国立研究開発法人
情報通信研究機構

Nov. 16, 2022
12th Asia-Oceania Meteorological Satellite Users' Conference
(AOMSUC-12)

Update of National and International Activities for Space Weather Research and Operation

Mamoru Ishii

National Institute of Information and Communications Technology

Today’s Topics

- National Activities
  - Report from the Committee for the advancement of space weather forecast hosted by MIC
  - Development of Satellite-based Space Weather sensors
- International Activities
  - Japanese Space Weather Visibilities in WIGOS

Today’s Topics

- National Activities
  - Report from the Committee for the advancement of space weather forecast hosted by MIC
  - Development of Satellite-based Space Weather sensors
- International Activities
  - Japanese Space Weather Visibilities in WIGOS

Consideration of Space Weather Alert Criteria

https://www.soumu.go.jp/main_content/000809610.pdf (written in Japanese)

Background

- The importance of space weather forecasting for stable operation of social infrastructures is increasing, and outside of Japan, such as in the United States, there is a growing movement to prepare for social risks of space weather, such as evaluation of social impacts and announcement of national strategies.
- In Japan, as one of the activities of the Grant-in-Aid for Scientific Research on Innovative Areas "PSTEP*" (2015-2019), the scale of space weather phenomena and their social impact on Japan were examined and summarized.
  *PSTEP : Project for Solar-Terrestrial Environment Prediction (https://www.isee.nagoya-u.ac.jp/pstep/)
- Although **the current alert criteria focus on the magnitude of the phenomena**, a forecasting and alert based on the social impact is necessary for users of space weather forecasting to determine specific responses.
- **The Ministry of Internal affairs and Communication (MIC) established "Committee for the advancement of space weather forecast" in Jan. 2022 and publish a report on June 21.**
- **Under this committee, WG established for considering new alert types and criteria that also take into account the magnitude of social impact caused by space weather**.

Items for Consideration

- Forecasting and alert types and criteria in the following field:
  Communications and Broadcasting, Positioning, Satellite Operations, Electric Power, Aircraft Exposure.

Meetings

- Three plenary meetings and 2-6 subgroup meetings for each field were held from January to April 2022.

Members

- Twenty-seven experts from Japanese research institutes/universities, companies, government agencies, and general associations participated as WG members.

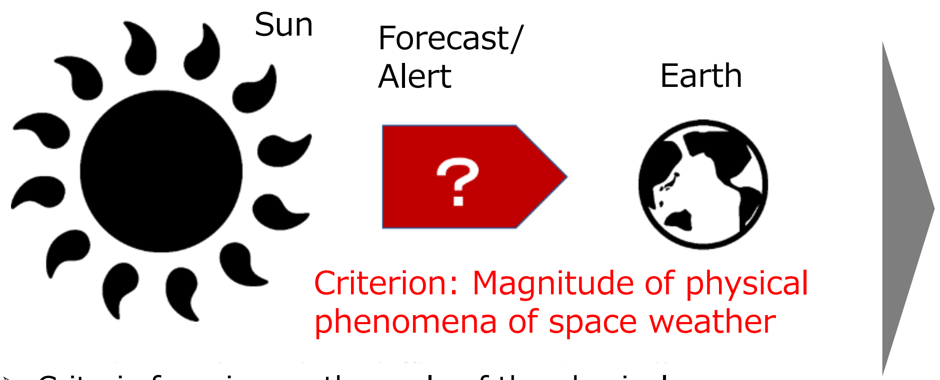
Introduction of new forecasting and alert criteria that take into account social impacts

○The purpose of space weather forecasting is to reduce the risks posed to social infrastructure by understanding and predicting hazards.

○Therefore, similar to the relationship between "magnitude" and "seismic intensity/tsunami warning" in earthquakes and tsunamis, forecasts and alerts should focus not only on the scale of physical phenomena of space weather, but also on the risk (damage) to social infrastructure.

○For this reason, new types and criteria of forecasts and alerts that take into account the social impact of space weather phenomena were considered. As a result, a total of 17 categories of forecasts and alerts were established in five fields, and criteria were developed for 12 of them.

