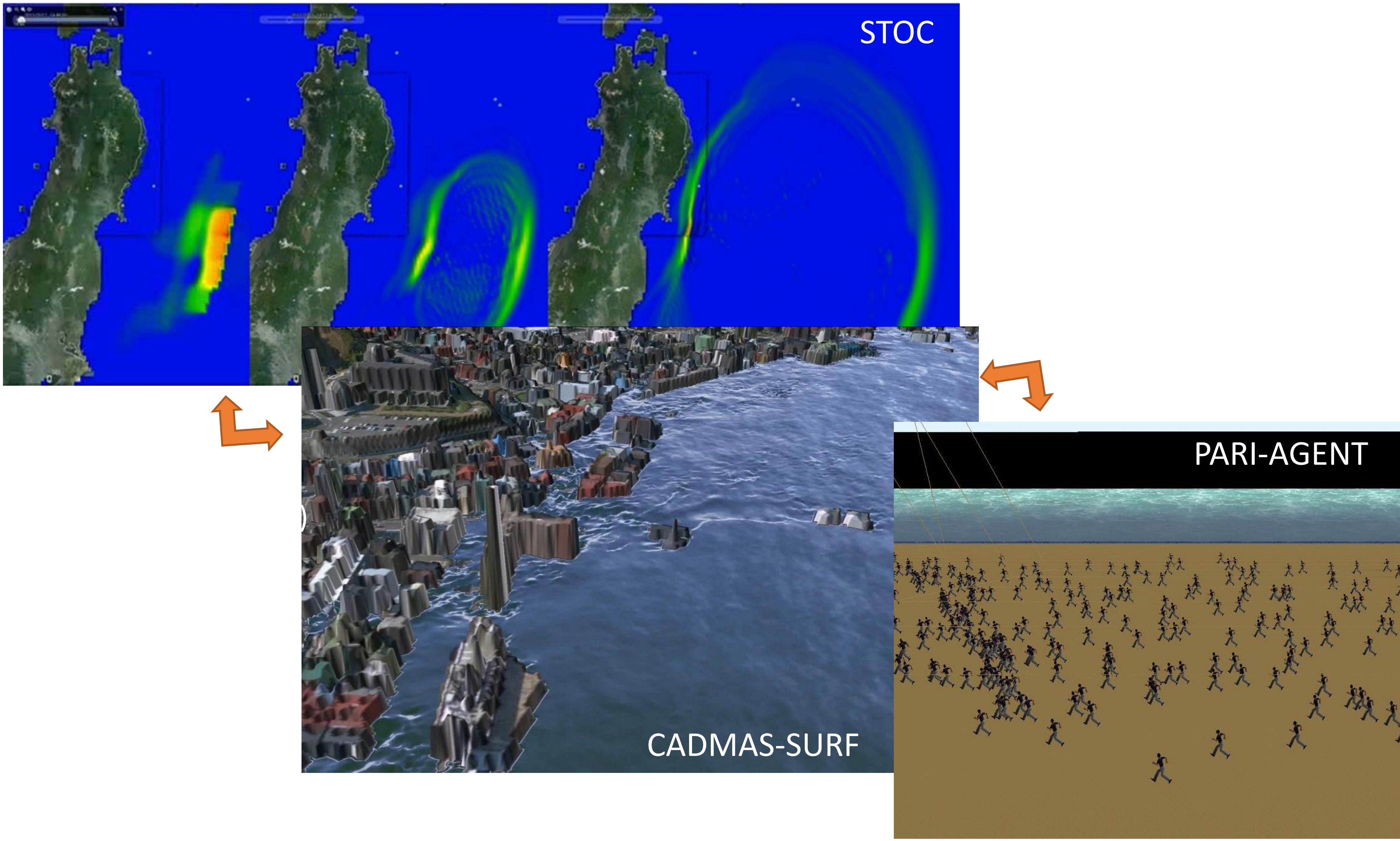
okes

Equation with VOF method

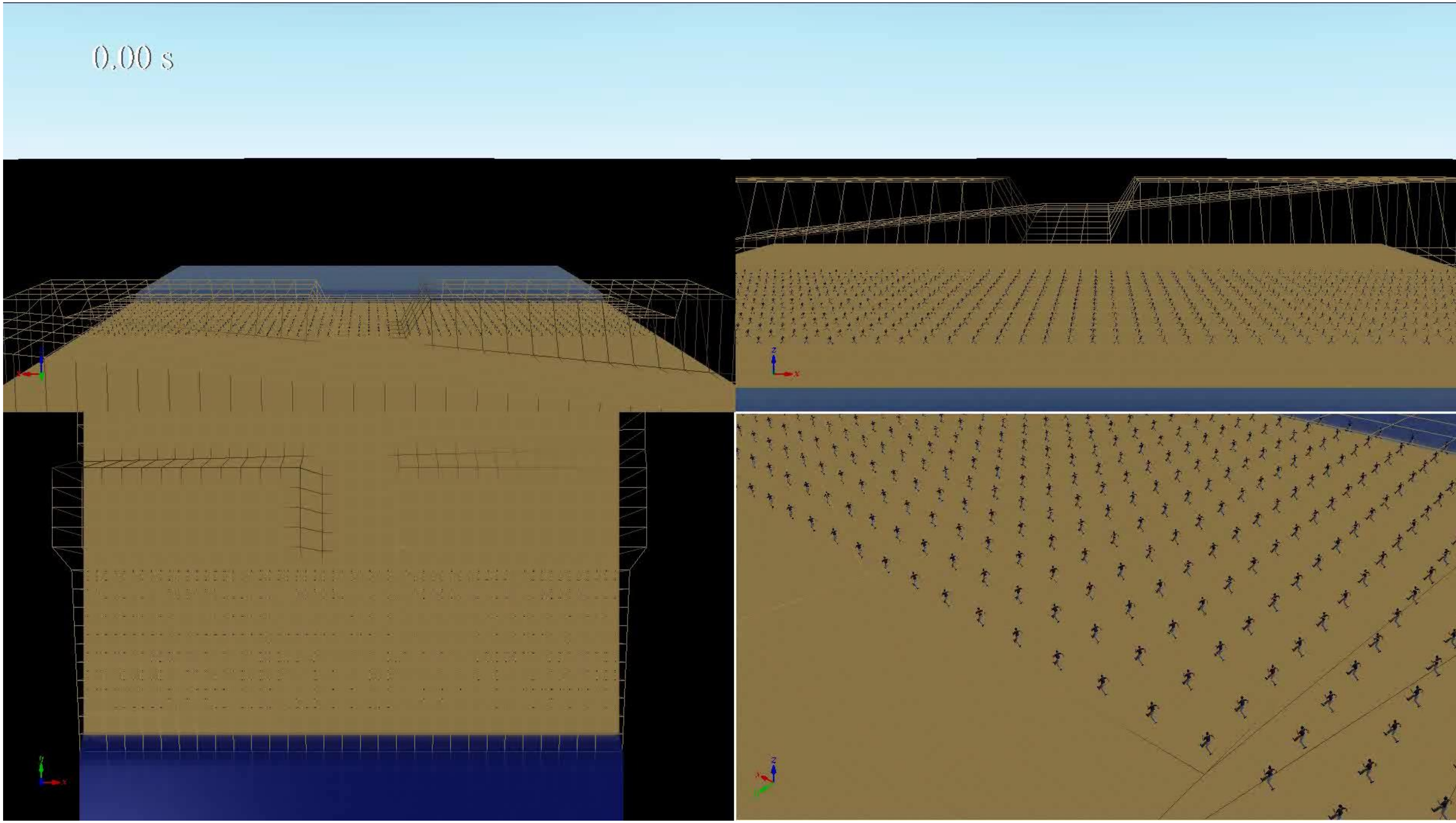




Final goal of our research



