Overview, Examples of Distinctive Research, and Collaborative Research of the International Research Institute of Disaster Science (IRIDeS), Tohoku University

—On the Occasion of the G7 Science and Technology Ministers' Visit to IRIDeS, Tohoku University—

May 13, 2023

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Greetings by the Director of International Research Institute of Disaster Science (IRIDeS), Tohoku University

Shinichi Kuriyama

Director
International Research Institute of Disaster Science (IRIDeS)
Tohoku University

It is a great pleasure to welcome the Ministers and our other distinguished guests to IRIDeS, Tohoku University and to have this opportunity to introduce the activities of IRIDeS of Tohoku University to the Ministers of Science and Technology and to everyone gathered here today from the G7 countries. This booklet provides an overview of the institute, examples of our distinctive research, and collaborative international research our researchers have conducted with scholars and organizations based in the G7 countries.

The vast damage caused by the Great East Japan Earthquake and Tsunami on March 11, 2011 affected the Tohoku Region where you are today. The disaster left approximately 20,000 casualties, and the direct physical damage from the disaster has been estimated to amount to 16.9 trillion yen. Many communities in Fukushima Prefecture have been lost due to the Fukushima Daiichi Nuclear Power Plant accident. More than ten years after the 2011 disaster, recovery efforts and the effects of the disaster are still ongoing.

Even before the Great East Japan Earthquake and Tsunami, researchers at Tohoku University had been applying our scientific knowledge in preparation for the next earthquake which we knew to expect. However, the reality of the 2011 disaster far exceeded our expectations. Tohoku University researchers did their utmost to investigate, report on, and support the affected areas in response to the disaster. About a year after the disaster, Tohoku University established IRIDeS, to prevent future natural events becoming great disasters. The Institute is characterized by two things. First it is interdisciplinary in its structure, in which researchers in engineering, science, humanities, social sciences, medicine, and specialists on disaster risk reduction work together. Secondly it has a strong practical focus whereby it directly aims to build a resilient society and benefit disaster victims.

In the more than ten years since its establishment, the Institute has sought to learn lessons from the Great East Japan Earthquake and Tsunami and how to prepare for the next disaster. We have also promoted the implementation of the "three major global agendas," that is to say the Sendai Framework for Disaster Reduction 2015-2030, which lays out the world's guiding principles for disaster reduction, alongside the Sustainable Development Goals (SDGs) and the Paris Agreement – and have made progress in cooperation with the G7 countries and many other stakeholders in Japan and abroad. We hope that the research cases included in this booklet will give you a glimpse of our accomplishments to date and will also provide suggestions regarding the usefulness, diversity, and potential of our disaster science.

As the world faces various risks, including disasters that are becoming more severe due to climate change and protracted wars, the importance of disaster science is only increasing. I would be more than happy if the G7 Science and Technology Ministers' visit to Tohoku University could become an opportunity for the G7 countries to deepen your interest in and understanding of the science that has developed from the lessons of the Great East Japan Earthquake and Tsunami, and further to promote international cooperation between us in the field of disaster science.

IRIDeS' Introduction and overview

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Introduction and overview
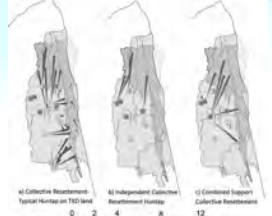
Liz Maly   2023.05.13

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Self-introduction

- Research on People-centered Housing Recovery:
  housing recovery to support life recovery, minimize disruption

Mississippi Cottage

Mt. Merapi Recovery, Indonesia

Rapido Housing in Texas

Temporary Wooden Housing after 3.11

Hurricane Katrina

San Francisco EQ Shacks

Temporary Housing in Hokkaido

Housing relocation after Typhoon Yolanda, Philippines.

2

History
Tohoku University and IRIDeS

- **1907**- Tohoku University was founded. We celebrated our 115 year anniversary last year in 2022

- **2007**- 100 years later, IRIDeS' precursor was formed, an interdisciplinary Disaster Research Group with researcher from humanities and sciences, to prepare for the predicted Offshore Miyagi Prefecture earthquake.

- **March 11, 2011**- Great East Japan Earthquake (GEJE)

- **April 2012**, IRIDeS established one year after the GEJE

- IRIDeS is the first university disaster research center in Japan to include medical experts, along with physical and social scientists

- IRIDeS has 60 full-time dedicated faculty, and more than 200 members including staff, concurrent, and visiting faculty members.

3

3.11
The Great East Japan Earthquake, Tsunami and Nuclear Disaster

4

3.11
The Great East Japan Earthquake, Tsunami and Nuclear Disaster

- 20,000 lives lost

- 561 km2 inundated

- 129,000 houses totally destroyed

- $169 billion in damage (not including nuclear accident)

- 470,000 evacuees (peak);

- 350,000 later in March 2011.

