

Application of the Geo-KOMPSAT image in detecting precursors of developing heavy rain cloud in summer season

3, November 2023

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Background & Purpose

- ❖ (Background) Since GK-2A was launched in December 2018, KMA was able to monitor weather and climate phenomena with enhanced satellite products which have short measurement cycle and high spatial resolution.

To support Increasing needs of mitigating weather disasters for severe weathers, NMSC/KMA has developed satellite-product based guidance for heavy rainfall forecasting.

> GK-2A : Geo-KOMPSAT-2A (*Geostationary KOrea Multi Purpose SATellite -2A*)

- ❖ (Purpose) Introduction to analyzing process and examples for supporting heavy rainfall forecasting using GK-2A satellite products including checklists of precursors phenomena with available weather data.

Heavy rain damages



Landslide, Aug. 11, 2022.



Flooding in agricultural land, on Jun 9, 2023



Flooding in residential area, Aug. 10, 2020



Record breaking rainfall in 115 years. Greater Seoul on Aug. 8, 2022.



Inundation into underpass, Jul. 15, 2023.

Summer season Monthly Precipitation (mm/month)

2019

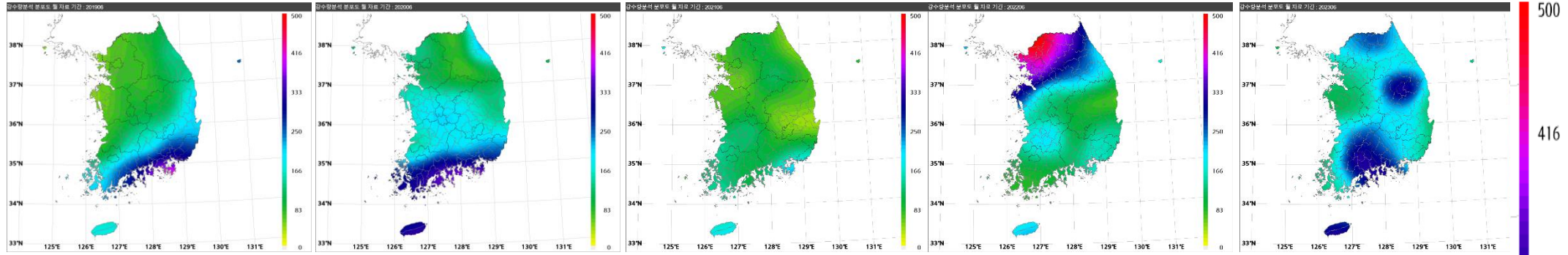
2020

2021

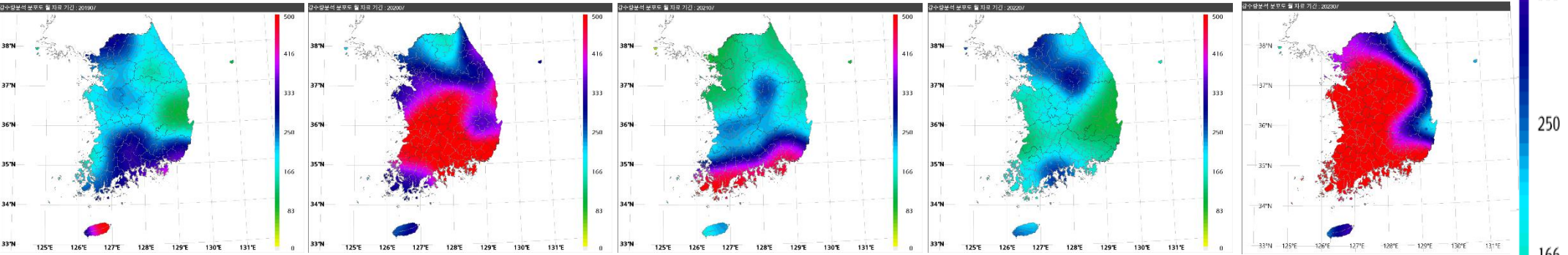
2022

2023

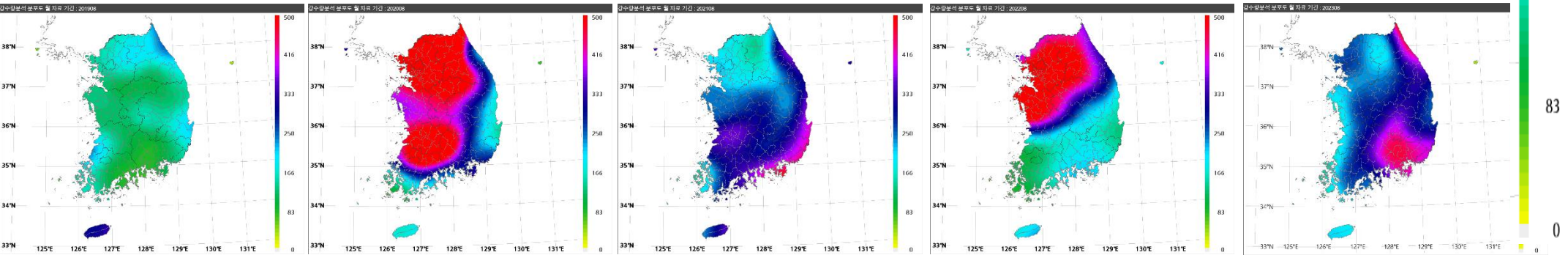
Jun



July



August



Typhoon events

YY	Affect	Landing
19	7	1
20	4	2
21	2	1
22	4	1
23	2	1

Survey of heavy rain case

< Heavy rain >

- Data from Automated Surface Observing System

- ✓ 0.5mm unit rain gauges
- ✓ 95 stations in the Republic of Korea
- ✓ June ~ August (2019 ~ 2023)