First Test of CADAMAS-AGENT



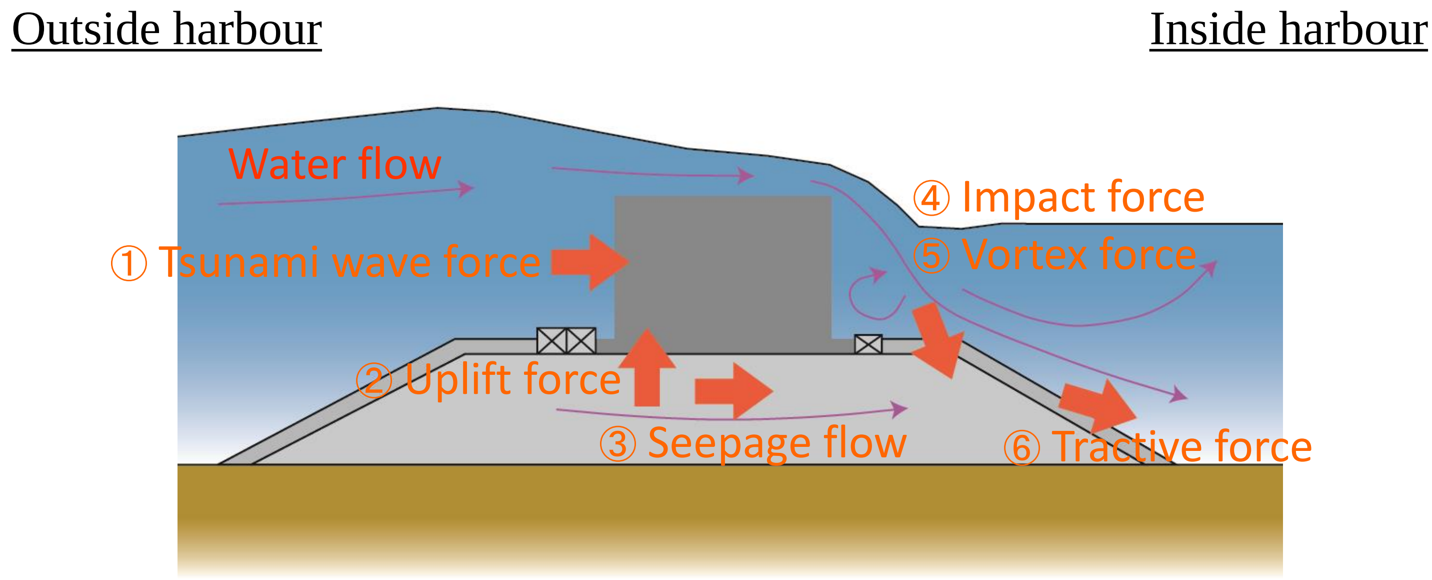
Stability of breakwater foundation under tsunami: Turbulent seepage flow induced mechanisms

