Science from an Operational Mission: An L5 Consortium meeting
London, 11-14 May 2015

NATIONAL RADIO RESEARCH AGENCY
KOREAN SPACE WEATHER CENTER

Space Weather Activities at KSWC:

what KSWC can offer an L5 Space-Weather Mission?

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Dong-Hun Lee (Kyung Hee Univ)

RRA NATIONAL RADIO RESEARCH AGENCY

Contents

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1. SWx Operations
2. Research Activities
3. National Preparations
4. *Possibles* for an L5 SWx mission

KSWC Overview

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➢ **The primary action agency of emergency measure to severe SWx, and the RWC Korea of International Space Environment Service**

MSIP MINISTRY OF SCIENCE, ICT AND FUTURE PLANNING

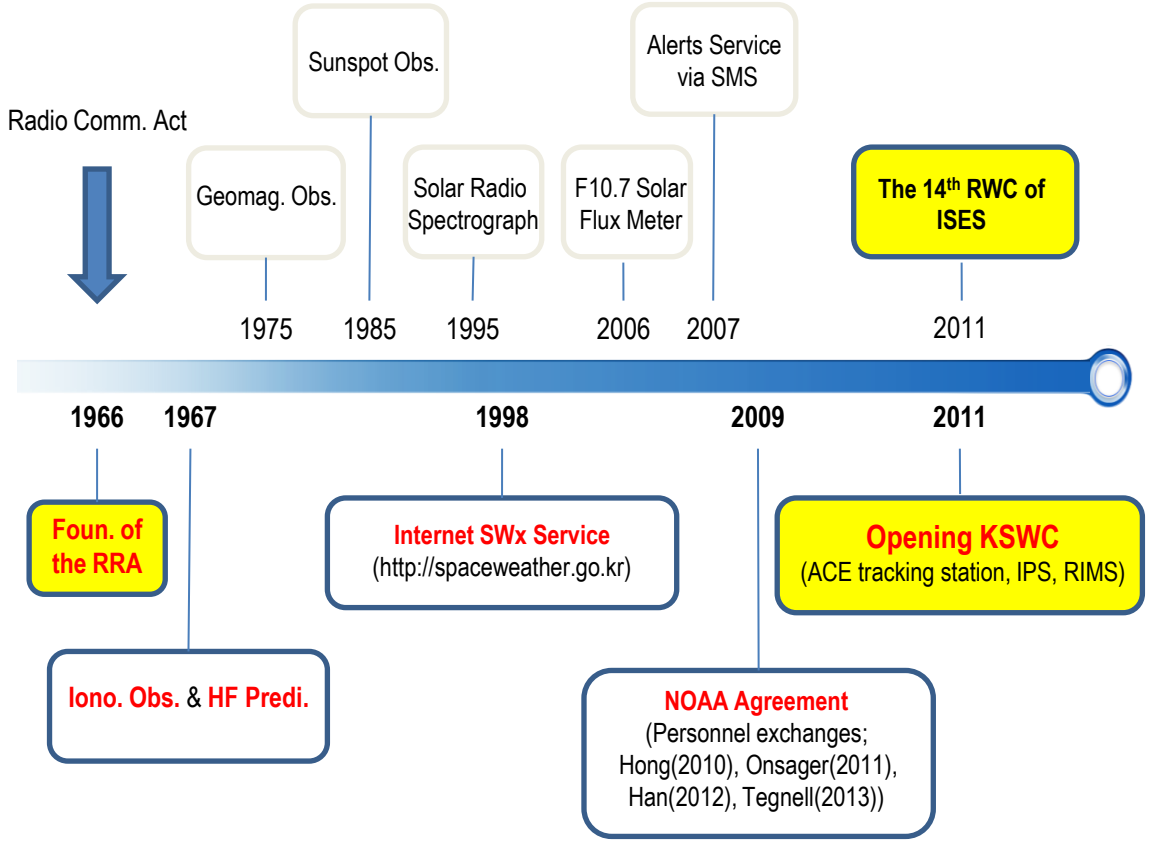
└ **RRA** NATIONAL RADIO RESEARCH AGENCY

└ **KSWC** KOREAN SPACE WEATHER CENTER

Since August 2011

- Planning Division
- R&D Division
- Forecast Division
- Observation Division

24 staff = 20 gov. + 4 technicians



SWx Operations – operational work flow

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Observation

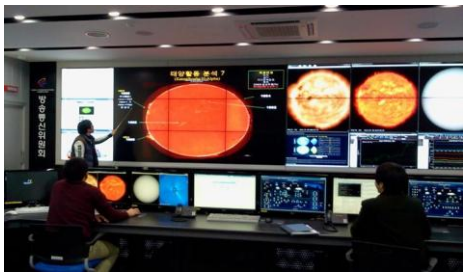
Ground Based

-  Ionosondes (x2) & TEC (x5)
-  Mag (x3)
-  SRS (30MHz~2.5GHz)
-  F10.7 Meter
-  IPS
-  RIMS (30MHz~18GHz)
-  GIC Monitor (x3)

Space

-  ACE Tracking

Products



Alerts & White Alerts

3-hourly Condi. & Forecast

3-day Forecast(daily)

27-day Forecast(weekly)

HF Prediction(monthly)

Models & Services

ASSA, IPS-Enlil,

NAIRAS, IRI-VOACAP, GIC, etc. (29ea.)

SMS

Email

www

FAX

Customers

- Satellite
- Comm.
- Defense
- Aviation
- Power

KBS olleh kt KARI SaTReC MBC tu SK telecom 한국아마추어무선연맹 THE KOREAN AMATEUR RADIO LEAGUE 합동참모본부 nis 국가정보원 항공교통센터 KOREAN AIR ASIANA AIRLINES MOTIE MINISTRY OF TRADE, INDUSTRY & ENERGY 한국전력공사

SWx Operations – observation network

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SWx Operations – satellite tracking facilities

