Fugaku Showcase

Future Living Proposed to the World by RIKEN Center for Computational Science at Expo 2025 Osaka, Kansai, Japan

5/11/2026

RIKEN Center for Computational Science (R-CCS)
Office of the Fugaku Society 5.0 Initiative

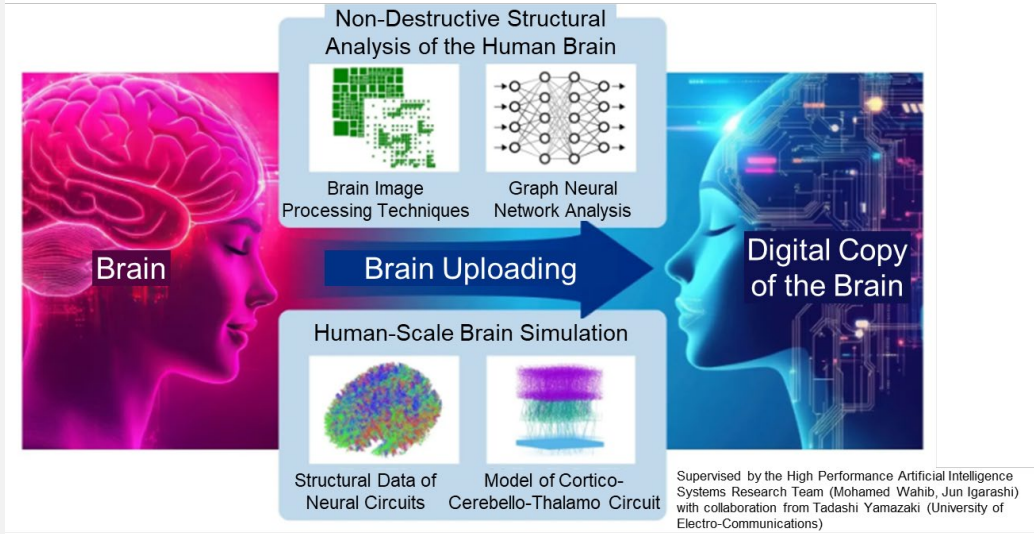
Note: This material was prepared and translated into English at Office of the Fugaku Society 5.0 Initiative with the cooperation of the respective research teams and participating institutions. The organization names, institutional affiliations, and research outcomes presented in these slides reflect the information available at the time of their preparation.

Future Living Proposed to the World by R-CCS at Expo 2025 Osaka, Kansai, Japan

R-CCS conducts cutting-edge research that integrates simulation, big data analytics, and AI through high-performance computing (HPC), aiming to contribute to the resolution of challenges faced by science and society and to foster innovative societal development. A portion of these efforts was showcased at Expo 2025 Osaka, Kansai, Japan.

Support by R-CCS for the Future of Life Signature Pavilion

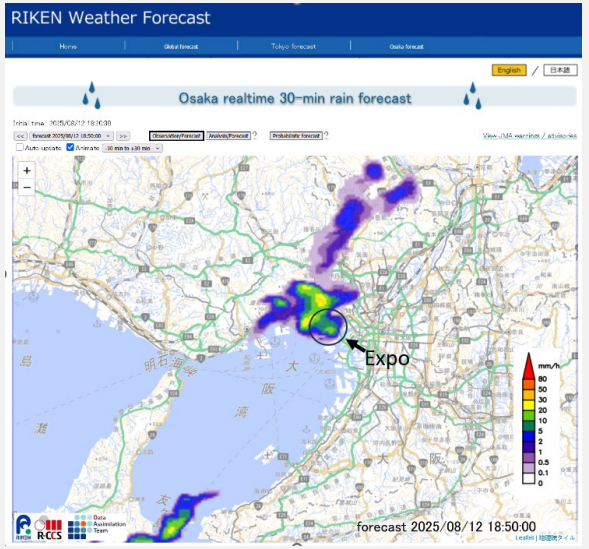
Panel exhibits introduced the “Human Whole-Brain Simulation,” which uses Fugaku to reproduce approximately 86 billion neurons of the human brain on computers in order to elucidate brain function mechanisms, along with the “Human Whole-Brain Analysis,” which investigates how the brain understands information and makes decisions using generative AI and image analysis technologies.



Supervised by the High Performance Artificial Intelligence Systems Research Team (Mohamed Wahib, Jun Igarashi) with collaboration from Tadashi Yamazaki (University of Electro-Communications)

R-CCS Initiatives under the Action Plan for Expo 2025 Osaka, Kansai, Japan, "Demonstration of Analysis and Real-time Distribution of Highly Accurate Data Using Remote Sensing Technology"

A world-first demonstration experiment was conducted on ultra-fast, high-performance real-time precipitation forecasting, predicting sudden torrential rain at the Expo site and surrounding areas every 30 seconds up to 30 minutes ahead, using Fugaku and two next-generation Multi-Parameter Phased Array Weather Radars.



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Support by R-CCS for the Future of Life Signature Pavilion

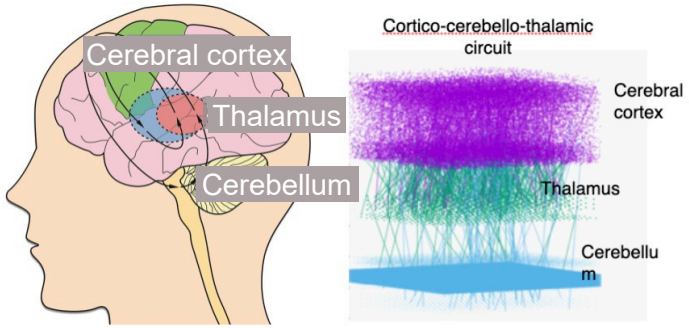
RIKEN Center for Computational Science
High Performance Artificial Intelligence Systems Research Team
Team Principal **Mohamed Wahib**
Senior Research Scientist **Jun Igarashi**

