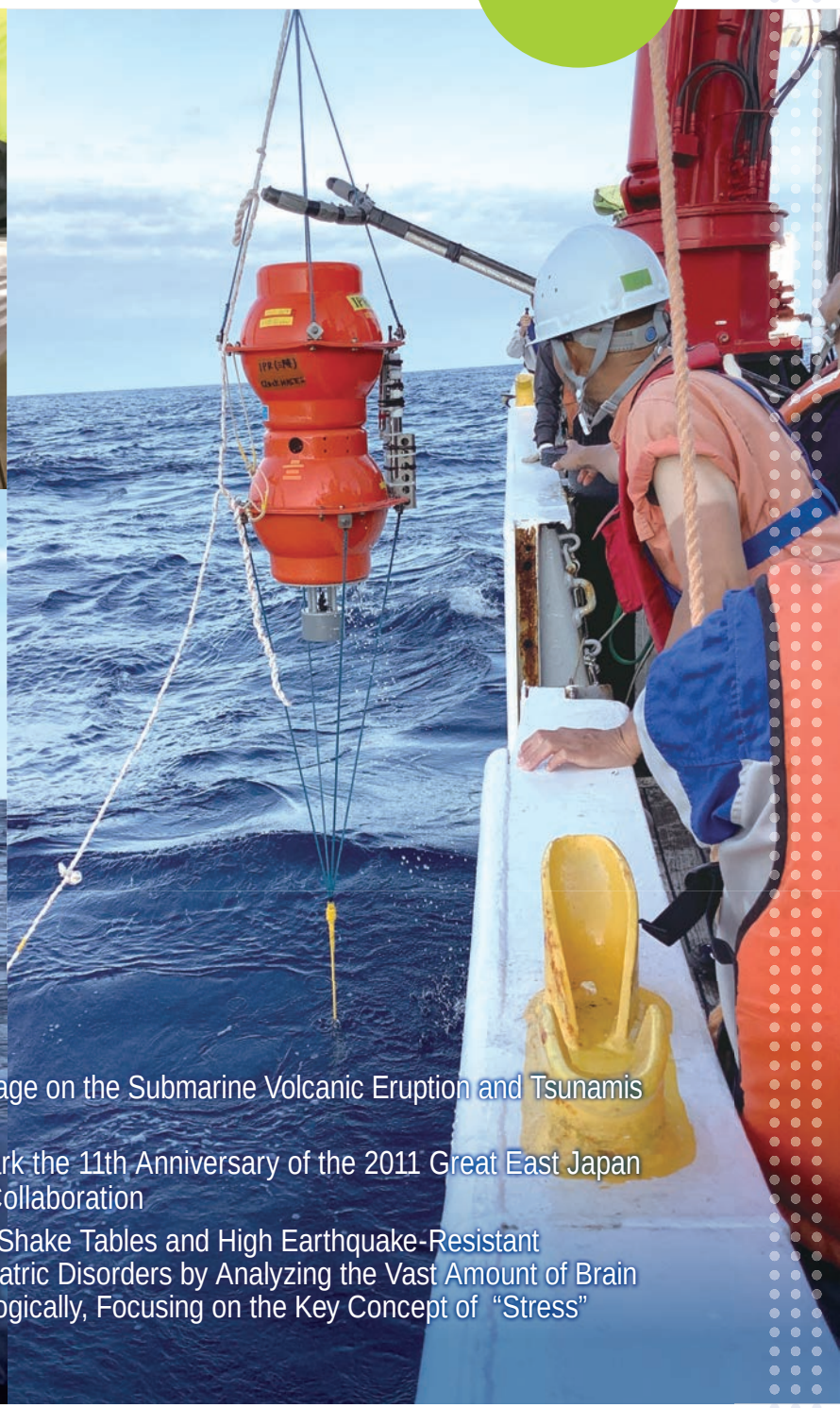
Conveying the results of practical disaster prevention research from TOHOKU to the world

IRIDeS NEWS

International Research Institute of Disaster Science, Tohoku University

2022



Topics

IRIDeS
International Research Institute of Disaster Science

Director's Greeting

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

Last year on March 11 marked the 10th anniversary of the 2011 Great East Japan Earthquake. IRIDeS published an edited book, *Lessons from the 2011 Great East Japan Earthquake: 51 Approaches to Disaster Science*, and held an annual symposium titled "Ten Years after the Great East Japan Earthquake and Beyond" to summarize our progress to date and express determination for the future.

IRIDeS was established in April 2012, about a year after the 2011 earthquake. The institute started with seven divisions and has been making steady progress in areas such as assessing damage caused by the Great East Japan Earthquake, clarifying the mechanisms of massive earthquakes and tsunamis, maintaining disaster archives, and supporting activities to pass on the disaster experiences and lessons to the future. We have also supported the recovery and Build-Back-Better efforts in the disaster-stricken areas and promoted the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR), a global guideline, all in collaboration with industry, government, and the private sector. We also worked hard to promote disaster response and risk reduction activities in Japan and abroad. IRIDeS was reorganized in April 2021 and now holds four divisions that continue to develop disaster science and practical studies on disaster risk reduction. IRIDeS will celebrate its 10th anniversary this coming April.

We have been affected by COVID-19 for more than two years now, but the situation is still serious both in Japan and abroad. The SFDRR includes infectious diseases as hazards, and IRIDeS has been working on research on infectious diseases, regarding them as disasters. At the end of 2021, it was estimated that an earthquake and tsunami in the Kuril Islands Trench and Japan Trench could cause approximately 190,000 human victims in the worst-case scenario. As risks of earthquakes in the Tokyo metropolitan area and Nankai Trough continue to rise, it is becoming more important to take measures against them. It is also an urgent issue to respond to the intensifying hazards caused by climate change. IRIDeS will continue to focus on these important social issues with the comprehensive knowledge gained from interdisciplinary research in order to contribute to the reconstruction of Tohoku and the disaster risk reduction not only in Japan, but also abroad.

Organization of IRIDeS

Risk Evaluation and Disaster Mitigation Research Division

Disaster Humanities and Social Science Division

Disaster Medical Science Division

Practical Research and Collaboration Division

Endowed Research Division
- Earthquake Induced Tsunami Risk Evaluation Lab (Tokio Marine and Nichido Fire Insurance)
- Earthquake Disaster Prevention for Urban Areas Lab (OYO Corporation)

Joint Research Division
- AEON Disaster-Resilient and Environmentally-Friendly City Creation Joint Research Lab
- Nippon Koei Resilient City Technology Implementation Joint Research Lab (will be launched in April 2022)

