



KMA plans for AI/ML exploitation

Presented to CGMS-51 Plenary day 3

CONTENTS

- NMSC/KMA intends to develop a strategic action plan, building on existing experience and facilitating the exploitation of satellite data including GK2A etc. through the AI/ML potential, understanding its limitation and strengths.
 - AI/ML has proven its potential for satellite in key action that could be good starting point to identify priorities for NMSC/KMA roadmap.
 - We made a roadmap from 2022 to 2024 which is composed of experimental and feasibility research projects. This can be pre-phase of GK5(follow-on of GK2A) products development.
- KMA started to operate “Cloud based data hub system” to enhance accessibility and usage of various meteorological and climate data including satellite data for external users in March 2023.
 - Consumer-customized APIs, established as an open platform that can create added value by supporting the decision-making of the country and society.
 - Data analysis platform for users. Applied cloud technology to provide users with computing resources, meteorological and climate data, software (R, Python, etc.) required for data analysis, and visualization analysis functions.

Development Perspectives for AI/ML at NMSC/KMA

- ✓ Ex. Forecasting mesoscale system life cycle with hazardous weathers.

Now-casting & short-term forecasting

- ✓ Ex. Dust detection, fire detection, cloud detection etc.

Feature detection

High quality grid products Proxy data

- ✓ Ex. Point to array data
- ✓ Ex. Proxy VIS(Radar) data and SR data

Improving decision making processes

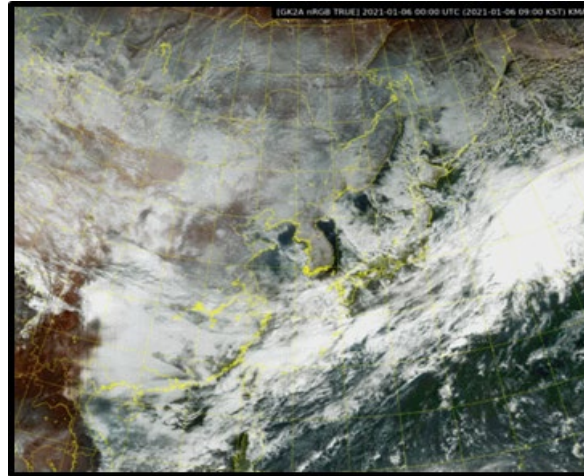
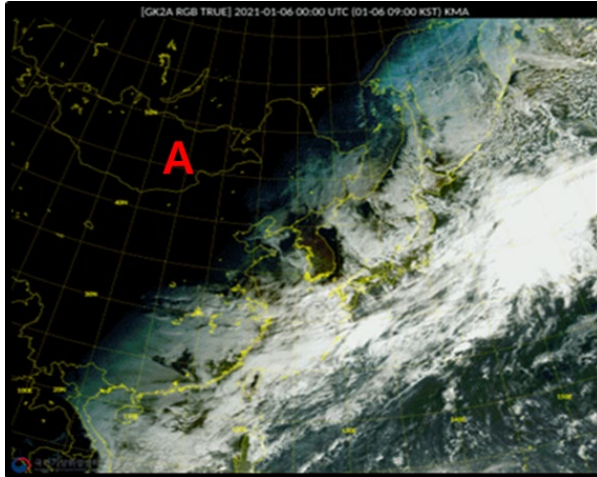
- ✓ Ex. Correct ensembles, tailored information



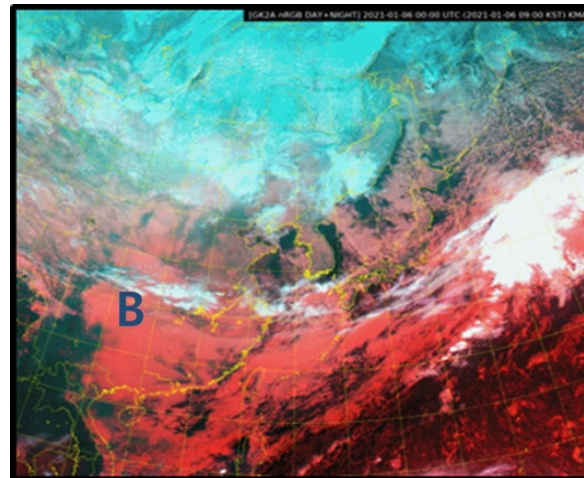
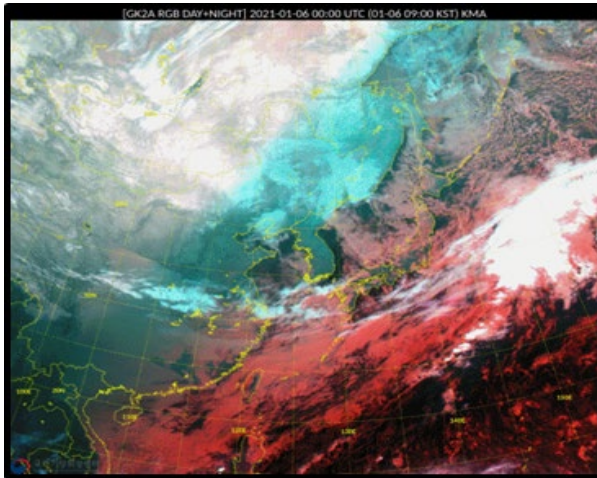
[Roadmap of AI/ML at NMSC/KMA from 2022 to 2024]

