国立研究開発法人
情報通信研究機構

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Technical Presentation, UN/COPUOS

Update of Japanese Space Weather Research and Operation

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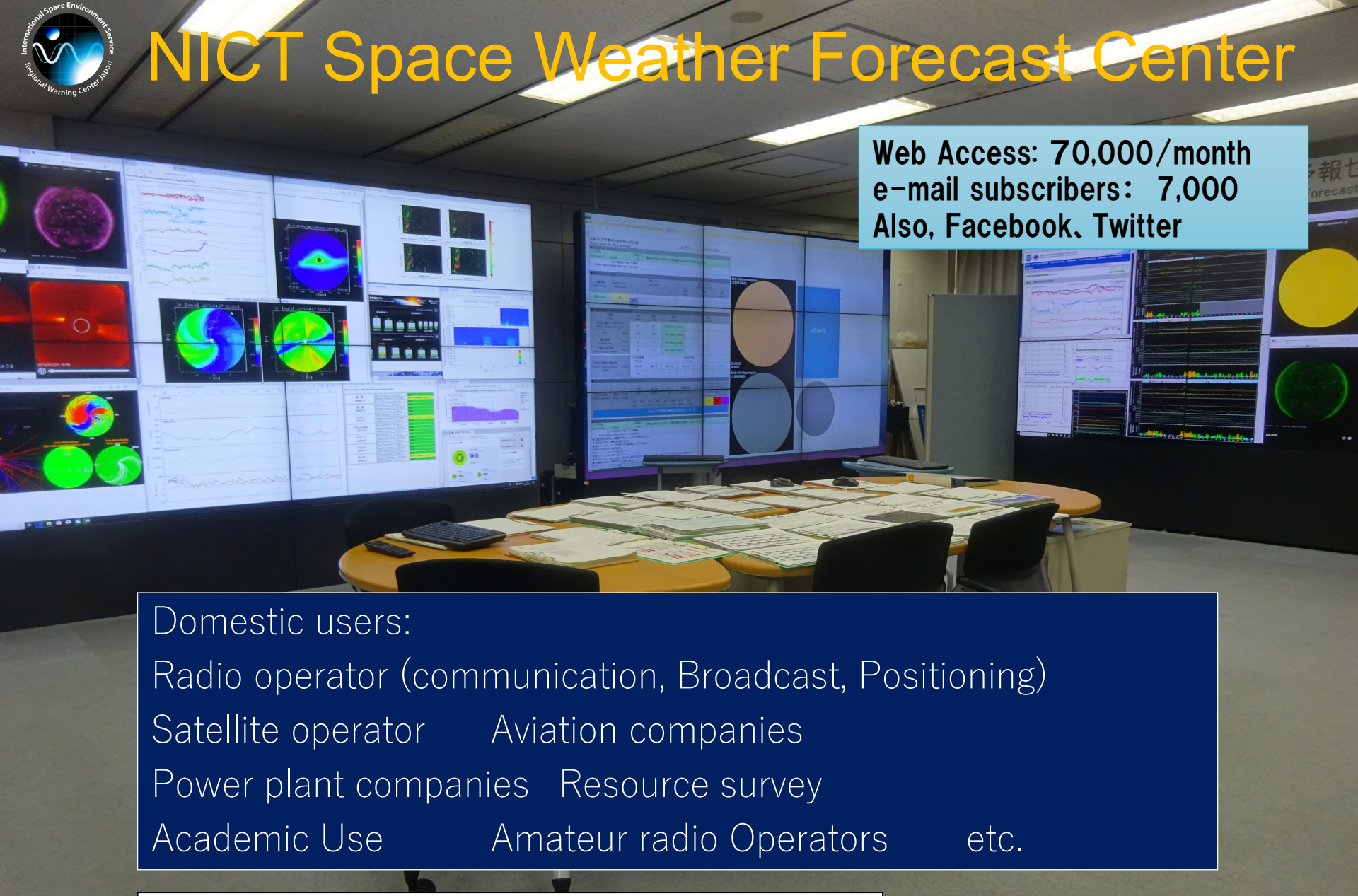
NICT Space Weather Forecast Center