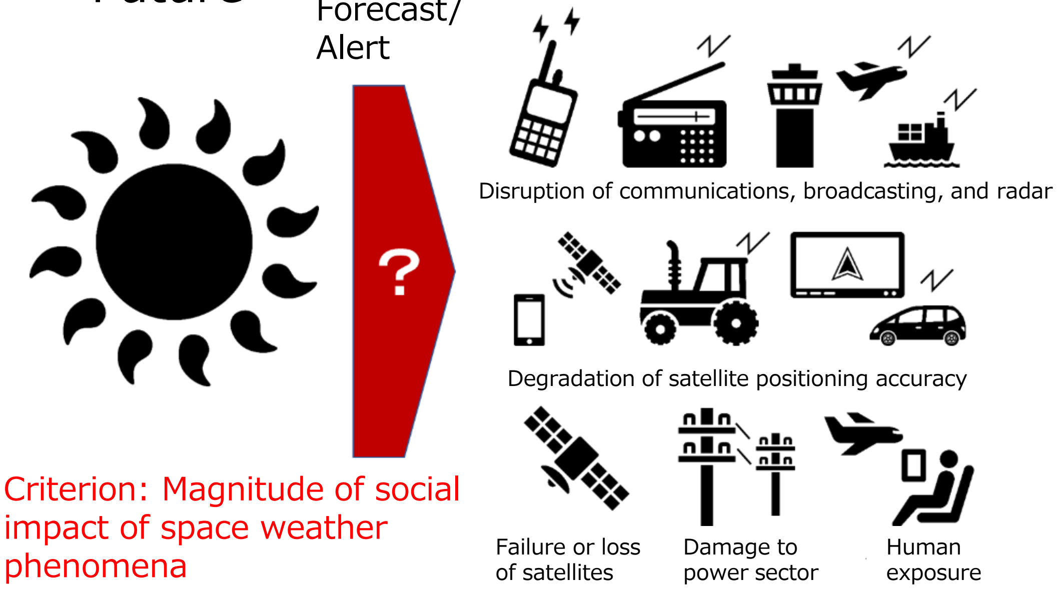
Now



Criterion: Magnitude of physical phenomena of space weather

- Criteria focusing on the scale of the physical phenomenon aspect of space weather (e.g., the amount of solar energetic particles, etc.)
- Difficult to intuitively understand the degree of danger of impacts on social infrastructure
- The presented information is academic in nature with technical terminology, making it difficult for the general public and media to immediately understand its meaning

Future



Criterion: Magnitude of social impact of space weather phenomena

- Easily understand the hazard posed by space weather phenomena
- Immediate understanding of the meaning of alerts by the general public and news media

Criteria for Communications and Broadcasting

- The PSTEP report classifies ionospheric or radio disturbance phenomena by type (ionospheric negative phase storms, radio blackouts, polar cap absorption, and plasma bubbles). Based on this, the types and thresholds of warnings and their social impacts were examined.
- In addition to the HF to VHF bands, the social impact of the UHF band (satellite communications) was added.
- Thresholds were established by considering international standards operated by ICAO, the U.S. NOAA, and the UKMO in the UK.
- Five alert criteria and thresholds were set for three of the criteria. Thresholds for the remaining two criteria were left for future study.

🟩 **Negligible impact**

🟨 **Potential impact requiring appropriate action**

🟥 **Potentially serious impact that makes it difficult to continue operation**

	Impact and damage	Space weather phenomena / physical quantities that can cause damage	Social impacts and criteria		
			Lv 1	Lv 2	Lv 3
	UHF band (satellite communication) **Radio intensity attenuation and scintillation**	**Plasma bubble**	🟩	**Threshold:** ROTI, S4, etc. (TBD) **Social Impact:** Scintillation beyond the fade margin of the L-band satellites may occur during nighttime in the low latitude.	**Threshold:** ROTI, S4, etc. (TBD) **Social Impact:** Scintillation beyond the fade margin of the L-band satellites frequently occurs during nighttime in the low-latitude and may also affect in the mid latitude.
	VHF band **Communication quality degradation (radio intensity attenuation)**	**Sporadic E layer**	🟩	**Threshold:** foEs (TBD) **Social Impact:** Radio waves from outside the line-of-sight range may cause interference.	**Threshold:** foEs (TBD) **Social Impact:** Frequent radio interference from outside the line-of-sight range.
	HF band **Radio intensity attenuation**	**Polar cap absorption**	🟩	**Threshold:** Proton (>10 MeV) 1,000 PFU or more **Social Impact:** Significant radio absorption occurs in high latitude areas (above 55 degrees) and continues for about two days.	**Threshold:** Proton (>10 MeV) 100,000 PFU or more **Social Impact:** Significant radio wave absorption occurs at high latitudes (above 52 degrees) and continues for about 3 days.
	HF band **Radio intensity attenuation**	**Radio blackout**	🟩	**Threshold:** X1 flare **Social Impact:** Wide absorption of radio waves on the day side, making the low frequency band unusable.	**Threshold:** X10 flare **Social Impact:** The entire HF band is blacked out in a wide area on the daytime side.
	HF band **Available frequency spectrum is reduced**	**Ionospheric storm (negative phase)**	🟩	**Threshold:** 30% reduction in MUF **Social Impact:** The frequency range for domestic and international communication is reduced by up to 30%.	**Threshold:** 50% reduction in MUF **Social Impact:** The frequency range for domestic and international communications will be reduced by up to 50-60%, and communications will not be possible during some time periods.

Worst-case scenario for extreme space weather events

Assumptions used for worst-case scenario

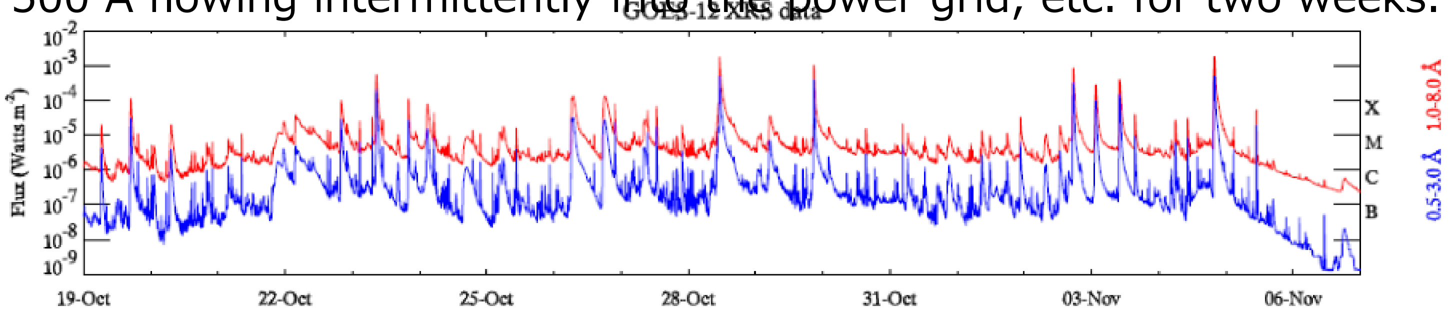
① Damage caused by extreme space weather phenomena (so-called extreme events) which occur once per 100 years or less was assumed.

