AOMSUC-12

Development of fog convergence technology and Application for road weather service based on geostationary meteorological satellites

Satellite Planning Division,
NMSC, KMA

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2. Road weather service
3. Future demands for GK series

1-1. Development of AOD convergence technology using GK-2A(AMI)/2B(GEMS)

NMSC &
UNIST (Prof. Sang-Seo, Park)

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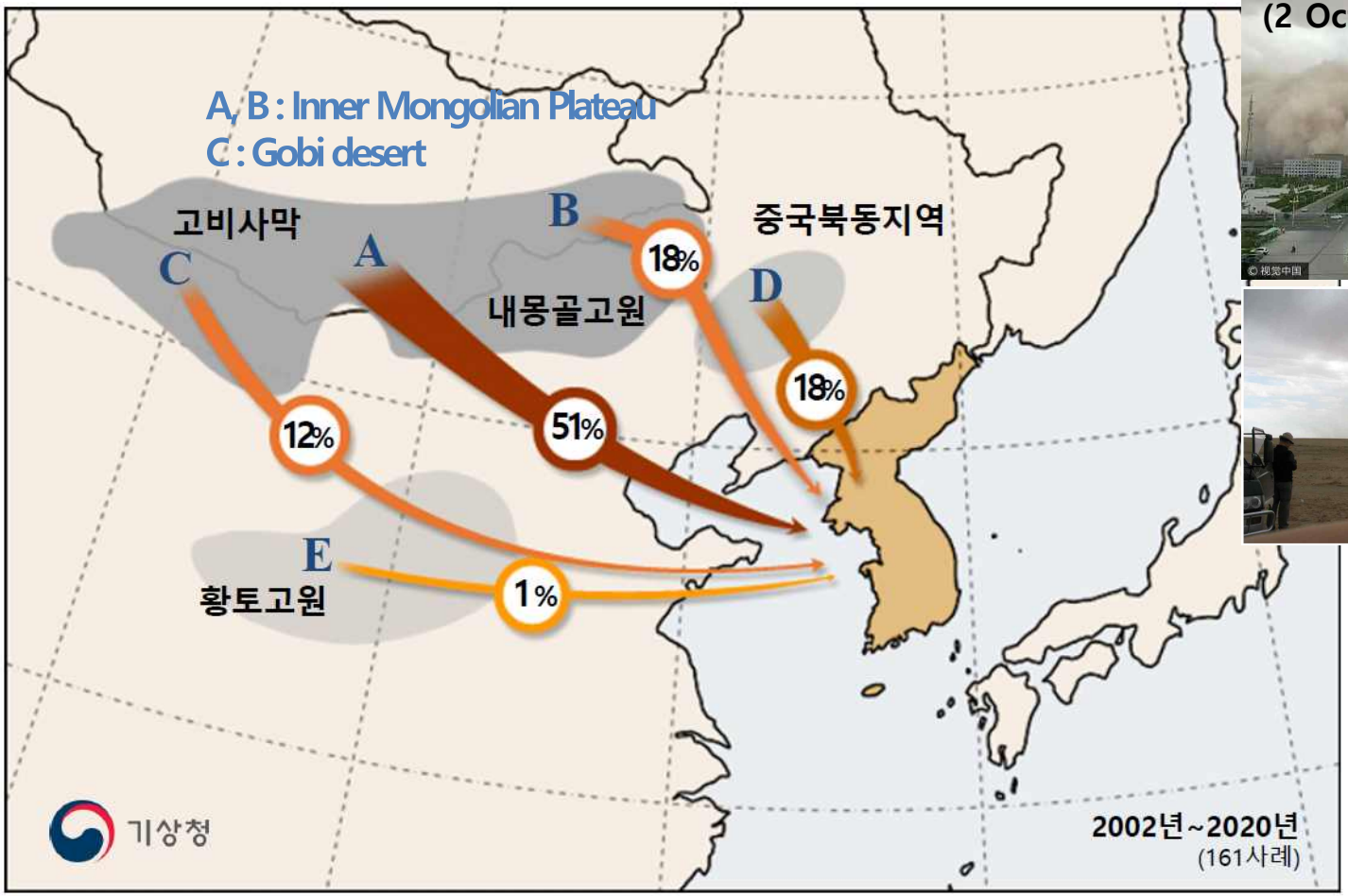
1-1. Development of AOD convergence technology

❖ Asian dust is one of the threats to public health over the Korean Peninsula from winter to spring

- This figure shows the Asian dust Source and inflow path based on 161 cases for 2002~2020

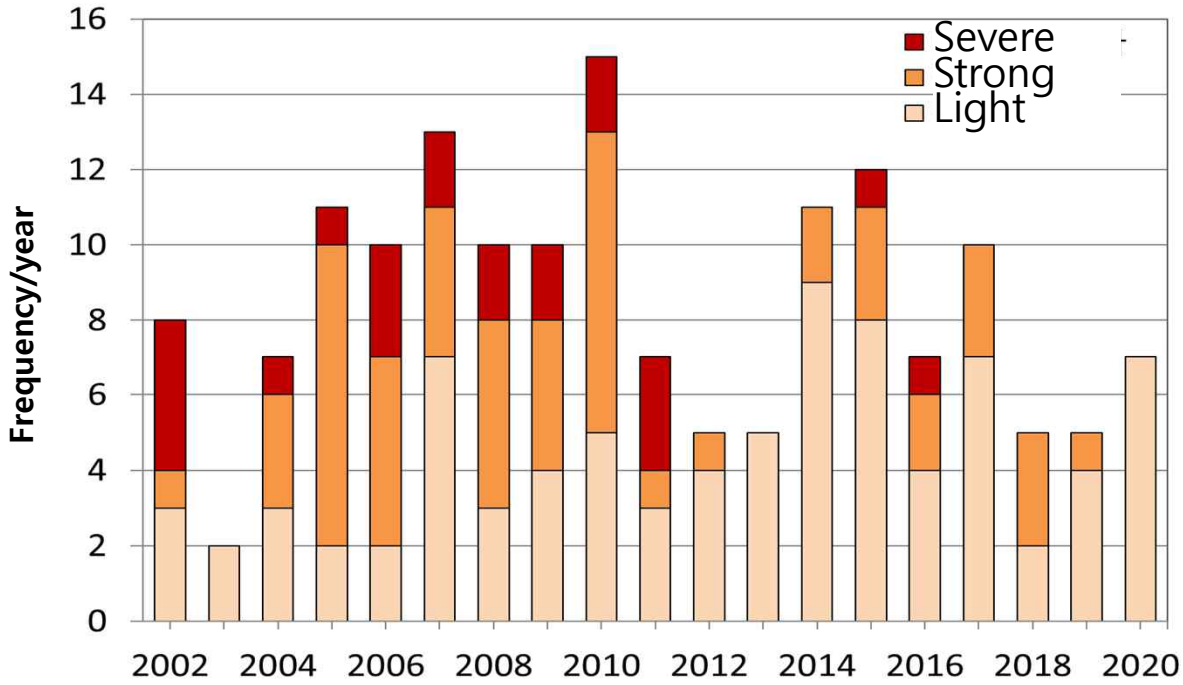


Data source : NIMS, KMA

1-1. Development of AOD convergence technology

❖ **This bar chart shows the frequency of Asian dust observed in South Korea from 2002 to 2020.**

- It implies the total frequency of Asian Dust doesn't decrease, so it is still a threat to public health inducing respiratory disease



Classification of Asian Dust according to mass concentration	
Severe	Over 800 μg/m³
Strong	300-800 μg/m³
Light	Below 300 μg/m³

Data source : NIMS, KMA

- We still need to develop 'the integrated Asian Dust monitoring system' based on meteorological satellite products including dust detection, AOD, aerosol efficient height, and mass concentration in the future.