Yamazaki Laboratory, Department of Computer and Network Engineering, Graduate School of Informatics and Engineering, The University of Electro-Communications
Associate Professor **Tadashi Yamazaki**

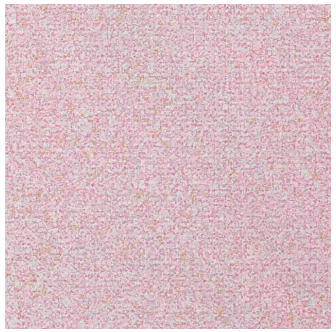
1. Human-Scale Brain Simulation of 86 Billion Neurons Using Fugaku

- Simulating large numbers of neurons on supercomputers is expected to advance our understanding of the brain.
- Simulations of the cerebral cortex, cerebellum, basal ganglia, and other regions using Fugaku, along with the development of brain modeling systems, are enabling research toward understanding the brain through simulations of various animal brains.

Human-Scale Brain Simulation



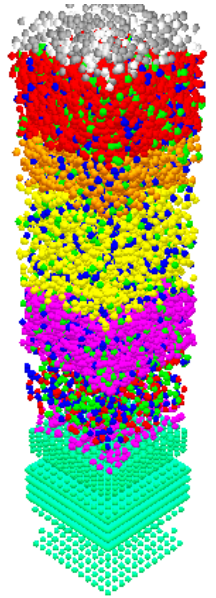
- 45 billion neurons, 35 trillion synapses (world-first human-scale simulation)
- Reproduction of resting-state brain activity corresponding to beta and gamma waves



Visualization of 45 billion neurons in the cerebral cortex, thalamus, and cerebellum
Igarashi et al., 2022, Neuroscience2022

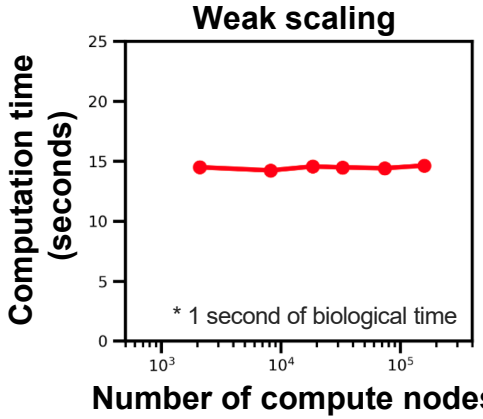
Development of the MONET Simulator to Harness Fugaku Performance
(Igarashi, Yamaura, Yamazaki 2019)

- Tile-based decomposition
- Concurrent execution of computation and communication
- Asynchronous communication for long-distance connections
- Cache blocking



Excellent scaling performance

MONET enables previously impossible human-brain-scale simulations, demonstrating excellent scaling performance (see figure below).



Even when the number of compute nodes required for simulation (x-axis) is increased by orders of magnitude, computation time (y-axis) remains nearly constant. This demonstrates that using MONET on a supercomputer with a large number of compute nodes, such as Fugaku, makes large-scale brain simulations feasible.

2. Large-Scale Image Data Analysis Using Large Language Models and Graph Neural Networks

- Advanced approaches are being developed for high-resolution medical image analysis, including brain imaging.
- High-resolution images contain rich information, requiring accurate segmentation. Traditional methods divide images into fixed-size patches, which imposes limitations.
- At R-CCS, novel methods for leveraging transformer models on supercomputers have been proposed, achieving accelerated processing. These methods are expected to be applicable to other image-processing tasks and domains in the future.

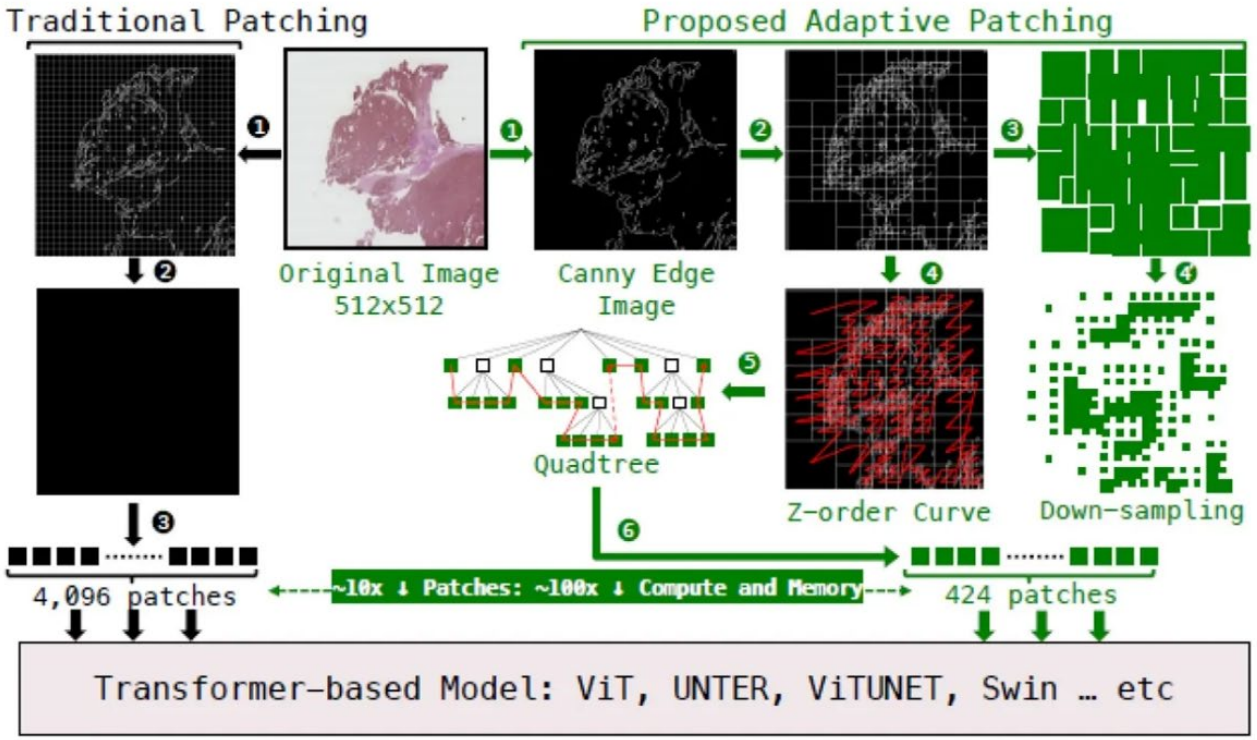
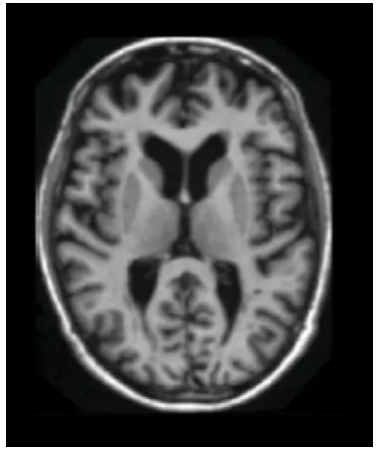


