2015 NOAA Satellite Conference(April 27, 2015)

KMA
Korea Meteorological Administration

Current Status and Future Plan of KMA Satellite Program

Sang Jin LYU

National Meteorological Satellite Center
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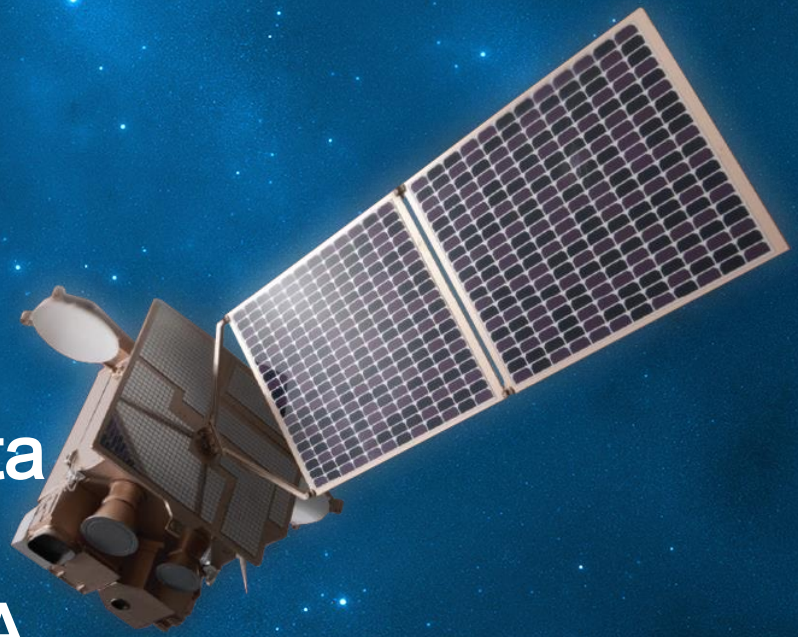
sjlyu@korea.kr

Contents



국가기상위성센터
National Meteorological Satellite Center

Current Status of COMS

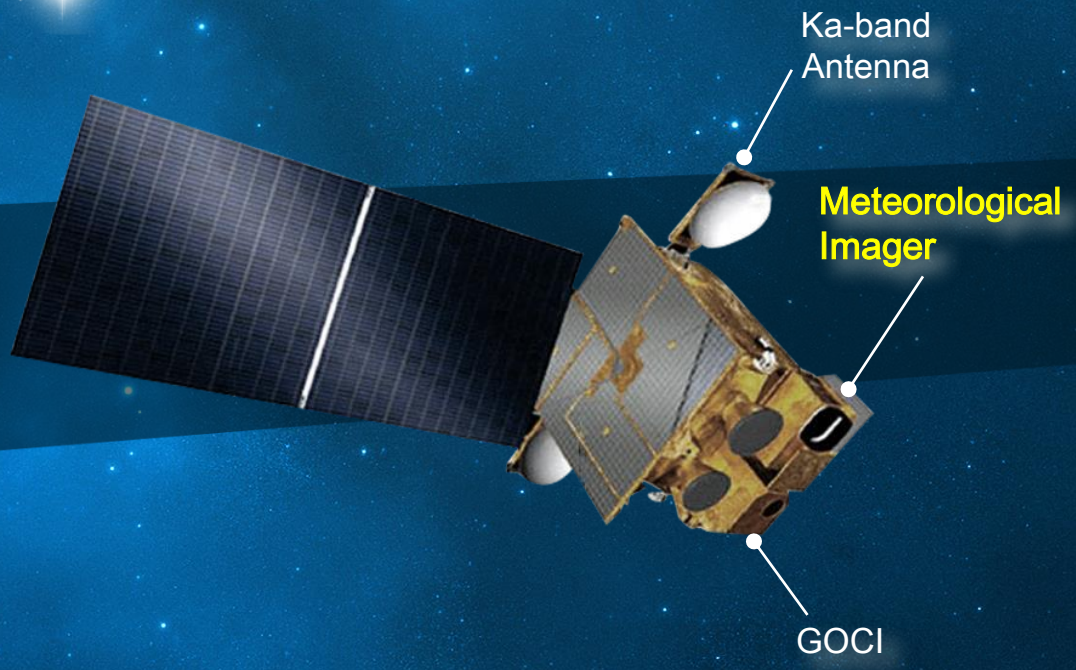
COMS Program

국가기상위성센터
National Meteorological Satellite Center

COMS is the first multi-purpose geostationary satellite for Korea in the application of Meteorology, Ocean and Communication

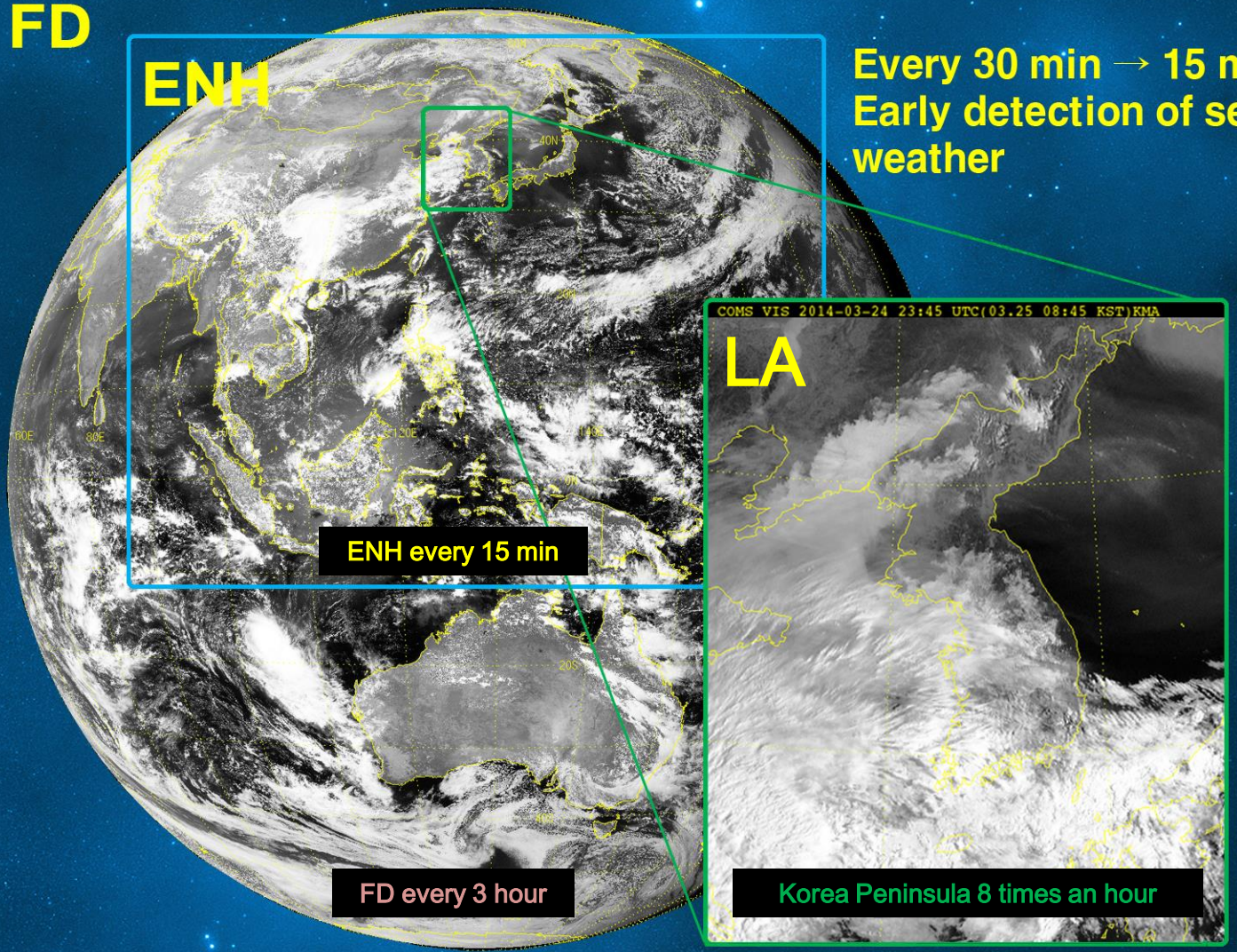
- Meteorological Mission : Continuous Observation to support weather forecasting and early detection of severe weather phenomena
- Development period : 2003 - 2010 (8 yrs)
- Orbit : 128.2°E over equator (36,000 km)
- Design life : 7 years
- Launch : June 2010
- Operation : April 2011 ~

Communication
Ocean and
Meteorological
Satellite



Observation Modes of COMS

국가기상위성센터
National Meteorological Satellite Center



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

COMS Data Services

국가기상위성센터
National Meteorological Satellite Center

Service via COMS(HRIT/LRIT)

- Asia-Pacific region covering 30 nations with 2.2 billion people
- 10 domestic stations and several foreign stations are operating
  ※ KMA supports some foreign stations via ODA

Service via FTP

- Domestic
  - 21 domestic KMA-related organizations such as the military, broadcasting companies, disaster prevention centers and local government
- International
  - EUMETSAT, CIMSS(US), Hongkong (on progress) etc.

Service via Internet

- NMSC provides COMS Level 1B data of all five channels and Level 2 products to users by posting the processed data on NMSC Website and DCPC/GISC-Seoul (http://nmsc.kma.go.kr/jsp/eng/contents/main/main.jsp)

Utilization of Foreign Satellite Data

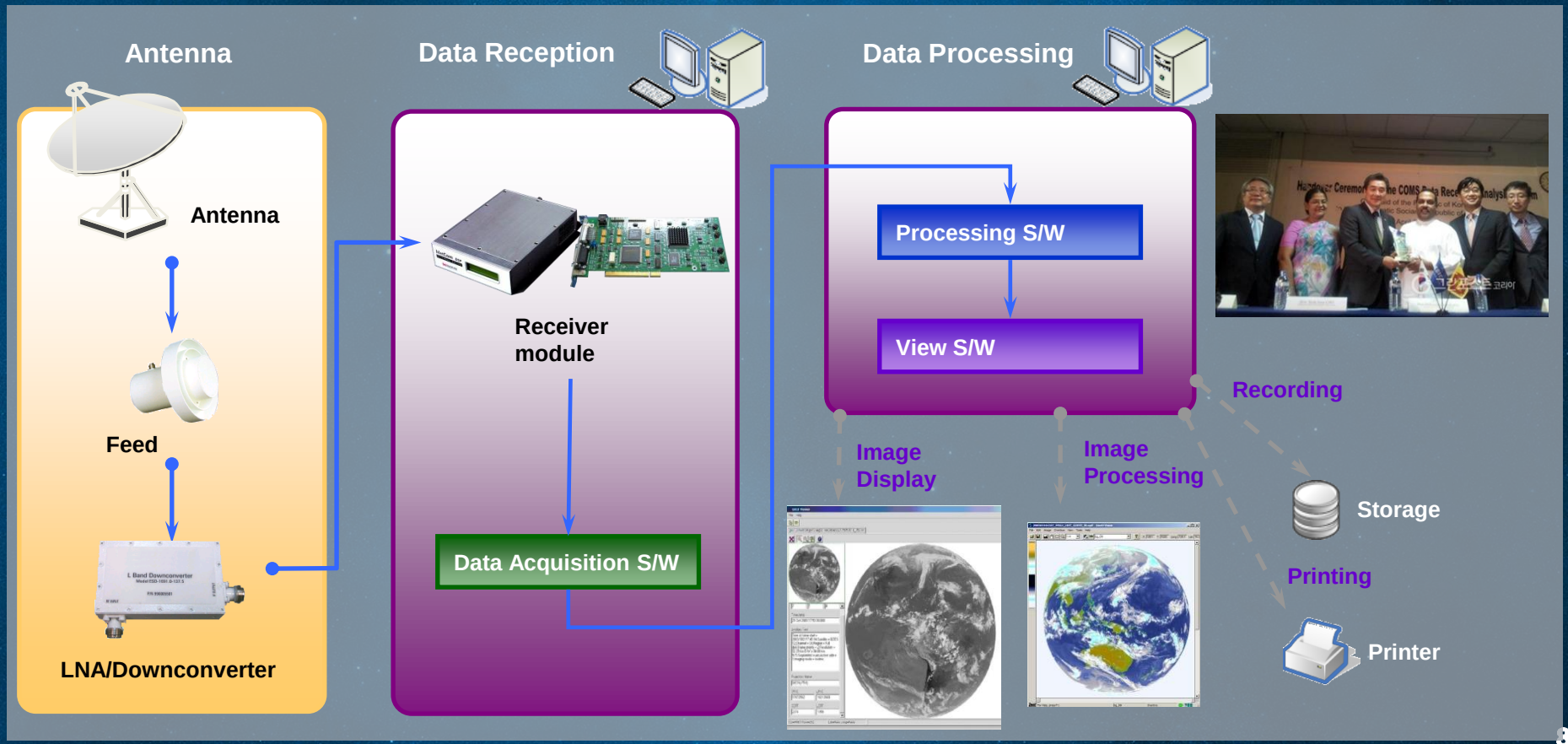
국가기상위성센터
National Meteorological Satellite Center

related government ministry, National Emergency Management Agency, Research Institute, University, related industries, etc.

