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Agenda Item 01
Discussed at Plenary

Subject	KMA updates since CGMS-50 and report on the medium to long-term future plans
In response to CGMS action/recommendation	
HLPP reference	
Executive Summary	<p>The KMA has been operating GEO-KOMPSAT-2A (GK2A, meteorological and space weather mission; AMI and KSEM) since July 25, 2019.</p> <p>The GEO-KOMPSAT-2B (GK2B) for the oceanic and environmental mission payload, GOCI-II and GEMS, respectively, observation data have released since 2nd half of 2021.</p> <p>KMA is trying a new approach to support weather forecast such as fog detection for road hazard weather service, simulated satellite images for nowcasting and very short-term forecasting, dust peak height, AI-based proxy radar data, and drought monitoring data using GK2A and GK2B, and so on.</p> <p>The Follow-ons of both GK2A and GK2B are in phase of feasibility study.</p> <p>KMA is also preparing meteorological micro-sat for the future, now in policy research.</p>
Action/Recommendation proposed	

1 INTRODUCTION

The Communication, Ocean, and Meteorological Satellite (COMS), the first Korean geostationary multi-purpose satellite has ended its meteorological mission on 31 March 2020, and the 2nd meteorological satellite, GEO-KOMPSAT-2A (GK2A) has been operational officially since July of 2019.

The GEO-KOMPSAT-2 (GK2) consists of a pair of satellites for multi-purpose. One (GK2A) is for meteorological dedicated satellite with the space weather as a piggyback mission. The other (GEO-KOMPSAT-2B, hereafter GK2B) is for ocean and environmental missions. Ocean mission is to monitor the ocean colour using an advanced Geostationary Ocean Colour Imager (GOCI) continuously. The environmental mission using Geostationary Environmental Monitoring Spectrometer (GEMS) is to monitor atmospheric environments globally with the first payload carried on the geostationary satellite. The GEO-KOMPSAT-2 program had been started under the cooperation with Ministry of Science, ICT and Future Planning (MSIP), Ministry of Oceans and Fisheries (MOF), and Ministry of Environment (ME) of Korean government, and kicked off in the middle of 2012. And the GK2A and 2B satellites was launched successfully in 4 December 2018, and 18 February 2020, respectively.

2 CURRENT SATELLITE SYSTEMS

The Korean current satellite systems for the meteorological mission or meteorological application are presented in Table 2.1.

Table 2.1 The Korean current satellite systems for the meteorological application

Sector	Satellite in Orbit P=pre-operational Op=operational B=back-up L=limited availability	Operator	Location	Launch date	Details on near real time access to L0/L1 data (Link)	Environmental payload and status
West Pacific	COMS (L)	ETRI	128.2°E	26/06/2010	-	Only communication payload is being operated under the limited conditions

	GK2A (Op)	KMA	128.2°E	04/12/2018	HRIT specification LRIT specification UHRIT specification	16-channel Advanced Meteorological Imager (AMI), Korean Space Weather Monitor (KSEM), Direct Broadcast via HRIT/LRIT and UHRIT
	GK2B (Op)	MOF(Ministry of Oceans and Fisheries), ME(Ministry of Environment)	128.2°E	18/02/2020	-	Advanced Geostationary Ocean Colour Imager (GOCI-II) Geostationary Environmental Monitoring Spectrometer (GEMS)

3 STATUS OF CURRENT GEO SATELLITE SYSTEMS

The GK2A (Meteorological and space weather mission; AMI and KSEM) was launched 4th December 2018 and the KMA has been operating officially since 25th July 2019.

The GK2B (Ocean and environmental mission; GOCI-II and GEMS) was launched 18th February 2020 and its images has been open to public since March 2021. The derived ocean and environmental products have released since the 2nd half of 2021.

3.1 Mission objectives, payload/instruments, products

The GK2A meteorological mission is performed by AMI with 4 visible, 2 near-infrared and 10 infrared channels (Table 3.1).