－Piping・Boiling・Bearing capacity decrease and failure・Seepage erosion・Overflow scour－

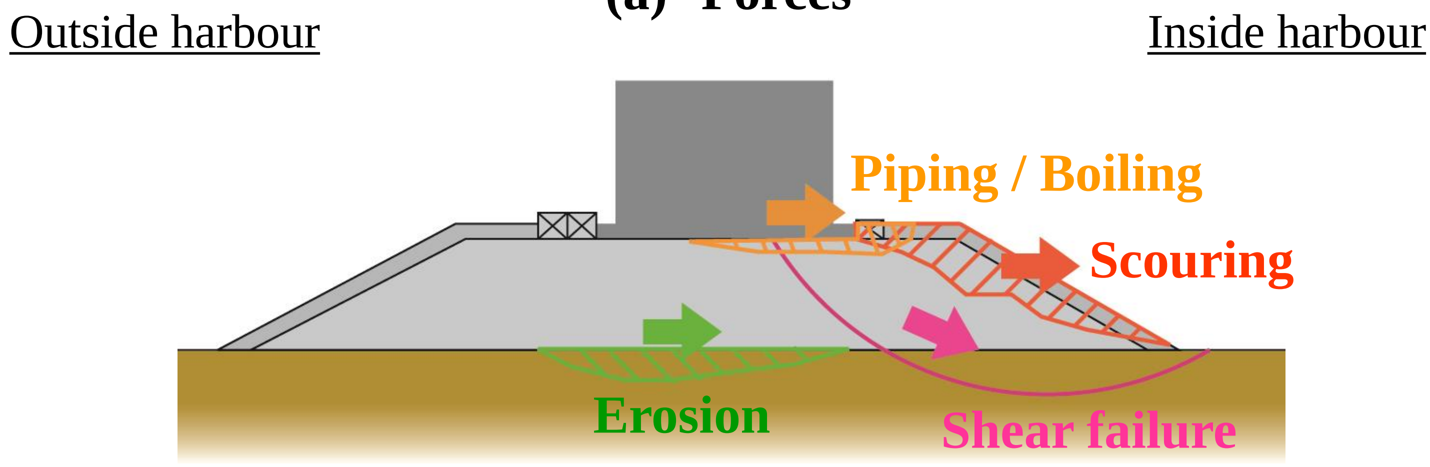
Shinji SASSA

Head of Soil Dynamics Group

Port and Airport Research Institute



(a) Forces



(b) Failure modes

Tsunami-induced forces on breakwaters and failure modes of the foundation

Reproduction of a prototype-scale stress field is important in clarifying the instability of foundation (mound) !

Centrifuge

Hydrodynamic-geotechnical centrifuge

Centrifuge is an useful tool to reproduce a prototype stress field.