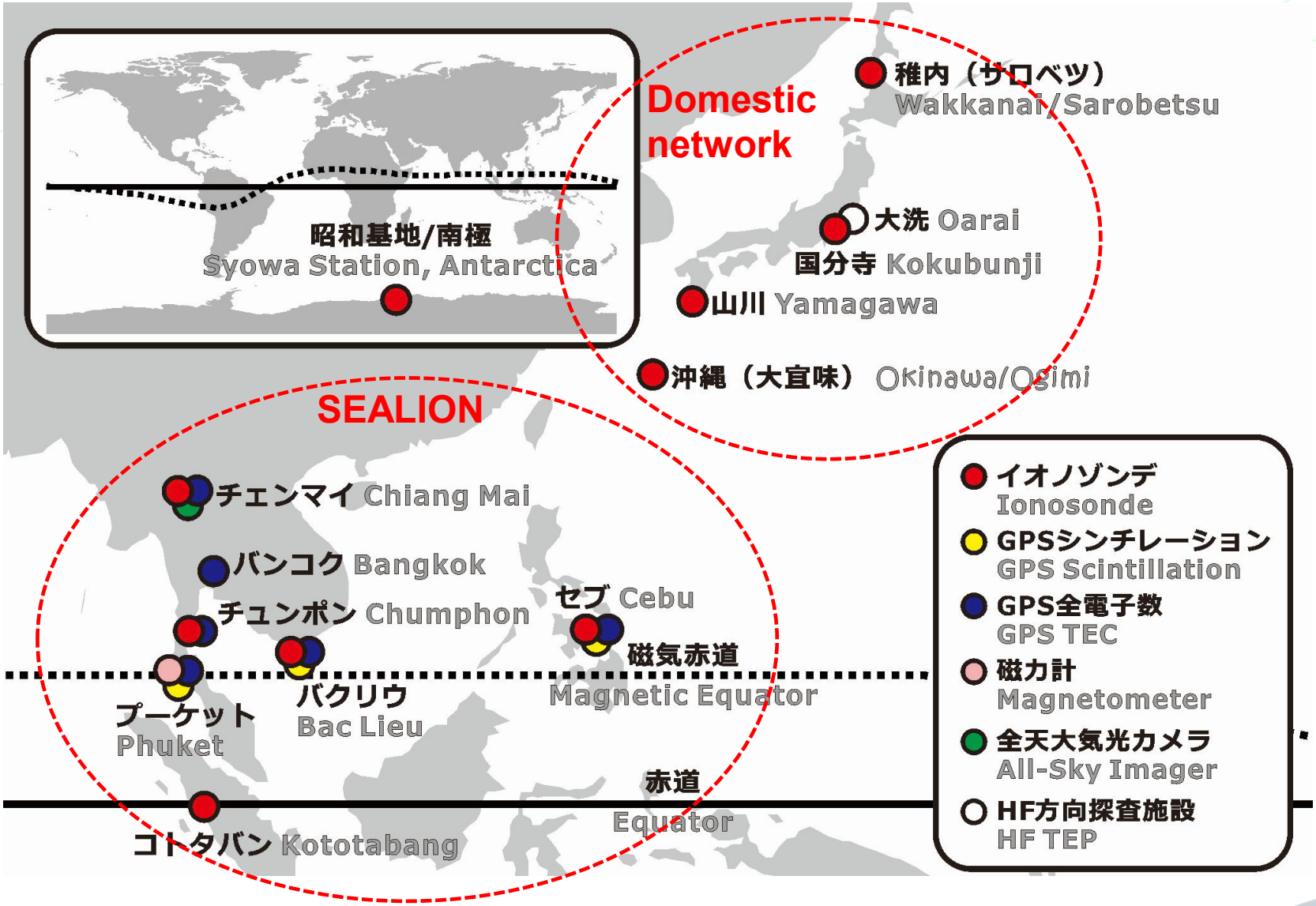


Web Access: 70,000/month
e-mail subscribers: 7,000
Also, Facebook、Twitter

Domestic users:
Radio operator (communication, Broadcast, Positioning)
Satellite operator　　Aviation companies
Power plant companies　Resource survey
Academic Use　　Amateur radio Operators　　etc.