The AMI observation data are disseminated to the users using satellite broadcasting system with Large/Medium/Small Scale Data Utilization Stations (L/M/SDUS) in Ultra High Rate Information Transmission (UHRIT) and High/Low Rate Information Transmission (H/LRIT) formats within 3 minutes after the end of earth observation scanning as well as landline data services. Also, KMA provide GK2A AMI level 1B (L1B) data through the real-time FTP for National Meteorological and Hydrological Services (NMHSs) and both L1B data and L2+ products through the National meteorological Satellite Center (NMSC) website as below for any users.

- Website address: <http://nmhc.kma.go.kr/enhome/html/main/main.do>

Mission objectives

The GK2A is a geostationary satellite developed to meet KMA's space-based observation missions. One is meteorological mission to observe real-time atmospheric phenomena in order to detect severe weathers and their hazardous impact scope and risk. The other is space weather mission to monitor and measure the physical quantities of the near-Earth space environment. The GK2A has Advanced

Meteorological Imager, AMI for the meteorological mission and Korea Space wEather Monitor (KSEM) for the space weather mission.

Payload/instruments

The AMI, the payload for meteorological mission of GK2A, is comparable to those of the ABI and AHI imagers on board GOES-16/17 and Himawari-8/9, respectively. The detailed specification of AMI is as follows;

- Multi-channel capacity: 16 channels (4 visible, 2 near-infrared and 10 infrared channels)
- High spatial resolution: 0.5~1.0 km for visible and 2 km for infrared channels
- Fast imaging: within 10 minutes for Full Disk observation
- Flexibility for the regional area selection and scheduling

The channel characterizations of the AMI are summarized in Table 3.1.

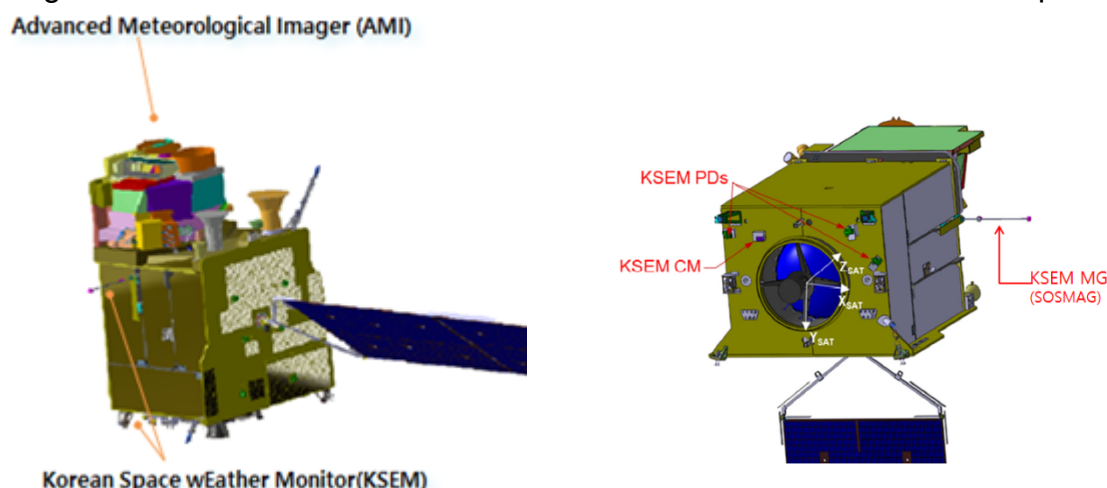
Table 3.1 Channel characterizations of the AMI for the GK2A satellite

