

Status report on the current and future satellite systems by KMA

Presented to CGMS-44 plenary session, agenda item [D]

Current Geo-Satellite : COMS

◆ COMS(Communication, Ocean, and Meteorological Satellite)

- Orbit : 128.2E (Launched on June 26, 2010)
- **MI : 5 Channel VIS/IR Meteorological Imager**
 - MI data Service via Satellite : Broadcast to M/SDUSs with H/LRIT
 - 16 products(CMW, Fog, AOD, cloud amount, Convective rainfall rate....)
 - Service via Landline [Website] KMA/NMSC homepage(for registered users)
[FTP] Access to NMSC FTP(for organization with MOU)
- **GOCI : Geostationary Ocean Color Imager**
 - 0.5km X 0.5km(ground sampling distance) with 1hr (8 times/day)
 - L1B RGB, Chlorophyll, Colored dissolved organic matter, Suspended solid
 - <http://kosc.kordi.re.kr/processingsoftware/gdaps/onlinehelp.kosc>
 - <http://map.naver.com> (for Public user)

Low Earth Orbit Satellites : Current

- **KOMPSAT-5(Aug. 22, 2013)** with 550km mean altitude and 97.6 deg inclination

Payload	Characteristics
COSI (primary)	<ul style="list-style-type: none">• SAR (Synthetic Aperture Radar)• X-band Radar with an active phased array antenna
AOPOD (secondary)	<ul style="list-style-type: none">• Dual frequency GPS receiver (GNSS-RO data)<ul style="list-style-type: none">– IGOR : Integrated GPS Occultation Receiver

- COSI : Corea SAR instrument, AOPOD: Atmosphere Occultation and Precision Orbit Determination
- GNSS-RO data is validated for operational use by KASI cooperating with UCAR and will be distributed regularly via internet in late 2015

- **KOMPSAT-3A(March 26, 2015)**

- ✓ Developed by Korea Aerospace Research Institute(KARI)
 - ✓ Purpose: earth observation(Optical +IR)
 - ✓ Resolution: Panchromatic: 0.55m, RGB: 2.2m, IR: 5.5m
 - ✓ Swath width: 12.0km, Altitude: 528km

Meteorological and Environmental Geo-Satellites : Future

Sector	Satellite in Orbit	Operator	Location	Launch date	Environmental payload and status
West Pacific	GEO-KOMPSAT-2A	KMA	128.2°E	May 2018	Advanced Meteorological Imager (AMI), Space Environmental monitoring payload Direct broadcast via UHRIT/HRIT/LRIT
	GEO-KOMPSAT-2B	MOF(Ministry of Ocean and Fisheries), ME(Ministry of Environment)	128.2°E	March 2019	Advanced Geostationary Ocean Colour Imager(GOCI-II), Geostationary Environmental Monitoring Spectrometer(GEMS)

- **GEO-KOMPSAT-2A, AMI(Advanced Meteorological Imager)**
 - Multi-channel capacity: 16 channels
 - Temporal resolution: within 10 minutes for Full Disk observation
 - Flexibility for the regional area selection and scheduling
 - Lifetime of meteorological mission: 10 years

GEO-KOMPSAT-2A, AMI(Advanced Meteorological Imager)