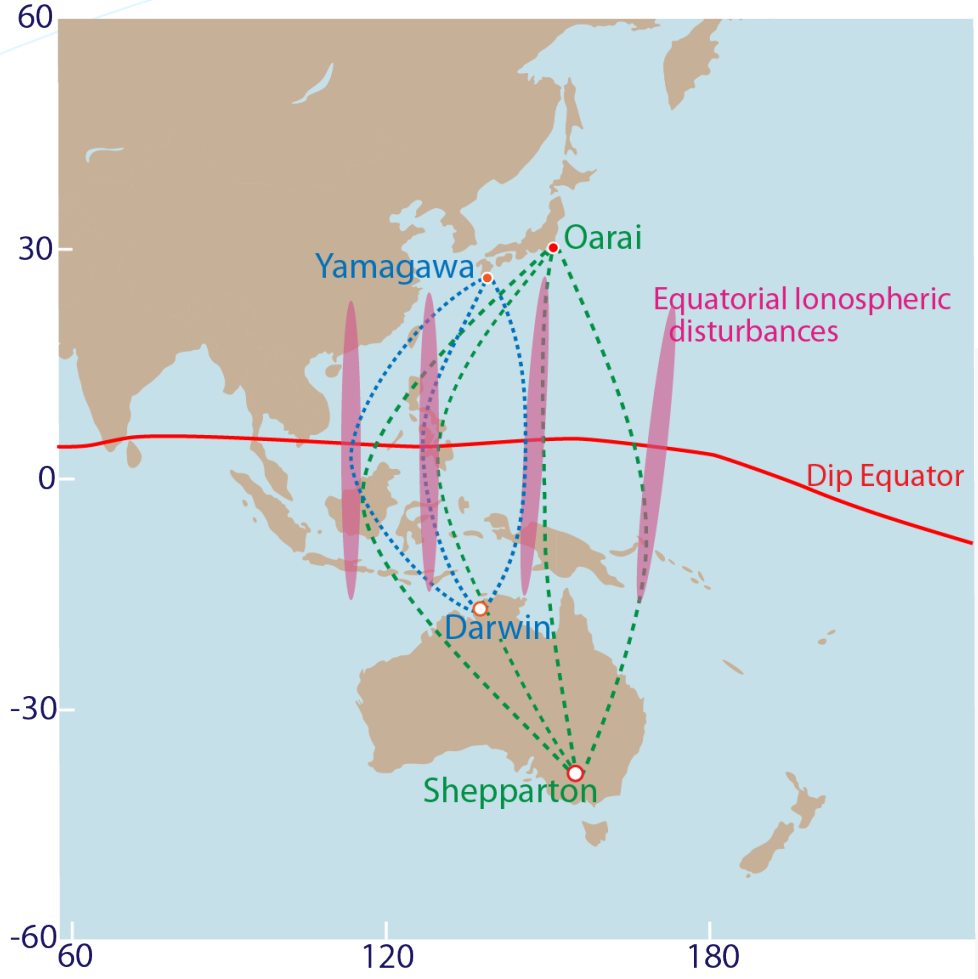
24/7 operation started on Dec. 1, 2019

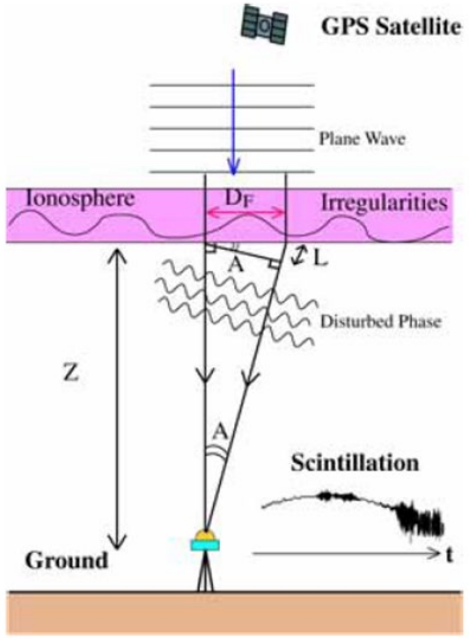
NICT Ionospheric Observation Network (2003~)