Cooperation with Asian-Pacific Countries

국가기상위성센터
National Meteorological Satellite Center

- Project : Establishment of receiving and analysis system of COMS
- Targets : Sri Lanka (`10~`12), Philippines (`13~`14), Laos (`13~`14)
- Contents : Receiving system(H/W, S/W)
  Operational monitoring and analysis system
  Technological support & Training



International Conference & Training

국가기상위성센터
National Meteorological Satellite Center

- **WMO RA II Pilot Project Virtual Laboratory(VLab) High Profile Training Event:** October, 2012 / NMSC, Korea
- **The 3rd Asia-Oceania Met. Sat. Users' Conference**
  - 29~12 October 2012 / Suite Hotel, Jeju Island, Korea
- **The 19th International TOVS Study Conference**
  - 26 March ~ 1 April, 2014 / Lotte Hotel, Jeju Island, Korea
- **The 1st KMA Satellite Conference**
  - **November, 2015(TBD) / Korea**
- **International Satellite Users' Training Course**
  - **two weeks in-residence training course, 2016~2018, NMSC, Korea**

국가기상위성센터
National Meteorological Satellite Center

Improvement in COMS Data

COMS Data Products

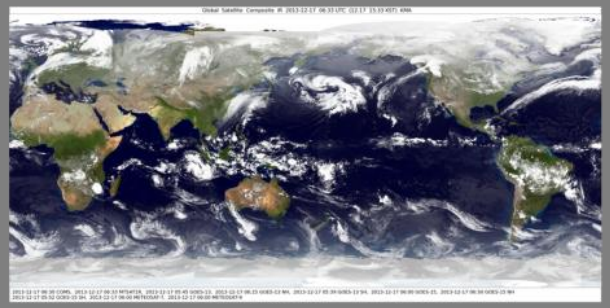
국가기상위성센터
National Meteorological Satellite Center

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

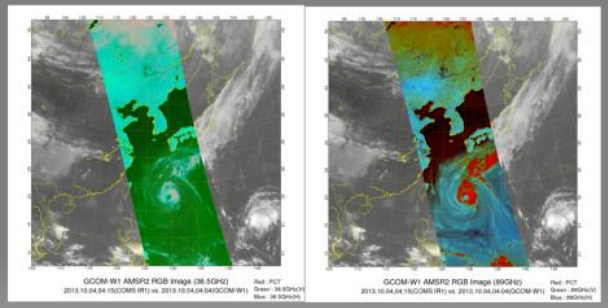
Utilization (1/2)

국가기상위성센터
National Meteorological Satellite Center

COMS Composite Images

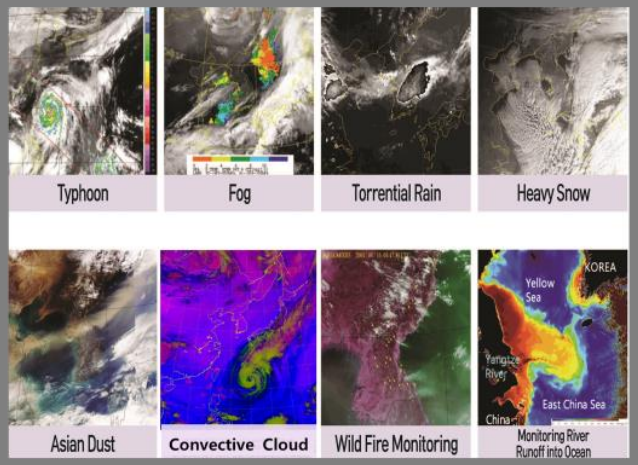


Global Satellite Composite Image

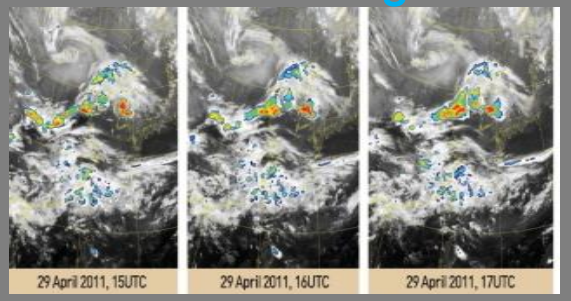


COMS+GCOM-W1(36.5GHz) COMS+GCOM-W1(89GHz)

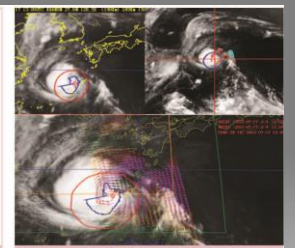
Disaster Mitigation



Short-term / Nowcasting



The Typhoon Scale Depending on the Radius of Strong Winds

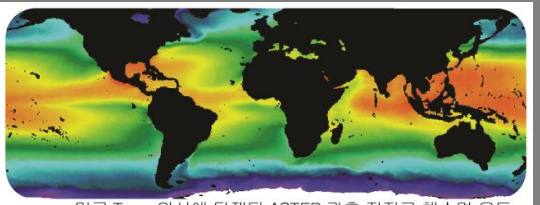


The radius of strong winds of Typhoon Kanun (#7) measured by the temperature of COMS (17 July 2012, 13:00KST) and verification using ASCAT wind data

Utilization (2/2)

국가기상위성센터
National Meteorological Satellite Center

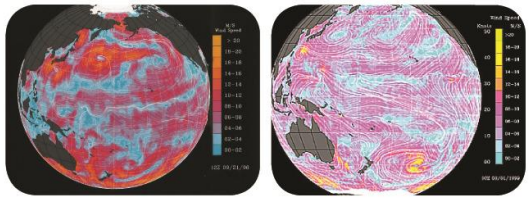
Ocean Meteorology



미국 Terra 위성에 탑재된 ASTER 관측 전지구 해수면 온도

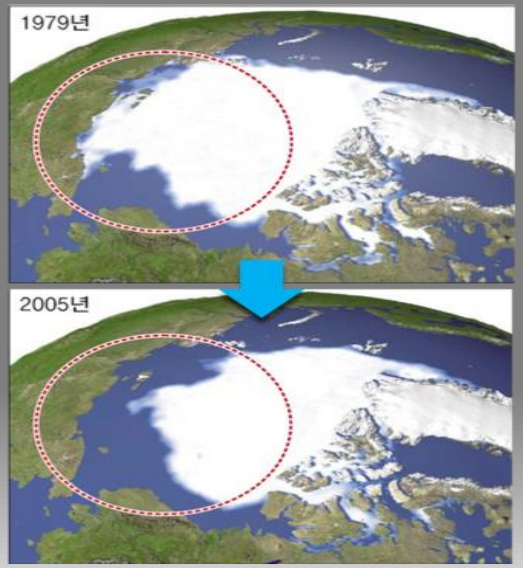
태안 기름유출(Oil Spill)

멕시코만 기름유출(Oil Spill)

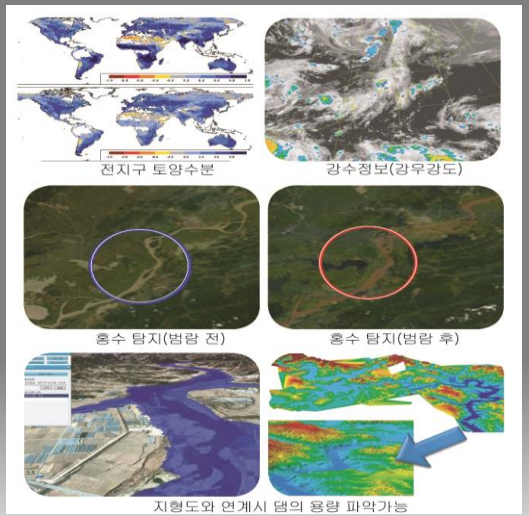


해수면 온도 및 해상풍

Climate/Environment Monitoring



Hydrology



전지구 토양수분

강수정보(강우강도)

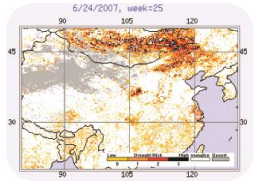
홍수 탐지(범람 전)

홍수 탐지(범람 후)

지형도와 연계시 댐의 용량 파악가능

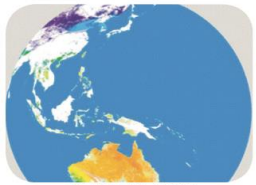
Agriculture

전지구 작황감시

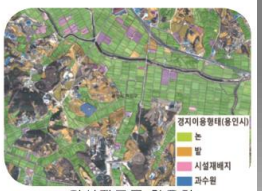


위성자료를 활용한 가뭄지수

산불탐지



위성자료를 활용한
전지구 지표면 온도



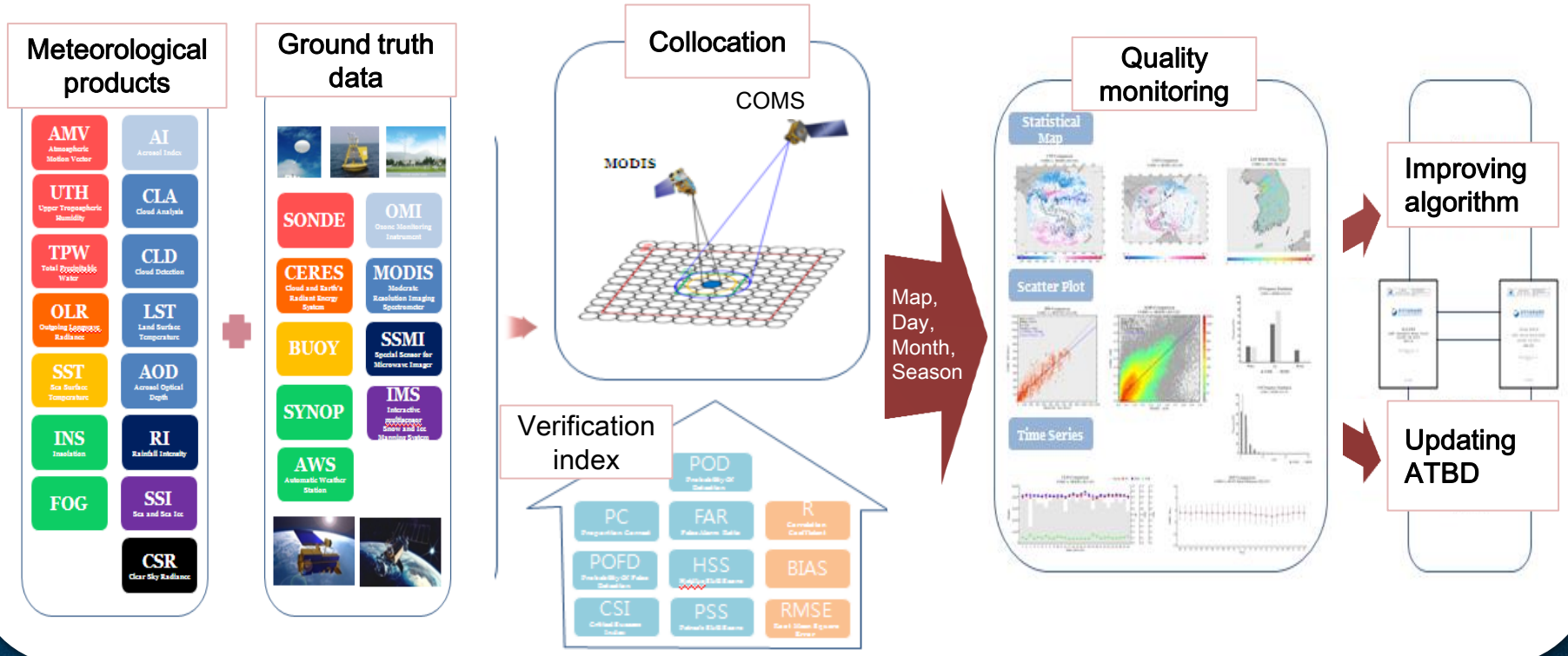
위성자료를 활용한
농경지 탐지 및 농경지 지도 작성

COMS product validation and improvement

국가기상위성센터
National Meteorological Satellite Center

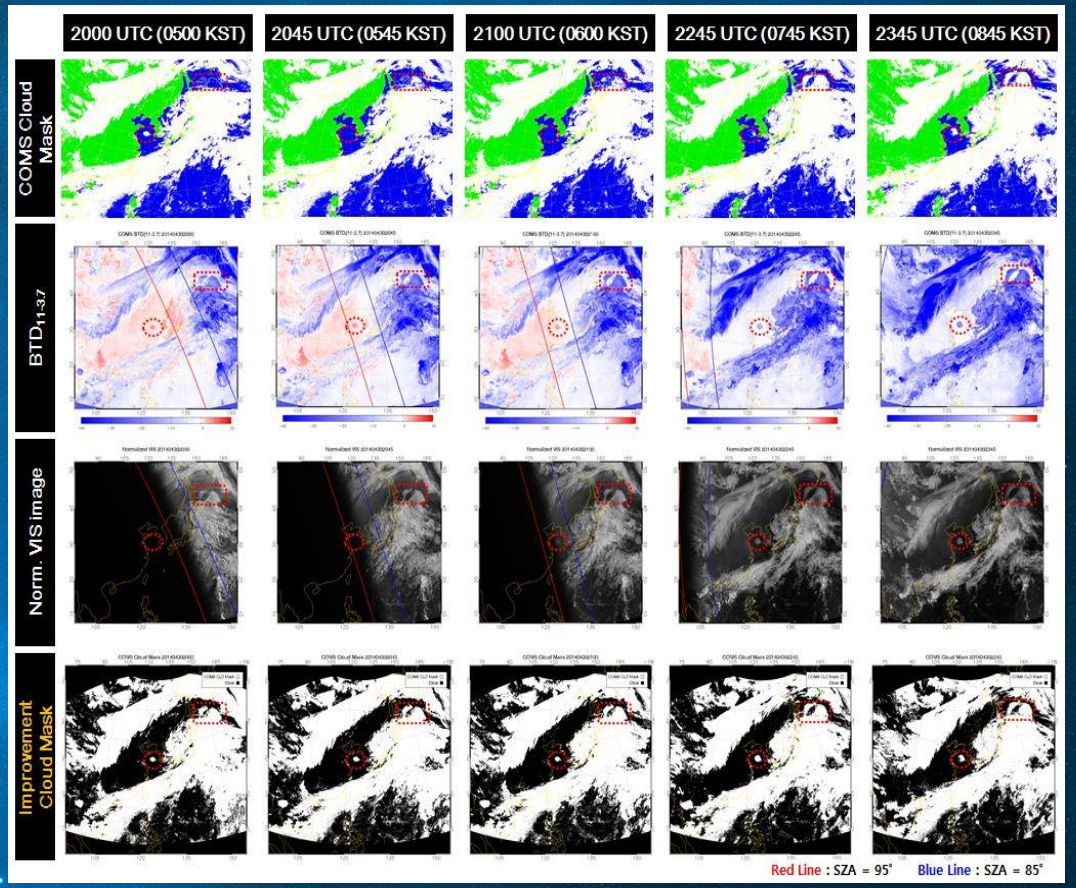
Algorithm improvement through the COMS data quality monitoring in real time and continuous feedback from users especially for operational forecast purpose

Meteorological products quality assessment system



Cloud Detection

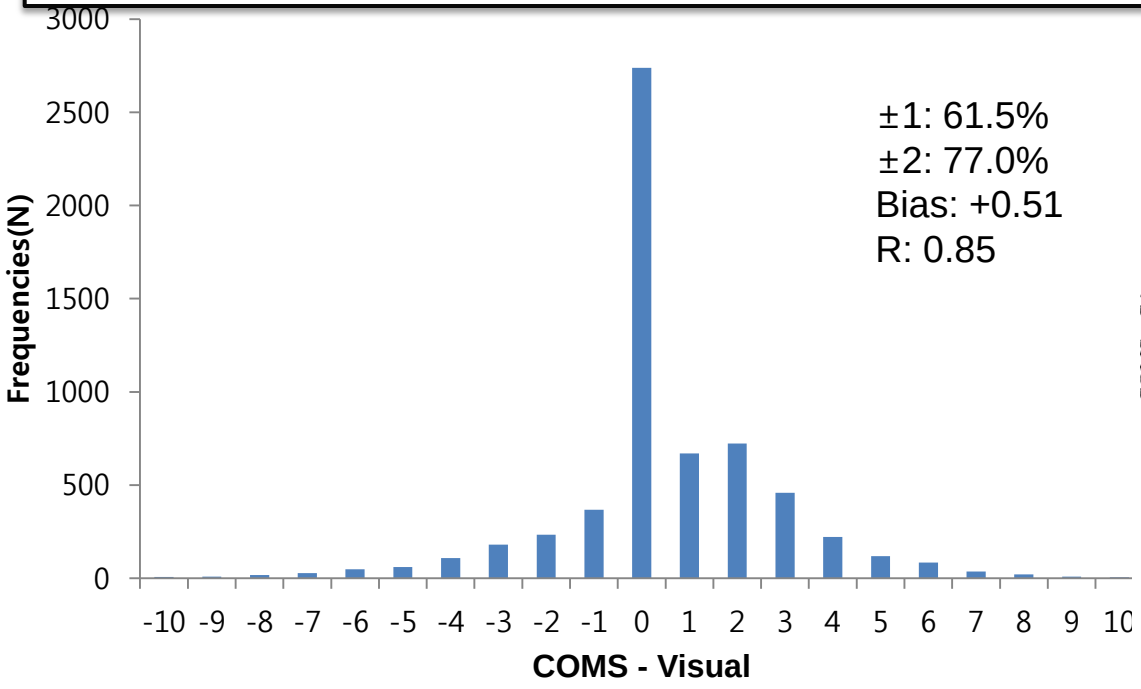
- Current Status of COMS Cloud Detection Algorithm
  - The operational COMS CLD algorithm shows that fog and low-level clouds are often undetected in the day-night transition area
- CLD Algorithm
  - Conventional static thresholds method : Single channel threshold, Dual channel BTD, Homogeneity ….
  - Discontinuity in the day-night transition regions
- To reduce discontinuity
  - Normalized Visible Reflectance
  - Dynamic Threshold (BTD11-3.7 μm)