Centrifuge experiment

Effective in

Water-Soil Interaction

Problems

such as wave-induced

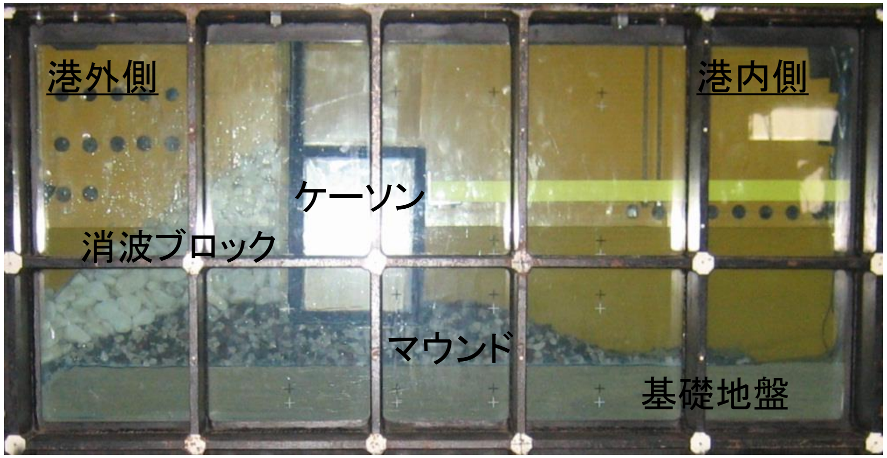
instability of seabed

soils

Experiment Model

60m-prototype

90m-prototype



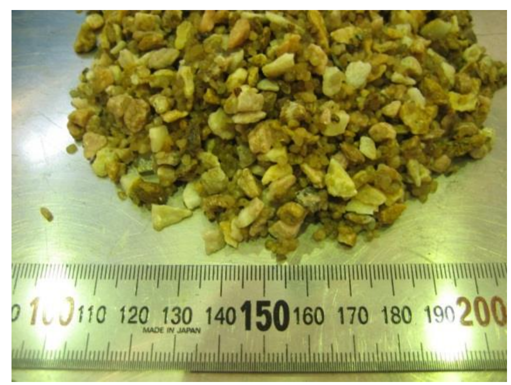
Omaezaki Breakwater

Kamaishi Breakwater

50g

75g

Mound materials used



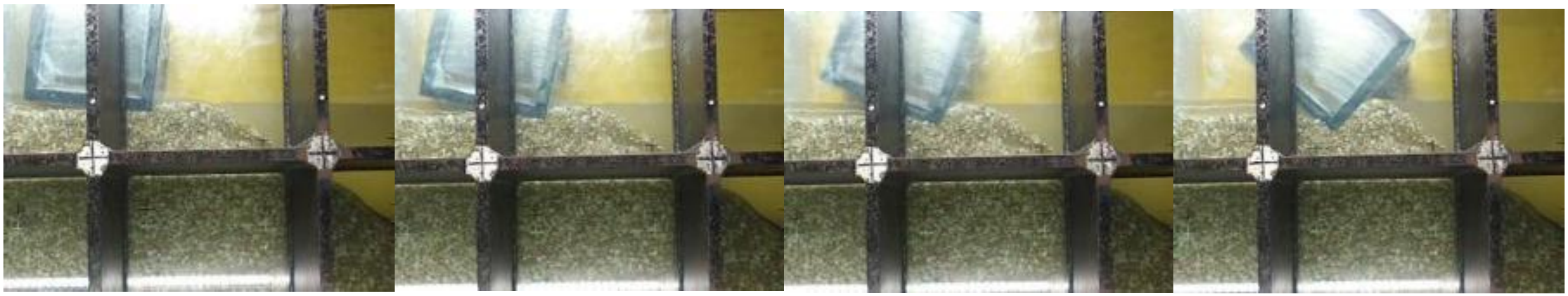
Omaezaki model
（200~400kg/block-prototype）

Kamaishi model
（5~100kg/block-prototype）

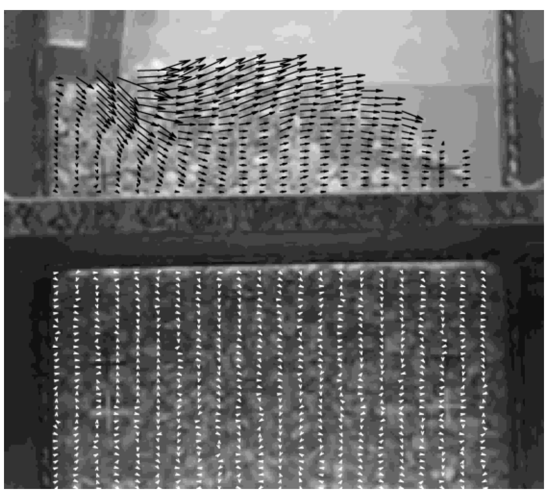
Seepage-flow induced bearing capacity failure