- As of March 2023, still more than 31,000 people officially living in evacuation (Reconstruction Agency)

USG HUMANITARIAN ASSISTANCE TO JAPAN
FOR THE EARTHQUAKE AND TSUNAMI

IRIDeS' mission

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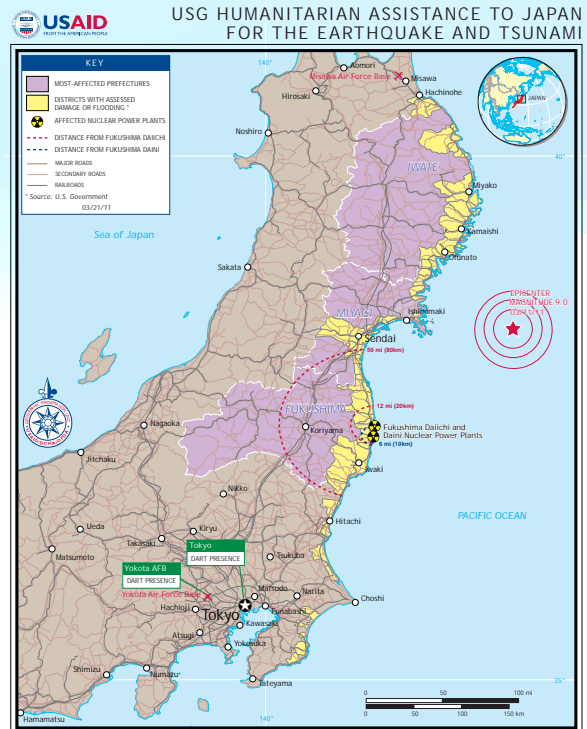
1. **Contribute** to the recovery of the Tohoku region

2. **Apply** the lessons from the 3.11 disaster and recovery

3. **Share** lessons and research for global disaster risk reduction

- Therefore, IRIDeS must have **multi-disciplinary** disaster science research that contributes to **practical disaster mitigation** in society.

- As our new director Prof Kuriyama says: "*Disaster Research is not just Science and Art, but needs Science and Heart*"

Research at IRIDeS:

Interdisciplinary research on historic mega-earthquakes

- Multidisciplinary research on the 1611 Sanriku Earthquake from geology, history, seismology and tsunami engineering.
- Analyzed historical documents and tsunami debris, and calculated simulations, from different perspectives
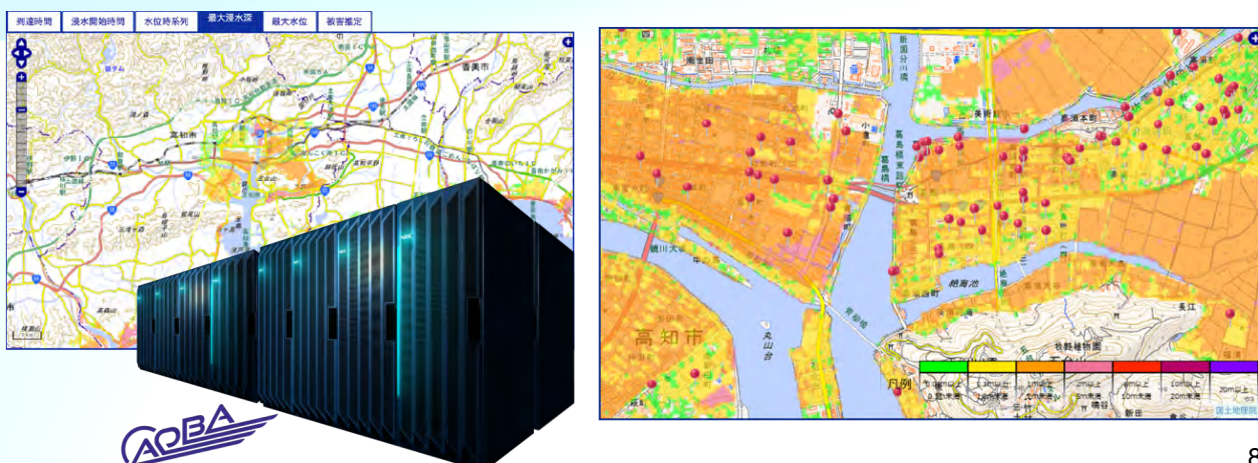- Found the 1611 earthquake caused a similar scale tsunami as 3.11
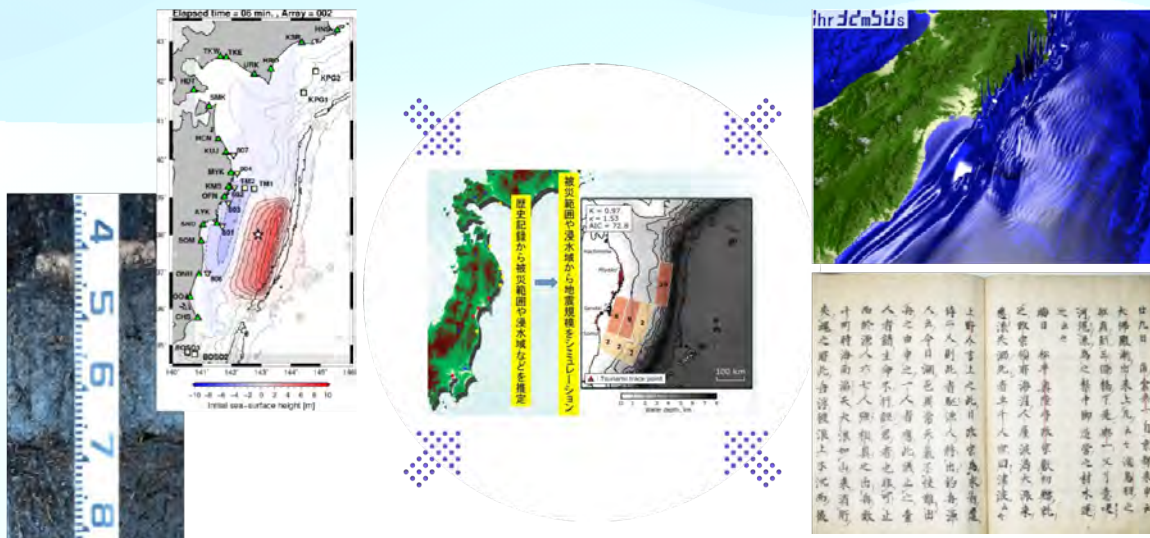
Research at IRIDeS:

