Satellite Programs & Applications of KMA: Current & Future

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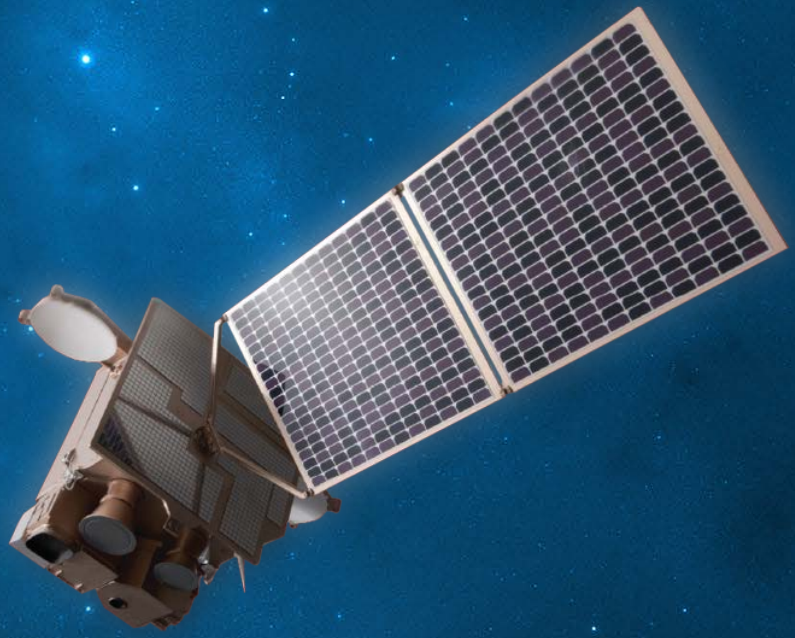
Contents



1. Current status of COMS
2. Application of satellite data
3. Plan for Geo-KOMPSAT-2A & LEO satellite

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Current status of COMS

Observation Schedule of COMS

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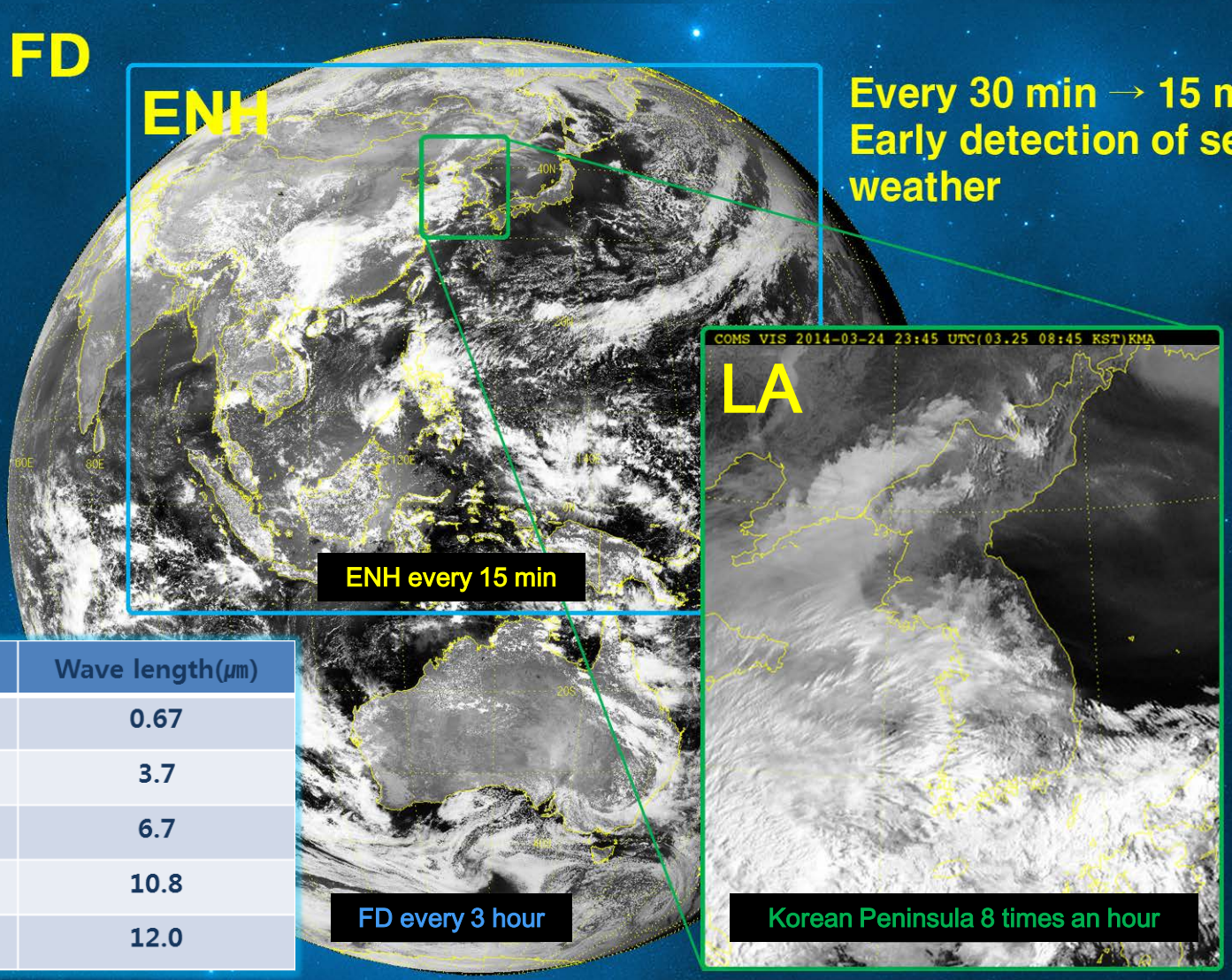

channel	Wave length(㎛)
Visible	0.67
Shortwave IR(IR4)	3.7
Water Vapor(IR3)	6.7
IR1	10.8
IR2	12.0

COMS VIS 2014. 3. 24 23:45 UTC[02. 14 08:45 KST] KMA

COMS Products

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16 Baseline Products : Development (2003-2010) and Operation (2011~)

Application of satellite data

Earth Environment Monitoring (Hydrology, Climate & Space Weather)

K-GPM Retrieval Algorithm: D/B, Inversion

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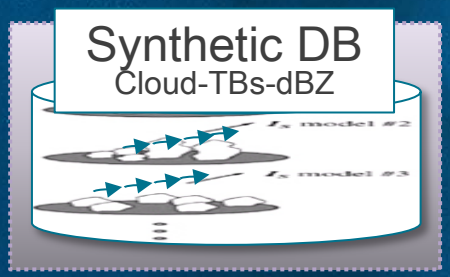
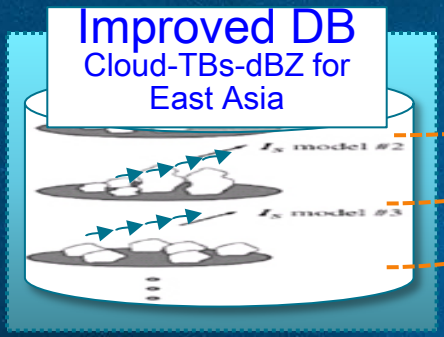
Bayesian retrieval algorithm





Prototype Algorithm Flow

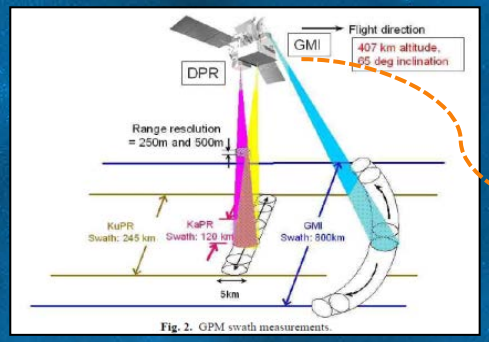
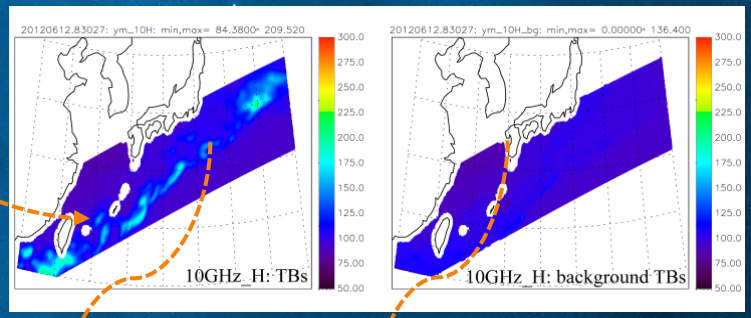


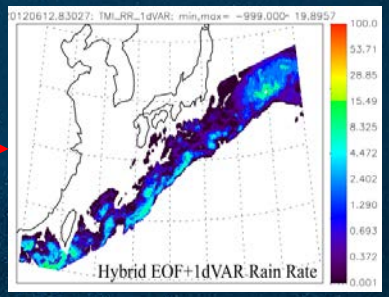
Fig. 2. GPM swath measurements.



$$\Delta T = T_B(\text{rain} - \text{pixel}) - T_B(\text{background})$$

$$\hat{E}(x) = \sum_j \frac{x_j \cdot exp\left\{-0.5\left[\Delta T_o - \Delta T_s(x_j)\right]^T\right\}(\mathbf{O}+\mathbf{S})^{-1}\left[\Delta T_o - \Delta T_s(x_j)\right]}{\hat{A}},$$

$$\hat{A} = \sum_{j,x_j>0} exp\left\{-0.5\left[\Delta T_o - \Delta T_s(x_j)\right]^T(\mathbf{O}+\mathbf{S})^{-1}\left[\Delta T_o - \Delta T_s(x_j)\right]\right\} + \sum_{j,x_j=0} exp\left\{-0.5\left[\Delta T_o - \Delta T_s(x_j)\right]^T(\mathbf{O}+\mathbf{S})^{-1}\left[\Delta T_o - \Delta T_s(x_j)\right]\right\}$$