Horizontal loading＋Seepage flow（model A, i=0.34）

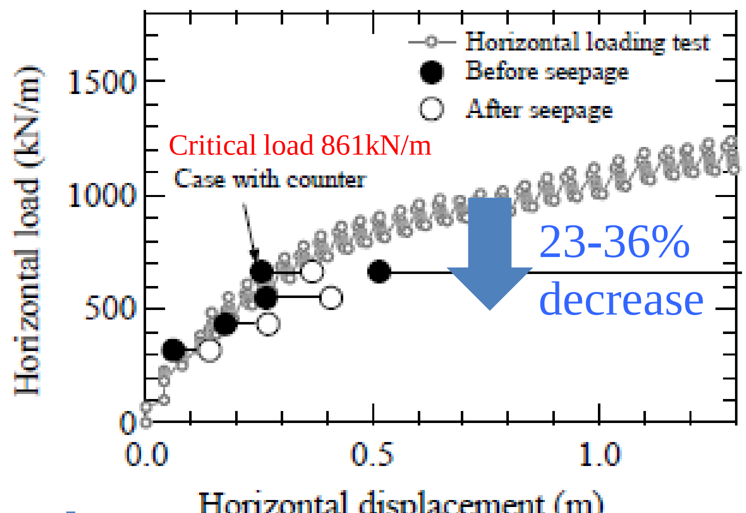
V=1732 kN, H=630 kN



Bearing capacity failure



Displacement vectors of the mound

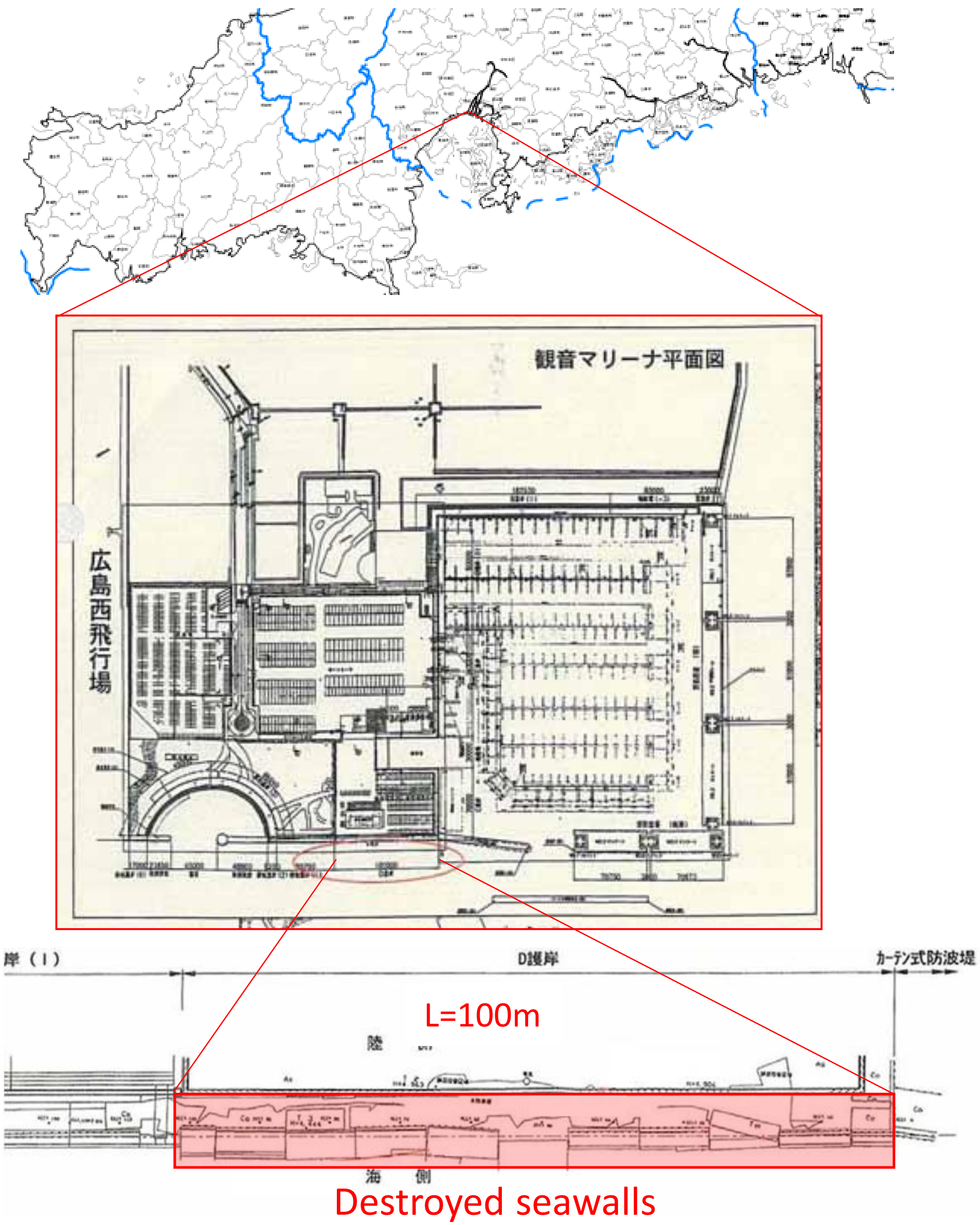


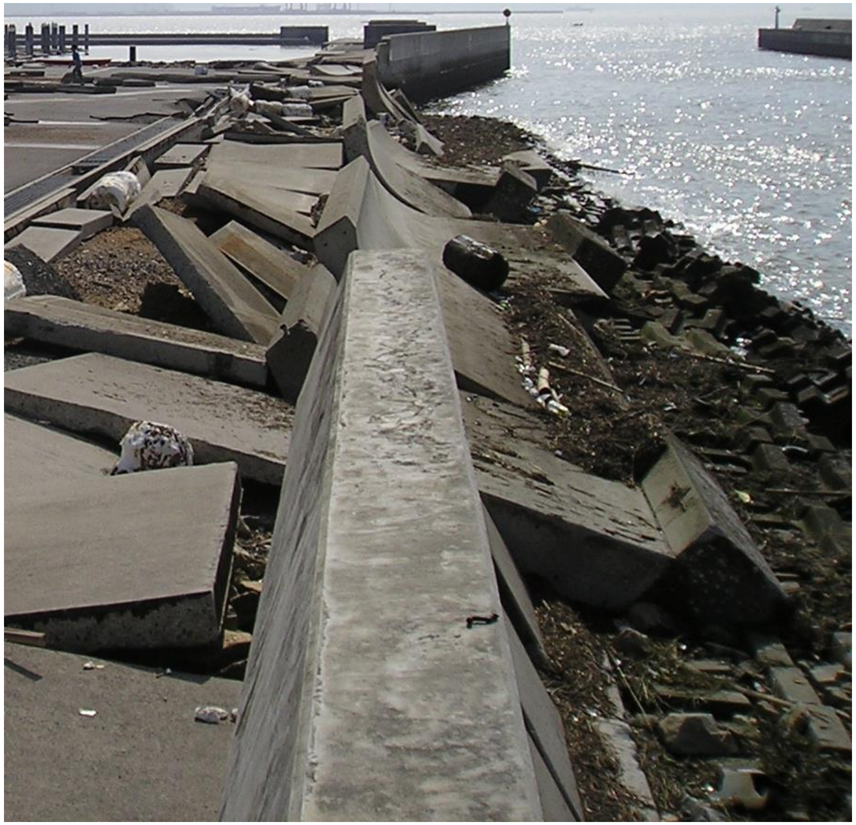
Bearing capacity to horizontal loading decreased by 30% due to seepage