Tsunami inundation and damage forecasting

- Creation of new real-time tsunami inundation estimation system, fusing real-time numerical modeling and geo-informatics.
- Launched as a function of the emergency response of the Japanese Cabinet Office in 2018.

Research and Response at IRIDeS:

DMAT, material rescue, emergency investigation

DMAT-Disster Medical Assistance Team

Emergency investigations including:

- Typhoon Haiyan, Philippines, 2013
- Gorkha Earthquake, Nepal, 2015
- Kanto-Tohoku Heavy rainfall Disaster, Japan, 2015
- Kumamoto Earthquake, Japan, 2016
- Hokkaido Eastern Iburi Earthquake, 2018
- Earthquake and Tsunami, Palu, Indonesia, 2018
- Yamagata Earthquake, Japan, 2019
- The 2019 East Japan Typhoon, Japan, 2019
- Fukushima Earthquake, Japan, 2021
- Türkiye-Syriah Earthquake, 2023

Historical materials rescue

Research and Recovery work:

Recovery planning, psycho-social care, radiation protection, science communication, recovery and disaster mitigation map-making

• Reconstruction and DRR mapping in disaster education

• Recovery planning and reconstruction projects

The practical guide to a "Reconstruction and Disaster Risk Reduction (R-DRR) Mapping"
Understanding the natural environment and the lives of those in your hometown

International Collaboration

- 2015 UN 3rd World Conference on Disaster Risk Reduction and World Bosai Forum

ArcDR3 Regenerative Urbanism project, with UCLA and APRU design schools

Co-Created 3.11 Exhibit at the Pacific Tsunami Museum (PTM) in Hilo, Hawaii

Association of Pacific Rim Universities (APRU) Multi-Hazards program and events

UN World Tsunami Awareness Day, Aceh Indonesia

https://xlab.aud.ucla.edu/irides-tohoku-arcdr3/   11

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Examples of Distinctive Research

Disaster Digital Twin & Smart Resilience

Shunichi KOSHIMURA, Ph.D.

Deputy Director

International Research Institute of Disaster Science, Tohoku Univ.

What is Smart Resilience?

Reduce functionality loss and recover quickly

F **(Functionality of Society)**

- **Human Activities**
- **Lifelines**
- **Medical Services**
- **Traffic**
- **Supply Chains, Economy**
- **Well-being**
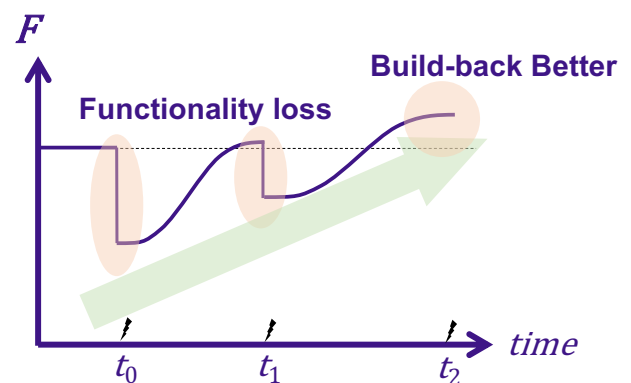
Modified after Bruneau et al. (2006)

Digital Twin

World Unique Nation-wide Real-time Tsunami Inundation Forecast Technology

RTi-cast

University-based start-up operating forecast system to government organizations and commercial clients.