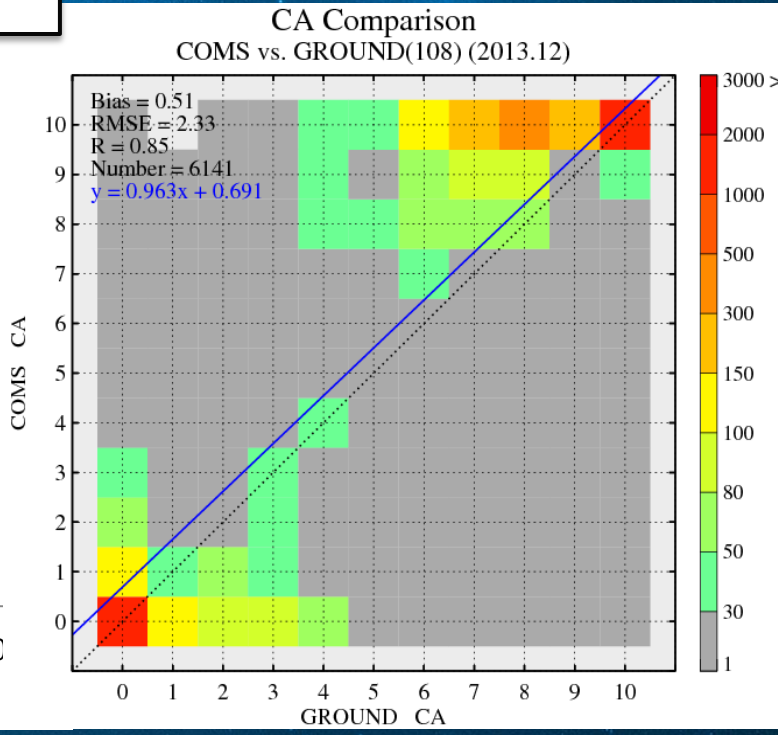


See the Poster # 3.32

Cloud Cover

Operational Cloud Cover from COMS vs visual observation at Seoul from Dec 2013 to Nov 2014



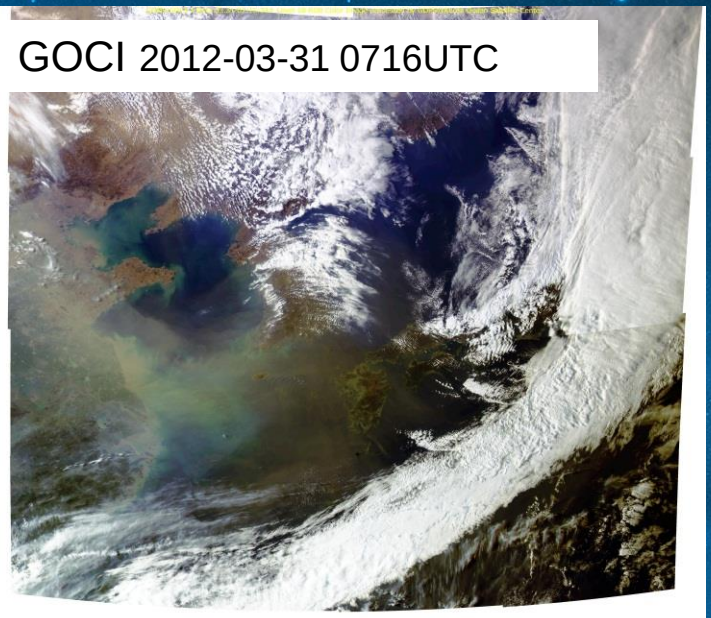


Improved Cloud Cover through modification of CLD module at Seoul in Jan 2014

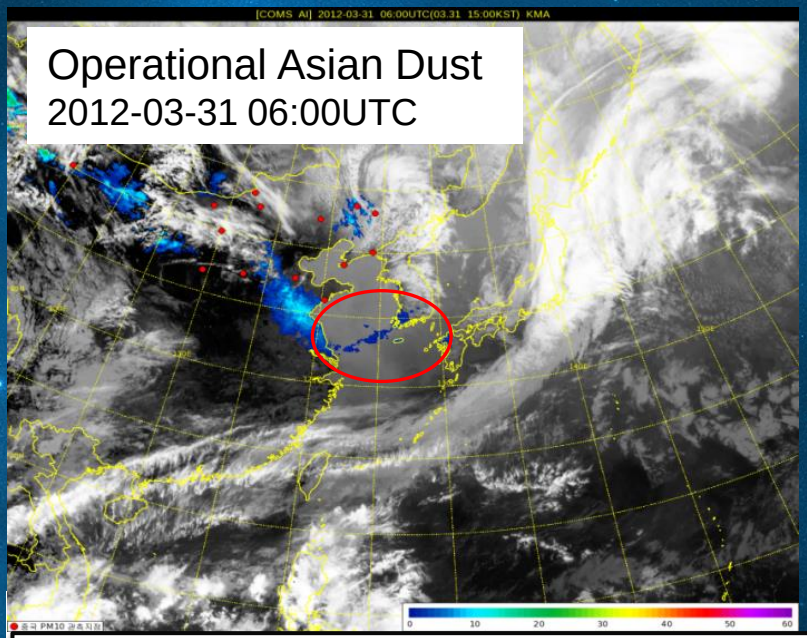
	±1	±2	Bias	RMSE	R
Operational	**65.8 %**	**77.6 %**	**+0.55**	**2.35**	**0.85**
Improved	**69.7%**	**80.9%**	**+0.29**	**1.90**	**0.90**

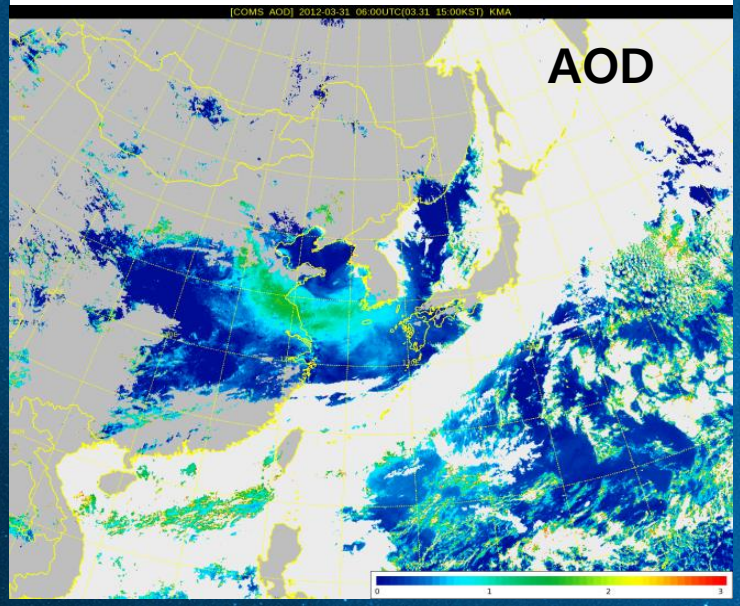
Asian Dust Detection

GOCI 2012-03-31 0716UTC

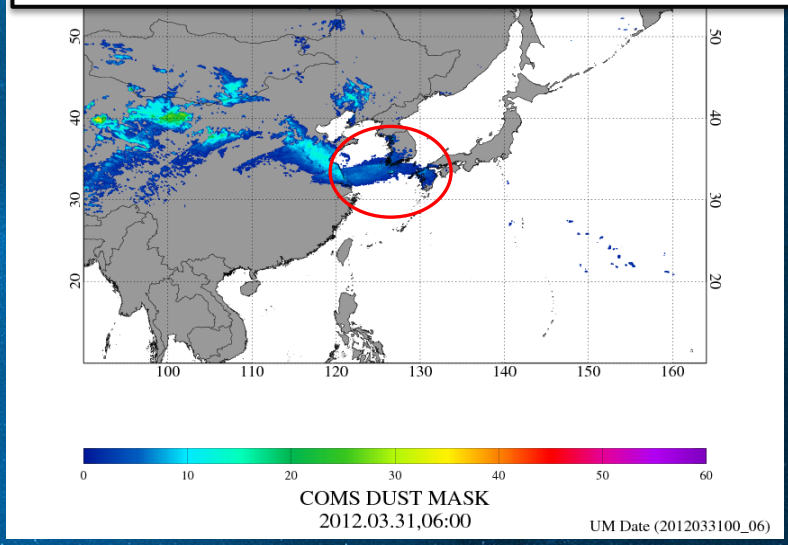


Operational Asian Dust
2012-03-31 06:00UTC

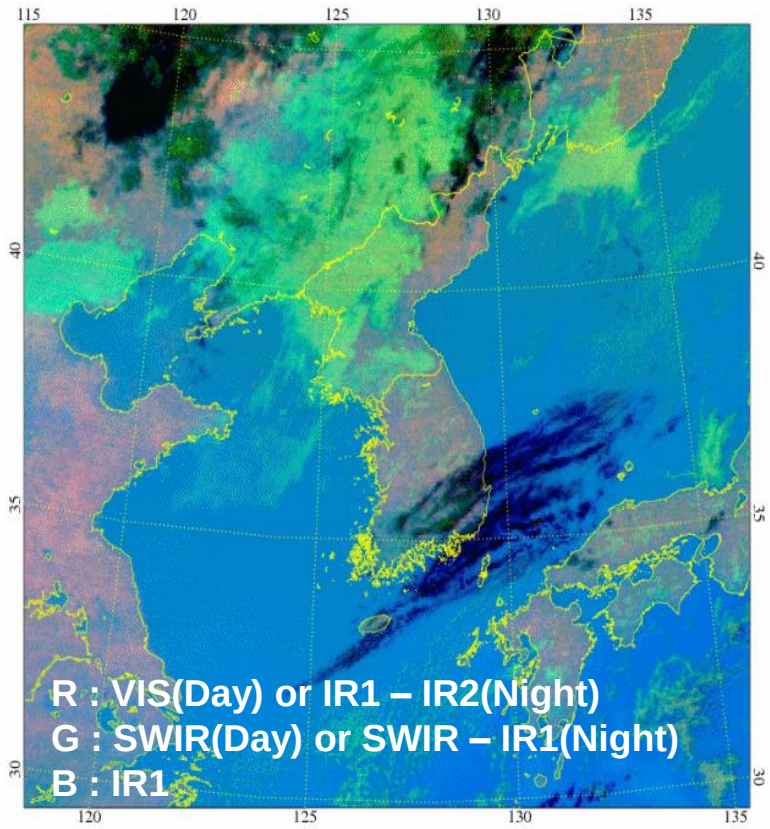




Correction for water vapor effect in $BTD_{11\text{-}12\mu m}$



RGB Fog Product

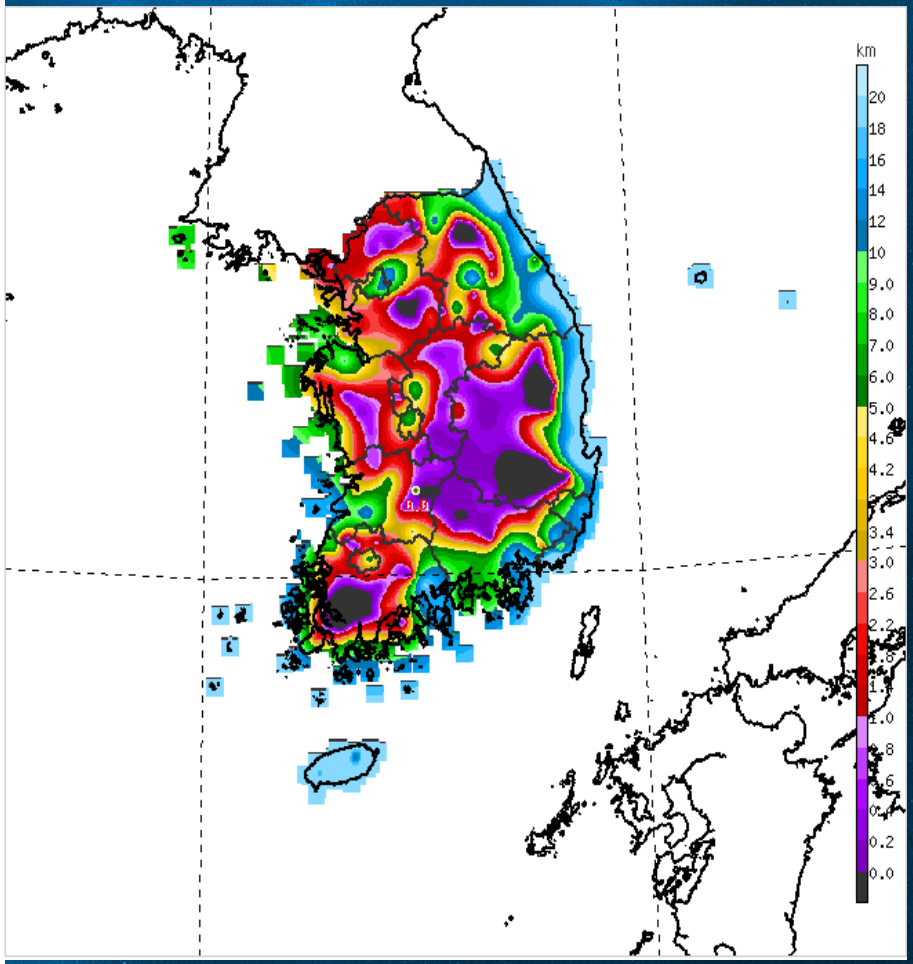


>> Day <<
Red : VIS
Green : SWIR Reflectance
Blue : IR1

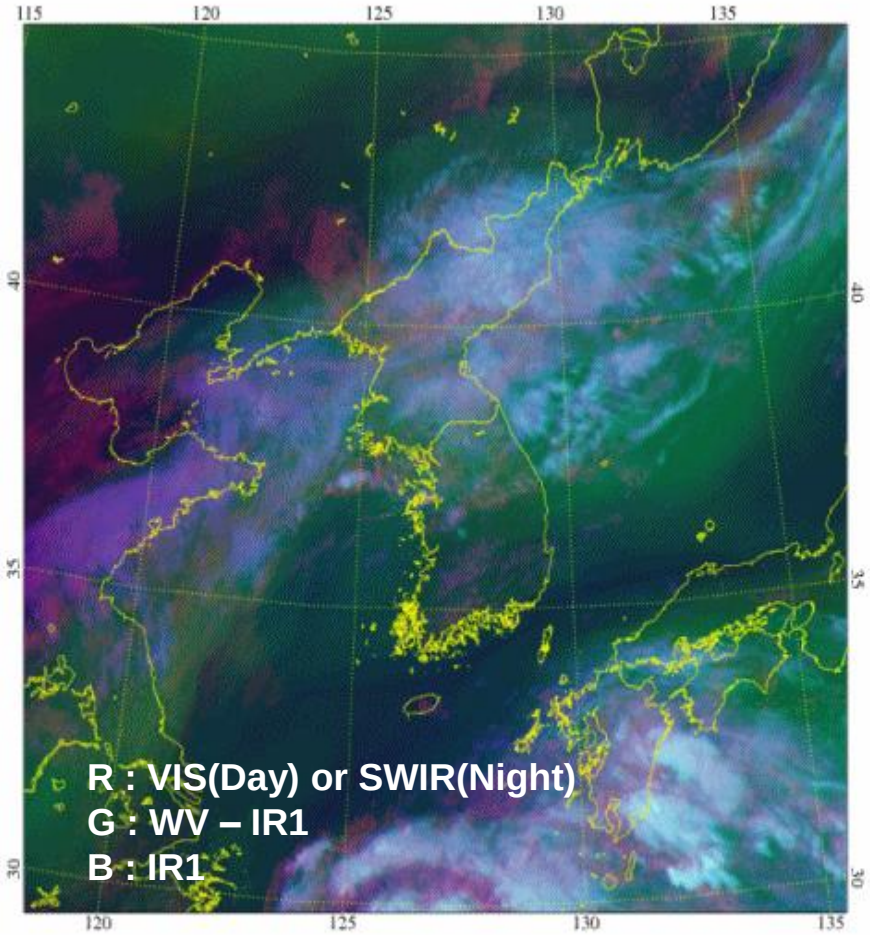
COMS RGB Product - Fog Analysis
2014.10.23, 17:00