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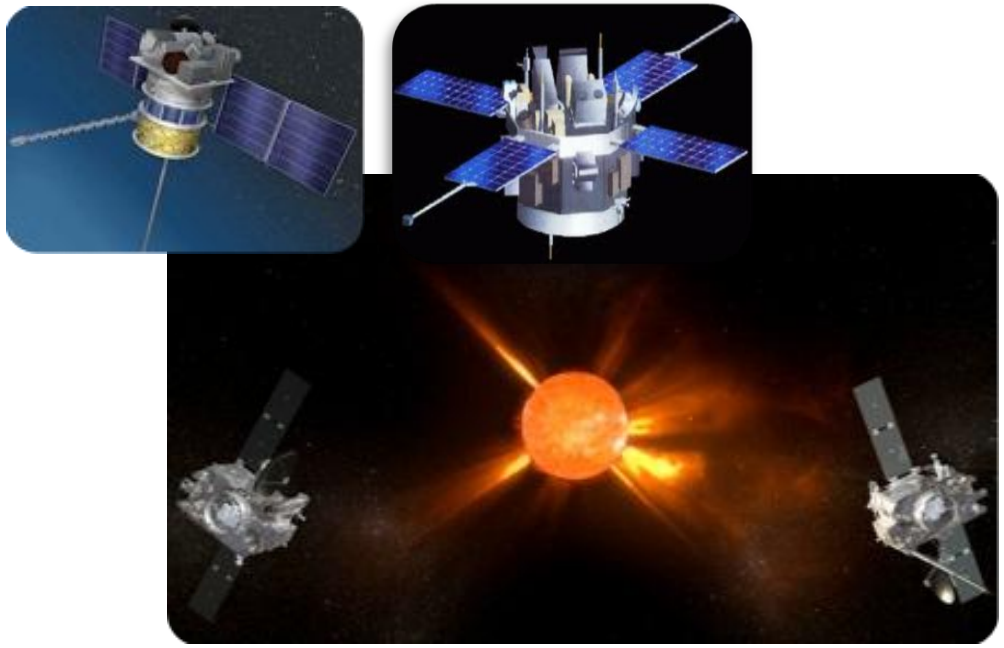
➢ ACE Tracking Antenna

- ✓ global tracking network for RTSW
- ✓ 13-meter dish antenna (S-band)
- ✓ in operation since Feb 2012
- ✓ upgrade for DSCOVR by Jun 2015

➢ New Tracking Antenna

- ✓ 13-meter dish antenna
- ✓ dual RF (X-band, S-band) & triple receiver switching for STEREO, ACE & DSCOVR
- ✓ in operation from Dec 2014



SWx Operations – GIC monitoring

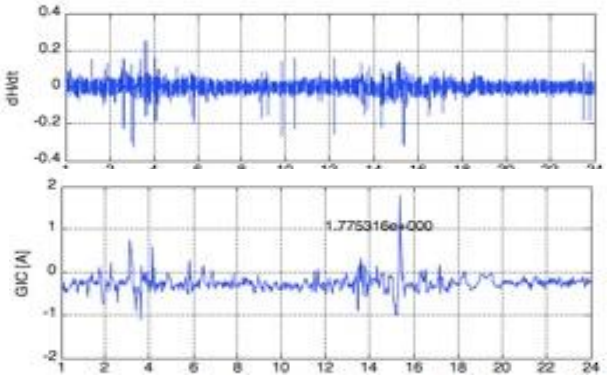
➢ GIC Measurement & Analysis

- ✓ GIC monitoring over 765KV & 154KV transmission facilities
- ✓ the first GIC monitoring systems in Korea
- ✓ 10A GIC was recorded during G3 storm time of Oct 2012

765KV (Singapyung, Oct. 2012)

765KV (Sintaebak, 2Q. 2013)

154KV (Jeju, 2Q. 2013)



HIOKI SENSOR UNIT 9555-10

HIOKI UNIVERSAL CLAMP ON CT 9279

SWx Operations - www.spaceweather.go.kr

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Korean Space Weather Center
RRA NATIONAL RADIO RESEARCH AGENCY

Regional Warning Center for International Space Environment Service

HOME | FAQ | SITE MAP | KOREAN

2013-10-26 15:30 (KST)
2013-10-26 06:30 (UTC)

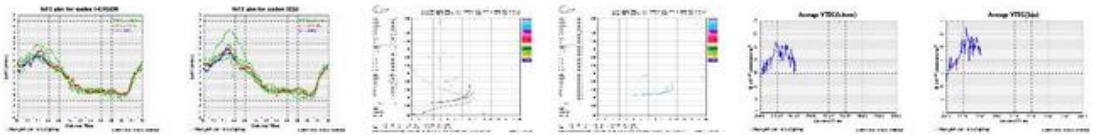
Alerts & Forecasts | Forecast Models | Real Time Data | Space Weather | Instruments | About the Center

Today's Forecast/ Prediction

Real time data

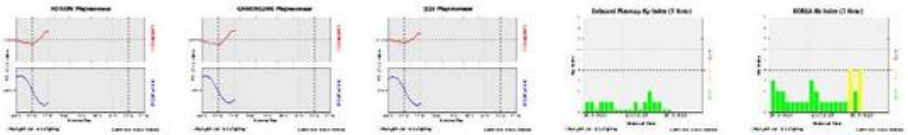
[Click for more detailed images]

Ionosphere



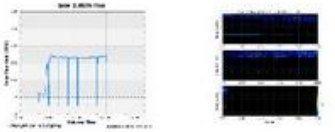
Icheon Ionosphere (foF2) | Jeju Ionosphere (foF2) | Icheon Ionosphere (ionogram) | Jeju Ionosphere (ionogram) | Icheon TECs | Jeju TECs

Geomagnetic activity



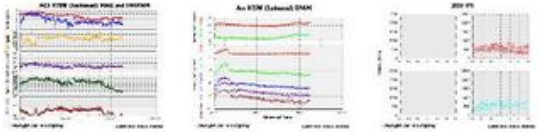
Icheon geomagnetic | Gangneung geomagnetic | Jeju geomagnetic | K_p Index | K_K Index

The Sun



Sunspot activity (28GHz) | Solar radio activities Icheon | Jeju | Solar Radio Noise Monitor

Solar Wind



SOLAR WIND: Mag field & Plasma | Low Energy Electrons & Protons | Solar Wind Ground scope for Solar Wind

Would you like to know the impact of space weather on the Earth?

