

KMA REPORT ON THE STATUS OF CURRENT AND FUTURE SATELLITE

In response to CGMS action/recommendation

GEO-KOMPSAT-2A (Meteorological and space weather mission; AMI and KSEM) has been operated since 25 July 2019 by the Korea Meteorological Administration (KMA).

GEO-KOMPSAT-2B (ocean and environmental mission; GOCI-II operated by the Ministry of Oceans and Fisheries and GEMS operated by the Ministry of Environment) was launched 18 February 2020 and its data have released the public since the 2nd half of 2021.

And follow-ons of both GEO-KOMPSAT-2A and GEO-KOMPSAT-2B are in phase of feasibility study.

*AMI : Advanced Meteorological Imager

*KSEM : Korean Space wEather Monitor

*GOCI-II : Geostationary Ocean Colour Imager-II

*GEMS : Geostationary Environment Monitoring Spectrometer

Report on the status of current and future satellite systems

1 INTRODUCTION

COMS (Communication, Ocean, and Meteorological Satellite), the first Korean geostationary meteorological satellite has ended its mission on 31 March 2020, and GEO-KOMPSAT-2A has succeeded its meteorological mission since July of 2019.

The GEO-KOMPSAT-2 consists of a pair of satellites for multi-purpose. One (GEO-KOMPSAT-2A, hereafter 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 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

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
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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)

2.1 Status of current GEO satellite systems

The GK2A (Meteorological and space weather mission; AMI and KSEM) has been operating since July of 2019.

The GK2B (ocean and environmental mission; GOCI II and GEMS) was launched 18 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.

2.1.1 Mission objectives, payload/instruments, products

The GK2A meteorological mission is performed by AMI with 4 visible, 2 near-infrared and 10 infrared channels (Table 2.1).

The AMI observation data are disseminated to L/M/SDUS (Large/Medium/Small Scale Data Utilization Stations) users in UHRIT(Ultra High Rate Information Transmission) and H/LRIT (High/Low Rate Information Transmission) formats within 3 minutes after the end of earth observation. Also, we provide GK2A AMI level 1B data through the real-time FTP for NMHSs (National Meteorological and Hydrological Services) and both level 1B data and level 2 products through NMSC (National Meteorological Satellite Center) website (<http://nmssc.kma.go.kr/enhome/html/main/main.do>) for any users.

In this report, we introduce the current status and future plans of GK2A AMI operation performance and data services.

Observation mission

The AMI, the payload for meteorological mission of GK2A, is comparable to those of the ABI and AHI imager on board GOES-16/17 and Himawari-8/9. 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 2.1.

Table 2.1: Channel characterizations of the AMI for the GK2A satellite

Bands	Center Wavelength	Band Width (Measured, um)	Resolution (km)	SNR	NEdT(K) (240/300K)	Radiometric Accuracy

		(measured, um)					
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

GK2A AMI Product retrievals and applications

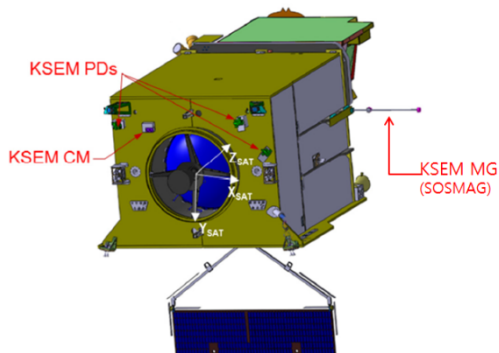
GK2A AMI has produced high spatiotemporal measurements with 0.5~2 km resolutions every 2 min around Korean Peninsula and 10 min for full disk area. To maximize the application of these rapid observational data for weather and climate monitoring, KMA has led to develop retrieval algorithms of the value 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 level 1B data from June 2019 (Table 2.2).

Table 2.2: GK2A AMI Meteorological and geophysical 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)	
* Blue: Primary Products			

KMA in coordination with KARI and KHU (KyungHee University) has developed to operate the first Korean space weather monitor, KSEM. It 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. KSEM specification is as follows:

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: ± 64,000nT (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: ± 3pA/cm² - Measurement resolution : 0.001pA/cm² 	Satellite Charging Index

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 2.3 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 2.3: 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 $Wm^{-2}\mu m^{-1}sr^{-1}$

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 (GEMS), Europe (Sentinel-4), and the US (TEMPO), which will be able to provide the “baseline” constellation data products.

