Proactive Environment Adaptation Technology for Living Safely and Securely

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Abstract

Changes in the Earth's environment are expected to have a significant impact on our social life. In this article, environmental adaptation technologies (technology to develop a platform for collecting and analyzing all types of information on the Earth, meteorological forecasting/control technology, lightning control technology, and electromagnetic barrier technology) for predicting various effects of changes in the Earth's environment, responding to such effects proactively, and achieving a resilient society by enabling humans to adapt to such changes are introduced.

Keywords: resilience, weather prediction, cosmic rays

1. Introduction

The frequency of extreme weather*1 has increased around the world [1]. In Japan, heavy rains and typhoons are common extreme-weather events but are difficult to observe and predict, causing severe damage. For this reason, highly accurate weather forecasting is important. Weather-forecasting technology has made significant progress from technology based on the experience and subjectivity of forecasting engineers to observation technology such as weather radar and numerical analysis using supercomputers. However, typhoon predictions, especially regarding intensity, are still done using satellite photographs.

Meteorological observations are carried out on a regular basis using an observation and forecasting system that uses observation data from land and sea on a global scale as well as from space. Since it takes only about 15 minutes from cumulonimbus formation to maturity and fluctuation occurs rapidly within a limited area of several square kilometers [2], observations, such as with satellites and AMeDAS (Automatic Meteorological Data Acquisition System), are not sufficient to respond to such extreme weather.

The rise in sea-surface temperature due to global warming and the meandering of mid-latitude westerlies increase the water vapor supply to typhoons [3]. Such climate change is caused by human activities as well as natural climate change of the Earth over the long term [4]. Examining, understanding, and diagnosing the state of the Earth's climate is crucial to the long-term prediction of climate change and the implementation of policies to curb the effects of anthropogenic causes. Wide-area observations are needed to assess the state of the Earth's climate. Such observations can be carried out using satellites, but there is a problem regarding observation accuracy (vertical components of the atmosphere, observation below the sea surface, etc.).

Therefore, we are investigating the technologies described in this article for making high-precision predictions on changes in the global environment, such as extreme weather and climate change, and making the impact less severe by implementing countermeasures in advance.

*1 Extreme weather: A phenomenon that exceeds a specific index, such as extremely high or low temperatures or heavy rain.

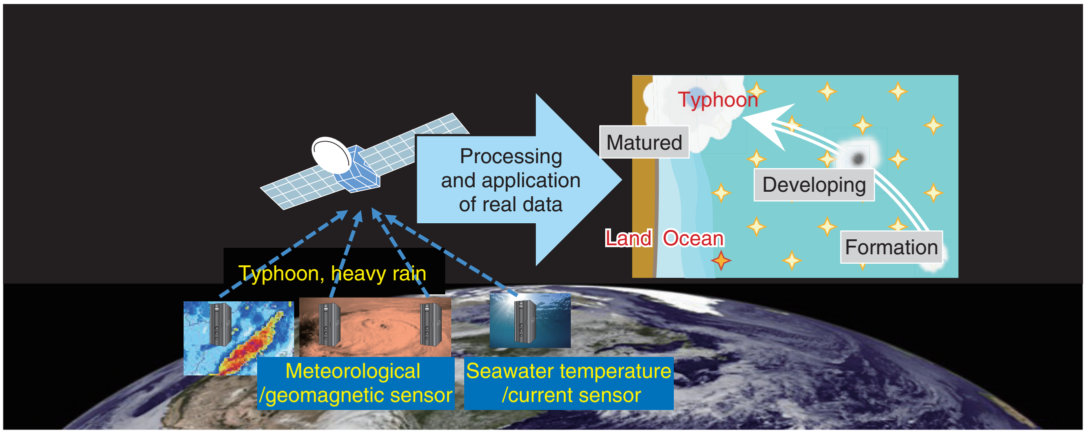

Fig. 1. Image of Earth-information analysis using satellite IoT platform.