Figure source: Adaptive Patching for High-resolution Image Segmentation with Transformers, Enzhi Zhang et al., arXiv:2404.09707v1 [cs.CV], https://arxiv.org/abs/2404.09707



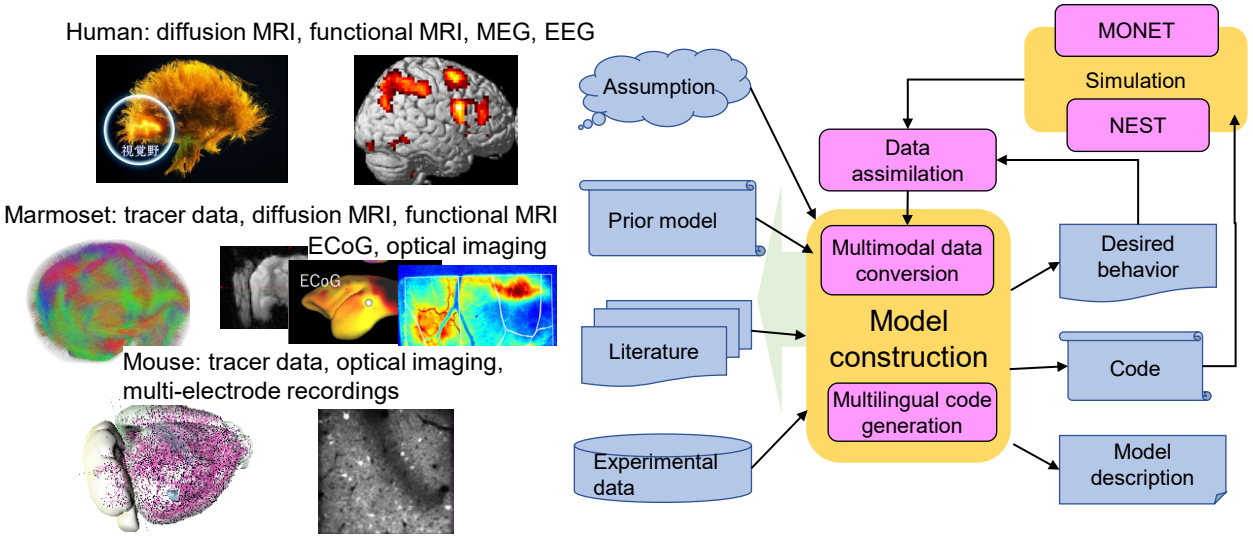
The proposed methods have been applied to high-resolution medical images, including brain images, advancing analysis.

fMRI images provided by Yuankai Huo (Oak Ridge National Laboratory)

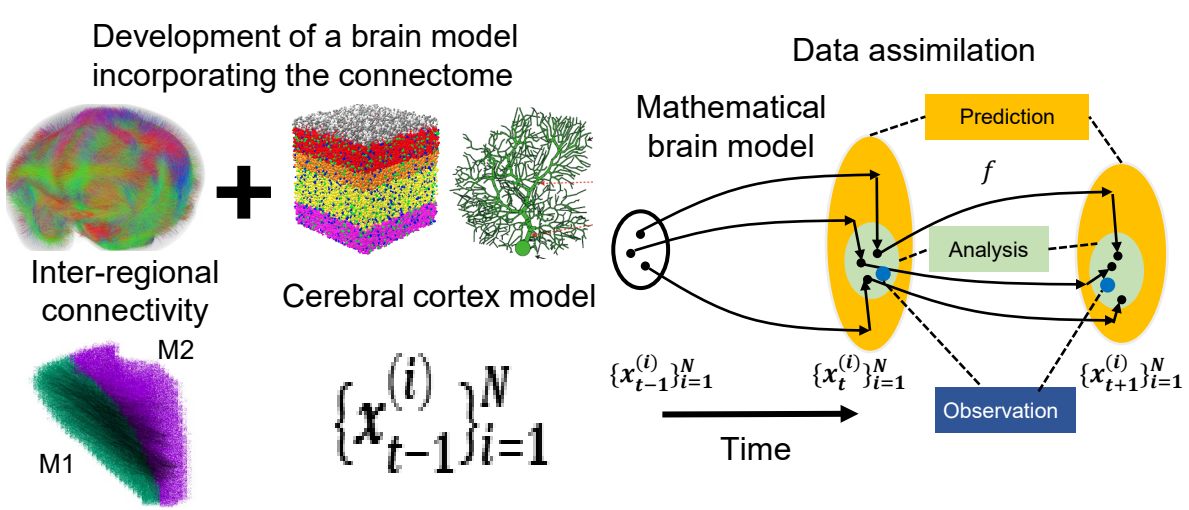
3. Elucidating Human Brain Information Processing Mechanisms Using Digital Twins

- Recent advances in measurement techniques for brain connectivity and neuronal activity have led to an explosive increase in brain data.
- We are constructing digital brains on Fugaku based on mammalian brain data.
- By leveraging data assimilation techniques, we aim to perform more accurate brain simulations to understand brain function and neurological disorders.