	2022	2023	2024
Object based Convective Initiation	<ul style="list-style-type: none"> operational product Improvement of AI based model for Convective Initiation 		
WV forecast Images	<ul style="list-style-type: none"> Feasibility study of satellite WV forecast image (+6hr) 		
Typhoon analysis information	<ul style="list-style-type: none"> Development of AI based model for estimation of intensity & center location of Typhoon using GK2A data. 		<ul style="list-style-type: none"> Update of AI based model for typhoon analysis information
Higher quality grid satellite products	<ul style="list-style-type: none"> Development of AI based model for evapotranspiration, soil moisture, insolation using GK2A, etc. 	<ul style="list-style-type: none"> Development of AI based model for all sky SST and all sky LST using GK2A, etc. 	<ul style="list-style-type: none"> Monitoring system for drought over Korean peninsula using AI based products
Proxy data	<ul style="list-style-type: none"> Development of AI based model for estimation of Nighttime proxy visible data, Proxy GPM data and Proxy radar data 	<ul style="list-style-type: none"> AI based 3D cloud information for aviation 	
Super-Resolution Satellite products	<ul style="list-style-type: none"> Development of AI based model for estimation of super-resolution LST 	<ul style="list-style-type: none"> Development of AI based model for IR channels including 3.9 used for Fog detection, Fog RGB image. 	<ul style="list-style-type: none"> Feasibility study for application of super-resolution data

Night time Proxy VIS data with CGAN, AI technique



Day-Night RGB image



Original RGB image
Coordination Group for
Meteorological Satellites



CGAN based RGB image

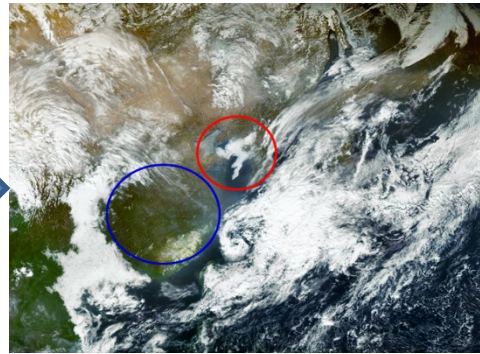
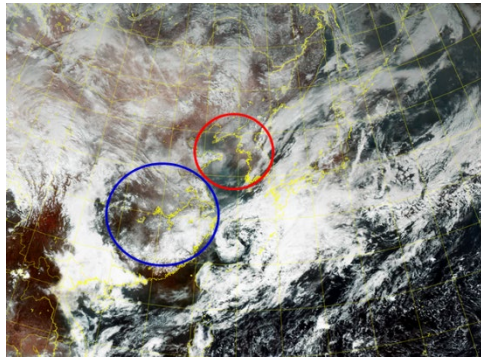
- RGB images* with proxy visible data has been provided operationally every 10 min for 24 hours in NMSC/KMA.