Supercomputer AOBA
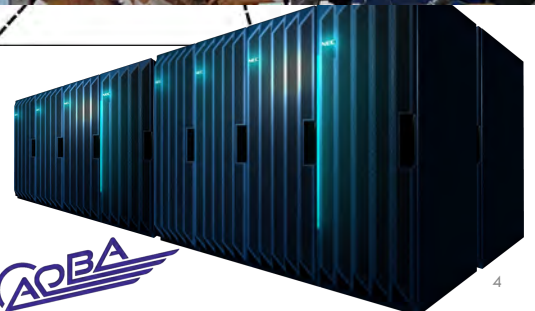
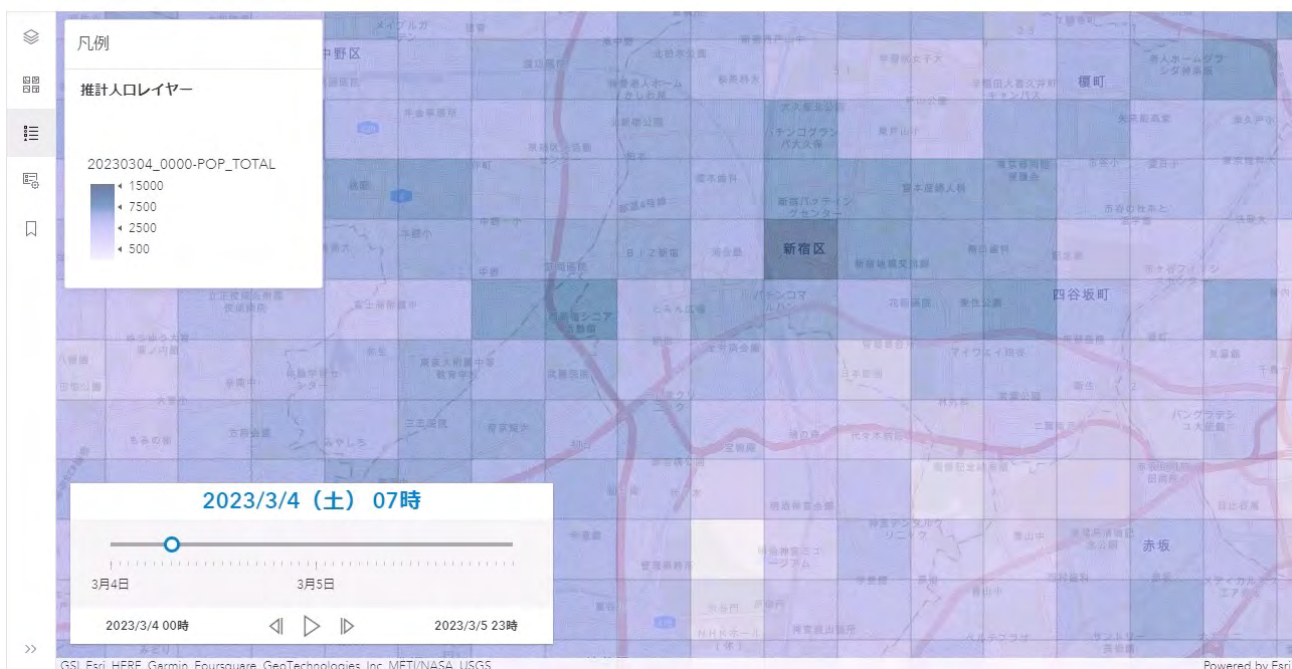# Nation-wide Real-time Population Estimates
Every hour, Every 500 m
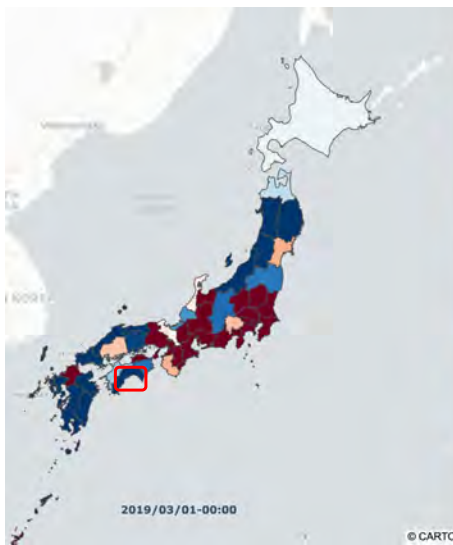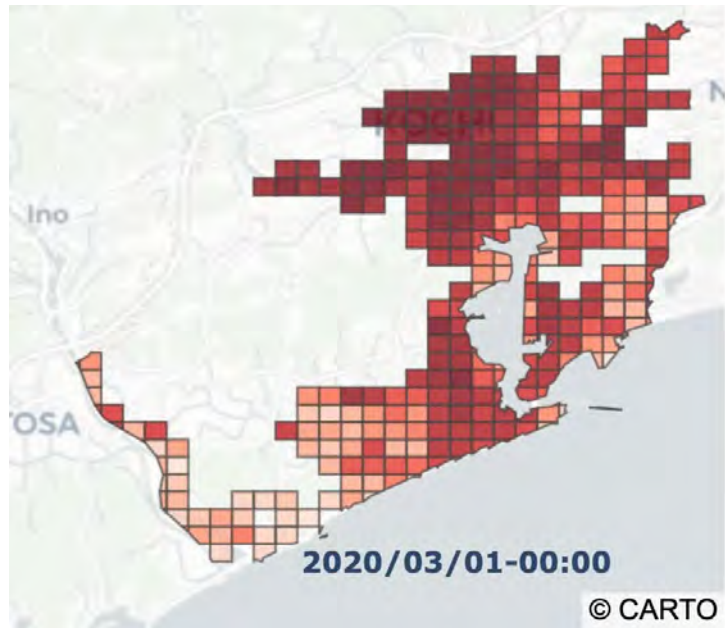
The Population at Shinjuku, Tokyo (5 March)