The GEMS is expected to contribute monitoring air quality and SLCFs(Short-Lived Climate forcers) 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 NO₂, HCHO, SO₂, and aerosol optical depth.

Table 2.4 shows the GEMS requirements for mission success.

Table 2.4: 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

2.1.2 Status of spacecraft

The GK2A mission has been operating since July 2019. The GK2A and GK2B are conducted by the Korea Aerospace Research Institute (KARI) using its Satellite Ground Control System (SGCS).

2.1.3 Impact on spacecraft due to space weather

Space weather related spacecraft anomalies (Items in bold are required)

Source: Recommendations for Contents of Anomaly Database for Correlation with Space Weather Phenomena, P. O'Brien, J.E. Mazur, T. Guild, November 2011, AEROSPACE Report No.TOR-2011(3903)-5.

1. Date and Universal Time of the anomaly	2. Fully specified location of the anomaly (spacecraft location)	3. Velocity or orbital elements at time of the anomaly	4. Eclipse state of the vehicle (full, penumbra, partial, none)	5. Vector to Sun in spacecraft coordinates	6. Velocity vector of spacecraft in spacecraft coordinates	7. Initial guess at type of anomaly (See taxonomy below)	8. Estimated confidence of that guess	9. Anomaly category (e.g., affected system or kind of disruption)	10. Vehicle identity	11. Notes (e.g. unusual operational states or recent changes to operations (recent commands, attitude scheme, etc.)

Taxonomy of Satellite Anomalies Caused by In Situ Charged Particle Environment (to be used for column 7):

- 1. Electrostatic discharge (charging)
 - 1.1 Surface charging
 - 1.1.1 Plasma sheet (subauroral)
 - 1.1.2 Auroral
 - 1.2 Internal charging
 - 1.2.1 Subsurface charging (e.g., beneath blanket)
 - 1.2.2 Deep charging (e.g., inside a box)
- 2. Single-Event Effects
 - 2.1 Protons
 - 2.1.1 Solar proton event
 - 2.1.2 Geomagnetically trapped protons
 - 2.2 Heavy ions
 - 2.2.1 Galactic Cosmic Rays
 - 2.2.2 Solar energetic particles
 - 2.2.3 Geomagnetically trapped heavy ions
- 3. Total Dose
 - 3.1 Long-term dose accumulation (multiple causes combined)
 - 3.2 Short-term (days or less) dose accumulation
 - 3.2.1 Solar protons
 - 3.2.2 Geomagnetically trapped protons
 - 3.2.3 Geomagnetically trapped electrons

2.1.4 Data transmission

The observed meteorological data by the GK2A AMI are broadcast to LDUS/MDUS/SDUSs (Large/medium/small-scale data utilization stations) after being converted into UHRIT (Ultra High Rate Information Transmission) and H/LRIT(High/Low Rate Information Transmission) 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 LDUS/MDUS/SDUSs services should proceed a formal application following the procedures outlined on the website of the National Meteorological Satellite Center (<http://datasvc.nmsc.kma.go.kr/datasvc/html/base/cmm/selectPage.do?page=static.reqStation>). The technical documentations to learn about the application procedures for becoming a user station and the description on how to decrypt the encrypted data are posted on the website.