* true color RGB image & day-night RGB image

- **[Strength]** Providing nighttime advanced as well as beautiful image

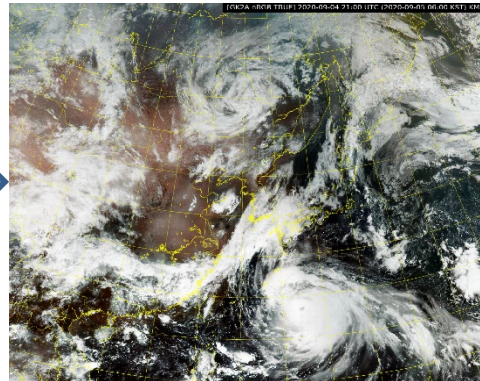
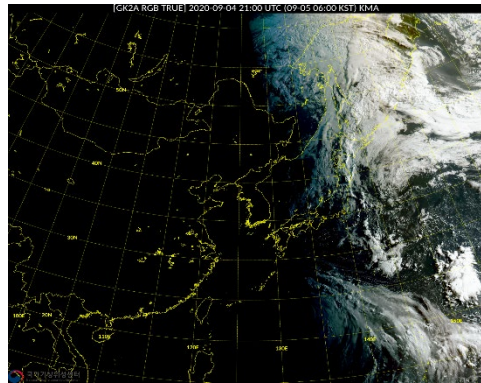
- **[Limitation]** Because proxy visible data is based on IR, when surface cooling occurs, clear area can be misidentified as cloud and snow, especially for wintertime. Dust or haze is not seen well in proxy RGB images during nighttime.

Proxy RGB images application using proxy VIS data



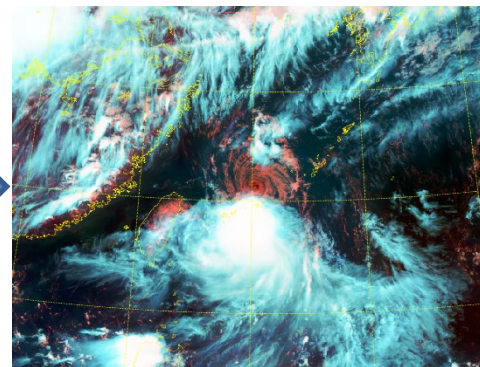
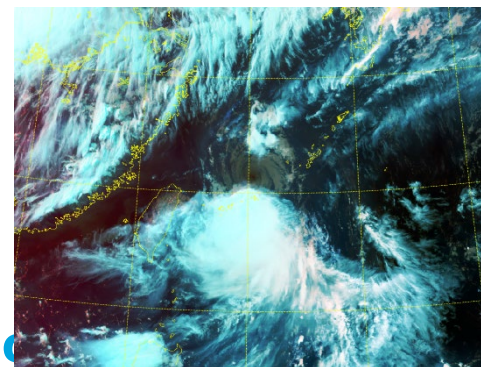
[Proxy VIS data improvement]

Red circle shows more distinct fog boundary and blue circle shows the removal of wrong cloud area with white color in previous images.



(left) Before sunrise image for 2020 Typhoon 「HAISHEN」

(right) Despite of nighttime, proxy true color RGB image shows typhoon center and size of typhoon and low pressure accompanied cloud band.



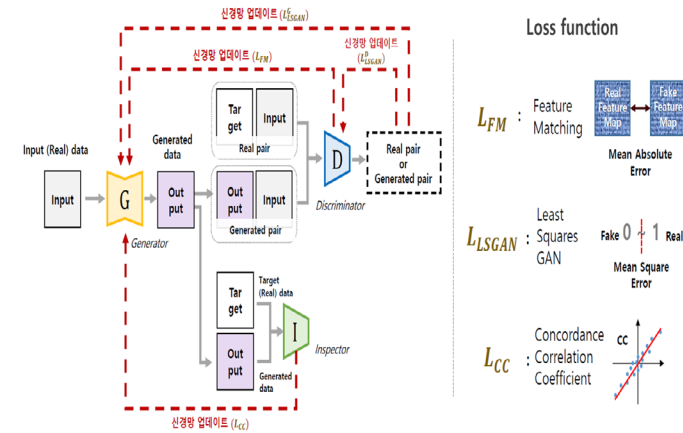
(left) After sunset image for 2021 Typhoon 「OMAIS」

(right) Despite of nighttime , proxy day-night RGB image shows the low cloud vortex of typhoon center more distinctively than original image (dark brown → red)

AI based proxy radar from GK2A/AMI data in East Asian region

New approach for users and AI application for weather support

- ❖ We have **no radar observation in western and southern part of Korea** as shown in below figure which is very significant area for monitoring severe weather such as typhoon or developed convective clouds crossing this area.
- ❖ Proxy radar is estimated from GK2A data by using AI technique (Pix2Pix(CGAN)) for no ground radar observation and provided to forecaster every 10 minutes.



