NATIONAL RADIO RESEARCH AGENCY

Space Weather Strategy and Action Plan of the Republic of Korea

Feb 2024

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**Korean Space Weather Center/RRA/MSIT*

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2. Recent Accomplishment
3. Plan to 25th Solar Maximum

1. Introduction

ROK Space Weather Capability(1)

MSIT MINISTRY OF SCIENCE and ICT

National Radio Research Agency

Official source to deliver space weather products & services in Korea

KOREAN SPACE WEATHER CENTER (KSWC)

Operation Center
Forecast & Alert, R&D, Observation

KMA Korea Meteorological Administration

- Space weather effect on (terrestrial) climate, weather, meteorological satellite

KASI

- Research on optical & radio astronomy, space science

KOPRI Korea Polar Research Institute

- Research on ionosphere, mesosphere in polar region

R.O.K Space weather Capability(2)

2011

Regional Warning Center

2012

Member of IPT-SwieSS

2014

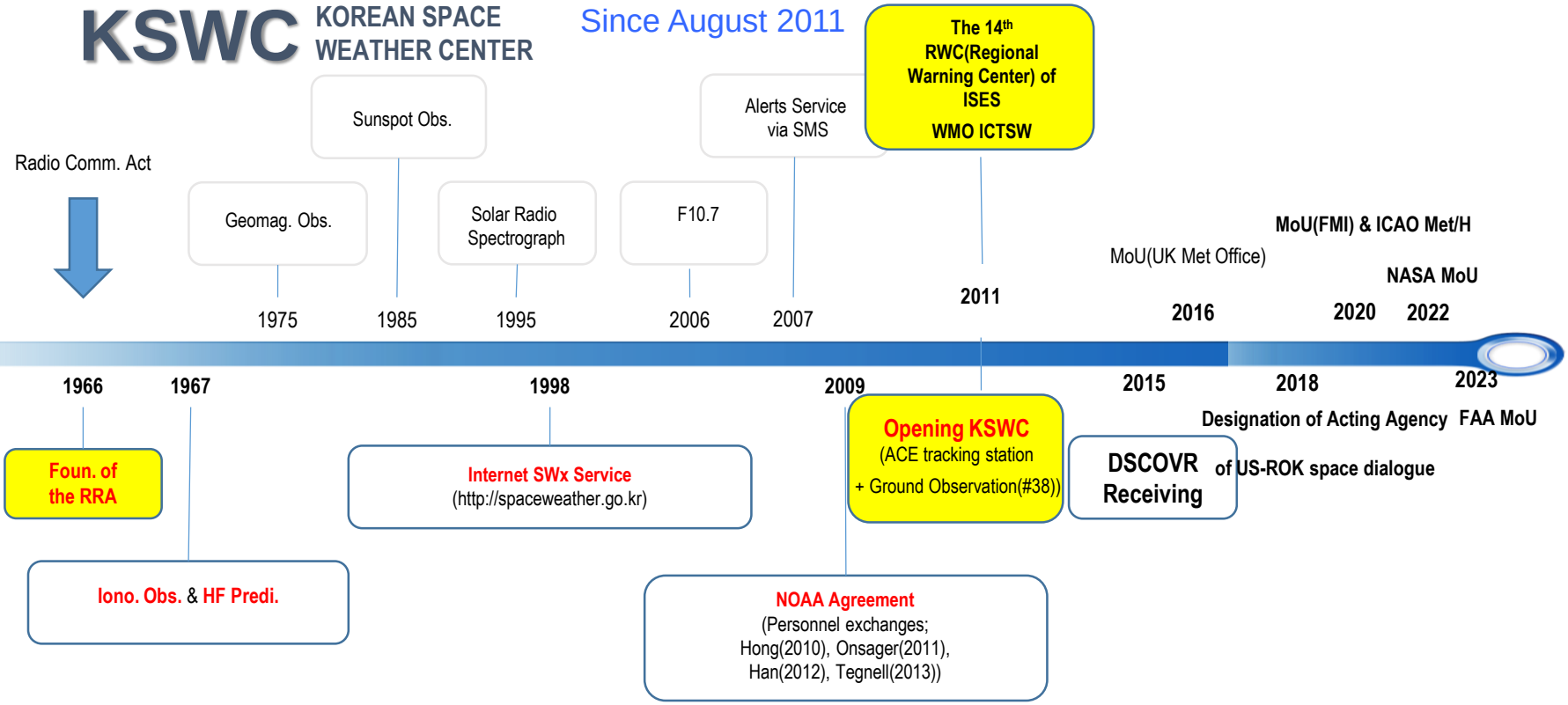
Delegate for Space Weather

1980S~

Leading Agency of ROK

ICAO MET/H