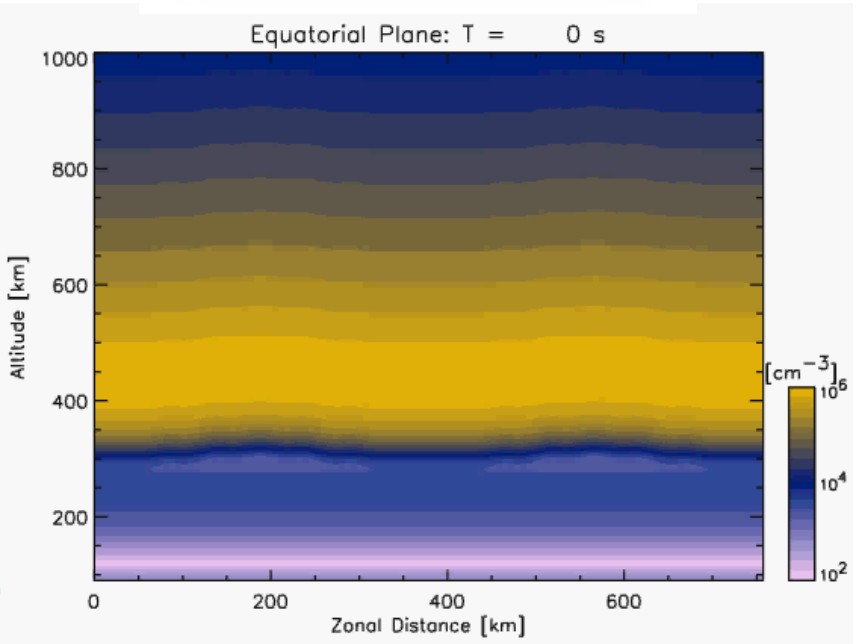


Plasma Bubbles

causes the disabilities of precise satellite positioning



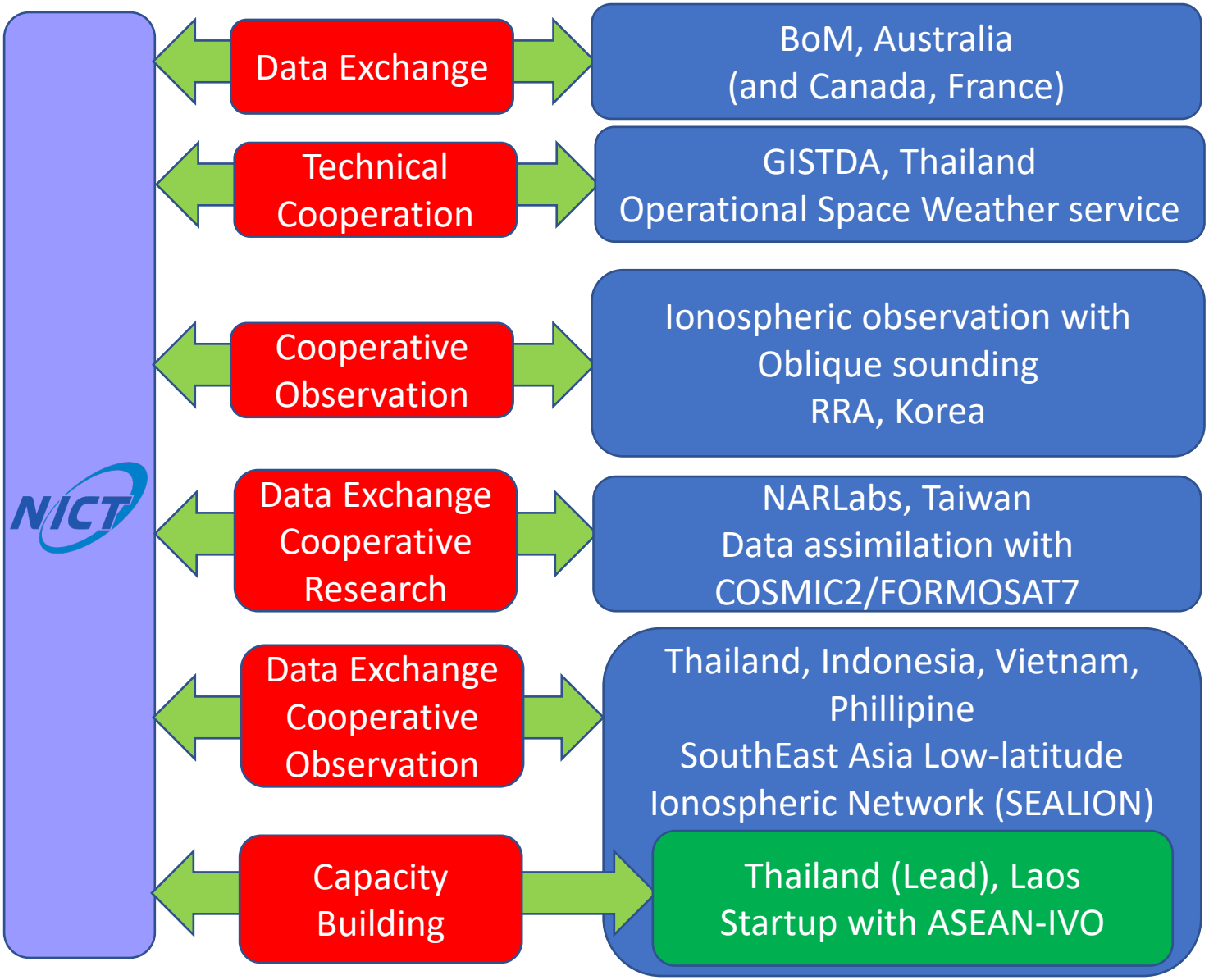




Yokoyama et al. (2015)