- Criteria for of Heavy rain watch and warning

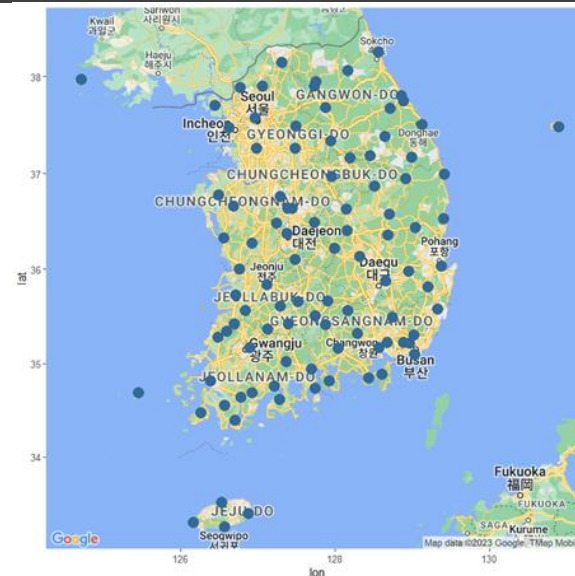
- ✓ Watch : **rainfall \geq 60mm/3-hour or \geq 110mm/12-hour**
- ✓ Warning : rainfall \geq 90mm/3-hour or \geq 180mm/12-hour

60 cases

< To detect precursors of heavy rain cloud >

- GK-2A products

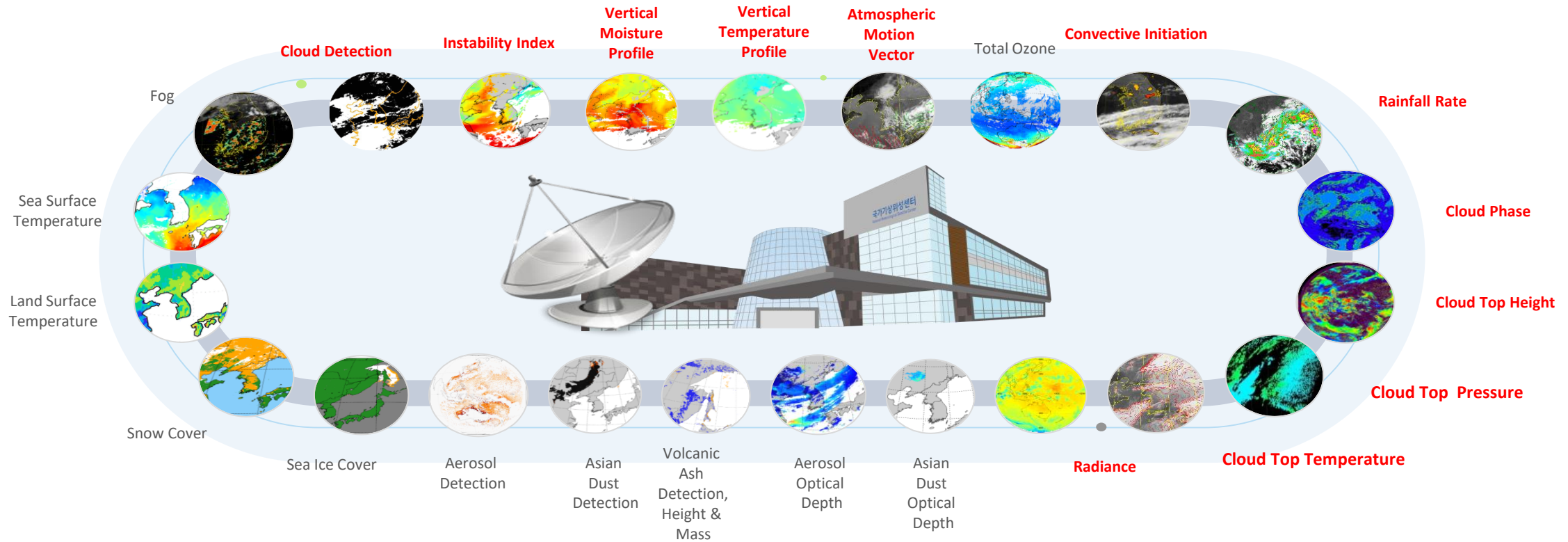
- ✓ Primary : Cloud detection, Instability Index, Moisture/Temperature profile, Atmospheric Motion Vector, convective initiation, rainfall rate, cloud phase, cloud top(height, pressure, temperature)
- ✓ Secondary : Overshooting top detection, total precipitable water



ASOS 95 Sites

GK-2A/AMI Geophysical Products

Primary Products



Secondary Products

- Fire Detection
- Vegetation Index
- Vegetation Green Fraction
- Surface Emissivity
- Surface Albedo

- Snow Depth
- Ocean Current
- **Cloud Type**
- **Cloud Amount**
- **Cloud Optical Depth**

- Cloud Effective Radius
- Cloud Liquid Water Path
- Cloud Ice Water Path
- Cloud Layer/Height
- Probability of Rainfall