The Population Anomaly at Shinjuku, Tokyo (5 March)

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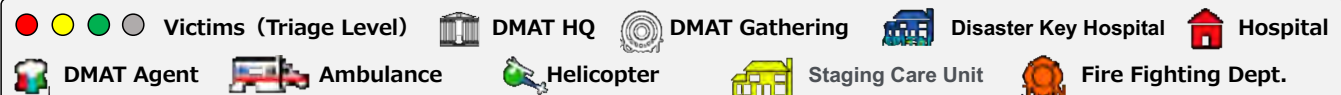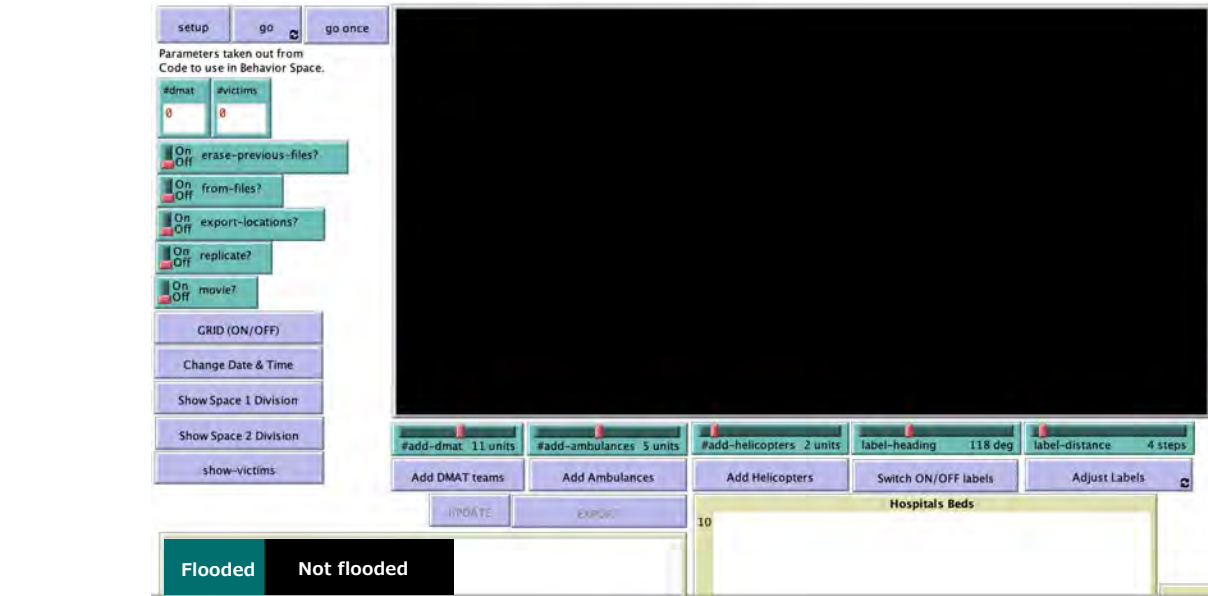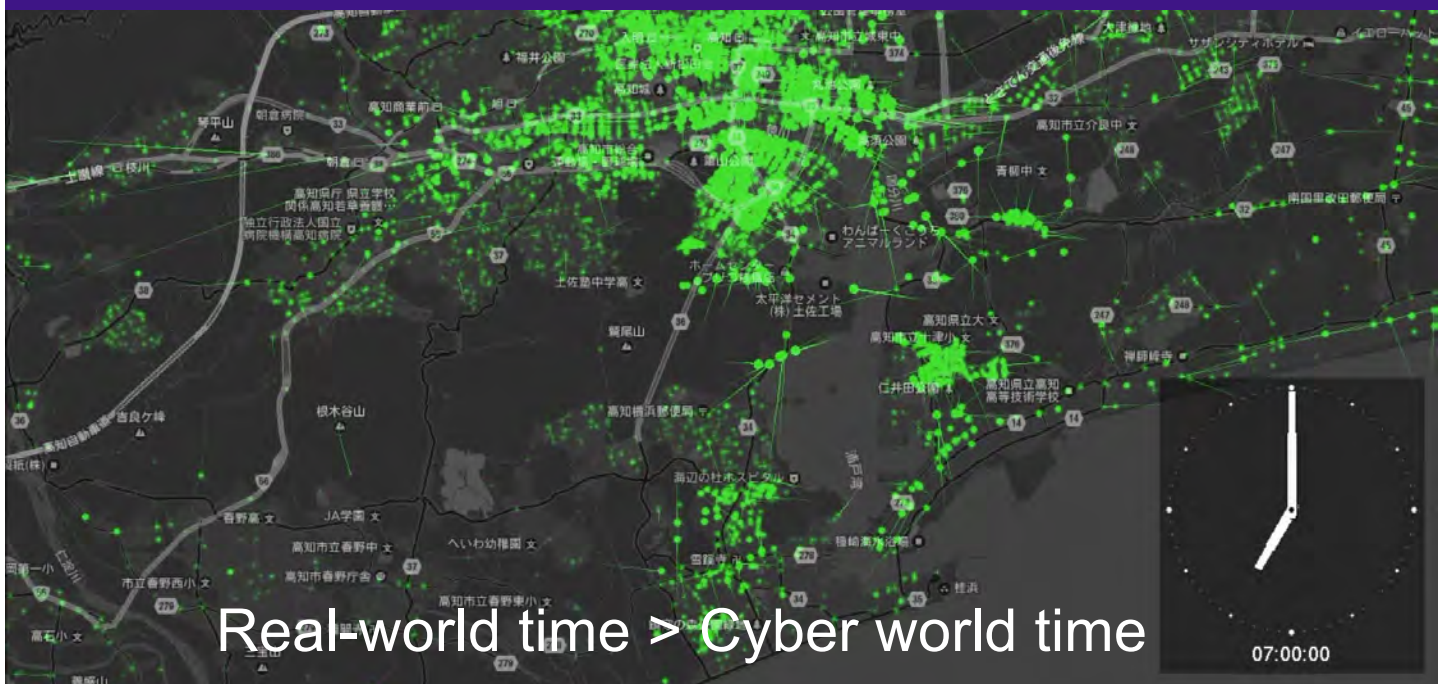# 2021 Atami Landslide, Shizuoka Prefecture
27 people were killed.
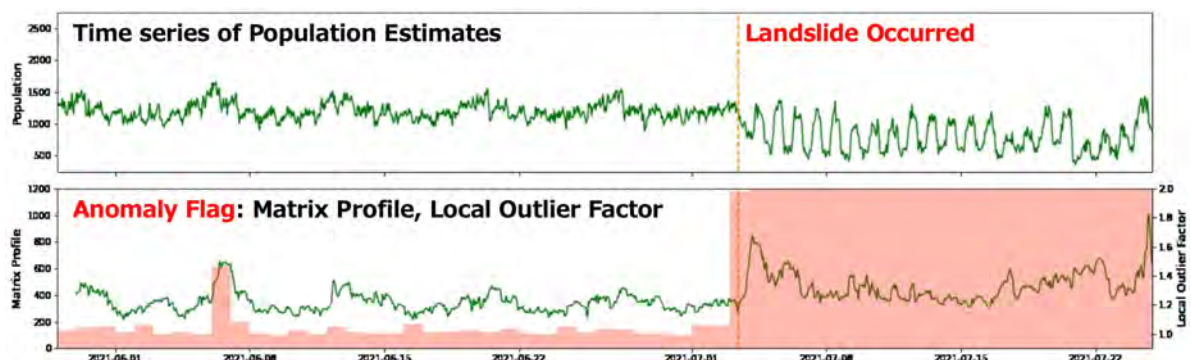
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Digital Twin Saving Lives – Medical Service –