Bands		Center Wavelength (measured, μm)	Band Width (Measured, μm)	Resolution (km)	SNR	NEdT(K) (240/300K)	Radiometric Accuracy
VNIR	VIS0.4	0.470	0.0408	1	250	-	5%
	VIS0.5	0.5086	0.0291	1	250	-	5%
	VIS0.6	0.6394	0.0808	0.5	120	-	5%
	VIS0.8	0.8630	0.0344	1	210	-	5%
	NIR1.3	1.3740	0.0155	2	300	-	5%
	NIR1.6	1.6092	0.0410	2	300	-	5%
MWIR	IR3.8	3.8316	0.1912	2	-	3/0.2	1K
	IR6.3	6.2104	0.8397	2	-	0.4/0.1	1K
	IR6.9	6.9413	0.4004	2	-	0.37/0.1	1K
	IR7.3	7.3266	0.1823	2	-	0.35/0.12	1K
	IR8.7	8.5881	0.3552	2	-	0.27/0.1	1K
LWIR	IR9.6	9.6210	0.3789	2	-	0.35/0.15	1K
	IR10.5	10.3539	0.4683	2	-	0.4/0.2	1K
	IR11.2	11.2285	0.6636	2	-	0.19/0.1	1K
	IR12.3	12.336	1.1072	2	-	0.35/0.2	1.1K
	IR13.3	13.291	0.5566	2	-	0.48/0.3	1.1K

※ SNR@100% albedo, NEdT@240/300K, calibration accuracy@100% albedo/300K

The KSEM, the payload for space weather mission of GK2A, consists of particle detector (PD), a set of dual magnetometers (mag), and a spacecraft charging monitor (CM). The energetic particle detectors simultaneously measure the population of charged particles in the energy range of at least 100 keV ~ 2 MeV for electrons and 100 keV ~ 20 MeV for protons, respectively, over the six viewing angles. The dual

magnetometer samples variations of low frequency magnetic fields at two different locations on a deployable boom to accurately measure the Earth's magnetic fields by separating the spacecraft contribution. The spacecraft charging monitor measures integrated fluxes of electrons above 1 MeV that is crucial for the satellite operation.



The specification of the KSEM sensors is presented in Table 3.2.

Table 3.2 The Specification of the KSEM Sensors

Sensor	Requirements	Application Field
Particle Detector	<ul style="list-style-type: none"> - Electron energy range: ~100keV ~ 2 MeV - Angular Resolution (pitch angle): 60° at least 	Global Electron Distribution Particles distribution on geostationary
Magnetometer	<ul style="list-style-type: none"> - Measurement range: $\pm 64,000\text{nT}$ (in 3 axes) - Field resolution: 1nT at least (on orbit) 	Prediction for Dst and Kp Index
Satellite Charging Monitor	<ul style="list-style-type: none"> - Current range: $\pm 3\text{pA/cm}^2$ - Measurement resolution: 0.001pA/cm^2 	Satellite Charging Index

Products and applications

GK2A AMI has produced high spatiotemporal measurements with 0.5~2 km resolutions every 2 minutes around Korean Peninsula and 10 minutes for full disk area. To maximize the application of these rapid observational data for weather and climate monitoring, KMA has led to develop retrieval algorithms of the value added products in cooperation with universities in Korea as well as the support from the internationally distinguished experts of satellite meteorology. Also, we focused the applications as well as the accuracy in the algorithm development to help satellite data interpreters, weather forecasters, typhoon forecasters and the users of satellite data in many other areas. The application areas include nowcasting, typhoon and ocean, surface, hydrology, fire, climate and atmospheric environment, and numerical weather prediction. Analysis skills and their guidance, some challenging products are included, which are not in 52 baseline

products. KMA has optimized the retrieval algorithms and validated the accuracies of the products by using the operational AMI L1B data from June 2019.