Global Centre for Disaster Statistics

Kesennuma Satellite Office

Public Relations Office

Administration Office

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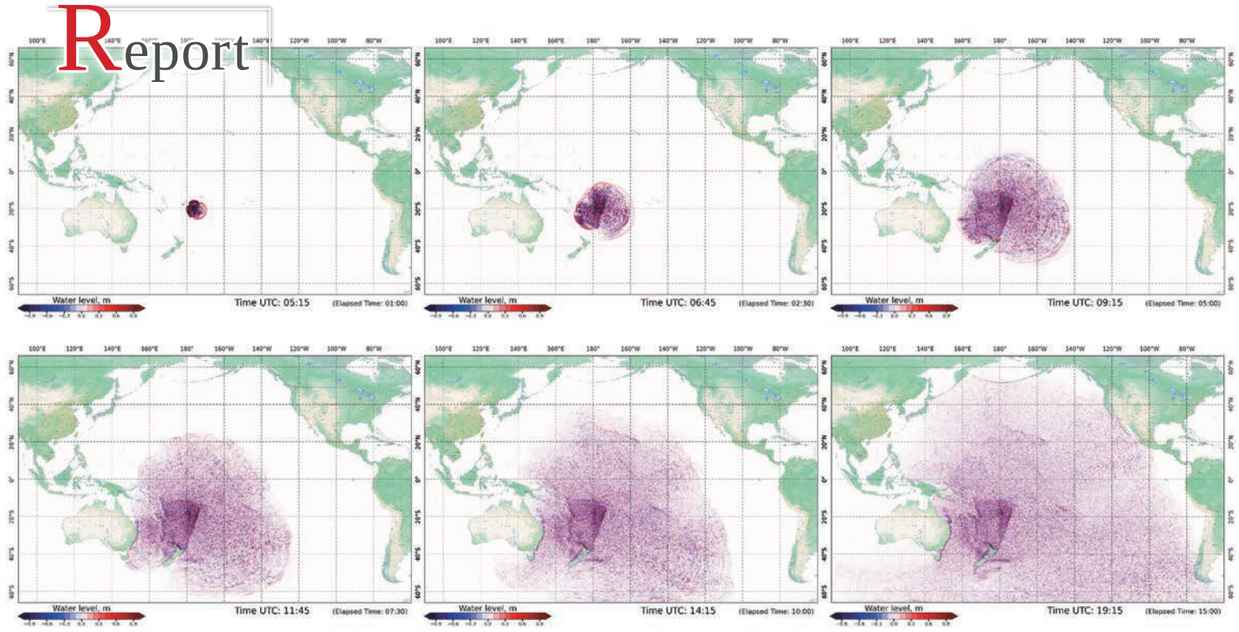


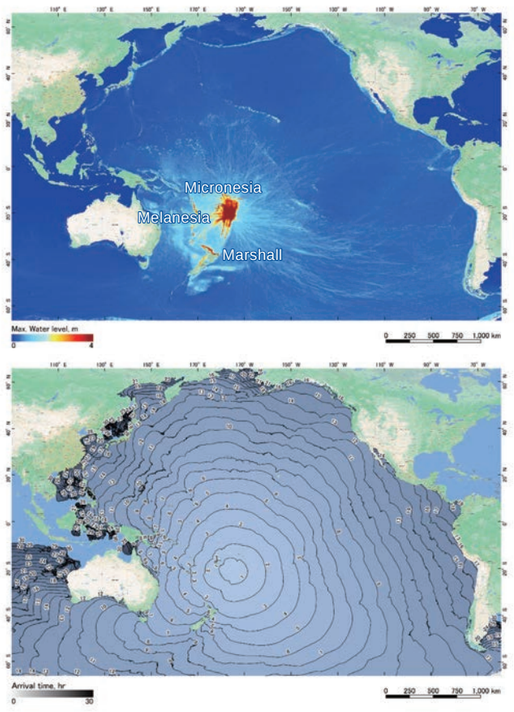
Tsunami Propagation to the Coast of Japan (from the analyzed results)

Launched a Featured Web Page on the Submarine Volcanic Eruption and Tsunamis in Tonga

On January 15, 2022, the submarine volcano Hunga Tonga-Hunga Ha'apai erupted off the coast of the Kingdom of Tonga in the South Pacific, causing tsunamis that reached Japan and other countries along the Pacific coast. IRIDeS researchers have collected relevant information and analyzed data since the time immediately after the eruption, launching a web page on January 31st, 2022, to post the results (https://irides.tohoku.ac.jp/research/prompt_investigation/2022_tonga-vol-tsunami.html).Dr.Kwanchai Pakoksung, Associate Professor Anawat Suppasri, and Professor Fumihiko Imamura analyzed the tsunamis caused by the submarine volcanic eruption in Tonga (excluding air-sea waves) and visualized the propagation of these tsunamis in a small area (Tonga region), a mid-sized area (Oceania), and a large area (the Pacific Ocean) using computer graphics (CG). The CG images can be viewed on the above web page.

The tsunamis that occurred at this time cannot be explained fully by existing scientific understanding. Professor Fumihiko Imamura has responded to media interviews since immediately after the disaster, explaining these tsunamis based on a hypothesis from the perspective of tsunami engineering.

In the future, IRIDeS researchers will collaborate with the Tongan government and researchers of other universities to conduct interdisciplinary surveys and studies on this disaster.



Maximum water level and arrival time

Various Activities Held to Mark the 11th Anniversary of the 2011 Great East Japan Earthquake

Activity 1

Great East Japan Earthquake Memorial Symposium 2022

The symposium

On March 5, 2022, IRIDeS held a symposium called “The Great East Japan Earthquake Memorial Symposium 2022: Development of the Research on Subduction Earthquakes and Preparation for the Future” at the Sendai International Center in Sendai, Japan, in a hybrid fashion, combining face-to-face and online methods. The symposium aimed at deepening our understanding of the latest research on subduction earthquakes and of future risks of major earthquakes and tsunamis. It also provided an overview of regional disaster risk reduction efforts based on lessons learned from the 2011 disaster, seeking for ways to enhance regional disaster preparedness.

In the first half of the symposium, Professor Hiroaki Takahashi of Hokkaido University and Professor Toru Matsuzawa of Tohoku University, who are both leading experts in earthquake research, gave keynote speeches. Their talks discussed the risk of future massive earthquakes along the Kuril Trench, the causes of the 2011 earthquake and tsunami, and its influence on the risk in the adjacent areas, including the difficulty of extra alert upon preceding seismic events in these regions. In the latter half, IRIDeS researchers discussed regional disaster mitigation based on perspectives of preparedness, emergency response, and recovery reconstruction, pointing out the importance of a holistic approach and coordination. More than 120 people participated in the symposium either face-to-face or online.

IRIDeS has held a symposium on the Great East Japan Earthquake every March since 2012. The origin of this symposium is the series of “Tohoku University’s Great East Japan Earthquake Debriefing Session,” [1)] which were regularly held to the public since one month after the 2011 disaster.
This year, the symposium was coordinated as a part of the “Sendai Bosai Future Forum” organized by the City of Sendai at the Sendai International Center (as it was last year also). Although the Forum was held with precautionary measures to prevent the spread of COVID-19, a diverse group of citizens who were interested in disaster risk reduction visited the venue.

During the Sendai Bosai Future Forum, in addition to the above symposium, IRIDeS held another event titled “Creating a Resilient Community: Activities of the AEON Disaster-Resilient and Environmentally-Friendly City Creation Joint Research Lab.” We set up an exhibition booth to introduce IRIDeS activities. It was also announced that the third World BOSAI Forum, supported by IRIDeS, would be held in March 2023.

1) Until March 2012, the event was held by the Research Group on Disaster Prevention and Management, which was the predecessor of IRIDeS.

Activity 3

World BOSAI Walk Tohoku +10

The World BOSAI Forum Foundation (WBF Foundation) is a general incorporated foundation that works closely with IRIDeS to realize BOSAI (disaster risk reduction) all around the world, aiming at decreasing the number of people who suffer from disasters. The WBF Foundation organizes and administers the World BOSAI Forum, an international conference open to the public, in cooperation with the International Disaster and Risk Conference IDRC Davos, Switzerland. In the spring of 2022, in addition to the regular forum, the Foundation is organizing an event titled “World BOSAI Walk Tohoku +10: Travel along the coast of Tohoku to discover Build Back Better,” which is supported by IRIDeS.

