国立研究開発法人
情報通信研究機構

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Science and Technical Sub Committee
Committee on the Peaceful Uses of Outer Space (UN/COPUOS)

# Update of Japanese Activities for Operational Space Weather Services

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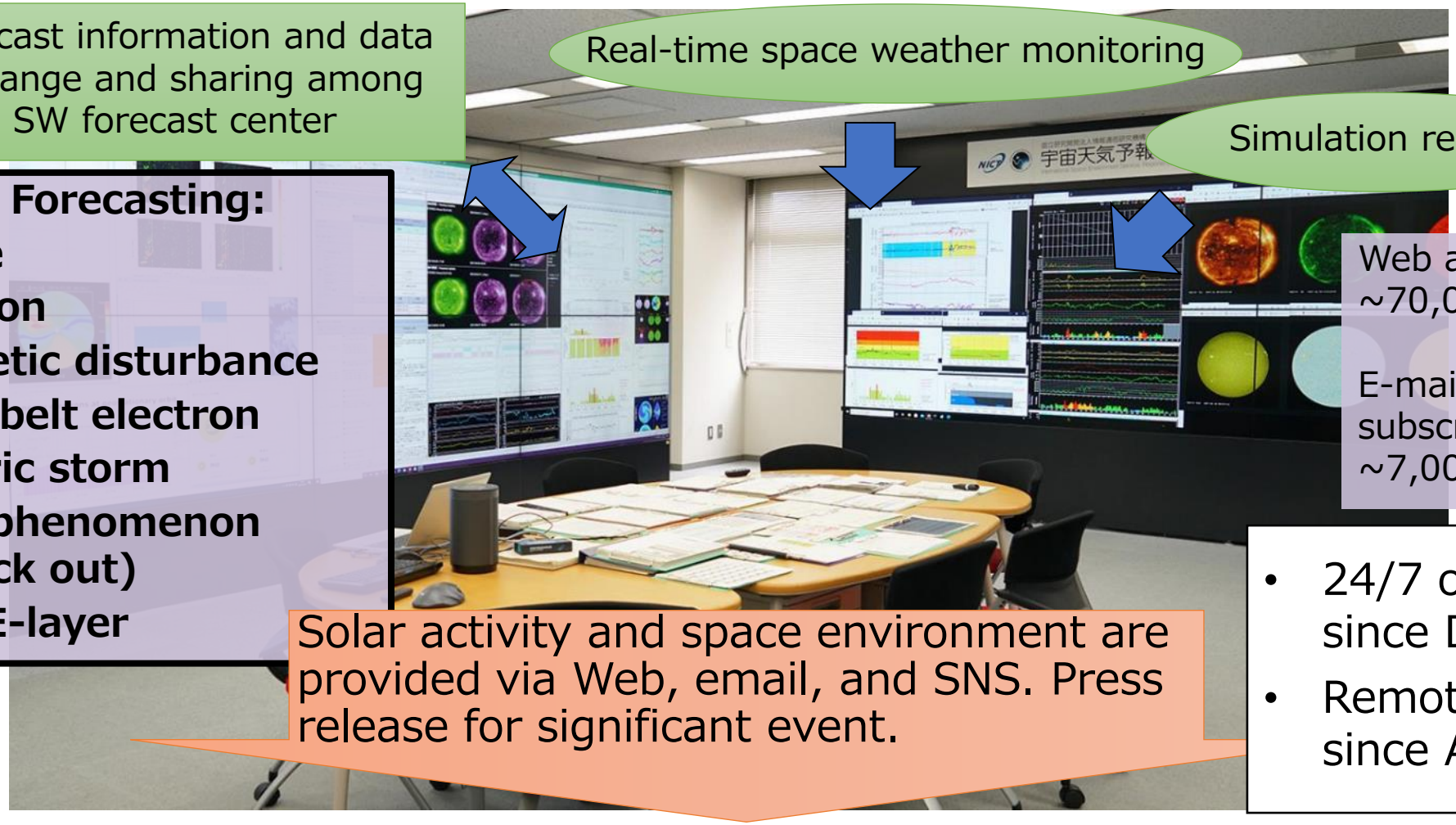
# NICT Space Weather Operation

Forecast information and data exchange and sharing among ISES SW forecast center

Real-time space weather monitoring

Simulation results



**Contents of Forecasting:**

- **Solar flare**
- **Solar proton**
- **Geomagnetic disturbance**
- **Radiation belt electron**
- **Ionospheric storm**
- **Dellinger phenomenon (radio black out)**
- **Sporadic E-layer**