K-GPM Retrieval Algorithm: G. Validation

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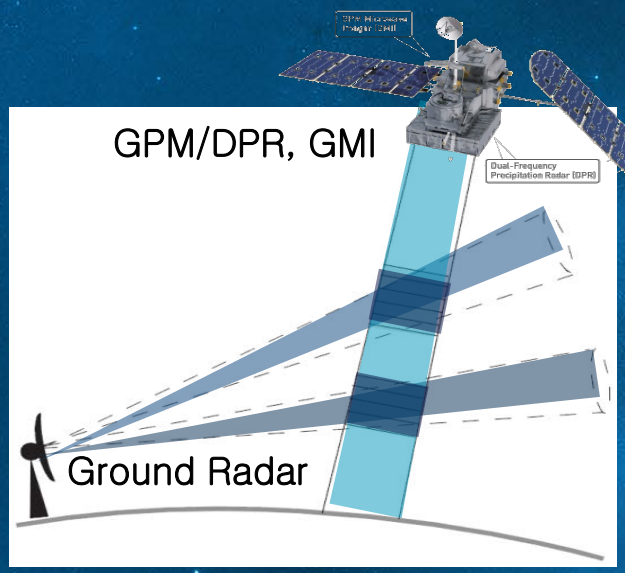
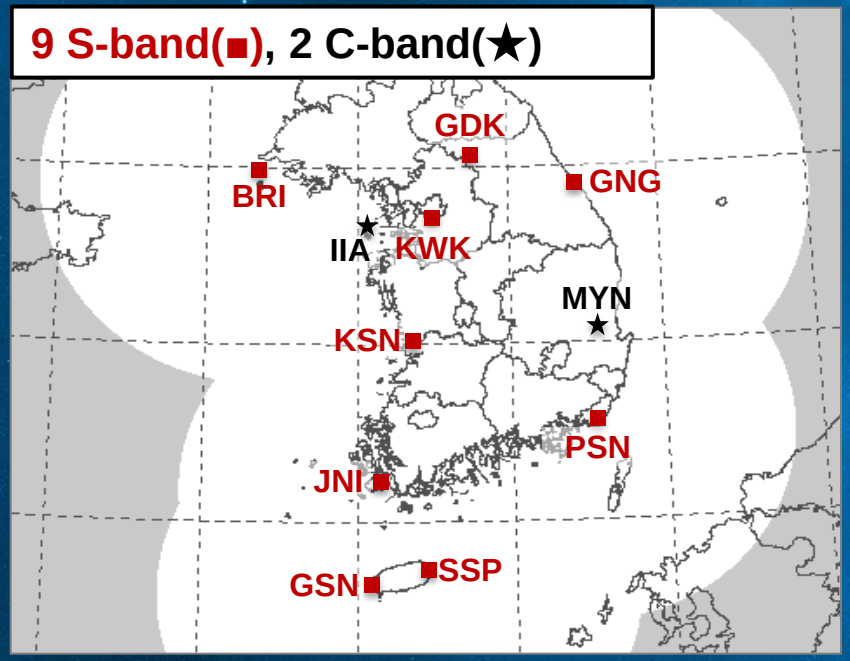
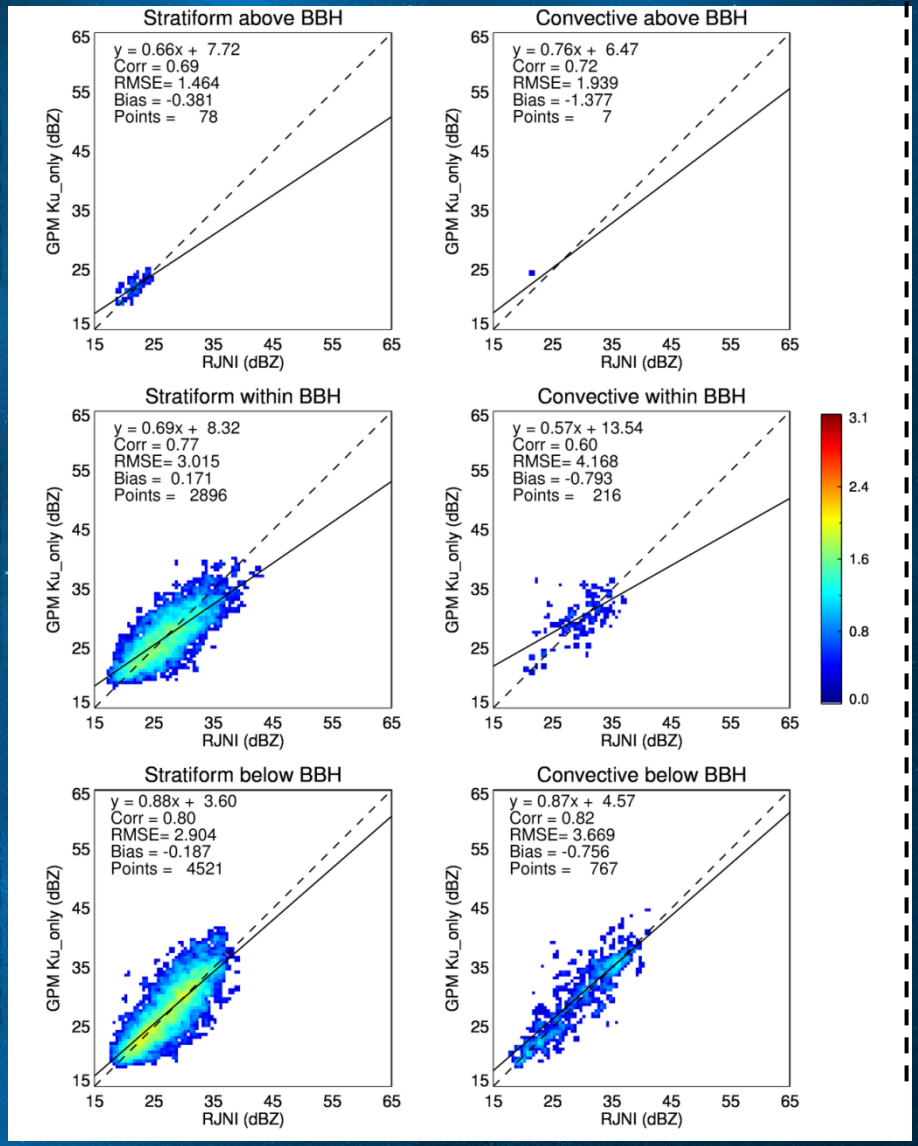




GPM
2014.03.08 ~ 2014.08.17



Evapotranspiration from COMS

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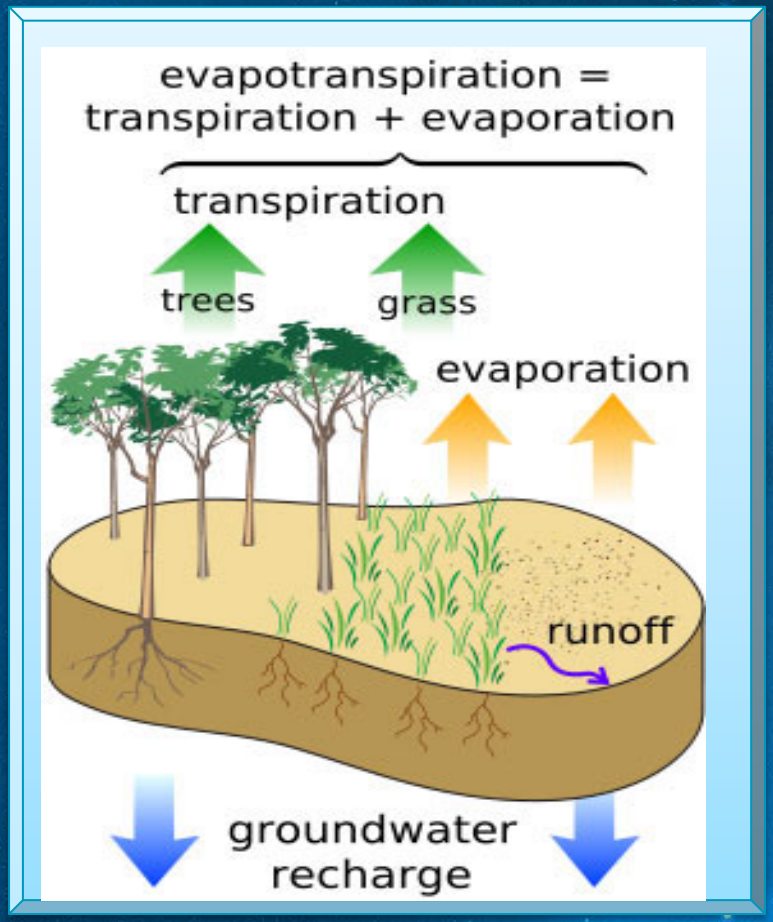
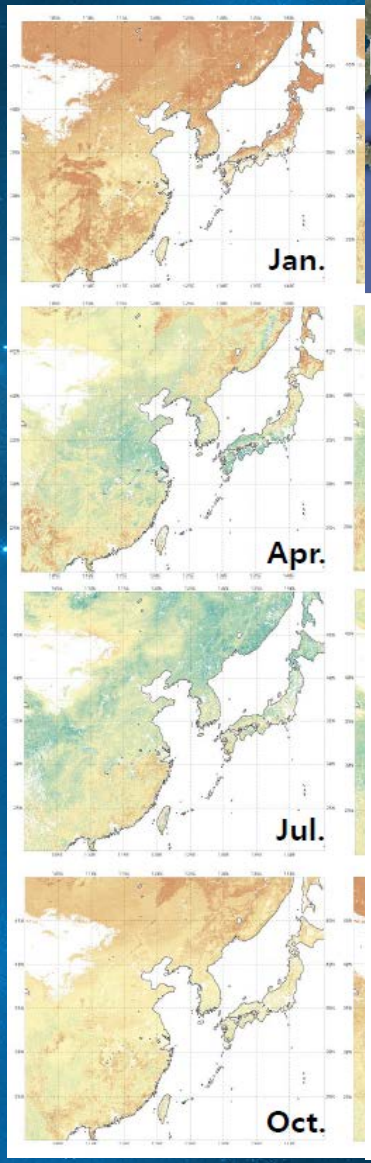
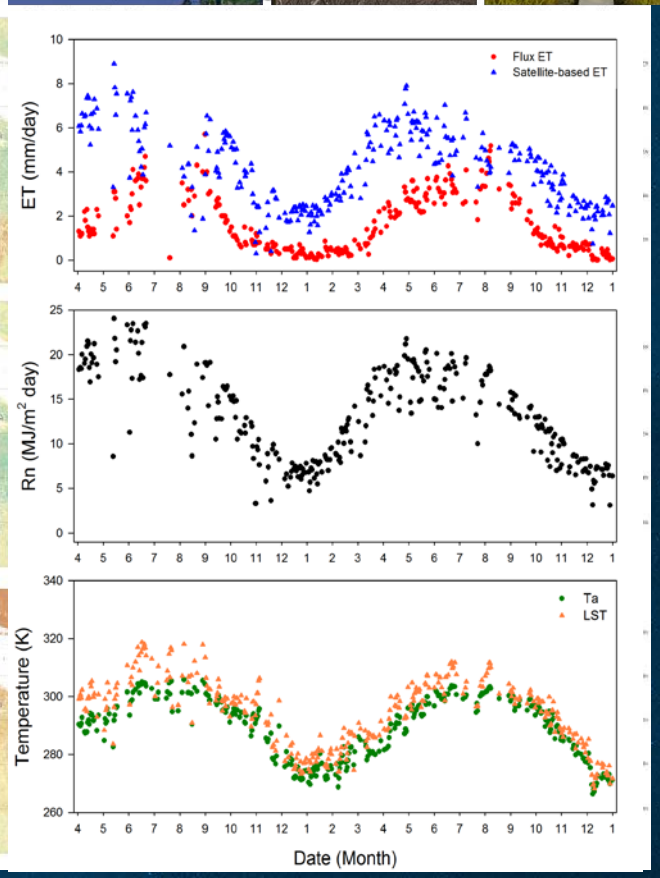


$$Rn = LE + H + G$$

$$\rightarrow LE = Rn - H$$

$$H = \rho \cdot c_p \frac{(Ts - Ta)}{r_a}$$





[Seolma Site]

Artic Sea Ice: http://seaice.kma.go.kr

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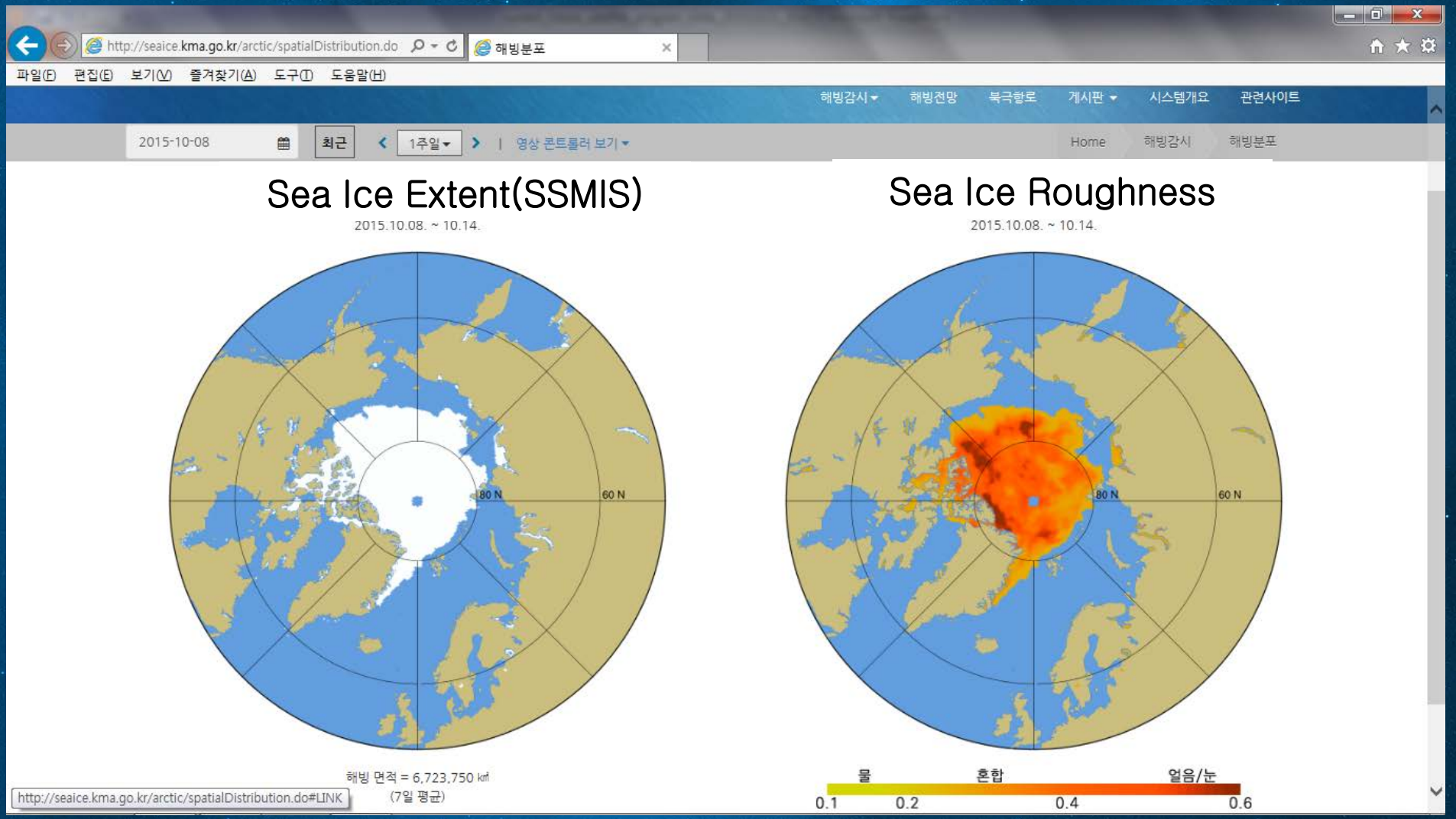