Bands	Center Wavelength		Band Width (Max, um)	Resolution (km)	GOES-R (ABI)	Himawari-8 (AHI)	
	Min(um)	Max(um)					
VNIR	VIS0.4	0.431	0.479	0.075	1	0.47	0.46
	VIS0.5	0.5025	0.5175	0.0625	1		0.51
	VIS0.6	0.625	0.66	0.125	0.5	0.64	0.64
	VIS0.8	0.8495	0.8705	0.0875	1	0.865	0.86
	NIR1.3	1.373	1.383	0.03	2	1.378	
	NIR1.6	1.601	1.619	0.075	2	1.61	1.6
	NIR2.2				2	3.35	2.3
MWIR	IR3.8	3.74	3.96	0.5	2	3.90	3.9
	IR6.3	6.061	6.425	1.038	2	6.185	6.2
	IR6.9	6.89	7.01	0.5	2	6.95	7.0
	IR7.3	7.258	7.433	0.688	2	7.34	7.3
	IR8.7	8.44	8.76	0.5	2	8.50	8.6
LWIR	IR9.6	9.543	9.717	0.475	2	9.61	9.6
	IR10.5	10.25	10.61	0.875	2	10.35	10.4
	IR11.2	11.08	11.32	1.0	2	11.2	11.2
	IR12.3	12.15	12.45	1.25	2	12.3	12.3
	IR13.3	13.21	13.39	0.75	2	13.3	13.3

vs. AHI

- addition 1.38 μm (NIR)
- subtraction 2.3 μm (NIR)

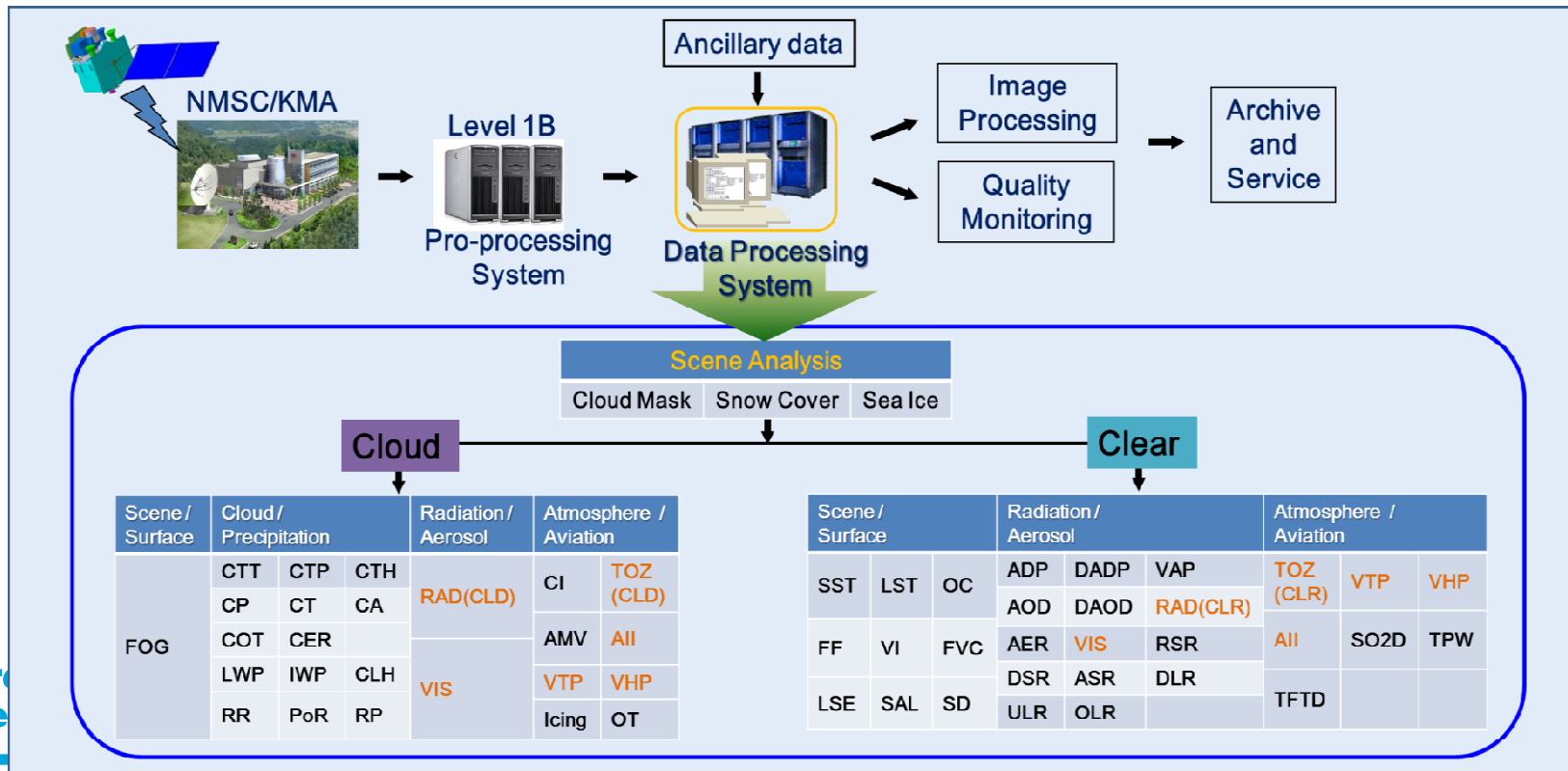
1.38 μm : favorable for cirrus cloud detection, cloud type and amount