| ● ● ● ● Victims (Triage Level) | 🏛 DMAT HQ | ◎ DMAT Gathering | 🏥 Disaster Key Hospital | 🏠 Hospital |
| 🧑‍🤝‍🧑 DMAT Agent | 🚑 Ambulance | 🚁 Helicopter | 🏫 Staging Care Unit | 🔶 Fire Fighting Dept. |

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Digital Twin Saving Lives
Personalized Alert

Real-world time > Cyber world time

07:00:00

Disaster Digital Twin and Smart Resilience

Mixed-Initiative of Human and Machine

Disaster Robotics for the Disaster Risk Reduction

Prof. Satoshi Tadokoro,   Director, Tough Cyberphysical AI Research Center, Tohoku University
Past President, 2016-2017 IEEE Robotics and Automation Society; President, International Rescue System Institute

Robotic Contribution to Disaster Risk Reduction

Marine Vehicles (Swimming Robots)
- Search, Structural Assessment, Repair
- ROVs (remotely operated vehicles) were effectively used for victim search at East Japan Earthquake, inspection and repair of plant facilities at Gulf of Mexico Oil Spill.
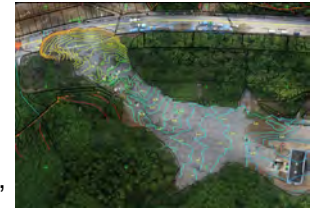
Outbreak

Response **Preparedness**

Recovery

Aerial Robots (Drones)
- Search, Overview Information Gathering, Structural Assess.
- Drones are widely used for mapping and imaging of wide areas, infrastructure inspection, victim search, etc.

(C) Luce Search, Hiroshima

Digitally Empowered Rescue Dogs
- Victim Search
- Robotic digital suits empower rescue dogs for estimation and record of positions, what they see, behavior, and reason why they bark.