KMA has been producing new retrieval with GK2A observation data for new approach to support weather forecast. The recent new products and products with improvement for new application are as follows;

- A new application of the GK2A Fog detection for Road Hazard weather service
- Radiative Transfer Model (RTM) simulated GK2A AMI images for nowcasting and very short-term forecasting
- Development of Dust Peak Height (DPH) using GK2A AMI/GK2B GEMS data
- AI-based proxy radar using GK2A AMI data in East Asia

Also, KMA has been continuously working to monitor climate change using satellite data as well as global various observation data. The recent work scope is as follows;

- Monitoring flash drought with an anomaly of GK2A Soil Moisture (SM) and Evapotranspiration (EVT)
- Greenhouse gas (GHG) monitoring with comparison between satellite and GAW, TCCON data

GOCI-II and GEMS onboard GK2B

Korea Hydrographic and Oceanographic Agency has been responsible for the definition of mission and user requirements, and for the operation of GOCI-II on GK2B.

The GOCI-II is a next generation of the GOCI, one of the major payloads in COMS, which was the first ocean colour imager in the world operating on the geostationary orbit. The GOCI had been developed to provide a monitoring of ocean colour around the Korean Peninsula to detect, monitor, quantify, and predict short term changes of coastal ocean environment for marine science research and application purpose. The GOCI-II has capacities of highly enhanced radiometric/geometric performance in comparison with those of GOCI.

Table 3.3 shows the spectral bands and radiance performance of GOCI-II including the new spectral bands. It is expected that additional spectral bands bring more specific coastal monitoring and application researches as well as more accurate atmospheric correction.

Table 3.3 Spectral Bands and Radiance Performance of the GOCI-II

Band	Band Center	Band-width	Nominal Radiance	Maximum Ocean Radiance	Threshold Radiance	Maximum Cloud Radiance	SNR @ nominal radiance
1	380 nm	20 nm	93	139.5	143.1	634.4	998
2	412 nm	20 nm	100	150.0	152.0	601.6	1,050
3	443 nm	20 nm	92.5	145.8	148.0	679.1	1,145
4	490 nm	20 nm	72.2	115.5	116.0	682.1	1,228

5	510 nm	20 nm	64.9	108.5	122.0	665.3	1,180
6	555 nm	20 nm	55.3	85.2	87.0	649.7	1,124
7	620 nm	20 nm	53.3	64.1	65.5	629.5	1,102
8	660 nm	20 nm	32.0	58.3	61.0	589.0	1,060
9	680 nm	10 nm	27.1	46.2	47.0	549.3	914
10	709 nm	10 nm	27.7	50.6	51.5	450.0	914
11	745 nm	20 nm	17.7	33.0	33.0	429.8	903
12	865 nm	40 nm	12.0	23.4	24.0	343.8	788
13	Wideband		-	-	-	-	-

※ Spectral radiances values are in $\text{Wm}^{-2}\mu\text{m}^{-1}\text{sr}^{-1}$

The GEMS on GK2B contributes to the understanding of pollution events globalization, source/sink identification, and long-range transport of pollutants and Short-Lived Climate Forcers (SLCFs), as a part of the activities of Atmospheric Composition Constellation under the Committee on Earth Observation Satellites (CEOS). This Constellation coordination activity is focused on collaboration to improve and extend data utilization from environmental missions including Korea's GEMS, Europe's Sentinel-4, and the US's Tropospheric Emissions: Monitoring of Pollution (TEMPO), which will be able to provide the "baseline" constellation data products.

The GEMS is expected to contribute monitoring air quality and SLCFs including ozone and aerosols over Asia in high temporal and spatial resolution. Using a scanning UV-Visible spectrometer, its observations can contribute to provide a set of tropospheric column products over the Asia-Pacific region at spatial resolution of 8 km and temporal resolution of 1 hour. Other products include NO_2 , HCHO, SO_2 , and aerosol optical depth.

Table 3.4 shows the GEMS requirements for mission success.