2022.07.30. 03 UTC

09 UTC

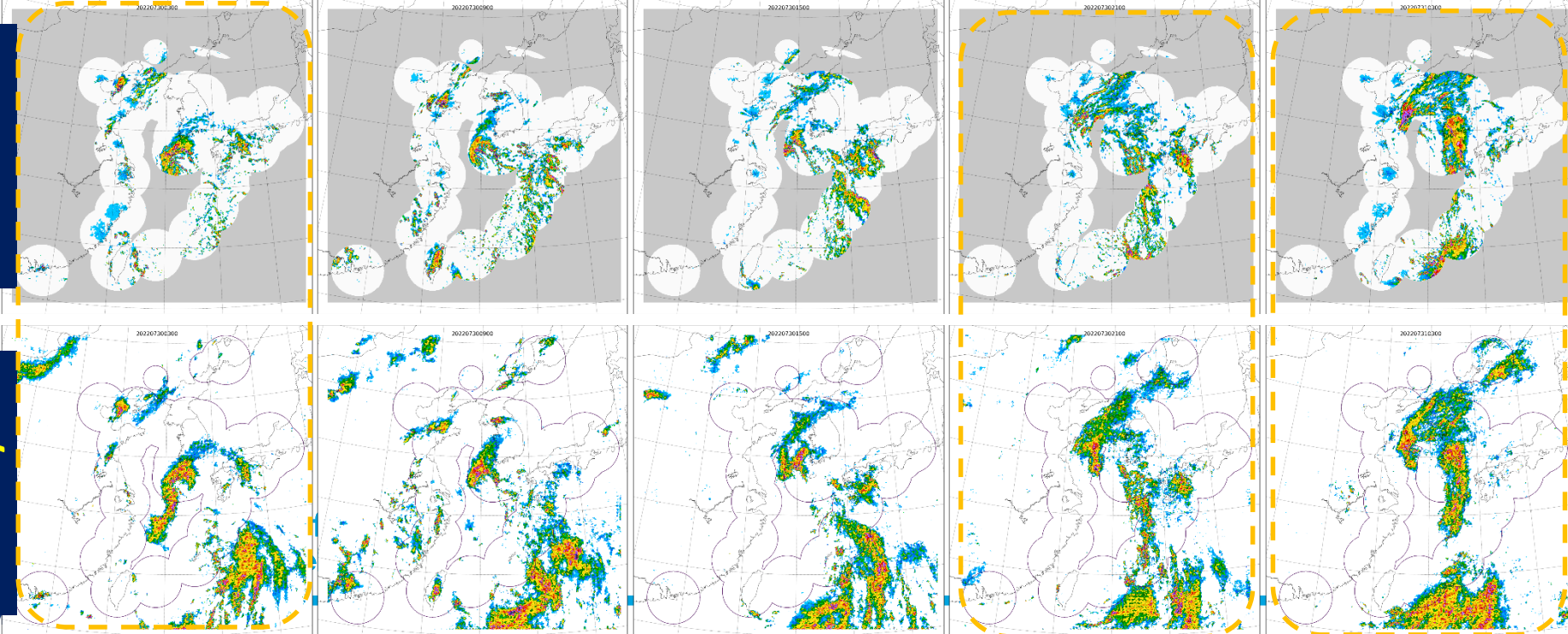
15 UTC

21 UTC

07.31. 03 UTC

Radar

Proxy



AI based proxy radar from GK2A/AMI data in East Asian region

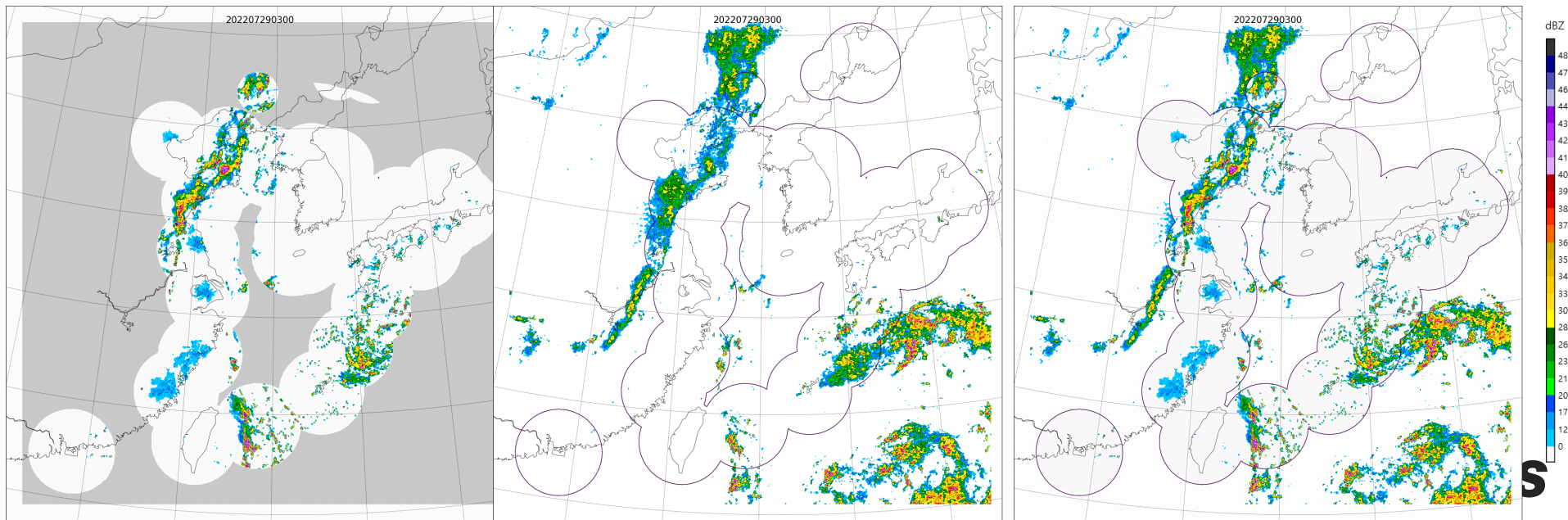
New approach for users and AI application for weather support