Intelligent Video Scopes (Snake Robots)
- Search, Structural Assessment
- Active Scope Camera, a snake robot, was effectively used for inspection in narrow confined space of crushed structures and industrial facilities.

Unmanned Ground Vehicles (Ground Robots)
- Search, Sensor Information Gathering, Sampling , Structural Assessment, Decontamination, EOD, etc.
- UGVs are intensively used for Fukushima-Daiichi NPP Accident, EOD, CBRNE, etc.

Remote Construction (Construction Robots)
- Remote construction machines were intensively used for construction, victim search, decontamination and repair at dangerous sites of volcanos, Fukushima-Daiichi Nuclear Power Plant Accident, earthquakes, landslides, etc. to significantly reduce disaster risks.

Gaps for Social Implementation

- Technology must be ready for practical use with enough high technology readiness level.
- Users, governments, researchers and industry must know the requirements, capabilities in real situations, potential future solutions, and social importance.
- Robotics must be continuously tested and used in the fields.
- Laws, regulations, international standards, and related social systems must be prepared.
- Business environments must be nurtured.
- Human resource of stakeholders (users, responders, engineers, researchers, managers, sales, etc.) must be rich.

Contact: Prof. Satoshi Tadokoro <tadokoro@tohoku.ac.jp>
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Professor, Graduate School of Information Sciences /
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International Rescue System

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TCPAI
Tough Cyberphysical AI Research Center
Tohoku University

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IEEE
Advancing Technology for Humanity

Quince for Fukushima-Daiichi
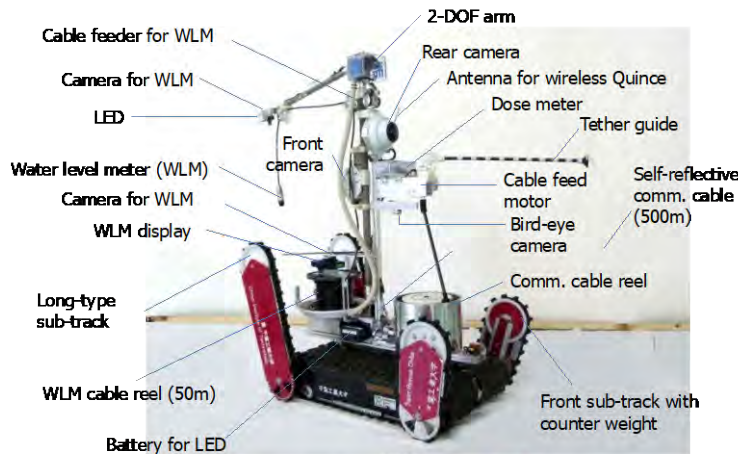
Quince was used in the Fukushima-Daiichi as the first national robot in the nuclear reactor building.

Dragon Firefighter, a Flying Hose

The hose flies and extinguish the fire origin directly in tower buildings and confined spaces.

SMURF for Search in Debris (HORIZON2020 CURSOR Project)

A swarm of the advanced miniaturized robots, SMURFs finds victim in debris by sensor fusion of VOC sensors, thermal images, voice sound, etc. Tohoku U developed the SMURF by collaboration with EU partners in a HORIZON2020 project, CURSOR led by THW.

Intl. Partnerships
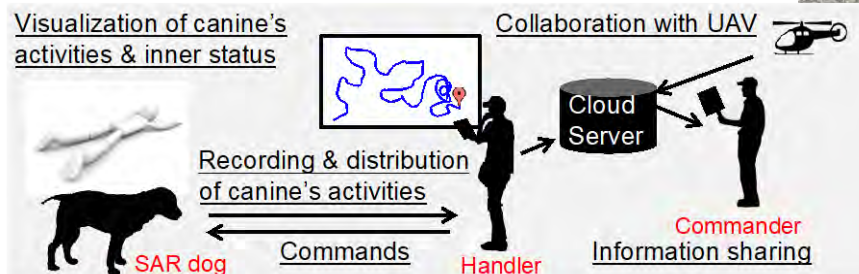- IEEE
- RoboCup
- EU HORIZON
- UNDRR

National Projects
- Cabinet Office ImPACT
- MEXT DDT
- F-REI Project

Cyber Rescue Canine

Rescue dogs are operated from a distance by remote monitoring and commanding.

Contact: Prof. Satoshi Tadokoro <tadokoro@tohoku.ac.jp>
Director, Tough Cyberphysical AI Research Center /
Professor, Graduate School of Information Sciences /
International Research Institute of Disaster Science, Tohoku Univ.

History Guides Disaster Science

Rescue of Damaged Historical Documents in the Great East Japan Earthquake

On March 11, 2011, the Great East Japan Earthquake struck. In the affected areas, many historical materials were damaged.

Historians at Tohoku University salvaged these after the disaster. We have preserved many historical documents with the help of conservation experts and citizen volunteers.

Why do we rescue historical documents?
1 These historical documents are valuable cultural heritage of Japan.
2 The information contained in these historical documents is important data for disaster science research.
3 People in the affected areas can regain their sense of place and identity and rebuild their resilience.