Web access: ~70,000/month

E-mail subscribers : ~7,000

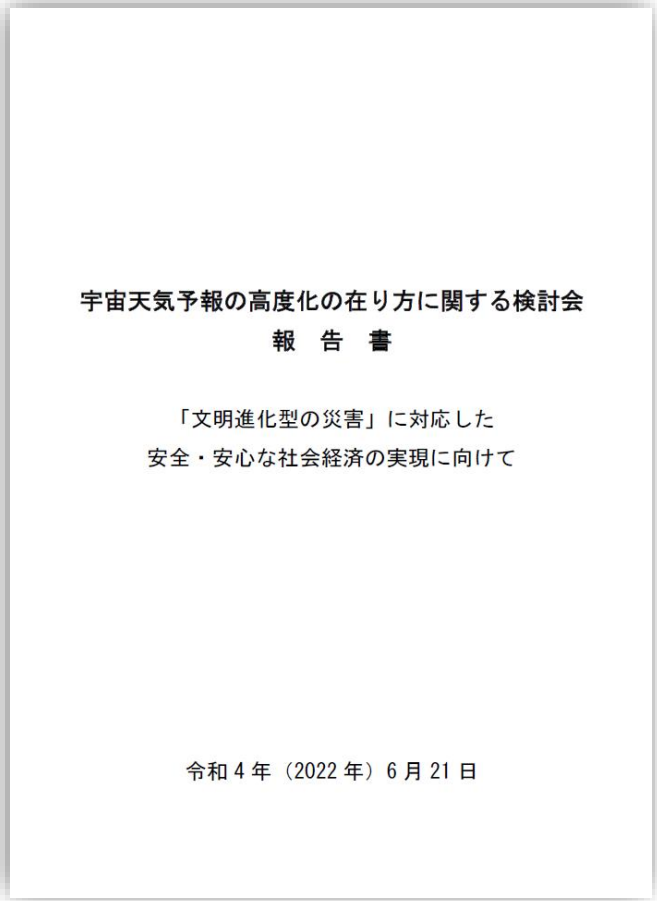
Solar activity and space environment are provided via Web, email, and SNS. Press release for significant event.

- 24/7 operation since Dec 2019
- Remote briefing since April 2020

Domestic users: satellite operator, aviation office and companies, power plant companies, HF telecommunicator/broadcaster, GNSS service provider/user, resource survey, Univ. and research institutes, amateur HF operators

# The first national document for space weather in Japan

**In Japan, “Study Group on the Advancement of Space Weather Forecasting” was established in the Ministry of Internal Affairs and Communications (MIC).**
**The report of study group (in Japanese) was published in June 2022.**



宇宙天気予報の高度化の在り方に関する検討会
報　告　書

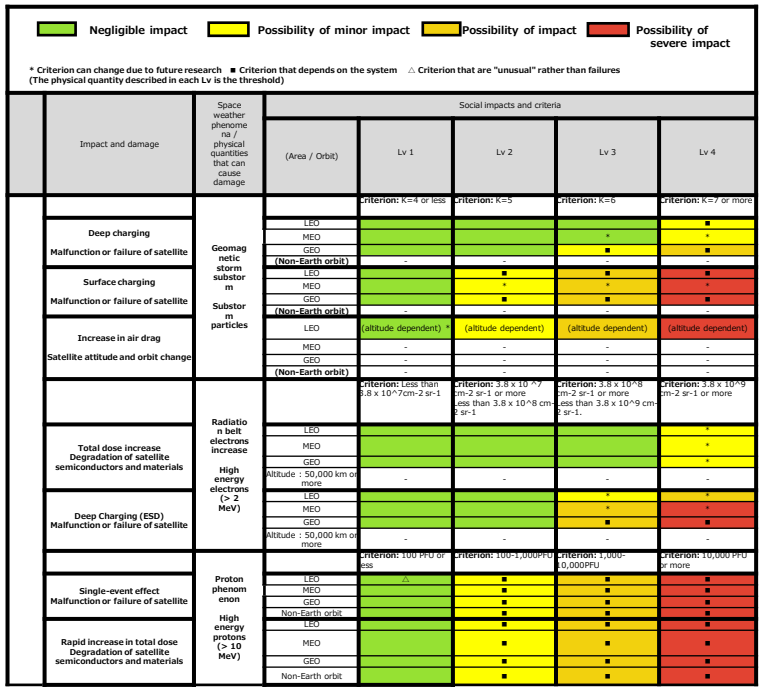
「文明進化型の災害」に対応した
安全・安心な社会経済の実現に向けて

令和４年（2022 年）６月 21 日

## Worst-case scenario for extreme space weather events occurring once per 100 years or less (excerpts)

- Communications and broadcasting are intermittently disrupted, causing socioeconomic disruption. Cell phone service is also suspended in some areas.
- Satellite positioning accuracy deviates by up to several tens of meters. Collision accidents with drones and other vehicles occur.
- Many satellites are damaged. A significant number of satellites are lost. Satellite-based services are suspended.
- Aircraft and ship operations are suspended worldwide. Significant disruptions to schedules and plans.
- Widespread power outages in non-resilient power infrastructure

## New forecast and warning criteria considering social impact



Negligible impact　Possibility of minor impact　Possibility of impact　Possibility of severe impact

* Criterion can change due to future research　■ Criterion that depends on the system　△ Criterion that are "unusual" rather than failures
(The physical quantity described in each Lv is the threshold)