2.3 μm : favorable for Land/cloud Properties

- Temporal resolution: within 10 minutes for Full Disk observation
- Flexibility for the regional area selection and scheduling
- Direct broadcast via UHRIT/HRIT/LRIT

GEO-KOMPSAT-2A : 52 Base-line Meteorological Products

- The algorithm prototype of products will be developed by 4 science groups until April, 2017
 - scene and sfc / cloud and precipitation / radiation and aerosol / atmosphere and aviation
 - 16 Korean Prof and 50 developers
 - Optimization of developed programs will be performed until 2018
 - Developed algorithms are strongly recommended to be published SCI and Documents
- MODIS, SEVERI, COMS, and AHI data are used as proxies to evaluate each algorithm



GEO-KOMPSAT-2A: Detailed 52 meteorological products

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)	

Coordination Group for

* Blue: Primary Products

Application Projects using Satellite products(2015~2019)

- To be designed to maximize the utilization of the satellite products for forecasters and NWP
- Recommended using GK-2A and the other satellite data, if necessary NWP and the other ground observation

Areas	Contents	
Nowcasting	<ul style="list-style-type: none"> • Cloud analysis • Heavy rainfall and snowfall analysis • QPF 	
Typhoon & Ocean	Typhoon analysis system based on Satellite SST, red tide, freezing over the ocean 3D Winds analysis	
NWP	Satellite data preprocess for NWP assimilation	
Hydrology & SFC & Verification	Soil moisture, Drought and Floods, Fire Fine Dust analysis Verification, grid and image composite technique	
Climate & Environmental Monitoring	Aerosol concentration, height, vertical distribution Greenhouse gases, atmospheric composition Energy budget, Air Quality model applications	

Data Service Plan : Geo-KOMPSAT-2A

[Via GK-2A broadcast]

- **Broadcast all 16 channels data (UHRIT)** of meteorological observations
- Maintain **L/HRIT broadcast** corresponding to COMS five channels