2. Technology to develop a platform for collecting and analyzing all types of information on the Earth

We are conducting studies on predicting weather and disasters in real time and with high accuracy by making extensive use of information from areas that have not been extensively observed such as the sea surface, underwater, and mountains. NTT's proposal of "In-orbit demonstration of 920 MHz band satellite Internet of Things (IoT) platform utilizing satellite multiple-input and multiple-output (MIMO) technology" was selected as an innovative satellite-technology demonstration theme by the Japan Aerospace Exploration Agency (JAXA) in May 2020 [5]. In this demonstration theme, we are currently investigating a system to cover areas where information cannot be collected using terrestrial communication infrastructure.

This system is a new sensor-network system that simultaneously acquires information from various IoT sensors on the ground with satellites over 550 km above the Earth then bundles, transmits, and analyzes it on the ground.

With this system, IoT sensors can be installed at desired positions to enable detailed meteorological observations for data acquisition and data assimilation[*2], which will enable predicting extreme weather that changes drastically, such as local heavy rains and typhoons (**Fig. 1**).

3. Meteorological forecasting and control technology

We will collect meteorological information by using the basic technology of Earth information analysis, construct a digital twin[*3] of meteorological phenomena of the whole Earth from the data, and enable the simulation of meteorological prediction and meteorological control on a digital twin.

In meteorological forecasting, we will investigate how to enable high-precision meteorological observation. In particular, we are designing a system for observing meteorological data and measuring data related to typhoons from the ocean and air. We will also study typhoon weather models in collaboration with universities.

We now discuss typhoons and lightning as examples of weather control. Regarding typhoon control, we are studying technologies such as for lowering the temperature of the nearby sea by exchanging water masses in the deep sea and shallow water to weaken the force of a typhoon and a technology for converting the energy of a typhoon into electricity (**Fig. 2**).

Regarding lightning control, we are developing a technology that guides lightning strikes to a safe

*2 Data assimilation: This is mainly done in Earth science to improve the reproducibility of numerical models. Simply put, it involves inputting actual observation data into a model to obtain more realistic results.

*3 Digital twin: A technology that reproduces various data collected from the real world on a computer as if they were twins. It is possible to conduct physical simulations that are as close to reality as possible from the enormous amount of data collected, which is an effective means for further improving the manufacturing process and services of products.

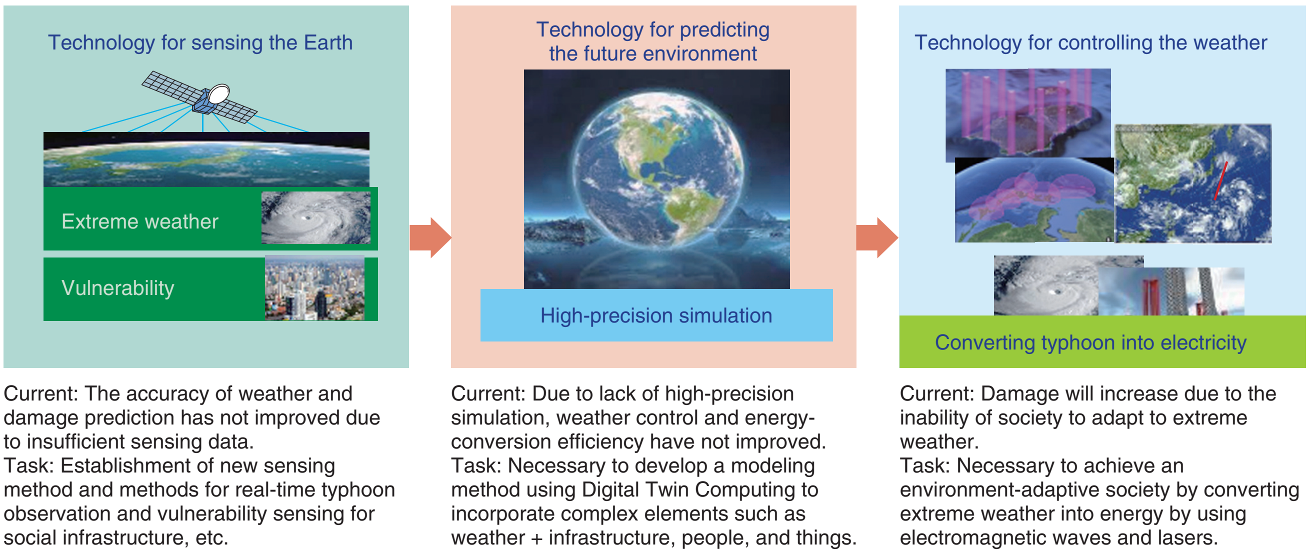

Fig. 2. Overview of weather prediction and control technology.