In this event, the Foundation members travel along the Tohoku coastal areas (mainly on foot) from Fukushima Prefecture to Aomori Prefecture, which were severely damaged by the 2011 Great East Japan Earthquake. During the walk, they communicate with local people who have worked on recovery and passing on their disaster-related experiences. Because of COVID-19, the number of participants is small, but the members update their travel on YouTube and other social networking services to share their experiences with others.

On February 23, the World BOSAI Walk kickoff was held at the Shioyazaki Lighthouse in Iwaki City, Fukushima Prefecture, and the members departed for their first destination: the Iwaki 3.11 Memorial and Revitalisation Museum. The group is going to move north through Miyagi and Iwate prefectures and will reach their final goal, Hachinohe City, Aomori Prefecture, on April 23. As Professor Yuichi Ono, the representative director of the WBF Foundation and also a faculty member of IRIDeS, says, “To people in Japan and abroad, we would like to convey how local people have been working on recovery and how they have felt.”

For more information, please visit: https://worldbosaiforum.com/bosaiwalk/

Feature 1

Activity 2

A Press Conference was Held on the Progress of the Research on Victims in the Great East Japan Earthquake

Since the fiscal year 2018, Assistant Professor Shuji Seto and Professor Fumihiko Imamura of IRIDeS have been analyzing data on the victims of the Great East Japan Earthquake, which was provided by the Miyagi Prefectural Police Headquarters. The research team continues to explore deaths by the earthquake and tsunami, while considering how to reduce casualties in the future. Every year in February, the research team holds a press conference to share the progress of the research with the media and society in general.

Dr. Fumihiko Imamura

Dr. Shuji Seto

On February 18, 2022, the team held the fourth press conference online to summarize and report on their findings during the fiscal year 2021. In the previous years, their focus has been mainly on casualties on land; this year, they provided a detailed analysis of the 568 people found at sea, and made suggestions on how to cope with hypothermia risks.

At the conference, Dr. Seto mentioned that the number of victims found at sea was higher in Ishinomaki City, Onagawa Town, and Kesennuma City, respectively. He also pointed out that the risk of people flowing out to the sea was higher around the Rias coastline than in the plain areas. Based on their research findings, the team also developed a hypothermia risk checklist, which was also shown in the conference. Dr. Imamura provided a supplementary explanation of the tsunami mechanism.

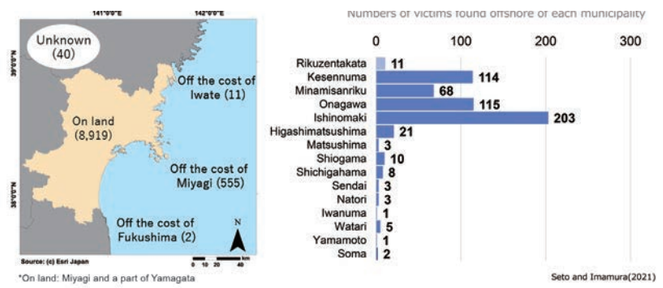
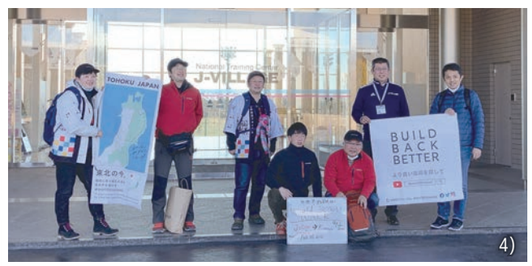


Figure: Numbers of victims found
From the presentation materials

Approximately 15 journalists and reporters attended the conference and asked many questions; they were mainly from the news and science departments of newspapers and television media in the Sendai and Tokyo areas. As Seto commented, “One of the important issues is how to protect lives in case people outflow to the sea, and how to find and rescue them as soon as possible. We will challenge these new issues shown in the conference this time. We would like to find ways to decrease people who lose their lives in the sea in a future tsunami disaster, as well as ways to reduce missing and unidentified people.”

＜World BOSAI Walk, Feb. 26 - 27, in Fukushima＞



1) Walking in Naraha Town.
2) Visiting a winery built for reconstruction in Kawauchi Village.
3) Visiting a specified landfill information facility, “Reprun Fukushima,” in Tomioka Town.
4) At “J Village,” which was used as a disaster response base for the nuclear power plant accident, Hirono Town.

Feature 2

IRIDeS Academia-Industry Collaboration

Academia–industry collaboration has been important for Tohoku University in recent years. Tohoku University regards social contribution as its third mission, following its first and second missions: education and research. Academia–industry collaboration is positioned at the core of the above-mentioned third mission, and thus Tohoku University departments, including IRIDeS, are making strong efforts in this area.

Recently, the Public Relations Office interviewed Prof. Hiroaki Maruya, Deputy Director of IRIDeS, to find out how academia–industry collaboration activities have been carried out at IRIDeS. Prof. Maruya has implemented collaborative projects with several companies in his laboratory. He is also the liaison from IRIDeS who introduces communications and relations between the University and industry.

Dr. Hiroaki Maruya, Deputy Director
Disaster Resilient Society Promotion Lab

Academia-industry collaboration takes diverse forms

When you hear the words “academia-industry collaboration,” the image that often comes to mind may be that of university researchers receiving funding from a company to jointly develop some technology or equipment, or to obtain a patent. However, there are many more forms of collaboration.

Regarding laboratories established for academia-industry collaboration, IRIDeS has created the Earthquake Induced Tsunami Risk Evaluation Lab (Tokio Marine and Nichido Fire Insurance), the Earthquake Disaster Prevention for Urban Areas Lab (OYO Corporation), and the AEON Disaster-Resilient and Environmentally-Friendly City Creation Joint Research Lab. The Nippon Koei Resilient City Technology Implementation Joint Research Lab will also be launched in April 2022 (see p.6). As well, there are joint research contracts between IRIDeS and industry. Many IRIDeS faculty members are conducting research and activities with business enterprises on a daily basis.

In IRIDeS, I am a member of the Practical Research and Collaboration Division, specializing in business continuity plans (BCPs) and disaster risk reduction (DRR) for companies and organizations. Thus, by nature, collaboration with industry is a part of my specialty. I am also a concurrent faculty member of the AEON Disaster-Resilient and Environmentally-Friendly City Creation Joint Research Lab, and I am supporting the creation of DRR measures for the AEON Mall, which is planned to be built on the former site of Tohoku University’s Amamiya Campus.

In addition, I attend corporate committees and provide advice under an academic advisory contract, which is also one of our academia-industry collaboration activities. Additionally, since 2014, I have been organizing monthly academia-industry-government study meetings where several IRIDeS researchers have participated and given presentations. In those meetings, researchers exchange opinions with business people and government officials. I consider that academia-industry collaboration includes such activities to organize those meetings where people from different backgrounds can have a common ground on DRR. Furthermore, based on academic guidance contracts with business enterprises, I have supported building corporate BCPs and I am preparing a textbook on corporate DRR training.