② It was estimated that a series of X10-class or larger solar flares over a two-week period, the largest of which exceeded the Carrington Event, with continuous solar radio bursts, radio blackout events, ionospheric storms, and plasma bubbles, and anomalous ionization in the D region of the ionosphere and superstorms in the F region lasting for two weeks.

③ During this period, it was assumed that ionospheric conditions occurred for two weeks such that radio signals from the GNSS (Global Navigation Satellite System) were delayed by a maximum of 37 m as the GPS L1 frequency delay (pseudo-distance).

④ It is assumed that the flux of high-energy protons above 10 MeV is above 10,000 PFU intermittently for two weeks or above 100,000 PFU continuously for several days.

⑤ The impact of solar flares during this period were assumed to hit the earth, causing intermittent large-scale geomagnetic storms for two weeks, the largest of which exceeded the Carrington Event, with natural currents of up to 500 A flowing intermittently into the power grid, etc. for two weeks.



X-ray flux variations observed by the GOES satellite in geostationary orbit during the October-November 2003 Halloween event. During this event, X-class flares occurred intermittently for about two weeks. [Weaver, Michael, Halloween space weather storms of 2003, NOAA technical memorandum OAR SEC-88, 2004, https://repository.library.noaa.gov/view/noaa/19648]

Report of the Council for Advancement of Space Weather Forecast (Summary)

https://www.soumu.go.jp/main_content/000813249.pdf (written in Japanese)

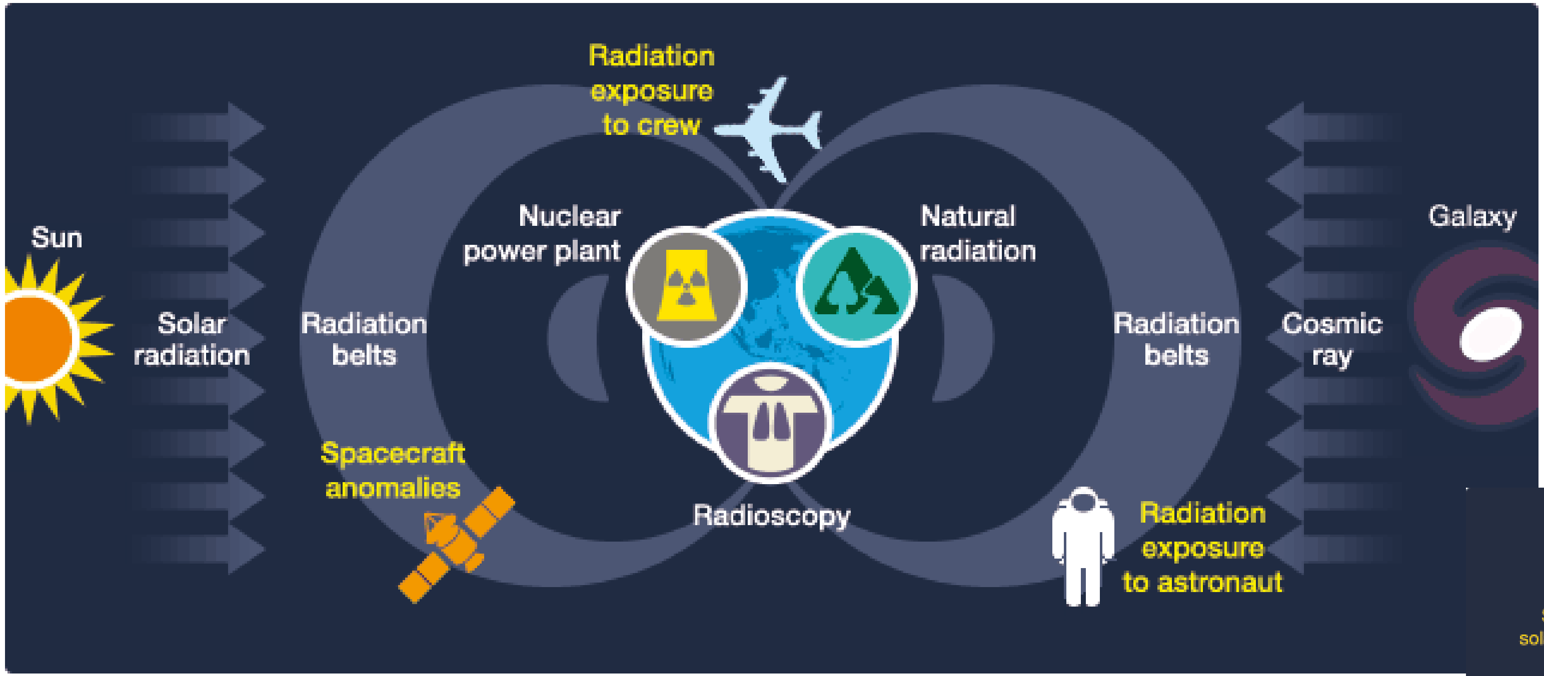
Worst-case scenario for extreme space weather events occurring once per 100 years or less (excerpts)