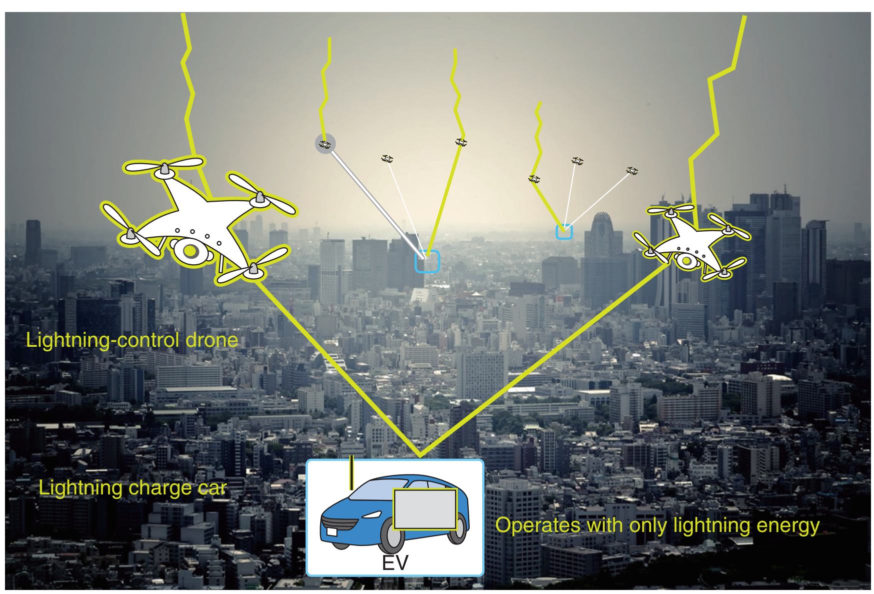

Fig. 3. Image of lightning control and lightning charging system using drone.

place using an air vehicle, such as a drone, with functionality to maintain flight even if it is struck by lightning, as shown in **Fig. 3**. **Figure 4** shows photographs of a drone with a grid-like Faraday cage*4 attached to it at the moment of a lightning strike that continued to fly and of the same model without the Faraday cage, which lost control after being struck by lightning and crashed. This confirms that the drone with the Faraday cage had high lightning resistance. We will also consider methods, such as that illustrated in Fig. 3, for collecting and using lightning energy and construct

*4 Faraday cage: A space surrounded by conductors, or a conductor cage or vessel used to create such a space. Since electric lines of force cannot enter the space surrounded by conductors, the external electric field is blocked and all the internal potentials are equal. It is also called a Faraday shield.

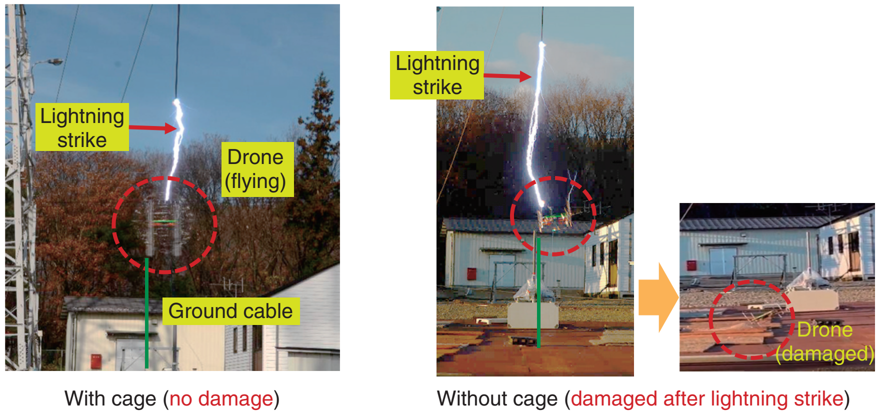

Fig. 4. Drone lightning-strike performance test (effectiveness of Faraday cage).

a lightning-control system for charging electric vehicles (EVs) that operate autonomously using only lightning energy to achieve a safe and secure society.