Helping companies develop human resources in charge of DRR and working on corporate DRR strategies together

As a part of joint research on DRR and BCPs, our lab has accepted young employees from companies as IRIDeS research associates to help those companies develop their human resources and corporate DRR strategies. These research associates are stationed at IRIDeS or commute here every week. They attend classes related to DRR at the School of Public Policy where I teach. Those joint researchers share their industry DRR experiences with university students, while acquiring a wide range of knowledge in those classes. They also discuss realistic corporate DRR issues with students and me, collaborate to find solutions, and bring back these findings to their companies.

Unlike other students who have not yet entered the workforce, those research associates are already familiar with how corporate organizations work. The DRR issues they are facing are tangible ones in the corporate world. Since we examine them together from an academic perspective and based on our knowledge of past cases, the response methods we derive will be realistic and creative.

IRIDeS Labs for Academia-Industry Collaboration

Earthquake Induced Tsunami Risk Evaluation Lab (Tokio Marine and Nichido Fire Insurance)

The lab was co-established by IRIDeS and Tokio Marine and Nichido in 2012. It combines IRIDeS’s academic knowledge of disaster science and Tokio Marine and Nichido’s practical knowledge of earthquake and tsunami risks based on its insurance business, and publishes the results for the public. To date, the lab has been continuously engaged in research on tsunami hazard assessments and tsunami fragility, developing human resources, supporting tsunami evacuation training, and disseminating disaster risk reduction education.

The water overflowed the low levees in front of the river.

Earthquake Disaster Prevention for Urban Areas Lab (OYO Corporation)

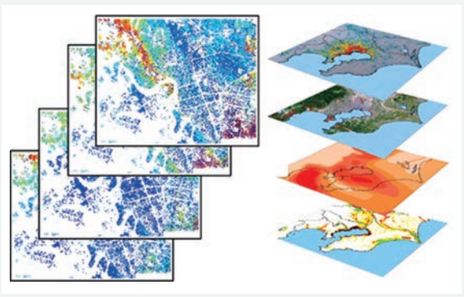
The lab was established in 2019 in collaboration with IRIDeS and OYO Corporation. Their research aims at presenting practical disaster prevention and mitigation solutions from the perspectives of geomorphology, geology, seismology, and earthquake engineering for large inland earthquakes directly beneath cities that may occur in the near future.

AEON Disaster-Resilient and Environmentally-Friendly City Creation Joint Research Lab

Established in October 2021, the lab aims at creating a safe, secure, and resilient community by developing an environment of greenery that will serve also as a regional center for disaster risk reduction. The lab has three main areas of research: disaster risk reduction, forest design, and countermeasures against infectious diseases.

Nippon Koei Resilient City Technology Implementation Joint Research Lab

This research facility will be launched in April 2022. Using various technologies in the field of data science, the lab will develop an interchangeable digital twin model that integrates data-driven, high-density, high-accuracy, and high-speed disaster-related information in cyberspace and real space, aiming to build a model for resilient cities.



Considering a new system for logistics in times of disaster

As another example of joint research, I am working with Maruwa Unyu Kikan Co., Ltd., on a system to transport and sort goods in times of disaster. Usually, responding to the national government request after a disaster strike, large trucks from nationwide and representative regional transportation companies operate for long-distance transports of relief supplies to disaster-stricken areas, arranged by organizations such as a prefectural truck association. However, it seems that trucks from medium- and small-sized companies have not actually been called upon. Thus, we started to look into ways to improve this situation. Also, in our lab, we are studying how logistics companies and local governments can work together, based on experiences from transport-related companies during the 2011 Great East Japan Earthquake. Our joint research involves academia-industry collaboration, examining each specific situation that could occur in the event of a disaster, discussing the nature of the bottlenecks and what resources can be used, in order to find actual solutions.

I also support the company proposing to local governments how logistics bases for relief supplies need to be prepared. The company and I have pointed out the importance of considering road access, mobile storage, and sorting of goods using forklifts and pallets to expedite transportation in and out of the city's logistics base. In general, local government personnel are subject to reassignments, so even in municipalities that have experienced a disaster and have received relief supplies in the past, those currently in charge do not always have detailed knowledge. Since major disasters do not occur often, it is important for those involved in academia, industry, and government to continue to exchange opinions on how to respond to disasters so that past experiences can be passed on to prepare for future disasters in a realistic manner.

In these academia-industry collaboration activities, I, as a researcher, present ideas to address the issues a company faces based on accumulated past examples of DRR matters and solutions, as well as on the latest response methods and plans of the national and local governments. The company examines my ideas to see whether they are feasible, and when it becomes clear that those ideas are actually effective, the company implements them immediately. Furthermore, such effectiveness and realization may be highly valued by the national and local governments. I would like to emphasize that researchers also learn much from companies during these processes. I consider that in practical disaster management, solutions can often be obtained from information on the ground. It seems true to describe that academia and industry are not only trading knowledge with each other, but also gathering in the lab and working together to develop new ideas swiftly.

Supporting the construction of a DRR center for academia, industry and government cooperation

As another example, I work on a project with a company that is putting up a building in Sendai City. The building will serve both as a response base in the event of a disaster and as a DRR center during normal times. The company, Fukuda and Partners Co., LTD., a Tokyo-based business entity that provides design and consulting services for logistics facilities, came to me for consultation. They wanted to develop a highly disaster-resistant building in Sendai to serve as a backup base in the event of a disaster, such as the Tokyo Inland Earthquake. Later, other companies I had been working with became deeply involved in this project, and the city of Sendai became interested in the project as well.

This building is earthquake-resistant and will be equipped with facilities necessary in the event of a disaster, including an emergency power supply, stockpiling, and manhole toilets. It can also be used as a temporary disaster shelter. During normal times, the center will serve as a corporate DRR center, where disaster response goods will be displayed and visitors can learn about DRR. Named the Sendai Nagamachi Center for Future Co-Creation, construction will be completed in March 2022, and IRIDeS would like to participate in its activities. This will be the first center in Sendai to dispatch information of corporate DRR.

An image of Sendai Nagamachi Center for Future Co-Creation

Future academia-industry collaboration

The above are examples of academia-industry collaboration that I have been involved in. Business entities are important actors of society and, thus, are within the scope of studies that target social matters. In these study areas, academia-industry collaboration inevitably happens.

The companies I collaborate with consider their own merit in working on DRR, of course, but they also take seriously corporate social responsibility (CSR) and building trust in society. The beneficiaries of their activities include governments and citizens.

The outcomes of academia-industry collaboration in my study on DRR of companies and organizations do not include development of machinery or the obtaining of patents. I would like to publish papers on academia-industry collaboration activities in which I have been involved (if they can be generalized and made public), but it is sometimes difficult to disclose strategies of individual companies. So, I work on results that are recognized as valuable, including dispatching information to society, system creation of society and business entities, and improvement of disaster response through industry-government collaboration.

Just as research is diverse, the contents of academia-industry collaboration vary, depending on partner companies and topics. Academia-industry collaboration will become increasingly important in the future in all fields. Business entities have their own way of thinking, which differs from that of universities in many ways. I hope that the next generation of researchers will understand the differences between academia and industry, acquire the knowledge necessary for collaboration, and explore new horizons of collaboration.