Application of CADMAS-SURF/3D-STR to Displacement of Seawalls

Port and Airport Research Institute, Japan
Seiji Hirano and Taro Arikawa

Introduction



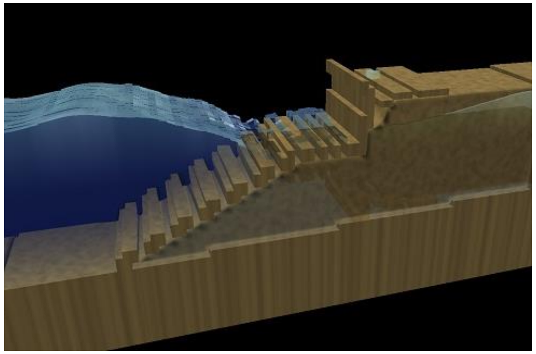


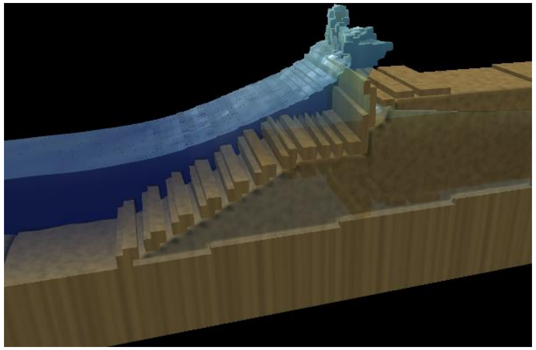
System of CADMAS-SURF/3D-STR (Arikawa et al., 2005)