Data-Driven Brain Model Construction Framework



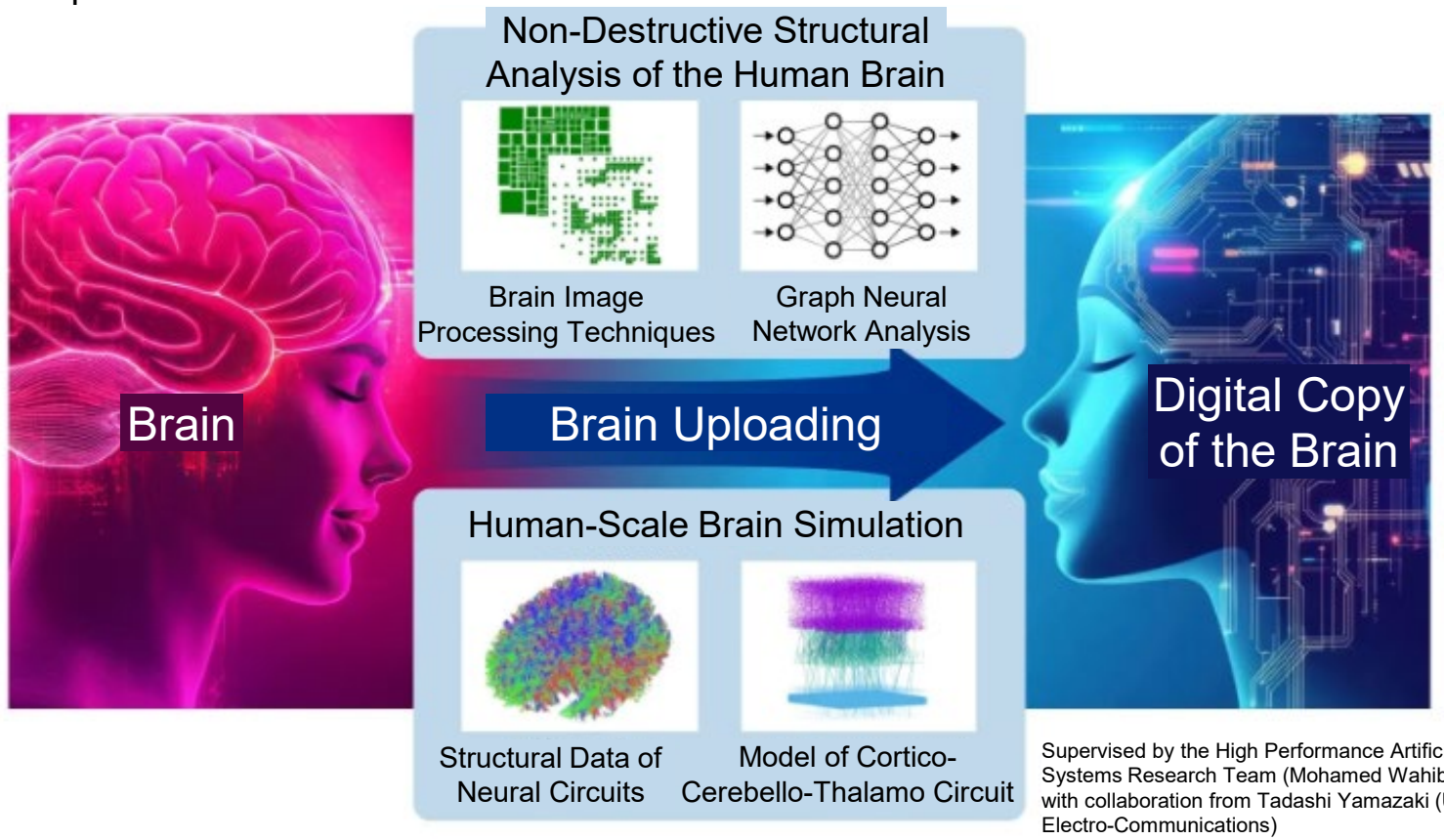
Whole-Brain Simulation and Investigation of Oscillatory Phenomena



Multi-species whole-brain data assimilation using comprehensive measurement information and exploration of specific oscillatory activity, Program for Promoting Research on the Supercomputer Fugaku
(Left figure) Subtask 1, (Right figure) Subtask 2.

4. Artificial General Intelligence Brought Forth by Human Whole Brain Simulation and Analysis - The Future of Creating a Digital Brain - (1/2)

- To develop artificial general intelligence (AGI) capable of flexibly handling a wide range of tasks, analysis of the human brain—the most advanced information processing system—is progressing. Fugaku is used for Human Whole-Brain Simulation, which reproduces 86 billion neurons on a computer while elucidating the mechanisms of brain function. Additionally, Human Whole-Brain Analysis employs generative AI and image analysis techniques to investigate how the brain perceives and makes decisions. These two technologies make it possible to develop AGI with human-like advanced intelligence and energy efficiency. Ultimately, this leads to a future in which a digital copy of the human brain exists in cyberspace.