R.O.K Space Weather Timeline

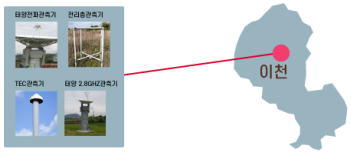


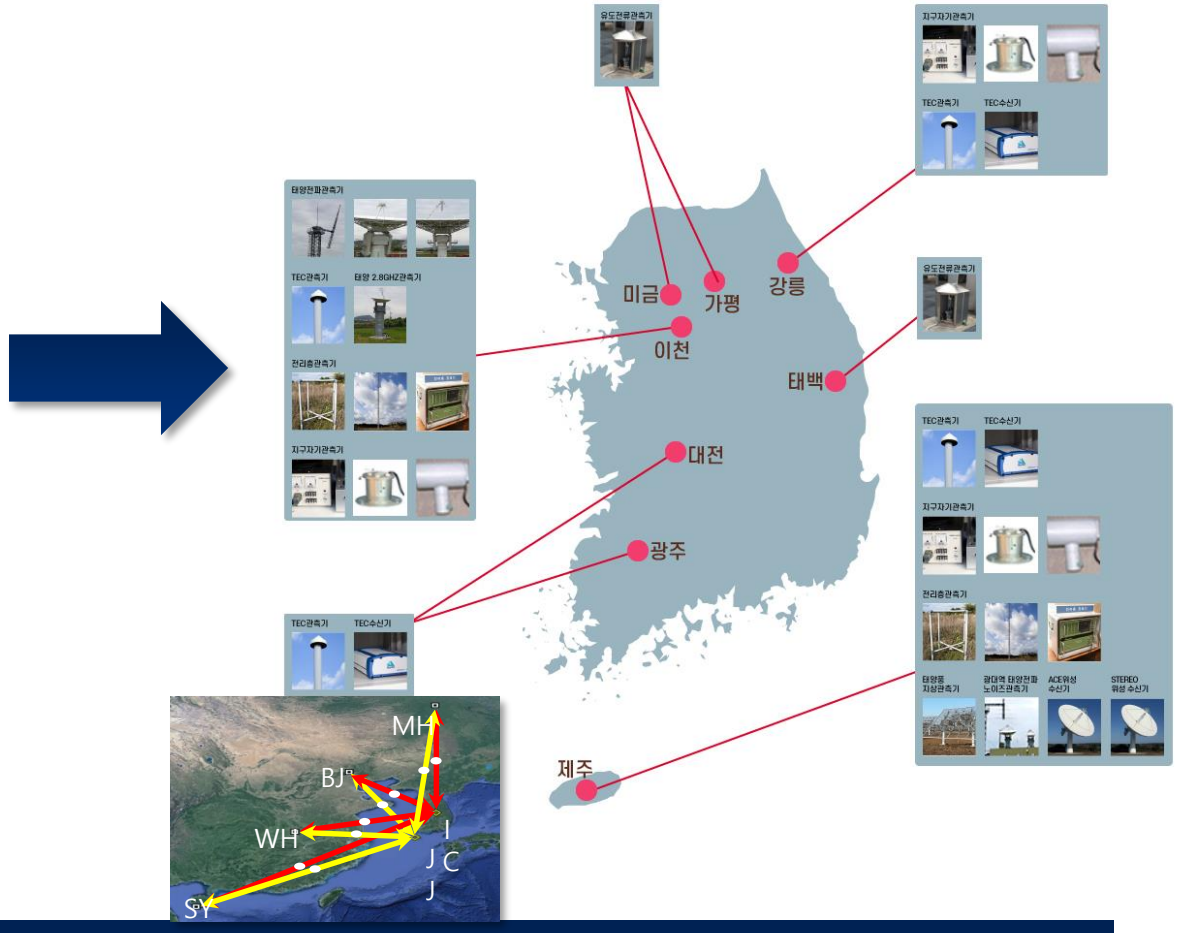
2. Recent Accomplishment

Observation networks

Before 2011

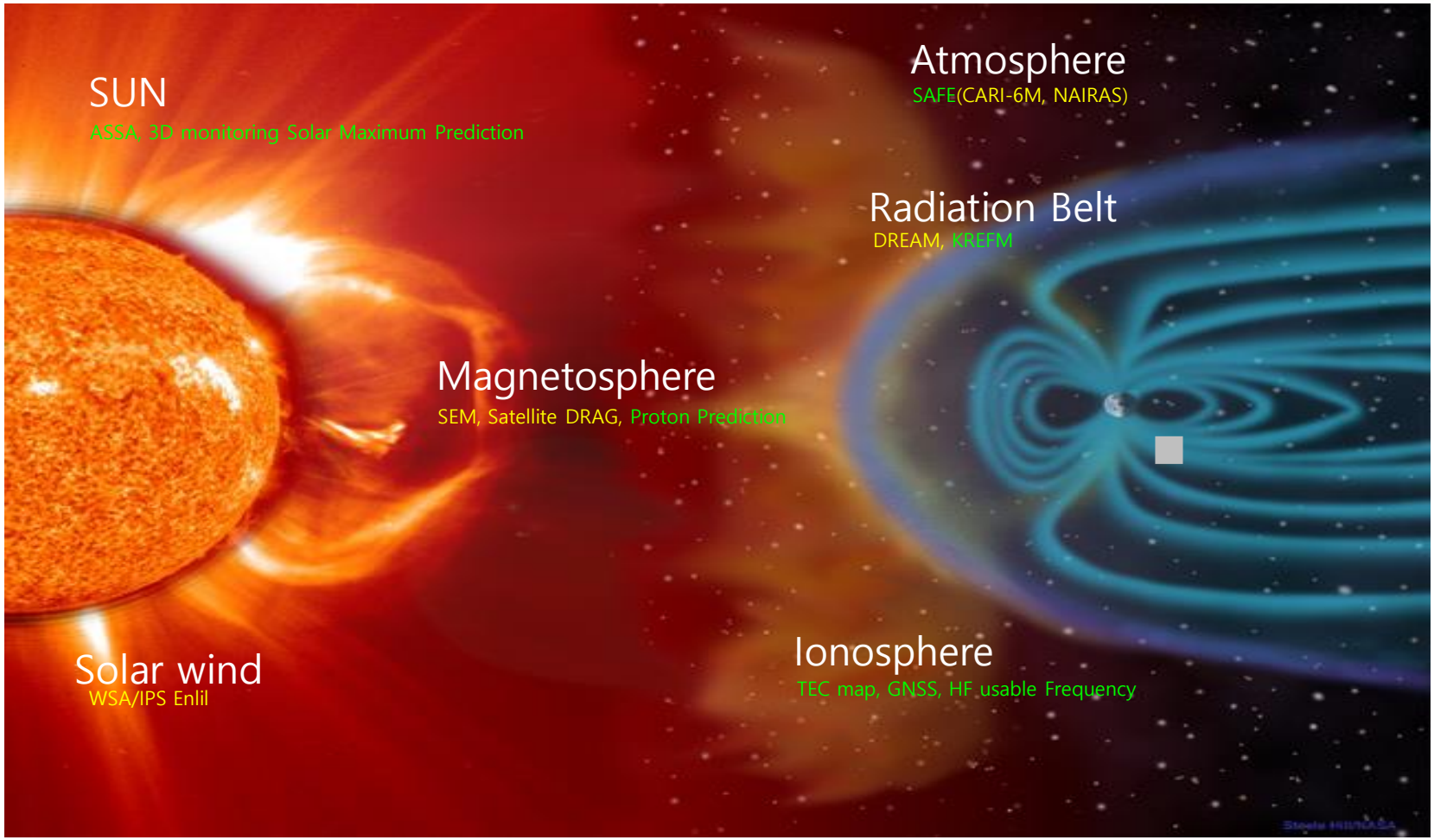
Since 2011





Newly established Geo-magnetometer at Jeju Site

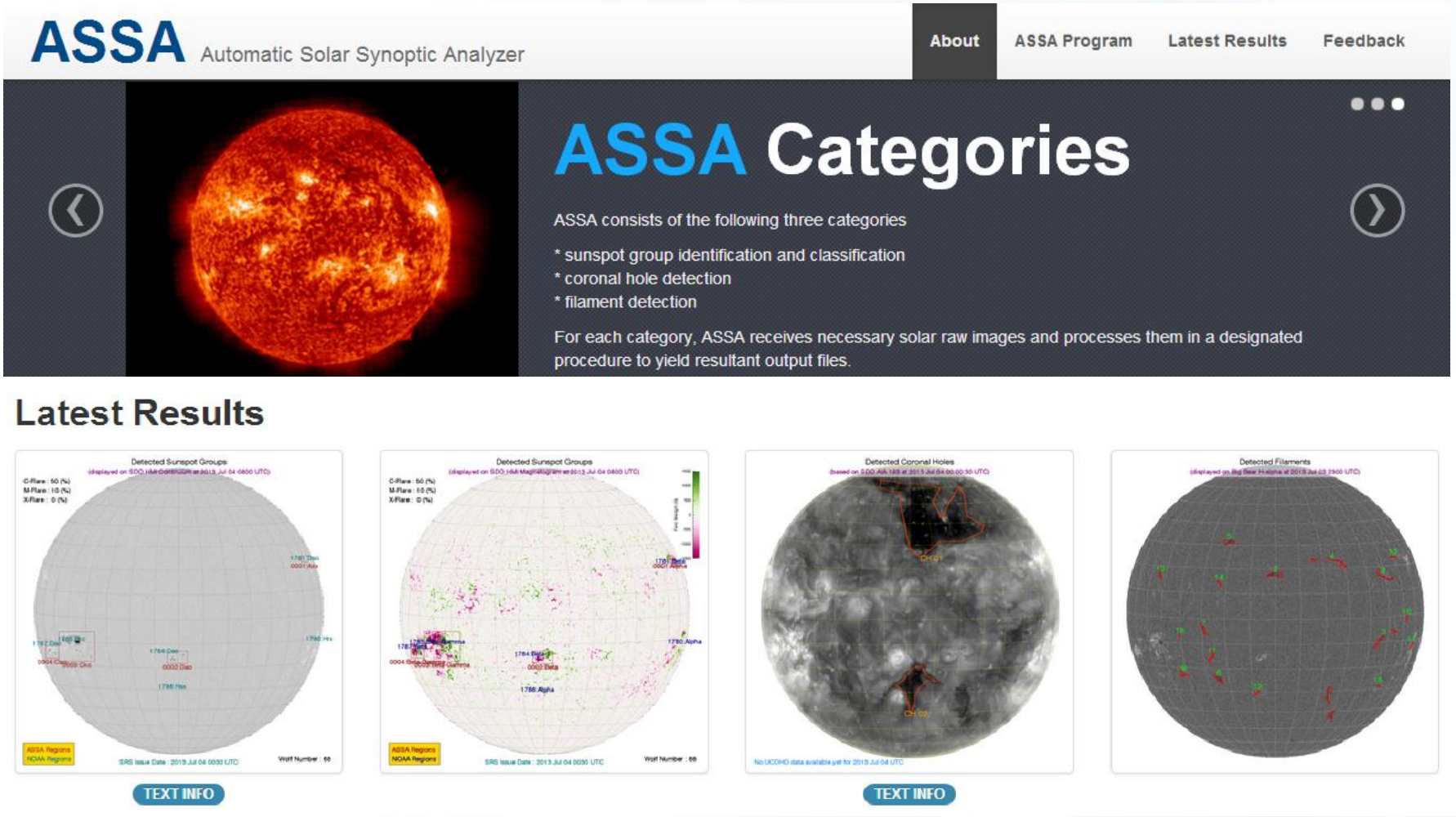
Physical/Numerical Model



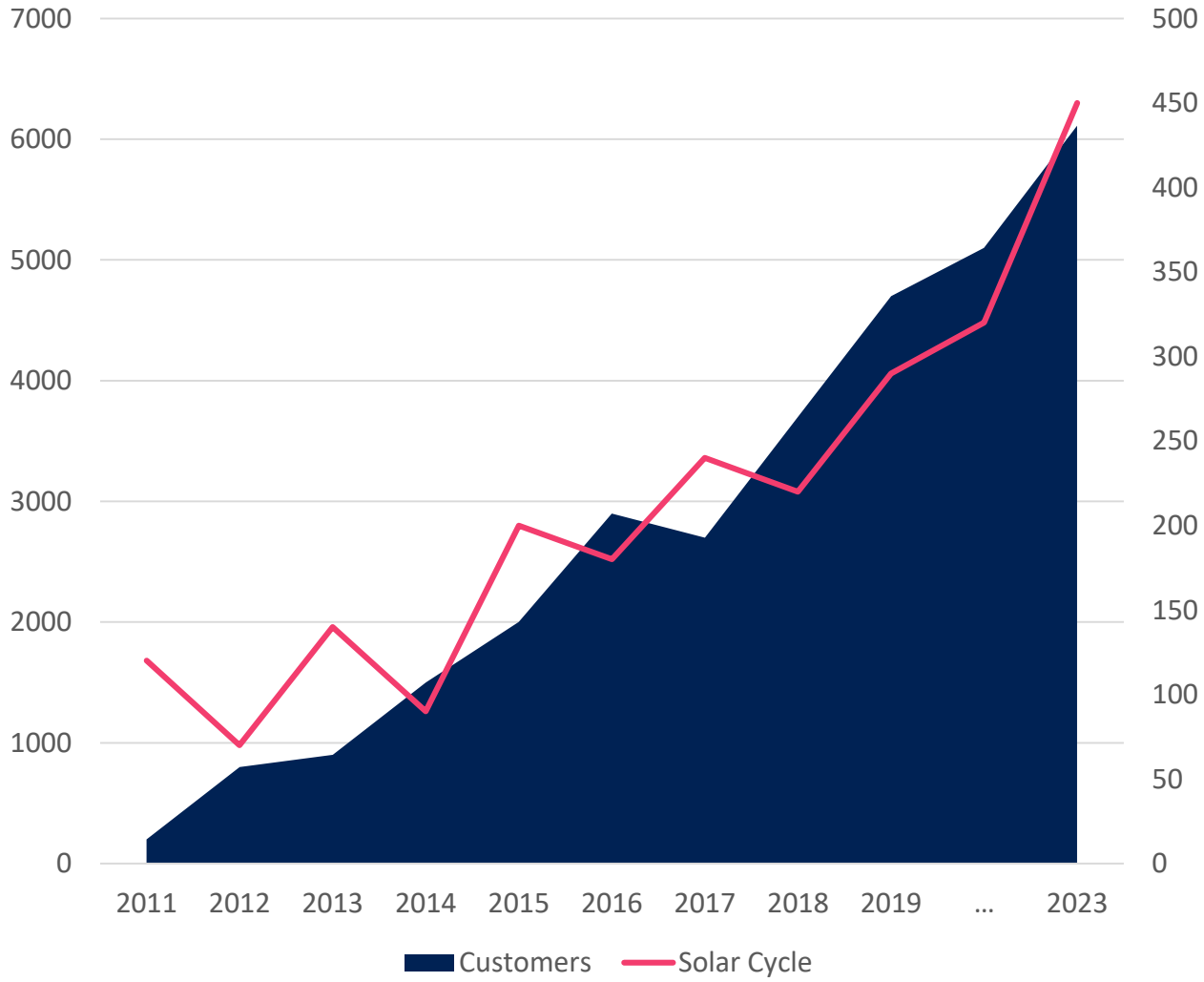
■Sun : 10 ■Geomagnetic field : 5 ■Ionosphere : 3 ■User tailored service : 20

R & D - ASSA

http://www.spaceweather.go.kr/assa



The number of Users



of field

- Government: 418
- Aviation: 438
- Defense : 488
- Satellite : 50
- Communications : 160
- Power gird: 75

National Risk Profile

Radio Wave ACT

Article 51 **(Establishment & Implementation of basic plan for the management of Space Weather Risks)**

The Minister of Science, ICT and Future Planning shall establish and implement a **basic plan for the management of space weather risks** including following in order to prepare, control and recover against disasters due to variation of space weather conditions in every 5 years.