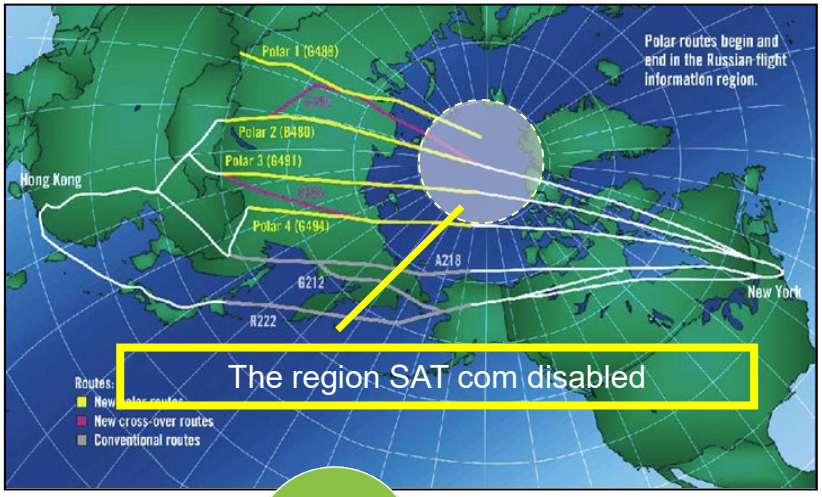
New VHF radar was installed in Chumphon city, Thailand for detecting equatorial plasma bubbles

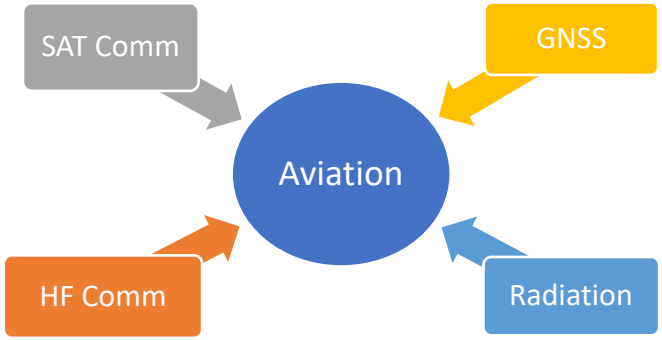
International activity of NICT in Asia

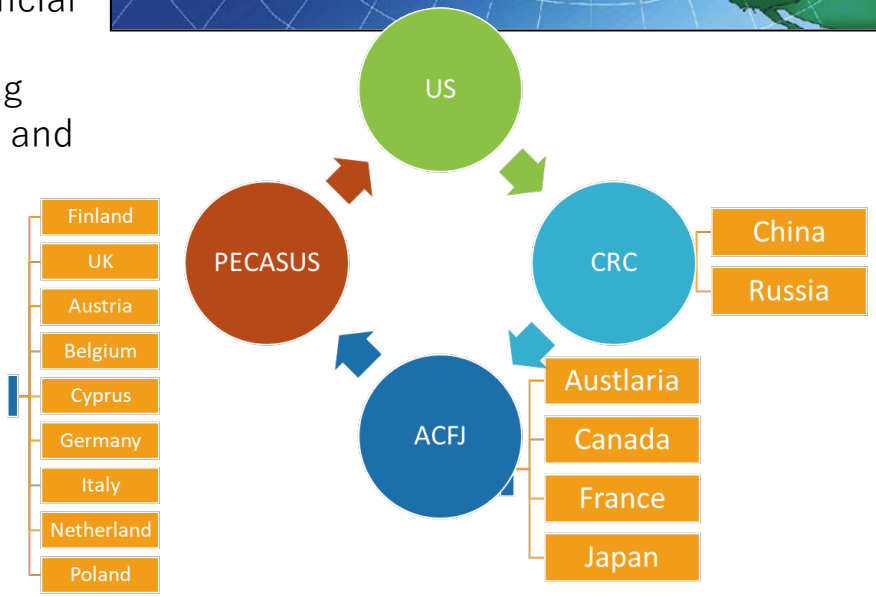


ICAO Space Weather Services

- ICAO, International Civil Aviation Organization started to provide space weather services since Nov. 2019 with three global centers (US, European consortium named PECASUS and ACFJ which is a consortium of Australia, Canada, France and Japan) with rotating their responsibility every two weeks. A new consortium, CRC, China-Russia consortium joined this rotation on the beginning of 2022.
- These global centers use their own observational data and models for monitoring and forecasting the ionosphere, which can cause inconsistency of official space weather forecast.
- NICT hosts data archive for collecting and sharing ICAO space weather center data for harmonizing and improving space weather forecast services.







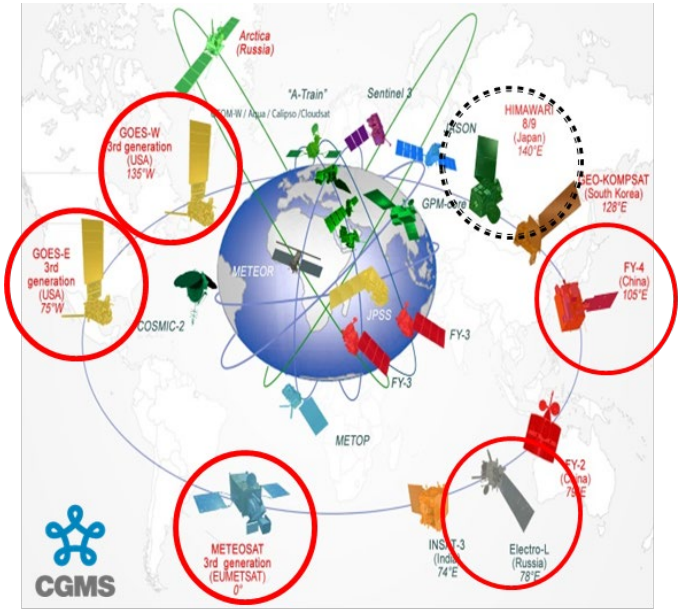
The four centers rotate their duty every two weeks.