1-1. Development of AOD convergence technology

❖ Comparison of characteristics of GK2A(AMI) and GK2B(GEMS) aerosol products

	GK2A (AMI)	GK2B(GEMS)
Wave-length	0.47, 0.51, 0.64, 0.86, 1.37,1.61, 3.83, 6.21, 11.2, 12.3	354, 388, 412, 443, 477, 490 nm
Spatial Resolution	2 km * 2 km	3.5 km* 8 km
Temporal Resolution	10 minutes	1 hour/scene
Covered Time Span	Daytime(Type, Total AOD, AE) 24-hour (Dust)	Daytime
Advantage	AOD (Total, Dust), AE, Type Day/Night Observation Accurate Dust Detection Cloud masking/surface reflectance High Spatial-temporal resolution	AOD (354, 500 nm), SSA (440 nm), Aerosol Height Aerosol Height Info. Aerosol Optical Properties Weak Surface sensitivity Consistent Aerosol Model (Especial to UV)
Dis-advantage	Low Optical Properties Land/Ocean Inconsistency Inconsistent Aerosol Model	No Night observation Low Spatio-temporal resolution Cloud masking/surface reflectance

- GK2A has the advantages of aerosol type, day/night observation, and high Spatio-temporal resolution, but GK2B GEMS has aerosol optical properties like single scattering Albedo.

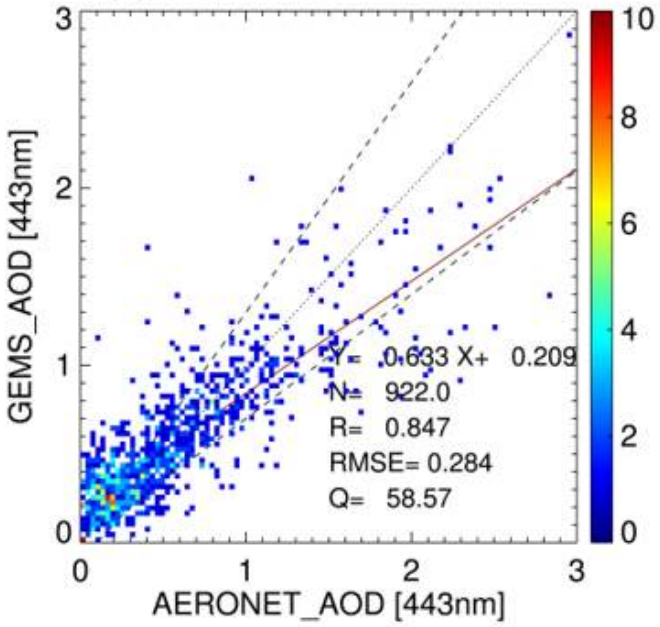
※ GK2A with AMI(advanced meteorological Imager) launched in 2018
GK2B with GEMS(Geostationary Environment Monitoring Spectrometer) and GOCI(Geostationary Ocean Color Imager) launched in 2020.

1-1. Development of AOD convergence technology

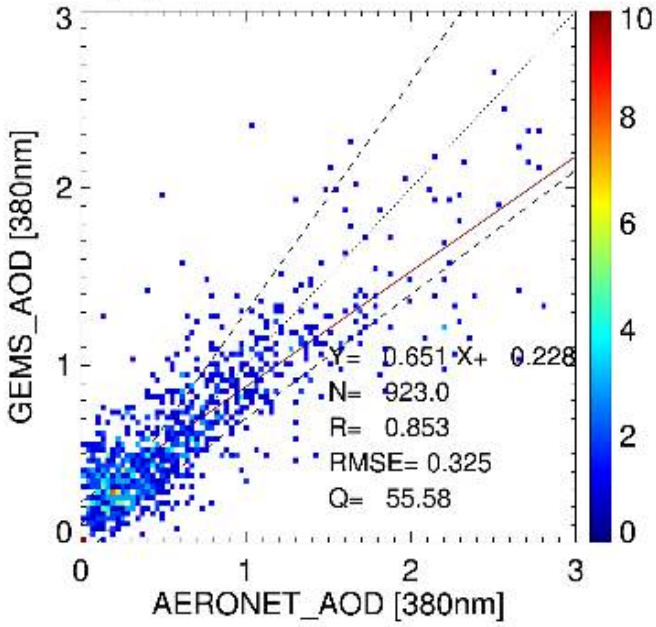
❖ **In the first step, we do an optical properties test of GK-2B(GEMS) aerosol products using AERONET data before fusion**

- Comparison of AOD(443, 380 nm) and SSA (440 nm) between AERONET data and GK2B(GEMS) aerosol products.

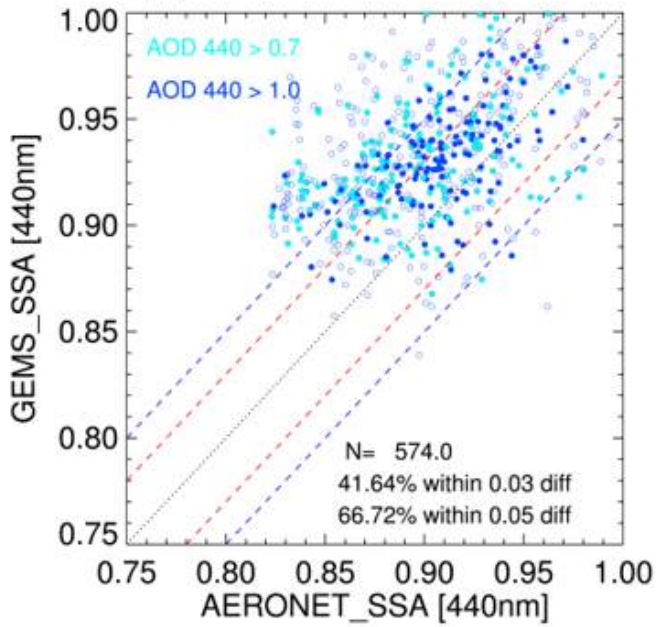
(a) AOD 443 nm



(b) AOD 380 nm



(c) SSA 440 nm



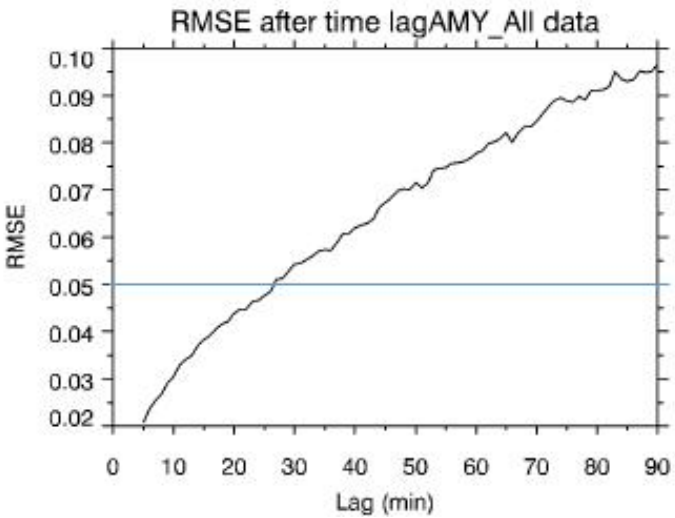
❖ **In the next step, we performed the consistency pre-check to re-grid GEMS' SSA data for colocation between GK2A and GK2B.**

1-1. Development of AOD convergence technology

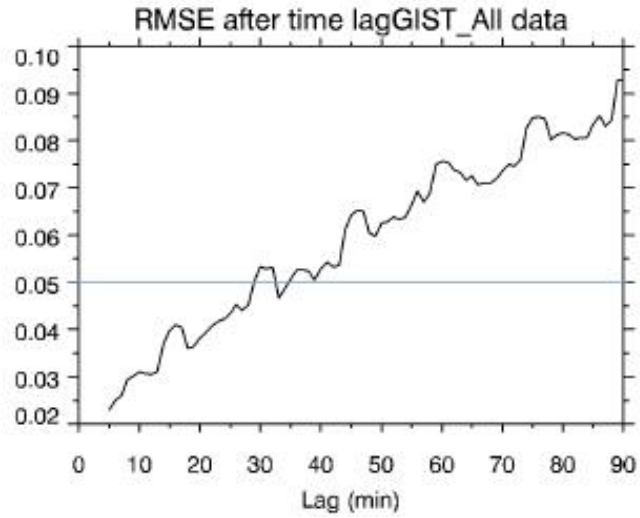
❖ Temporal consistency check about SSA(440nm) data of the Asian Dust

▪ RMSE .vs. lag auto-correlation coefficient of SSA data (AERONET Lv. 1.5) in AMY, GIST and Yonsei Univ. sites.