Space Weather Services

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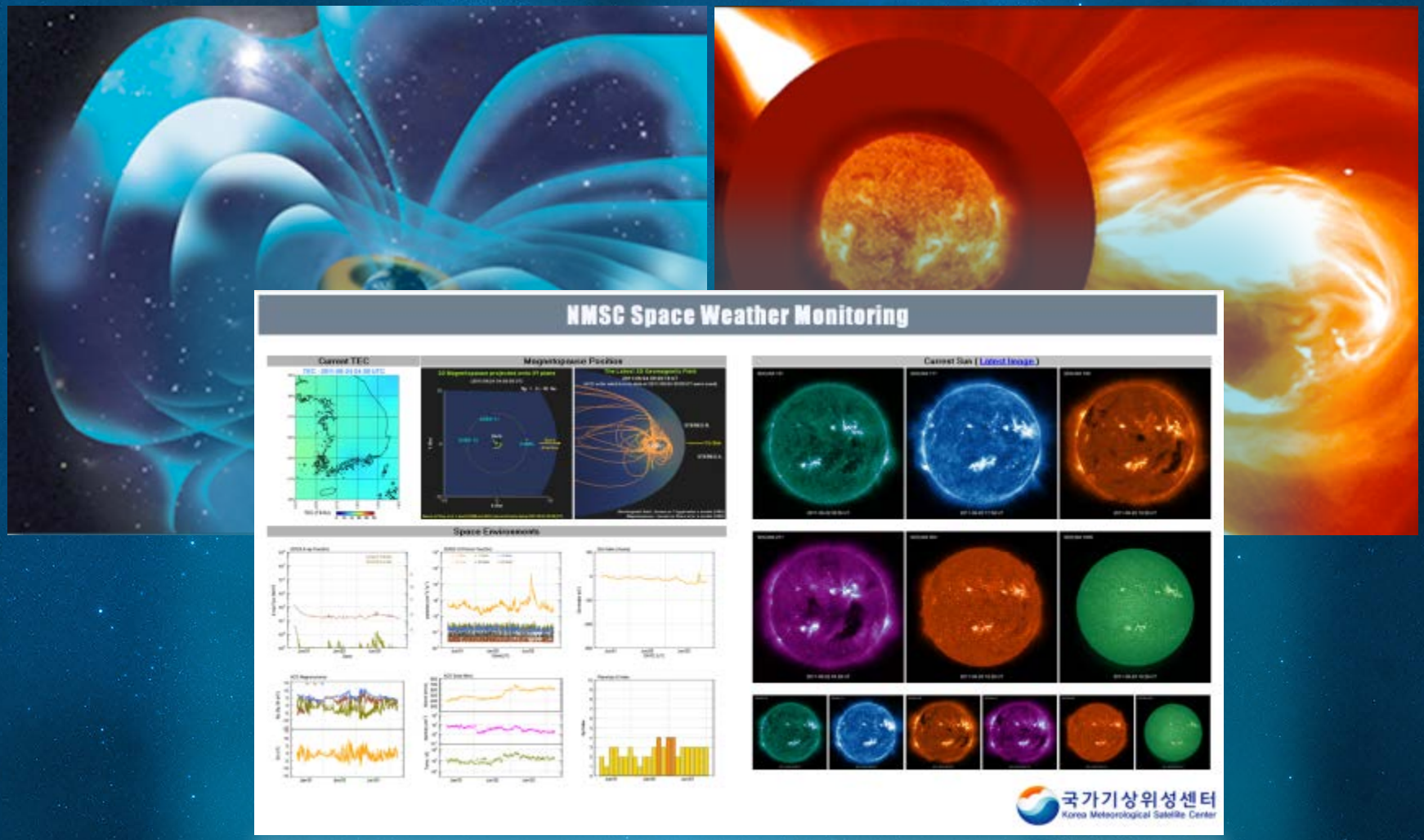
- Development of public warning system & prediction model for the space weather services
- Space environment sensor to be installed on GEO-KOMPSAT-2A



Plan for Geo-KOMPSAT-2A & LEO satellite

Geo-KOMPSAT-2 Program

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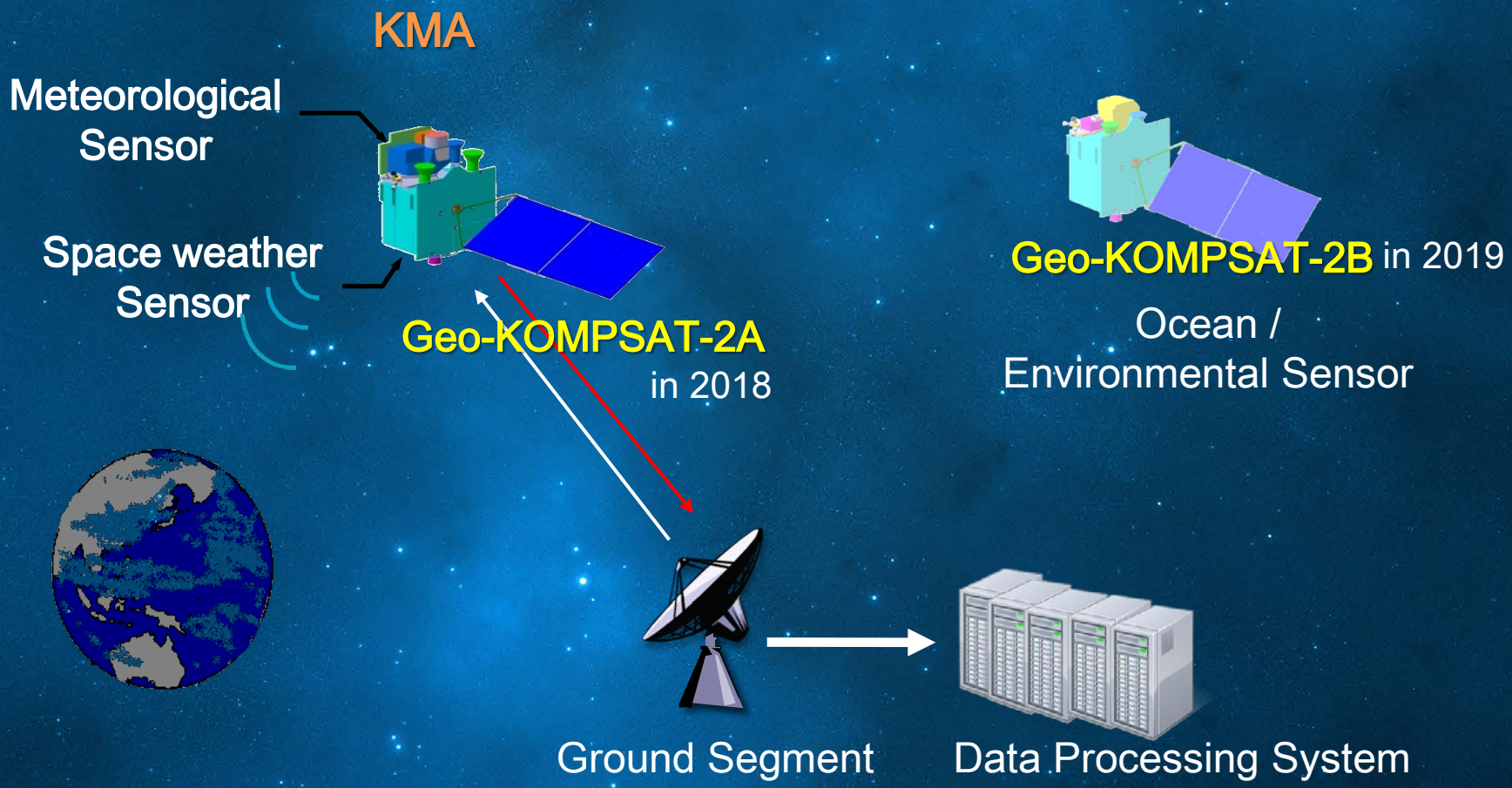
→ GK-2A for the next generation Meteorological Imager and SWx monitoring
→ GK-2B for the Ocean Color and Atmospheric Trace Gas monitoring



AMI(Geo-KOMPSAT-2A)

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◆ AMI(Advanced Meteorological Imager) (cf. AHI/Himawari-8/9, ABI/GOES-R)

Channels	Wavelengh(㎛)					
	AMI (GK-2A)	ABI (GOES-R)	AHI (Himawari)	MI (COMS)	SEVIRI (MSG)	MODIS
1(VIS) blue	0.470	0.470	0.46			0.466 (B03)
2(VIS) green	**0.511**		**0.51**			0.554 (B04)
3(VIS) red	0.640	0.640	0.64	0.675	0.6	0.647 (B01)
4(VIS)	0.856	0.865	0.86		0.8	0.857 (B02)
5(NIR)	**1.380**	**1.378**				1.382 (B26)
6(NIR)	1.610	1.610	1.6		1.6	1.629 (B06)
NIR		**2.250**	**2.3**			2.114 (B07)
7(IR)	3.830	3.90	3.9	3.75	3.9	3.788 (B20)
8(WV)	6.241	6.185	6.2		6.2	6.765 (B27)
9(WV)	6.952	6.95	7.0	6.75		6.765 (B27)
10(WV)	7.344	7.34	7.3		7.3	7.337 (B28)
11(IR)	8.592	8.50	8.6		8.7	8.529 (B29)
12(IR)	9.625	9.61	9.6		9.7	9.734 (B30)
13(IR)	10.403	10.35	10.4	10.8	10.8	B30+B31
14(IR)	11.212	11.20	11.2			11.019 (B31)
15(IR)	12.364	12.30	12.3	12.0	12.0	12.032 (B32)
16(IR)	13.31	13.30	13.3		13.4	13.365 (B33)

Observation Domain & Schedule(TBD)