Discussion of space weather monitoring with operational satellites

It is necessary to monitor the electro-magnetic condition in the radiation belt over Japan for precise space weather forecast and estimation of impact on social infrastructure. On the other hand, there are no available satellite data over the west Pacific area and use GOES satellite data which is over the US. We have started the discussion of development of satellite sensor for monitoring space weather over Japan.

We now plan to develop some instruments for measuring space weather under the cooperation with JMA. Our target satellite is Japanese next-generation meteorology satellite, “HIMAWARI” which will plan to launch in FY2028. We are going to develop proton and electron spectrometers and satellite charging monitor in this project.

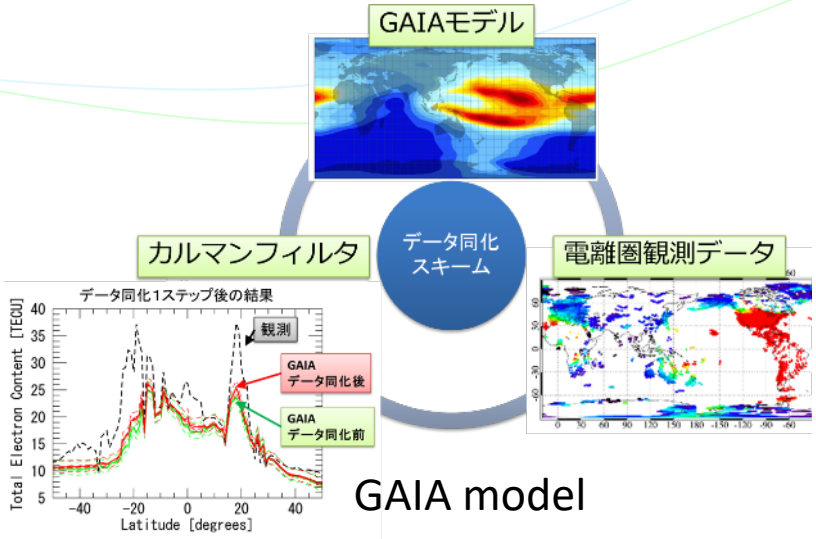
The developing scheme of operational satellite and sensors are much different from that of scientific use, and it is also challenging to establish the development scheme of operational space weather sensors.



CGMS (Coordination Group for Meteorological Satellites)のメンバーとして現在運用中の気象衛星の配置図。赤丸で囲われた衛星は宇宙環境モニタを搭載。

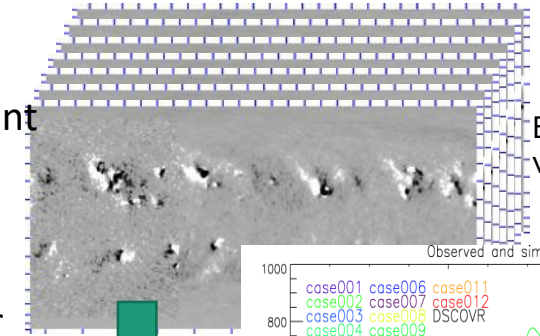
Data assimilation with numerical model in operational space weather

We have been developing an atmosphere-ionosphere coupling model named “GAIA” for forecasting ionospheric condition as a part of space weather.
We succeeded to build a prototype of real-time data assimilation system using GAIA for daily space weather forecast in the last mid-term research project period. In the present period, we start the operational use of GAIA model for space weather forecast using observational data as input parameters.

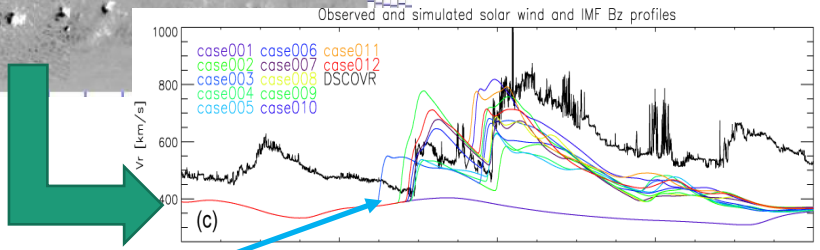


GAIA model

We have been trying same approach in the different area, solar wind. It is important to estimate the arrival time of solar storm after solar flare for preparing against any disasters in social infrastructure. We have been developing the solar storm model named “SUSANOO” and use ensemble simulation with various initial condition for estimate the arrival time of solar storms.



