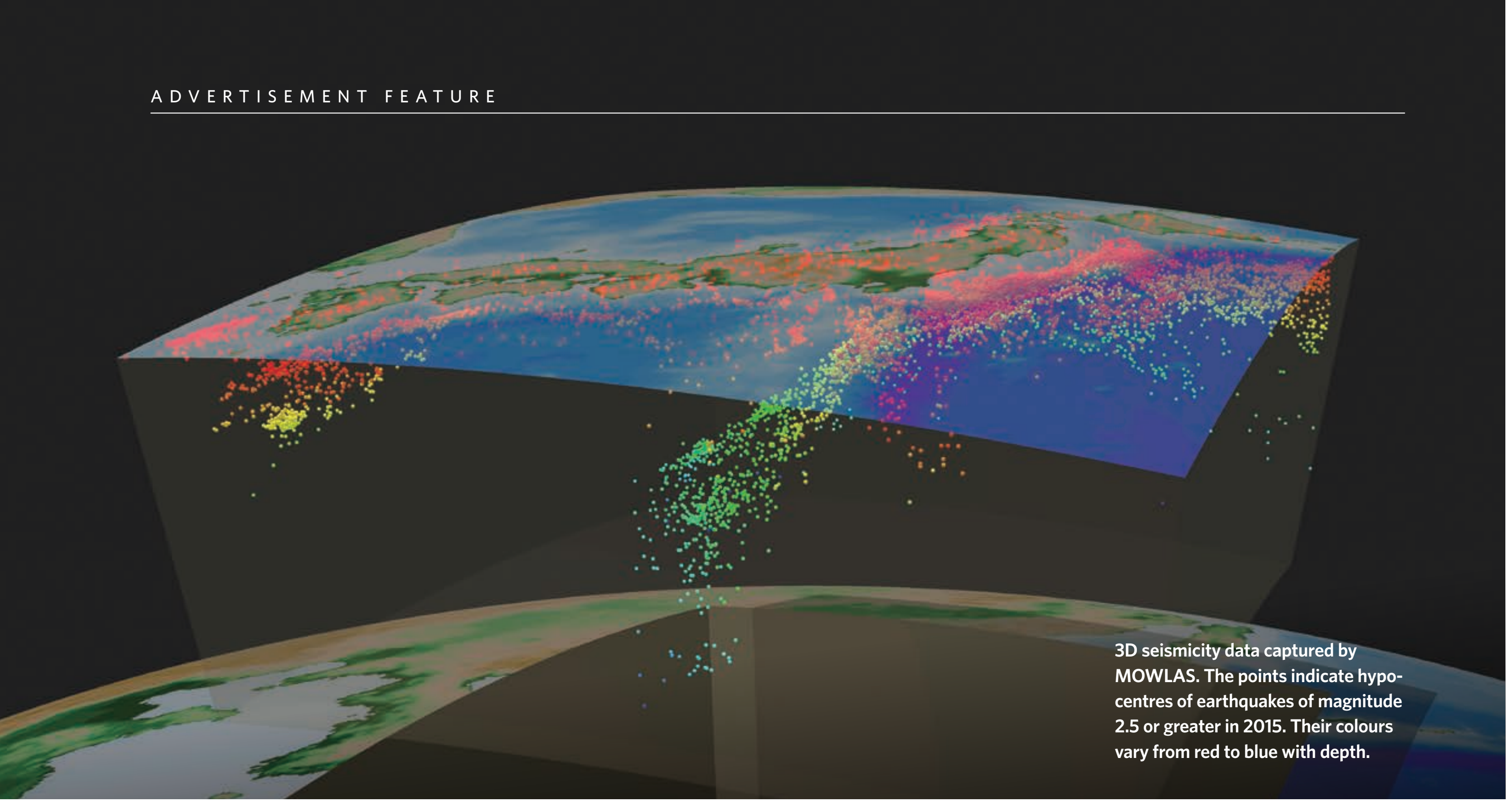


3D seismicity data captured by MOWLAS. The points indicate hypo-centres of earthquakes of magnitude 2.5 or greater in 2015. Their colours vary from red to blue with depth.