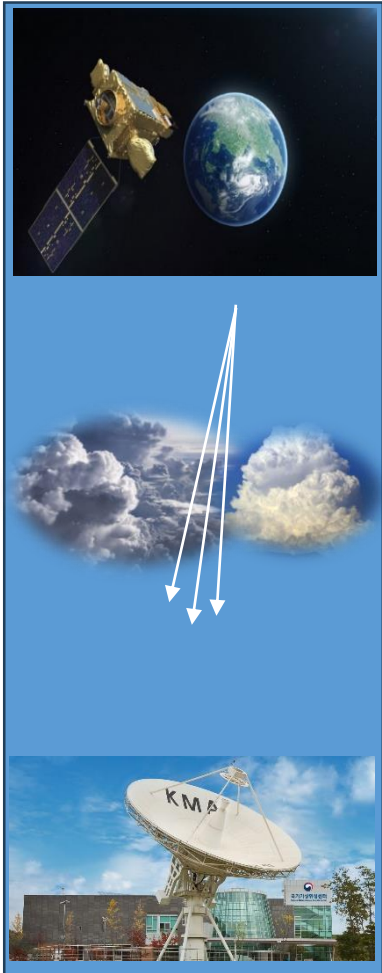
- **Rainfall Potential**
- Aerosol Particle Size
- Visibility
- Absorbed SW Radiation (SFC)
- Downward SW Radiation (SFC)

- Reflected SW Radiation (TOA)
- Downward LW Radiation (SFC)
- Upward LW Radiation (SFC)
- Upward LW Radiation (TOA)
- Aircraft Icing

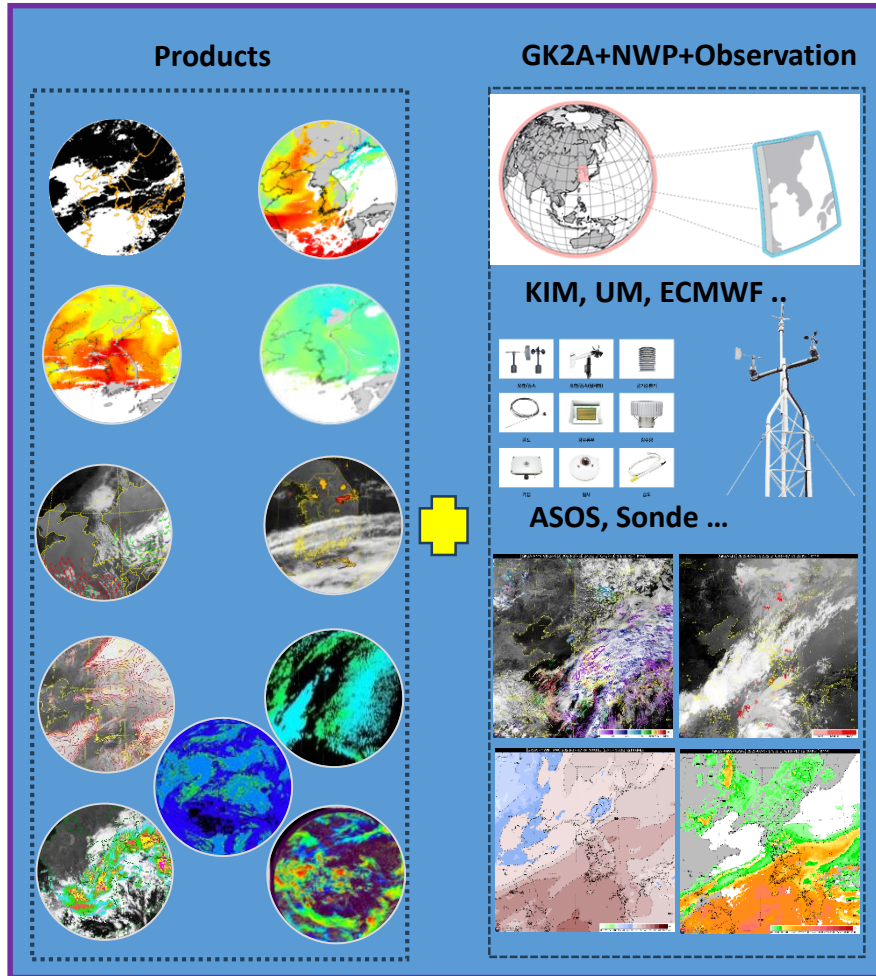
- **Overshooting Top Detection**
- SO2 Detection
- **Total Precipitable Water**
- Clear Sky Turbulence

Schematic diagram of GK-2A information service

GK-2A



NMSC Satellite information system

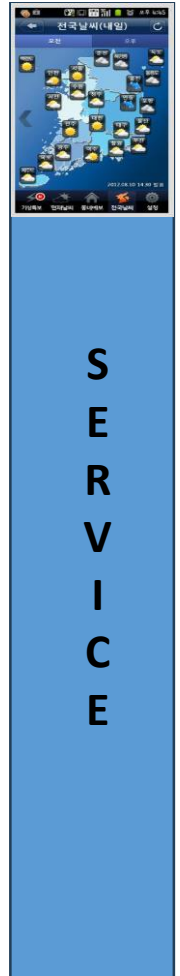
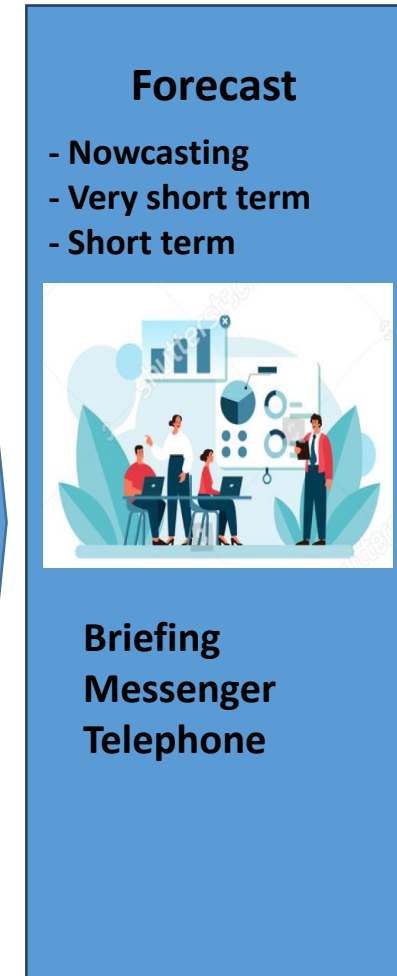