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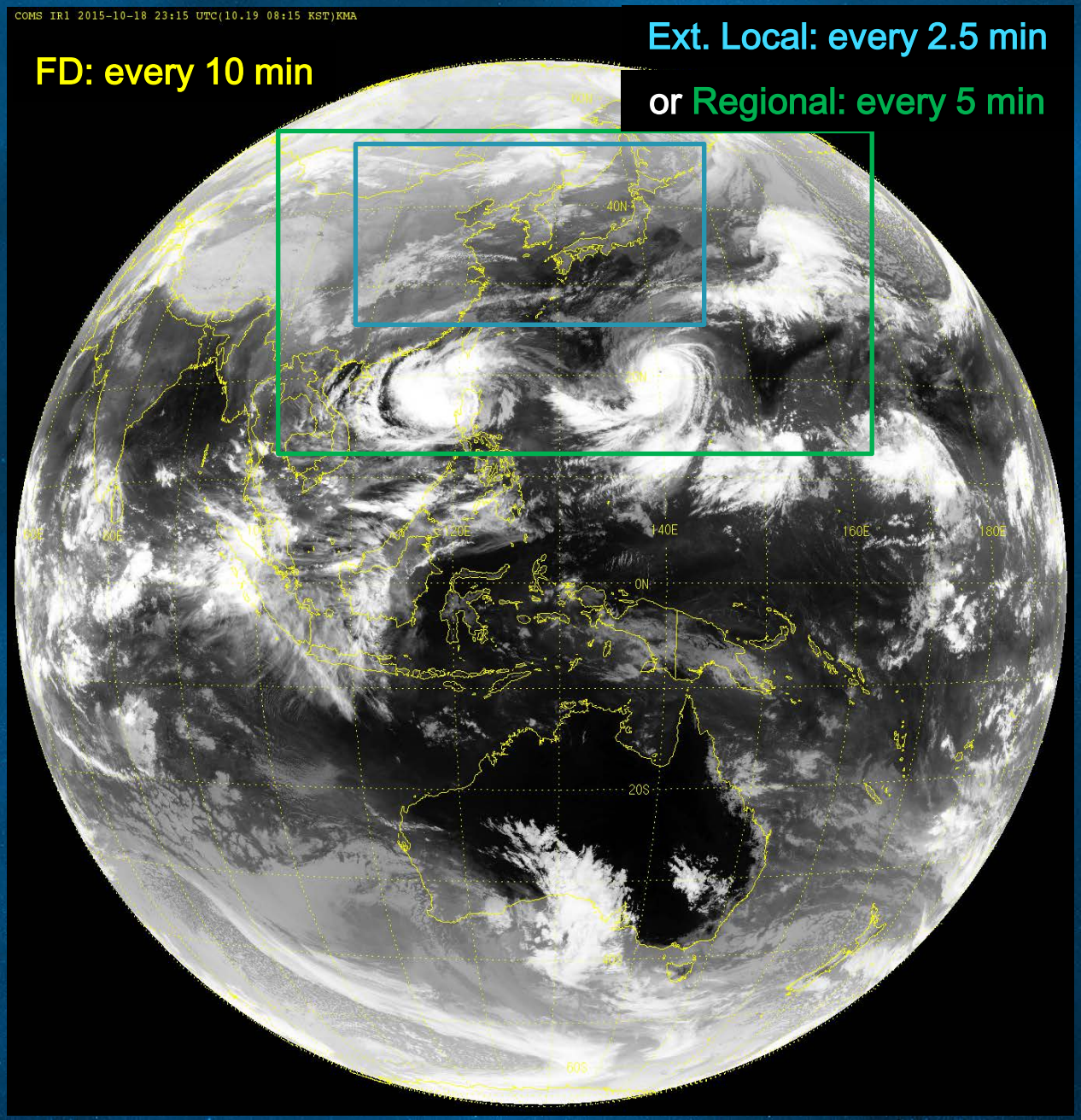

KSEM (Korean Space Environmental Monitor)

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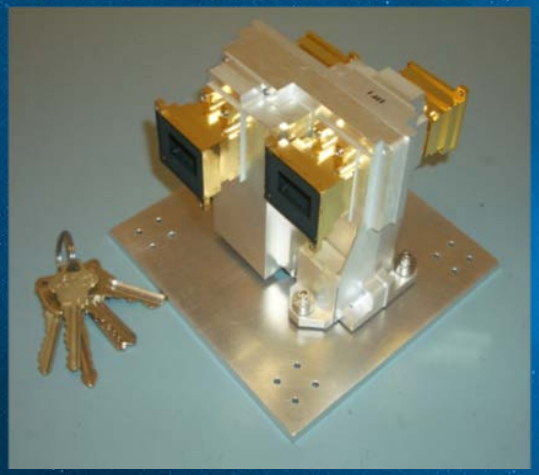
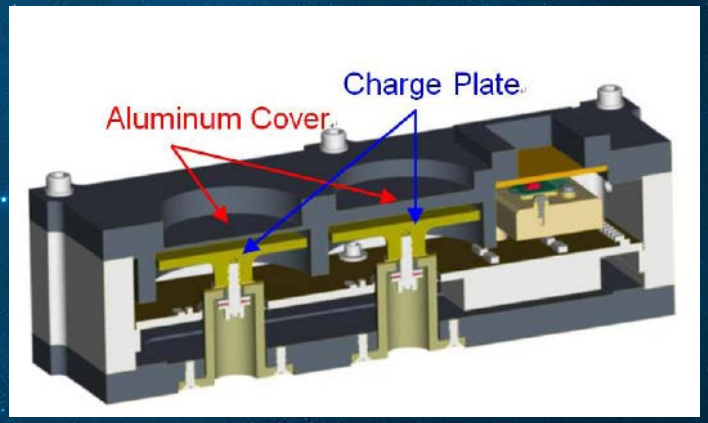
KSEM specification

Sensor Unit	Measurement Range	Accuracy	Time Resolution	Remark
PD	100KeV ~ 2MeV	<30%(ΔE/E)	0.33s	6 measurement direction
MG	-350nT ~ +350nT	<1nT	<0.1s	Boom type
CM	-3pA/cm^2 ~+3pA/cm^2	<0.01 pA/cm^2	< 1s	-



Particle detector (3ea)

Magnetic field sensor(2ea)



Charging Monitor(1ea)

Development of space weather products

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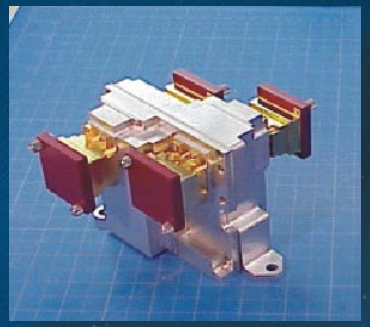
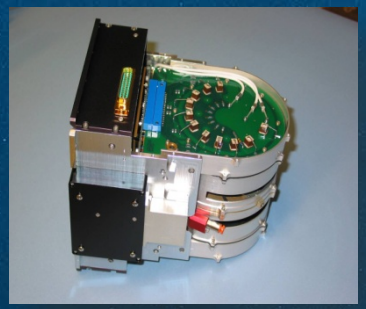
◆ **Korea Space Environment Monitor(KSEM)**

Measurement of electron on mid energy range and magnetic field

Support for satellite operation, aviation safety, impact on weather & climate



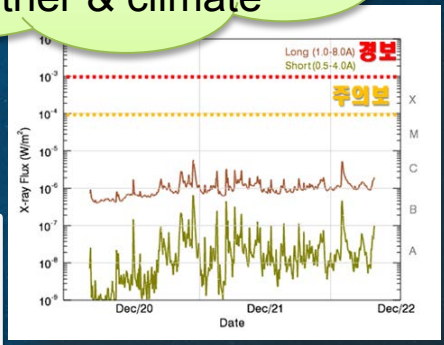


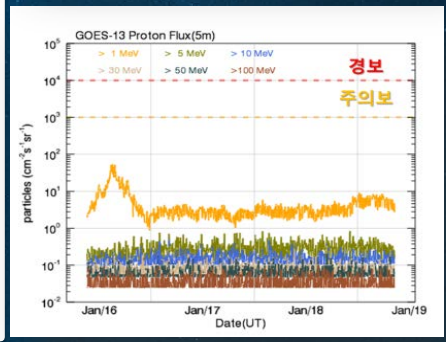
Data

- Time(satellite position)
- Energy channel (electron)
- Particle flux (each direction)
- Magnetic field flux(3axis)
- Background flux
- Noise
- Payload monitoring data (Voltage, darkcurrent, etc.)

Products(5)

- real-time high energy particle distribution over the radiation belt
- 3D particle distribution /prediction
- deep dielectric charging prediction index
- geomagnetic storm index(2)





GOCI-II(Geo-KOMPSAT-2B)

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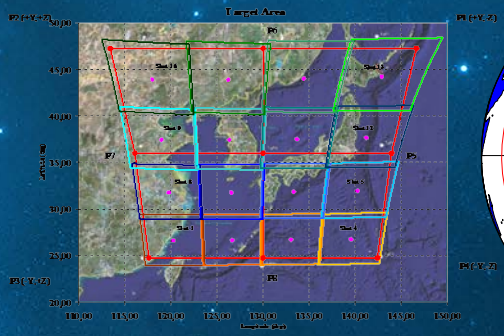
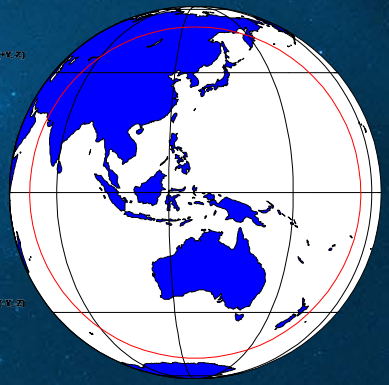
➢ GOCI-II(Geostationary Ocean Colour Imager-II)

- **the succession and expansion of the mission of GOCI**.
- supporting **user-definable observation requests** such as clear sky area without clouds and special-event areas, etc.
- 10 times daily regional and 1 time **daily global observation**
- higher spatial resolution, **300m×300m, and 13 spectral bands**

Items	GOCI Specs	**GOCI-II Specs**
Bus	COMS	**GEO-KOMPSAT-2B**
Increased band number	8 bands	**13 bands**
Improved spatial resolution	500m	**300m**
More observations	8 times/day	**10 times/day**
Pointable & Full Disk coverage	Local Area	**Local Area + Full Disk**



Selected LA



FD (Red Circle)

GEMS(Geo-KOMPSAT-2B)

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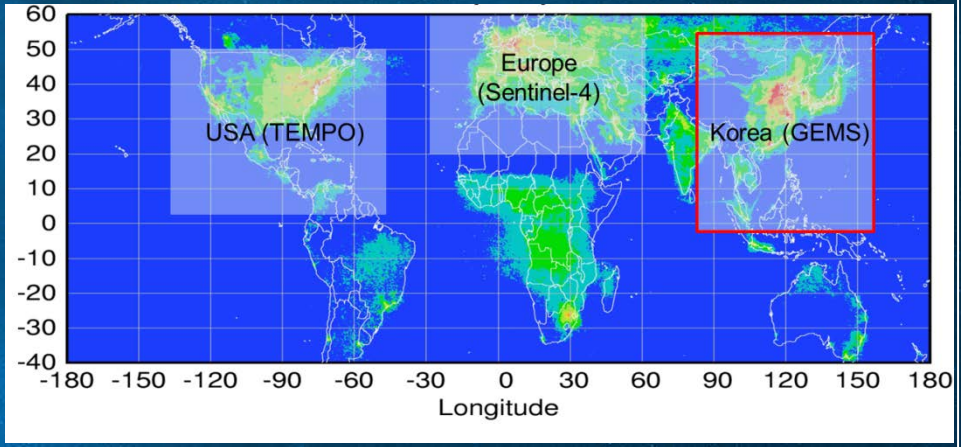
➢ GEMS(Geostationary Environmental Monitoring Spectrometer)

- Contributing to Atmospheric Composition Constellation under the Committee on Earth Observation Satellites (CEOS)
  - understanding of the globalization of pollution events, source/sink identification, and long-range transport of pollutants and short-lived climate forcers (SLCFs)
  - baseline : Korea (GEMS), Europe (Sentinel-4), and the US (TEMPO)

Bus	GEO-KOMPSAT-2B
Payload	Scanning UV-Visible(300-500 nm) Spectrometer
Measurement	O3, NO2, SO2, HCHO, Aerosols
Duty cycle/Imaging time	8 images during daytime (30 min imaging + 30 min rest) × 8 times/day
Field of regard	> 5,000 km(N/S) × 5,000 km(E/W) N/S: 45° N∼5° S, E/W: Selectable between 75° E∼145° E



Development of Meteorological Products(1/2)