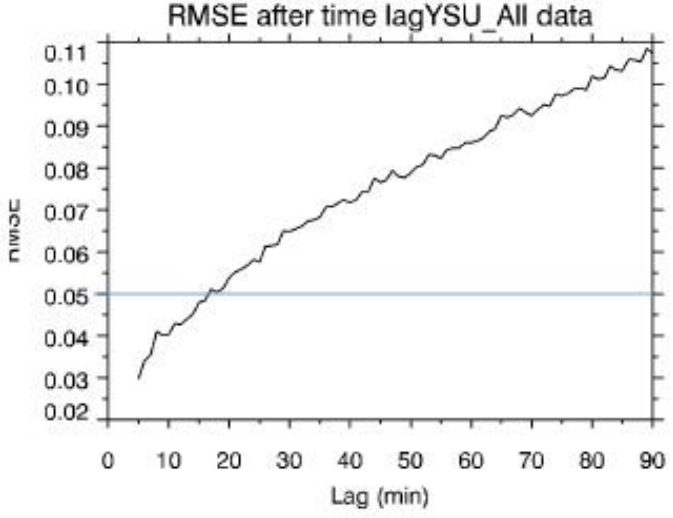
AMY



GIST



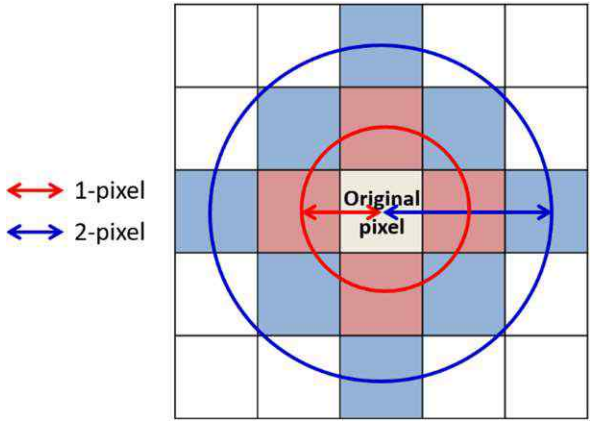
Yonsei Univ.



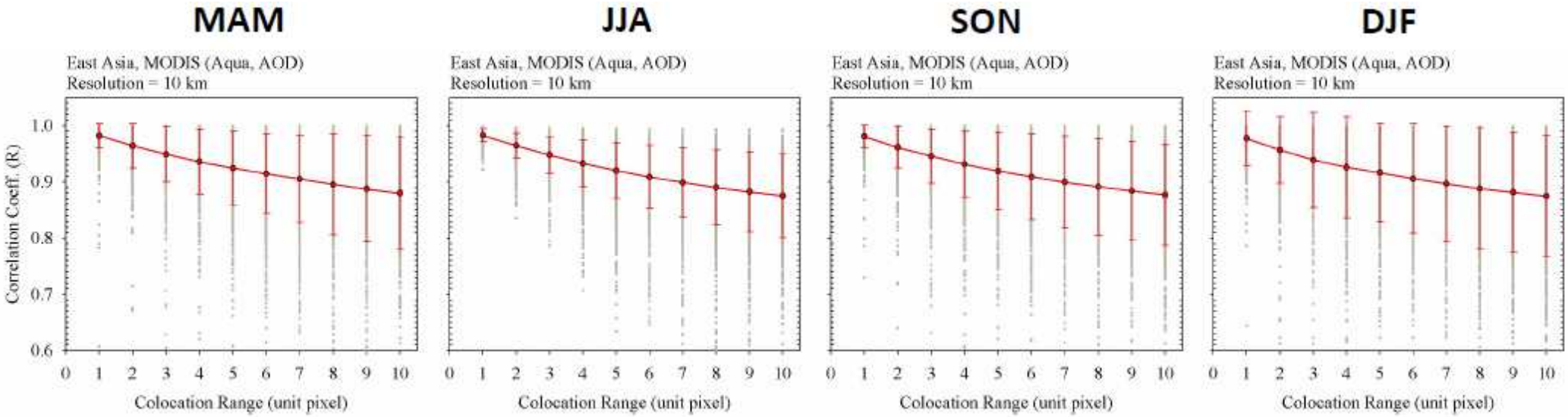
➢ On the base that RMSE is under 0.05, Result is showing that temporal consistency of SSA values is maintained for 30 minutes.

1-1. Development of AOD convergence technology

❖ Spatial consistency check of Aerosol Optical Depth(AOD) data in East Asia



▪ Pixel-lagged correlation coefficients of MODIS(Aqua) AOD by season in the East Asia area.

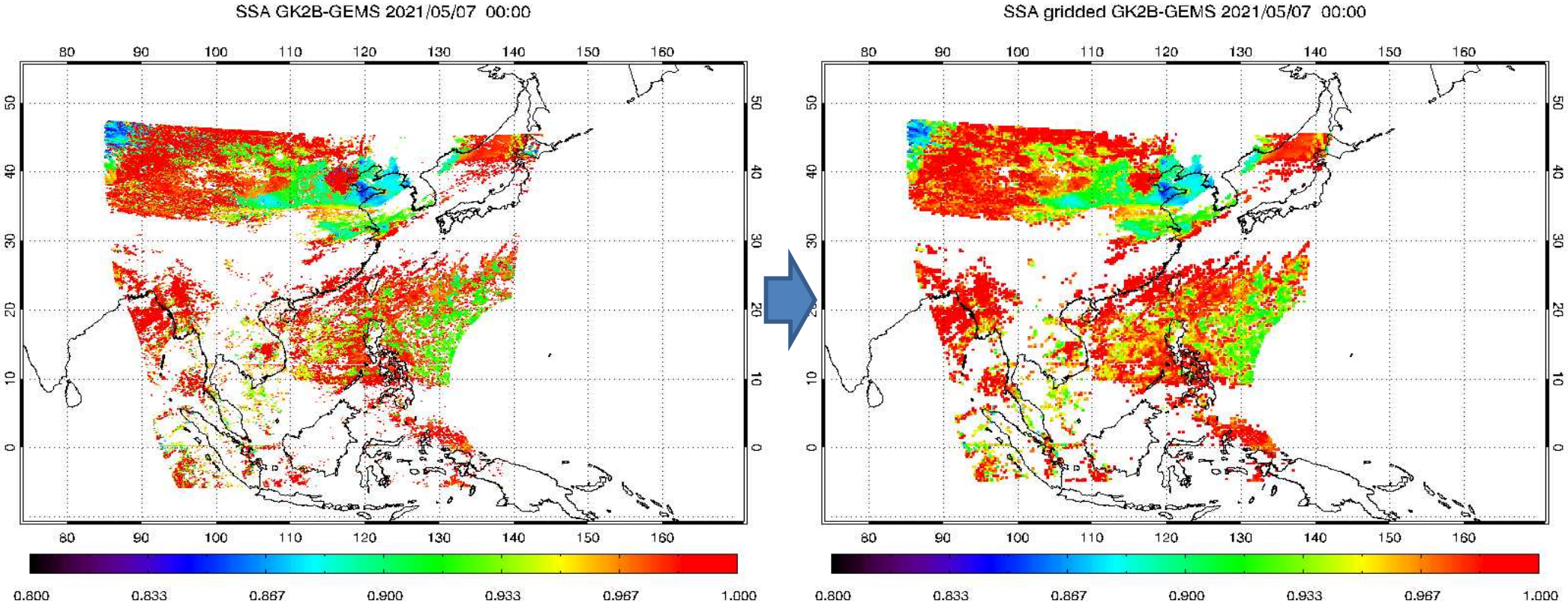


➢ On the based that correlation coefficient is over 0.95, spatial consistency of MODIS(Aqua) AOD in East Asia is maintained within about 3 pixels (~30 ㎞).