- ❖ **Validation Results with ground radar reflectivity(June, 2022)** R: 0.6/RMSE:6.0 dBz/Bias:0.3dBZ
- ❖ Proxy radar tends to overestimate in terms of presence or absence of precipitation, therefore false alarm ratio is large and underestimate in terms of intensity of reflectivity, especially for stratus cloud with heavy rain which is similar result to IR based precipitation.
- ❖ It still needs optimization of AI model with the more tailored dataset

**Composited
Ground Radar (<240km)**

Proxy Radar

Ground radar + Proxy radar



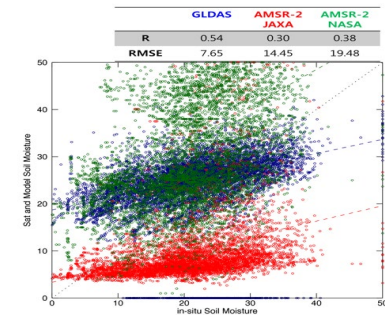
High quality grid satellite products

- We found AI products has better accuracies than those of conventional algorithm
- High quality AI products make important role in evaluating qualities of in-situ measurements and reducing budget for their maintenance.
- We will expand AI technique for more in-situ measurements including GHG (CO₂) and estimate long-term AI based products (EVT, SM, LST, SST etc.) for supporting climate mission such as drought or heatwave over Korean region.

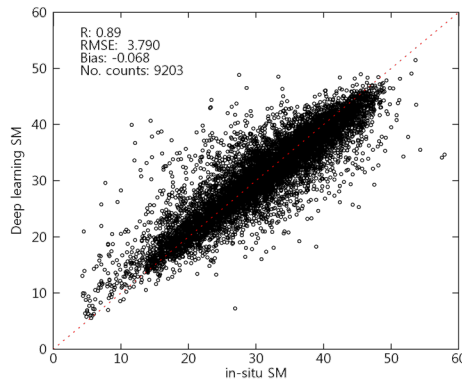
Products	Operation	Resolution	Area	Accuracy(RMSE) (Old→New)
Cloud Amount	Nov. 2021	10 min. / 2km	Korea	4.59→2.94
Evapo-transpiration	March, 2021	day / 1km	Korea	1.22→0.66 (mm/day)
Insolation	Sept. 2021	1 hour / 2km	Korea	0.24→0.17 (MJ m ⁻²)
Soil Moisture	June 2022	day / 500m	Korea	11.63→4.3 (%)
UV index	Feb. 2023	1 hour / 2km	Korea	0.52

High quality grid products (point to array products) with AI

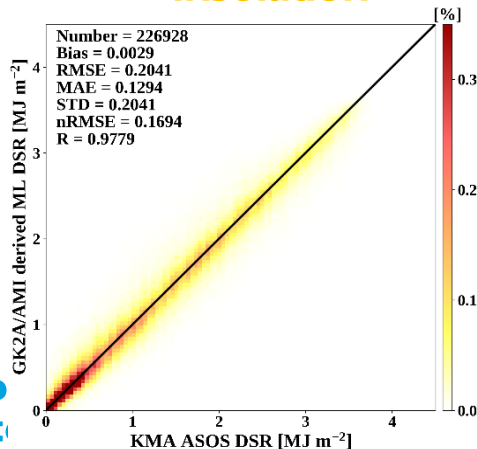
- By using in-situ measurements / Ex. SM, EVT, INS, CA etc.
- [Strength] Satellite can observe for in-situ sparse or absent area
- To expand for more in-situ measurements including GHG (CO2)