A scene of a discussion between academia and industry

Public Relations Office Column
My Experiences of the Great East Japan Earthquake

Professor Shinichi Egawa
Head, Public Relations Office
International Cooperation for Disaster Medicine Lab

Eleven years have passed since the Great East Japan Earthquake. In the afternoon of March 11, 2011, I was in my room on the 8th floor of the Tohoku University School of Medicine, after my Friday morning outpatient clinic. Feeling a sudden violent shaking, I could not move at all and started thinking, "This is a very big earthquake. It must be the Miyagi prefecture offshore earthquake we anticipated." I felt relieved as the first shakings subsided, but the feeling was momentary. The second violent quakes came soon afterwards, the intensity of which was even stronger. Watching books falling off from bookshelves, I concluded that my situation should be safe. I thought, "My office is rather small and has pillars in four corners, and thus shouldn't be too fragile. There are no heavy objects falling down to put me under either." However, I also concluded, "If the ceiling or the floor falls out, I would die." I endured the time, holding my laptop in my arms, thinking, "I would need this when I survive." Soon after the trembles subsided, I left my office to confirm the safety of all members of the medical office and remote laboratory, and evacuated them outside. Responding to the announcement that Tohoku University Hospital immediately set up the disaster response headquarters, I joined them to assess damages of the hospital and other related hospitals. Within Tohoku University Hospital, there is the main office of Gonryo Kyougikai, which is a nonprofit organization for collaboration among the university hospital and affiliated hospitals, and where I have been involved in its management as the Secretary General since 2008. Those experiences and the laptop computer I brought helped me considerably in grasping the situation.

A year after the earthquake, Dr. Susumu Satomi, who was the hospital director at the time, became the president of Tohoku University, and I was appointed as a professor of International Cooperation for Disaster Medicine Lab, IRIDeS. Having dealt with many patients with intractable pancreatic cancer, I have come to the realization that the only thing I can be sure of is "We will all die someday. And both the universe and the earth have beginning and end." It seemed strange but at the same time natural to me that our country achieved the world's longest life expectancy and disaster resilience. Also, I wished to unravel differences and similarities between the usual medical care and disaster medicine. Since then, I have been studying and writing papers on the disaster medical system and its development after the earthquake, including DMATs, disaster base hospitals, disaster medical coordination, disaster medical information systems, and wide area transportation, all of which I did not know much about at the time of the 2011 earthquake.

The Sendai Framework for Disaster Risk Reduction, the global guideline formulated at the Third United Nations World Conference on Disaster Risk Reduction in 2015, refers to the word "health" 34 times, seeking to protect people's physical and mental health in harmony with the SDGs and the framework for adaptation to climate change. Misfortune happens anytime, but we human beings can turn misfortune into fortune. I hope that every one of us will cherish our short but indispensable lives.

Research on Shake Tables and High Earthquake-Resistant Structures

Associate Professor Ryuta Enokida
Earthquake Engineering Lab

Introduction

Dr.Ryuta Enokida (Associate Professor, IRIDeS) is currently working on research for earthquake-resistant structures with applications of automatic control.

He describes the meaning of "control" as making something move as wanted. He added, "Its example can be found in our daily life. For example, at cooking pasta, we pour a little cold water into a pot when water is about to boil over. This is also control." In academic fields, however, control approaches are more complicated and sophisticated. Control has been adopted in various academic fields such as mechanics, aerospace, finance, and chemical industries. In the earthquake engineering field, control approaches are used for mitigating the vibration of buildings during earthquakes and for vibration experiments based on seismic data recorded during actual earthquakes in the past.

One of his research subjects is closely related to the vibration experiments using a shake table, which enables us to artificially generate seismic vibration. Recently, he solved one important issue of the shake table by developing a novel control method to improve its performance.

Shake table experiment
(National Research Institute for Earth Science and Disaster Resilience)

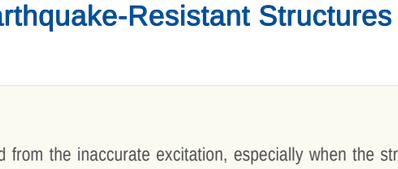
Innovations to improve performances of shake tables

In a typical shake table experiment, a structure such as a building is placed on a table, and an earthquake is simulated to examine how much the building is damaged. Then, based on the records taken, engineers explore measures to make buildings stronger.

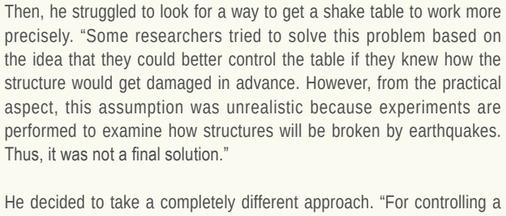
The shake table experiment had a major issue since the early days of its development. The shake table works properly when the structure is intact, but once some damage appears to the building itself, the structural property changed by the damage jeopardizes the accuracy of the table movement. "The shake table ideally has to produce the intended earthquake excitation stably with high accuracy, no matter what happens on the table. But this was not possible due to technical limitations. Researchers had to accept the experimental results obtained from the inaccurate excitation, especially when the structure was severely damaged, because they had no choices," says Enokida. Then, he struggled to look for a way to get a shake table to work more precisely. "Some researchers tried to solve this problem based on the idea that they could better control the table if they knew how the structure would get damaged in advance. However, from the practical aspect, this assumption was unrealistic because experiments are performed to examine how structures will be broken by earthquakes. Thus, it was not a final solution."

He decided to take a completely different approach. "For controlling a shake table more accurately, I came up with a method named nonlinear signal-based control (NSBC), which does not require the assumption on the structural conditions." When some damage appears to a structure, it has nonlinear dynamics, indicating that its force and deformation are not proportional. In order to control a system with nonlinearity, conventionally, the controller itself also has to have the nonlinearity characteristic to cancel out the nonlinearity in the system. However, Enokida's new method is based on a completely different concept, and it enables us to control the nonlinear system by a linear control. Through actual shake table experiments, he confirmed that the new method could accurately control the table even after a structure on the table became severely damaged. In an experiment using the seismic record of the 1995 Great Hanshin-Awaji Earthquake, the new method achieved 100% accuracy, whereas a conventional method fell to 84.3%.

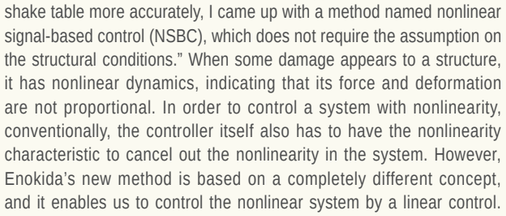
Enokida has published these results[1] and the method itself is currently being evaluated for a patent. According to him, a key of this development was integrating well what he learned from different engineering fields such as architectural, mechanical, and control engineering.



Conceptual diagram of NSBC



Experimental results of a conventional method



Experimental results of NSBC

Reactions to the new method

There was a great response at a conference when he introduced this method. However, this did not mean that people immediately shifted from the conventional method to the new one. "Some expense is required for the introduction of the new method. Some people hesitate to change what they have been relying on for a long time. Also, they might be caring about a slight chance of unstable behavior of shake tables caused by its introduction," says Enokida.

The development of the new method has clearly highlighted limitations of conventional approaches. "Researchers have discussed seismic structural responses obtained from shake table experiments, knowing that the earthquake excitation realized by the table was not necessarily accurate," says Enokida. Now, NSBC enables us to obtain genuine properties of structures under a specific type of earthquake.