>> Night <<
Red : IR1 - IR2
Green : SWIR - IR1
Blue : IR1

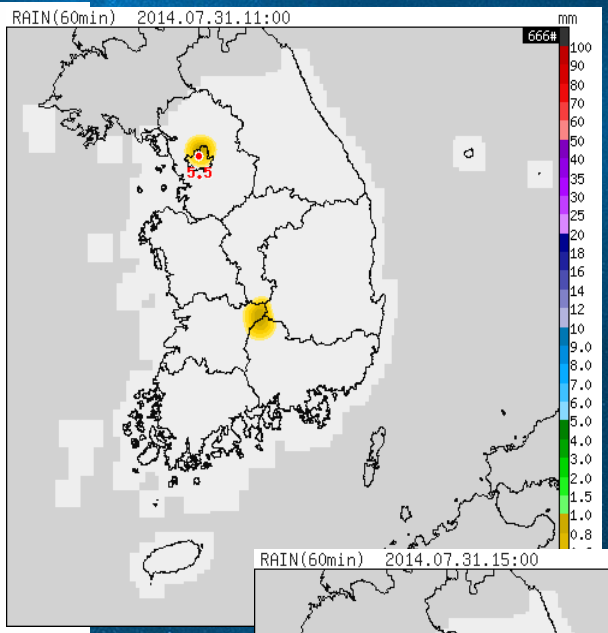
Ground Visibility(2014.10.23. 21:00UTC)

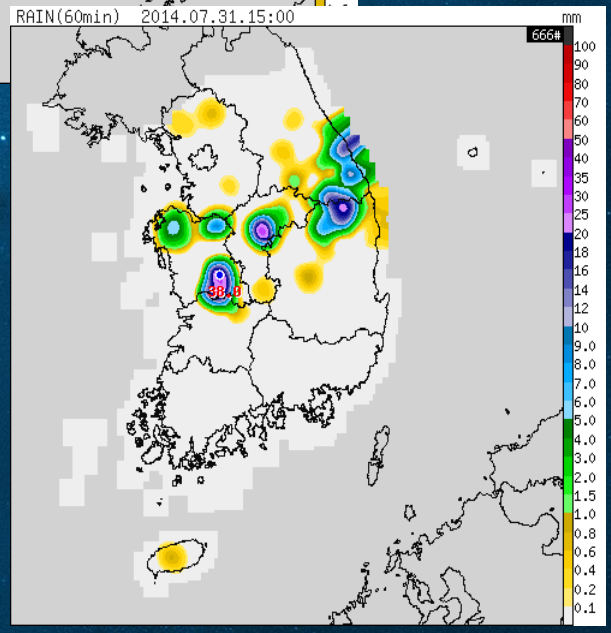


RGB Water Vapor & Cloud Product

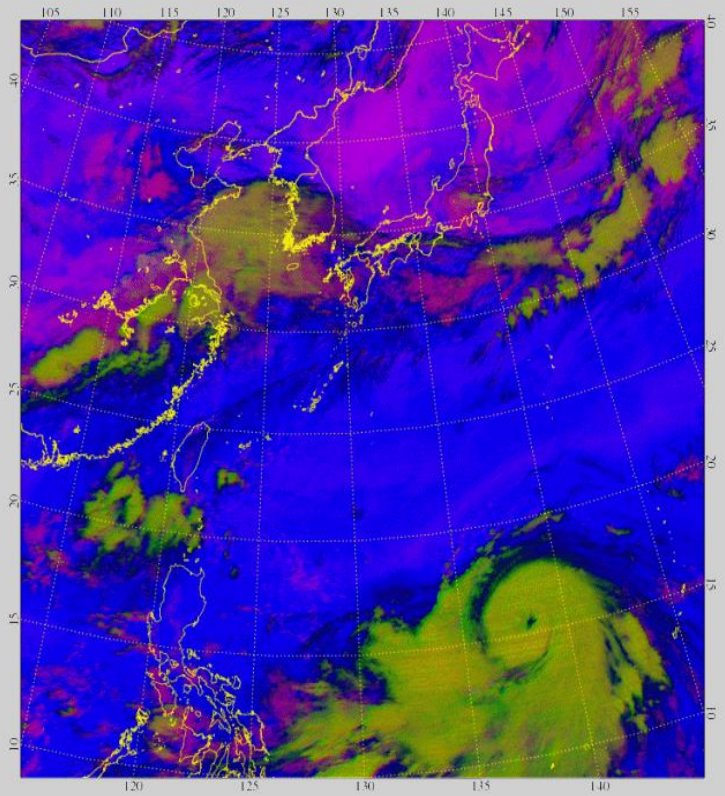


COMS RGB Product - Cloud & Water Vapor Analysis
2014.07.31, 00:45
Red : VIS(Day) or SWIR(Night)
Green : WV - IR1
Blue : IR1





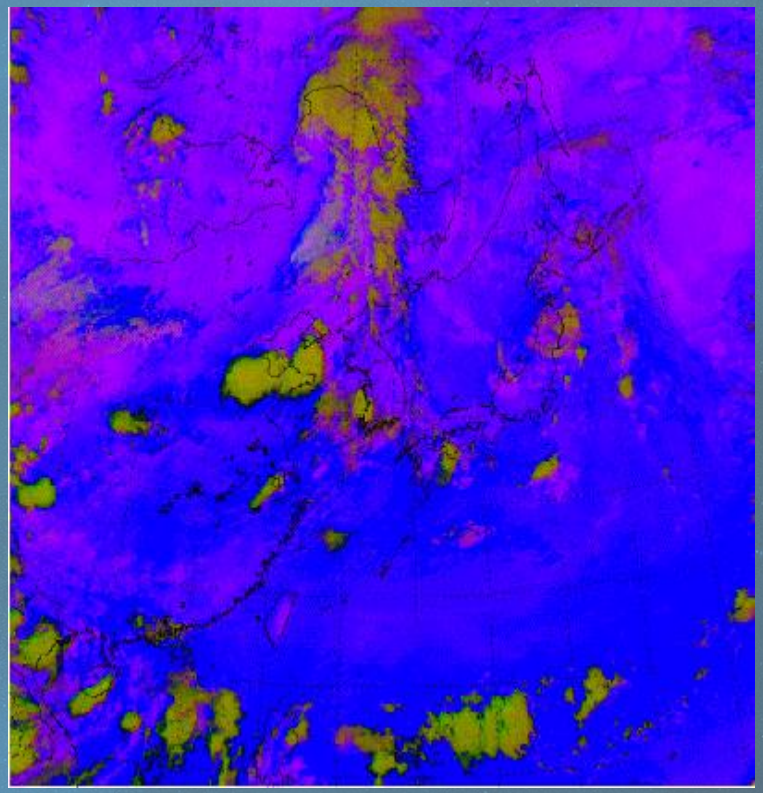
RGB Convective Cloud Product



COMS RGB Image (Convective Cloud)
2014.07.05.0000UTC

2014 8th Typhoon 'NEOGURI'

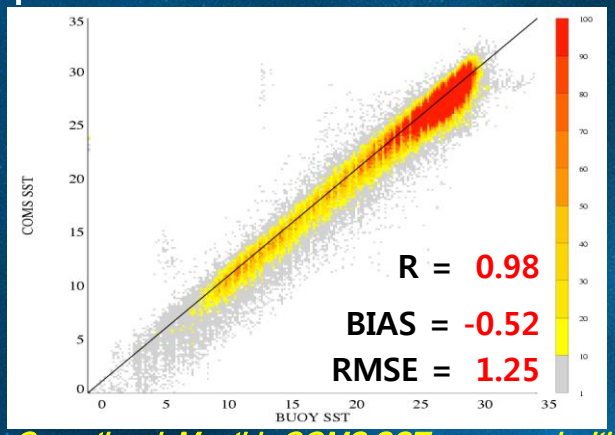
Color	Channel (㎛)	Threshold (K)
Red	IR12.0 – IR10.8	-4 ~ 2
Green	WV6.75 – IR10.8	-20 ~ 15
Blue	IR10.8	210 ~ 300



2013 Stationary rainy front
('Chang-Ma' in Korean)

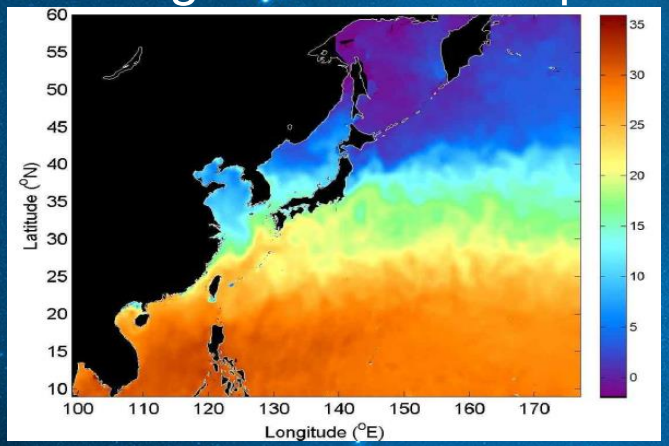
Sea Surface Temperature Composite

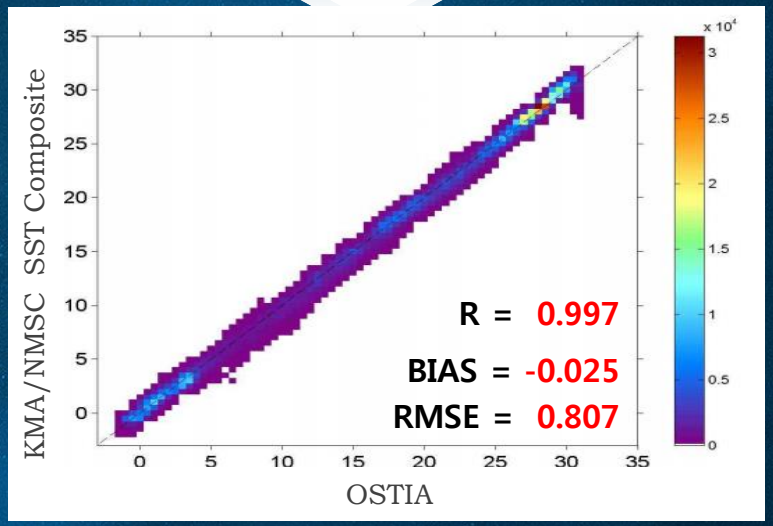
- Operational COMS SST



Operational Monthly COMS SST compared with buoy at April 2011 to January 2012(Unit: ℃)

- KMA Regional SST Composite



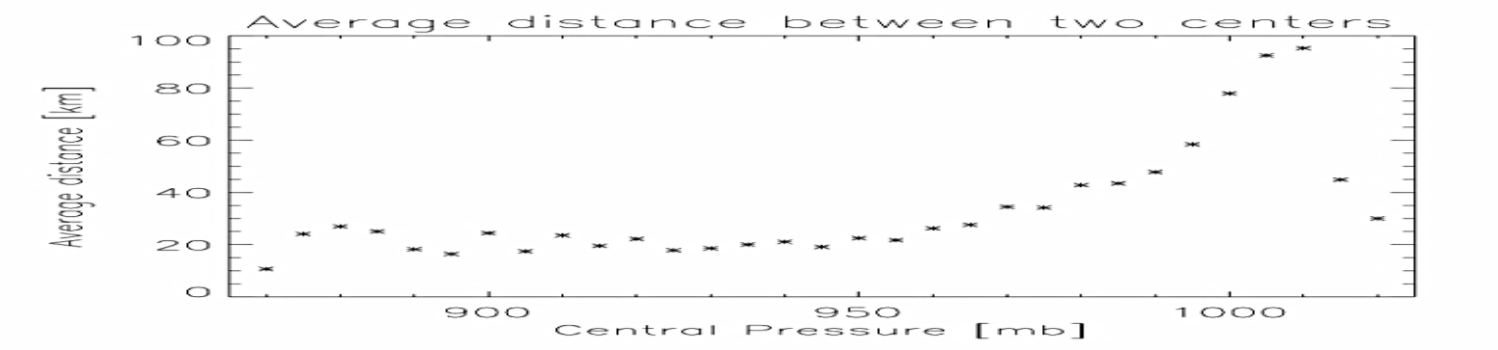


Composite SST validation results by KMA./NMSC SST compared with OSTIA at 13th May, 2013(Unit: ℃)

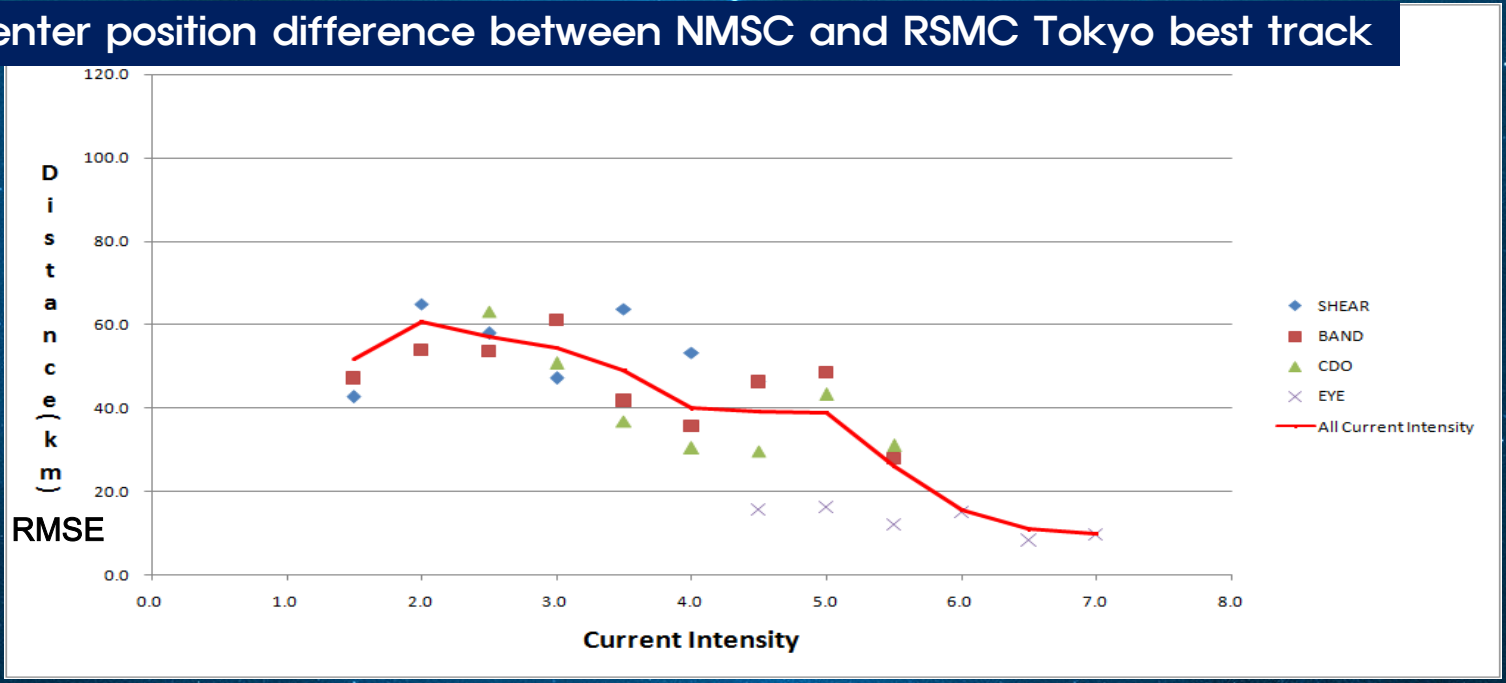
To improve surface condition on KMA's NWP Model(Plan)