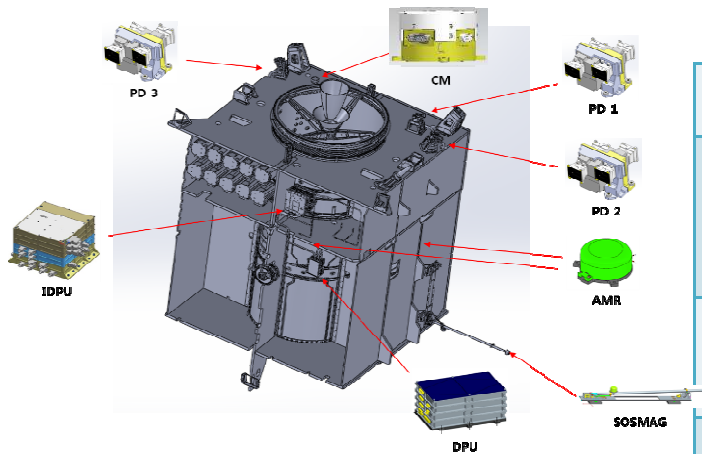
Categories	UHRIT	COMS-like H/LRIT	
		HRIT	LRIT
Service			
Data Rate	≤ 31 Mbps	3 Mbps	~512 Kbps
Frequencies	Uplink : S-band Downlink : X-band	Uplink : S-band , Downlink : L-band * Same Frequencies band with COMS	
Data Type	AMI Image(16 Ch.) Alphanumeric text Encryption Key Message * Additional info could be added in the future	AMI Image(5 Ch.) Alphanumeric text Encryption Key Message GOCI-II products(TBD)	AMI Image (5 Ch.) Alphanumeric text Encryption Key Message Lv2 products GOCI-II image file
Mode	FD	FD	FD
Station	LDUS	MDUS	SDUS

[Via Landline]

- Cloud service similar to Himawaricloud is under development (completed in 2018)
- Renovated web-based service system is under development (completed in 2018)
- GK-2A data also will be available in DCPC-NMSC (<http://dcpc.nmsc.kma.go.kr>)

Korean Space wEather Monitor (KSEM) on Geo-KOMPSAT-2A

1. KSEM Specification



Sensor	Specification
Energetic Particle Detector	<ul style="list-style-type: none"> Measurement range : (electron) 50keV ~ 2 MeV (proton) 100keV ~ 20 MeV Angular resolution : 60° at least (pitch angle) Time resolution : 0.33s
Magnetometer (ESA, SOSMAG)	<ul style="list-style-type: none"> Measurement range : -6,400 ~ +6,400nT in 3 axes Field resolution : 1nT at least (on orbit) Time resolution : 0.1s
Satellite Charging Monitor	<ul style="list-style-type: none"> Current range: -3 ~ +3pA/cm² Measurement resolution : 0.01pA/cm² Time resolution : 1s

2. KSEM products and utilization

Level 1 : dissemination in 5 min.

Observation(Level 1) requiring space monitoring

PD : High energy particle flux	MAG: Magnetic field in 3 axis(x, y, z)	CM : Satellite internal charging
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Level 2 : dissemination in 30 min. after Level 1

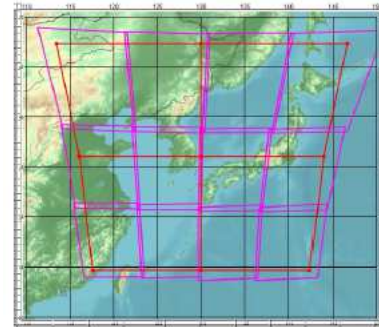
Products (Level 2) requiring space monitoring

Particle flux around Magnetosphere	Particle flux for the targeted satellite orbit	Satellite Charging Index	Magnetospheric Disturbing index (Dst, Kp)	Prediction on Magnetospheric Disturbing index (Dst, Kp)
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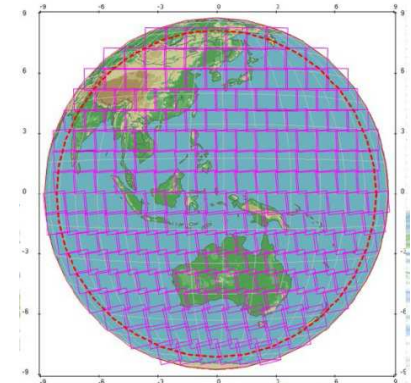
FUTURE GEO-KOMPSAT-2B, GOCI-II : March 2019

- 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, **250m×250m** (at Eq), and **12 spectral bands**
 - 1 additional channel for star sensing, lunar calibration (once a month)