Supervised by the High Performance Artificial Intelligence Systems Research Team (Mohamed Wahib, Jun Igarashi) with collaboration from Tadashi Yamazaki (University of Electro-Communications)

4. Artificial General Intelligence Brought Forth by Human Whole Brain Simulation and Analysis - The Future of Creating a Digital Brain - (2/2)

“Can We Create a Brain?” [1]

It is predicted that by 2030, whole-brain simulation of the mouse, and by 2040, of non-human primates, will be feasible to investigate the reproducibility of brains.

If whole-brain simulations of mice and non-human primates succeed, a roughly tenfold increase in computing power would enable human whole-brain simulation.

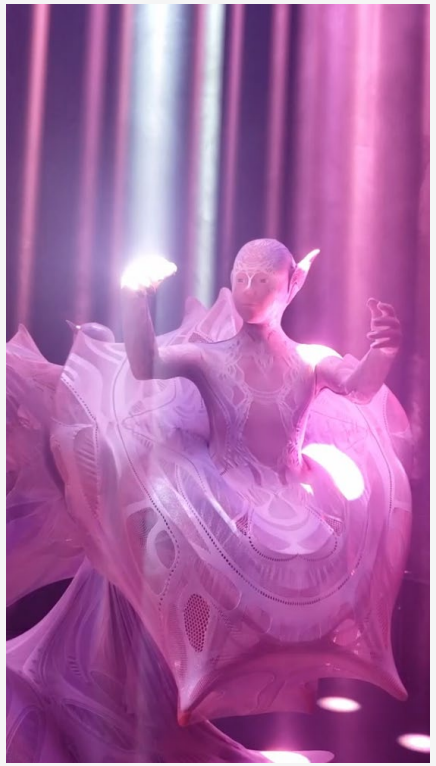
The rapid progress in AI since 2022 is expected to further accelerate the creation of the human brain [2].

[1] J. Igarashi, The Future of Mammalian Whole-brain Simulations Estimated from Technological Trends in Supercomputers and Brain Measurements https://doi.org/10.3902/jnns.28.172

[2] J. Igarashi, Future projections for mammalian whole-brain simulations based on technological trends in related fields, 2024, Neuroscience Research

5. Support by R-CCS for the Future of Life Signature Pavilion

- Since 2022, RIKEN and the University of Electro-Communications have participated in discussions on "Near-Future Technologies" aimed at realizing the world 50 years from now, forming the scientific foundation of the pavilion concept.
- As a result, one of the "Near-Future Technologies"—"Artificial General Intelligence Brought Forth by Human Whole Brain Simulation and Analysis - The Future of Creating a Digital Brain -"—was envisioned as the 50-year-ahead scenario. Panels illustrating this technology were created and exhibited in the pavilion.



Expo 2025 Osaka, Kansai, Japan
Hiroshi Ishiguro
The Future of Life signature pavilion

A family drama set in a society where brain and mind information can be transferred to robots

RIKEN and the University of Electro-Communications participated in discussions on the scientific basis of the concept

- Brain measurement technologies
- Construction of digital brains
- Integration into robots

R-CCS Initiatives under the Action Plan for Expo 2025 Osaka, Kansai, Japan, "Demonstration of Analysis and Real-time Distribution of Highly Accurate Data Using Remote Sensing Technology"

RIKEN Center for Computational Science

Data Assimilation Research Team

Team Principal	Takemasa Miyoshi
Senior Research Scientist	Shigenori Otsuka
Research Scientist	James Taylor
Research Scientist	Arata Amemiya
Postdoctoral Researcher	Yuta Tarumi

Computational Climate Science Research Team

Team Principal	Hirofumi Tomita
Senior Research Scientist	Seiya Nishizawa

Operations and Computer Technologies Division

Deputy Division Director	Yuji Iguchi

Advanced Operation Technologies Unit

Unit Leader	Keiji Yamamoto

Data Integration Technology Unit

Unit Leader	Toshihiko Kai

Software Development Technology Unit

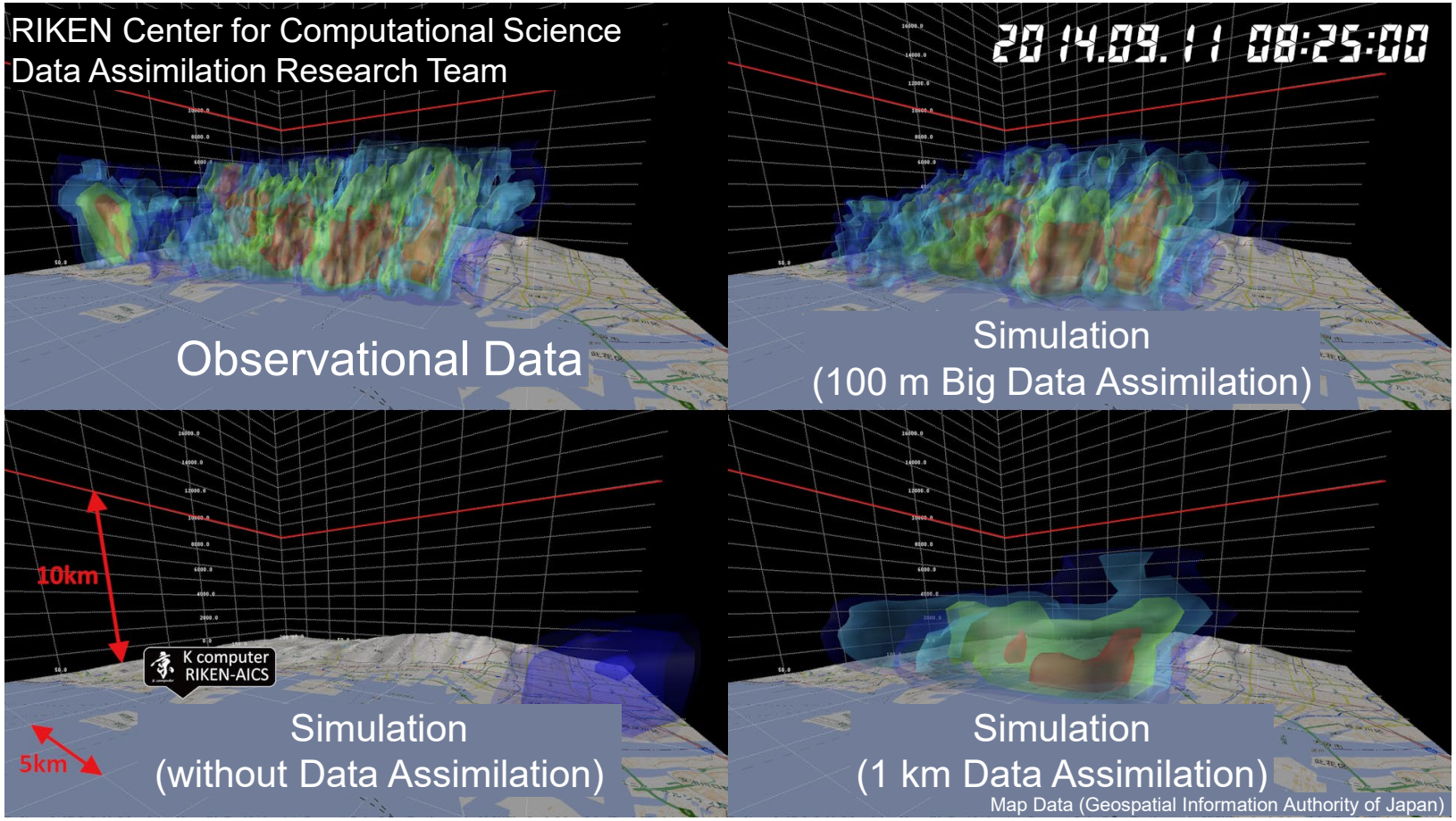
Senior Technical Scientist	Yoshifumi Nakamura