Tropical Cyclone Analysis: Uncertainty estimation

Center position difference in the best tracks from RSMC Tokyo and JTWC

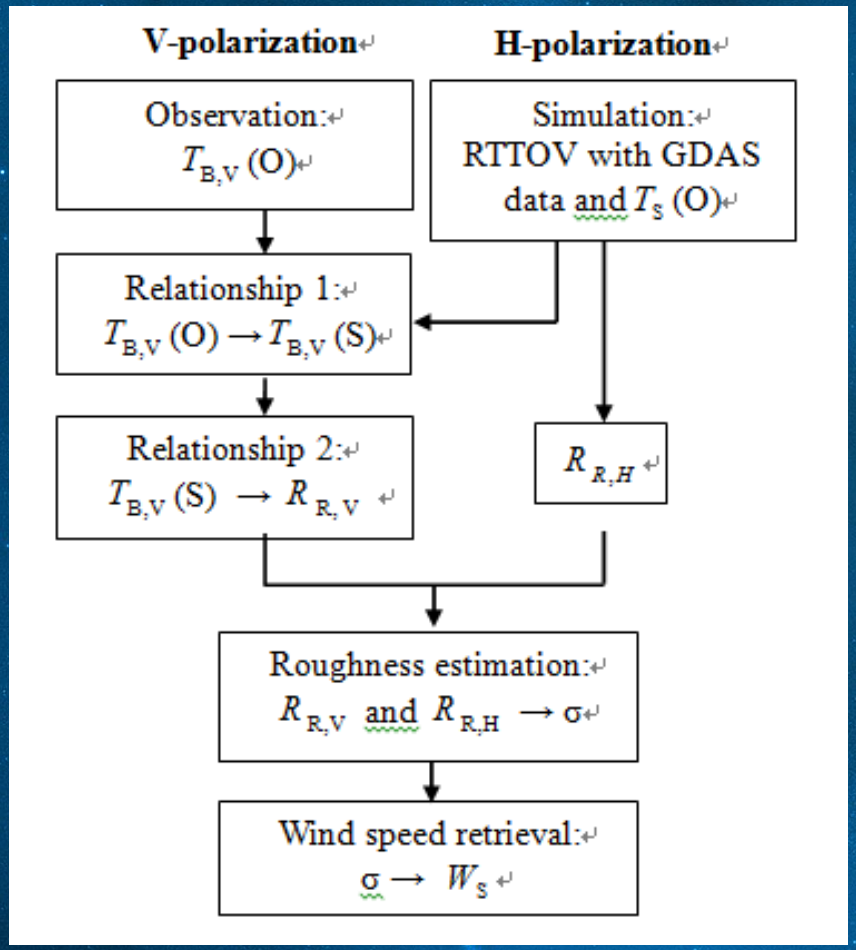


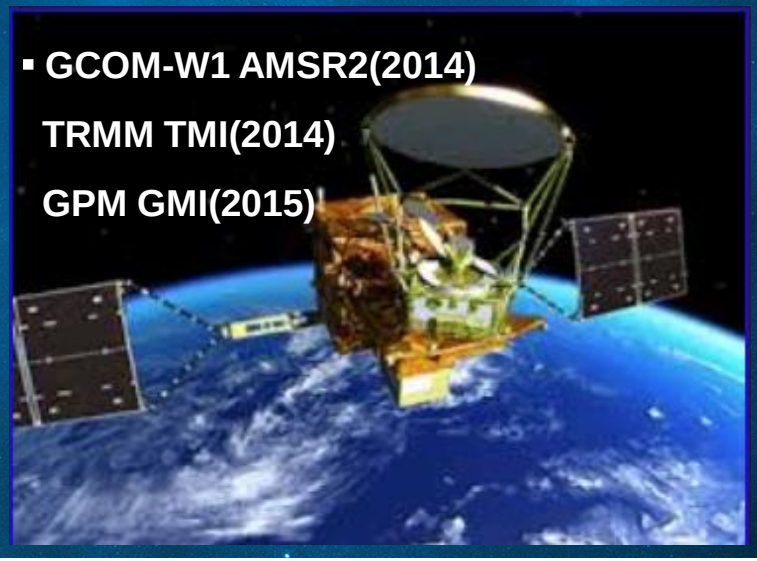
Center position difference between NMSC and RSMC Tokyo best track



Tropical Cyclone Analysis: Sea Surface Wind

Derivation of Sea Surface Wind from MW data regardless of rain condition

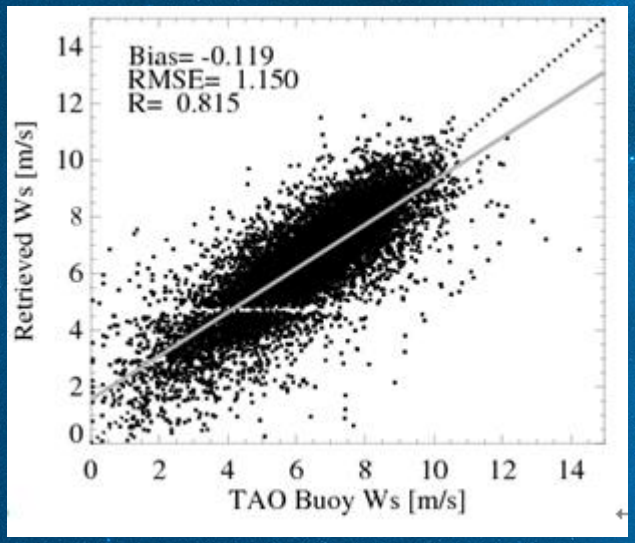




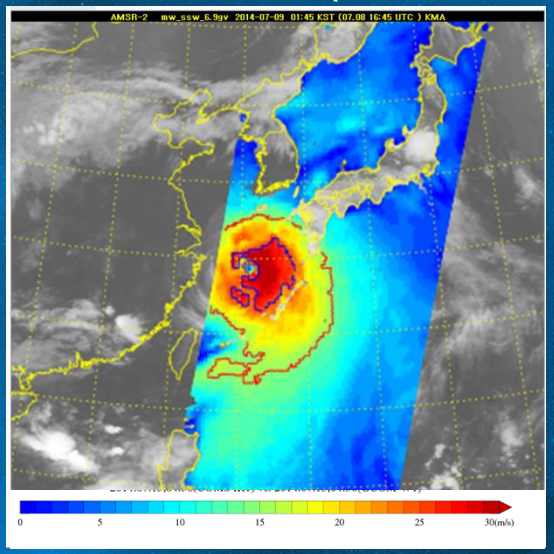
Band [GHz]	Polarization	Spatial Resolution (3-dB footprint size) [km x km]
6.93	V,H	62 x 35
7.3	V,H	62 x 35
10.65	V,H	42 x 24
18.7	V,H	22 x 14
23.8	V	19 x 11
36.5	V,H	12 x 7
89.0	V,H	5 x 3

Tropical Cyclone Analysis: Sea Surface Wind

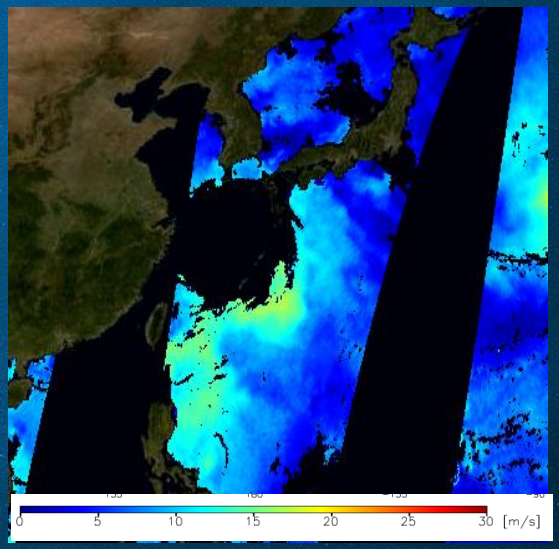
2014 8th Typhoon 'NEOGURI'
(2014. 07. 08. 16:45UTC)



Obs. Wind vs Retrieved Wind



Retrieved Wind from 6.9GHz

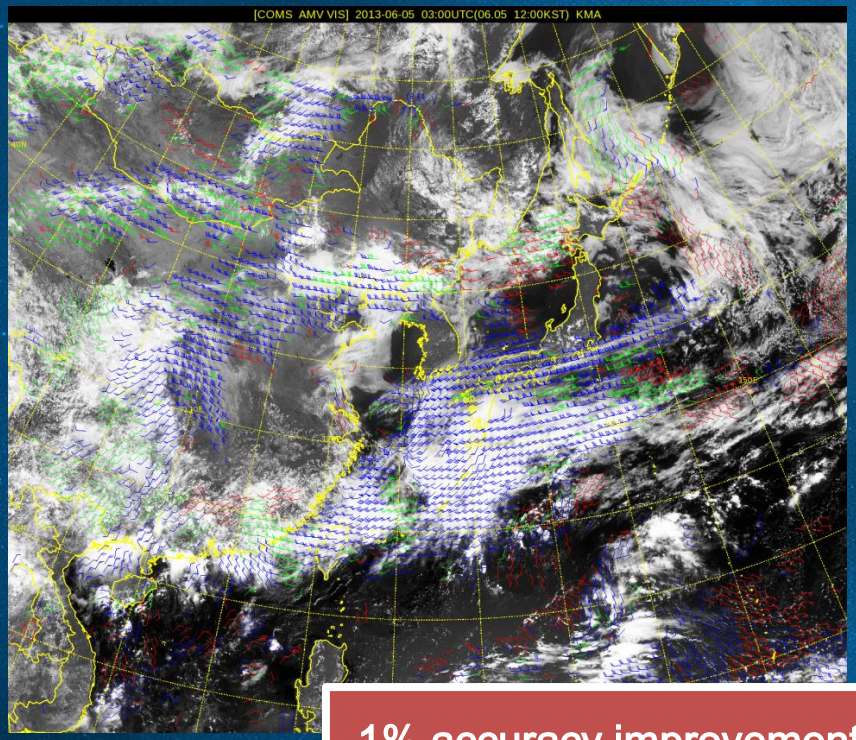


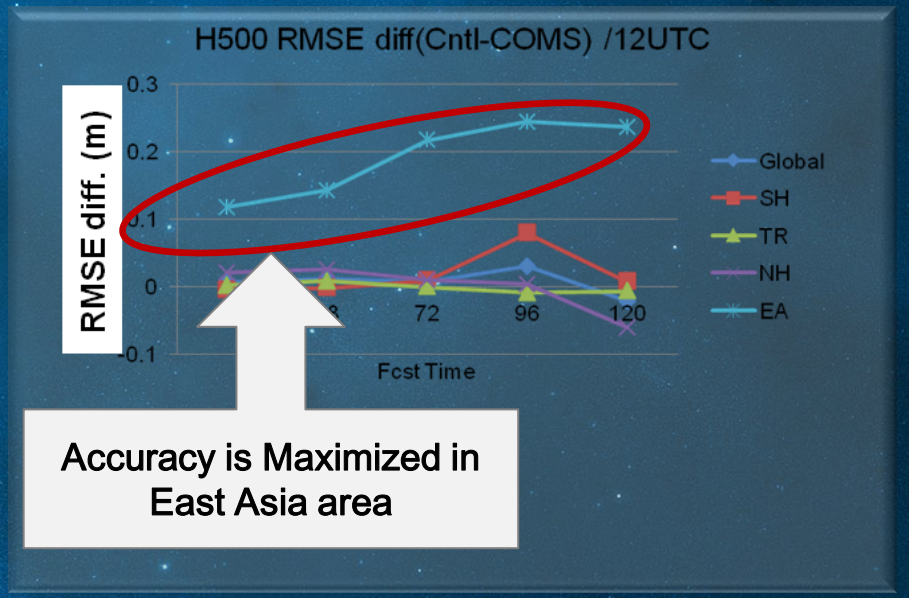
Retrieved Wind from 36.5GHz

NWP Support(1/3)

국가기상위성센터
National Meteorological Satellite Center

- Development of techniques for supporting NWP
  - COMS products quality management(AMV, sea ice, snow etc.)
  - NWP sensitivity test
  - Analysis of characteristic of satellite data utilized in NWP
  - Improving RTM simulation





1% accuracy improvement of NWP through COMS AMV assimilation

NWP Support(2/3)

국가기상위성센터
National Meteorological Satellite Center

KMA's Operational Data Assimilation of Sat. Data

Sensor or data	Satellite	Input Variable	Operational Model		
			Global	Regional	Local
ATOVS(MW_S) AMSU-A/B, MHS, HIRS	NOAA Metop-A/B	Temperature Humidity	○	○	
AIRS(IR_S)	Aqua	Temperature Humidity	○		
IASI(IR_S)	Metop-A/B	Temperature Humidity	○	○	
Satwind (AMV)	GEO 6(COMS) LEO 2	Wind(p)	○	○	
Satwind (Scatterometer)	METOP-A/B	Sea Surface Wind	○	○	○
GPS_RO	METOP-A/B COSMIC	Temperature	○	○	
CSR	COMS	Humidity	○		

NWP Support(3/3)