- 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

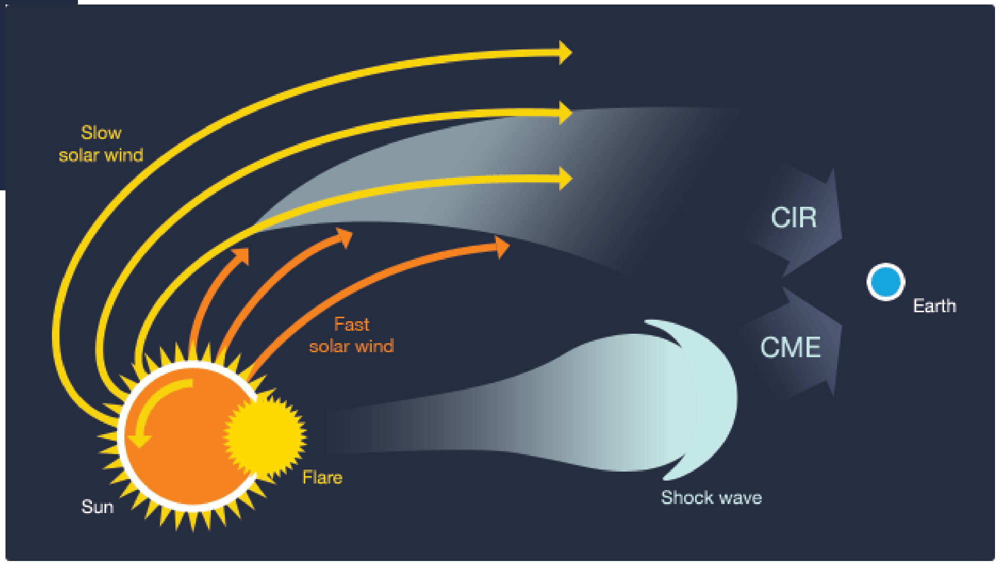
Today’s Topics

- National Activities
  - Report from the Committee for the advancement of space weather forecast hosted by MIC
  - Development of Satellite-based Space Weather sensors
- International Activities
  - Japanese Space Weather Visibilities in WIGOS

Distribution of hazardous space radiations near Earth

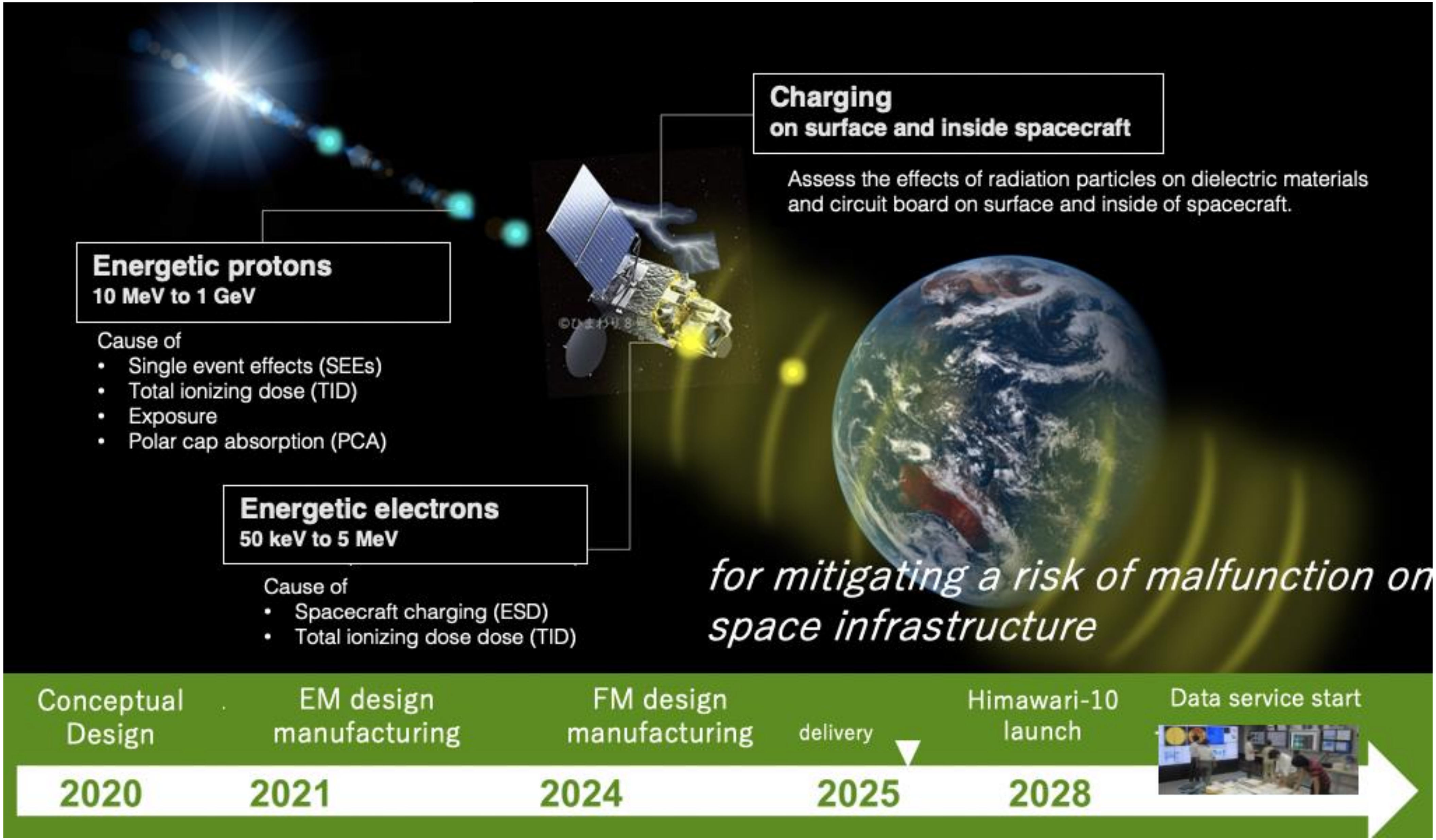


Radiation that comes from outside the Earth is called “space radiation” and includes high-energy particles originating from far-off galaxy and from explosive solar activities such as solar flares and coronal mass ejections. High-energy particles trapped in the geomagnetic field are another form of space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

CHARMS Mission: *Simultaneous measurements of space radiation and spacecraft charging on Japanese geostationary meteorological satellite*



Charging
on surface and inside spacecraft

Assess the effects of radiation particles on dielectric materials and circuit board on surface and inside of spacecraft.