Ensemble simulation with various initial condition



Plural simulation results

Success to estimate the arrival time of solar storm

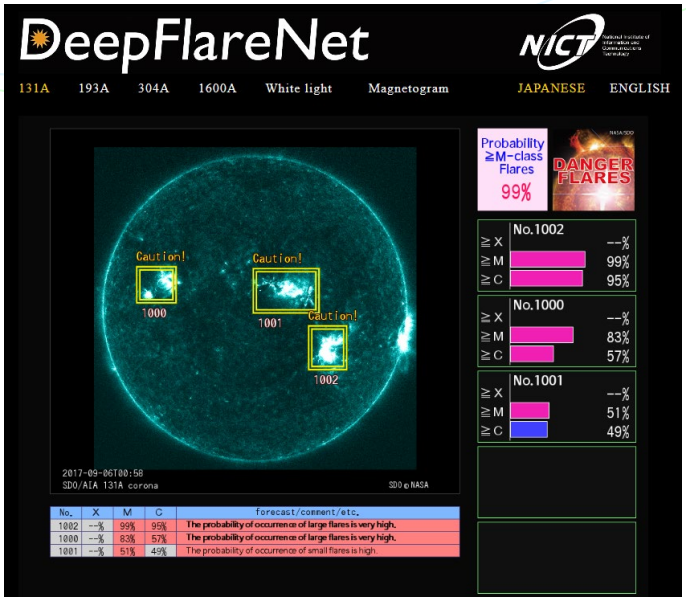
SUSANOO model

Applied AI technique in Space Weather forecast

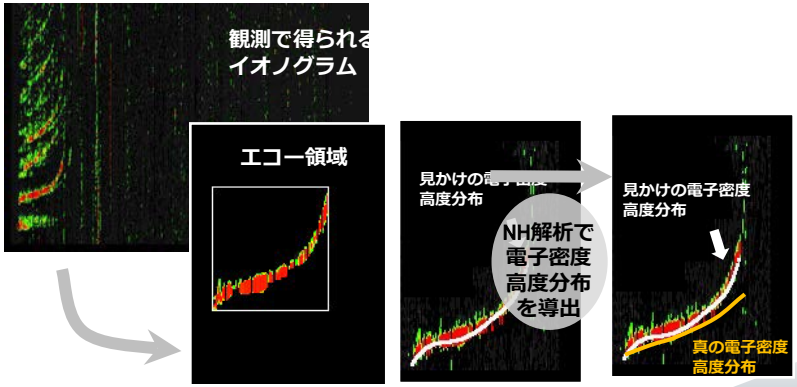
Artificial Intelligence (AI) is a powerful tool in space weather forecast. The processes in the interaction from the sun, solar wind, magnetosphere and ionosphere still have unknown parts which makes difficult the space weather forecast. On the other hand, there are an amount of observing data from the ground/satellite which can be used for teacher data in AI method.

We have been developing the solar flare prediction model “DeepFlareNet” used deep learning method on the base of SDO solar image dataset. We use this system in the discussion of operational space weather forecast.

Another trial is to use AI for automatic scaling in ionogram. The ionogram is image data obtained from ionosonde observation and it is necessary to scale the image to detect any physical parameters. For many years, skilled scalers had worked the scaling, but it is difficult to obtain the data in real time. We now try to solve the issue with AI.



URL https://defn.nict.go.jp



An example of Application: HF-START

HF-START (High Frequency Simulator Targeting for All-users' Regional Telecommunications) is HF propagation simulator that is developed to meet the needs of space weather users for, but not limit to, telecommunications.

HF-START service consists of "Real-time Information" and "Web Tool".

Real-time Information

We serve real-time information for domestic and global users.
For domestic use, some selective values are provided as the following parameters; transmitting frequencies, the locations of transmitter and receivers using 3D electron density estimated from tomography in Japanese GNSS network "GEONET".
For global use, some selective values are provided same as domestic use, and 3D electron density is estimated from numerical model "GAIA".

Real-time information on HF propagation is automatically updated twice an hour. Information at minutes 15th and 45th will be delivered with 15-minute latency. If the real-time data is missing, the most recent information will be displayed with "Not latest" indicator.