1. Matters concerning **observation** and **surveillance** of variation of **space weather conditions;**
2. Matters concerning **forecasts and alerts** of space weather risks;
3. Matters concerning **R&D** (Research and Development) and **international cooperation** for the prevention of and preparing against space weather risks.
4. Other matters necessary to provide against space weather risks.

National Risk Response

Space Weather Alerts

ACT	Alerts (Scale)	Authority
▪ Radio Wave Act (Article 61)	▪ Solar Activities Alerts	▪ Space Weather Center

NOAA SWx Scales (R,S,G)

1 ~ 2	Send alert messages	*KSWC level*	Forecast Team
3	Notify to key customers	*Ministry level*	Director of KSWC
4 ~ 5	Notify to related Ministries	*National level*	Director of KSWC

Situation Assessment Meeting

Space Weather Disaster Alerts

ACT	Alert(Scale)	Authority
✓ Framework Act on the Management of Disasters and Safety ✓ Radio Wave Act (Article 51)	✓ Over Scale 4 of SW Alert	✓ Ministry of Science, ICT and Future Planning

Alert(Scale)	Authority
Attention	Section Chief
Caution	Undersecretary
Alert	Vice-minister
Serious	Minister

3. Plan to 25th solar Maximum

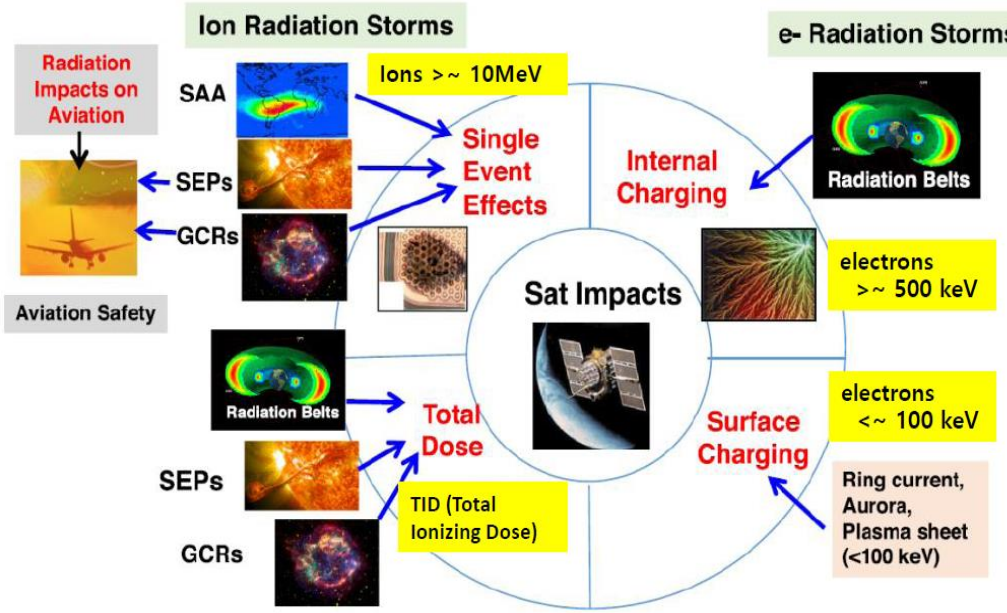
New Research Program

- Space Weather Environment for LEO/GEO Satellites
- > 10 MeV Solar Proton Events with Automatic CME detection
- Solar Synoptic Magnetograms Using Deep Learning
- Prediction Model for Sporadic E-Layer Occurrence
- Advancement of space weather radio observation equipment & data processing

→ **Total Estimated budget for the Modeling Process is about 8 Million USD (Year 23-27)**

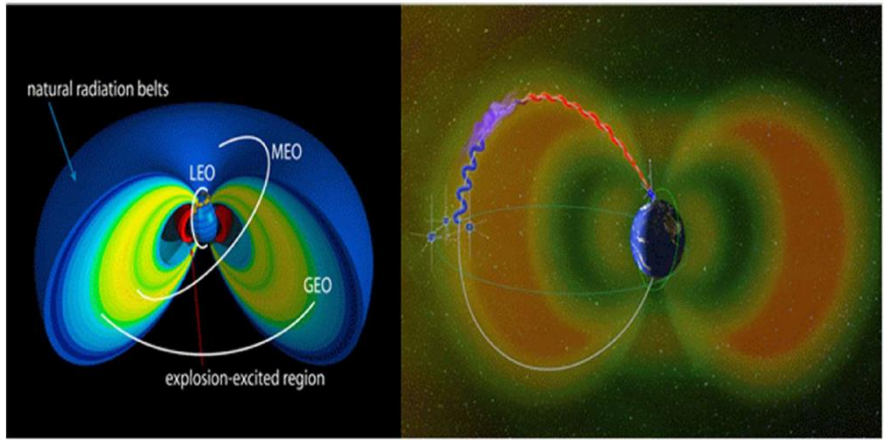
1) Space Weather Environment for LEO/GEO Satellites