| Impact and damage | Space weather phenomena / physical quantities that can cause damage | (Area / Orbit) | Lv 1 | Lv 2 | Lv 3 | Lv 4 |
|---|---|---|---|---|---|---|
| | | | Criterion: K=4 or less | Criterion: K=5 | Criterion: K=6 | Criterion: K=7 or more |
| Deep charging / Malfunction or failure of satellite | Geomagnetic storm substorm / Substorm particles | LEO | | | | ■ |
| | | MEO | | | * | * |
| | | GEO | | | ■ | ■ |
| | | (Non-Earth orbit) | - | - | - | - |
| Surface charging / Malfunction or failure of satellite | | LEO | | ■ | ■ | ■ |
| | | MEO | | * | * | * |
| | | GEO | | ■ | ■ | ■ |
| | | (Non-Earth orbit) | - | - | - | - |
| Increase in air drag / Satellite attitude and orbit change | | LEO | (altitude dependent) * | (altitude dependent) | (altitude dependent) | (altitude dependent) |
| | | MEO | - | - | - | - |
| | | GEO | - | - | - | - |
| | | (Non-Earth orbit) | - | - | - | - |
| | Radiation belt electrons increase / High energy electrons (> 2 MeV) | | Criterion: Less than 3.8 x 10^7cm-2 sr-1 | Criterion: 3.8 x 10 ^7 cm-2 sr-1 or more Less than 3.8 x 10^8 cm-2 sr-1 | Criterion: 3.8 x 10^8 cm-2 sr-1 or more Less than 3.8 x 10^9 cm-2 sr-1. | Criterion: 3.8 x 10^9 cm-2 sr-1 or more |
| Total dose increase Degradation of satellite semiconductors and materials | | LEO | | | | * |
| | | MEO | | | | * |
| | | GEO | | | | * |
| | | Altitude：50,000 km or more | - | - | - | - |
| Deep Charging (ESD) Malfunction or failure of satellite | | LEO | | | * | * |
| | | MEO | | | * | * |
| | | GEO | | | ■ | ■ |
| | | Altitude：50,000 km or more | - | - | - | - |
| | Proton phenomenon / High energy protons (> 10 MeV) | | Criterion: 100 PFU or less | Criterion: 100-1,000PFU | Criterion: 1,000-10,000PFU | Criterion: 10,000 PFU or more |
| Single-event effect Malfunction or failure of satellite | | LEO | △ | ■ | ■ | ■ |
| | | MEO | | ■ | ■ | ■ |
| | | GEO | | ■ | ■ | ■ |
| | | Non-Earth orbit | | ■ | ■ | ■ |
| Rapid increase in total dose Degradation of satellite semiconductors and materials | | LEO | | ■ | ■ | ■ |
| | | MEO | | ■ | ■ | ■ |
| | | GEO | | ■ | ■ | ■ |
| | | Non-Earth orbit | | ■ | ■ | ■ |

https://www.soumu.go.jp/main_sosiki/kenkyu/space_weather/index.html

# Development of NICT warning operation system for new warning criteria

## Target field

**HF Communications and broadcasting, Space system operation, aviation human exposure**

→ The criteria in these fields have been considered and determined in the Study Group.

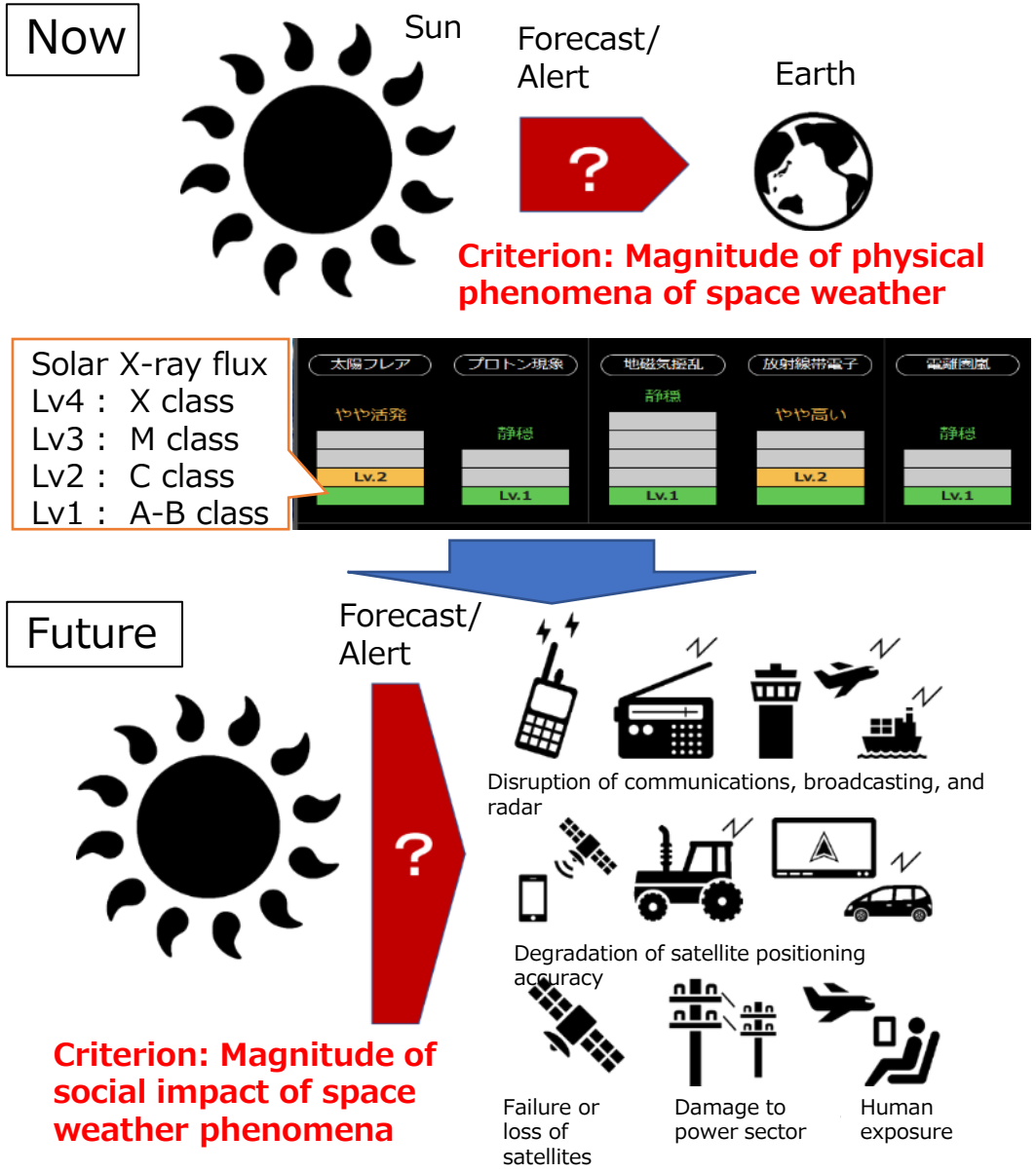
The other criteria will be added into operation system after determination.