Main program

call subroutine

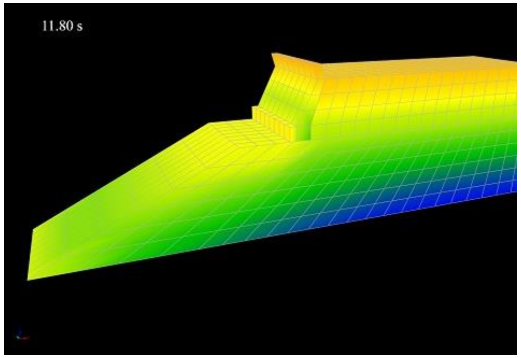
call subroutine

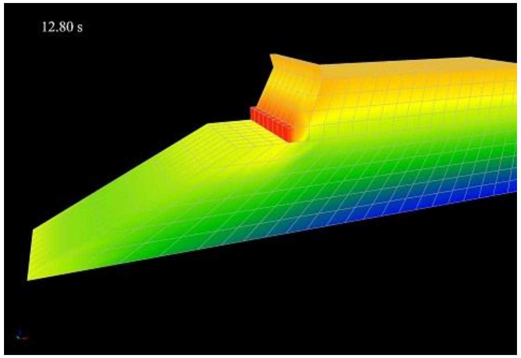




CADMAS-SURF/3D
(VOF method)

STR3D
(FEM)