NMSC



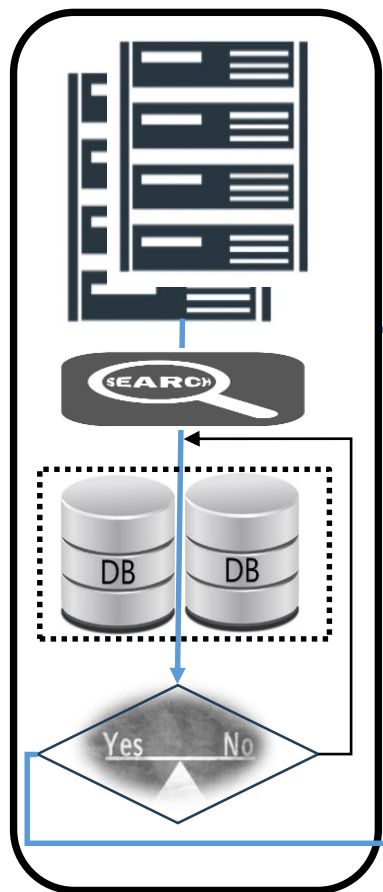
NMC

NMC : National Meteorological Center

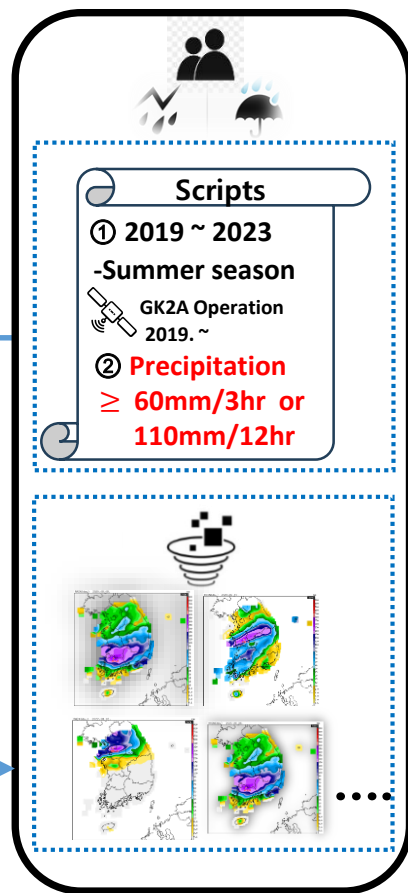


For heavy rainfall quick guidance

National Climate Data Center

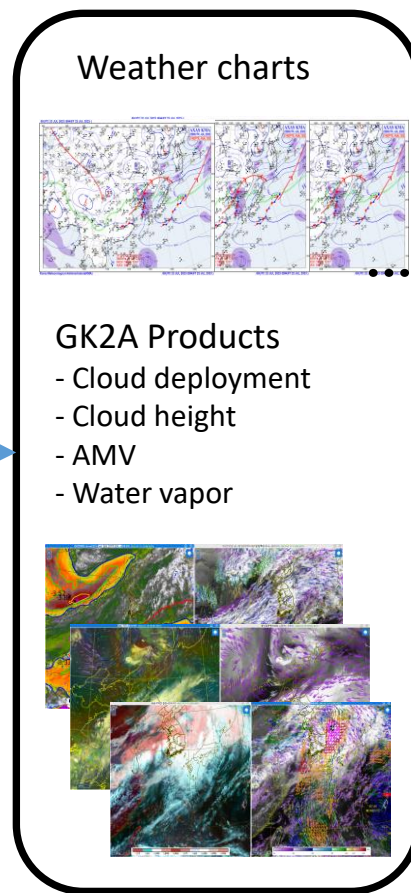


Select & Collect

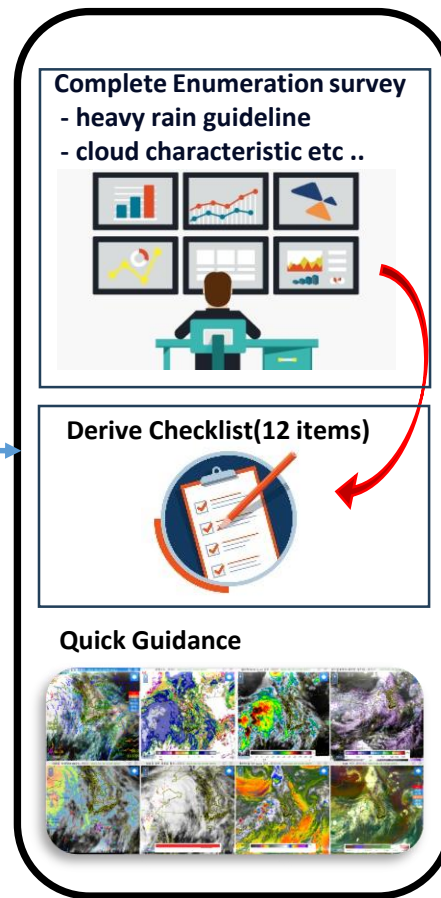


60 cases

Satellite Information System

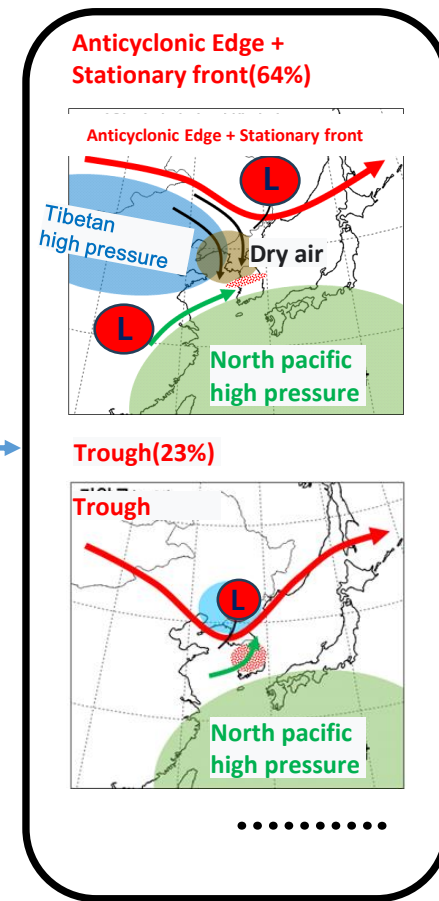


Human Intelligence



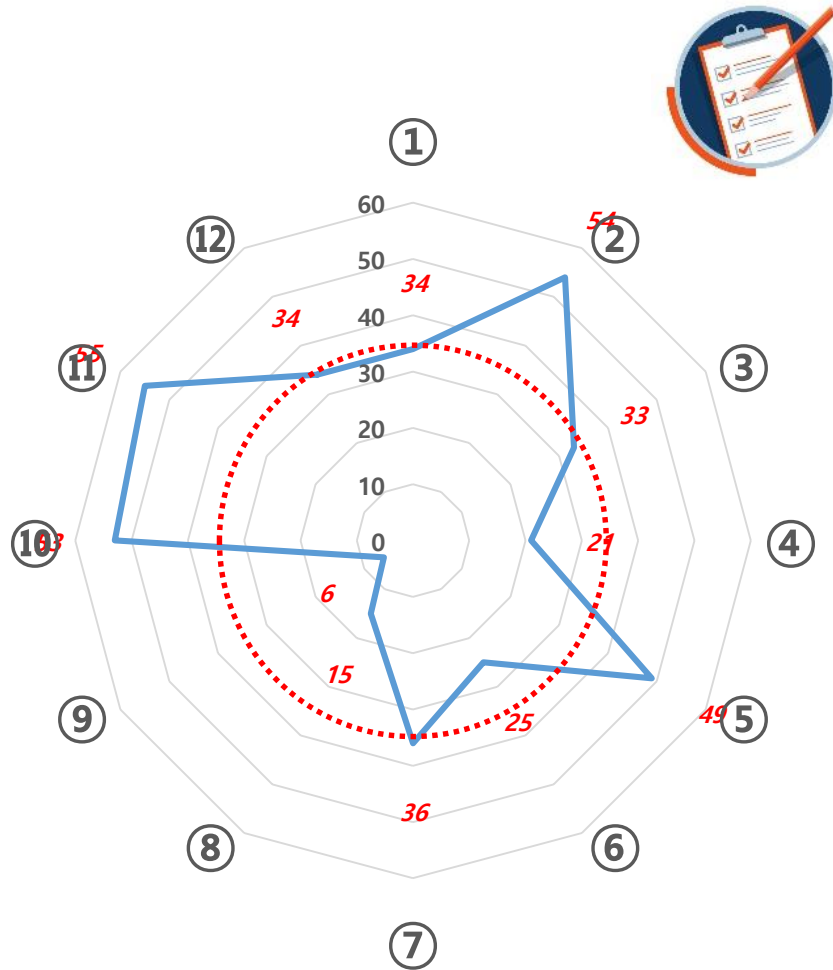
Utilization of forecast work

KMA Guidance



87% of heavy rain

Heavy rainfall potential check items

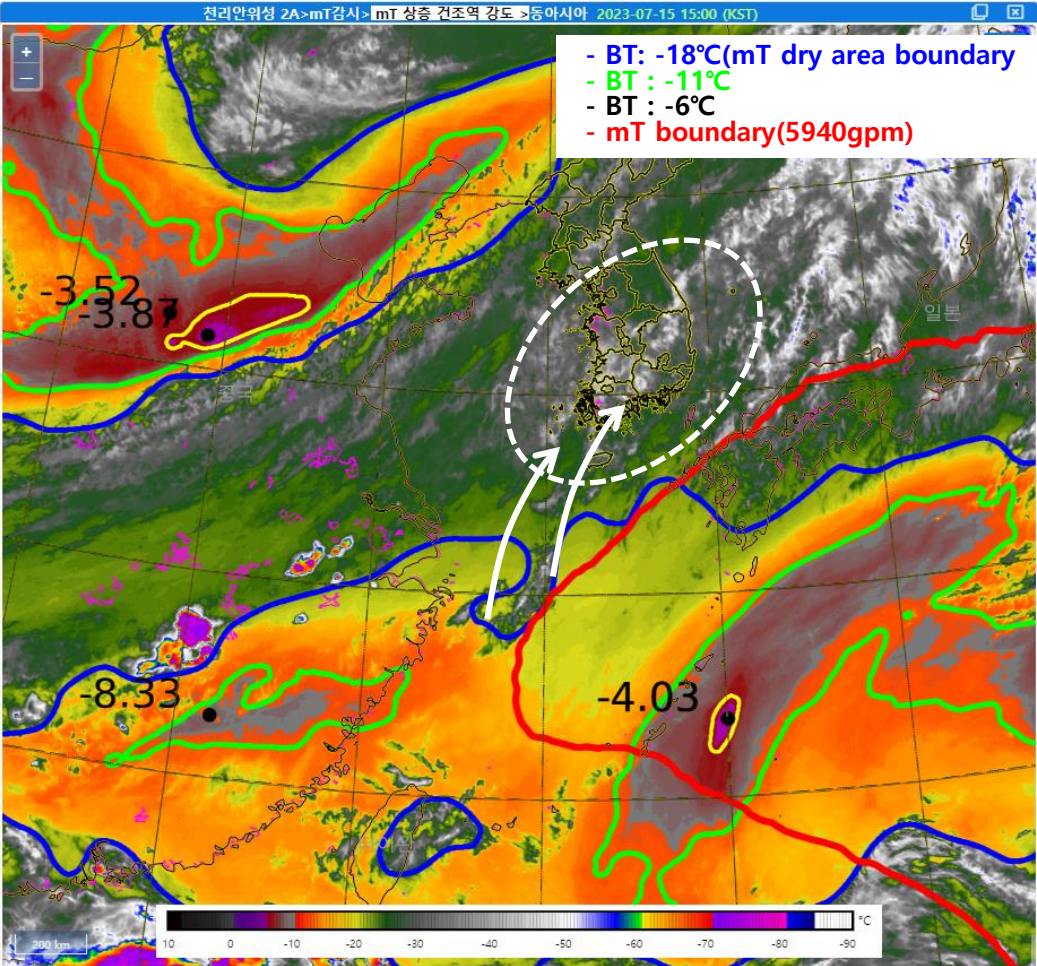


