



Real-time Lightning 3D Imaging and Forecasting Project for Sustainable and Reliable Supply of Energy and Storm Disaster Early Warning

~High-resolution electromagnetic lightning observation network in various frequency range~

Takeshi Morimoto*⁽¹⁾, Mohd Riduan Ahmad⁽²⁾, Farah Hani Nordin⁽³⁾, Manabu Akita⁽⁴⁾, Yuji Takayanagi⁽¹⁾, Muhammad Haziq Mohammad Sabri^(1, 2), Daohong Wang⁽⁵⁾, Takeshi Kudo⁽⁶⁾, Kazuo Yamamoto⁽⁷⁾, Tatsuo Torii⁽⁸⁾, and Zafri Baharuddin⁽³⁾

(1) Kindai University, Osaka, Japan; e-mail: morimoto@ele.kindai.ac.jp

(2) Universiti Teknikal Malaysia Melaka, Melaka, Malaysia (3) Universiti Tenaga Nasional, Selangor, Malaysia (4) University of Electro-Communications, Tokyo, Japan (5) Gifu University, Gifu, Japan (6) Otowa Electric Co., Ltd., Hyogo, Japan (7) Chubu University, Aichi, Japan (8) University of Fukui, Fukui, Japan

Lightning is a major natural phenomenon that poses risks to electrical infrastructure, public safety, and economic activities. The west coast of the Malay Peninsula, particularly the Malacca Strait region, experiences intense lightning activity with over 200 thunderstorm days annually. This results in power outages, infrastructure damage, and increased vulnerability to severe weather events. Addressing this issue, an international collaborative research project was launched under the Science and Technology Research Partnership for Sustainable Development (SATREPS) program. The project's objective is to enhance real-time lightning forecasting and mitigation strategies through advanced observation networks and artificial intelligence (AI)-based predictive modeling.

The project, initiated in June 2023 as a five-year collaboration between Japan and Malaysia, focuses on the following key aspects:

- Establishing a high-resolution lightning observation network
 - Conducting real-time 3D imaging of lightning discharge processes and charge structures in thunderclouds
 - Developing short-term lightning risk forecasting methods and implementing early warning.

A comprehensive electromagnetic field observation network has been established, consisting of:

- Low-frequency (LF) and very-high-frequency (VHF) electromagnetic sensors
- High-speed optical and gamma-ray detectors
- Electric field mills and Rogowski coils to improve charge distribution analysis
- Artificially triggered lightning (RTL) experiments to study lightning initiation mechanisms

The collected data is processed using advanced algorithms to reconstruct 3D lightning channel structures. The algorithm to estimate charge distributions inside thunderclouds that can operate in real-time is being developed with a spatial resolution of approximately 500 meters.

These methods enable real-time monitoring of lightning activity, allowing for early warnings of severe weather events such as flash floods and hailstorms. Additionally, IoT-based control systems are being designed to enhance the resilience of power infrastructure by preemptively mitigating lightning-induced failures. The project aims to translate its research outcomes into practical solutions, including:

- A real-time lightning nowcasting system integrated with power grid management
- AI-driven automatic power switching devices to prevent voltage instability
- Collaboration with meteorological agencies to enhance weather forecasting capabilities

This SATREPS project represents a significant step toward mitigating lightning-related risks in Malaysia and beyond. By leveraging cutting-edge technologies and international collaboration, it aims to improve energy reliability, enhance disaster preparedness, and contribute to the broader field of atmospheric science. The results of this research will provide valuable insights for both academia and industry, fostering long-term advancements in lightning forecasting and protection systems.

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