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- KMA/NMSC has started to develop algorithms of fifty-two meteorological products for nowcasting, numerical weather prediction, climate and so on.
- Development Schedule
  - 2014-2016 : Algorithm Development
  - 2017-2018 : Validation and Integration of Algorithm for Operation
- 4 Algorithm Groups
  - Cloud and Precipitation, Radiation and Aerosol, Atmosphere and Aviation, Scene analysis and Surface information
  - Radiative Transfer Model and Calibration/Validation
- New techniques in GK-2A product development
  - Establishment of "algorithm test-bed" to share data and optimize scientific algorithm to operation system
  - Introduction of "optimal estimation" for consistency within cloud products "Discriminate clouds optical properties" for increase of products accuracy
  - Utilization of "machine learning" to detect some phenomena more accurately

Development of Meteorological Products(2/2)

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Scene & Surface Analysis (13)	Cloud & Precipitation (14)	Aerosol & Radiation (14)	Atmospheric condition & Aviation (11)
Cloud detection	Cloud Top Temperature	Aerosol Detection	Atmospheric Motion Vector
Snow Cover	Cloud Top Pressure	Aerosol Optical Depth	Vertical Temperature Profile
Sea Ice Cover	Cloud Top Height	Asian Dust Detection	Vertical Moisture Profile
Fog	Cloud Type	Asian Dust Optical Depth	Stability Index
Sea Surface Temperature	Cloud Phase	Aerosol Particle Size	Total Precipitable Water
Land Surface Temperature	Cloud Amount	Volcanic Ash Detection and Height	Tropopause Folding Turbulence
Surface Emissivity	Cloud Optical Depth	Visibility	Total Ozone
Surface Albedo	Cloud Effective Radius	Radiances	SO_2 Detection
Fire Detection	Cloud Liquid Water Path	Downward SW Radiation (SFC)	Convective Initiation
Vegetation Index	Cloud Ice Water Path	Reflected SW Radiation (TOA)	Overshooting Top Detection
Vegetation Green Fraction	Cloud Layer/Height	Absorbed SW Radiation (SFC)	Aircraft Icing
Snow Depth	Rainfall Rate	Upward LW Radiation (TOA)	
Current	Rainfall Potential	Downward LW Radiation (SFC)	
	Probability of Rainfall	Upward LW Radiation (SFC)	

Lessons from COMS

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- ✓ It is not enough to provide each L2 product separately for the purpose of operational forecast
  - Insufficient accuracy
  - Limited information on the internal structure of cloud and rain
  - Too much data already to analyze
- ✓ If the users such as forecasters do not understand the properties and limitations of satellite data, they do not use L2 products in their decision making processes.
- ✓ Therefore, it is essential to develop integrated analysis and application facilities using L2 products together with available data such as MWs, surface and NWP data to support decision makers.
- ✓ And we need to prepare a practical guidance for users and train them before we launch the new satellite to maximize the utilization of satellite data .

Development of Integrated Analysis & Application Facilities

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1. Nowcasting
   - Objective cloud analysis through conceptual model
   - Early detection & warning of convective cloud & rain
   - QPE by composite & short-term prediction of L1 and L2

2. Tropical Cyclone & Ocean
   - Improvement of objective TC analysis(ADT)
   - Intensification & weakening of TC: OHC, MPI, Vertical Shear
   - 3-D Wind structure: MWs + IR + HRW + SSWs + NWP

3. Supporting Data Assimilation & NWP
   - QC & observation error estimation(R)
   - Observation operator(RTM) & 1D-Var
   - Impact of satellite data in terms of analysis improvement

4. Hydrology & Environment
   - Soil moisture, evapotranspiration & drought
   - Flood, wild fire & Asian dust(height, concentration)

❖ Tools for composite & downscaling, standard frame of validation

Application Facilities: Analysis & Nowcasting

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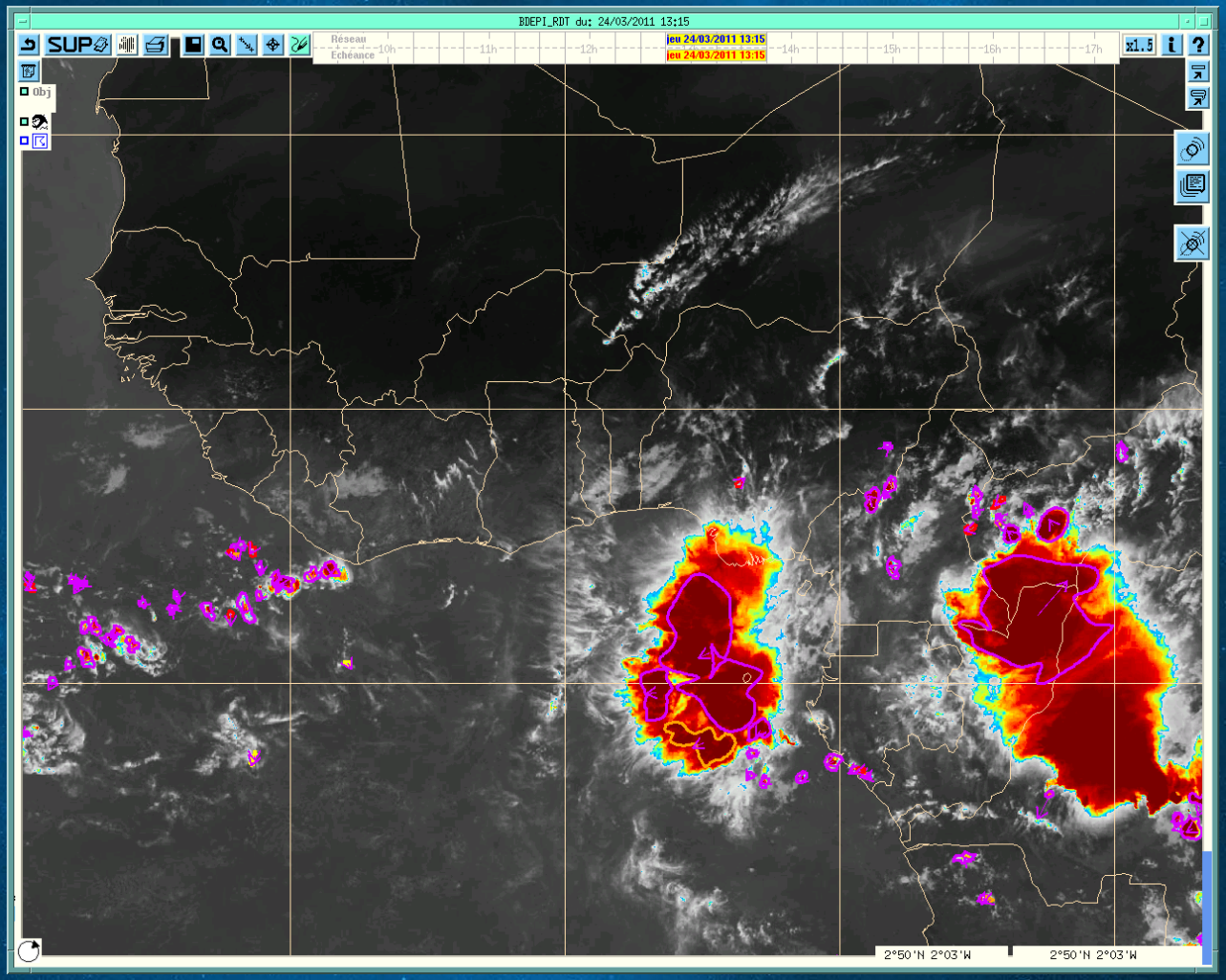
- Objective cloud analysis through conceptual model
- Early detection & tracing of rapidly developing convective cloud & rain



Courtesy of MeteoFrance

Application Facilities: Analysis & Nowcasting

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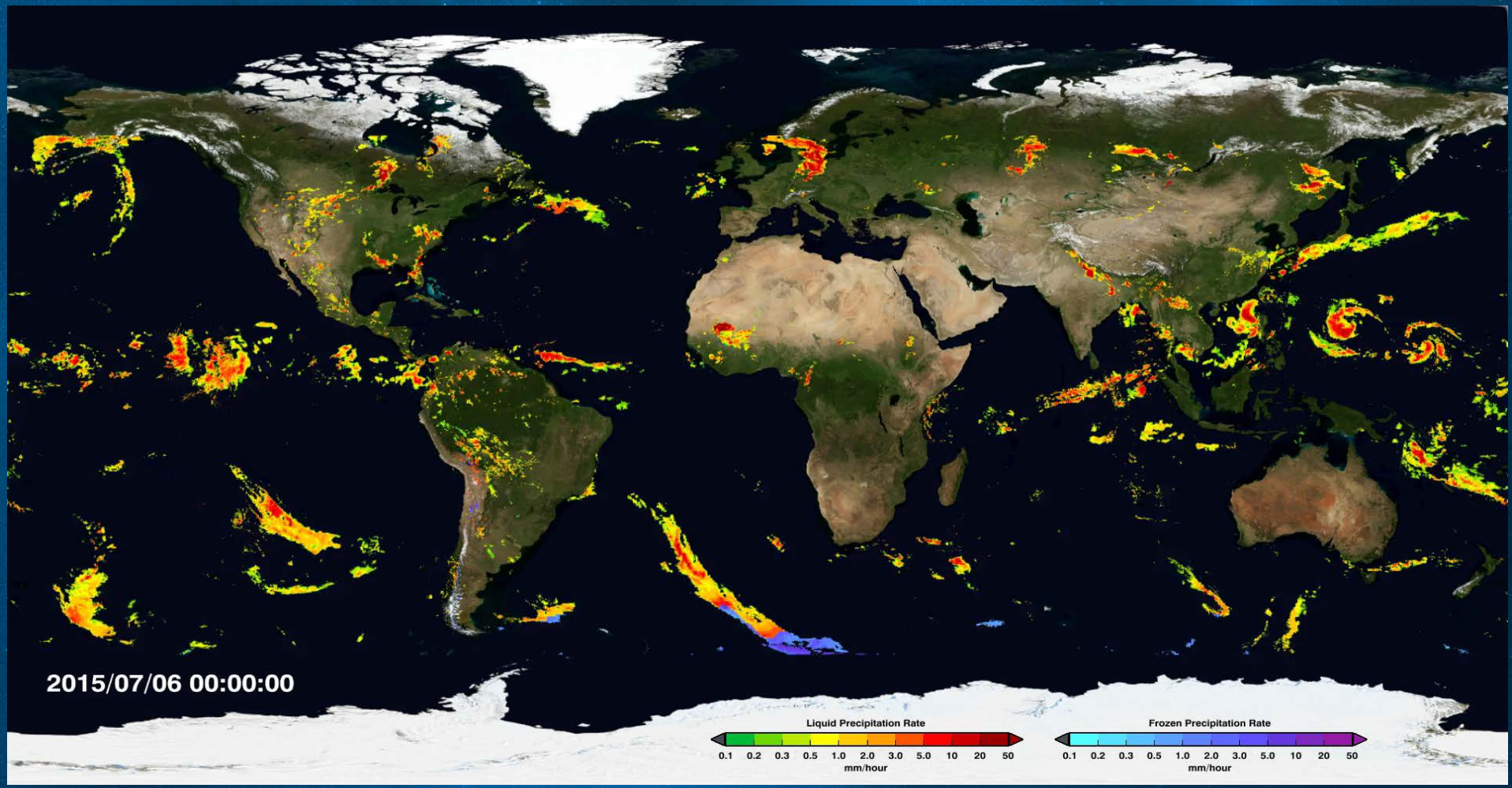
- QPE: composite of MWs + IR(every 10 min, < 10km)
- Short-term prediction(+6hrs) of L1, L2 & RGB products