## Contents and timing of warnings

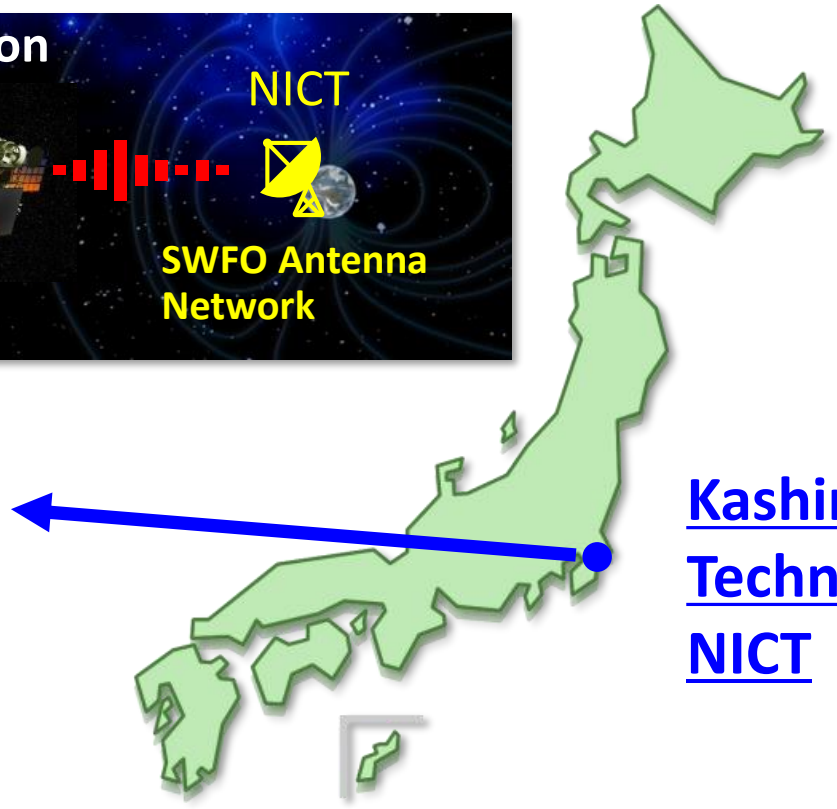
- **Three levels: Green (normal), Yellow (caution), Red (warning) in each field**
- **E-mail is automatically disseminated in case that the observation values exceeds the Yellow and Red criteria.**
- Social impacts in each field are described in the e-mail according to the levels.
- **In case of the red level of solar flare, NICT will manually disseminate an additional report** including detail forecasting.

## Schedule and method

- The new warning system will be operated in parallel with the current warning system and is planned to open for public in 2024.



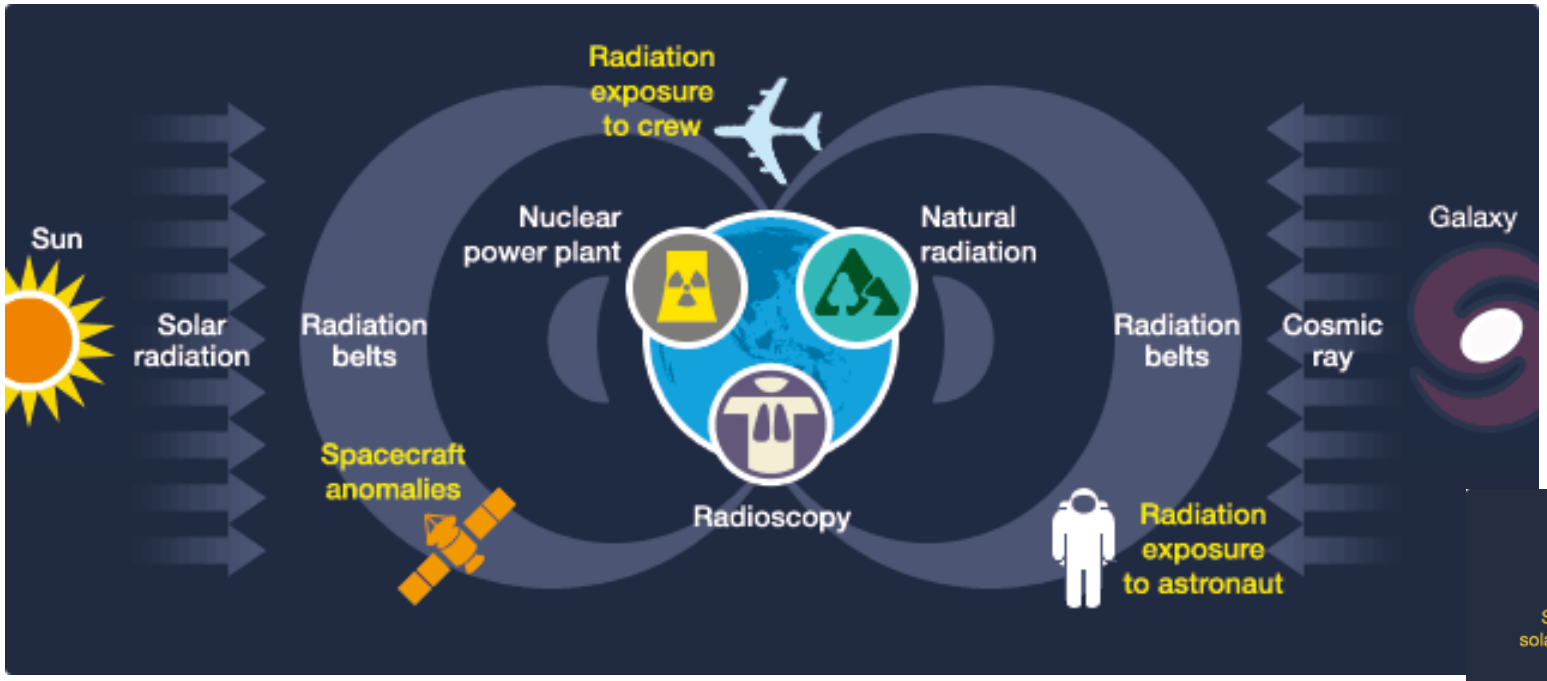
# Ground station of SWFO Antenna Network