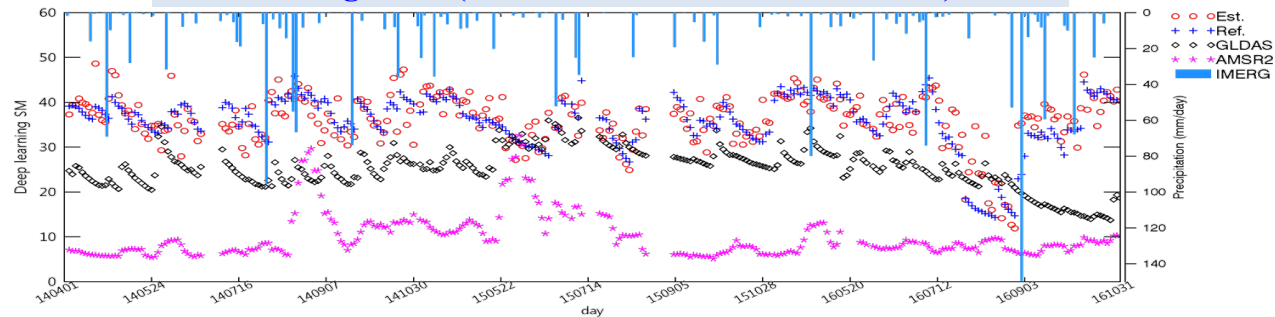
• Soil Moisture



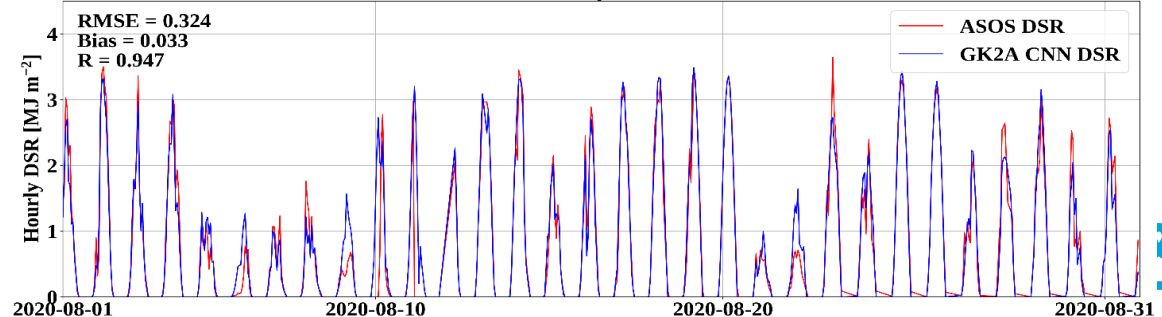
• Insolation



Youngcheon (R: 0.87/RMSE: 3.10/Bias: -0.157)



Time series of hourly DSR at Station 115

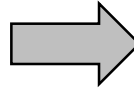
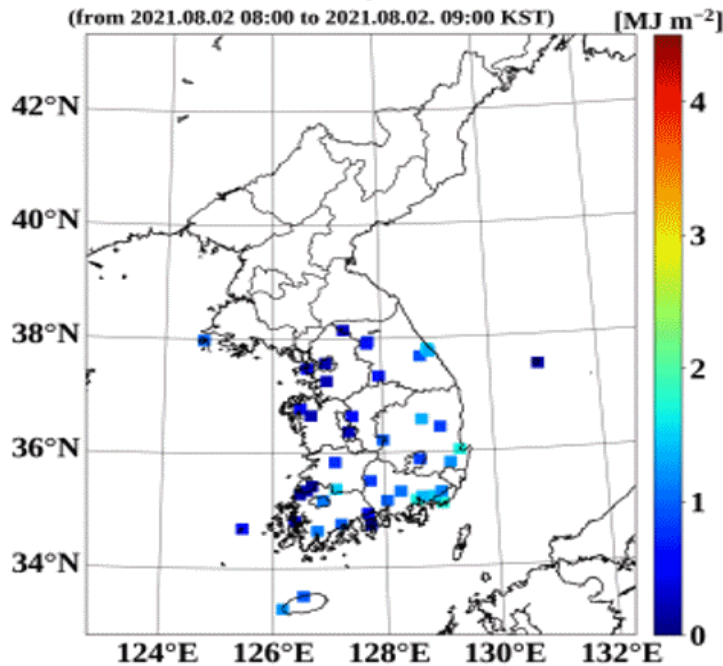