4. Electromagnetic barrier technology

The Proactive Environmental Adaptation Technology Group is also engaged in research and development for technologies that will innovate the future of society and the environment from a space perspective. For humans to advance into space, create living spaces, and live for a long time in space, the impact of powerful cosmic rays[*5] from the sun and other stars on the human body and precision equipment must be reduced. Therefore, we are investigating the evaluation of cosmic rays and the development of barrier technology to reduce their impact.

The impact of cosmic rays on the ground is mainly derived from neutrons, but in space, protons are the main source. Since protons have an electric charge, they can form an electromagnetic barrier (**Fig. 5**) that blocks and refracts cosmic rays with strong magnetic and electric fields.

Verification in space is required to study this technology, but it is not easy to transport experimental materials into space. Therefore, we are developing a technology for designing electromagnetic barriers in virtual space by digitally twinning spacecraft, space stations, and lunar bases in cyberspace. To do this, we will first conduct simple experiments and simulations using a proton accelerator.

If this research progresses, not only will we be able to live in space for a long time but manned planetary exploration and lunar bases will no longer be dreams. It will also be possible to build an ultra-high security and highly reliable datacenter in outer space.

5. Conclusion

We are developing an IoT network platform using satellite MIMO to carry out more detailed weather observations to make highly precise predictions and take countermeasures regarding extreme weather and climate change, which are expected to have a greater impact in the future. We will develop a weather-prediction technology that uses analysis data from digital twins and work on achieving the goal of prediction/control of extreme weather. We will also study electromagnetic barriers that block and refract cosmic rays and create an environment where people can safely and securely live and work in space.

*5 Cosmic rays: High-energy radiation that travels through space. The main component of cosmic rays is protons, which originate from the sun and other stars. There is concern about the effects on electronic devices and living organisms due to long-term cosmic ray exposure.

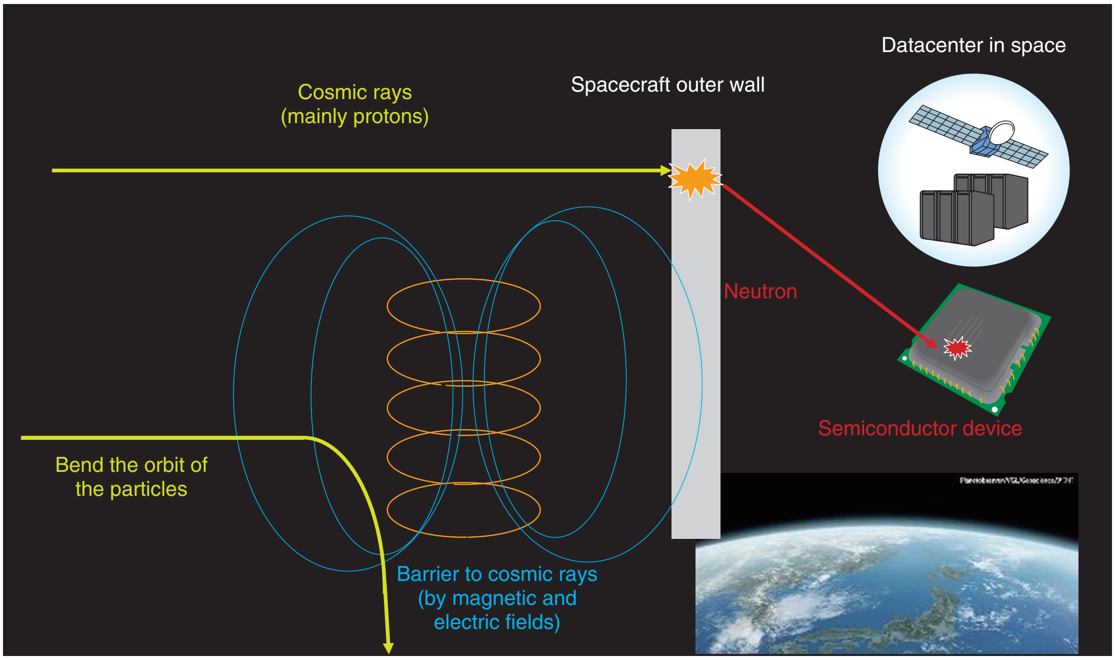

Fig. 5. Electromagnetic barrier system in space.

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