IMERG(30min, 10X10km): 2015.7.6–7.13

Application Facilities: Typhoon and Ocean

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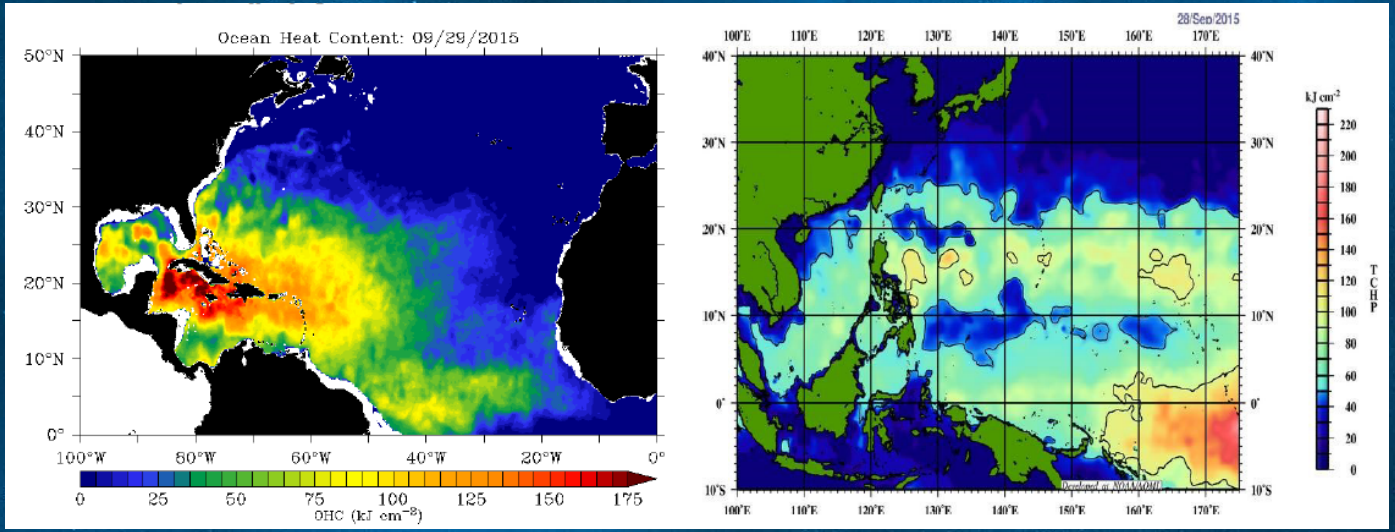
- Improvement of objective TC analysis(ADT) for NW Pacific
- Detection of TC intensification & weakening: OHC, MPI, Vertical Shear

Ocean Heat Content: SST + SSH + Mixed Layer Depth

RSMAS/
Univ of Miami

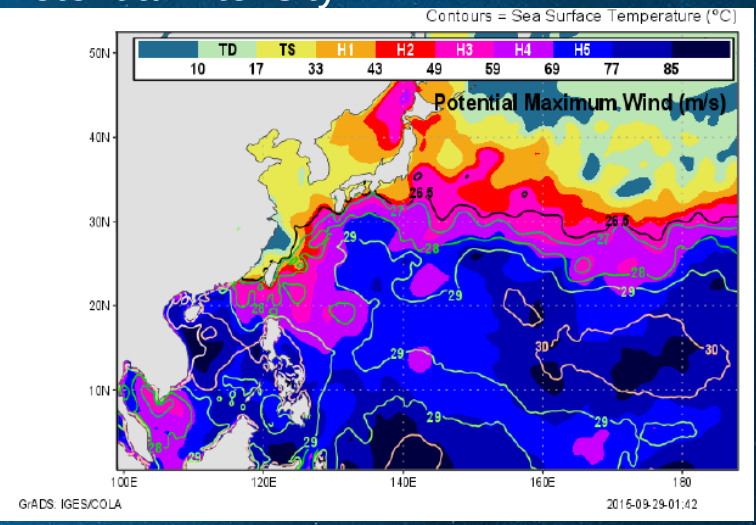


AOML/
NOAA

Maximum Potential Intensity

$$V^2 = \frac{SST - T_0}{T_0}\frac{C_k}{C_D}(k^* - k)$$ (Emanuel, 1999)

$T_0 = TC\ outflow\ temperature$
$C_D = Drag\ coefficient$
$C_k = Enthalpy\ Exchange\ coefficient$
$k^* = Saturation\ Enthalpy\ of\ sea\ surface$
$k = Surface\ Enthalpy\ in\ TC\ environment$



Application Facilities: Typhoon and Ocean

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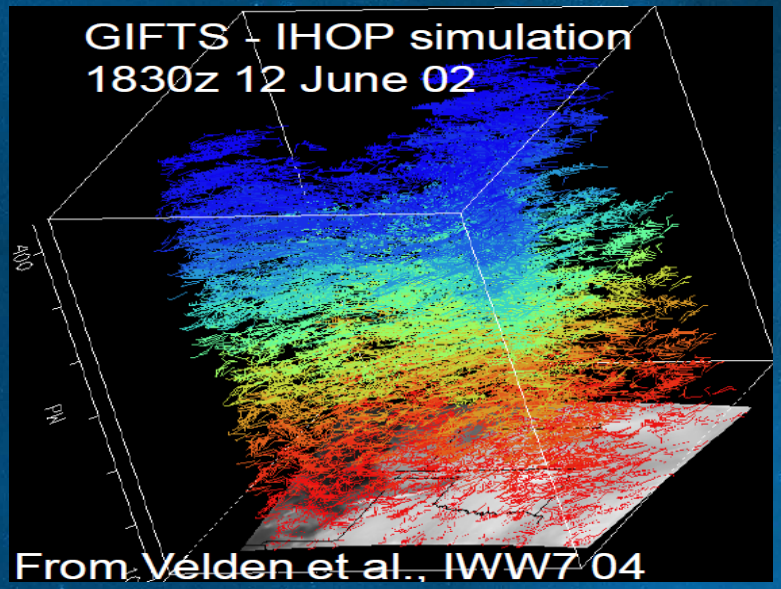
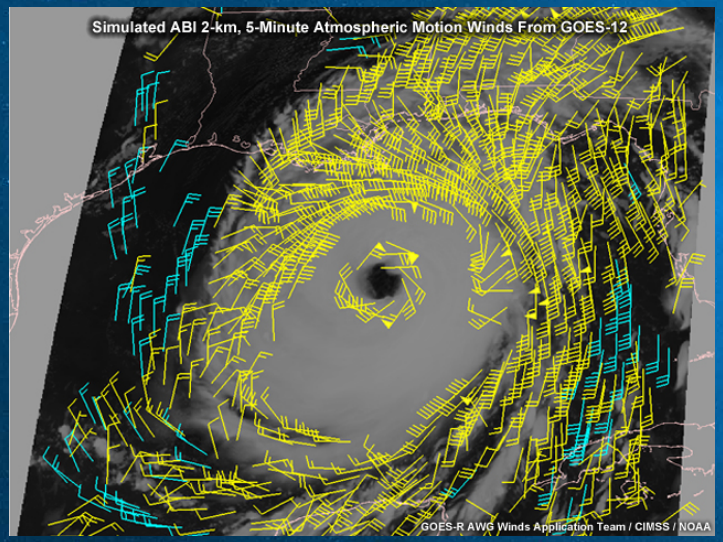
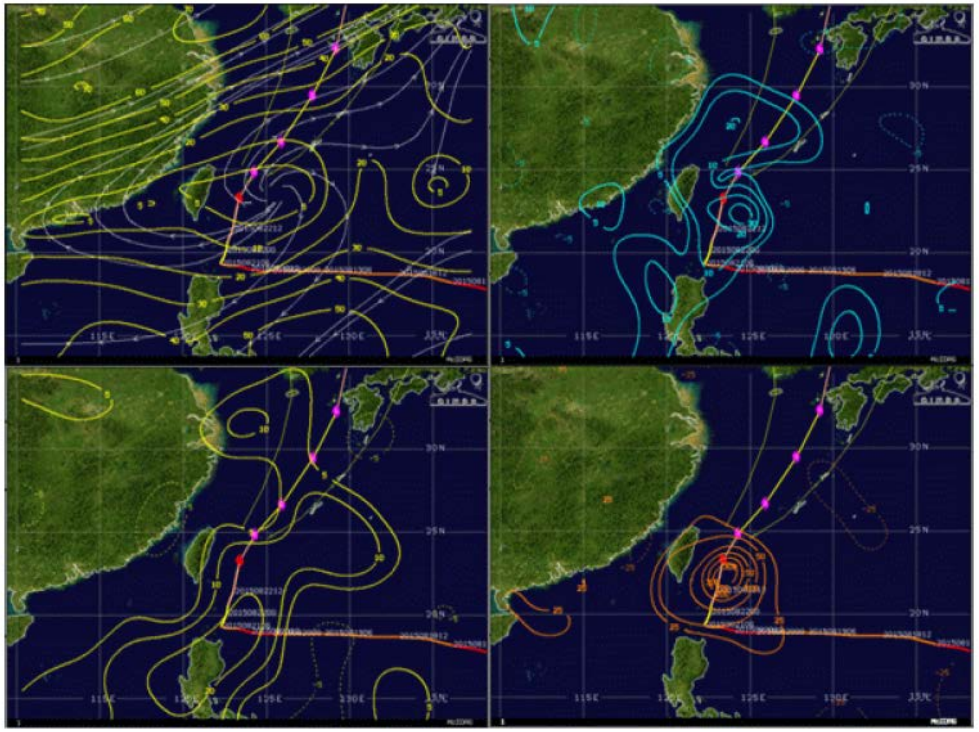
- 3-D wind structure: MWs + IR + AMV + Scatterometer Wind





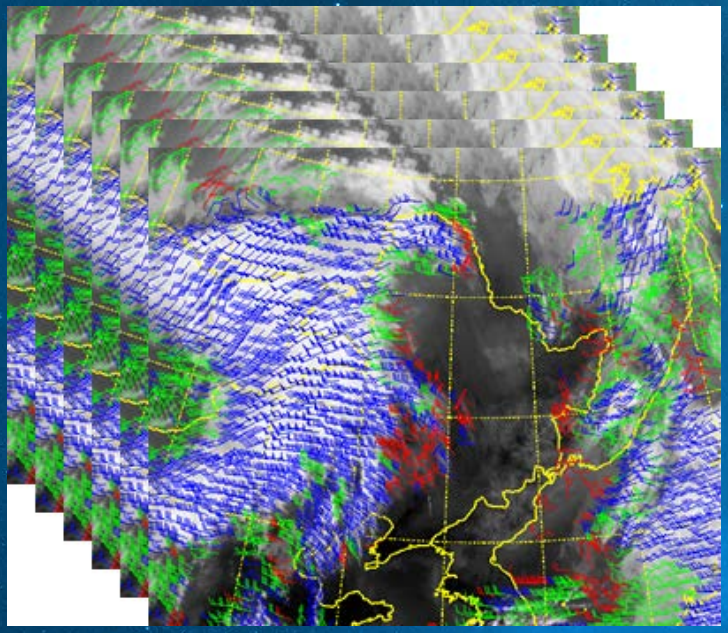
Shear, Div, Conv, Vorticity(CIMSS)



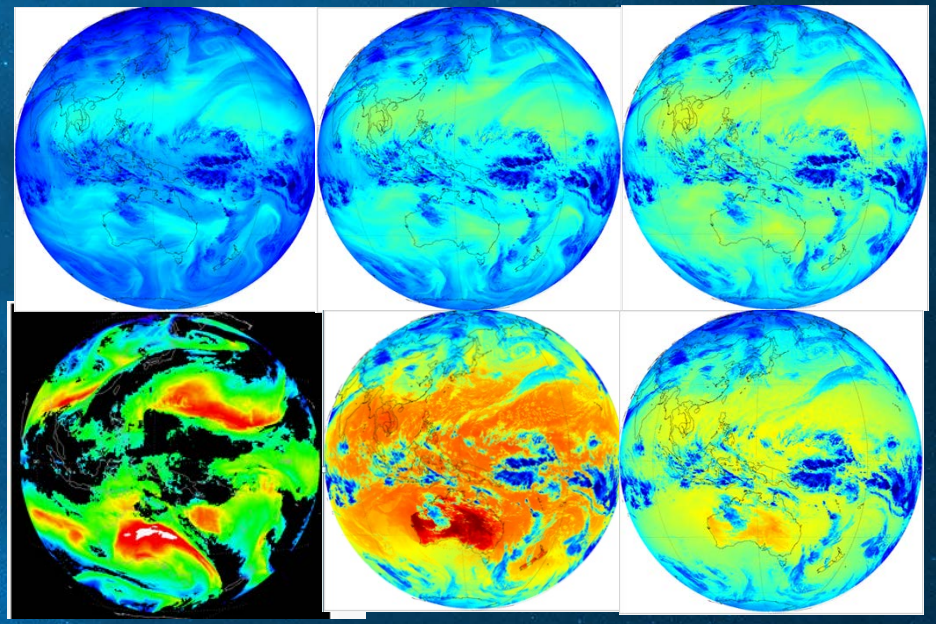
Application Facilities: Data Assimilation & NWP