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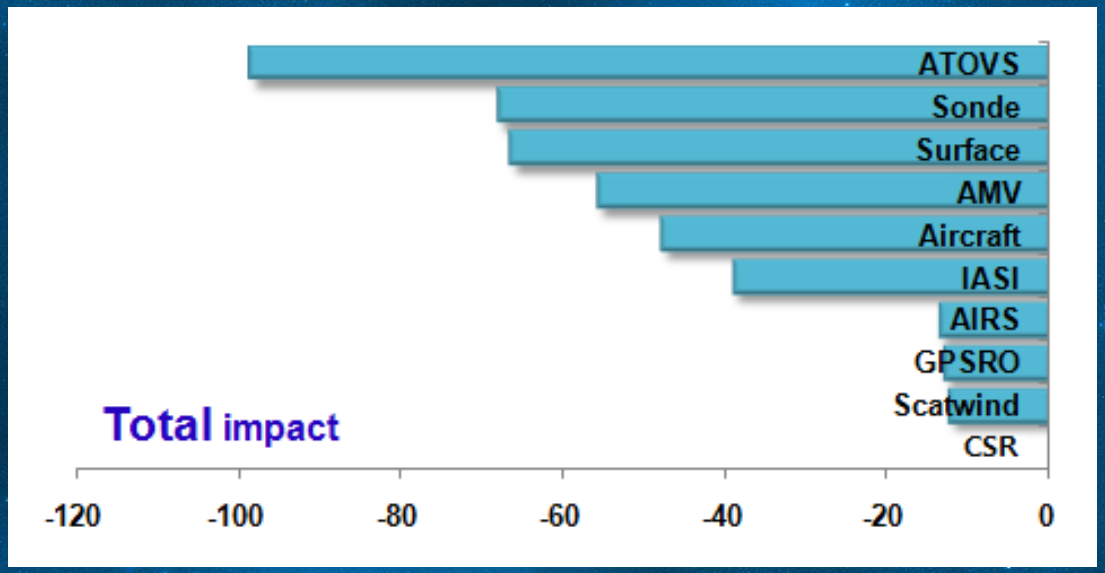
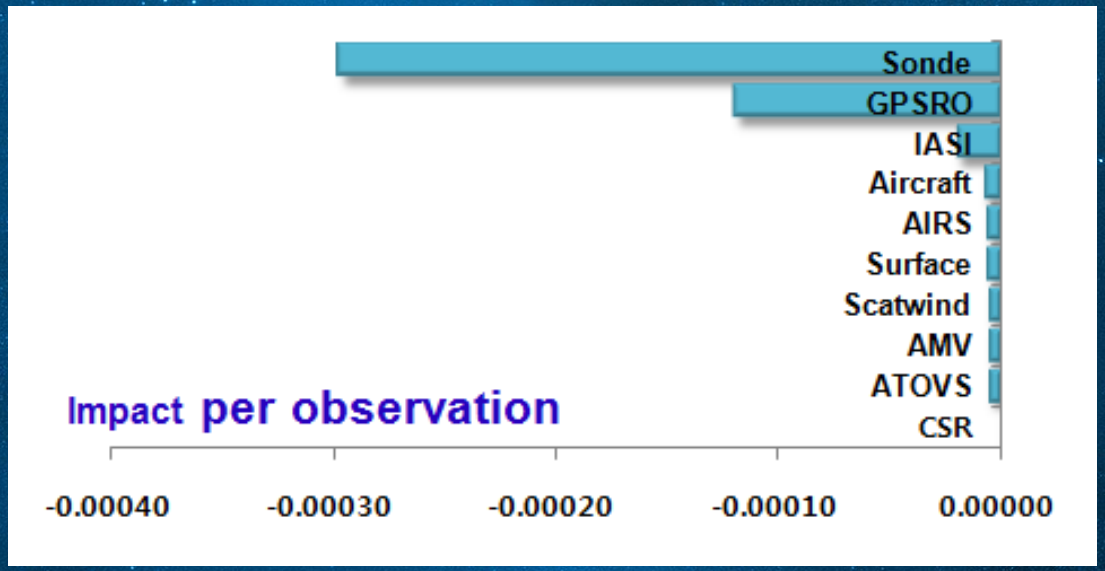
National Meteorological Satellite Center

Forecast Sensitivity to Observation





Aviation Met. Services

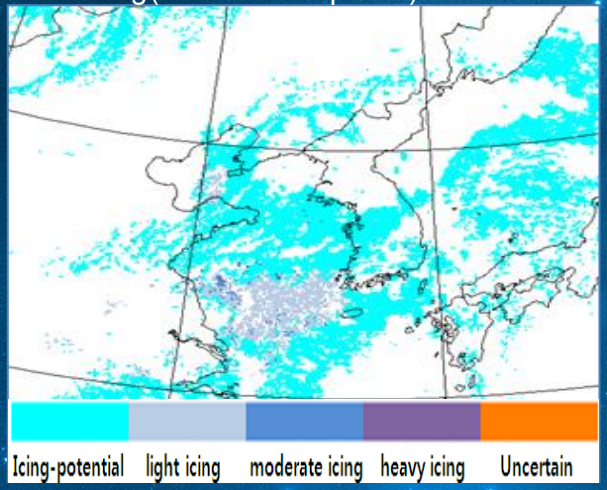
국가기상위성센터
National Meteorological Satellite Center

- Development of turbulence & icing area analysis based on COMS data
- Aviation meteorological information to KAMA

  - Turbulence, Flight Icing
  - Convective Initiation, Tracking of convective cloud
  - Asian dust storm, Volcanic Ash

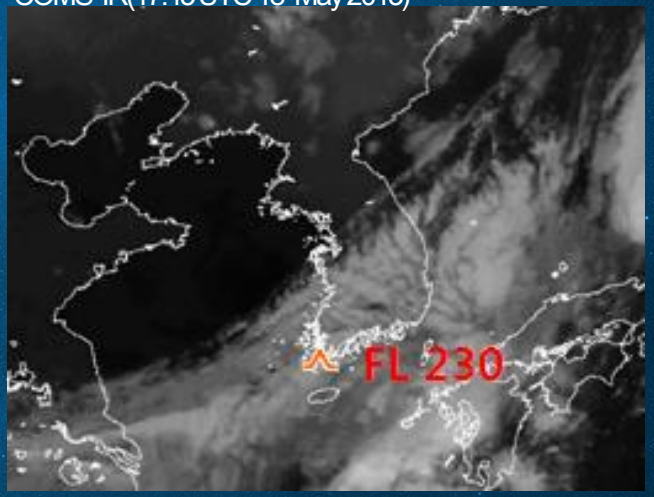
* Flight Icing

COMS Icing (19:45 UTC 2 Sep. 2013)



* Turbulence

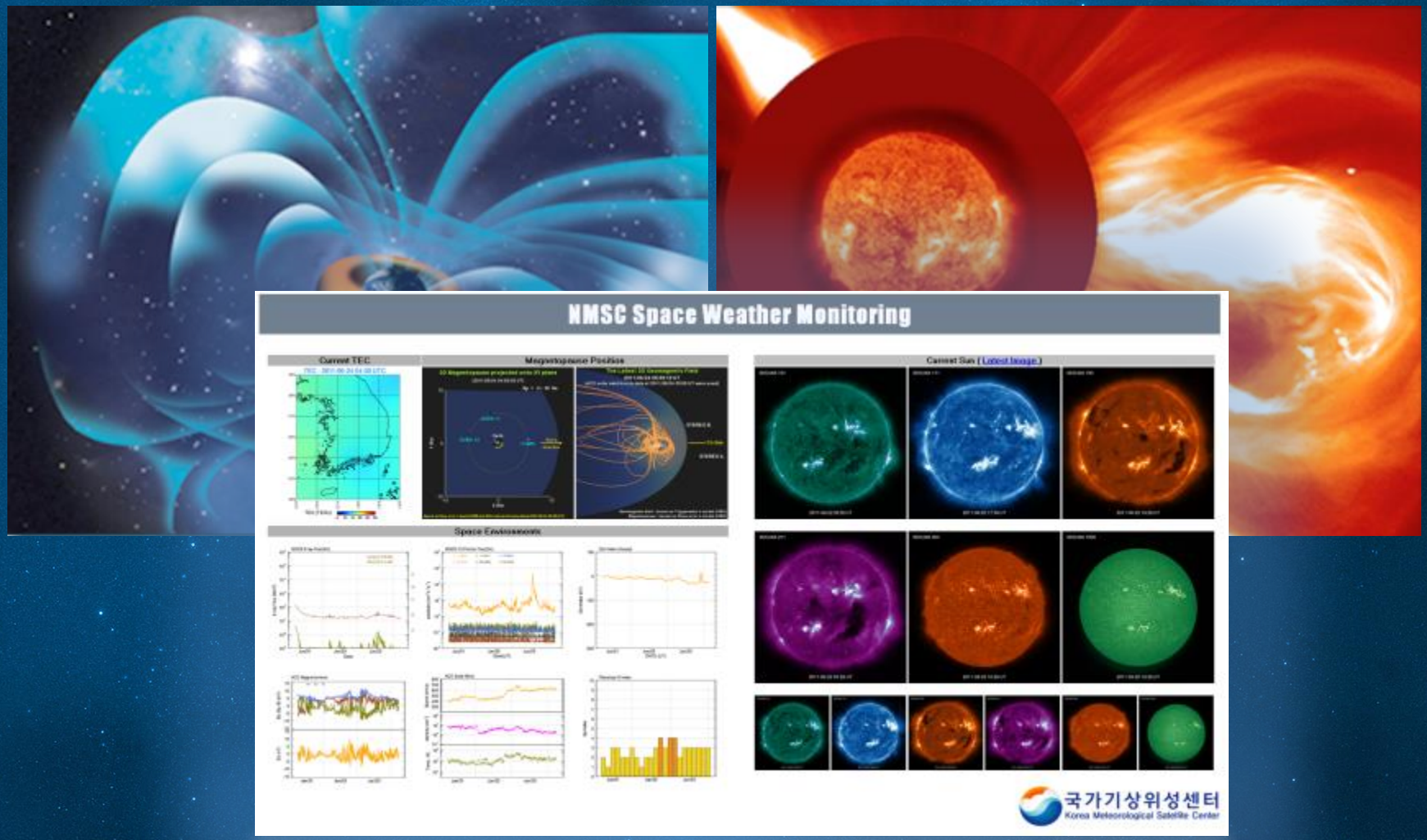
COMS IR(17:45 UTC 18 May 2013)



Space Weather Services

국가기상위성센터
National Meteorological Satellite Center

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



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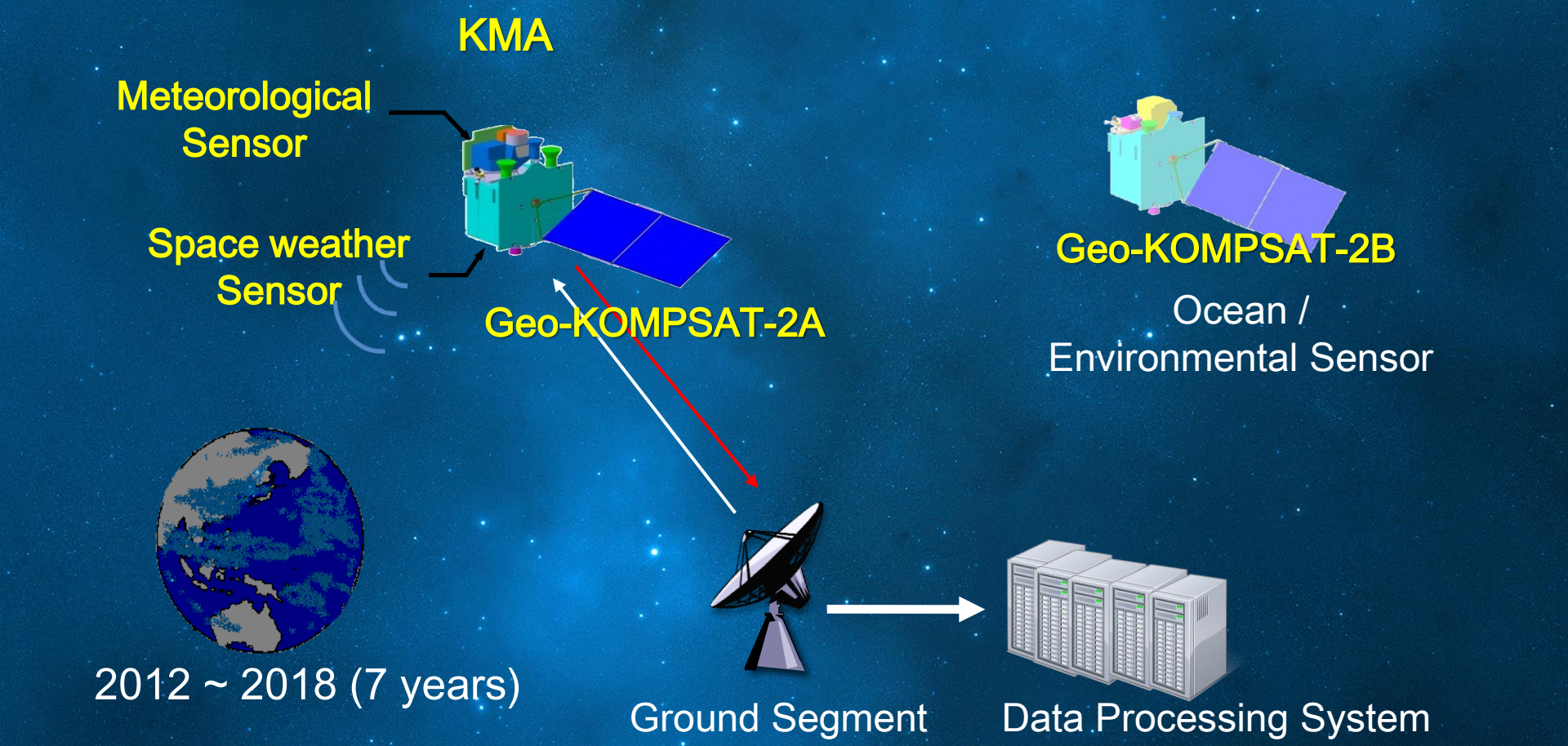
National Meteorological Satellite Center

Plan of Geo-KOMPSAT-2A

Geo-KOMPSAT-2 Program

국가기상위성센터
National Meteorological Satellite Center

→ 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)

국가기상위성센터
National Meteorological Satellite Center

- AMI(Advanced Meteorological Imager)
  - 16 spectral bands

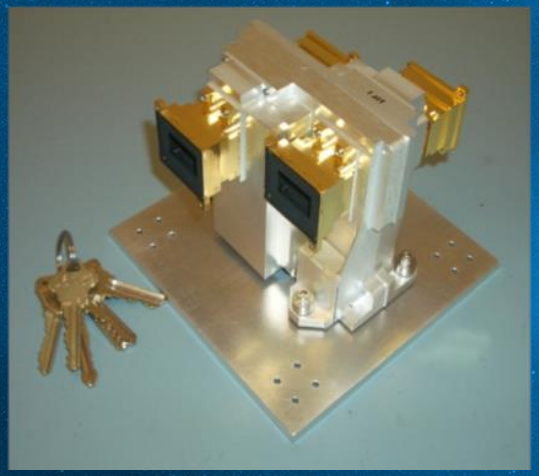
		Geo-KOMPSAT-2A AMI					COMS MI	
Channel	Band name	wavelength (μm)	resolution (km)	SNR	NEdT(K) (240/300K)	Radiometric Accuracy	Wavelength (μm)	Resolution (km)
1	VIS0.4	0.47	1	250		5%		
2	VIS0.5	0.51	1	250		5%		
3	VIS0.6	0.64	0.5	120		5%	0.675	1
4	VIS0.8	0.856	1	210		5%		
5	NIR1.3	1.378	2	300		5%		
6	NIR1.6	1.61	2	300		5%		
7	IR3.8	3.9	2		3/0.2	1K	3.75	4
8	IR6.3	6.185	2		0.4/0.1	1K		
9	IR6.9	6.95	2		0.37/0.1	1K	6.75	4
10	IR7.3	7.34	2		0.35/0.12	1K		
11	IR8.7	8.5	2		0.27/0.1	1K		
12	IR9.6	9.61	2		0.35/0.15	1K		
13	IR10.5	10.35	2		0.4/0.2	1K	10.8	4
14	IR11.2	11.2	2		0.19/0.1	1K		
15	IR12.3	12.3	2		0.35/0.2	1.1K	12.0	4
16	IR13.3	13.3	2		0.48/0.3	1.1K		

KSEM (Korean Space Environmental Monitor)