Energetic protons
10 MeV to 1 GeV

Cause of
- Single event effects (SEEs)
- Total ionizing dose (TID)
- Exposure
- Polar cap absorption (PCA)

Energetic electrons
50 keV to 5 MeV

Cause of
- Spacecraft charging (ESD)
- Total ionizing dose dose (TID)

for mitigating a risk of malfunction on space infrastructure

Conceptual Design
2020

EM design manufacturing
2021

FM design manufacturing
2024

delivery
2025

Himawari-10 launch
2028

Data service start

Next Himawari/CHARMS-e & p

(performance requirement of electron & proton measuring sensors)

- Targets
  - Energetic electrons in the outer radiation belt (Van Allen belt)
  - Energetic protons in solar energetic particles and galactic cosmic ray

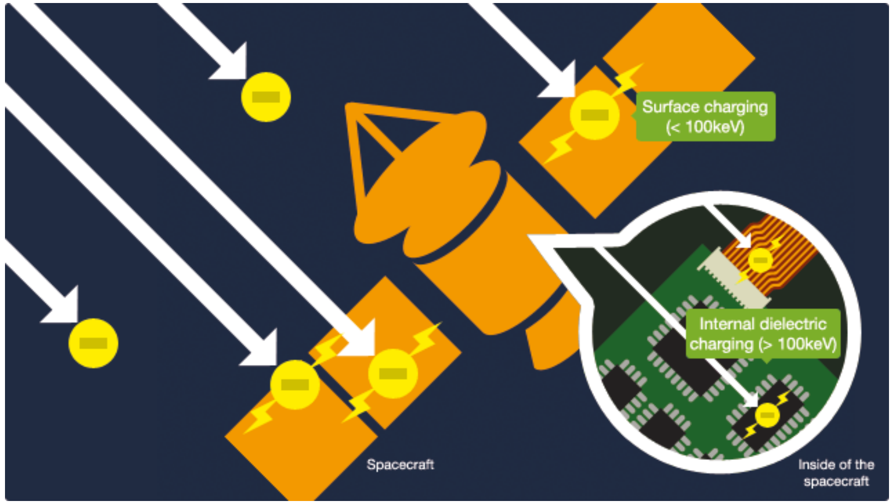
- Missions
  - High-energy particles that cause spacecraft malfunctions and degradations (ESD, SEEs, and TID), HF communication failure in the polar regions due to PCA, and space radiation exposure (polar aircraft and space activities) will be monitored, and are used space radiation nowcasting and forecasting, and issue warnings to space weather users.

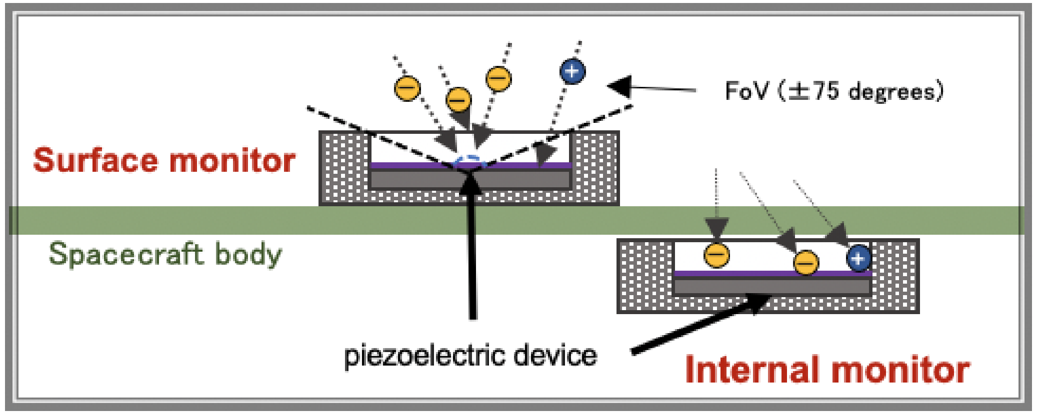
	CHARMS-e(lo)	CHARMS-e(hi)	CHARMS-p(lo)	CHARMS-p(hi)
Particle	electron	electron	proton	proton
Energy range	50–1200 keV	0.8–4, >2, >4 MeV	10–250, >10, >100 MeV	250–1000 MeV
Energy resolution	< 20%	< 10%	< 20%	–
Energy channels	8 differential flux	6 differential flux 2 integral flux	6 differential flux 2 integral flux	8 differential flux
Field of view	±20 degrees	±20 degrees	±20 degrees	±20 degrees
Viewing direction *Reverse by yaw flip	1: East (*West) 2: South (*North)	1: East (*West) 2: South (*North)	1: East (*West)	1: East (*West)
G-factor	0.0005 cm^2 sr	0.1 cm^2 sr	0.2 cm^2 sr	1.5 cm^2 sr
Time resolution	1 s	1 s	10 s	10 s
Detector	SSD	SSD	SSD	Cherenkov

Next Himawari/ CHARMS-c

(performance requirement of charging measuring sensors)