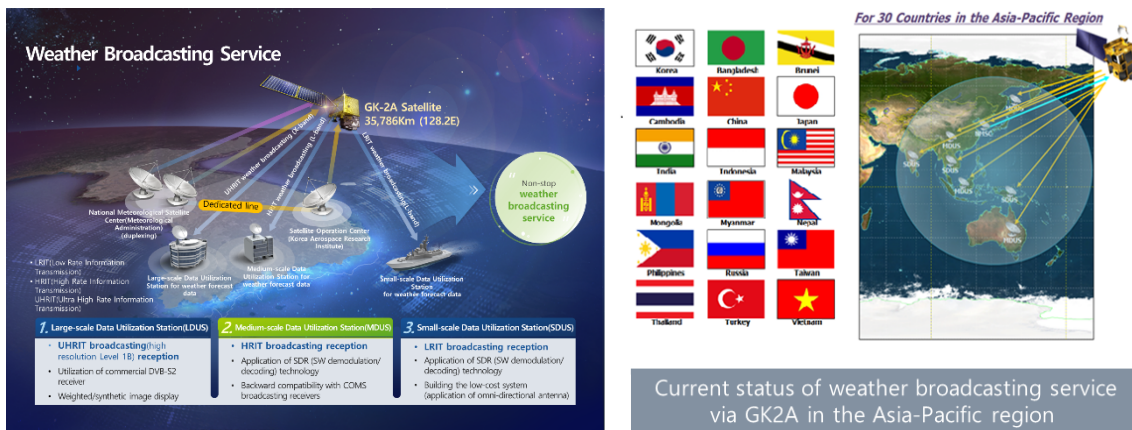


Figure 2.1: Concept of AMI UHRIT and H/LRIT direct broadcasting

Currently, the UHRIT provides 16 channels of 10 minutes interval FD (full disk) images in full spectral and spatial resolution and three kinds of Level 2 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.

Below table is satellite broadcasting frequency band of the GK2A.

Table 2.5: GK2A xRIT (UHRIT and H/LRIT) broadcasting frequency band.

Category	Center Frequency (MHz)	Bandwidth (MHz)
UHRIT (X-Band)	8070	20

HRIT (L-Band)	1695.4	5.2
LRIT (L-Band)	1692.14	1

To ensure the direct usability of the GK2A meteorological data, all 16 channels data of FD (Full Disk) in 10 minutes and LA (Local Area) in 2 minutes of the AMI observations are available on real-time FTP via landline, which is named as the GK2A AMI RFS (Real-time FTP Service).

2.1.5 Projects, services

(1) Service via Satellite

Please refer to 2.1.4.

(2) Service via Landline

Besides the GK2A RFS referred in 2.1.4., the NMSC provides GK2A level 1B data of all 16 channels and level 2 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.

Table 2.6: The list of GK2A MI products

No.	Products	Resolution	Period (Full Disk)	Start Date of Service
1	Cloud Detection(CD)	2 km	10 min.	31 Oct. 2019
2	Atmospheric Motion Vector(AMV)	32 km	30 min.	
3	Clear Sky Radiance(CSR)	32 km	10 min.	
4	Vertical Temperature Profile(VTP)	6 km	10 min.	
5	Vertical Humidity Profile(VHP)	6 km	10 min.	
6	Atmospheric Instability Indices(AII)	6 km	10 min.	
7	Total Precipitable Water(TPW)	6 km	10 min.	31 Oct. 2019
8	Sea Surface Temperature(SST)	2 km	1-, 5-, 10-day composition	31 Mar. 2020
9	Land Surface Temperature(LST)	2 km	10 min.	
10	Snow Cover(SC)	2 km	10 min.	
11	Sea Ice(SI)	2 km	1 day	
12	Dust Aerosol Detection(DAD)	2 km	10 min.	
13	Forest Fire(FF)	2 km	10 min.	
14	Total Column Ozone(TCO)	6 km	10 min.	
15	Downward Shortwave Radiation at Surface(DSR)	2 km	10 min.	
16	Outgoing Longwave Radiation at TOA (OLR)	2 km	10 min.	
17	Fog Detection(FD)	2 km	10 min.	

18	Cloud Phase(CP)	2 km	10 min.	
19	Cloud Amount(CA)	2 km	10 min.	
20	Cloud Type(CP)	2 km	10 min.	
21	Cloud Top Height(CTH)	2 km	10 min.	
22	Cloud Effective Radius(CER)	2 km	10 min.	
23	Cloud Liquid Water Path(CLWP)	2 km	10 min.	
24	Rainfall Rate(RR)	2 km	10 min.	

Also, In order to promote GK2A AMI and KSEM data utilization in public and private sectors as well as the NMHS, KMA has implemented the open API service of the GK2A data including 66 products of AMI and 8 products of KSEM (see CGMS-50-KMA-WP-03) 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>)

(3) DCPC-NMSC

As a part of WIS DCPC project lead by WMO, NMSC is operating DCPC-NMSC website and providing the GK2A AMI data as below list.