System Operations and Development Unit

Technical Scientist	Mitsuo Okamoto

1. Sudden Torrential Rain Forecast Method with 30-Second Updates

- Sudden torrential rain is a serious threat, as conditions can change drastically within just five or ten minutes, making advance prediction and preparation extremely difficult. In 2016, Team Leader Takemasa Miyoshi and colleagues developed a pioneering “sudden torrential rain forecast method” capable of forecasting weather up to 30 minutes ahead at 100-meter spatial resolution, updated every 30 seconds—a scale unprecedented in both space and time.



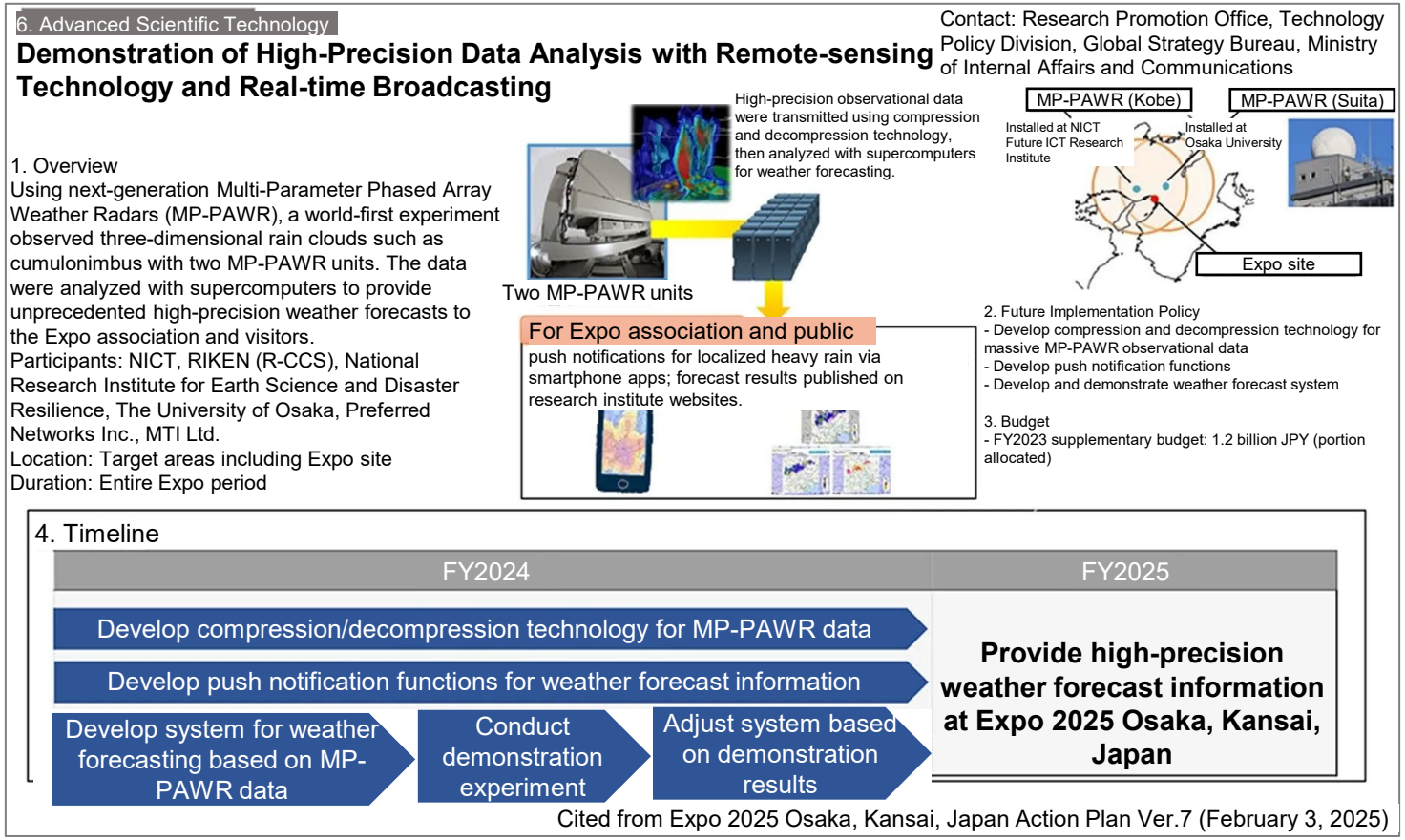
2. Weather Prediction Revolution Pioneered by the Supercomputers K Computer and Fugaku

- To address the growing threat of heavy rain disasters, we have revolutionized weather forecasting through "Big Data Assimilation," which combines vast sensor-derived datasets with large-scale simulations on next-generation supercomputers.