Data on pressure →

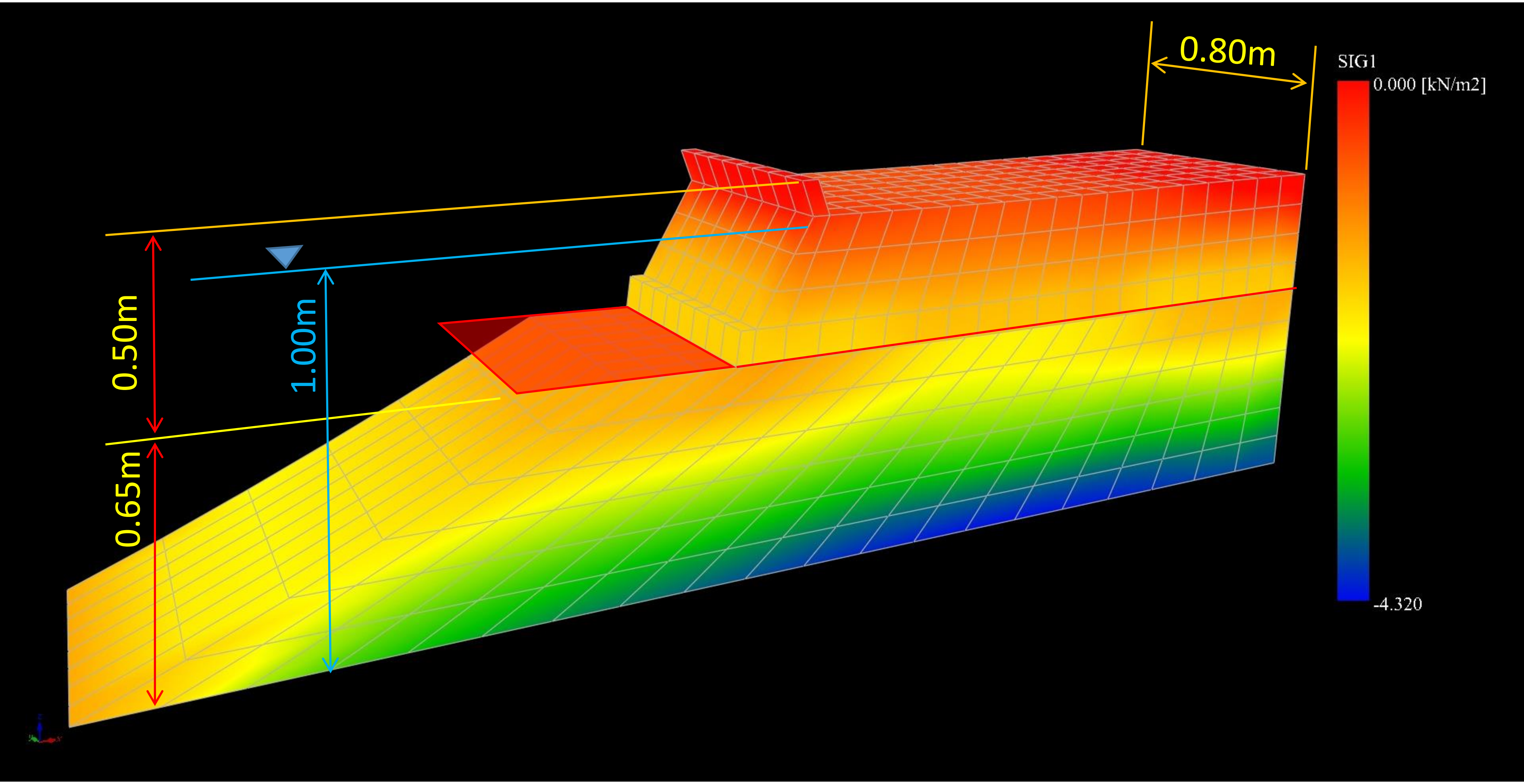
← Data on displacement

Images of CADCADMAS-SURF/3D

calculation step

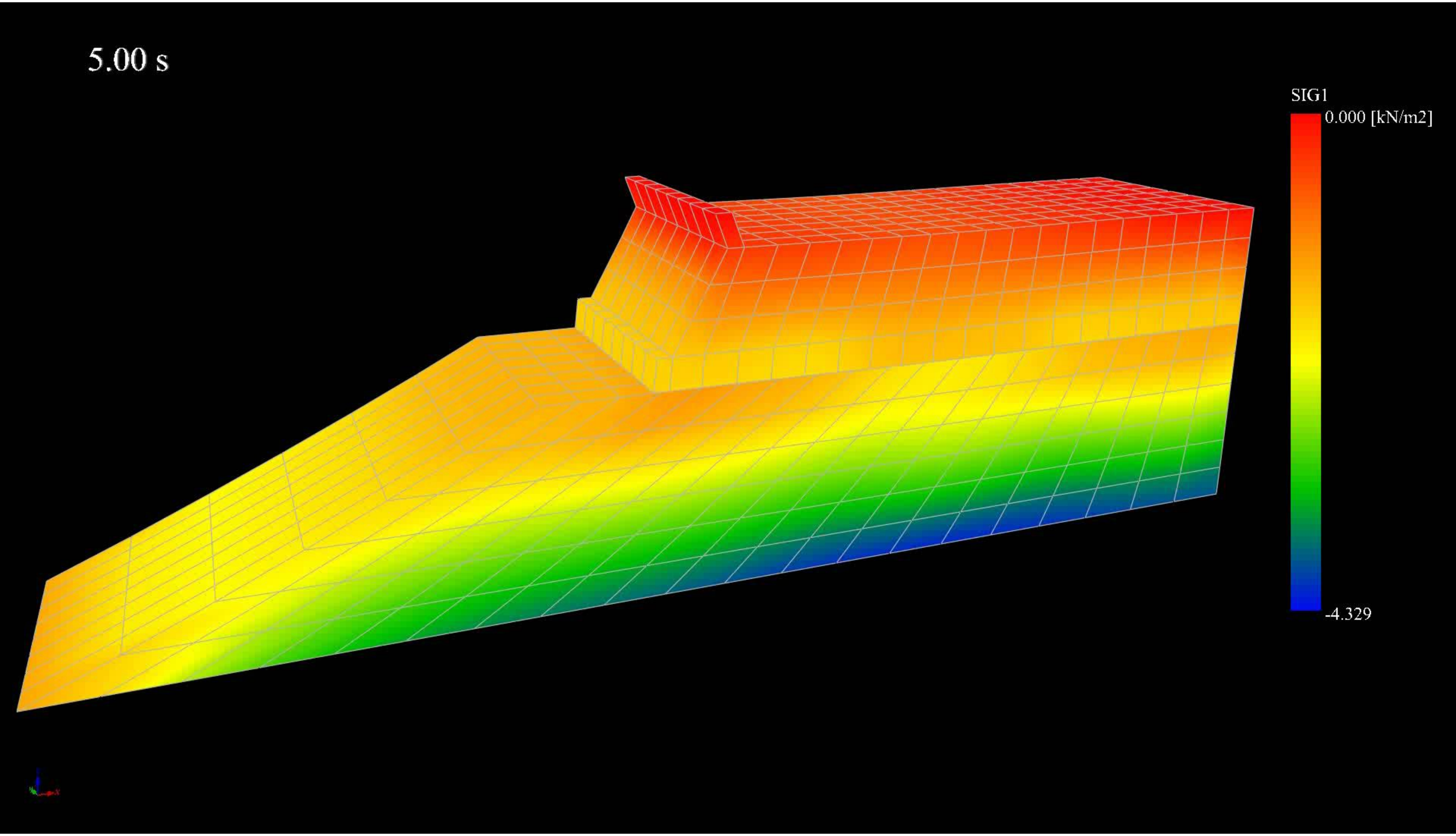
calculation step

Model on a calculation



Modeling in FEM calculation of a Leaning Revetment

Result of a calculation



Some remarks

Numerical modeling and large-scale experiments in PARI had been performed under supports by other financial projects. We feel some difficulties to perform them under CONCERT_Japan project, as funds are limited. Careful attention might be paid on which part of physical/numerical experimental results will be belong to this projects.

For the financial limit, we PARI are going to consume most of our budget in visiting European partners or inviting them, in order to promote exchange useful information and publishing results so on.