1-1. Development of AOD convergence technology

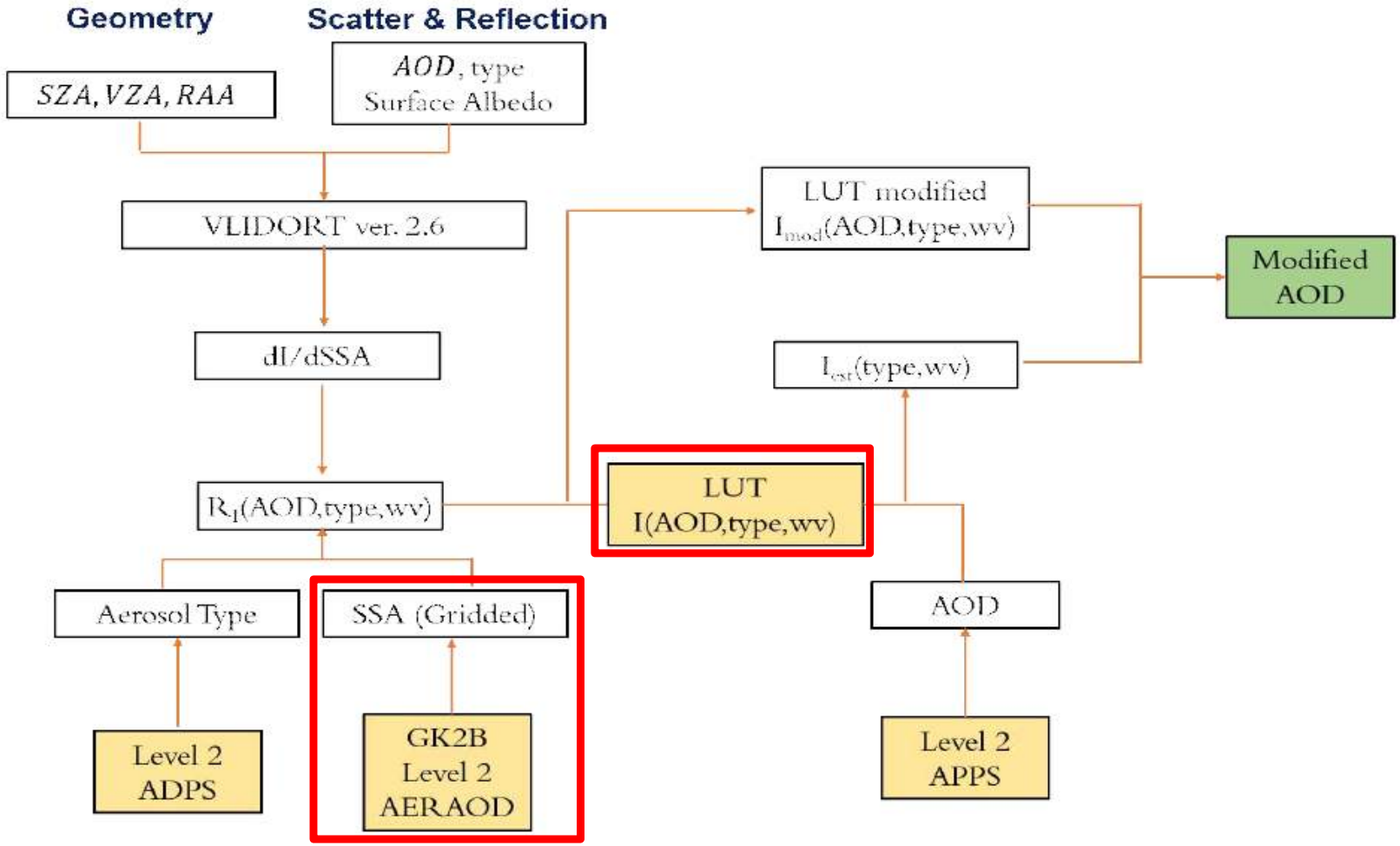
❖ The re-gridded GEMS SSA for colocation between GK-2A/2B in the Asian dust case considering the pre-check results. (2021/05/07 00:00 UTC)

- ✓ Spatial Consistency: Gridding with 0.25 degree(<30km) resolution
- ✓ Temporal Consistency: +/- 30 minutes Pixel dataset
- ✓ Reference Number of Pixel for gridding >2 dataset
- ✓ Combined Data: SSA (354, 388, 440 nm)
- ✓ QA/QC & AOD > 0.2



1-1. Development of AOD convergence technology

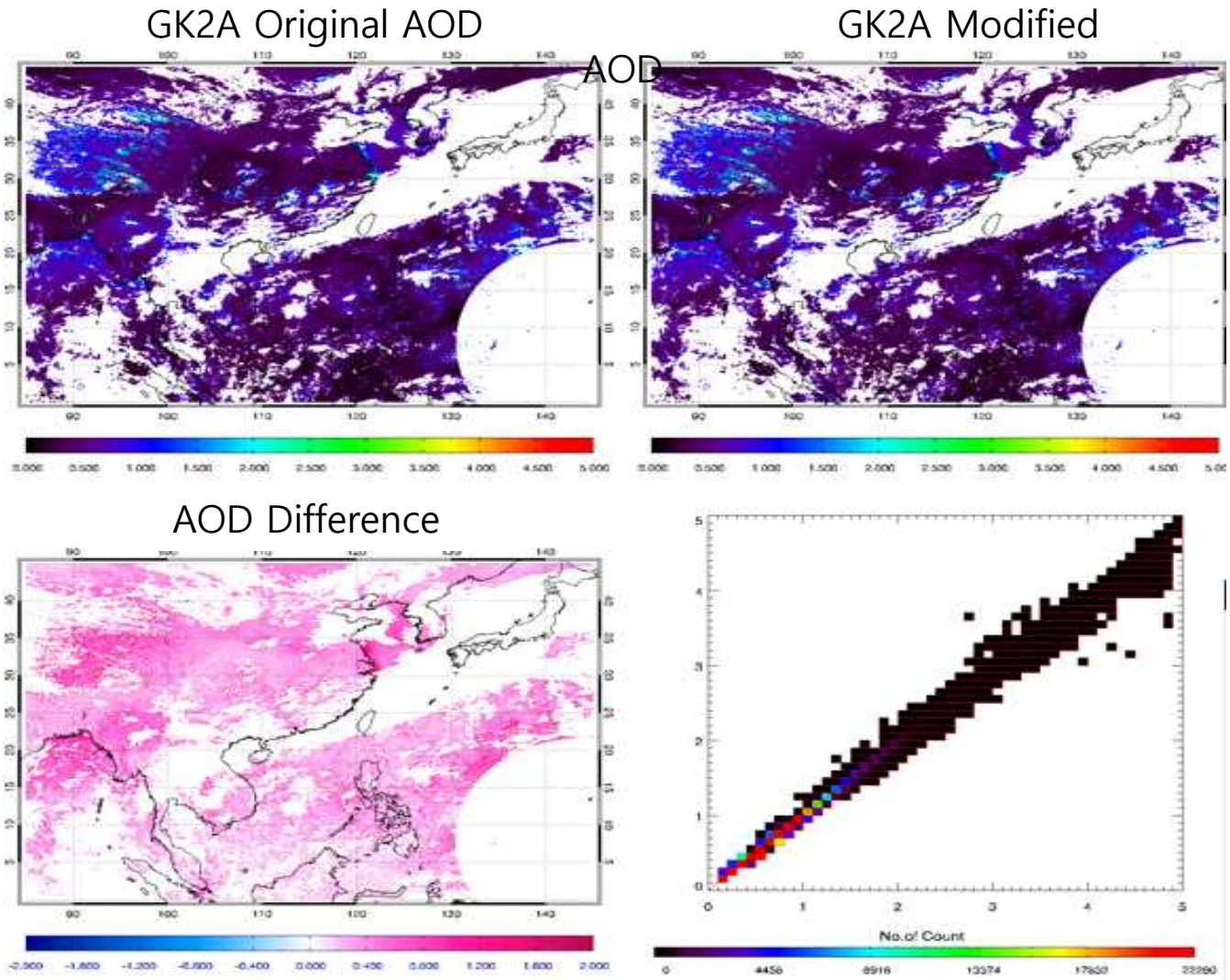
❖ Flow chart of modified GK-2A AOD algorithm



- We use the re-gridded GK2A SSA data and new Look-Up-Table from the aerosol model considering aerosol optical properties by aerosol type to calculate the modified AOD.