국가기상위성센터
National Meteorological Satellite Center

- QC & Obs Error Estimation(R)
- Observation Operator(RTM) & 1D-Var
- Impact of satellite data in terms of analysis improvement
- Assimilation of new sat data: HRW, All Sky Radiance, Precipitation, Surface



High Resolution Wind



All Sky Radiance

Application Facilities: Hydrology & Environment

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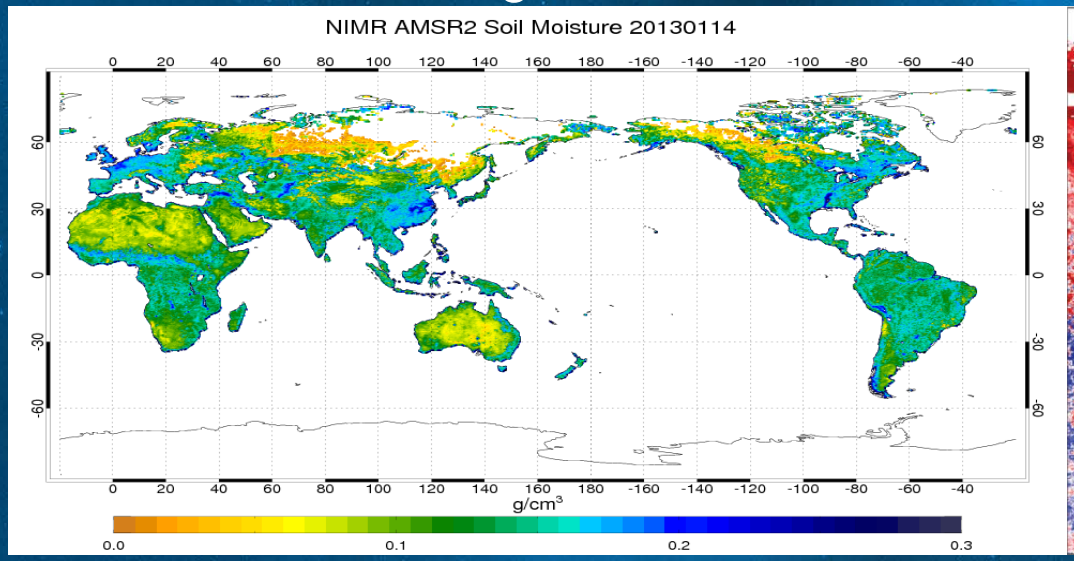
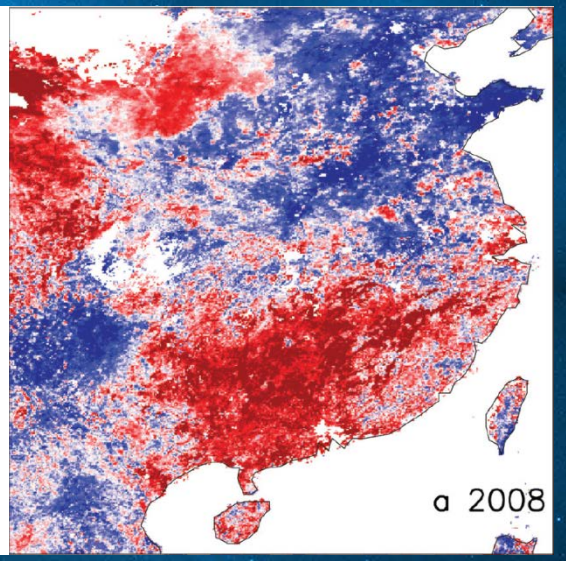
National Meteorological Satellite Center

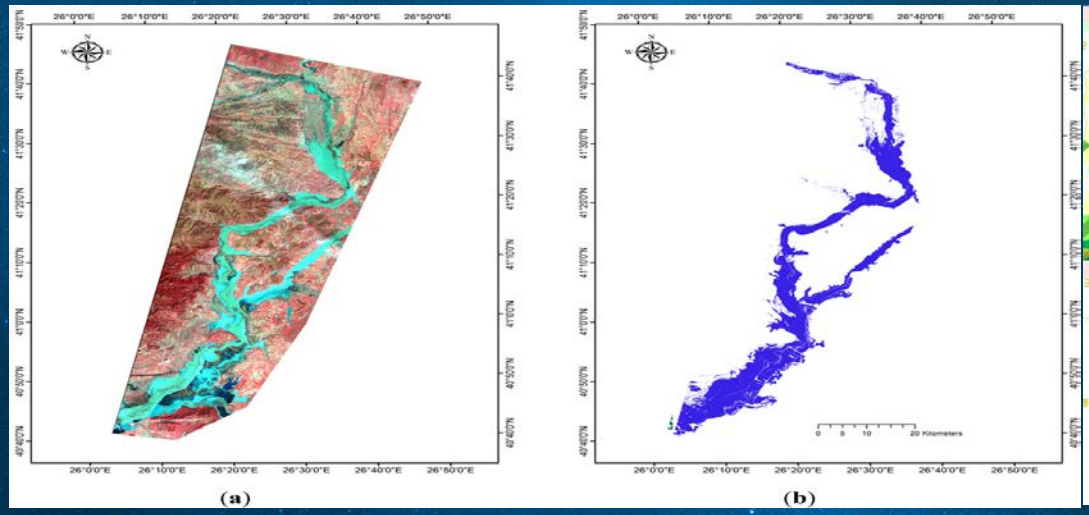
- Soil Moisture & Drought: MWs + IR + VIS + Surface

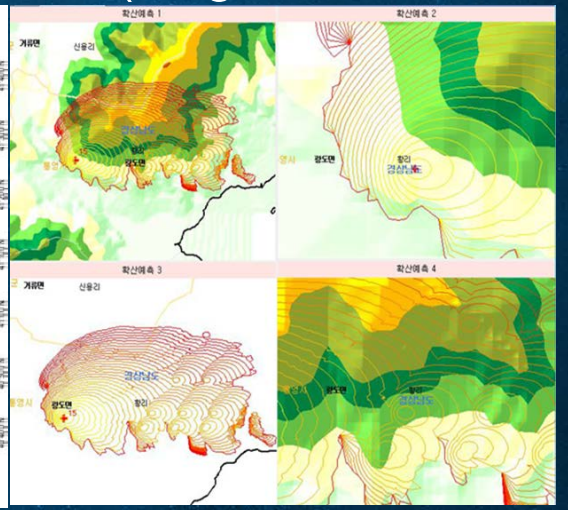




Mu et al.(2013)

- Flood & Wild Fire: IR + VIS + Surface; Asian dust(height, concentration)





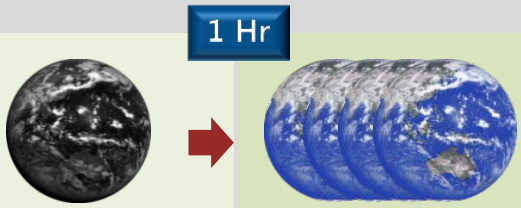
COMS MI vs. GEO-KOMPSAT-2A AMI

국가기상위성센터
National Meteorological Satellite Center

4 times spatial resolution

COMS	Geo-KOMPSAT-2A
VI 1km IR 4km	VI 0.5~1km IR 2km

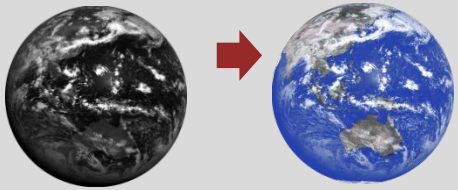
6 times temporal resolution



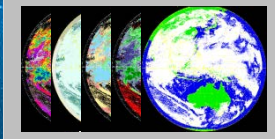
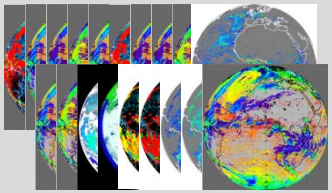
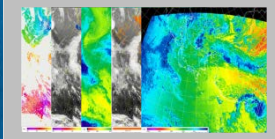
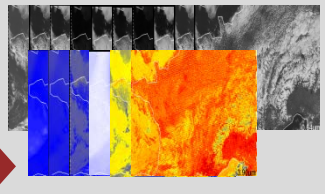
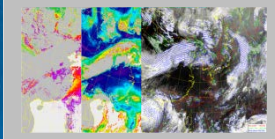
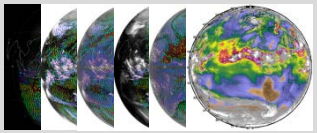
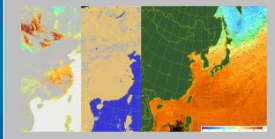
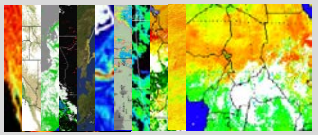
3 times number of channels

5 channel (vis 1, IR 4)

16 channels (vis 4, NIR 2, IR 10)

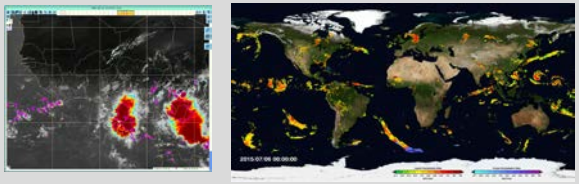


3.5 times number of products

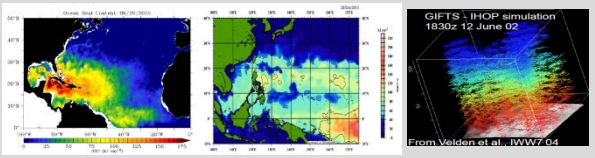
COMS	Geo-KOMPSAT-2A
Cloud/Precipitation (5→19)	
	
Radiation/aerosol (5→16)	
	
Atmospheric Motion/Conditions(3→6)	
	
Surface information(3→11)	
	
16 products	52 products

4 Application Facilities

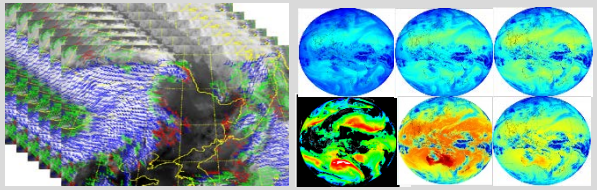
Analysis & Nowcasting



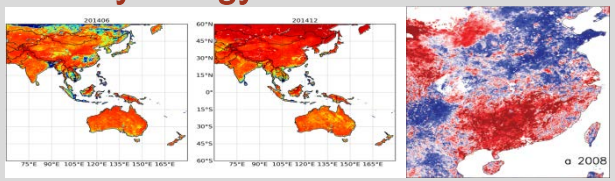
Typhoon & Ocean



Data Assimilation & NWP



Hydrology & Environment



GK-2A Data Service Plan via GK-2A

국가기상위성센터 National Meteorological Satellite Center

- **Broadcast all 16 channels data in UHRIT**
- **Maintain L/HRIT broadcast** corresponding to COMS five channels
  - Develop the functions to generate COMS-like L/HRIT image data from GK-2A obs.
  - KMA will support technical issues on receiving GK-2A L/HRIT for COMS S/MDUS
- **GOCI-II** data on GK-2B will be **broadcasted by GK-2A in HRIT**

	GK-2A (TBD)	COMS -> GK-2A	
	Ultra HRIT	HRIT	LRIT
Data Rate	≤ 31 Mbps	3 Mbps	~256 Kbps
Contents	16 channel data Alpha-numeric text Encryption Key Message	5 channel data (VIS, IR1, IR2, SWIR, WV) Alpha-numeric text Encryption Key Message GOCI-2 data	5 channel image (VIS, IR1, IR2, SWIR, WV) Alpha-numeric text Encryption Key Message Level 2 Data (Cloud Info.) GOCI-2 image
Resolution	0.5 ~ 2km (Full resolution)	1 ~ 4km	-
Domain	FD	FD	FD
User	LDUS	MDUS	SDUS