More detailed information for the nonprofessional on space weather, radio communications and satellites etc. GO

Educational cartoons on space weather for kids GO

Obervation Data Go

Space Weather Report Go

Research Activities – tailored prediction models

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Solar Activity	ASSA : Automatic Solar Synoptic Analyzer solar cycle prediction
Solar Wind	WSA-Enlil + Cone (Dr. Dusan Odstrcil & SWPC) IPS Solar Wind Reconstruction (Dr. Bernard Jackson & STELab. of Nagoya Univ.)
Satellite	**GEO environment monitor** **LEO satellite drag prediction**
Aviation	**polar route SWx monitor** **radiation dose prediction**
Power Grid	local GIC prediction local GIC map
Navigation	local TEC map local GPS ionospheric error map
Communications	**local ionospheric model** (IRI-2012 + VOACAP + local data) real-time usable HF frequency

Research Activities – support for satellite user group

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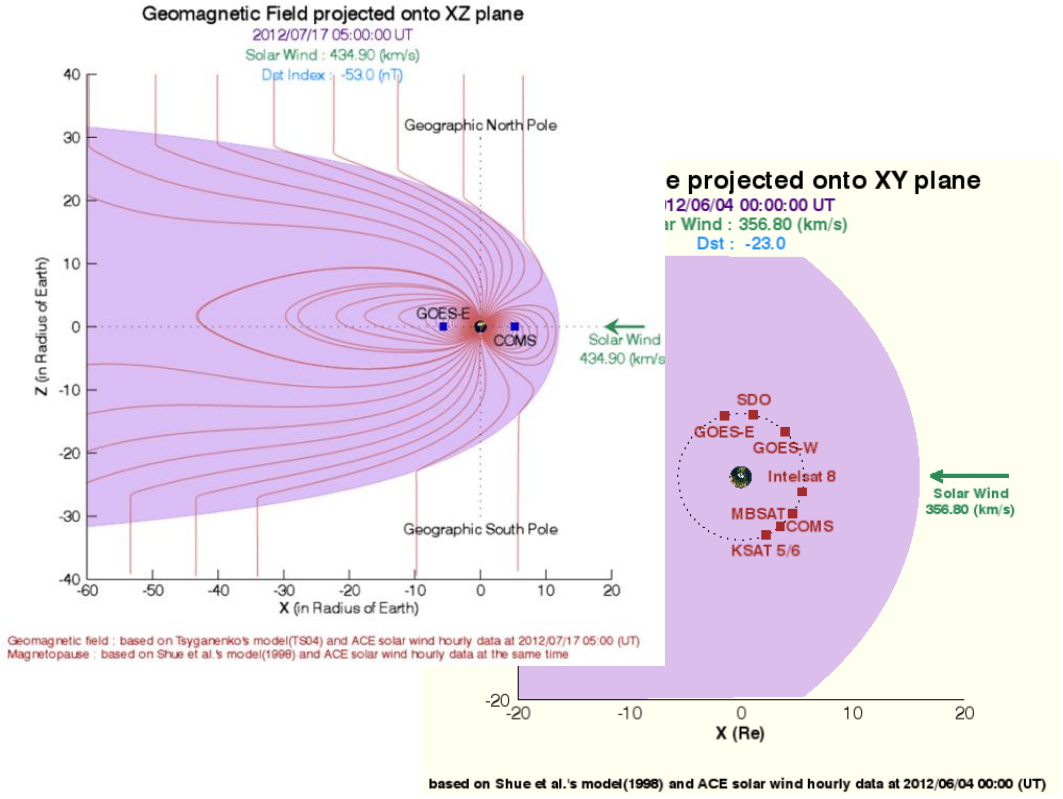
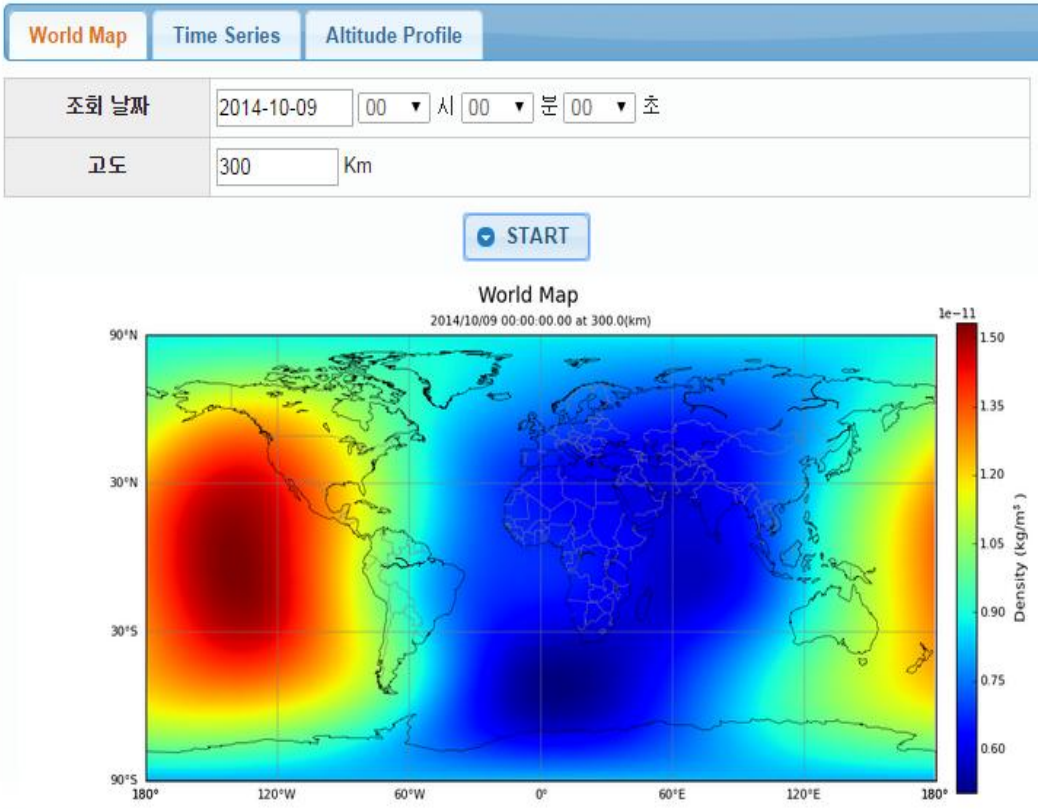
➢ GEOs Environment Monitor (Dev: 2012)

- ✓ Tsyganenko 2004 & Shue 1998 model
- ✓ Latest ACE SW and Kyoto Dst index
- ✓ Supports KSAT 5 & 6, COMS, MBSat, Intelsat 8, GOES, SDO



➢ LEOs Satellite Drag Prediction (Dev: 2013)

- ✓ Thermospheric mass density distribution
- ✓ Global map, Time series, & Vertical profile