Items	GOCI Specs	GOCI-II Specs
Bus	COMS	GEO-KOMPSAT-2B
Increased band number	8 bands (412~865 nm)	12 bands (380 ~ 865nm)
Improved spatial resolution	500m	250m (at 130E, Eq)
More observations	8 times/day	10 times/day
Pointable & Full Disk coverage	Local Area	Local Area + Full Disk



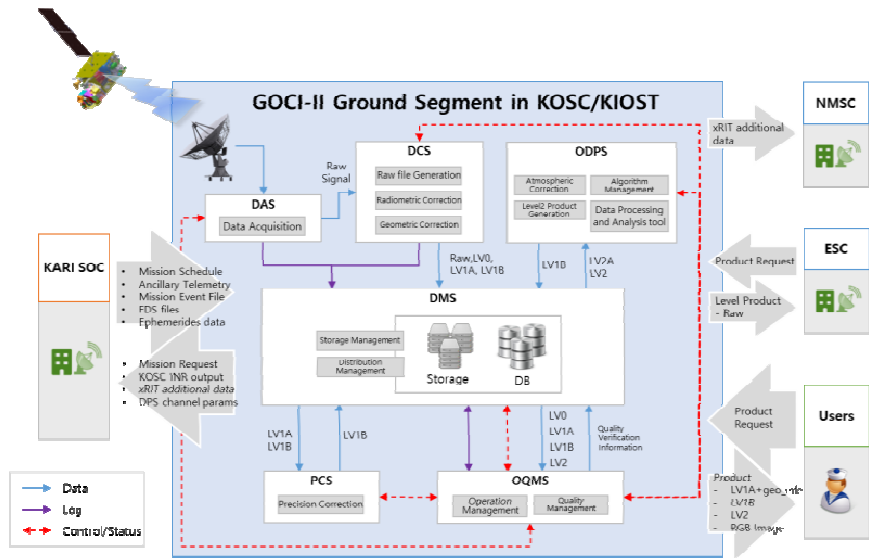
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FUTURE GEO-KOMPSAT-2B, GOCI-II : March 2019

- G2GS(GOCI-II Ground Segment system)
 - **New ground segment for GOCI-II**
 - To satisfy the needs of users like more and faster data processing
 - 24 times bigger data size than GOCI (Lv0~Lv2 all products)
 - 2 times faster processing timeliness than GOCI
 - Current developing status is the detailed design of ground segment systems (G2GS CDR will be held on end of 2016)



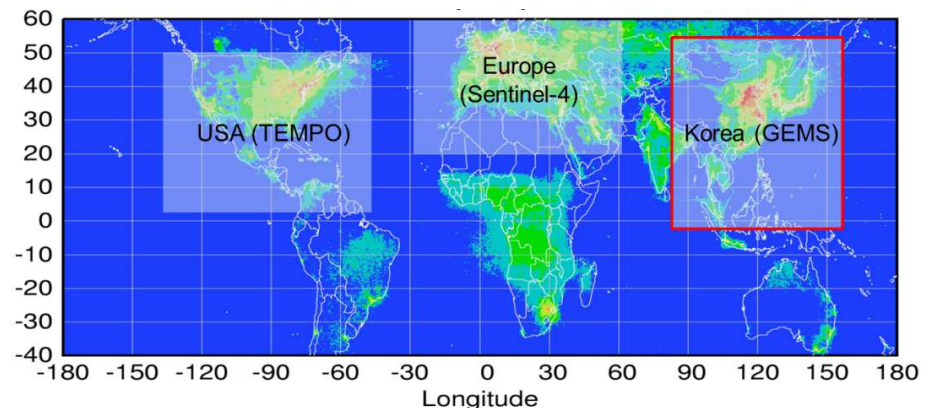
Specification Comparison between GOCI and GOCI-II