- Target
  - Charge distribution and total charge inside materials (insulators/dielectrics) exposed to space environment
- Mission
  - Space charge distribution will be measured and used as warning information for operators. Also, the changes in material properties over mission time in the real space environment will be measured and are reflected in satellite design standards.
- Functions/Performance
  - Pulsed Electroacoustic (PEA) method
  - Spatial resolution: ~5µm
  - Time resolution: 1 min
  - Lower limit: 0.2-0.5 [C/m^3]
  - Field of view: 150°
- Mounting position
  - Exposed surface of the satellite and inside the satellite enclosure





Today's Topics

- National Activities
  - Report from the Committee for the advancement of space weather forecast hosted by MIC
  - Development of Satellite-based Space Weather sensors
- International Activities
  - Japanese Space Weather Visibilities in WIGOS

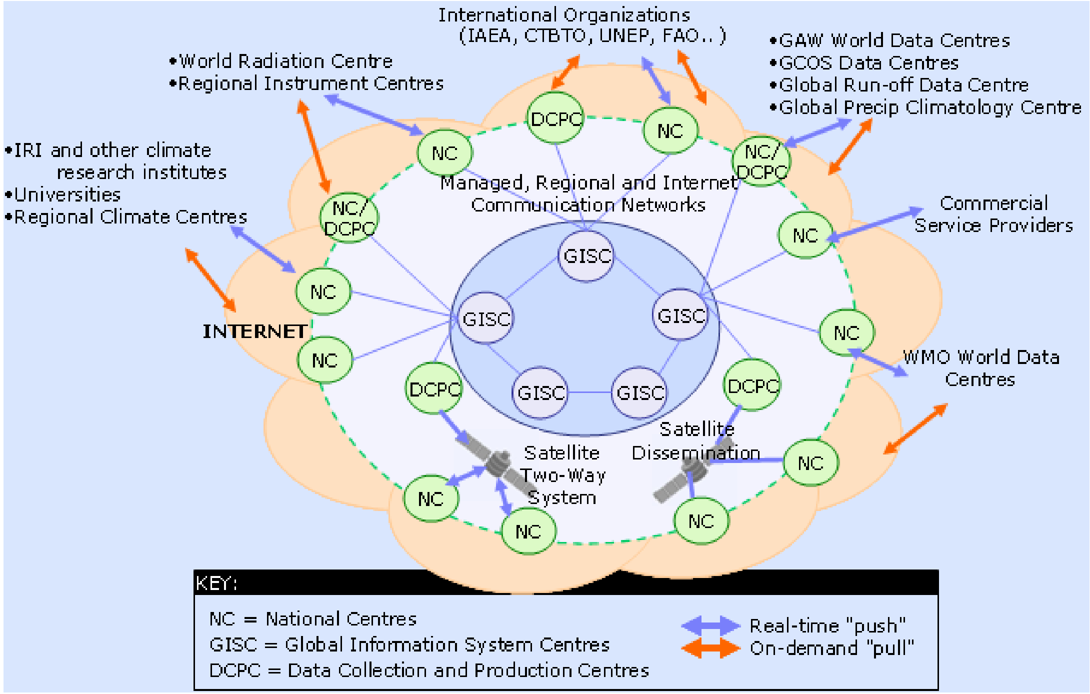
WIGOS

- The WMO Integrated Global Observing System (WIGOS) is one of WMO’s top priorities as the new overarching framework for all WMO observing systems.
- Current global challenges demand a significant worldwide upgrade of space- and surface-based observations and predictions. In response, WIGOS provides a new, integrated approach incorporating the most recent scientific and technical advances.
- The WIGOS framework promotes network integration and partnership outreach, and engages the regional and national actors essential for successful integration of these systems. These national and international WIGOS partnerships allow WMO Members to:
  - build observing capabilities
  - achieve better national, regional and global coverage
  - improve economic efficiency.
- WIGOS is enhancing our understanding of the Earth System by supporting improved weather and climate products and services, and providing significantly more, improved observations.

WMO Information system (WIS)

- The WMO Information system (WIS) is a coordinated global infrastructure responsible for telecommunications and data management functions and is owned and operated by WMO Members. WIS provides an integrated approach suitable for all WMO Programmes to meet the requirements for routine collection and automated dissemination of observed data and products, as well as data discovery, access, and retrieval services for weather, climate, water, and related data produced by centres and Member countries in the framework of any WMO Programme