Research Activities – support for aviation user group

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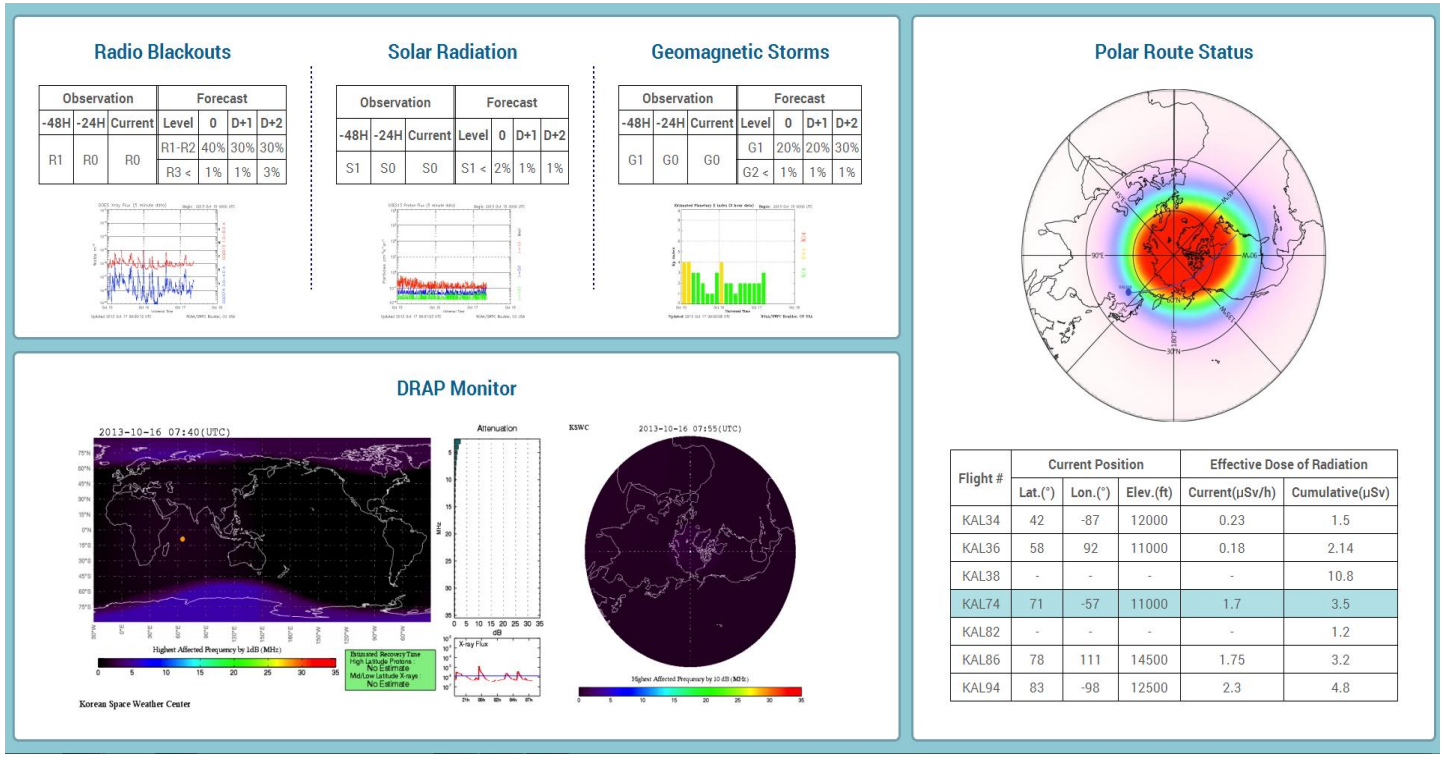
➢ Polar route SWx monitor (Dec 2013~)

- ✓ A tailor made system - live flight position tracking (for Korean Air & Asiana Air)
- ✓ provide HF attenuation (D-RAP+PCA) & radiation dose rate (CARI-6)

➢ ARMAS-Lite Project (2014~)

- ✓ Automated Radiation Measurements for Aviation Safety
- ✓ fly with airplanes of NOAA & NCAR
- ✓ comparison with NAIRAS model