What happens when a huge structure is shaken by an earthquake?

As one of further studies on NSBC, Enokida is developing an experimental method to examine properties of huge structures subjected to earthquakes. During shake table experiments, structures exceeding certain limitations (e.g., size or weight) cannot be placed on a shake table. For example, a high-rise building such as the Tokyo Sky Tree cannot be put on the table. Seismic performances of high-rise buildings in Japan are evaluated by numerical simulations, although some other countries examine such buildings by experiments based on those scaled models. If we could evaluate the seismic performance of huge structures through more realistic approaches, we could more reasonably enhance the seismic resistant capacity of the structures.

For this purpose, Enokida is currently working on an experimental technique where only a core part of a building is physically tested and the rest of it is numerically simulated in computation simultaneously integrating data obtained in the real and numerical domain. This technique was originally developed in Japan, and was first implemented in the field of architectural and civil engineering in the 1960s. He has incorporated NSBC into this experimental technique for achieving shake table tests on a huge structure, and its research results have been published in a paper [2]. By further improving this method, it will be possible to perform a high-rise building experiment at a similar cost of a low-rise building (e.g., two to three stories) on a shake table. "This paper contains many mathematical equations and this may not be something that many people immediately respond to. But it clearly showed some progress on the development of shake table experiments for high-rise buildings," states Enokida.

Working as a "goalkeeper": minimizing damage from earthquakes for building a resilient society

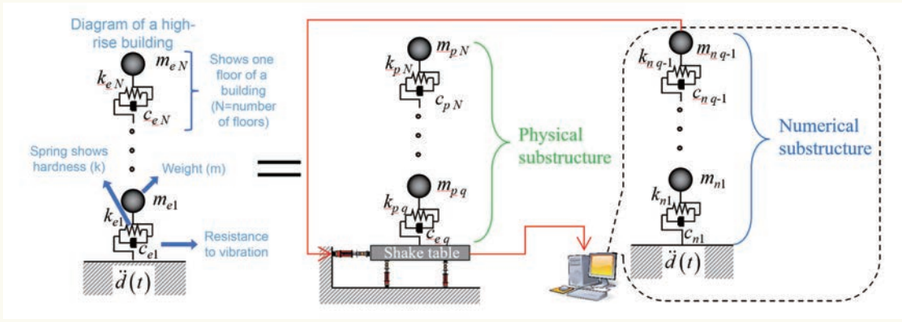
Ryuta Enokida was born in Shizuoka Prefecture wherein the occurrence of a huge earthquake has been a great concern since the 1970s. When he was an elementary school student, the 1995 Great Hanshin-Awaji Earthquake occurred. This event inspired him to be a researcher on earthquake engineering. However, when he was a doctoral student, he was very shocked by the 2011 Great East Japan Earthquake, and felt depressed about the engineering limitations against such natural hazards. Long after the event, he reached the conclusion that we will never know fully what is useful for future earthquakes. Today, he primarily focuses on studies that he believes are necessary. "Earthquake engineering is expected to think about how to reduce losses by natural hazards, rather than gaining something. It is like a goalkeeper's job and it does not have a fabulous aspect. But I believe someone has to do this," he says.

One key aspect to the NSBC development originated from his architectural engineering studies. "If architectural and control engineering are more closely connected with each other, it would be more beneficial to academic fields and industries. Someday, I would like to write a basic textbook focusing on the application of control theory."

Some researchers focus on either theory or practice, but he prefers to be involved with both and keep a balance. "Theories and numerical simulations and experiments are supporting each other, and they work well when they are in good harmony, just like an engine and a wheel. I feel very rewarded when results obtained by experiments match with theoretical considerations," says Enokida. Regarding future work, he will further promote the use of NSBC and accelerate the development of the experimental technique for high-rise buildings. In addition, he is interested in a study to minimize the occurrence of electric power failures even during a huge earthquake.

1) R. Enokida, & K. Kajiwara. Nonlinear signal-based control for single-axis shake tables supporting nonlinear structural systems. *Structural Control and Health Monitoring, 26* (9), e2376 2019. https://doi.org/10.1002/stc.2376. (This paper was published by Dr. Enokida as a member of the National Research Institute for Earth Science and Disaster Resilience (NIED) before he joined IRIDeS.)

2) R. Enokida. Nonlinear substructuring control for simultaneous control of acceleration and displacement in shake table substructuring experiments. *Structural Control and Health Monitoring, 29* (2), e2882 2021. https://doi.org/10.1002/stc.2882.



Conceptual diagram of a high-rise building experiment integrating an experiment and a numerical simulation

Research on Factors of Psychiatric Disorders by Analyzing the Vast Amount of Brain Data: Considering Disaster Psychiatry Biologically, Focusing on the Key Concept of "Stress"

Specially Appointed Assistant Professor
Mizuki Hino
Disaster Psychiatry Lab

Introduction

Schizophrenia is a life-altering mental disorder that affects about 1% of the population, and thus is an important issue that psychiatry has addressed. There are two aspects that contribute to schizophrenia: inherited genetic factors and acquired environmental factors. A disaster can also become an environmental facet in schizophrenia.

Dr. Mizuki Hino, an assistant professor at IRIDeS, focuses mainly on the biological aspects of schizophrenia, examining the human brain in detail to discover the various factors associated with this mental disorder.

Examining what happens when cells are subjected to stress

Hino has been studying changes that occur when cells are stressed from the time he was a university student until after he received his Ph.D.

"Stress" was originally a technical term in physics and engineering: when an object is pressured externally, its shape becomes distorted, and the force accumulated internally tries to repel against the outside pressure. The situation where the object is trying to return to its original state is called a "state of stress." Later, "stress" began to be used also as a medical term, based on the idea that strain appears as a nerve or physical disorder when an external force is applied to a human or animal. Furthermore, "stress" has extended beyond the academic world and now is used in our everyday language.

If the strength of the force is increased to a certain level, the body and mind will return to normal when the force is relaxed. However, if too much force is applied, the body and mind will break down. The force that strangles the mind and body—the factor that causes stress—is originally defined as a "stressor," but it is also called "stress" in daily life (e.g., "Waiting for you is a stress on me.").

Within the field of medicine, the term "stress" has become more widely used. It has been expanded to include not only stress in animals and humans as living individuals, but also stress at the cellular level and in the components of cells (e.g., "endoplasmic reticulum (ER) stress"). This stress at the cellular level was Hino's first research theme.

He majored in cell biology in graduate school and studied the changes that occur when cells are exposed to heat, a stressor. "When exposed to heat or other stresses, cells synthesize a set of proteins that protect themselves. It has also been shown that these proteins make cells more resistant to subsequent stimuli when cells are first exposed to an acceptable stress," explains Hino. After earning his Ph.D., he observed the changes in cells when they were irradiated. "When skeletal muscle cells were irradiated with ionizing radiation, cytoplasmic autophagy activity was enhanced. It is possible that autophagy[1)] participated in the active removal of damaged area in the cells." These research findings are only at the cellular level and cannot be immediately applied to humans as individuals. However, it is informative to know that cells under stress react in order to survive.

Participation in brain research in the field of psychiatry

Later, Hino started participating in the research on psychiatry, employing the methods he had developed in biology. One of the most popular methods in psychiatry has been psychoanalysis wherein the analyst treats a patient through dialogue. This is because mental activities are very complex, and also because it is difficult to directly analyze the brain of a living person. In recent years, however, psychiatric research based on material evidence has developed further, and is examining donated brains after death.