1-1. Development of AOD convergence technology

❖ Comparison between original AOD and Modified AOD (00UTC 29 April 2021)



- Modified AOD values increase a little in the Korean West Sea located in the Asian Dust belt in the Asian dust case(29 April 2021), but GK2A AOD data still need to update more.

1-2. Development of FOG convergence technology using GK-2A(AMI)/2B((GOCI2)

NMSC &
Kongju National University
(Prof. Myoung-Seak Suh)

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1-2. Development of FOG convergence technology

❖ Comparison of fog products for GK2A(AMI) and GK2B(GOCIⅡ)

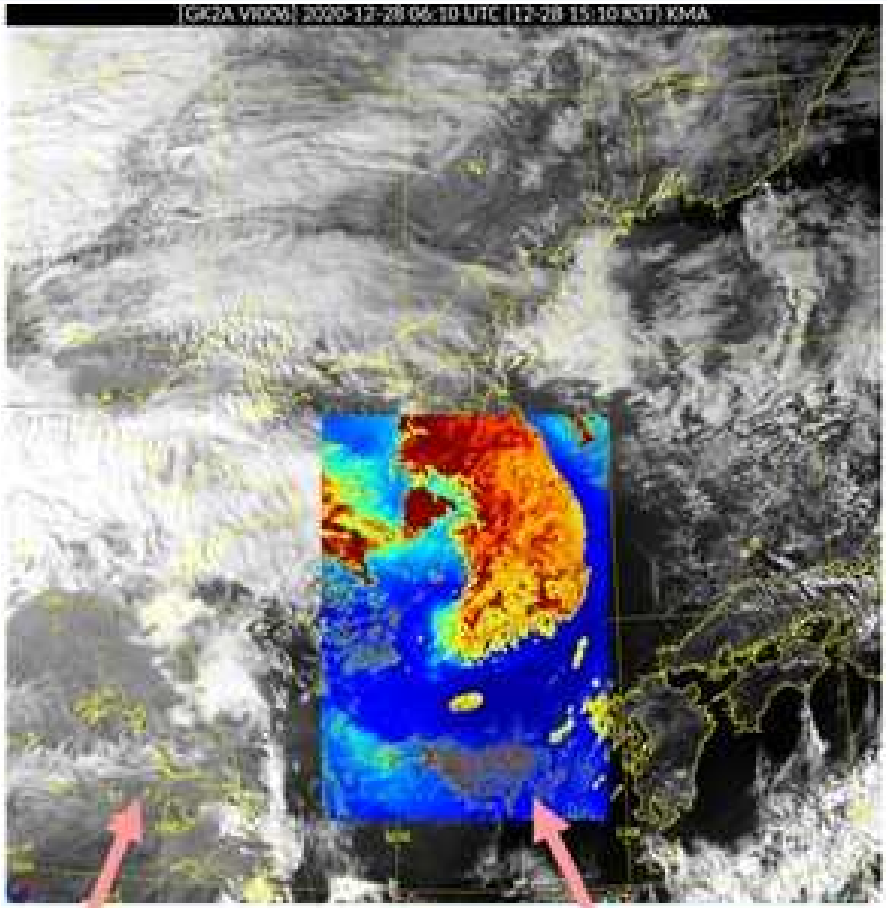
	GK2A/AMI Fog product	GK2B/GOCIⅡ $\rho_c(0.66\ \mu m)$	Goal
Frequency	**10 min**	1 h	**10 min**
Spatial resolution	500 m	**250 m**	**250 m**
Domain	Korean peninsula	Slot 7	Slot 7
Unit	Category	%	Category
Range of valid values	1: Clear 2: Middle or High Cloud 3: Unknown 4: **Probably Fog** **5: Fog** 6: Snow 7: Desert or Semi-desert	0~100	1: Non-fog 2: **Probably Fog** **3: Fog**

- Goal of this study is to make detailed 250 m resolution fog detection data every 10 minutes in the slot 7 area.

1-2. Development of FOG convergence technology

❖ The left figure is the Blending target area(7 slot area) and the figure on the right shows visibility meter data for quality control.

Target area (GEMS 7 slot)