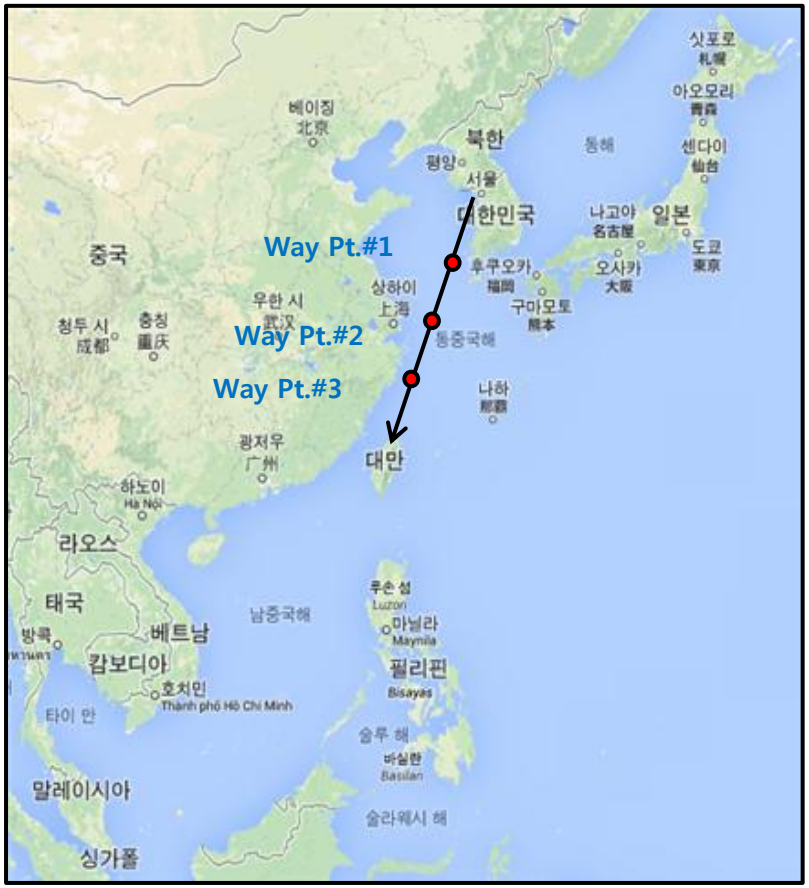


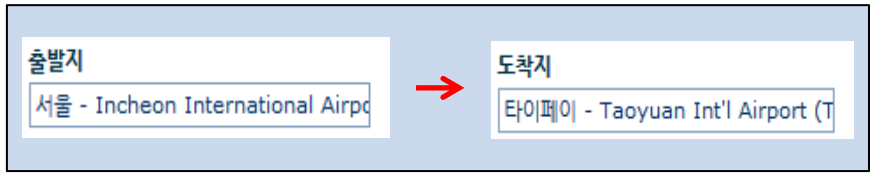
Flight #	Current Position			Effective Dose of Radiation	
	Lat.(°)	Lon.(°)	Elev.(ft)	Current(μSv/h)	Cumulative(μSv)
KAL34	42	-87	12000	0.23	1.5
KAL36	58	92	11000	0.18	2.14
KAL38	-	-	-	-	10.8
KAL74	71	-57	11000	1.7	3.5
KAL82	-	-	-	-	1.2
KAL86	78	111	14500	1.75	3.2
KAL94	83	-98	12500	2.3	4.8

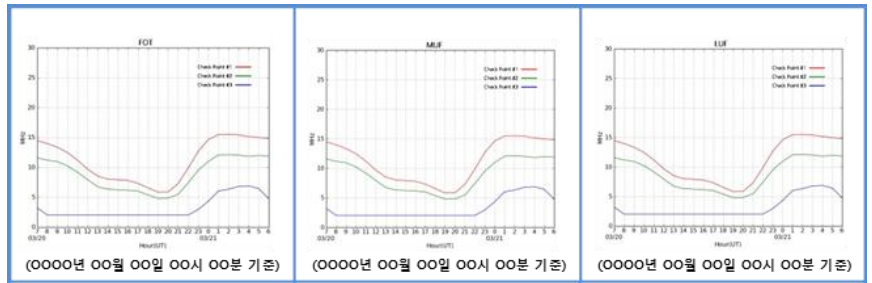
Research Activities – HF communications

➢ Ionosphere & HF Model (Dev: 2013~)

- ✓ IRI-2012 + VOACAP + Ionosonde data assimilation
- ✓ real-time usable HF frequency for airlines, ships, military, etc
- ✓ expanded the model coverage to East Asia in 2014







Way Pt #1	Way Pt #2	Way Pt #3

	Tx			Rx
	Way Pt #1	Way Pt #2	Way Pt #3	Seoul Radio Station
Lat. (°)	00.00	00.00	00.00	00.00
Lon. (°)	000.00	000.00	000.00	000.00

National Preparation

➢ Space Weather Response Guideline (2012)

✓describes possible damages from space weather

✓suggests example actions to prevent/minimize damages

✓5 areas : satellite, airline, navigation, power grid, communications

➢ National Plan for Space Weather (2012)

✓vision : “Safe Korea without Space Weather Disaster”

✓5-year plan (2013-2017)

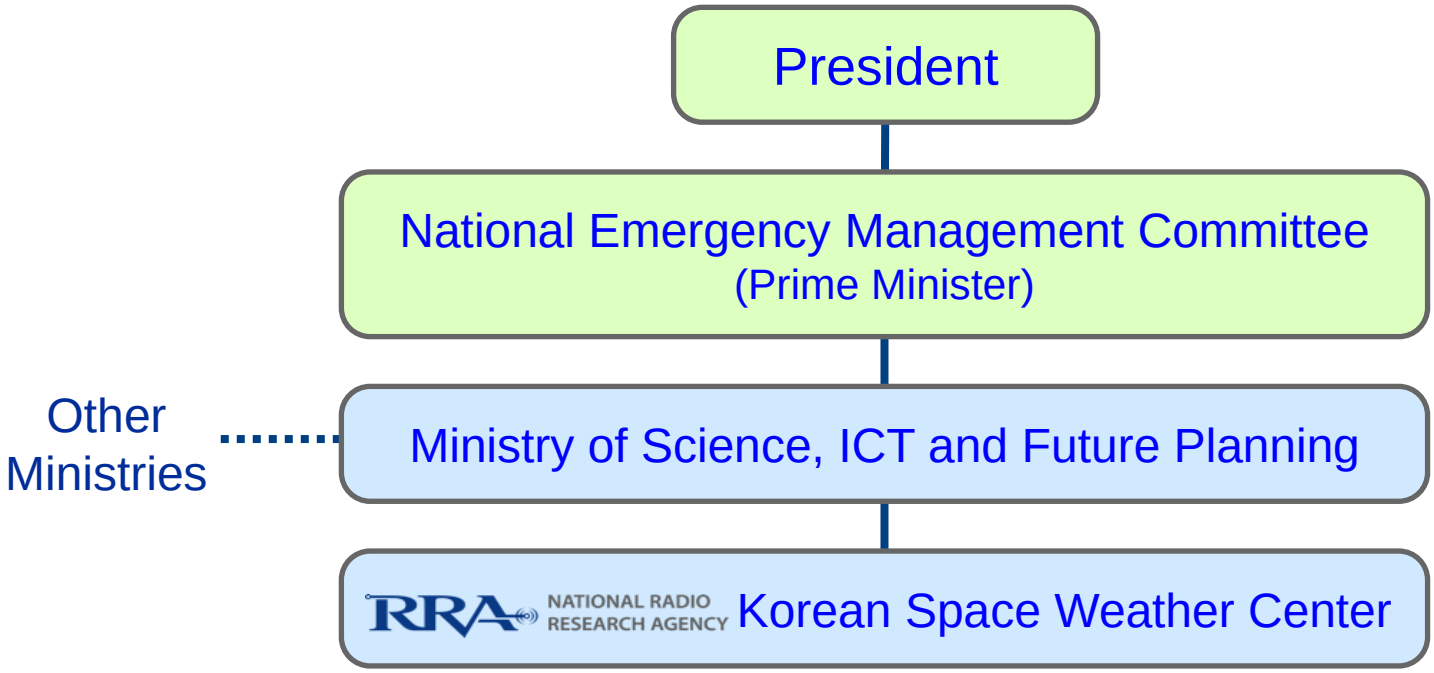
- provides accurate forecasts & real-time alarms
- develops advanced models
- expands observation networks
- space weather awareness-raising

➢ Space Weather Disaster Management Manual (Feb. 2013)

✓space weather was included in the national risk assessment process

✓the government's official manual was approved

- describes the roles & responsibilities of related ministries and agencies
- removing confusion & increasing efficiency among different organizations