국가기상위성센터
National Meteorological Satellite Center

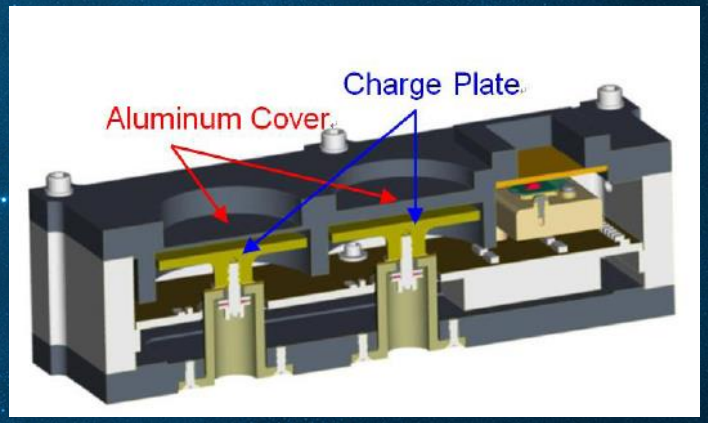
◆ KSEM specification

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)

국가기상위성센터
National Meteorological Satellite Center

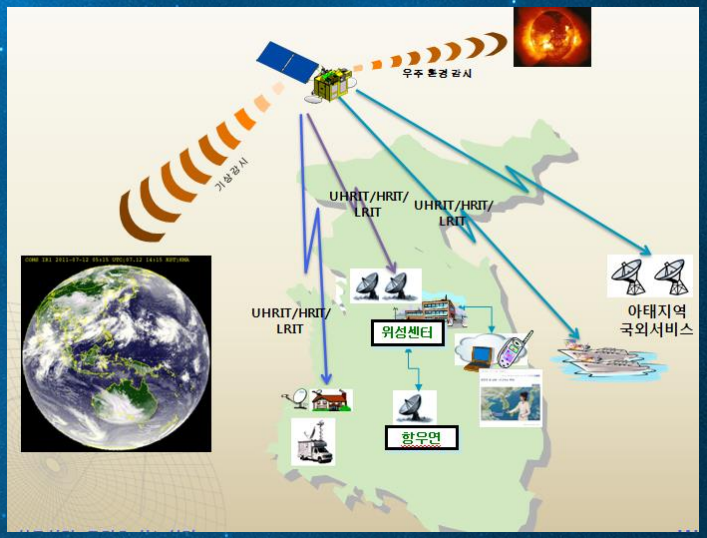
Development of GK-2A Ground Segment

Development of GK-2A Ground Segment

국가기상위성센터
National Meteorological Satellite Center

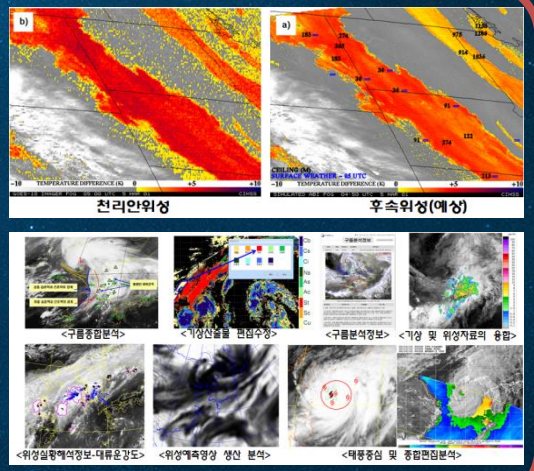
Outline

- Development of GeoKOMPSAT-2A ground segment
  - Develop Level 2 products algorithms
  - Develop integrated analysis and application facilities
  - Develop meteorological/space weather data processing system
  - Establish satellite control system
  - Develop data management and service system
  - Integration test & normal operation preparation
- Period : 2014 ~ 2019 (6yrs)



Mission

- Enhancing forecast/climate monitoring based on high resolution measurements
- Generation of the baseline meteorological products , and application to hydrology, agriculture, disaster mitigation etc.
- Dissemination of GK-2A data via satellite broadcast system, LRIT/HRIT/UHRIT
- Supporting satellite operation with space weather monitoring



Development of Meteorological Products(1/2)

국가기상위성센터
National Meteorological Satellite Center

- KMA/NMSC has started to develop algorithms of fifty-two meteorological products for applying 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
  - Development "algorithm test-bed" to optimize scientific algorithm to operation system
  - Introduction of "optimal estimation" for consistency within cloud products "Discriminate clouds optical properties" to increase of products accuracy
  - Utilize "machine learning" to improve some product data accuracy

See the Poster # 3.42

Development of Meteorological Products(2/2)

국가기상위성센터
National Meteorological Satellite Center

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)	

Development of Integrated Analysis & Application Facilities

Forecast support(21)		Analysis support(19)	
Typhoon	Center position	**Conceptual model**	Objective analysis
	Intensity & Central pressure		Objective prediction
	Max. wind speed & Radius of 15m/s WS		Real-time analysis of severe weather
	Development & Weakening condition		Typhoon conceptual model
	Trajectory & Prediction		'JANGMA' conceptual model
Nowcasting	Cloud analysis	**Surface & Environmental Analysis**	Wildfires analysis
	Precipitation analysis		Drought analysis
	Yellow dust analysis		Flood analysis
	Convective cloud analysis		Heavy snow analysis
	Severe weather analysis		Aerosol analysis
Aviation	Air-route cloud analysis		Smog analysis
	Turbulence analysis		Fog analysis
	Aircraft icing analysis	**Statistical Analysis**	Time series analysis
	Volcanic Ash analysis		Spatial analysis
Marine Weather	SST analysis		Down-scaling analysis
	Ocean current analysis		Sat. Data composition & analysis
	Sea fog analysis		Composition into uniform space-time grid
	Sea ice analysis		Data quality analysis
Numerical Weather Prediction	Predicted image products		Data monitoring tech.
	Error analysis of NWP input data		
	Forecast Sensitivity Test		

COMS MI vs. GEO-KOMPSAT-2A AMI

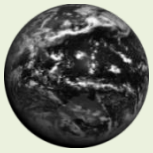
국가기상위성센터 National Meteorological Satellite Center

4 times spatial resolution

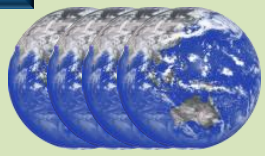
COMS	Geo-KOMPSAT-2A
VI 1km	VI 0.5~1km
IR 4km	IR 2km

4 times temporal resolution

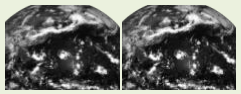
1 Hr



1 FD

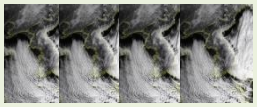


4 FD



2 NH

10 NH

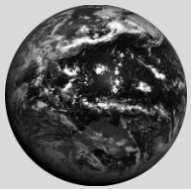


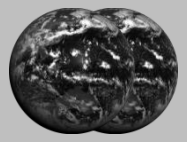
4 Korea

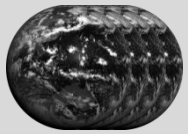
Every 2 min Korea

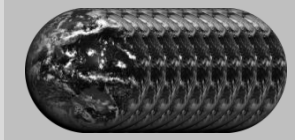
3 times number of channels

	COMS	Geo-KOMPSAT-2A
VI	1 channel (achromatic)	4 channels (color)
NIR	O	2 channels
IR	4 channels	10 channels
	5 channels	16 channels



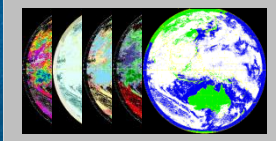


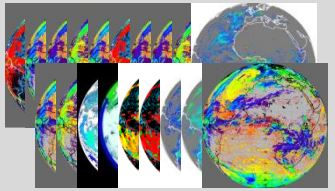


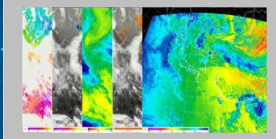


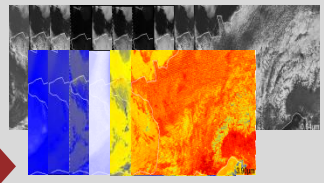
3.5 times number of products

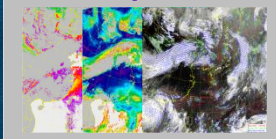
COMS	Geo-KOMPSAT-2A
Cloud/Precipitation (5→19)	
Radiation/aerosol (5→16)	
Atmospheric Motion/Conditions(3→6)	
Surface information(3→11)	
16 products	52 products

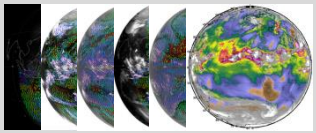


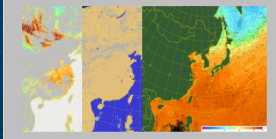


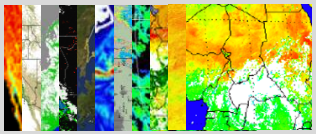












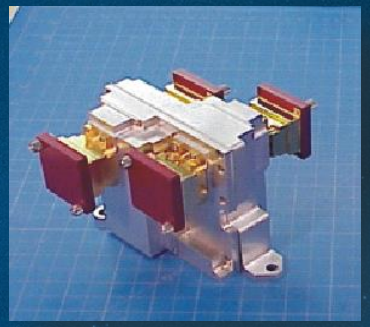
Development of space weather products

국가기상위성센터
National Meteorological Satellite Center

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

Measurement of electron on mid energy range and magnetic field

Support for stable operation of GEO-KOMPSAT-2A

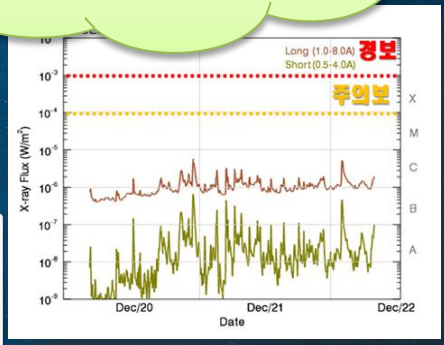


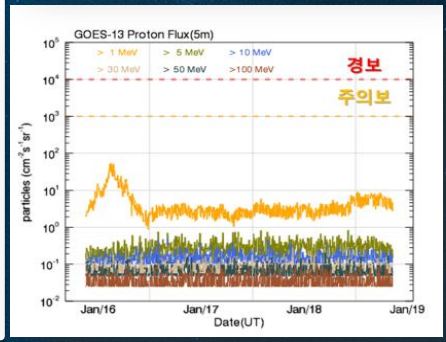
Data

- 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)





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

국가기상위성센터
National Meteorological Satellite Center

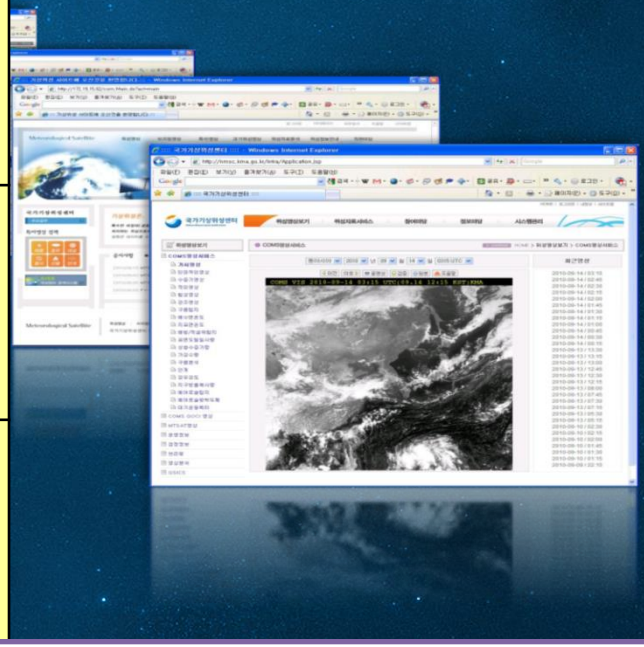
- **Broadcast all 16 channels data in UHRIT**
- **Maintain L/HRIT broadcast** corresponding to COMS five channels
  - Develop the functions to generate COMS-like L/HRIT image data from GK-2A obs.
  - KMA will support technical issues on receiving GK-2A L/HRIT for COMS S/MDUS
- **GOCI-II** on GK-2B data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

	GK-2A (TBD)	COMS -> GK-2A	
	Ultra HRIT	HRIT	LRIT
Data Rate	≤ 31 Mbps	3 Mbps	~512 Kbps
Data Type	To Be Determined	Image (VIS, IR1, IR2, SWIR, WV) Alpha-numeric text Encryption Key Message	Image (VIS, IR1, IR2, SWIR, WV) Alpha-numeric text Encryption Key Message Level 2 Data (Cloud Info.) GOCI Image file
Mode		FD, ENH	FD, ENH
User		MDUS	SDUS

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

- Currently, NMSC provides COMS level 1B data of all five channels and level 2 products to users by posting the processed data on NMSC website (membership is needed)
- **Upgraded & user-friendly web-based system will be established for GK-2A data service**

Products	Resolution	Period	Start Date of Service
Cloud analysis (cloud type, phase and am ount)	4 km	15 min.	1 Apr. 2011
Cloud top pressure/temperature/height (CTP/CTT/CTH)	4 km	15 min.	
Atmospheric Motion Vector (AMV)	64 km	1 hour	
Cloud detection (CD)	4 km	15 min.	
Fog (FOG)	4 km	15 min.	
Aerosol index (AI)	4 km	15 min.	
Sea surface temperature (SST)	4 km	1-, 5-, 10-day composition	10 Aug. 2011
Rain intensity (RI)	4 km	15 min.	
Outgoing longwave radiation (OLR)	4 km	1 day	
Upper tropospheric humidity (UTH)	36 km	15 min.	
Land Surface Temperature(LST)	4 km	15 min.	10 Feb. 2012
Snow and Sea Ice (SSI)	4 km	1 day/8 day	
Total Precipitation (TP)	4 km	15 min.	
Clear Sky Radiance (CSR)	28 km	15 min.	



http://nmsc.kma.go.kr/jsp/eng/contents/main/main.jsp

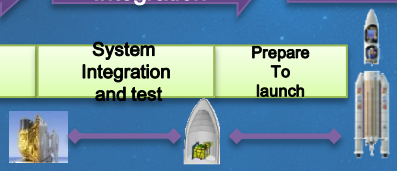
Milestone for the Geo-KOMPSAT-2A

국가기상위성센터
National Meteorological Satellite Center

PAYLOAD AND SATELLITE

Satellite bus design and Review → Integrate Module → Satellite system integration → Launch/IOT/Operation

Analysis of system requirements | Preliminary design | Critical design | Instrument Integration and test | System Integration and test | Prepare To launch | launch / IOT | Satellite operation



Start | SRR | PDR | EQSR /CDR | TRR | Environmental Test | Delivery | Launch

2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Operation/utilization /service

GROUND SYSTEM

Preliminary design | Critical design | Implementation /verification | Integration test /idealization | IOT /Supporting operation

DATA RECEIVING AND PROCESSING SYSTEM

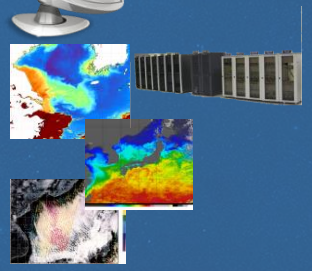
System requirements /Standards creation | Preliminary design | Critical design | System implementation | Install /Testing | Training operator | Launch | Supporting operation