Historical Disaster Research through Collaboration of Humanities and Science

When the Great East Japan Earthquake struck, the mass media said that it was a once-in-a-thousand-years disaster. However, historical documents show that a large-scale earthquake and tsunami had occurred in the Tohoku region in 1611. IRIDeS has attempted to elucidate the earthquake and tsunami that occurred in 1611 by having historians review historical documents and collaborate with science and engineering researchers.
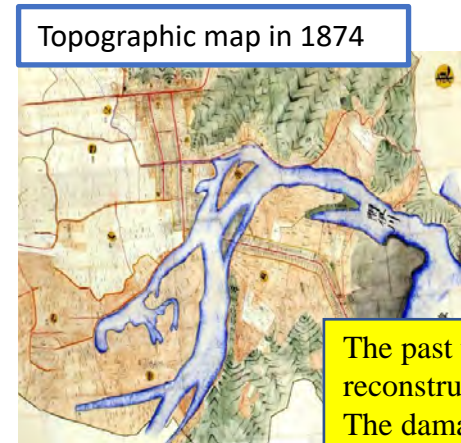
History

Collaboration

Geology

Tsunami Engineering
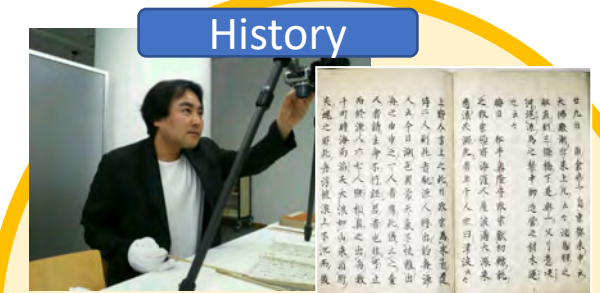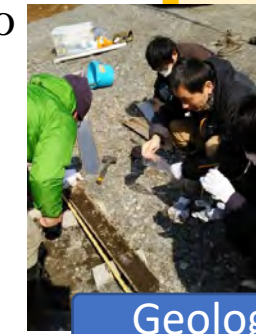
Through this collaboration, we were able to show that the earthquake and tsunami 400 years ago were close in magnitude to those of 2011.

Disaster prevention research using historical data

IRIDeS studies historical landform changes from historical documents and analyzes the relationship to damage caused by current disasters. The results will be used for future disaster prevention.
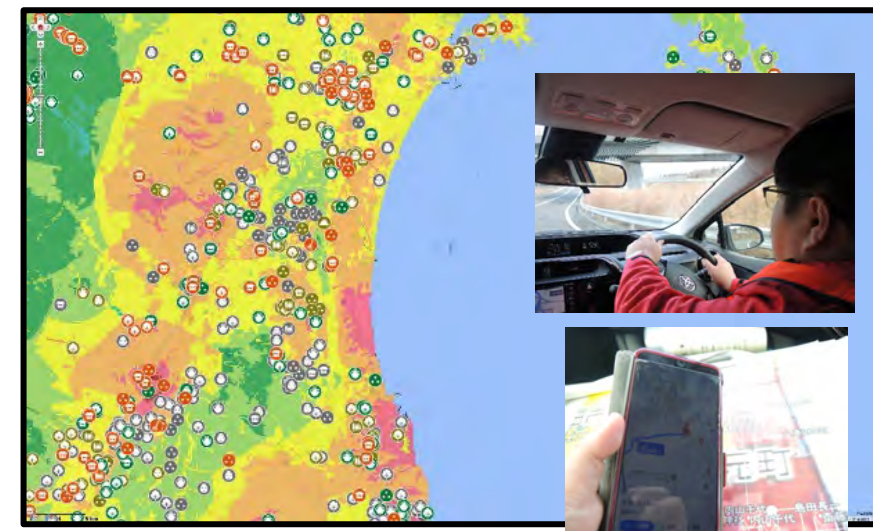
Topographic map in 1874

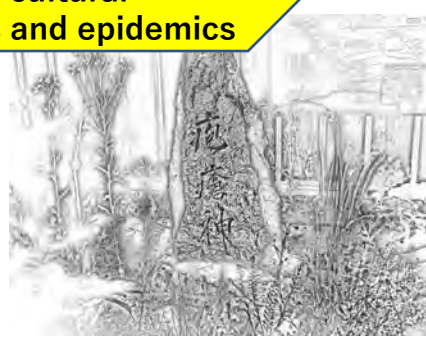The tsunami of 2011 hit Miyako City Hall. This site used to be a riverbank.

The past topography is visually reconstructed from historical maps. The damage caused by the 2011 tsunami is superimposed on this.

Technologies for Preserving Cultural Heritage and Analyzing History

Use optical copy techology to record data on stone monuments. Research cultural practices related to disasters and epidemics

Data Conversion of Historical Pictorial Drawings Using Ultra-High Definition Scanning Equipment

Utilize online maps for cultural heritage rescue in times of disaster.

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