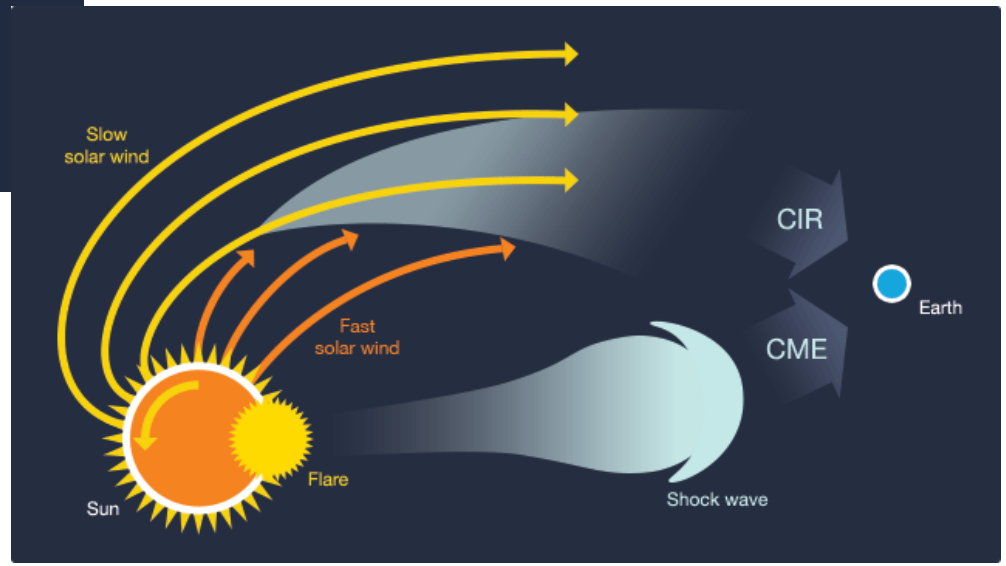
[Kashima Space Technology Center, NICT]

- Space Weather follow-on mission Lagrange 1 (SWFO-L1) is a deep-space mission planned by NOAA in USA, operating at Lagrange 1 (L1) point to monitor solar wind disturbances before they reach the Earth.
- A 7.3m diameter parabolic antenna was constructed at Kashima Space Technology Center, NICT in March 2023 for real-time receiving of SWFO-L1 observation data as a member of SWFO Antenna Network.