❖Radiation & Charging Effects



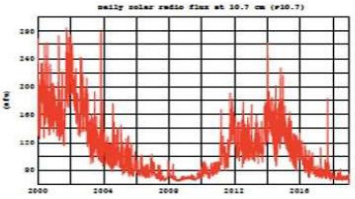
[Zheng et al., Space Weather, 2019]

❖High Energy Particles & Van Allan Radiation Belt

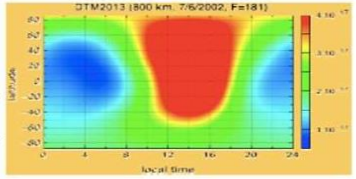


[Reeves et al, 2020, AMOS Conf; Zhang et al. 2022, Nat Comm]

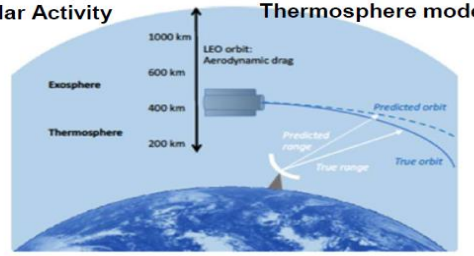
❖Satellite Drag Effects

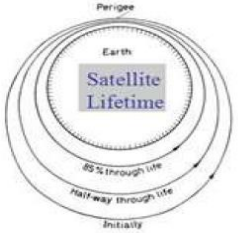


Solar Activity



Thermosphere model





❖ Space Debris

Large Constellations and Safety of Flight - Spacecast 35

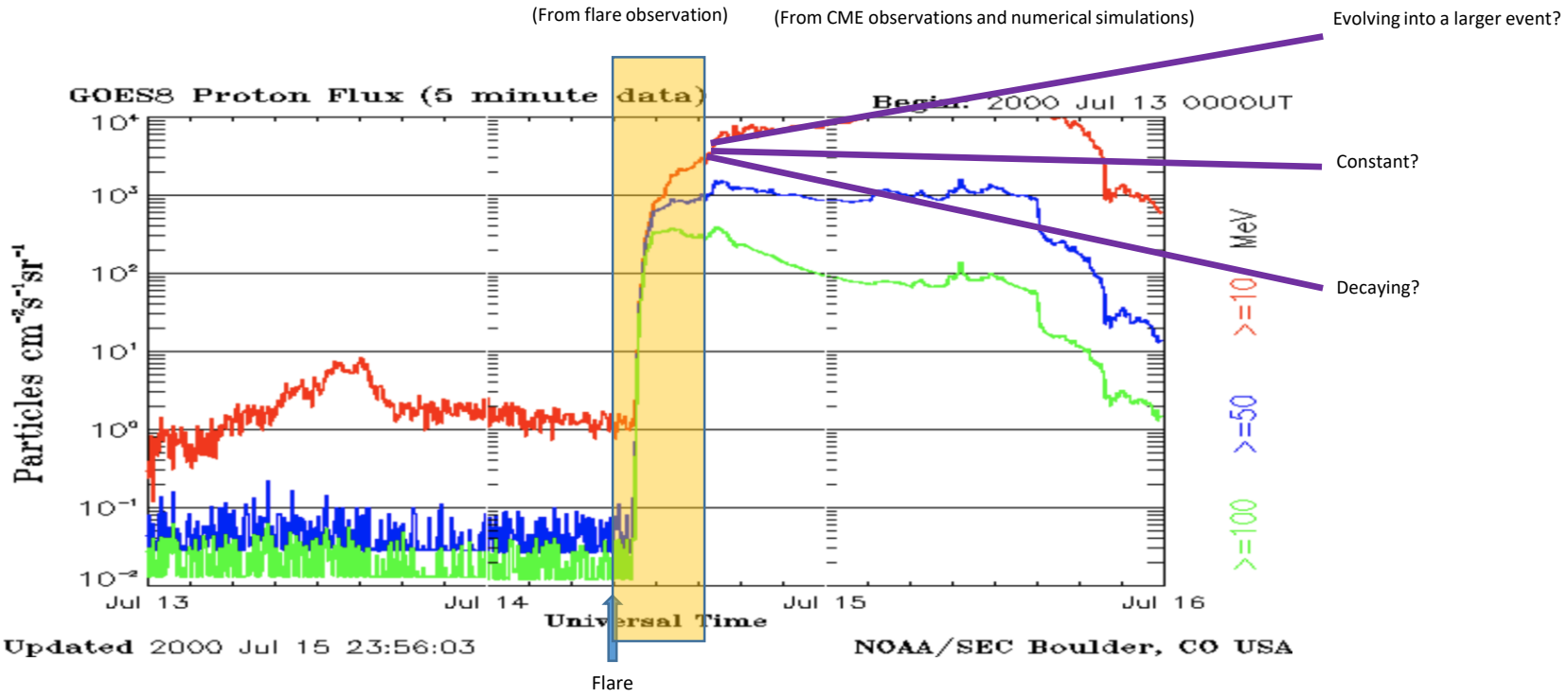
Encounters in 10 years of non-intervention ops (circa 2020, p. 3)