Hino participated in brain research on schizophrenia for the first time at his previous affiliation, Fukushima Medical University, and has continued the research since arriving at IRIDeS in April 2021. "We have been investigating the characteristics of the brains of patients with schizophrenia at the cellular, molecular, and genetic levels. As a result, we have discovered several proteins, their RNAs, and metabolites, whose expression levels are affected in the brains of patients with schizophrenia. On the other hand, we have also realized that schizophrenia cannot be easily understood through existing methods. I consider that this disease is caused by a complex combination of genetic and environmental factors," says Hino.

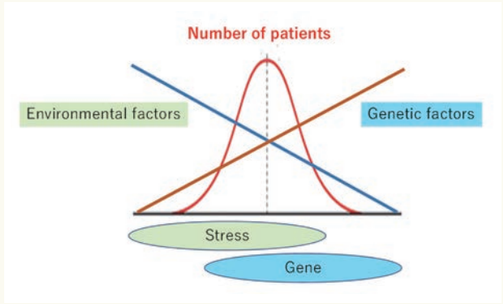
Another challenge is how to decipher the vast amount of data collected on bio-information, including data on the brain. The complete nucleotide sequence of the human gene was determined in 2003, which was realized by a huge project over 13 years involving the United States and six other countries. Today, the same analysis can be conducted in one day, using a single machine and at a much lower cost (100,000 yen). Since most of the data in the entire nucleotide sequence is common to all humans, researchers often extract and study only the gene sequences that characterize an individual. However, the amount of such data is still huge. "For example, with regard to the generic sequences, which characterize an individual, data over hundreds of thousands of items can be easily obtained from just one person. Combining the data with ones of, say, 20 people, the data amount becomes even larger," states Hino.

Based on these results, his research team looks for patterns and characteristics. "In the brains with schizophrenia, we have found characteristics such as a particularly large amount of a certain protein. However, the elimination of this protein does not simply cure schizophrenia. Thus, we should conduct further research, such as looking for the relationship between this result and the other characteristics we found," says Hino. In dealing with huge amounts of data, Hino works with many other researchers including informatics specialists. Mysteries and hints are buried within the huge quantity of data, and when scientists dig something up, further mysteries appear. "With advancement of machines that handle bio-information quantitatively, making use of exhaustive data has recently become an important topic in medicine in general," says Hino.

Considering biological and environmental factors to understand psychiatric disorders

Hino has been conducting research on schizophrenia mainly from biological perspectives, but he points out that environmental factors are also important in addition to genetic aspects. "The degree of how much each of inherited genetic factors and of environmental factors affects the disease onset should vary among individuals. Environmental factors may be reworded as stress," he says. There have been cases where schizophrenia has subsequently increased in places where there was starvation, such as in the Netherlands. People who have been exposed to a great deal of stress during their fetal and childhood years need to be watched carefully, at least until they are about 20 years old when the onset of schizophrenia peaks. Natural disasters, including the Great East Japan Earthquake, also cause a great deal of stress, and thus people who have been affected by them need to be monitored for a long time. This is necessary not only for schizophrenia, but also for mental disorders in general.

In the Disaster Psychiatry Lab where Hino works, Professor Hiroaki Tomita (IRIDeS concurrent) is leading research on social aspects of mental illness from a variety of approaches. Associate Professor Yasuto Kunii, who joined the Lab in 2020, conducted research on the brain with Dr. Hino at Fukushima Medical University where they previously worked. While there, Dr. Kunii also studied inpatients who had to be moved out from psychiatric hospitals in the evacuation zone after the Fukushima Daiichi nuclear accident. One aspect of this study was that it also served to shed light on social factors associated with these patients' evacuation destinations. Referring to the study, Hino suggests that people with mental disorders may face more stress and could become more vulnerable especially in an event of disaster; considering these social aspects as well as biological ones is important also to understand people with mental disorders in a holistic manner and to contribute to improvement of their quality of life.



Factors for schizophrenia (schematic diagram)
There are few cases where the disease is caused only by environmental factors (stress) or only by genetic factors. Both characteristics tend to be involved in the disease development.

About the future

Hino has been conducting research on disaster psychiatry biologically, focusing on the key concept of stress. He hopes to explore other factors further, leading to the development of drugs for schizophrenia. According to Hino, "There are already drugs for schizophrenia, which help many people. At the same time, those drugs do not work well for some people. If the genetic information of schizophrenia will be uncovered more, we may be able to create drugs that are tailor-made for individuals with fewer side effects, helping to restore lost human functions." One of the most important goals of medical science is to conduct research that will lead to a treatment of patients with schizophrenia so they can live again as they did before the disease's onset. Researchers on schizophrenia at the genetic level of the brain now have to deal with a huge amount of new data, but they are also seeing great possibilities for future treatments.

1) Autophagy is a phenomenon in which a cell consumes its own components from within. Dr. Yoshinori Ohsumi was awarded the 2016 Nobel Prize in Physiology or Medicine for this research.

Activities

Activity 01

IRIDeS Friday Forum Focused on "Passing Down Disaster Memories and Diversity"

Assistant Professor Julia Gerster
Disaster Culture and Archive Studies

IRIDeS regularly holds a "Friday Forum" to facilitate exchange among IRIDeS members and non-members and to bolster interdisciplinary research. The forum is usually held on Friday evenings, about five times a year, and involves three or four presenters on a given theme. Because of COVID-19, the forum has been held online since May 2020.

On November 26, 2021, the 75th Friday Forum held was titled "Exploring how to pass down disaster memories: From perspectives of gender and diversity." The three guest speakers included Dr. Sunhee Lee (Assistant Professor, Tohoku University Center for Northeast Asian Studies), Mr. Hiroyasu Yamauchi (Director and Curator, Rias Ark Museum of Art), and Ms. Hikaru Suzuki (former member of the Fukushima Prefectural Soma High School broadcast station). The presenters discussed various aspects of diversity including an analysis of exhibitions at disaster memorial museums, the importance of passing down disaster memories based on the local culture, and the use of gender and diversity in disaster dramas and documentaries.

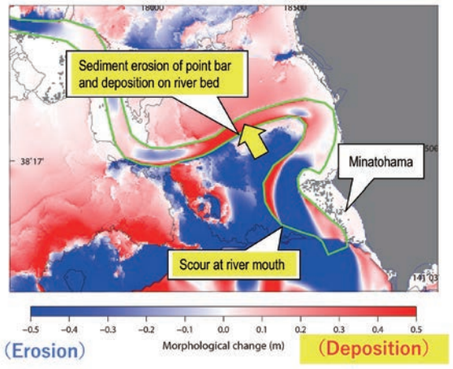
Assistant Professor Julia Gerster of IRIDeS moderated and organized the forum along with other IRIDeS faculty members. "I specialize in cultural anthropology, and one of my research interests is collective memories. Regarding passing down disaster memories and lessons, it is important to consider who is choosing what aspects of memory, and for whom they are passed on. From that perspective, I organized this forum and asked the three guest speakers to share their experiences and thoughts with us," said Dr. Gerster. The forum involved speakers of different ages, genders, nationalities, and professions who discussed their diverse experiences in passing down disaster memories, sharing the possibilities of various activities and challenges. The presentations were followed by a lively question and answer session. Approximately 50 people participated in this forum.