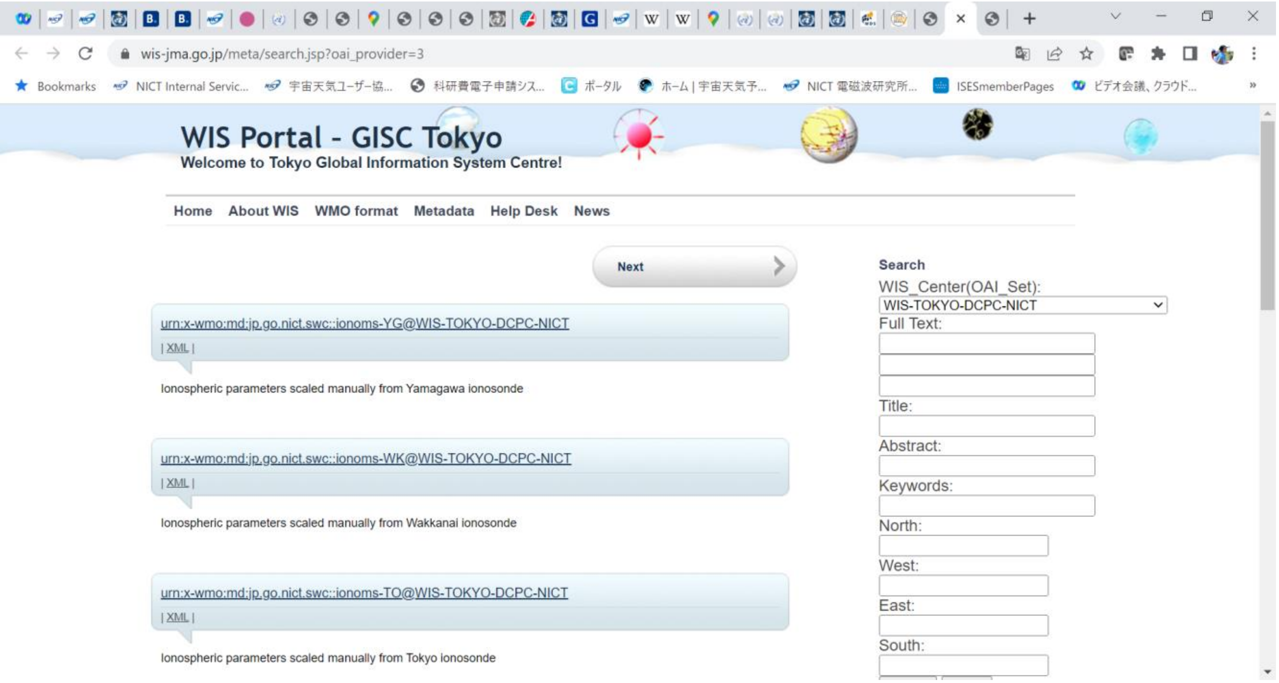
- WIS is composed of three types of centres and a communications network
  - National Centres (NCs)
  - Data Collection or Production Centres (DCPCs)
  - Global Information System Centres (GISCs)



Our action in DCPC

NICT provides the following data with DCPC since January 2016.

- Data catalogue of DCPC NICT Space Weather Information Center :(Search “NICT” on WIS metadata catalogue.)
- Ionospheric parameters scaled manually from ionosonde at four sites
- ionogram at four sites
- Ionospheric parameters scaled automatically from ionosonde at four sites
  - Japanese Sites: Wakkanai, Tokyo, Yamagawa and Okinawa



WIS Portal - GISC Tokyo

Welcome to Tokyo Global Information System Centre!

urn:x-wmo:md:jp.go.nict.swc::ionoms-YG@WIS-TOKYO-DCPC-NICT

| XML |

Ionospheric parameters scaled manually from Yamagawa ionosonde

urn:x-wmo:md:jp.go.nict.swc::ionoms-WK@WIS-TOKYO-DCPC-NICT

| XML |

Ionospheric parameters scaled manually from Wakkanai ionosonde

urn:x-wmo:md:jp.go.nict.swc::ionoms-TO@WIS-TOKYO-DCPC-NICT

| XML |

Ionospheric parameters scaled manually from Tokyo ionosonde

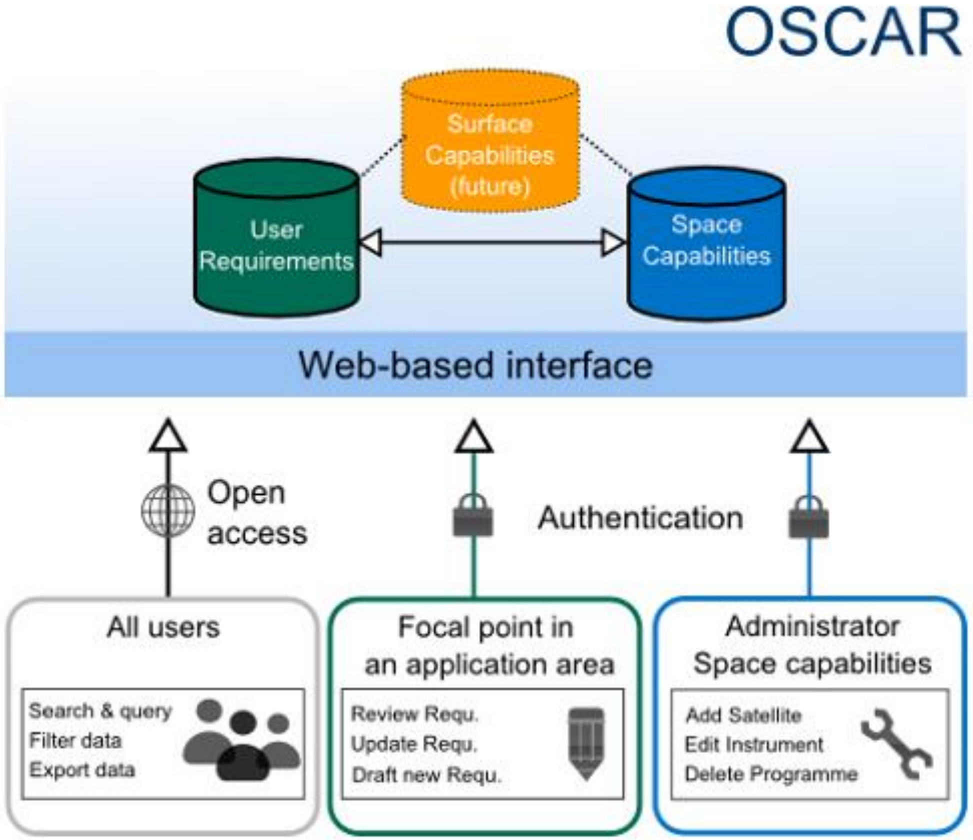
WIS_Center(OAI_Set): WIS-TOKYO-DCPC-NICT