Carrington Tracking Facility in Korea

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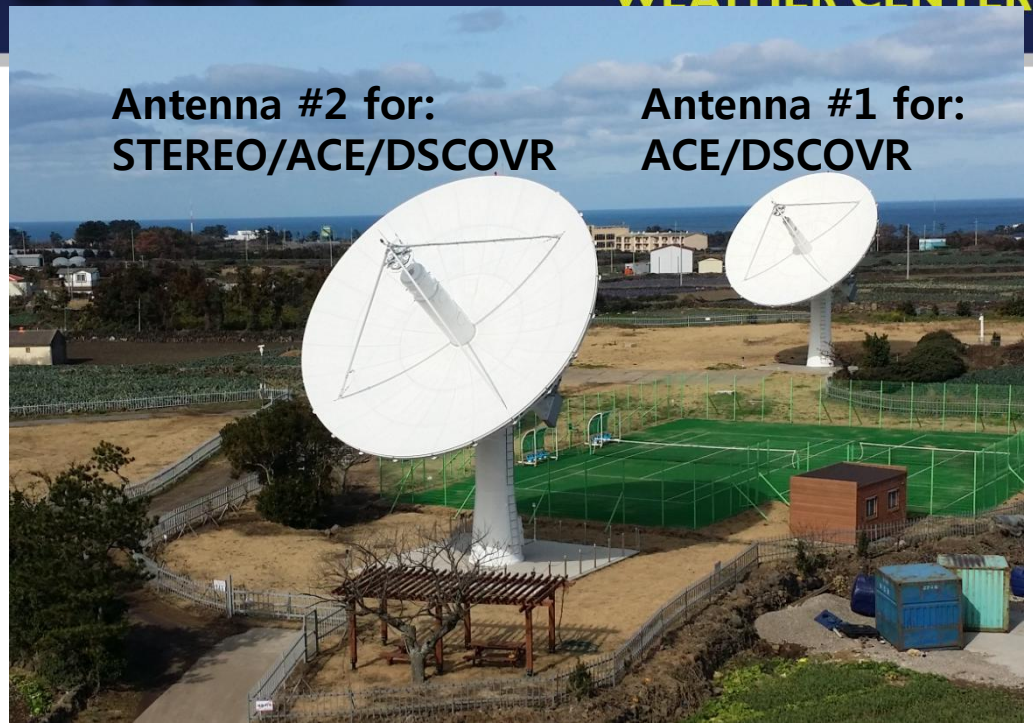
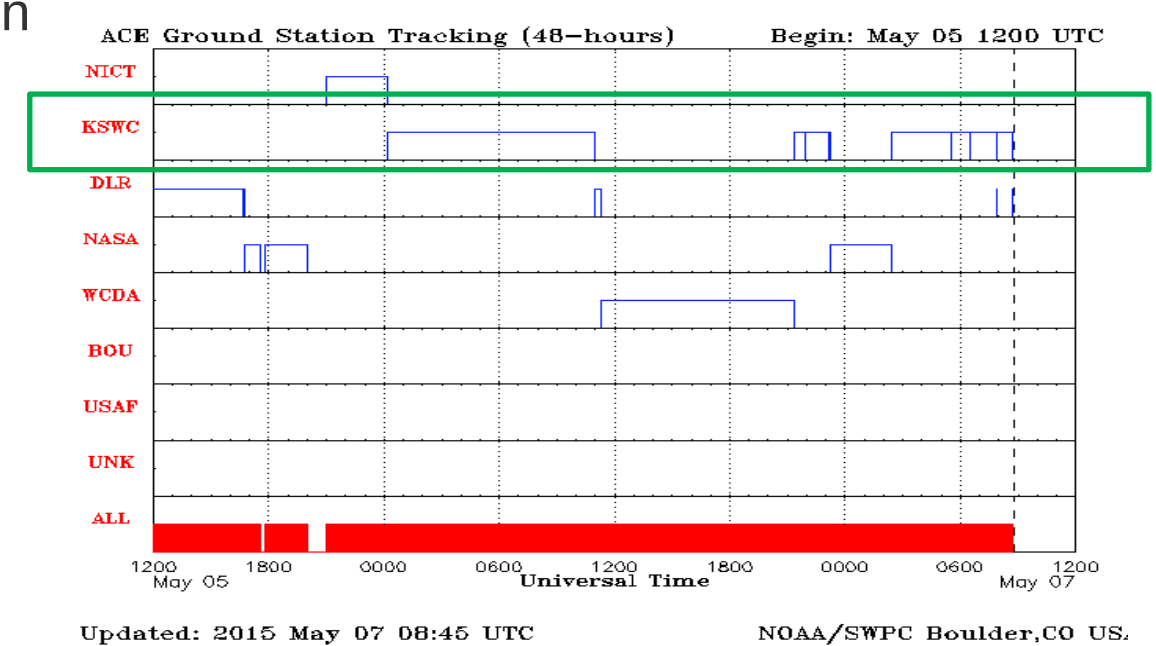
➢ Satellite Tracking Antenna

- ✓ Construct new Cassegrain antenna (15-meter or bigger) at Jeju, Korea
- ✓ One of global tracking network, serve East Asia region
- ✓ 14H in Summer, 10H in Winter season receiving capability
- ✓ Well maintained by trained operators (ACE/STEREO/DSCOVR tracking experience)