# Distribution of hazardous space radiations near Earth



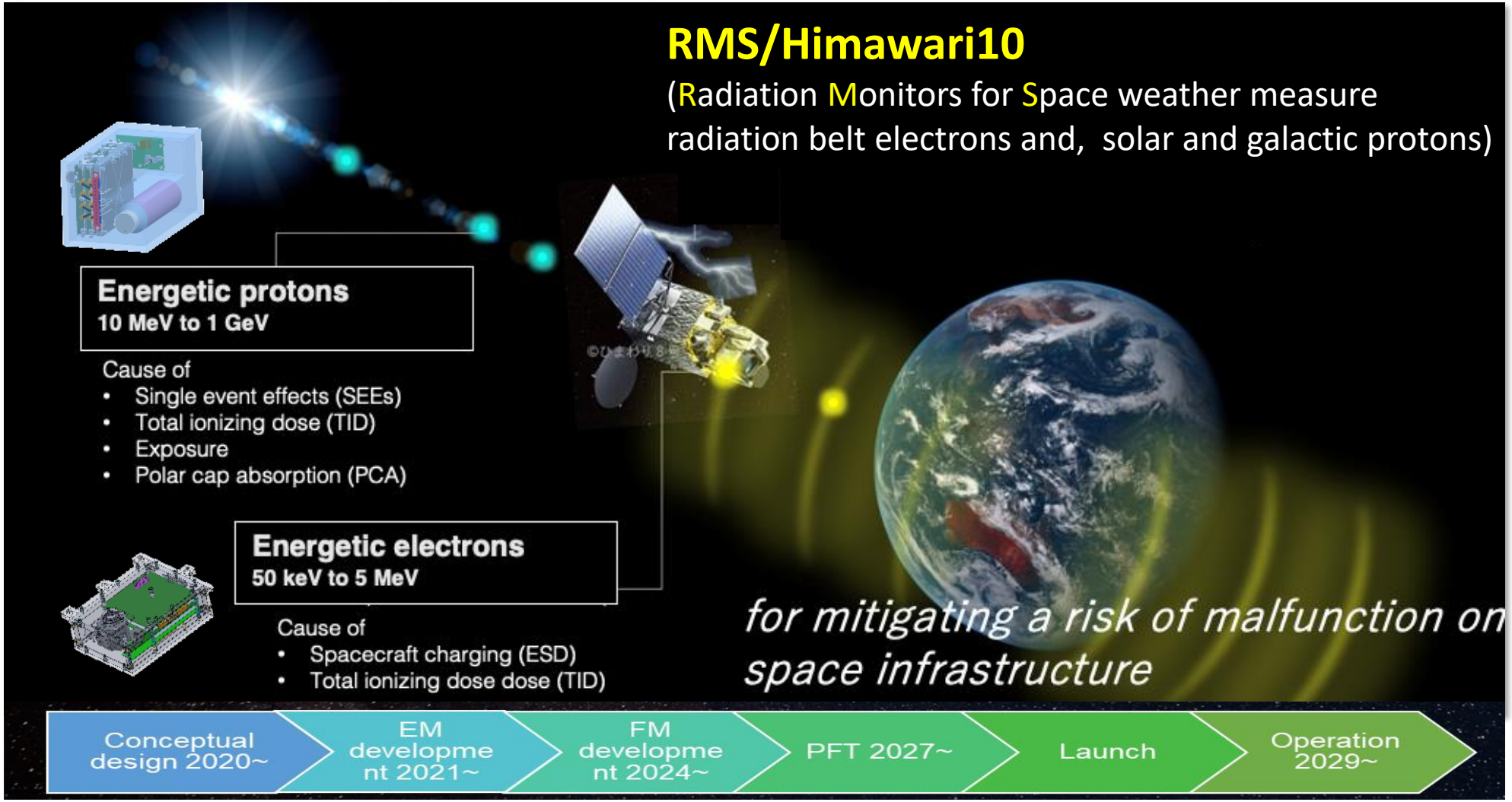

Radiation that comes from outside the Earth is called “space radiation” and includes high-energy particles originating from far-off galaxy and from explosive solar activities such as solar flares and coronal mass ejections. High-energy particles trapped in the geomagnetic field are another form of space radiation.




Space radiation cannot easily reach the surface of the Earth due to the Earth’s geomagnetic field and the atmosphere. However, for astronauts working at altitudes of about 400 km, radiation exposure can be a health hazard. Even for spacecraft flying around the Earth, space radiation can cause damage and spacecraft failure. ESD and SEE, TID due to space radiation and plasma is major concern for mission life of any space system.

# High energy particle sensors aboard Himawari 10

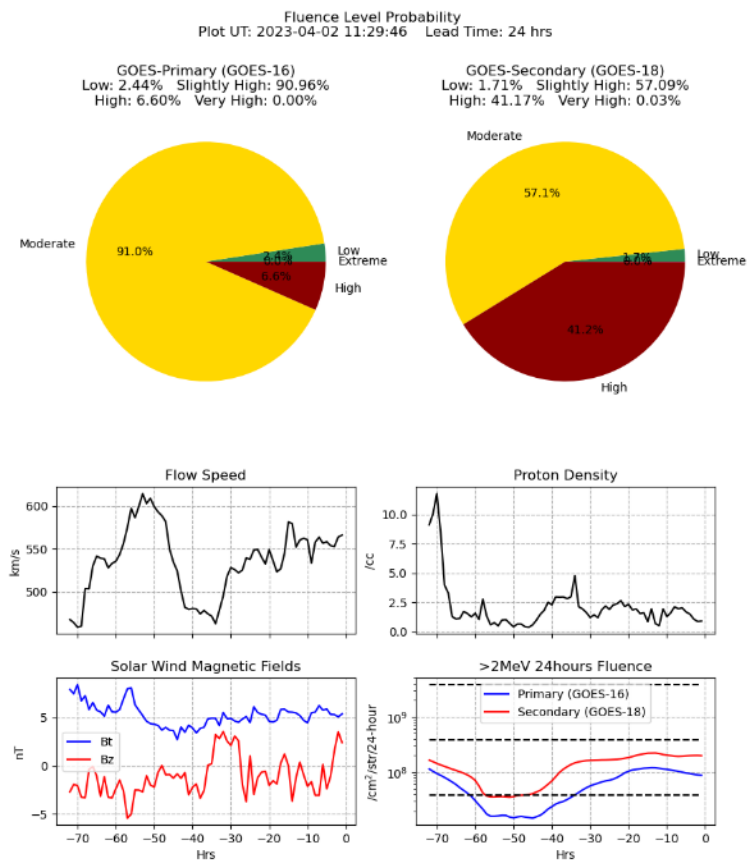
**Develop engineering models of high energy particle sensors aboard Himawari 10 (Japanese meteorological satellite)**