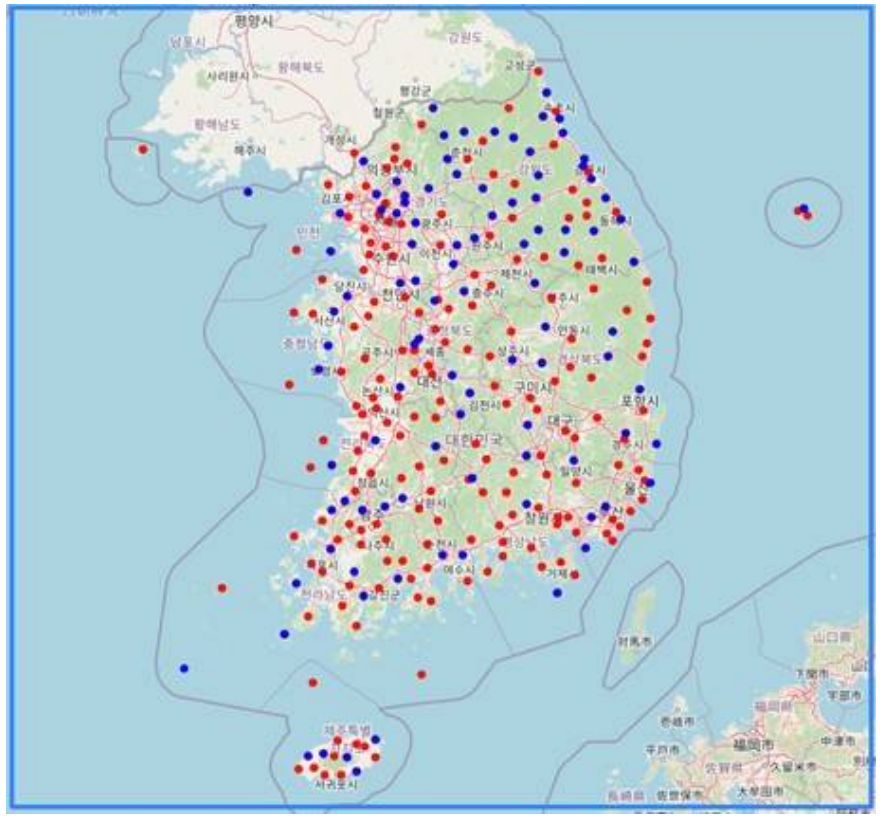
GK2A Korea Area

GK2B 7slot Area

The visibility meter data

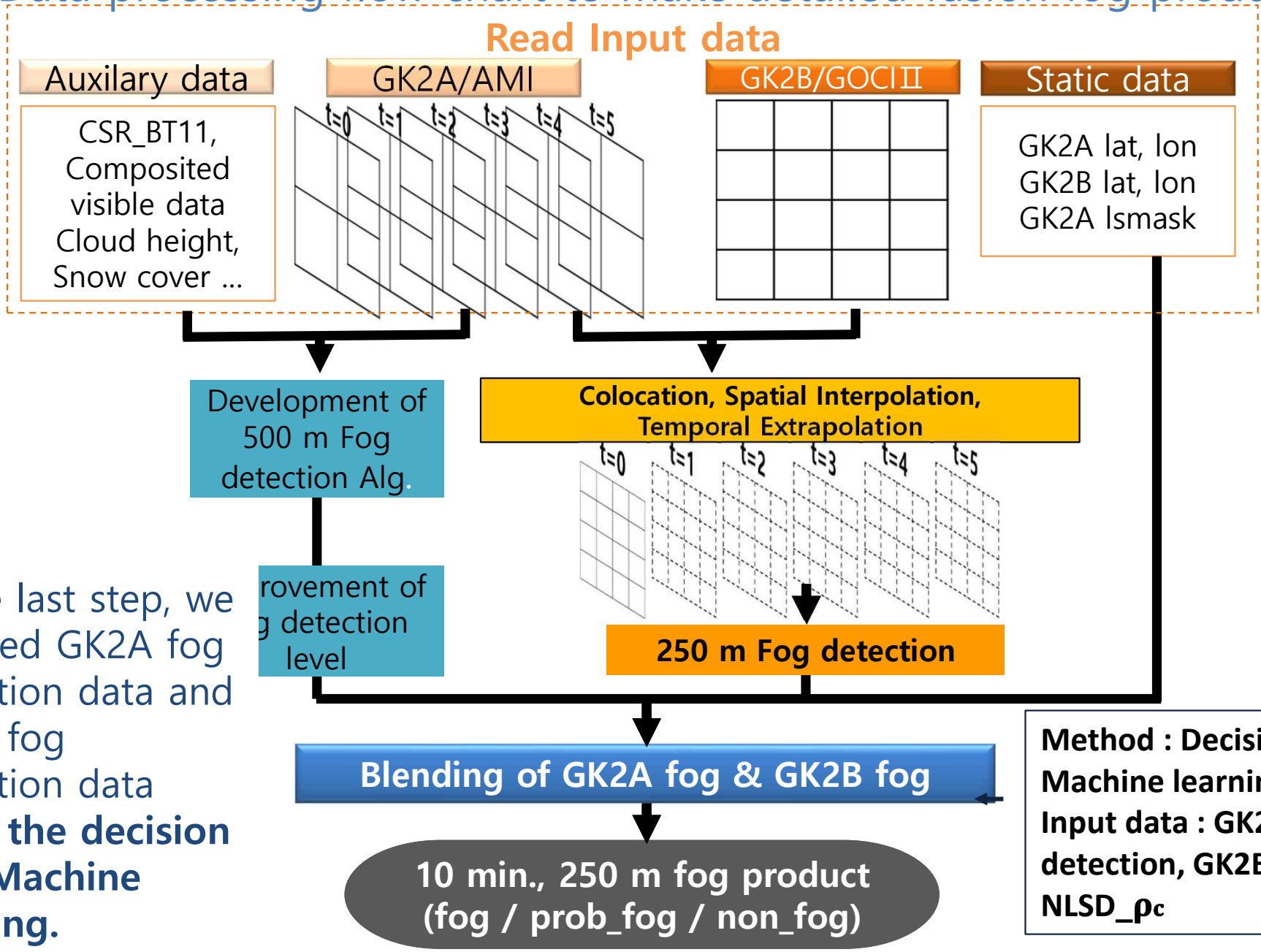
- Quality control of visibility data
- High-quality visibility data were used

※ selected stations (•) excluded stations (•)



1-2. Development of FOG convergence technology

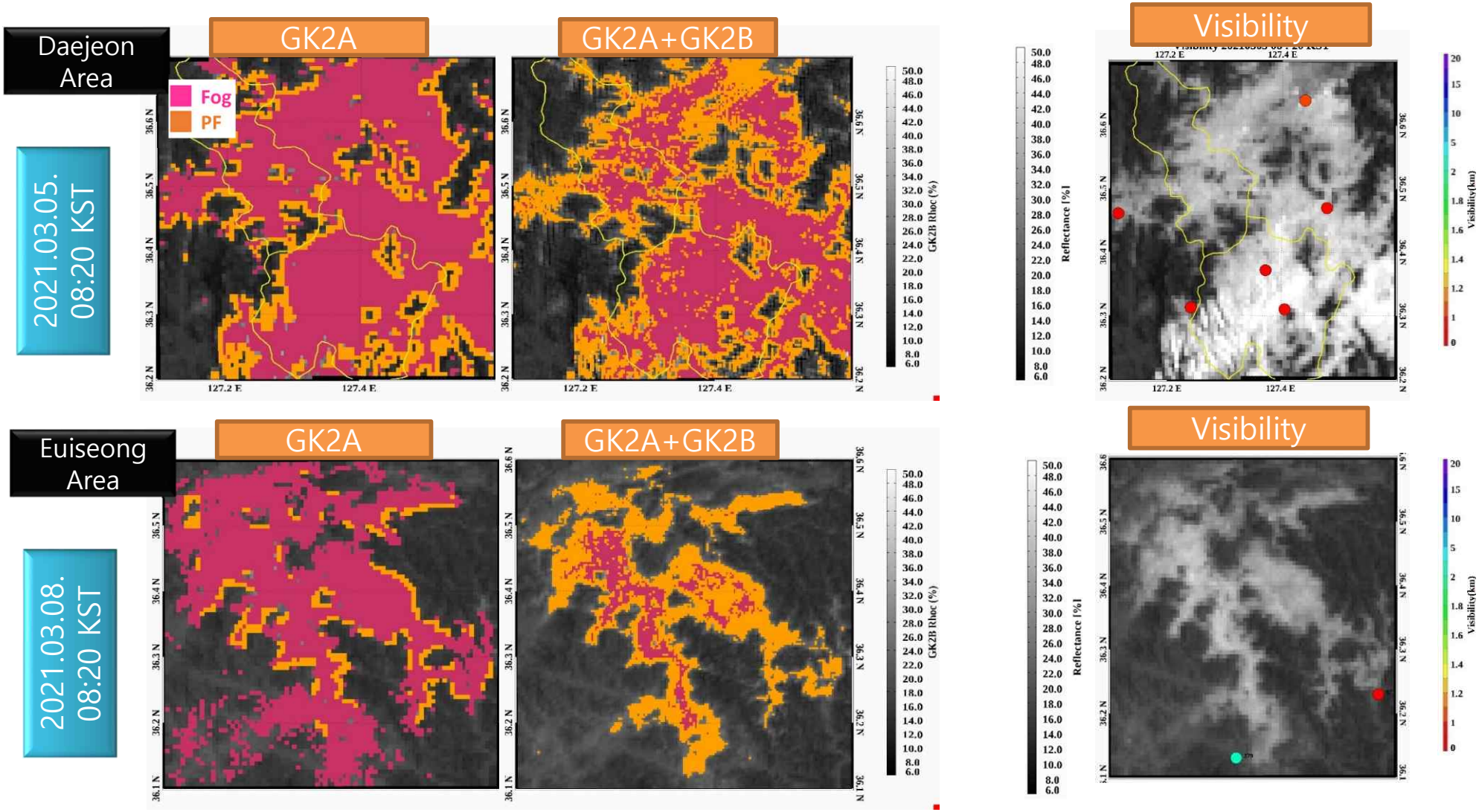
❖ Data processing flow chart to make detailed fusion fog product



In the last step, we blended GK2A fog detection data and GK2B fog detection data using **the decision tree Machine learning.**

Method : Decision tree of Machine learning
Input data : GK2A fog detection, GK2B ρ_c, NLSD_ρ_c

1-2. Development of FOG convergence technology



- The results are more details boundaries of GK2A/2B fusion fog detection are very similar to the high reflectance area of visible channel images, and The fog detection areas also looked a little more accurate in the GK2A/2B fusion fog detection products.