Integration of Big Data and Large-Scale Simulation

3. The World's First Demonstration at Expo 2025 Osaka, Kansai, Japan

- As part of the Action Plan for Expo 2025 Osaka, Kansai, Japan, "Demonstration of Analysis and Real-time Distribution of Highly Accurate Data Using Remote Sensing Technology," a world-first demonstration was conducted using Fugaku and two state-of-the-art Multi-Parameter Phased Array Weather Radars (MP-PAWR) to perform ultra-fast, high-precision real-time forecasting in the Kansai region, including the Expo site.
- Weather radars can experience "rainfall attenuation," where heavy rain obscures the rain behind it. Using two radars mitigates this effect, allowing rain behind heavy precipitation to be detected. Furthermore, accurate wind information improves the precision of rainfall forecasts.



Cited from Expo 2025 Osaka, Kansai, Japan Action Plan Ver.7 (February 3, 2025)

4. Contribution to “A laboratory for a future society” demonstrated by Expo 2025 Osaka, Kansai, Japan

- In the demonstration experiment, to forecast sudden torrential rain occurring within 5–10 minutes ("guerrilla downpours"), approximately 17% of Fugaku’s computing resources were exclusively used to produce 30-minute-ahead forecasts at 500-meter resolution, updated every 30 seconds. The forecast data obtained from the demonstration were published on RIKEN Weather Forecast webpage and on MTI Ltd.’s smartphone app "3D Amagumo Weather" during the Expo period (August 5–31), under a license for forecasting services according to the Meteorological Service Act. Through the Action Plan for Expo 2025 Osaka, Kansai, Japan, RIKEN contributed to the Expo.

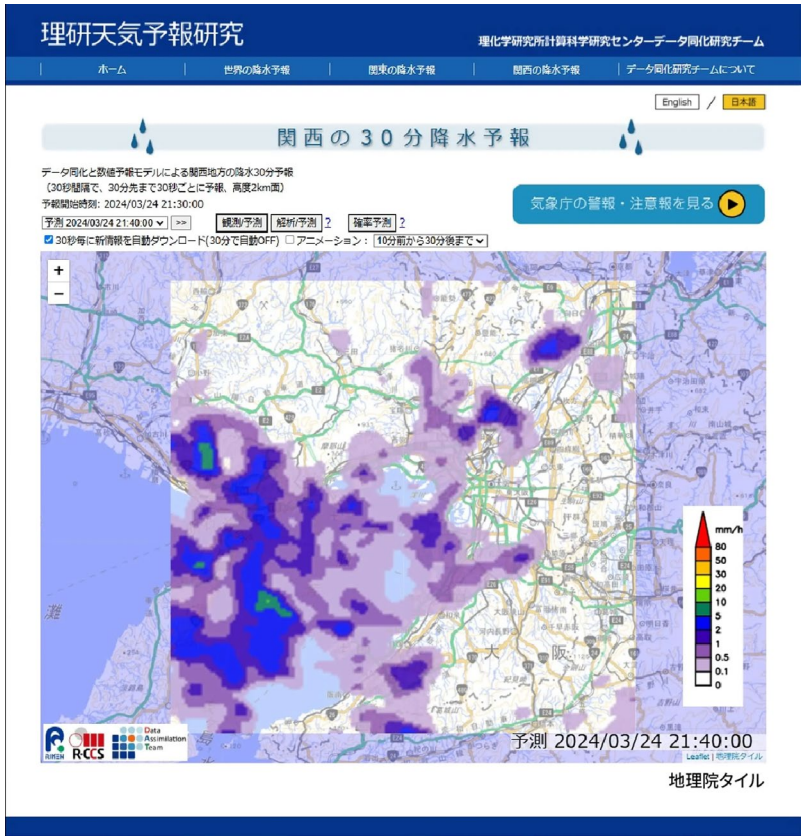


Image of RIKEN Weather Forecast webpage

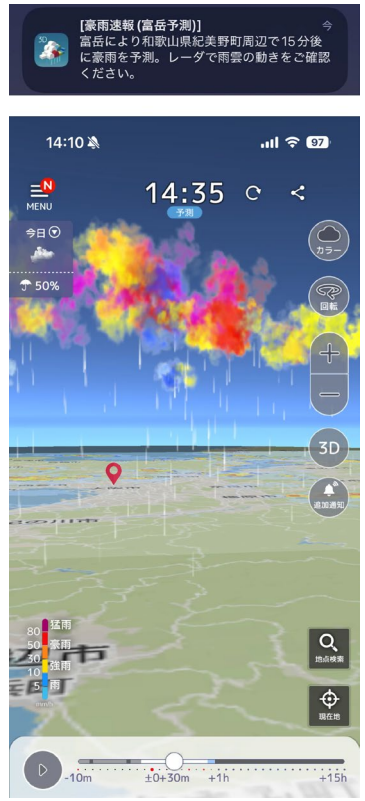


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Image of the smartphone application