SATELLITE CONTROL SYSTEM

Review and analysis of requirements/standards/design | Selection of TTC and RF production companies | Integration and install TTC system | Install control S/W and interface testing | Training operator | Test operation and verification

DATA PROCESSING SYSTEM

2014 Algorithm development I | 2015 Algorithm development II | 2016 Algorithm Development III | 2017 System construction SW optimization | 2018 Operational test and verification



DATA MANAGEMENT AND SERVICE SYSTEM

2014: Analysis of user requirements; Set up system requirements; Preliminary/critical design

2015 ~ 2016: Develop system; Verify system

2017 ~ 2018: -Operational test and complement

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National Meteorological Satellite Center

Plan for LEO Satellite

National Space Development Plan

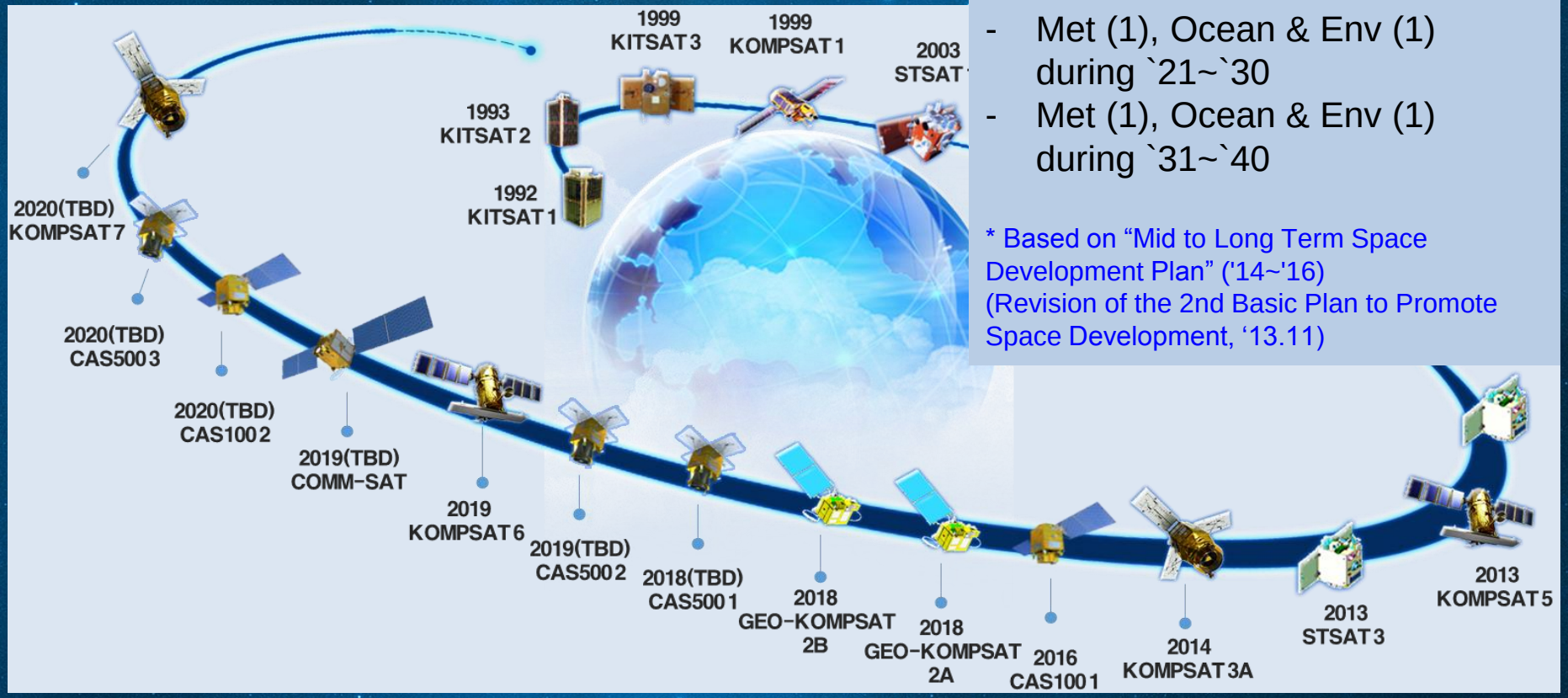
국가기상위성센터
National Meteorological Satellite Center

- Develop Earth observation KOMPSAT satellites, standa
  next generation medium satellites, and space science·
  generation small satellites
- Develop MEO and GEO satellites for meteorology, oce
  communications, early warning·augmented navigation,
  applications

LEO (~500kg)
- MW (3), hyperspectral (3), SAR (8) during `21~`30
- MW (16), hyperspectral (4), SAR(12) during `31~`40

GEO
- Met (1), Ocean & Env (1) during `21~`30
- Met (1), Ocean & Env (1) during `31~`40

* Based on “Mid to Long Term Space Development Plan” (‘14~’16)
(Revision of the 2nd Basic Plan to Promote Space Development, ‘13.11)



LEO Meteorological Satellite(Background)

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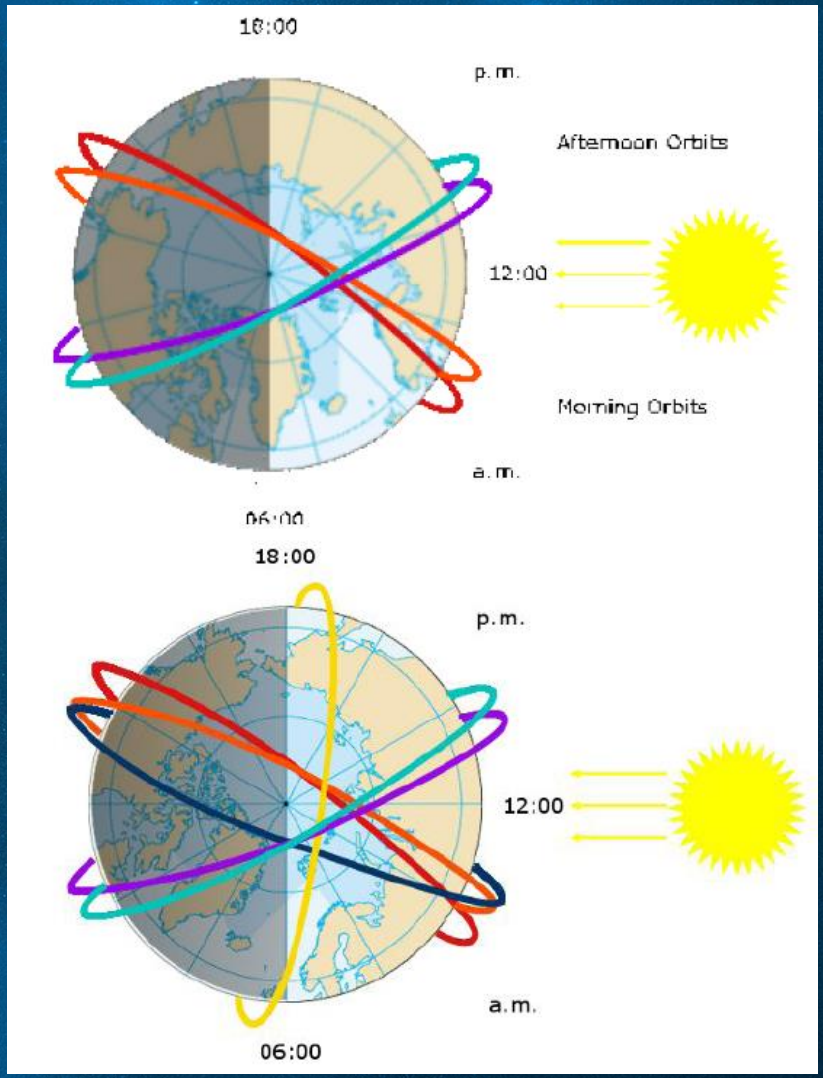
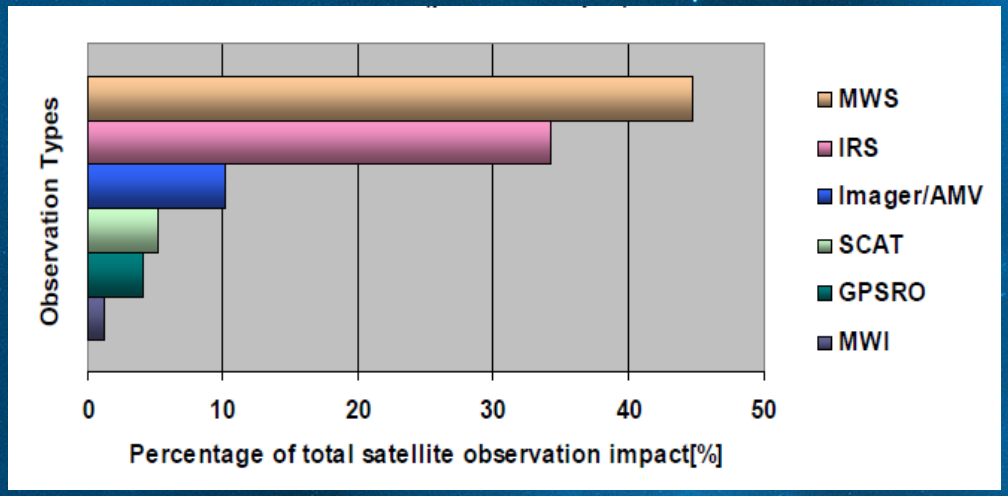
National Meteorological Satellite Center

- The new baseline for the core LEO constellation is to be deployed over three orbital planes around 13:30, 17:30 and 21:30 Equatorial Crossing Time (ECT) in Local Solar Time (LST).
- This should ensure regular sampling of the atmosphere avoiding too large a temporal gap around dawn and dusk, in order to satisfy as far as possible the observing cycle requirements from NWP and climate monitoring for atmospheric temperature and humidity profiles. In addition, in-orbit redundancy should be available around these orbital planes, to the extent possible.

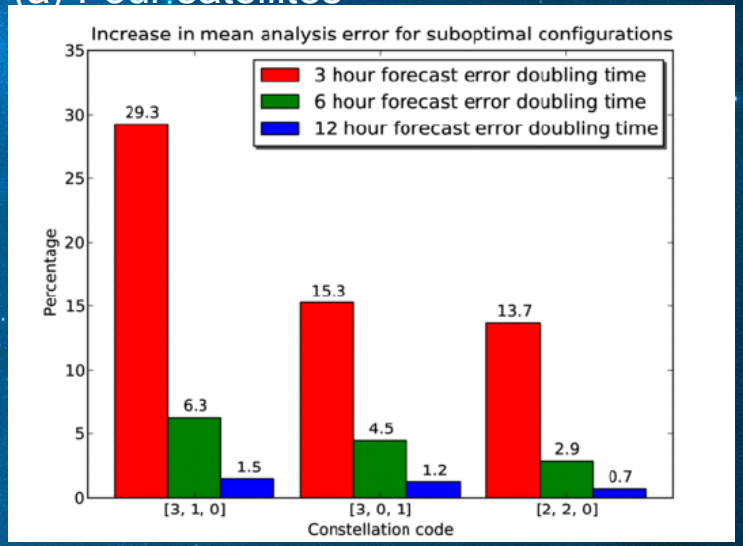


LEO Meteorological Satellite(Background)

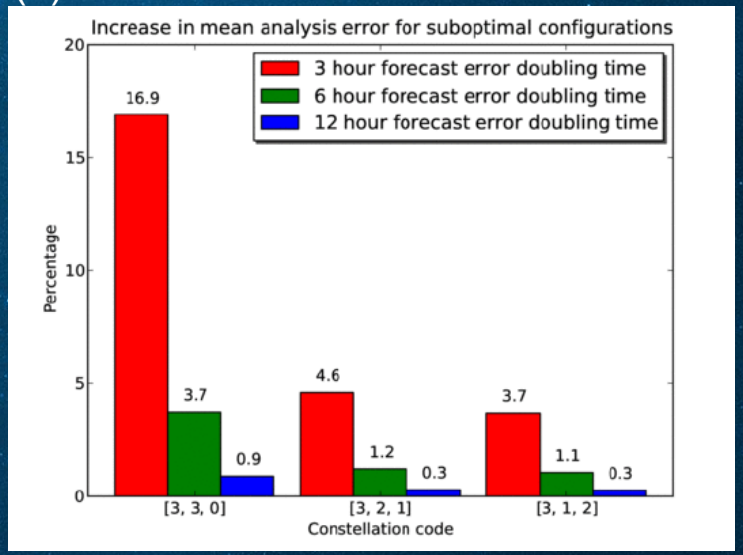


- Large impact of MW sounder(45%) and IR sounder(34%) *[MetOffice, 2012]*
- With four and six satellite with three different orbits [mid-morning, afternoon, early morning] orbit:
- Uniform distribution among three orbits including early morning orbit → minimum error

(a) Four satellites



(b) Six satellites



# of satellite [Mor, Aft, Early Morning orbit]

LEO Meteorological Satellite

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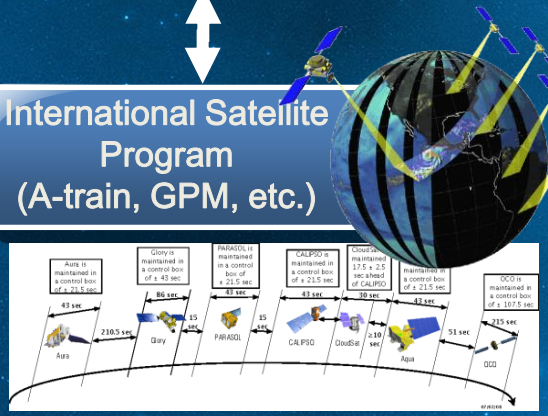
LEO satellite operation

Observation in all-weather conditions

International Satellite Program (A-train, GPM, etc.)

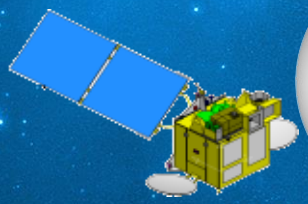


Generating numerical model input data
(Cloud, land surface, Ocean, Construction of Atmosphere data)

Monitoring climate change factor
(sea ice, stratospheric and tropospheric temperature, water cycle factor)

Standard observation of weather factor
(heavy rain, typhoon precipitation, snow cover, strong wind)

- Improve weather forecast accuracy
- Standard monitoring of severe weather
- Water control for preparing disaster
- Understanding climate change
- Managing future water resources
- Preparing future climate
- Advanced country of weather observation-contribution to international society, improving global positioning



GK-2A + LEO satellite joint operation system

Mutual complement
Synergy effect

LEO Satellite development plan

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National Meteorological Satellite Center

Plan research 2015

- **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

Secure a budget 2016

- **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 micro MW sounder

Satellite development 2017-

- **Development of the LEO satellite**
  - Kick-off development of LEO satellite program
  - Satellite bus, system
  - Ground segments dev

Launch /Utilization 2022-

- **Application**
  - Apply to weath
  - Data utilization
  - Supply standar

- Development period (plan) : ~ 2022 (or earlier)
- Altitude / orbit : 500~900 km / Sun-synchronous & Early Morning Orbit (TBD)
- Satellite (with platform and payload) : ~500kg, Instrument : ~150kg
- Instrument : MW Imager or Sounder, IR Sounder/ RO, space weather monitor
  - ATMS, CrIS-like, GMI-like (new instruments), AMSU, SSMI
- Sensor Technology
  - International technology cooperation or joint development

Thank You !