- ① *Updraft zone in front of the boundary of the upper dry area of North pacific High*
- ② *Updraft zone in front of the dry area due to the Low pressure trough*
- ③ Compressed wet zone between the North and South dry zones
- ④ Warm advection accompanied by Low pressure in warm conveyor belt
- ⑤ *Lower cumulus clouds from strong southwesterly air stream*
- ⑥ Cirrus cloud as divergent in the upper strong wind zone
- ⑦ *Upper layer cold core*
- ⑧ Meso-scale system on the stationary front
- ⑨ Periodic upper-level wave inflow on the stationary front
- ⑩ *The cooling rate of the developing convective cloud lasts less than $-3^{\circ}\text{C}/10\text{minutes}$*
- ⑪ *Clouds thickness of 10 km or more*
- ⑫ Heavy rainfall critical index of 30 or higher

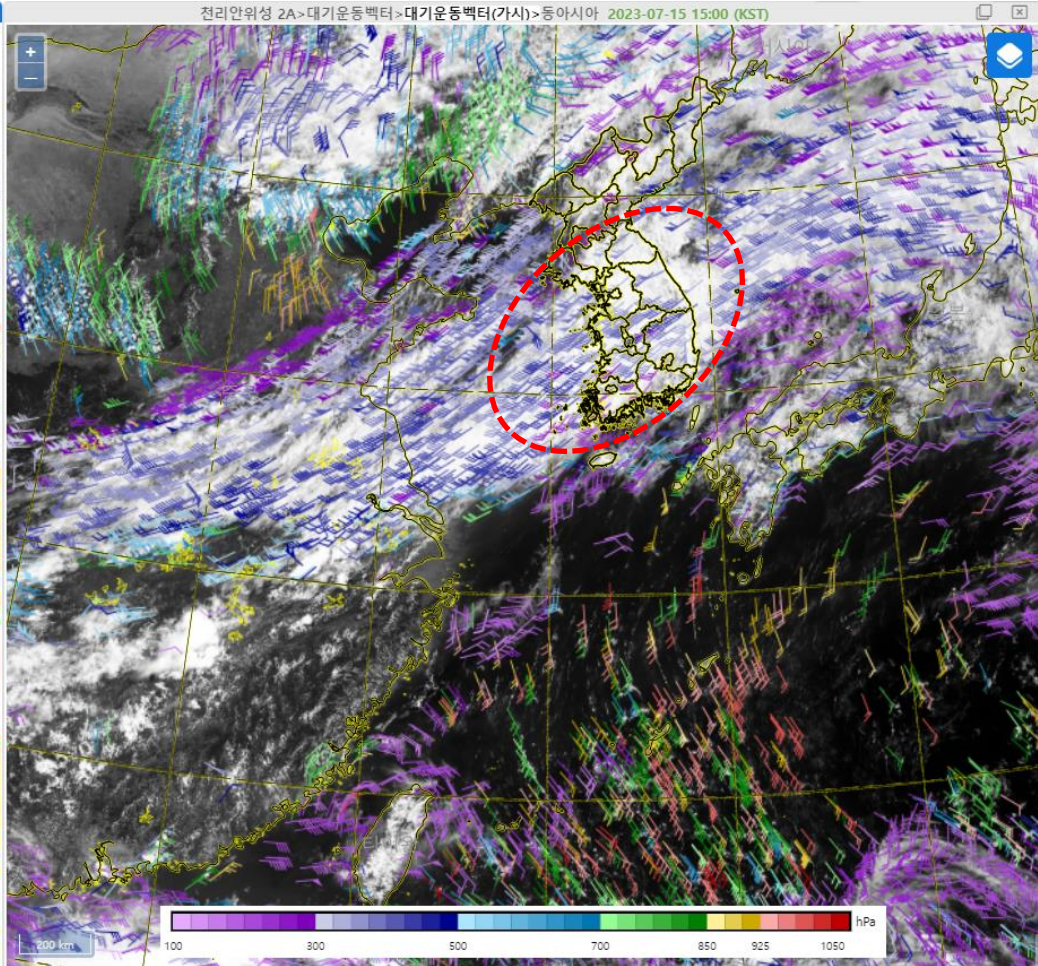
- ❖ 60 rainfall cases during 2019 to 2023 corresponding to heavy rain warning were surveyed. → Each case was checked by heavy rain precursors' checklist in 12 items.
- ❖ If there are more than 6 items in the checklist, it was recognized that the possibility of localized heavy rain was high.
- ❖ Apply the checklist item for system in order to Utilization of forecast work.