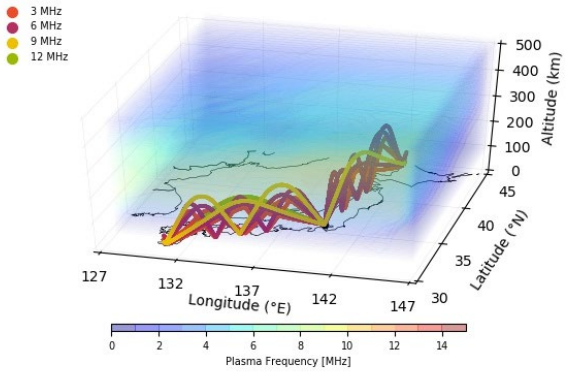
Web Tool

HF-START web tool is a web application of the radio propagation simulator. Users can enjoy inputting the parameter by themselves. An instruction manual is available at Readme .
This website is operated by the Space Environment Laboratory, Applied Electromagnetic Research Institute in the National Institute of Information and Communications Technology. Should you have any feedbacks, please contact us.

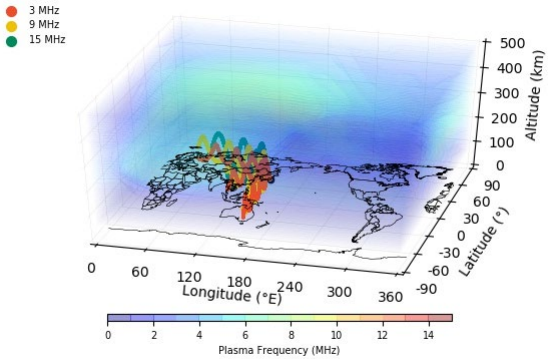
URL: hfstart.nict.go.jp

HF-START Web Tool

HF
Simulator
Targeting for
All-users'
Regional
Telecommunications



Domestic Model



Global Model

Space Weather benchmark in Japanese society

Insufficient evaluation　Effects are negligible　Effects require adequate measures, e.g., back up preparation　Events prevent continuous operations and problems have long duration

＊ Results may change by future studies　■ Effect depends on the system　△ different from normal

Field	Effect and hazard	Causal space weather phenomena	Occurrence probability and effect				
			Daily-several per year	Once per year	Once per 10 years	Once per 100 years	Once per 1000 years
Electricity	Black out (Overcurrent in power lines)	Geomagnetically induced current (GIC)					＊
Satellite operation	Spacecraft surface charging	Substorm electron				＊	＊
	Spacecraft internal charging	Energetic electron				＊	＊
Radio Communication and Broadcasting ■	High frequency (HF) hazard	Ionospheric negative storm				＊	＊
		Dellinger phenomenon				＊	＊
		Polar cap absorption (PCA)				＊	＊
		Plasma bubble				＊	＊
	Very high frequency (VHF) hazard	Sporadic E-layer	△	△	△	△	△
		Plasma bubble				＊	＊
Positioning ■	Poor positioning accuracy	Ionospheric positive storm				＊	＊
		Plasma bubble				＊	＊
		Fast propagation of TEC structure in auroral region				＊	＊
Human space activity	Astronaut exposure	Solar energetic particles (SEP)					＊
Daily life on the Earth's surface	Exposure on the ground	Solar energetic particles (SEP)					＊
Aviation	Communication failure	Ionospheric negative storm				＊	＊
		Dellinger phenomenon				＊	＊
		Polar cap absorption (PCA)				＊	＊
		Plasma bubble			＊	＊	＊
		Sporadic E-layer			＊	＊	＊
	Poor positioning accuracy	Ionospheric positive storm	＊	＊	＊	＊	＊
		Plasma bubble	＊	＊	＊	＊	＊
		Fast propagation of TEC structure in auroral region	＊	＊	＊	＊	＊
	Aircrew exposure	Solar energetic particles (SEP)					＊

- Another recent result is the space weather benchmark in Japanese society.
- This document reports the space weather impact in each field, for example, power grid, satellite operation, communication etc in Japanese society.
- Especially we discuss the scale and occurrence frequency of the impact.
- We think that the users can discuss cost and benefit for preparedness for space weather disaster in each field.
- This discussion is now improving in Japanese government. We will publish a report on June, 2022.

Summaries

- Space weather disasters occurrence is very rare, but if occurred, they could seriously affect on social activities.
- We, NICT has a long history to provide space weather information operationally.
- It is essential to have international cooperation for operating space weather services for covering global observation network and evaluate model performance. We have a lot of cooperative projects with other countries.
- Japan contributes to ICAO space weather services under the cooperation with Australia, Canada and France since 2019. Especially we contribute to harmonize the quality of service among global centers with constructing data sharing system.
- Under the cooperation with domestic academic organizations, we have been developing ground based/satellite sensors, numerical and empirical models.
- The discussion of social impact from Space weather is started in Japanese government since Jan. 2022. We will publish a report in June.