Table 3.4 Payload Requirement of the GEMS

Item	Requirement
Lifetime	> 10 years after IOT
Reliability	> 0.85 @ 7 years
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
Duty cycle/Imaging time	8 images during daytime (30 min imaging + 30 min rest) × 8 times/day
Ground sampling distance	< 7 km(N/S) at Seoul GSD area < 56km ² at Seoul (Aspect ratio shall be less than 1:3)
Spectral range	300 nm to 500 nm

Spectral resolution	< 0.6 nm
Spectral sampling	< 0.2 nm
Signal-to-noise ratio	> 720 @ 320 nm > 1500 @ 430 nm
Data quantization	≥ 12 bits
MTF (Instrument level)	> 0.3 in N/S direction @ Nyquist frequency > 0.3 in E/W direction @ Nyquist frequency
Radiometric calibration accuracy	< 4%
Spectral calibration accuracy	< 0.02 nm
Polarization factor	< 2% (310-500 nm) No inflection point within 20nm for all wavelength range

3.2 Status of spacecraft

GK2A

GK2A was launched on December 4, 2018. It has been located at 128.2°E. GK2A has two payloads, AMI and KSEM for meteorological and space weather missions each. It will be working continuously until 2031.

GK2B

GK2B was launched on February 18, 2020. It has been located at 128.2°E. GK2B has two payloads, GOCI-II and GEMS for oceanic and environmental missions each. It will be working continuously until 2031.

3.3 Ground segment matters

Both of GK2A and GK2B are conducted by the Korea Aerospace Research Institute (KARI) using its Satellite Ground Control System (SGCS) since launch satellite.

KMA has two antennas to receive the observation data for the GK2A at National Meteorological Satellite Center (NMSC). Ministry of Environment and Ministry of Oceans and Fisheries have their antennas to receive the GK2B GEMS data and GOCI-II data each at their satellite centers, National Environmental Satellite Center and National Ocean Satellite Center, respectively.

3.4 Data transmission

GK2A AMI observation data are transmitted by broadcast to L/M/SDUS system users after being converted into UHRIT and H/LRIT formats. KMA provide the UHRIT and H/LRIT services free of charge and those data are encrypted to identify the users of UHRIT and H/LRIT. The domestic and foreign users who want to use L/M/SDUS services should proceed a formal application following the procedures outlined on the website of the NMSC of KMA below;

- <http://datasvc.nmsc.kma.go.kr/datasvc/html/base/cmm/selectPage.do?page=static.reqStation>

The technical documentations to understand about the application procedures for becoming a user station and the description on how to decrypt the encrypted data are posted on the website.