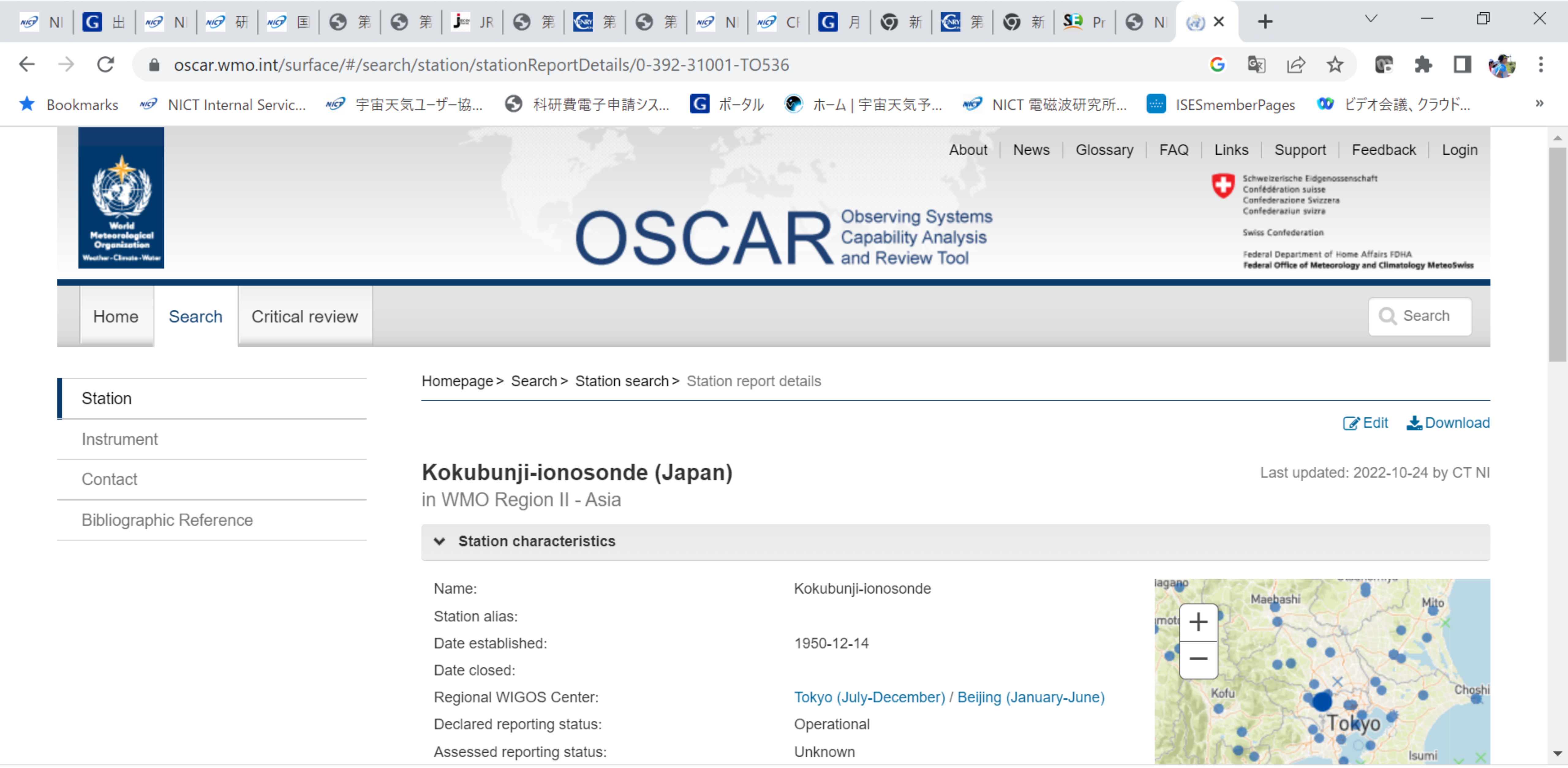
https://www.wis-jma.go.jp/meta/search.jsp?oai_provider=3

Japan is the second country to become DCPC as space weather providers following Australia.

OSCAR

- OSCAR is a resource developed by WMO in support of Earth Observation applications, studies and global coordination.
- It contains quantitative user-defined requirements for observation of physical variables in application areas of WMO (i.e. related to weather, water and climate). OSCAR also provides detailed information on all earth observation satellites and instruments, and expert analyses of space-based capabilities.
- The tool constitutes a building block of WIGOS and more specifically, the so-called Rolling Requirements Review process. OSCAR targets all users interested in the status and the planning of global observing systems as well as data users looking for instrument specifications at platform level. To continue, please select one of the following modules:
  - Observation Requirements
  - Satellite Capabilties
  - Surface based Capabilties





Homepage > Search > Station search > Station report details

Kokubunji-ionosonde (Japan)

in WMO Region II - Asia

Last updated: 2022-10-24 by CT NI

Station characteristics

Name:	Kokubunji-ionosonde
Station alias:	
Date established:	1950-12-14
Date closed:	
Regional WIGOS Center:	Tokyo (July-December) / Beijing (January-June)
Declared reporting status:	Operational
Assessed reporting status:	Unknown

Japan is the second country to register space weather information following Canada.

Summary

- In Japan, “Committee for the advancement of space weather forecast” was established in the Ministry of Internal Affairs and Communications (MIC) and publish a report in June 2022.
- Based on this report, NICT will take necessary researches and actions, such as researches toward the actual operation of the new space weather alert criteria established by the WG.
- We now started a project to develop and deploy instrument for measuring space environment for safe and stable use of satellite operation, aviation and human activities in space. We plan to develop three kinds of sensors to measure energetic protons and electrons, and charging on surface and inside spacecraft.
- As an international activities, we contribute to develop space weather information services in WIGOS. NICT provides the ionospheric data with DCPC since January 2016, and registered metadata in OSCAR surface database.