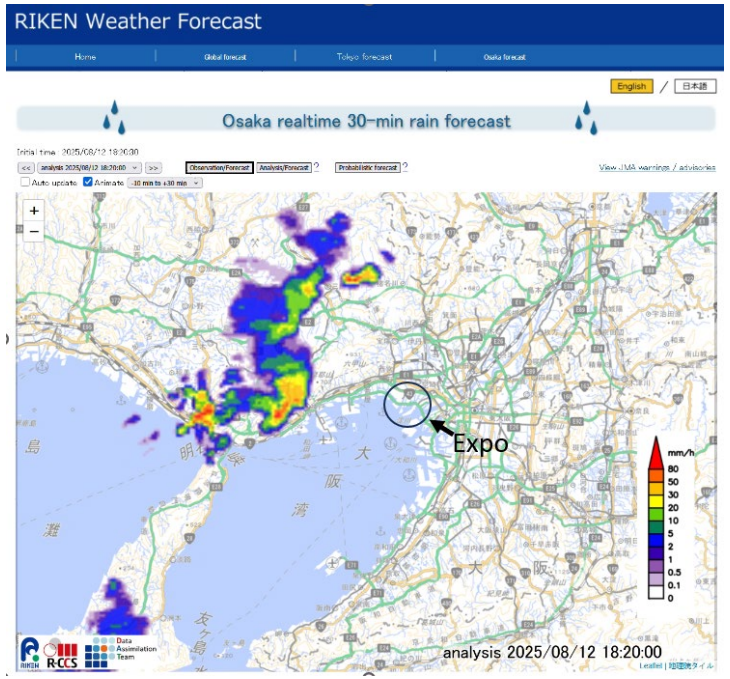
5. Results of the Demonstration Experiment

- During the demonstration experiment period, multiple instances of localized heavy rainfall were successfully predicted with high accuracy. The forecast information was promptly delivered to the Expo Association and visitors via RIKEN Weather Forecast webpage and push notifications on the smartphone app.

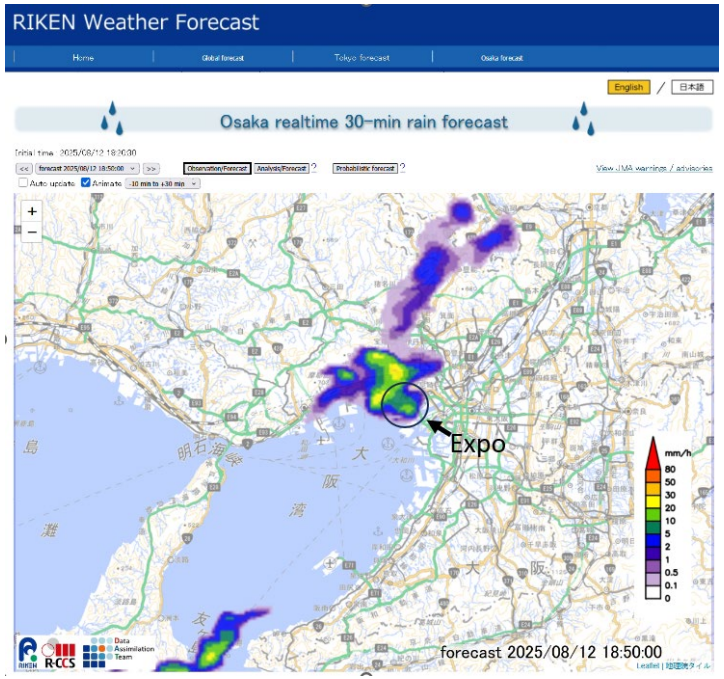
[Observation/Forecast Example: On August 12, 2025, at 18:20, a 30-minute-ahead forecast predicted localized heavy rainfall.]

Example of forecast delivery on the RIKEN Weather Forecast webpage

Observation at 18:20

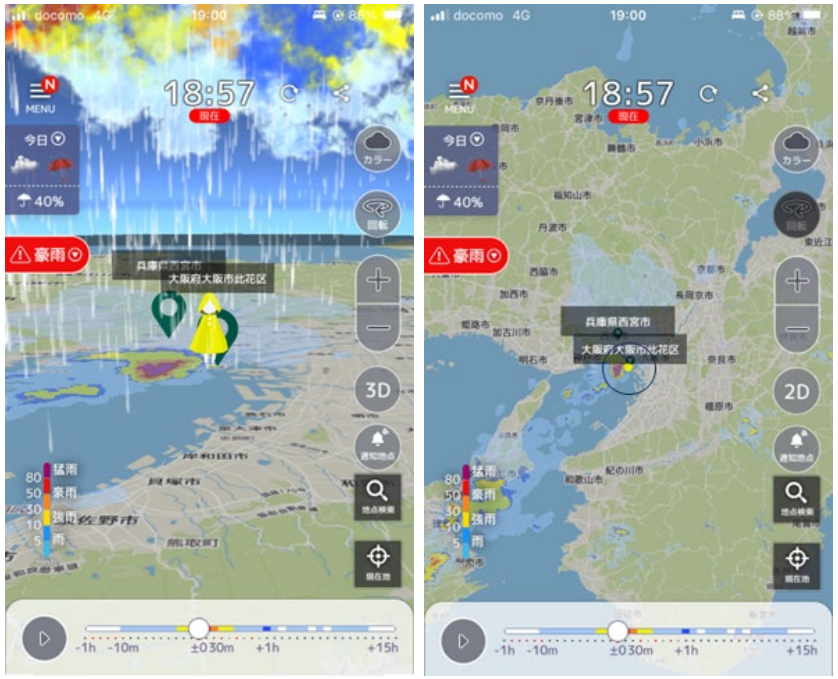


30-minute-ahead forecast at 18:20



Rapid eastward movement of a band of cumulonimbus clouds producing rainfall exceeding 80 mm/hour was predicted

Smartphone screen shot of 3D rain cloud watch app showing rain at Osaka Expo site (circled)



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Forecast information delivered with 3D rendering and push notifications