Specification	GOCI	GOCI-II
4X increased spatial resolution with full-disk mode	<p>GOCI</p> <p>500m</p>	<p>GOCI-II</p> <p>250m</p> <p>Local Area</p> <p>1km</p> <p>Full-disk</p>
2X more number of observation times	<p>8 times/day</p>	<p>10 times/day</p> <p>Local Area(Event)</p> <p>1 times/day</p> <p>Full-disk</p>
1.5X number of bands	<p>8 bands(VIS/NIR)</p>	<p>13 bands(VIS/NIR, WideBand)</p>
2X Level 2 Products	<p>GOCI</p> <p>total 13 products</p> <p>2 kinds (ex. nLw)</p>	<p>GOCI-II</p> <p>76 products</p> <p>4 kinds (ex. Rayleigh-corrected data)</p> <p>Basic Product(LV2A)</p> <p>17 kinds (ex. Fishery Information)</p> <p>Ocean Product(LV2)</p> <p>5 kinds (ex. Aerosol type)</p> <p>Aerosol Product(LV2)</p>

FUTURE GEO-KOMPSAT-2B, GEMS : March 2019

- 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



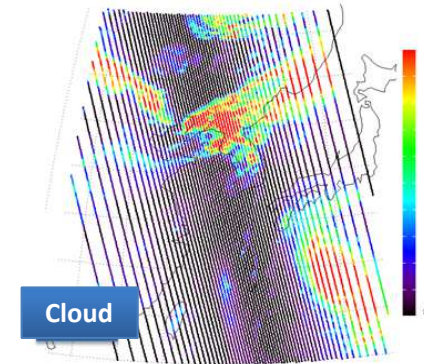
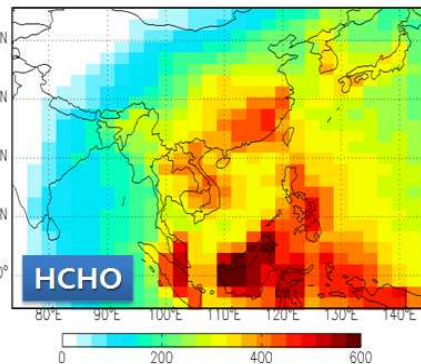
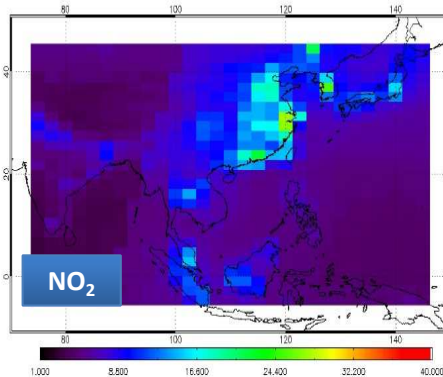
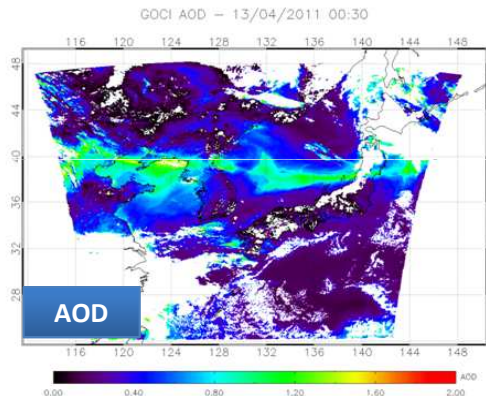
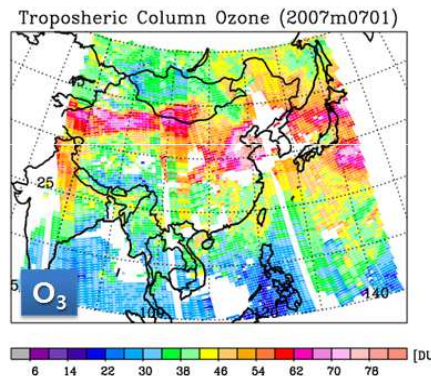
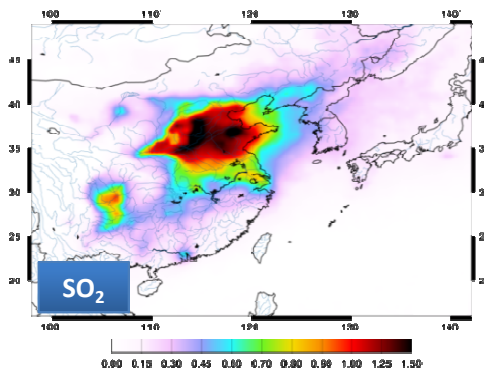
FUTURE GEO-KOMPSAT-2B, GEMS : March 2019