Carrington Data Center Facility in Korea

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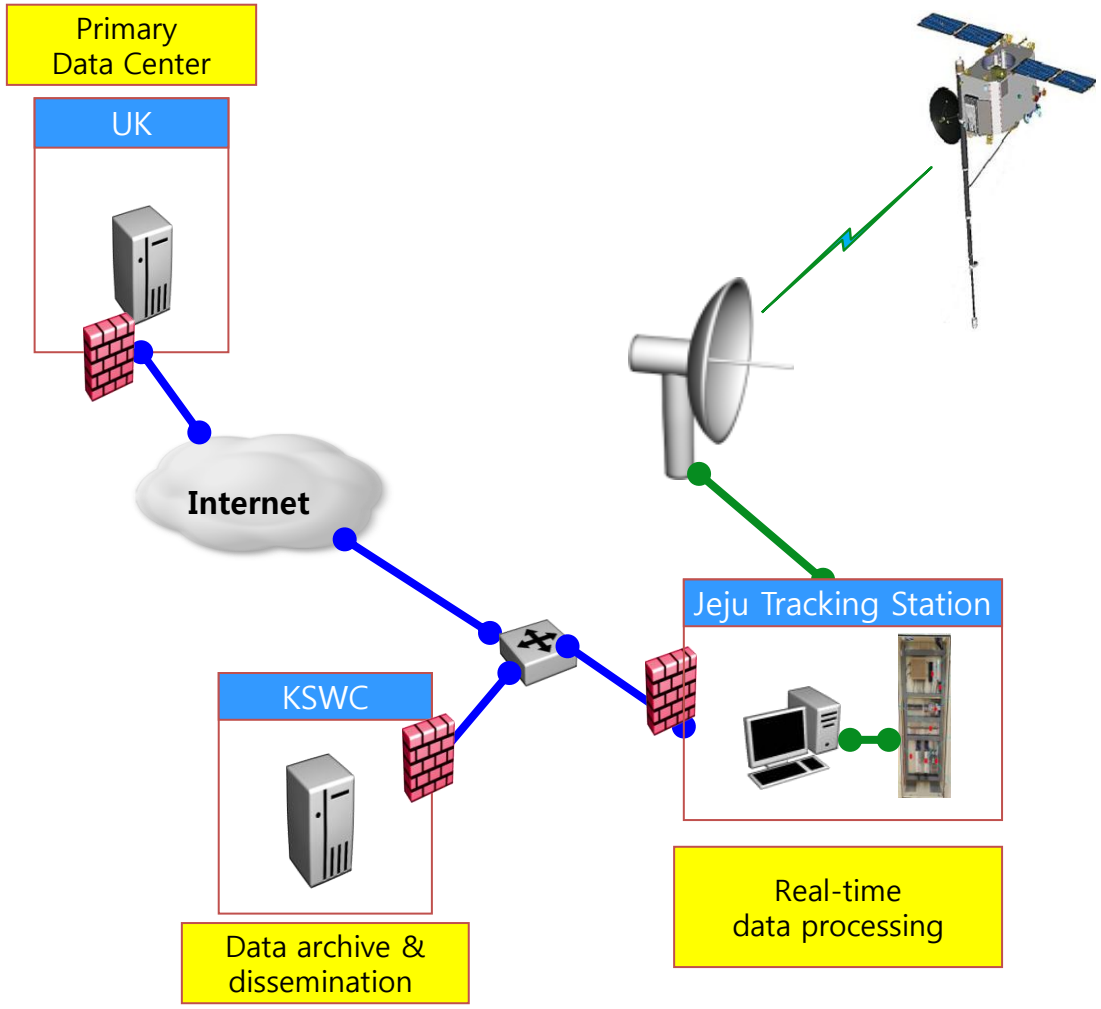

➢ Auxiliary Data Center

- ✓ New 24x7 & real-time operational data center at Jeju, Korea
- ✓ Checking dataset quality, producing climate records, performing analyses, & calibrations
- ✓ Data archive & data disseminations
- ✓ New SWx product & service development

Carrington Data Center Facility in Korea

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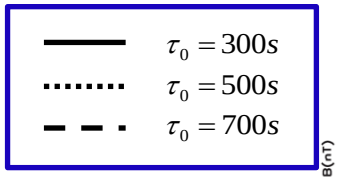
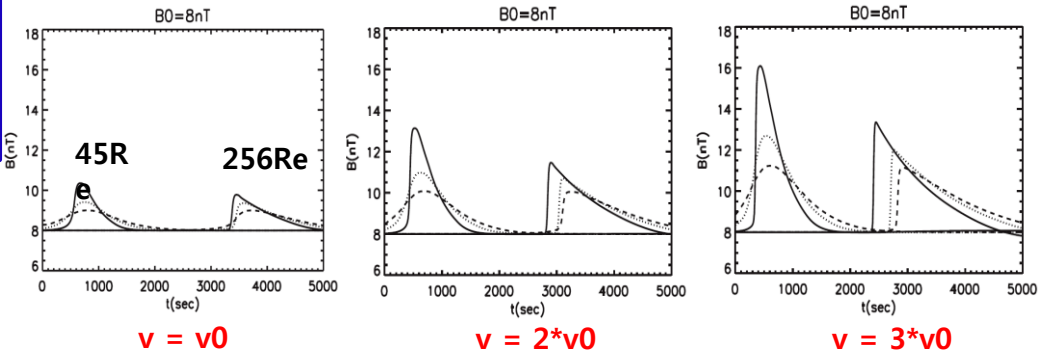
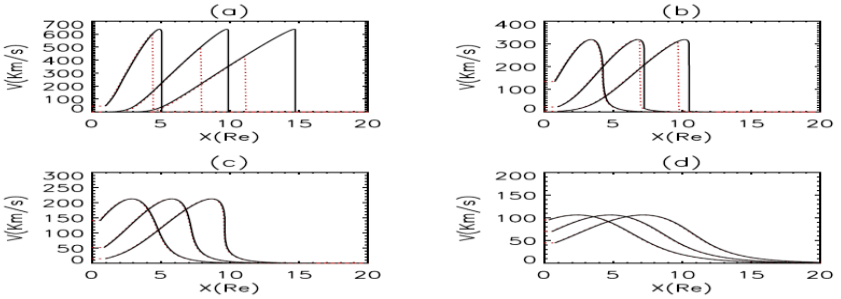
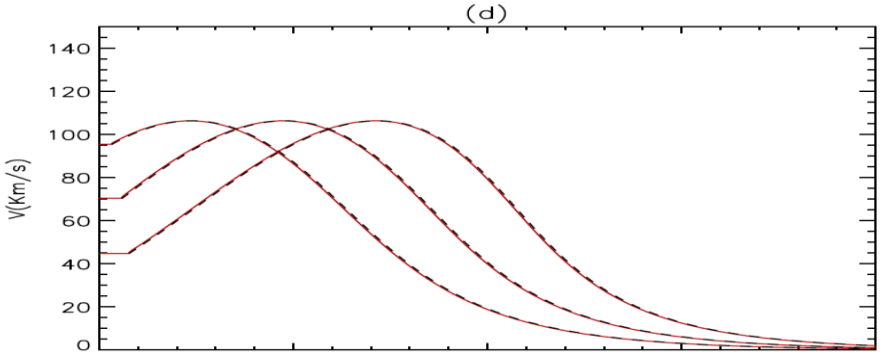
$$x = X(\tau) + (t-\tau)\left\{\dot{X}(\tau) \pm C_T[\dot{X}(\tau)]\right\}$$
$$v = \dot{X}(\tau).$$
$$\frac{C_T}{V_{Ao}} = \frac{v - v_o}{2V_{Ao}} - \frac{C_{So}^2}{2^{\frac{1}{3}}V_{Ao}^2}\left(\frac{v - v_o}{V_{Ao}}\right)^{\frac{1}{3}}$$