1-2. Development of FOG convergence technology

❖ This table shows the quantitative validation with visibility meter data

	POD		FAR		KSS		Bias		ETS	
	2A	**2A+2B**	2A	**2A+2B**	2A	**2A+2B**	2A	**2A+2B**	2A	**2A+2B**
2020. 12.28	0.32	**0.44**	**0.66**	0.73	-0.34	-0.29	**0.93**	1.64	0.20	0.20
2021. 02.07	**0.74**	0.63	**0.71**	0.79	**0.02**	-0.15	**2.58**	2.95	**0.25**	0.19
2021. 03.05	0.71	**0.73**	**0.44**	0.46	0.27	0.27	**1.25**	1.36	**0.46**	0.45
2021. 03.08	**0.84**	0.75	**0.72**	0.73	**0.12**	0.02	2.97	**2.79**	**0.27**	0.25
2021. 03.14	**0.87**	0.80	0.77	**0.58**	0.10	0.21	3.71	**1.92**	0.22	**0.37**
2021. 04.17	0.23	0.23	**0.80**	0.83	**-0.57**	-0.60	**1.15**	1.38	**0.11**	0.10
Mean	**0.67**	**0.68**	**0.64**	**0.63**	**0.03**	**0.06**	**1.87**	**1.80**	**0.31**	**0.32**
SD	**0.28**	**0.24**	**0.14**	**0.16**	**0.34**	**0.37**	**1.17**	**0.73**	**0.13**	**0.15**

- The results are a little bit better than before fusion in the POD, FAR and Bias about mean

2. Road weather service based on Satellite data

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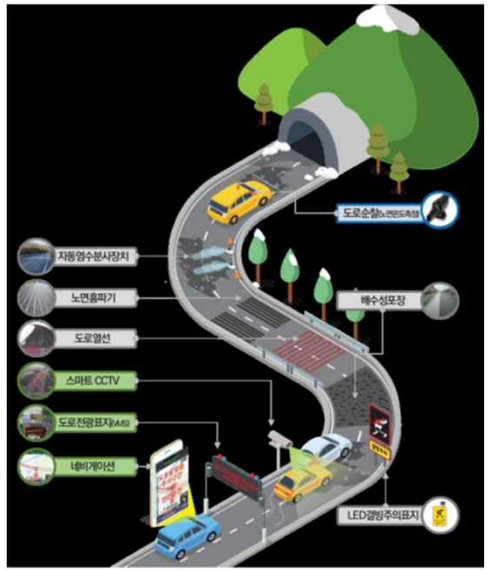
2. Road weather service based on Satellites

❖ The 4 types of harsh weather impact to traffic jam and accident



- Accident rate according to road surface conditions

Road Surface Condition	Accident Rate
Dry bare surface	0.19 – 0.23
Wet, bare surface	0.26 – 0.29
Packed snow	0.50
Loose snow	0.48
Black ice	0.85

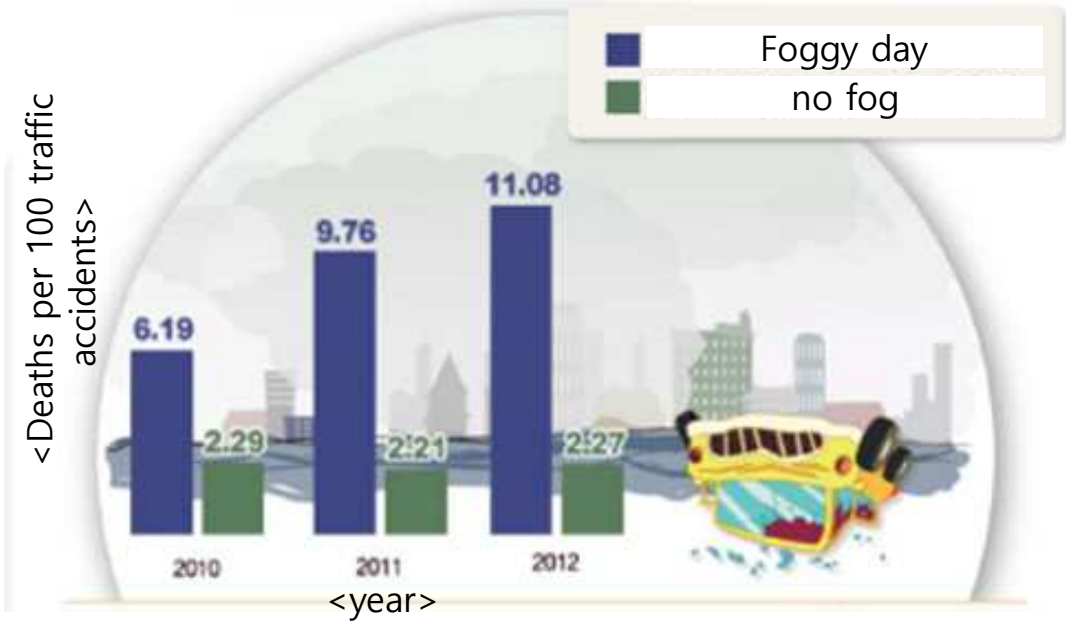
Note: The accident rate is based on personal injuries per million vehicle miles. Data source : Korea Road Traffic Authority

It shows that the accident rate is very high when the road is covered with black ice.

2. Road weather service based on Satellites

❖ Relationship between fog and traffic accident

Change of traffic accident deaths in foggy day



Road Traffic Act

Drivers should reduce speed by 50% when visibility is less than 100 meters (The vehicle rate which obeys the act is only 0.15%)

- Results of the actual measured vehicle speeds on the Korean highway according to visibility conditions.

Visibility condition	Measured vehicle speeds
Clear day	103.3 km/h
Visibility 50~100m by fog	96.8 km/h
Visibility below 50m by fog	93 km/h

Data source : Korea Road Traffic Authority

2. Road weather service based on Satellites

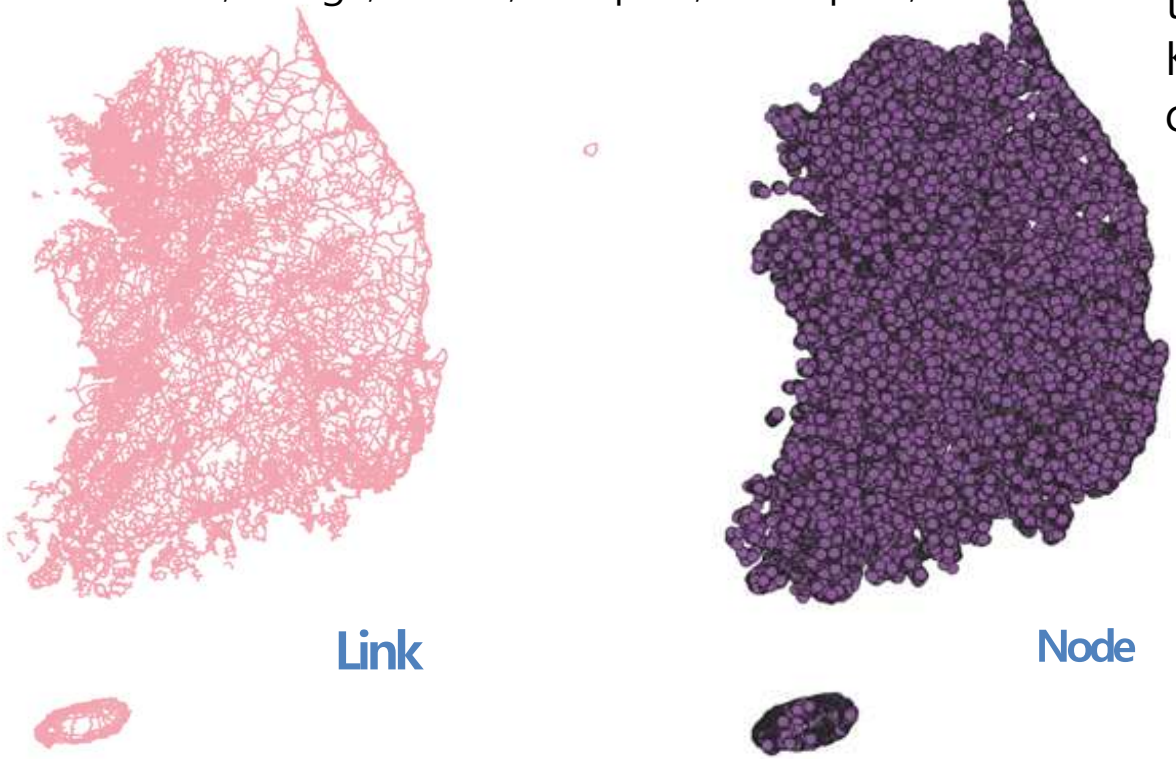
❖ Intelligence transportation system and node-link data

Road Rank
Highway (composed of 9452 links and 300187 nodes)
City national road
National road
Provincial road etc.

Road Type
General road, bridge, tunnel, overpass, underpass, etc.

ITS* National Transport Information Center
* Intelligence transportation System

The ITS provides real-time node-link data(its shapefile format), which has traffic jams, arrival time, and road weather, to Korean all car navigation companies.