- All 16 channels level 1B in netCDF and PNG graphic file format
- 24 level 2 products in netCDF and PNG graphic file format as listed in table 2.5

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

Open API

HOME > Support > Open API

- OpenAPI Application Procedure
- OpenAPI Service List
- Make URL
- Frequently Asked Questions

1. OPEN API user

The KMA/NMSC Open API service can be available to any person who wants to use the NMSC data

2. Application

If you want download data through the Open API system, you need to sign up the NMSC website membership and apply to issue your key

Open API application form(download) : submit to kmabigdata@korea.kr

※ Key format: NMSCxx

3. PC specification and related source

Recommendation spec: 8 GB or more RAM, 64 bit OS and Windows 10

Open API download program (for Windows 10, Python, Linux)

※ If you have a trouble of memory capacity, you need to increase memory allocation for this work or add RAM of your PC.

4. Procedure of the downloading data through the Open API

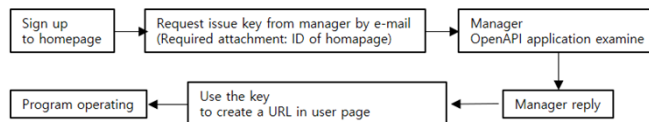


Figure 2.2: Main page of Open API in NMSC website

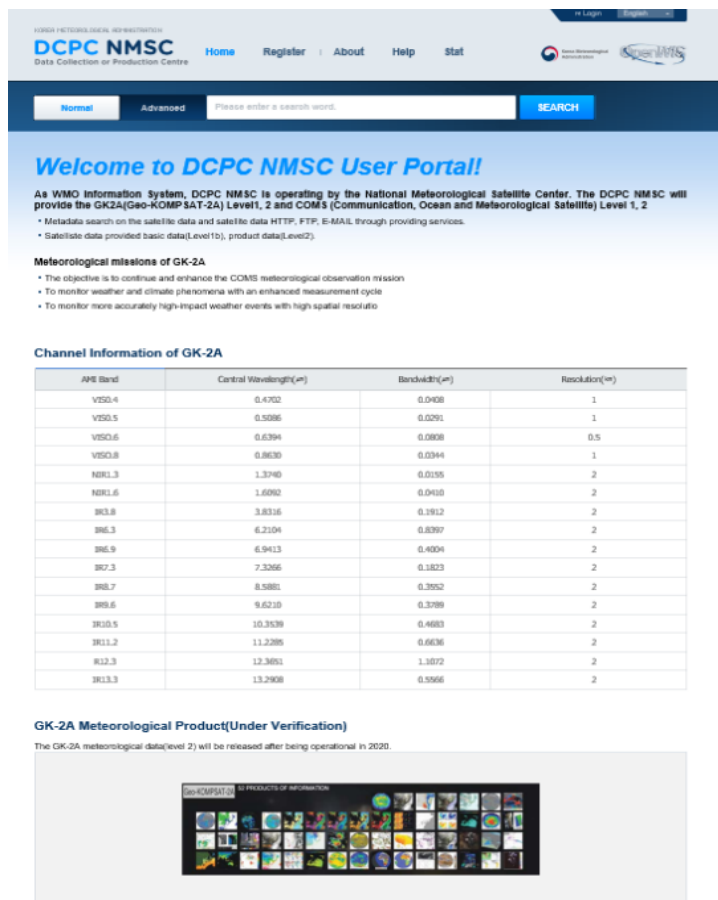


Figure 2.3: Main page of DCPC-NMSC website

3 FUTURE SATELLITE SYSTEMS

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

3.1 Status of future GEO satellite systems

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

**3.1.1 Mission objectives, spacecraft, payload/instruments, products
Observation mission**

3.1.2 Ground segment matters

3.1.3 Data Service

3.2 Status of future LEO satellite systems

Not applicable

3.3 Status of future HEO [or other] satellite systems

Not applicable

**4 ACTIONS AND/OR RECOMMENDATIONS FOR CONSIDERATION BY
CGMS PLENARY SESSION**

Not applicable

5 CONCLUSIONS