➤ GEMS Performance vs. Key Requirements

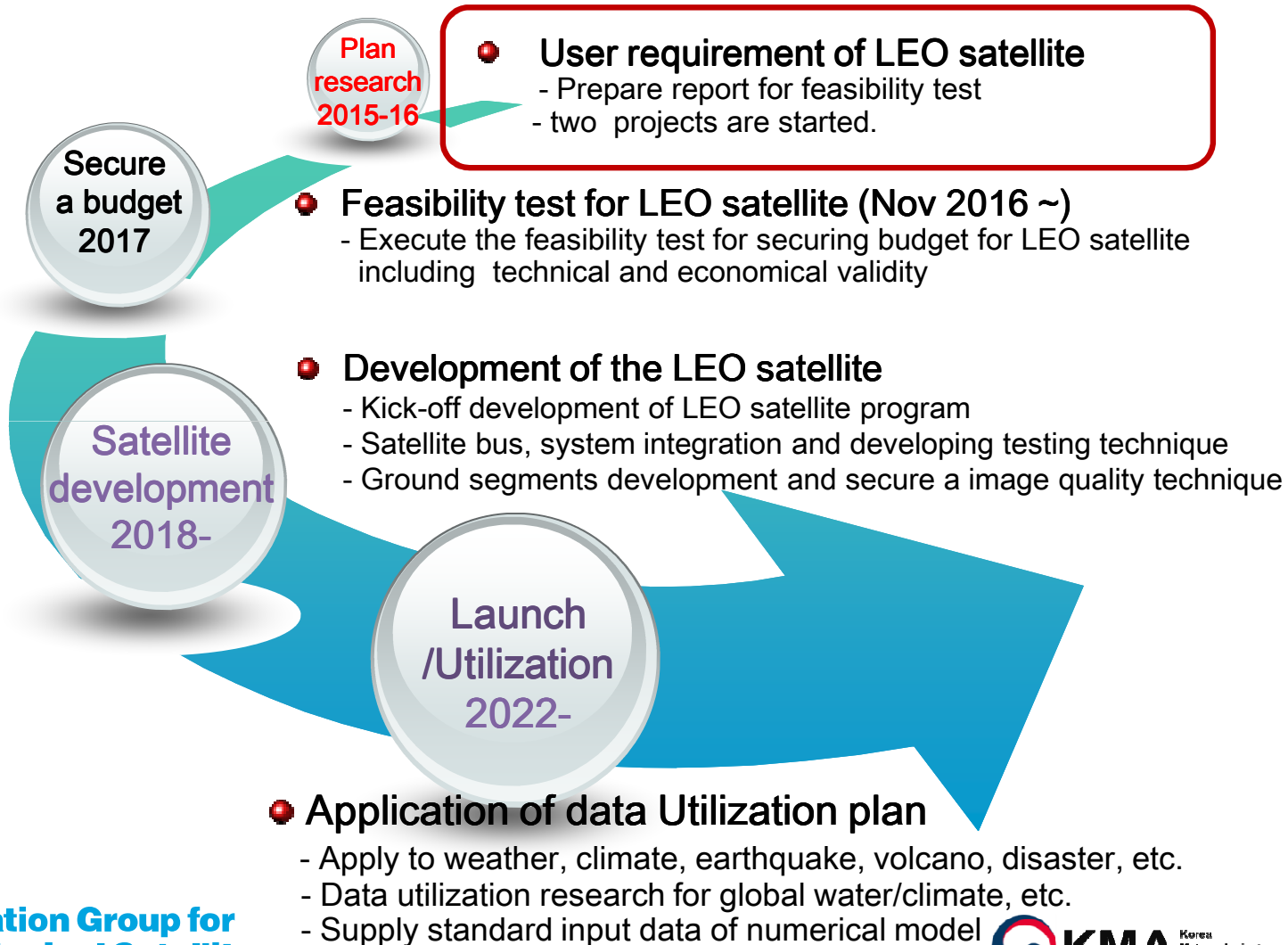
Requirement	Value	Predicted Performance	Margin	Verification Method
Mission Life	10 years after IOT	> 10 years	N/A	Analysis
N-S Field of Regard	5 S to 45 N (7.681 deg)	> 5 S to 45 N (7.722 deg)	0.53%	Analysis and Test
E-W Field of Regard	75 E to 145 E (5.287 deg)	>75 E to 145 E (5.455 deg)	3.10%	Analysis, Demonstration, Inspection
Revisit Time	30 min imaging + 30 min rest	30 min imaging + 30 min rest	N/A	Demonstration
GSD	< = 7 km N-S over Seoul	6.941 km	0.86%	Analysis and Test
Keystone	<= 0.2 pixel	0.1 pixel	94.10%	Analysis and Test
Smile	<= 0.2 pixel	0.09 pixel	115.31%	Analysis and Test
MTF	< 0.3 at Nyquist	0.51 N-S 0.44 E-W	69.28% @ 500 nm 46.88% @ 500 nm	Analysis and Test
Spectral Range	300 nm to 500 nm	300 nm to 500 nm	N/A	Analysis and Test
Spectral Bandwidth	<= 0.6 nm FWHM	0.599 nm FWHM over spectral range, 0.8 nm FWHM at 400 nm synthetic channel (charge injection row)	0.02%	Analysis and Test