#	Operator	# S/C	Alt (km)	Current RSO catalog average number			~200,000 RSO catalog average number		
				Collisions in 10 years	3km warnings in 10 years	1km maneuvers in 10 years	Collisions in 10 years	3km warnings in 10 years	1km maneuvers in 10 years
39	OneWeb	2,560	1,200	**0.32**	**754,868**	**83,874**	**2.49**	**10,832,864**	**1,203,652**
40	OneWeb_next	720	1,200	0.17	286,598	31,844	1.69	4,726,261	525,140
41	OrbComm	16	750	0.00	40,930	4,548	0.00	303,482	33,720
42	Orora.Tech	100	650	0.02	198,308	22,034	0.05	1,799,993	199,999
43	Planet	200	500	0.02	167,124	18,569	0.03	1,607,487	178,610
44	PlanetiQ	18	775	0.00	54,882	6,098	0.00	449,177	49,909
45	Reaktor	36	495	0.00	26,014	2,890	0.01	264,686	29,410
46	Satellogic	300	477	0.02	236,040	26,227	0.02	2,254,977	250,553
47	Sky/Space Glbl	200	507	0.02	180,456	20,051	0.05	1,712,964	190,329
48	SkySat	6	500	0.02	6,009	668	0.12	48,980	5,442
49	Space_Norway	2	25,799	0.00	0.29	0.03	0.00	0.63	0.07
50	SpaceX	4,425	1,200	**6.43**	**2,050,452**	**227,828**	**77.73**	**30,310,084**	**3,367,787**
51	SpaceX_VLEO	7,488	350	0.99	315,000	35,000	23.90	9,318,590	1,035,399
52	SpaceX_next	60	580	0.23	73,743	8,194	1.95	758,544	84,283
53	Space_X_M-T	20,940	500	**43.13**	**13,753,896**	**1,528,211**	**404.53**	**157,747,388**	**17,527,488**
54	Space_X_U-W	9,000	330	0.93	347,030	38,559	21.86	10,053,221	1,117,025
55	Swarm	150	443	0.08	53,333	5,925	0.98	833,160	91,462

[Large Constellations & Safety of Flight, Spacecast 35]

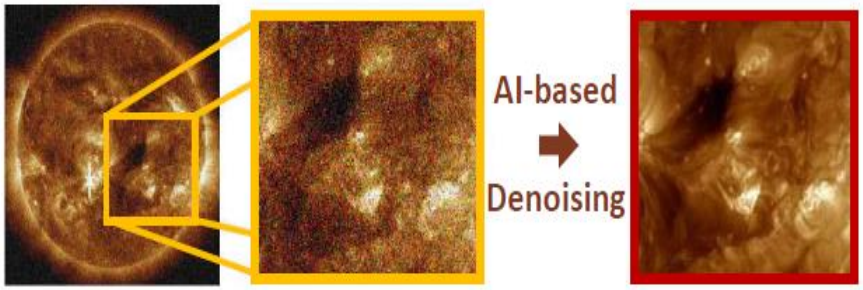
2) Modeling > 10 MeV Solar Proton Events with Automatic CME detection

- **Modeling Near-Earth > 10 MeV Solar Proton Event Prediction by Probing into Solar Wind Condition with Automatic CME detection**
- **Making the prediction of the timing and scale of Solar Radiation Storms:**
  - After obtaining the flare magnitude from GOES X-ray flux data, predict within 10 minutes the peak intensity of the prompt component of the GOES >10 MeV proton
  - After obtaining CME observations of the event, predict the 12 hours long time-intensity profile of the GOES >10 MeV proton

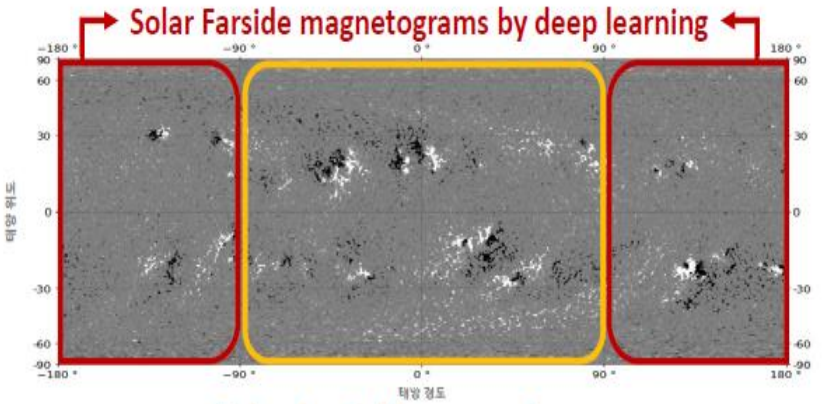


3) Development of Solar Synoptic Magnetograms Using Deep Learning

1 Improvement of Solar Data by Deep Learning



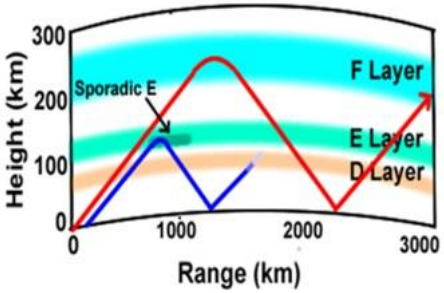
2 Generation of Solar Farside Magnetograms by Deep Learning