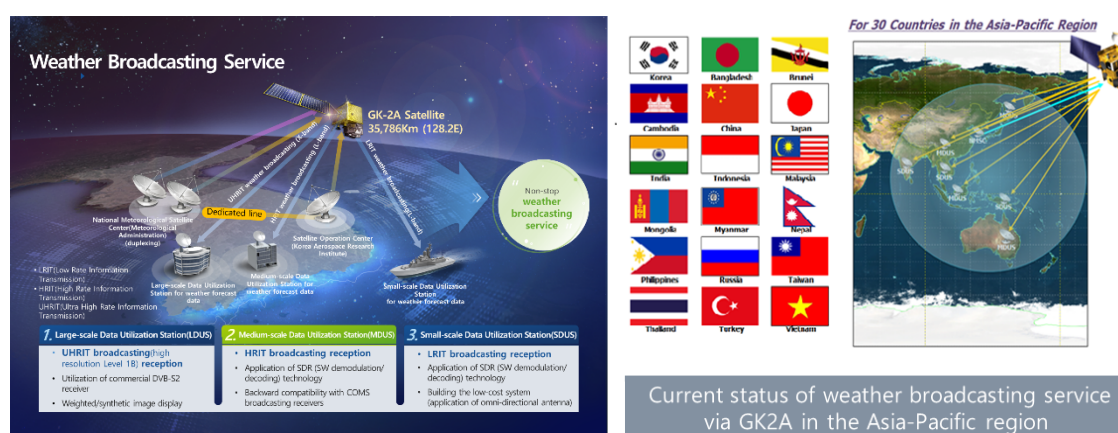


Figure 3.1 Concept of GK2A AMI UHRIT and H/LRIT direct broadcasting

Currently, the UHRIT provides 16 channels of every 10 minutes Full Disk (FD) images in full spectral and spatial resolution and three kinds of L2 meteorological products images (Rainfall Rate, Sea Surface Temperature, Cloud Top Products). The HRIT provides 5 channels of FD images with the same spatial resolution of COMS Meteorological Imager (MI). And LRIT provides marine weather information including GK2A IR image, sea surface wind, sea surface temperature, sea ice, weather chart, typhoon information, etc. and emergency disaster information in text format. In March 2020, NMSC started to broadcast emergency disaster information provided by foreign weather agencies via LRIT for ships over Asian and Oceanic oceans.

Also, 16 channels data of GK2A AMI's FD in 10 minutes and Local Area (LA) in 2 minutes are available on real-time FTP via landline which is named as the GK2AAMI RFS (Real-time FTP Service).

3.5 Projects, services

Service via Satellite

Please refer to 3.4.

Service via Landline

Besides the GK2A RFS referred in 3.4., the NMSC provides GK2A L1B data of all 16 channels and L2+ products to users by posting the processed data on NMSC website (<http://datasvc.nmsc.kma.go.kr/datasvc/html/main/main.do?lang=en>).

All registered members of the website can log on, search, and download those data up to 100GB for one-time request. Here is the list of GK2A meteorological products open to users. More products are under development and they will be available after being operational.

Also, in order to promote GK2A AMI and KSEM data utilization in public and private sectors as well as the NMHSs, KMA has implemented the open API service of the GK2A data including 66 products of AMI and 8 products of KSEM in the NMSC website from November 2020.

- 1) OPEN API user: KMA Open API service can be available to any agency, company, academia and person that want to use the GK2A AMI and KSEM data
- 2) Application: If you want download data through the Open API system, you need to sign up the NMSC website membership (or sign in using SNS(google, facebook) account) and apply to issue your key using application form

(<http://datasvc.nmsc.kma.go.kr/datasvc/html/base/cmm/selectPage.do?page=static.openApi2>)

DCPC-NMSC

As a part of WIS DCPC project lead by WMO, NMSC is operating DCPC-NMSC website and providing the GK2A AMI data such as all 16 channels L1B in netCDF and PNG graphic file format and 24 of L2 products in netCDF and PNG graphic file formats.

The registered user can search, access, download the GK2A meteorological data on this user portal web address: <http://dcpc.nmsc.kma.go.kr>

Open MET Data Portal

KMA is also preparing the portal website for the unification service of meteorological and climate data include GK2A AMI's data.

3.6 User statistics

None available.

4 FUTURE SATELLITE SYSTEMS

The KMA and Ministry of Science and ICT (MSI) are preparing to develop the GEO-KOMPSAT-5 (GK5) following GK2A. GK5 will be have meteorological imager like as AMI but improvement with 18 channels.

KMA is also preparing small size satellite such as microsats or cubesats with payloads for the GHG detection and for the rim sounding with Global Navigation Satellite System – Radio Occultation (GNSS-RO) technique.

5 STATUS OF FUTURE GEO SATELLITE SYSTEMS

The follow-ons of both GK2A and GK2B are in phase of feasibility study.

6 STATUS OF CURRENT LEO SATELLITE SYSTEMS

KMA's meteorological micro-satellite development plan is in phase of policy research.

7 ACTIONS AND/OR RECOMMENDATIONS FOR CONSIDERATION BY CGMS PLENARY SESSION

KMA has no actions or recommendations for consideration by the CGMS-51 Plenary Session.

8 CONCLUSIONS

This agency report summarizes the status of KMA's current and future satellite systems for the CGMS-51 Plenary Session.