FUTURE GEO-KOMPSAT-2B, GEMS : March 2019

- Products : Trace gas (SO₂, O₃, NO₂, HCHO), Aerosol Properties
 - (Column Density) NO₂, SO₂, HCHO, O₃ (possibly CHOCHO, BrO)
 - (O₃) column density @ troposphere and stratosphere, entire quantity, profile
 - (Aerosol) Optical depth, Index, Single scattering albedo, height
 - (Cloud) effective cloud cover, pressure
- Surface reflectance, UV index



FUTURE LEO SATELLITES for meteorological use



FUTURE LEO SATELLITES for meteorological use

- **Development (plan) : ~ 2022 (or earlier)**
 - **Altitude/orbit : 500~900km / Sun-synchronous (TBD), dawn-dusk orbit**
 - **Satellite : ~500kg, instrument : ~150kg**
 - **Possible Instrument : MW Sounder such as ATMS, AMSU, SSMI**
 - : CRIS with limited channels**
 - : GPM**
- ~ one or two instrument due to the weight of payloads(~150kg)
- ~ instrument type will be decided for feasibility test
- **International cooperation / joint development for payload and sensors**

Announcements by KMA

❖ The Joint 7th Asia-Oceania / 2nd American Meteorological Society (AMS)-Asia / 2nd KMA International Meteorological Satellite Users' Conference to take place

- 21-28 October 2016, Songdo city, Incheon
- <http://nmsc.kma.go.kr/aomsuc7/main.jsp>

- Daily schedule

21~22 October	Training on meteorological satellite data usage
24~27 October	The Joint 7th AOMSUC / 2nd AMS-Asia / 2nd KIMSC International Meteorological Satellite Users' Conference
28 October	The 4th meeting of the Coordinating Group of the RA II WIGOS Project

Thank you