CNN generated Insolation using GK2A CNN : Convolutional Neural Network

KMA ASOS 44 ground-observation sites

- Spatial resolution : about 67 km x 67 km

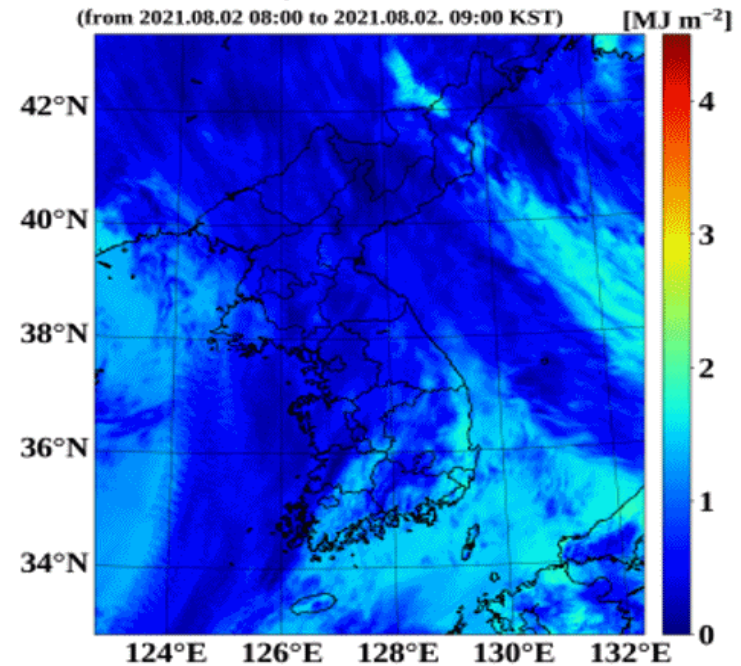
(a) KMA ASOS hourly DSR



CNN generated GK2A INS

- Spatial resolution : **2 km x 2 km**

(b) GK2A hourly DSR

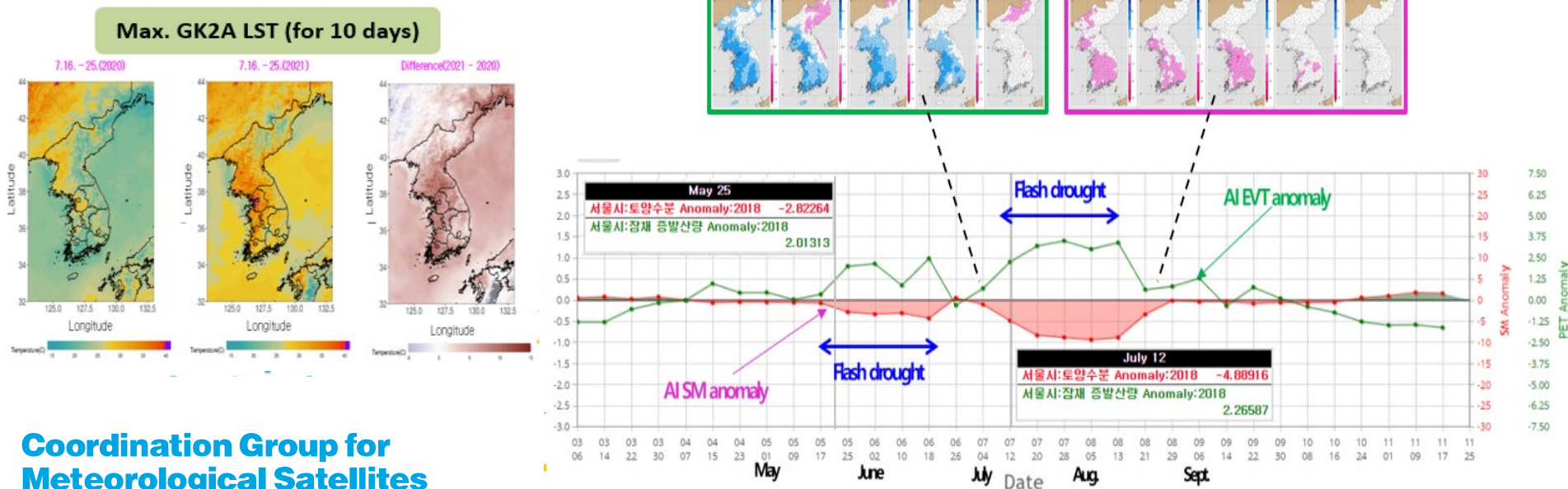


- ❖ High quality, high spatial satellite based INS data can be utilized for climatological map and is also useful for supporting Solar industry.