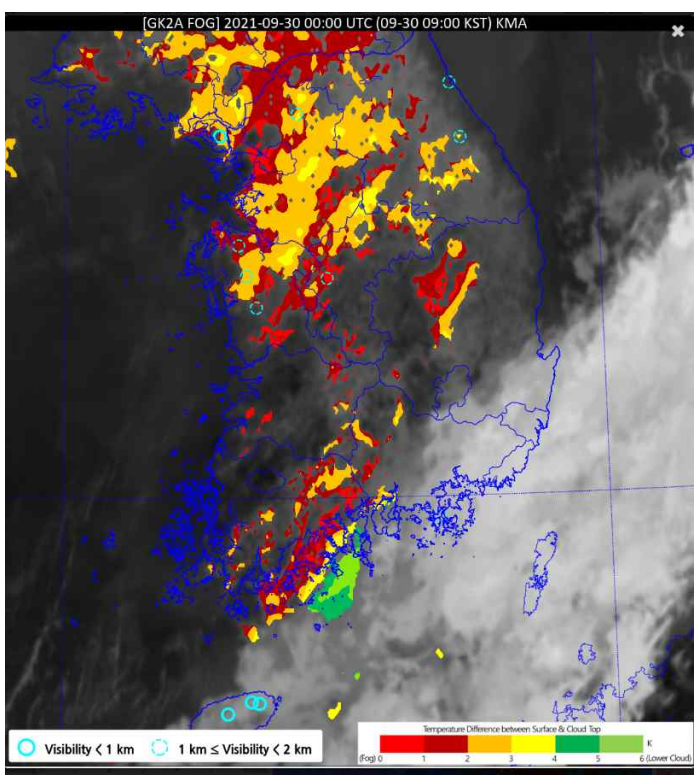
Link

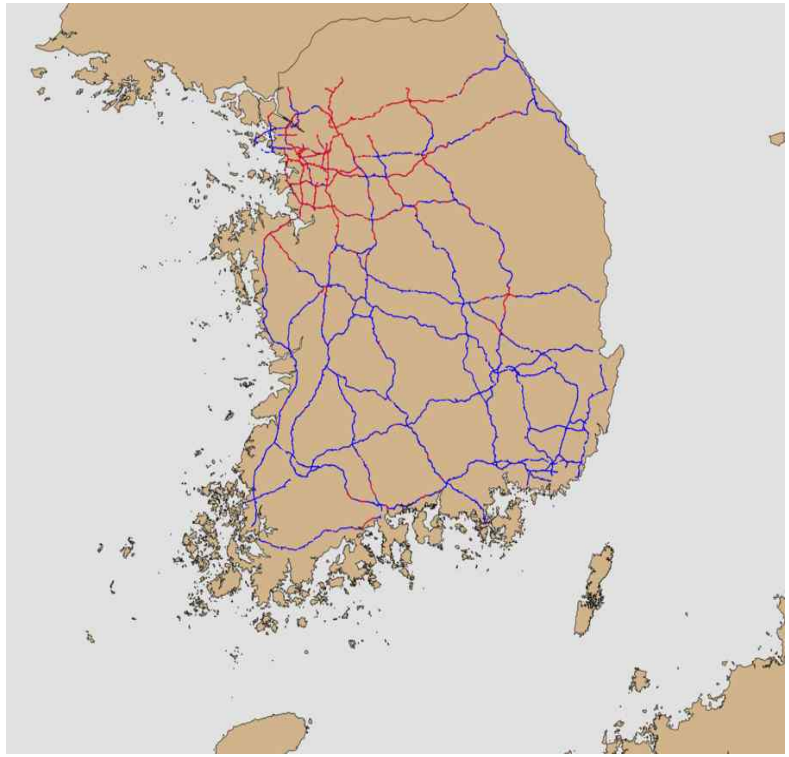
Node

2. Road weather service based on Satellites

❖ A case test for converting GK2A fog detection data to node-link data in the radiation fog case in the morning of Autumn. <09:00 LST 30 September 2021>

Adaptation section : All of 26 Highways in Korea (with 9,452 links and 300,187 nodes)
Method : lat./long information of 300,187 nodes match with the closest pixel data of GK2A fog detection product.





※ It is necessary to select a key node point to reduce the node number for providing real-time fog information every 10 minutes.

2. Road weather service based on Satellites

❖ The construction project of road weather observatories on the Central Inland Highway was started by KMA in 2022.

the Central Inland Highway

The project constructs 13 observatories along the Central Inland Highway(302 km) to measure real-time black ice, fog, wind, etc. on the road.

The final mission of the program is to construct of total 165 sites on 4,456km of 26 highways until 2025 for road weather service.

NMSC needs these preparations

- **Data validation** (GK2A .vs. visibility data of road weather sites)
- **Threshold value optimization** of GK2A fog detection product (1km to 200m or 100m of visibility meter)
- **Expended road weather service** applied to all road ranks (This requirement comes from the navigation company)

3. Future demands for GK series

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Example of future demands for GK-series

❖ Global real-time weather fields based on Meteorological Satellites (not forecasting data by NWP)

<Motivation>

- Operation Dawn of Gulf of Aden: It is a kind of Korean military operation for pirate suppression at the Gulf of Aden of Somalia in 18. January 20

- Military operation for COVID vaccine transportation in 2020.

<Application Area>

- Department of Defense, Air Force

<Korean Warship 'Choiyoung' of the Operation Dawn>

❖ Aviation Weather Service optimized to UAM(Urban Air Mobility) and Drone at the outside region of the controlled airspace

<Motivation>

- Increase in drone use and commercialization of Urban Air Mobility
- Extended adaptation of Flexible Use Airspace

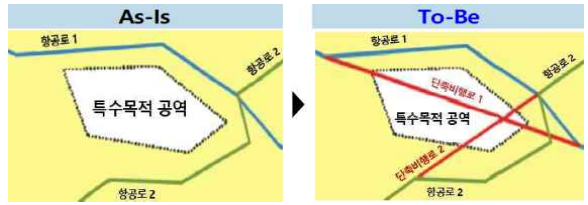
(This means that the drone can fly more freely everywhere because of the release of the strict flight ban areas)

- Transformation to digital aviation information system(DAIM)

<Application Area>

- Hyundai Motor, Ministry of Land Infrastructure and Transport, Air Force

<UAM concept image of Hyundai corp.>



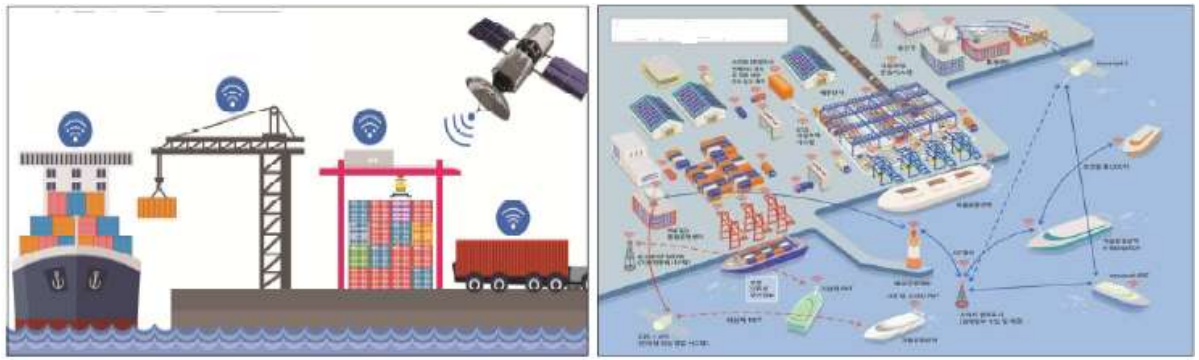
<Concept of Flexible Use Airspace>

Example of future demands for GK-series

❖ High-resolution fog and wind gust products to support severe weather for digital harbor

- The digital harbor concept is a kind of port with an automatic logistics processing system. And it is also a complex harbor that combines marine sports and culture based on AI, Intelligent CCTV, sensors, and IoT.

<Application Area>
- Ministry of oceans and Fisheries



<Digital harbor concept by Korea Ministry of oceans and Fisheries>

Thank you

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