① Updraft zone in front of the boundary of the upper dry area in Northern Pacific High

Water vapor(7.3 μ m) color

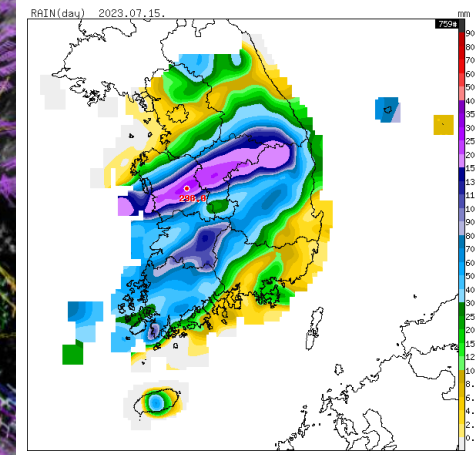


Atmosphere Motion Vector



2023. 07.15. 15:00KST

298.8mm/day



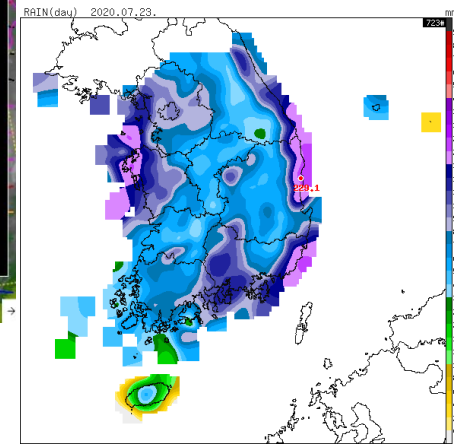
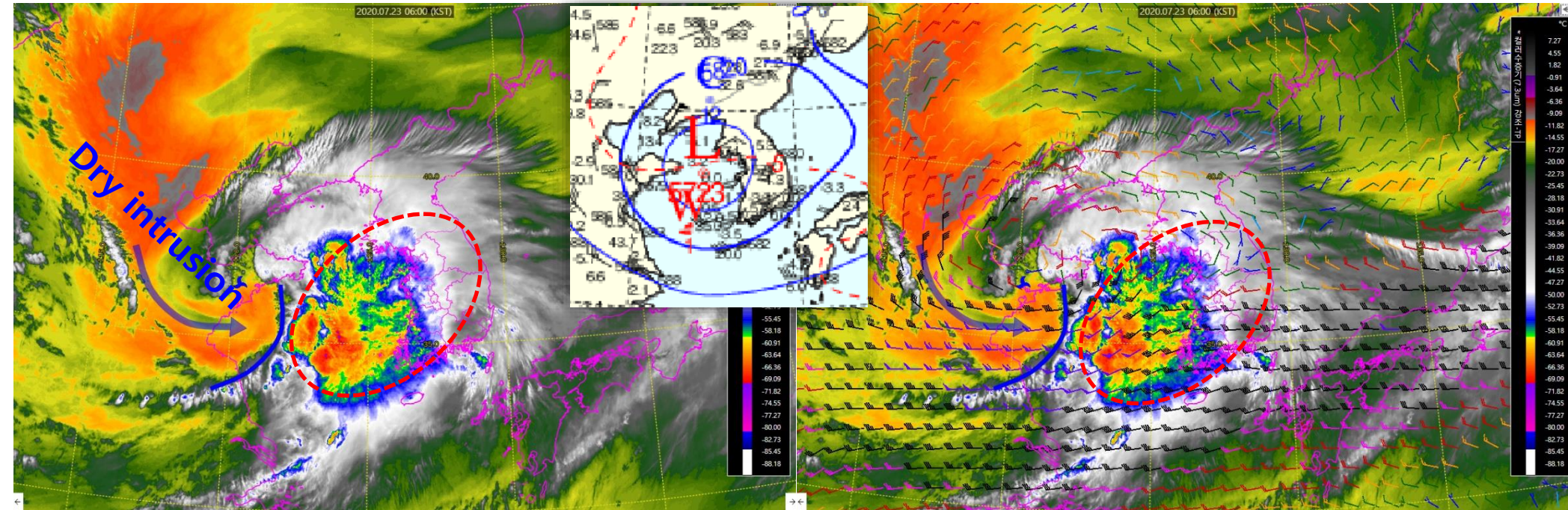
- The updraft zone clouds developing along the boundary of the expanding Maritime Tropical dry area flow into Korean Peninsula.
- As the boundary of the upper dry area above -11°C moves northward, the closer the distance to the convective cloud, the stronger convective clouds develop.