**Coordination Group for
Meteorological Satellites**

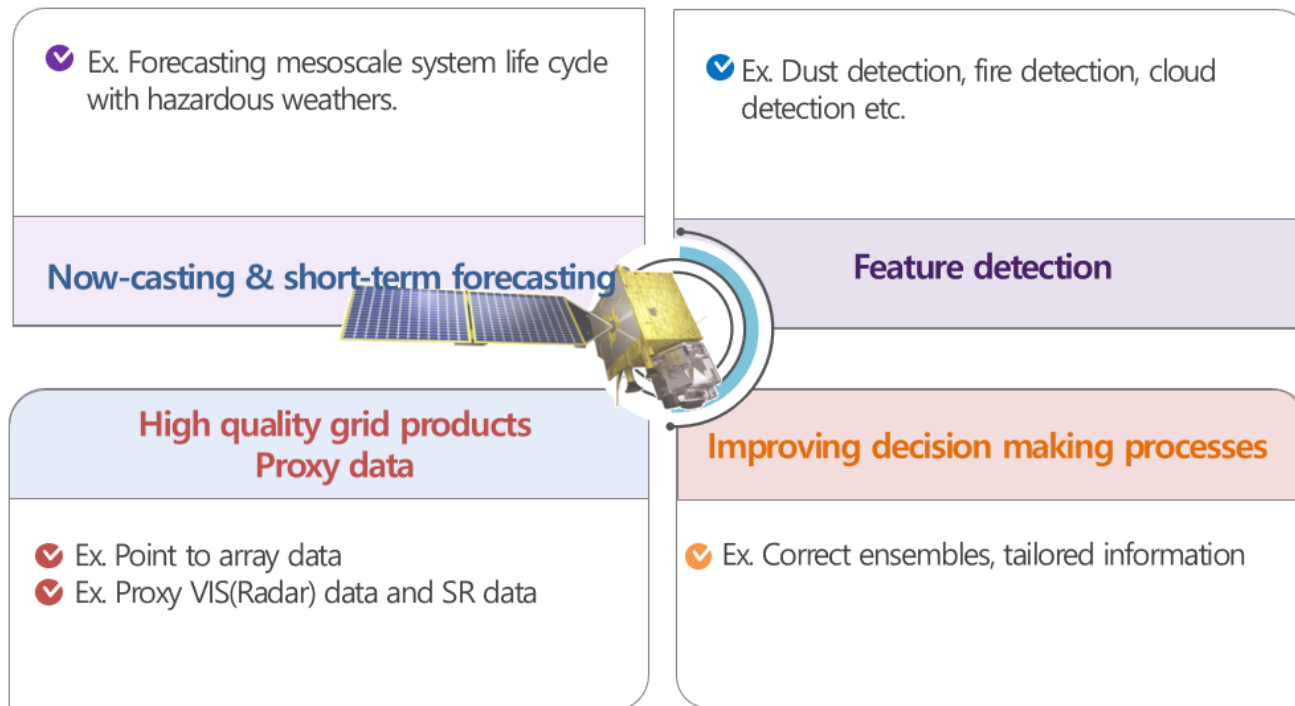
Monitoring flash drought with anomaly of AI based SM and EVT

- ❖ KMA has been interested in **flash drought due to heat waves (heat-wave type flash drought)**. It is characterized by a lack of rainfall, high temperatures and low soil moisture that can lead to crop failure, water shortages, and increased risk of wildfires.
- ❖ We experienced **an extreme heat wave in the summertime of 2021** as shown in left side figure.
- ❖ We reproduced AI based EVT and SM products from April, 2010 and calculated anomaly values by using 10 years AI products and used for monitoring drought.
- ❖ As shown in below timeseries plot, **anomaly of SM and EVT represented negative and positive signal, respectively from July to Aug.** It means evapotranspiration increased and soil moisture decreased due to heat waves for an averaged year.



SUMMARY

1. Continue to explore promising AI products through cooperation of CGMS members.
2. Try to improve AI products by operational utilization for weather and climate mission.
➔ Need to make a strategic action plan for AI application in near future.



Thank you