4) Development of the Prediction Model for Sporadic E-Layer Occurrence

Sporadic E(Es) Layer

- ✓ Es layer has significant influence on radio communications and broadcasting, and predicting the occurrence of sporadic E layer is one of the most important issues in space weather forecast
- ✓ Because of the highly complex behavior of sporadic E layer, the prediction of Es layer occurrence has been one of the most difficult issues in space weather forecast
- ✓ To explore the possibility of predicting Es layer occurrence, we performed statistical analysis of Es layer occurrence over korea and employed the machine learning based method

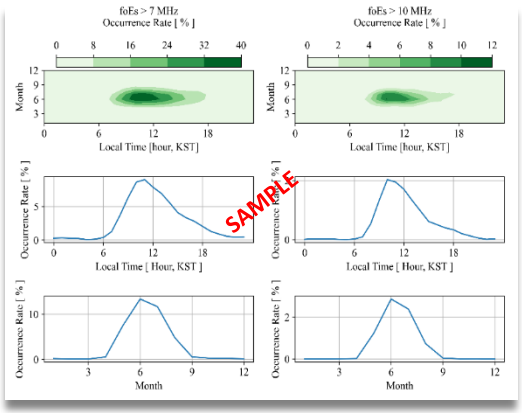


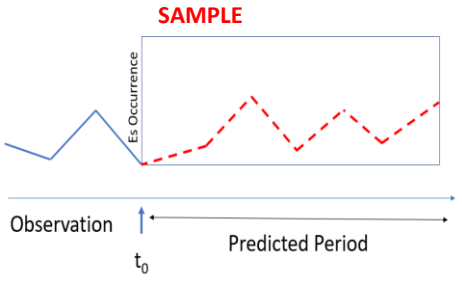
Research Objectives

- ✓ Statistical analysis and modelling of Es layer occurrence over mid-latitude stations
  1. Diurnal, seasonal and solar cycle variations in Es layer occurrence
  2. Correlation analysis of Es layer occurrence
  3. Development of prediction models for Es occurrence using machine learning(ML) based method

Expected Results

1. Local time, seasonal distribution of Es layer occurrence over mid-latitude stations
2. Solar cycle variation of Es layer occurrence
3. Basic quantity for ML based model
4. Real-time Es occurrence forecast system





Global Satellite Program – SWFO, IMAP

Collaboration of the New establishment of the Satellite dishes for the IMAP/NASA & SWFO/NOAA, LV1 data is ready to be opened !

Interstellar Mapping and Acceleration Probe

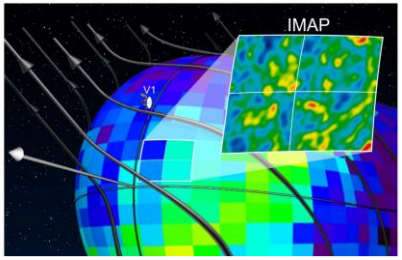


Table 1. Nominal Payload for IMAP Mission	[kg]	[W]
High Sensitivity, High Resolution ENAs		
1. Solar Wind & PUI ENAs	20	18
2. High Energy ENAs	7	7
Other Samples of Interstellar Matter		
3. Interstellar Neutrals (w Low-E ENAs)	15	15
4. Pickup Ions	10	8
5. ACRs/GCRs	5	5
6. Interstellar Dust	8	16
In Situ/Background Payload with RTSW		
7. Ly-α Photometry	4	4
8. Interplanetary Magnetic Field	3	3
9. Solar Wind Ions & Electrons (two sensors)	7	7
10. Solar/Interplanetary Energetic Particles	3	3
Full Science Payload (CBE)	**80**	**86**
30% Contingency	24	26
TOTAL PAYLOAD ALLOCATION	**104**	**112**

1 – 4. Pick Up Ions & Energetic Neutral Atoms :

physical processes and interaction between the heliosphere and the local int… medium → understanding the physical mechanism of **particle acceleration**

R.O.K. International collaboration

- **COSPAR(12-21 July 2024, Busan)**

  – PSW Session 7 : International Cooperation

-Organized by Kichang Yoon, Terry Onsager(NOAA SWPC),

-Mamoru Ishii(ISES director), Suzy Bingham(WMO, UK), M. Kuznetsova(NASA CCMC)

- **ISES(20-21 July 2024, Busan)**

  – Exchange operational forecast & technology Among members

https://naver.me/IFIwLWKd

OR

All Material of the Plan could be downloaded via GOOGLE DRIVE

Thank You for your attention.

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