MASSIVE MONITORING HELPS PREPARE FOR MEGAQUAKES

THE REAL-TIME DETECTION AND SIMULATION OF NATURAL DISASTERS could reach new heights with new observation networks and better integration of data in Japan.

Within the next 30 years, the southwest coast of Japan is expected to be hit by a magnitude 8–9 earthquake and tsunami originating in the Nankai Trough, a seafloor depression where the Philippine Sea Plate is subducting. There are fears that such an event could take up to 230,000 lives — more than 10 times the number that perished in the tsunami that hit northeastern Japan in 2011.

To help the region become better prepared for such a megaquake, a widespread observation network on the seafloor is being developed.

Called N-net (Nankai Trough Seafloor Observation Network for Earthquakes and Tsunamis), this new observation network will be the latest addition to Monitoring of Waves on Land and Seafloor (MOWLAS), a suite of seven independent observation networks covering the entire Japanese archipelago and its surrounding waters. When combined with insights from other networks within MOWLAS, N-net will enhance the early warning of earthquakes and tsunamis as well as furnish new data on how earthquakes happen.

The integration of data from new sources such as N-net, as well as those owned by government organizations and private companies, is critical for taking disaster risk reduction to the next level, says Kaoru Takara, president of the National Research Institute for Earth Science and Disaster Resilience (NIED), which is based in Tsukuba, about 50 kilometres northeast of Tokyo.

KAORU TAKARA
NIED President

"Natural hazards are becoming more severe, frequent and widespread in Japan. More than ever, society must be prepared to cope with any type of natural hazard in all its phases," Takara says. "Thankfully, new sources of data and advanced computing technologies are accelerating digital transformation in the field of disaster risk reduction."

A SEAMLESS NETWORK

The observation networks comprising MOWLAS form the backbone of Japan's monitoring systems for earthquakes, tsunamis and volcanic eruptions. They include highly sensitive seismographs capable of detecting microearthquakes that are imperceptible to people and strong-motion networks for measuring the intensities of large earthquakes; MOWLAS also has volcano observation networks to monitor eruptions.

MOWLAS has more than 2,100 observation stations. "This comprehensiveness is unrivaled by any other country," notes Shin Aoi, director-general of NIED's Network Center for Earthquake, Tsunami and Volcano.

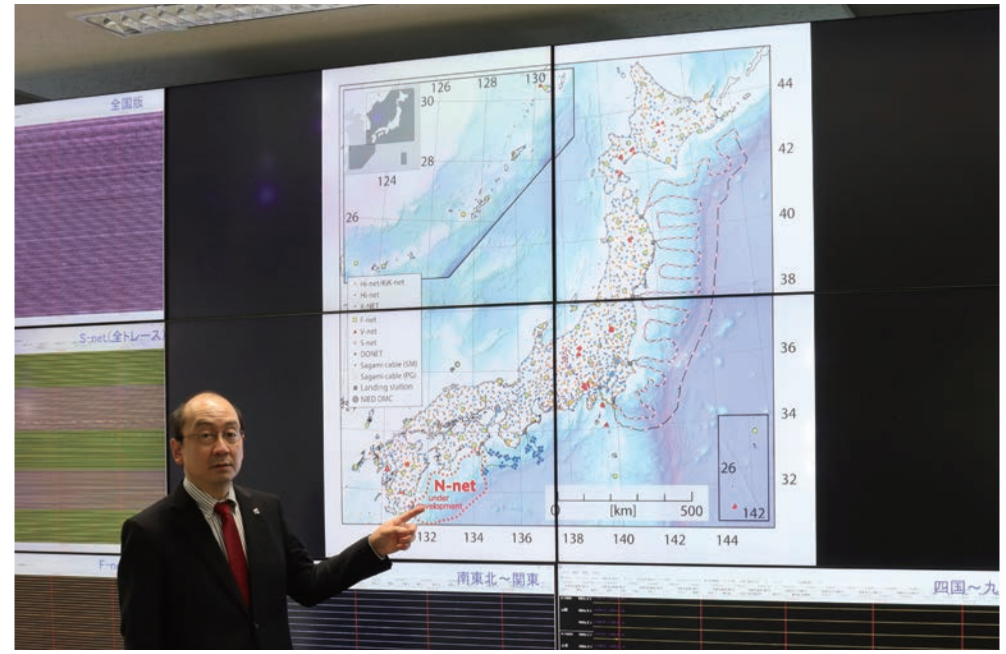
The completion of a seafloor observation network off the Pacific coast of eastern Japan — named S-net (Seafloor observation network for earthquakes and tsunamis along the Japan Trench) and constructed in response to the 2011 Tohoku earthquake and tsunami — boosted MOWLAS's capabilities, as it generates a wealth of ocean data that can be combined with land data.