[Lee et al., JGR, 2000]

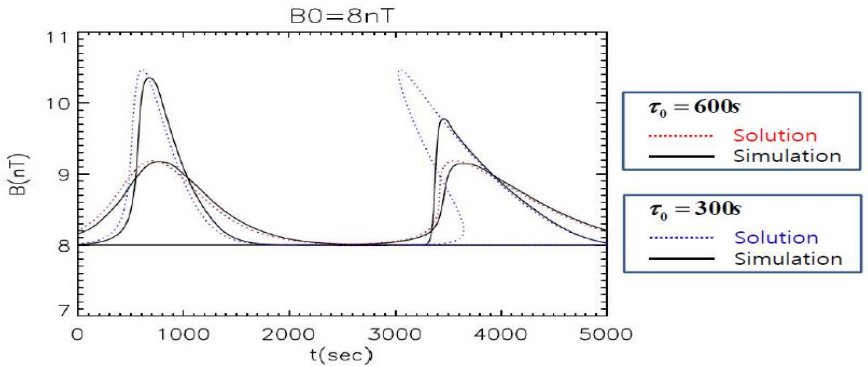








Shock formation (at 45Re and L1)



➢ L1/L5-Earth simulation database

- ✓ Adopt an accurate numerical model based on the exact analytical solutions
- ✓ Develop simulation database for various time histories at L1, where the instantaneous arrival signal at the Earth is available
- ✓ Incorporate L5 data into the simulations

Carrington SWx in Korea

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Participants - expected	Current activities
KSWC (Korea Space Weather Center)	● **SWx Primary Action Agency** ● **Official SWx announcement** ● **International Representative**
KAIST/SaTReC (KAIST Sat Tech Research Center)	● Small LEO scientific satellites ● LP/SST/ESA
KASI (Korea Astron. & Space Sci. Ins.)	● Basic SWx research ● SDO ground station
KHU (Kyung Hee Univ)	● Cubesats (particle detectors) ● Biggest SWx group
KOPRI (Korea Polar Research Ins.)	● SWx at Polar (N/S) bases ● Thermosphere/Ionosphere Research
Other univ, labs,…	

➢ Further *possibles* in swX

- ✓ KSWC will look for any possibilities in L5 swXs
- ✓ Try to find out financial sources as the L5 mission has an operation-purpose
- ✓ Encourage an official consortium in Korea if necessary as a PI agency

Why interests in SWx?

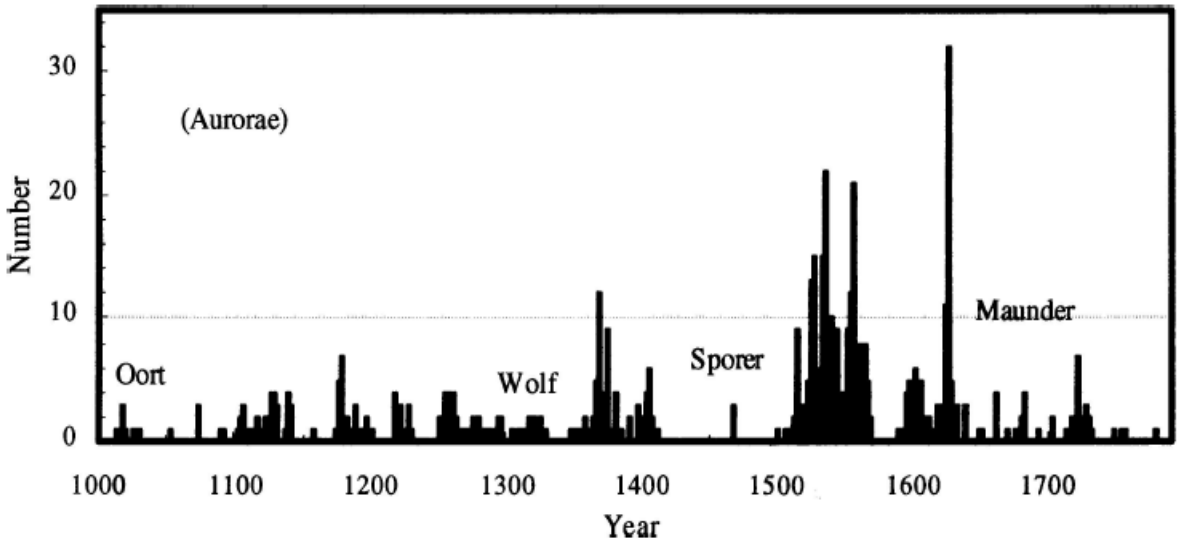

Figure 1. Distribution of auroral records of 11th–18th centuries.

1) *Koryo-Sa*: the Annals of Koryo Dynasty (918–1391).
2) *Choson Wangjo Sillok*: the Annals of Choson Dynasty (1392–1910).
3) *Jeungbo Munheon Bigo*: an encyclopedia of 250 volumes, which was published in 1770 and revised later in 1908.
4) *Seungjeongweon Ilgi*: daily journals written by official-scholars in the office of the royal secretary during Choson Dynasty.
5) *Daedong Yaseung*: unofficial history book of 71 volumes, during Choson Dynasty.

➢ Facts about SWx in Korea….

- ✓ SK: GG Lat < 40, GM Lat < 30?
- ✓ NK: GG Lat < 45, GM Lat < 35?
- ✓ Limited in size ~ 1000km x 1200 km

* However, in history,

- ✓ *1000-1799*, 788 auroral events

1000-1391: 245 events

[Lee et al., Sol Phys, 2004]

cf) 1000-1499: only 322 (lat < 55)
all over the world

[Krivsky & Pejm, 1988; http://www.ngdc.noaa.gov/stp/aeronomy/aurorae.html]

Summary

- **KSWC will fully support an L5 SWx operation mission,**
- **secure Carrington tracking facilities,**
- **establish a new data center which allows real-time process as well as simulation database,**
- **and look into swX opportunities with other groups in Korea.**

* Timely information about swX plans will be appreciated.

(e.g., appropriate partners and financial sources in Korea)

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

Thank you!

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