# Applications for users related with high energy particles

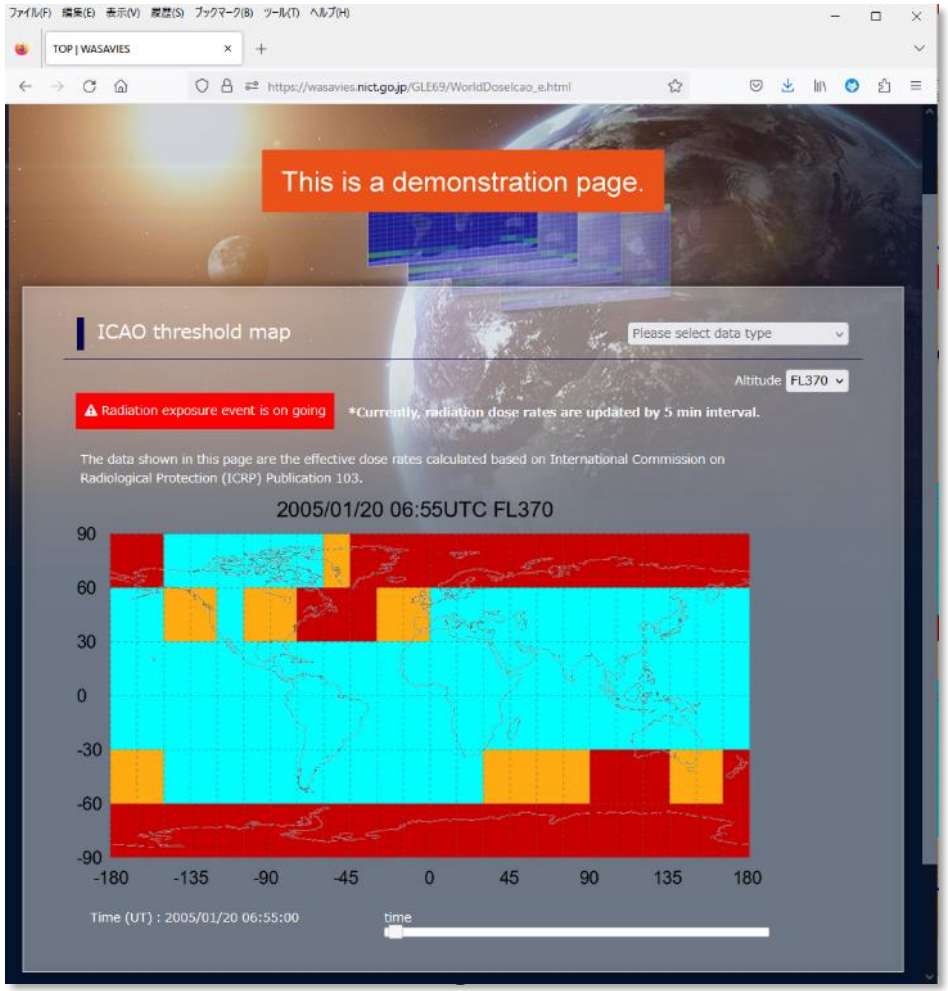
## AI-based radiation belt electron forecast model (Rade-AI)

**Develop AI-based radiation belt electron fluence probabilistic forecast model.**




## Improve WASAVIES

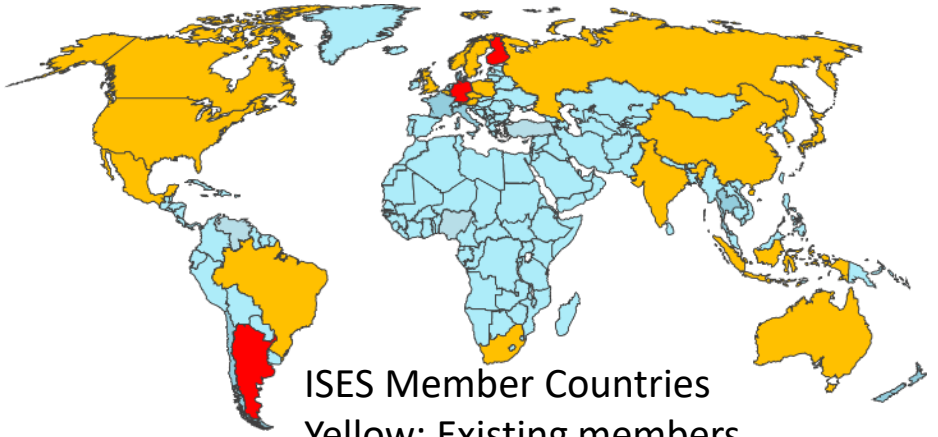
**Release ICAO threshold map for radiation dose rate on WASAVIES website.**



# International Activities

## International Space Environment Services (ISES)

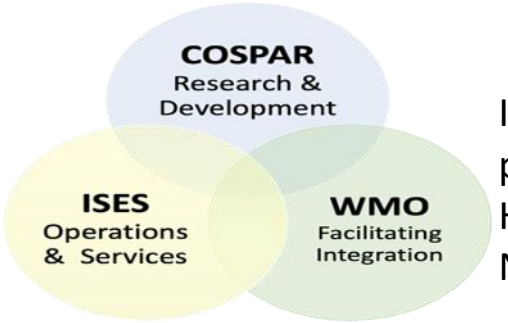
- ISES is a community of organizations that provide operational space weather forecasting services and has been active since 1962.
- It is the only organization in the world that is active in space weather information distribution, and many of its members serve as core members of other space weather-related organizations.
- As of Jan 2024, 21 Regional Warning Centers, 3 Collaborative Expert Centers, and 4 Associate Warning Centers are members. Dr. Ishii of NICT was elected as Director in 2023.



ISES Member Countries
Yellow: Existing members
Red: Joining after 2020

## WMO-ISES-COSPAR Collaboration

- UN/COPUOS STSC issued recommendations on space weather services in February 2022. COSPAR-ISES-WMO is required to lead space weather related activities and has begun to consider.
- In September 2022, the three organizations discussed and prepared the “Coimbra Declaration”. NICT contributed to this effort, as a representative of ISES.
- NICT also contributes to hold the first International Space Weather Coordination Forum (ISWCF) on November 2023 at WMO Headquarters in Geneva, Switzerland.




ISWCF meeting participants at WMO Headquarters, Geneva, November 17, 2023.

# Activities for Capacity building in NICT

- NICT has an internship program to support the travel fare to NICT and staying expense for students.
- In addition, we have received staffs for giving training as space weather forecasters since 2014, especially from the South East Asian countries.