"The energy of the 2011 earthquake and tsunami was underestimated by a factor of about 40, in part because of the sparsity of observations at sea," says Aoi. "S-net has improved detectability of micro-earthquakes by up to tenfold." S-net data have led to discoveries such as a slow slip along the Japan Trench, and have enabled the early detection of tsunamis that occur in the Pacific Ocean near Japan.

"S-net has demonstrated how valuable it is to establish observation networks in uninhabited areas, because the energy of earthquakes that occur in the ocean propagate to land as seismic waves," explains Aoi. "It's especially important to combine land and ocean data when earthquakes occur in coastal areas. For early warning, the location and magnitude of the earthquake must be estimated in a matter of seconds, so it helps to have land and seafloor networks combined beforehand."

Covering a currently unmonitored region of ocean, N-net will use next-generation systems that combine the strengths of other networks within MOWLAS. Aoi anticipates N-net data will add an extra 20 seconds to earthquake early warning. "Seismologists have been working to gain an extra sub-second extension for early warning," says Aoi. "The fact that we think we can add 20 seconds offers an indication of how groundbreaking this will be," he adds. N-net is also expected to add as much as 20 extra minutes for direct detection of tsunamis.

With new data flowing from N-net, it will become increasingly important to find new ways of processing data in real time so that it can contribute to disaster mitigation. Machine learning is a particularly promising tool for achieving this.



▲ Shin Aoi, director-general of NIED's Network Center for Earthquake, Tsunami and Volcano, indicating the new N-net sensor network on a map showing all of Japan's observation networks.

LUBRICATING DATA SHARING

Just as vital as generating data is the ability to share it easily with different parties when a disaster hits, as the 2011 Tohoku catastrophe illustrated.

"When the Disaster Medical Assistance Team (DMAT) arrived on site, they struggled to send patients to hospitals as they had no information about the extent to which a given hospital, or the roads that lead to it, had been affected," explains Yuichiro Usuda, director-general of the Disaster Information Research Division. "We learned later that other organizations had such information at the time, but that there was no effective way to share it with professionals seeking it."

A NIED project that merges data across organizations is also reshaping the way information is shared in emergency situations. Usuda is leading the development of the Shared Information Platform for Disaster Management (SIP4D), which connects information systems from diverse organizations. SIP4D automatically converts the different data formats used within organizations so that they can be combined for analysis and management of disaster situations.

In one instance, the Information Support Team (ISUT) used SIP4D to merge data from gas providers and municipalities — this revealed evacuation centres without gas and the number of people in each, helping set priorities when dispatching services for enabling people to bathe. In another, they connected data about network outages among major mobile phone carriers and the number of people in evacuation centres to determine base stations that require urgent restoration.

Due to its success, SIP4D was included in the Japanese government's Basic Disaster Management Plan, which outlines the standard protocol for disaster preparedness.

Next-generation tools will draw on SIP4D to create digital twins, or replicas of reality, in cyberspace. A key feature of the tool — called Cyber–Physical Synthesis for Disaster Resilience (CPS4D) — is its ability to run real-time simulations during disaster response.

"During Typhoon Hagibis in 2019, the news showed shocking footage of rivers flooding and bullet trains being submerged in water," says Usuda. "That led to relief efforts being centered in areas with media coverage, despite other communities suffering worse damage."

Were a similar situation to occur in the future, CPS4D could synthesize data on real-time rainfall observations, flooding predictions, and estimated number of people affected to simulate future burden on disaster-relief staff. "This suggests decision-making about where support teams should be sent to," Usuda adds.

In the coming years, Takara plans to make SIP4D and other information products more easily accessible to a wider audience. "Disaster resilience is built together by society," Takara says. "Enhanced usability and awareness of our tools will ultimately make everyone better prepared." ■

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