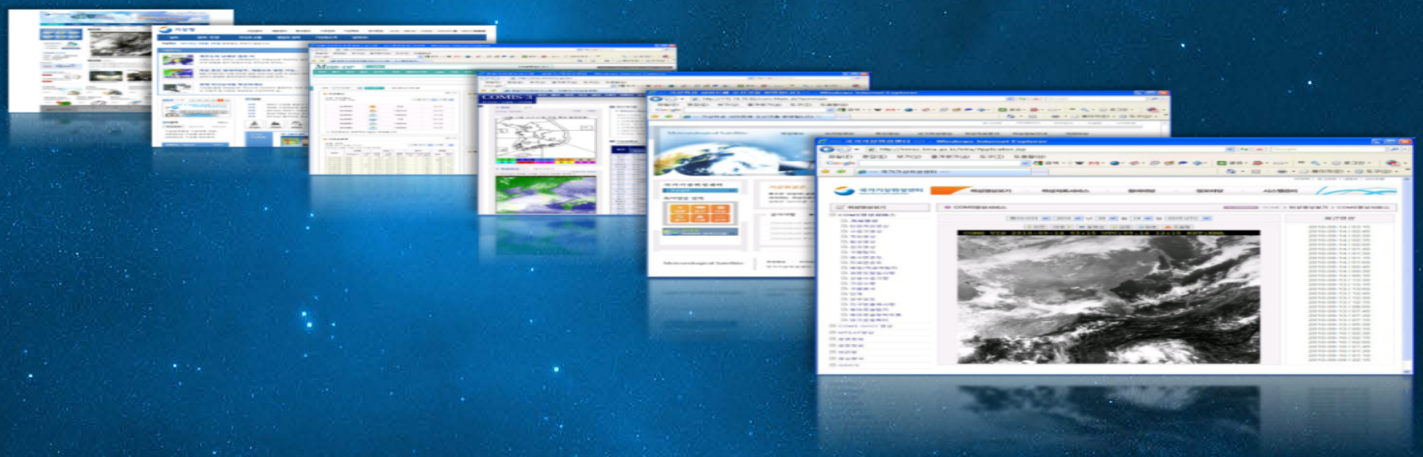
GK-2A Data Service Plan via land line(website)

[Internet Service]

- Data service of all 16 AMI channels in full resolution similar to HimawariCloud is under consideration
- All Level 1B and some of Level 2 data will be available on DCPC-NMSC website
  (http://dcpc.nmsc.kma.go.kr/openwis-user-portal/en/src/main.home)

[Web-based Retrieval & Analysis Tools]

- Upgraded & user-friendly web-based system will be established for GK-2A data usage in operational forecast and research



Milestone for the Geo-KOMPSAT-2A

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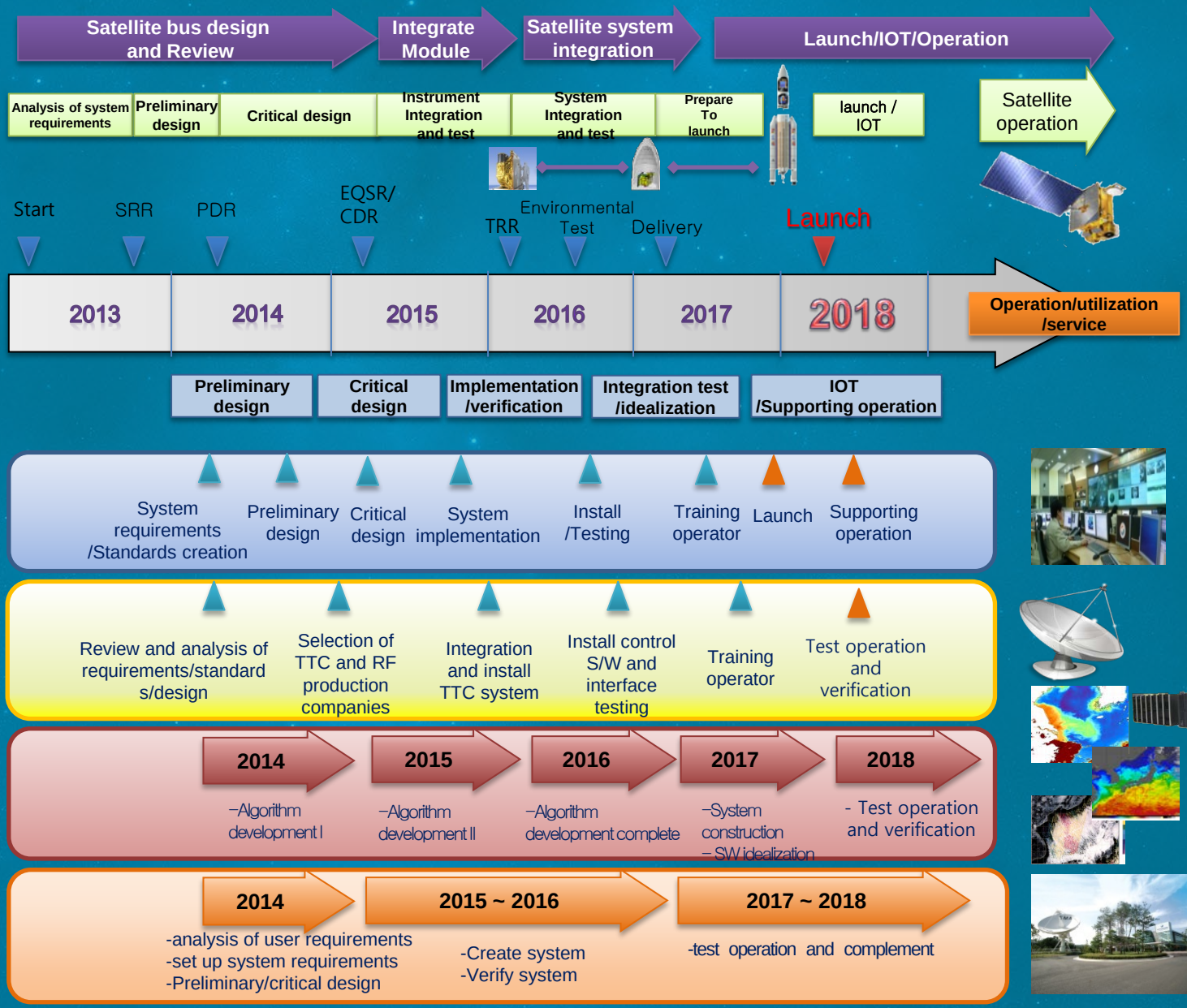
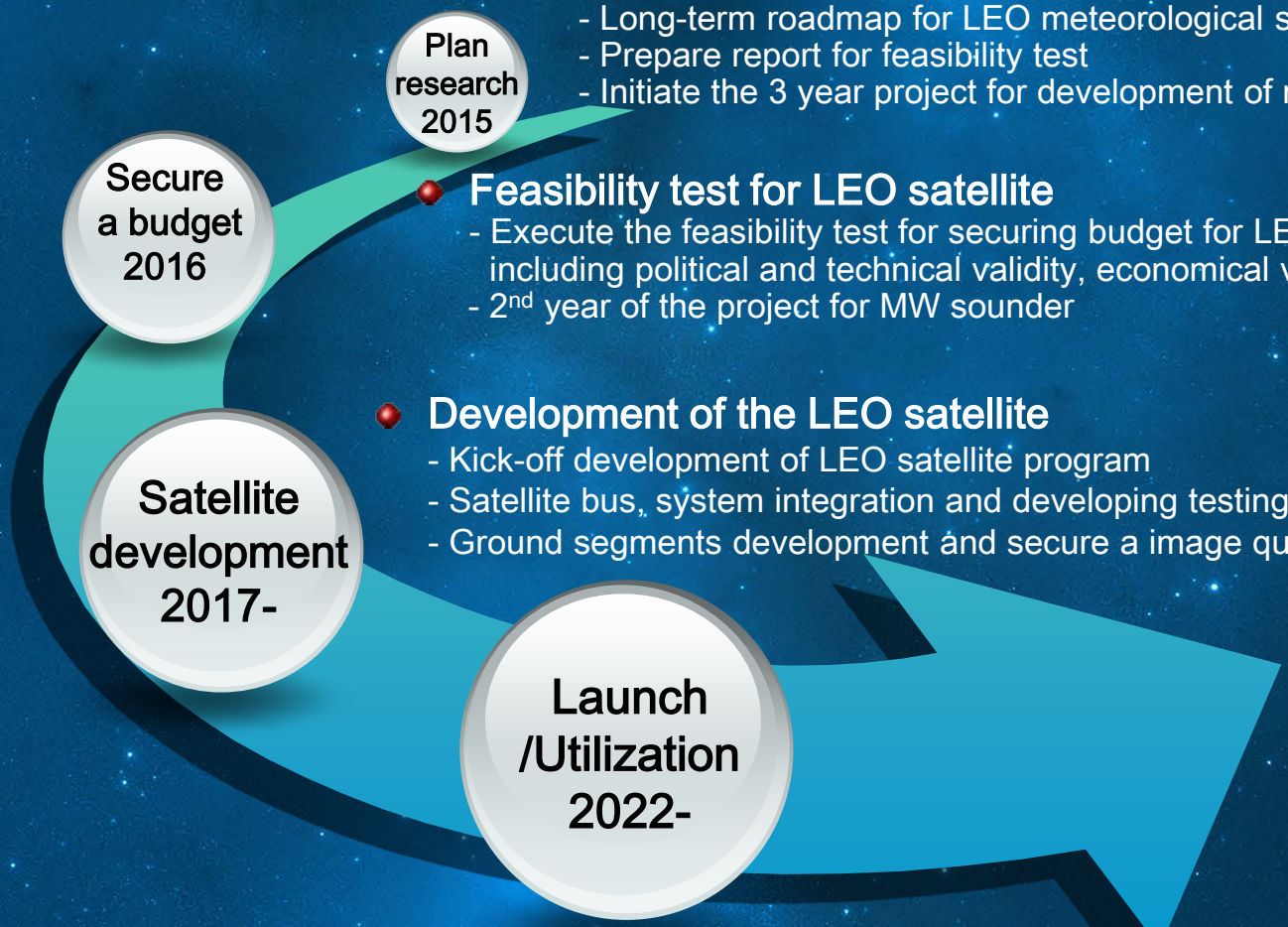
National Meteorological Satellite Center



LEO Satellite development plan

국가기상위성센터
National Meteorological Satellite Center



- **User requirement of LEO satellite**
  - Long-term roadmap for LEO meteorological satellite development
  - Prepare report for feasibility test
  - Initiate the 3 year project for development of micro MW sounder
- **Feasibility test for LEO satellite**
  - Execute the feasibility test for securing budget for LEO satellite including political and technical validity, economical validity
  - 2nd year of the project for MW sounder
- **Development of the LEO satellite**
  - Kick-off development of LEO satellite program
  - Satellite bus, system integration and developing testing technique
  - Ground segments development and secure a image quality technique
- **Application of data Utilization plan**
  - Apply to weather, climate, earthquake, volcano, disaster, etc.
  - Data utilization research for global water/climate, etc.
  - Supply standard input data of numerical model

LEO Satellite development plan

국가기상위성센터
National Meteorological Satellite Center

- Development (plan) : ~ 2022 (or earlier)
- Altitude/orbit : 500~900km/Sun-synchronous(TBD), early morning orbit
- Satellite : ~500kg; Payload: ~150kg
- Possible Payload : MW Sounder such as ATMS & AMSU

  : IR Sounder such as CrIS with limited channels

  : MW Imager such as GMI

  ~ one or two instruments depending on weight of payloads(~150kg)

  ~ instrument type will be decided based on feasibility test
- International cooperation / joint development for payload and sensors

Thank You !

Announcements about next conferences

➢ The 7th Asia-Oceania Meteorological Satellite Users' Conference

- Jointed with the 22nd AMS Satellite Conference & 2nd KMA IMSC
- Venue: Incheon(Song-do), Republic of KOREA
- Date: 23 – 29 October, 2016

  2-day Training, 4-day Conference, one-day Meeting for WIGOS

➢ The 1st KMA International Meteorological Satellite Conference

- Venue/Date: Palace Hotel, Seoul/16-18 November, 2015
- Main Programs
  - : GK-2A Development & Ground Segment
  - : GK-2A Algorithms & Applications
  - : Space Weather
  - : Development of Low Earth Orbit Satellite
  - : Student Research Competition