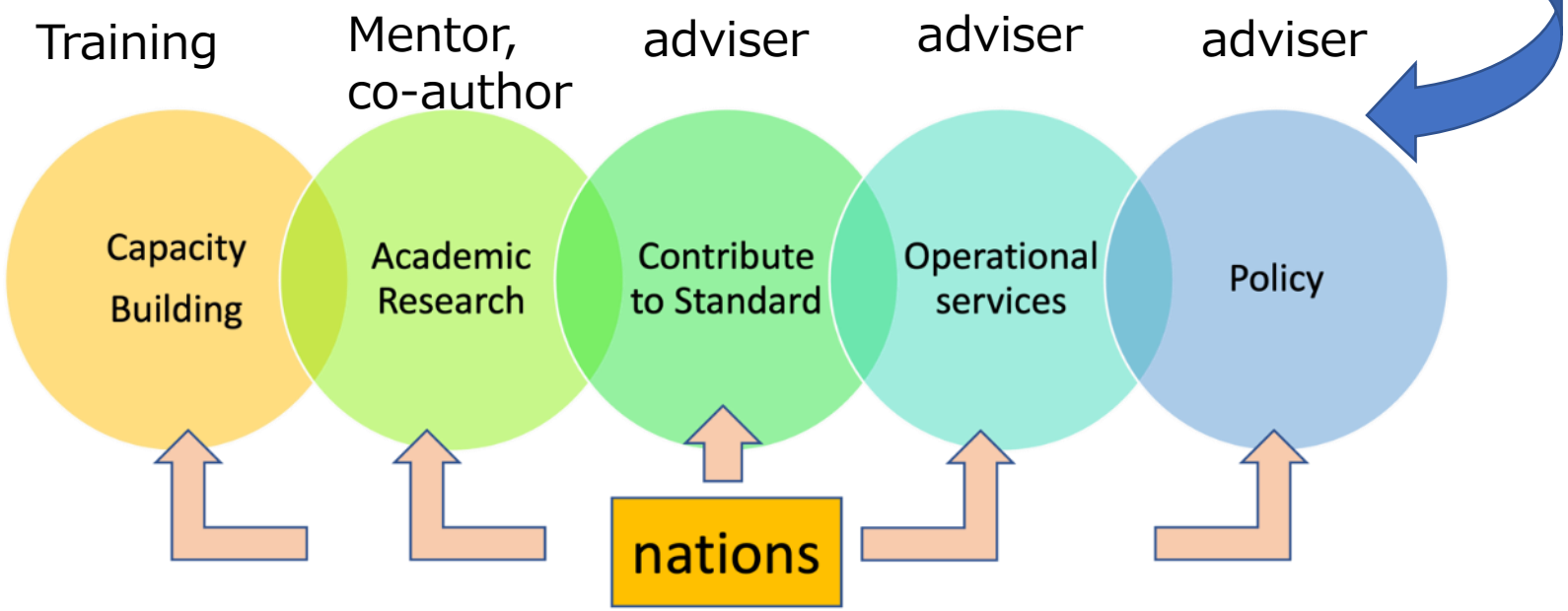
| Period | country | affiliation | # of visitors |
|---|---|---|---|
| Jan. 2013 | Korea | Kiyong Hee Univ. | 2 |
| Sep. 2014 | Indonesia | LAPAN | 2 |
| Apr. 2014-<br>Mar. 2015 | Malaysia | UKM | 1 |
| Sep. 2015 | Malaysia | ANKGASA | 2 |
| Sep. 2018 | Thailand | KMITL | 3 |
| Oct.- Dec. 2022 | Thailand | GISTDA | 2 |

# Fostering Asia-Oceania Countries in Developing Space Weather's Research Capacities Through AOSWA

**Asia-Oceania Space Weather Alliance (AOSWA) 2023 special session: Connect the Local Observation to Global Network**

Convener: Dr. Septi Perwitasari (NICT, Japan)
Co-convener: Dr. Shanzana Nurul (UKM, Malaysia)

**Survey correct information on the local space weather research and observation (R&O) activities of AOSWA members**




- Strategy to help developing countries tailored with their needs

AOSWA 2023
Asia-Oceania Space Weather Alliance
MALAYSIA

Connect Local Observation to Global Network Survey

**This survey aims to collect information on the local space weather research and observation (R&O) activities of AOSWA members. The result will be used to tailor the future strategy to help the development of space-weather R&O activities.**

Explanation of each phase:
1. **Capacity building**: Training phase, e.g., Instrument installation, observation, data analysis training etc.
2. **Academic research**: Phase where space-weather research (data analysis, journal writing, etc) is underway.
3. **Operational Service**: Phase where a space weather-center has been established and operational service is conducted daily.
4. **Contribute to standardization**: Phase where you already have a contribution to the international standard, e.g., data format standard, protocol of services (ICAO, WMO). It is necessary to have quite enough experience in academic and operational space weather activity for contributing to standardization.
5. **Policy Making**: Policy making phase, e.g., space weather disaster management policy, etc.

# Summary

- In Japan, NICT has developed a warning operation system for new criteria based on the report of “Study Group on the Advancement of Space Weather Forecasting” published in June 2022.
- We has been constructed a 7.3m diameter parabolic antenna at Kashima for real-time receiving of SWFO-L1 observation data as a member of SWFO Antenna Network.
- We are working on RMS project to develop instruments to measure energetic particles in GEO for safe and stable use of satellite operation, aviation and human activities in space. EM development is almost completed and we will proceed to FM development.
- We contribute to international activities such as ISES, WMO, COSPAR, ITU, ICAO, etc. and  to capacity building through giving training as space weather forecasters and communications through AOSWA.