Activity 02

Reconstruction of the 1611 Keicho Oshu Earthquake and Tsunami Around the Tagajo Area

Associate Professor Daisuke Sugawara
Tsunami Engineering Lab

In 1611, a major earthquake and tsunami struck the Pacific coast of Tohoku region. Until recent years, the size of the 1611 earthquake and tsunami was considered similar to that of the 1933 Sanriku Earthquake and Tsunami—a disaster that caused severe damages mainly along the Sanriku Coast of Iwate and Miyagi Prefectures. Thus, the 1611 disaster was named "Keicho Sanriku Earthquake and Tsunami." However, the progress of research, especially after the 2011 Great East Japan Earthquake, revealed that the size of the 1611 earthquake and tsunami was much larger than previously estimated, and its damage extended throughout Oshu, which is the name of ancient province that comprised the Pacific side of Tohoku region. Thus, scientists call it "Keicho Oshu Earthquake and Tsunami" today.



One of the analysis results (from Sugawara's presentation).

On December 4, 2021, a symposium titled "New developments in disaster science guided by history V: Research on the 1611 Keicho Oshu Earthquake and Tsunami integrating arts and science" was held at IRIDeS in a hybrid style that combined face-to-face and online methods. In the symposium where over 200 people participated, 10 researchers from various fields of the humanities and sciences made a presentation on their latest views and findings regarding the 1611 disaster. Associate Professor Daisuke Sugawara of the Tsunami Engineering Lab, IRIDeS, gave a talk regarding numerical modeling of inundations and topographic changes caused by the 1611 Keicho Oshu Earthquake and Tsunami in the area around the ancient Tagajo castle[1], which was achieved by collaborations with experts on cultural heritages, engineering, and earth science.

The outline of Dr. Sugawara's talk was as follows. First, he developed a digital elevation model (DEM) of the past Tagajo area using aerial photographs taken in 1961, at which time anthropogenic modifications of the coast and land had not yet been made. Second, he corrected the DEM, considering present topography, elevations of the paleo-surface of archaeological sites, and findings from historical documents, in order to reconstruct in the most possible detail the paleo-topography of the Tagajo area in the Keicho period. Finally, he analyzed how the 1611 tsunami changed the topography through a numerical modeling of tsunami sediment transport. The results showed that simulated topographic changes and sand deposition well coincide with descriptions in the historical documents and findings from the archaeological surveys.

Sugawara says, "We were able to provide physical explanations that support historians' findings by using the approach of coastal engineering. However, various issues still remain, such as assessment of uncertainty in the reconstructed topography; further research is necessary. We would like to illustrate a clearer view of the 1611 great tsunami. Field surveys and new evidences will be a key for that."

1) Tagajo is an archaeological castle site, located in Tagajo City, Miyagi Prefecture.

Activity 03

Award Ceremony of the 5th Ishinomaki City Reconstruction and Disaster Risk Reduction Map Contest

In the afternoon of January 12, 2022, the award ceremony for the 5th Ishinomaki City Reconstruction and Disaster Risk Reduction Map Contest was held at Ishinomaki City Disaster Risk Reduction Center, Miyagi. Participating in the ceremony was Professor Takeshi Sato of IRIDeS, who chairs the Ishinomaki School Disaster Risk Reduction Promotion Committee. This year, the contest had a total of 97 entries from elementary and junior high schools in Ishinomaki City. At the award ceremony, the Ishinomaki Mayor's Award and other prizes were given to the outstanding works. Dr. Sato awarded the "Tohoku University IRIDeS Special Prize" to two groups: students from the sixth grade of Oyachi Elementary School, and third year pupils from Iinogawa Junior High School.

Elementary and junior high school students in Ishinomaki City started to explore local areas to learn about their reconstruction and disaster risk reduction one year after the 2011 Great East Japan Earthquake, with the cooperation of the Ishinomaki City Board of Education, and they have been working on the maps since then. This activity is based on *The Practical Guide to a "Reconstruction and Disaster Risk Reduction (R-DRR) Mapping"*, which is produced by the International Collaborating Center of Disaster Education Research and Implementation, IRIDeS[2]. The guide describes a method for creating a handmade map by knowing the history and attractive places of a local community as well as reconstruction and disaster risk through information of topographical maps, hazard maps, and interviews with families and local people. Each school has selected its own community-based topic and has been engaged in mapmaking referring to the guide.

In the current Map Contest, the work of Kitakami Elementary School showed the history of tsunamis and the evacuation sites with topographical maps, which was easy to understand, and thus was highly evaluated for the Ishinomaki Mayor's Award. The other prize-winning works were also excellent and focused on tsunamis, floods, nuclear disasters, and landslides. The critique noted the increasing quality of the maps year by year.

However, as Sato says, "The mapmaking activity is not the end goal, but just a means to bridge children with local people, contributing to reconstruction and sustainable community development." Sato and other members of the International Collaborating Center of Disaster Education Research and Implementation of IRIDeS sometimes provide advice to schools and students as needed, but the role of the experts is only subsidiary. The mapmaking activity of each school occurs autonomously.

2) *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*
http://drredu-collabo.sakura.ne.jp/cms/wp-content/uploads/jissen_no_tebiki_en.pdf

Students from Iinogawa Junior High School who received "IRIDeS Special Prize" for the evacuation map in case of nuclear disaster (with Professor Sato at the far-right end).

Information

■ Notice ■

- Please visit the following website for the latest research activities of IRIDeS:
  HP https://irides.tohoku.ac.jp/eng/

The newsletter IRIDeS NEWs will be delivered in a different form beginning the next fiscal year.
We hope you will continue to enjoy our newsletters.

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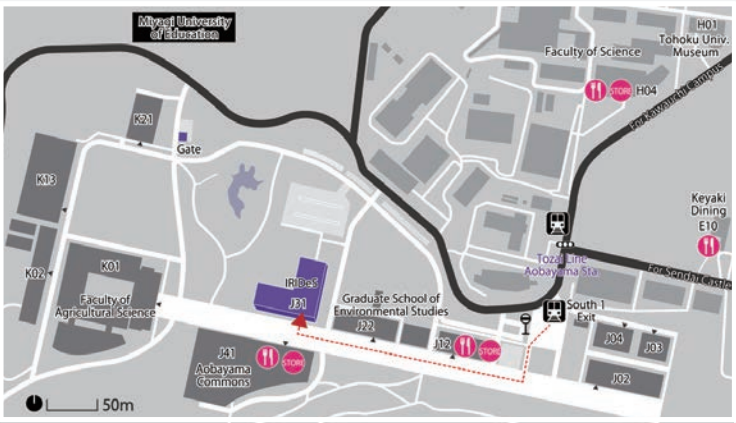

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Editor's Note

We have published IRIDeS NEWs since 2017. The style of our newsletter will be different in the next fiscal year, but we will continue to communicate the diverse IRIDeS research activities in both Japan and overseas. We look forward to your continued support.

(Natsuko Chubachi, IRIDeS Public Relations Office)

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Front cover, upper left: On-deck preparation for a seafloor pressure gauge
Front cover, bottom left: Deploying an autonomous vehicle for satellite-acoustic measurement
Front cover, right: Recovering a seafloor acoustic ranging system
Back cover, upper: Waveform monitoring of undersea acoustic ranging