② Updraft zone in front of the dry area due to Low pressure trough

Water vapor(7.3 μm) color + weather chart(500hPa)

Water vapor(7.3 μm) color+ 500hPa Wind vector

2020. 07.23. 06:00KST

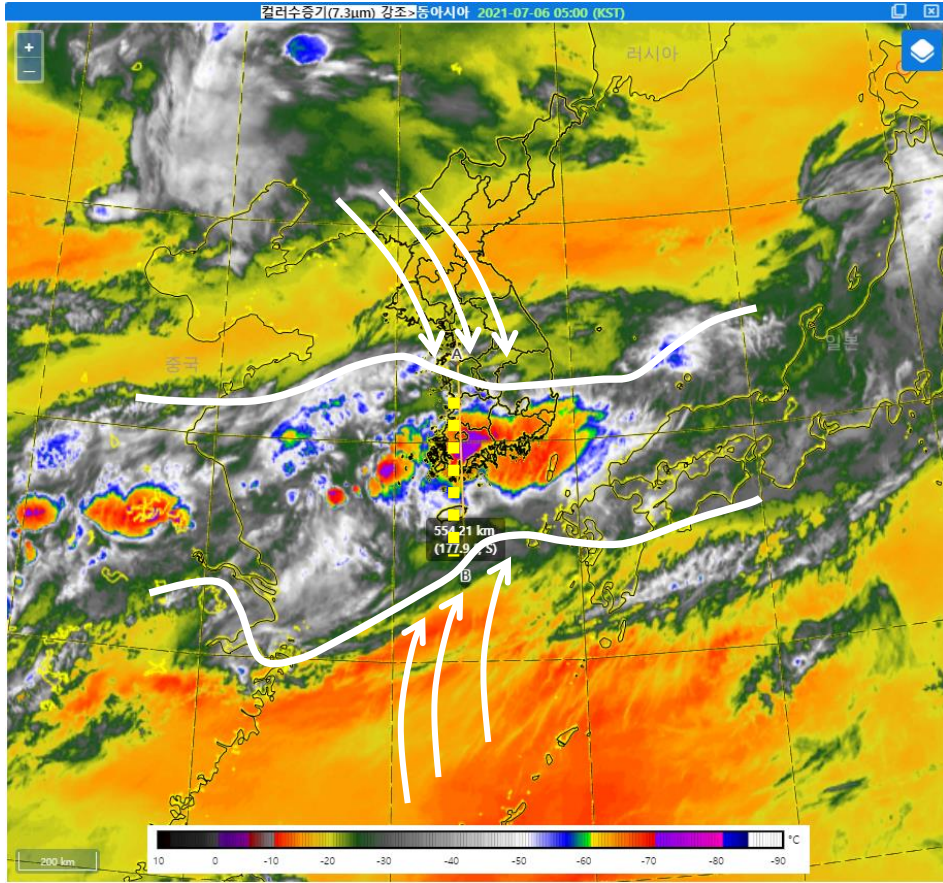


2020. 07.23. Rain(day)

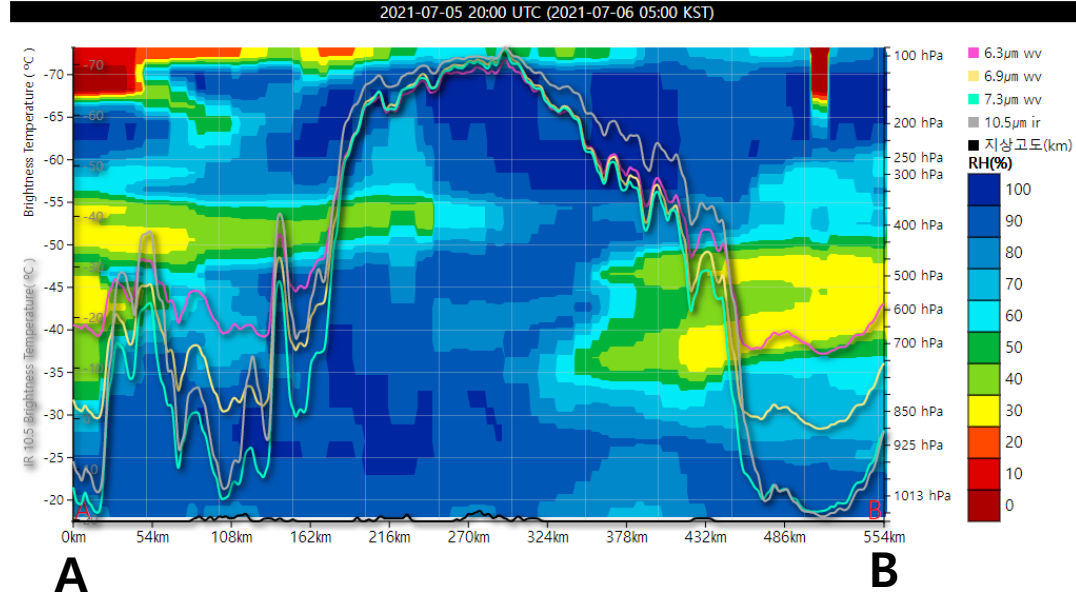
- Updraft zone in front of the dry intrusion due to a trough.
- As the dry area accompanying the trough is strengthened, strong convective clouds are developed rapidly in the forward direction of Korean Peninsula.

③ Compressed wet zone between north and south dry zones

Water vapor(7.3μm) color

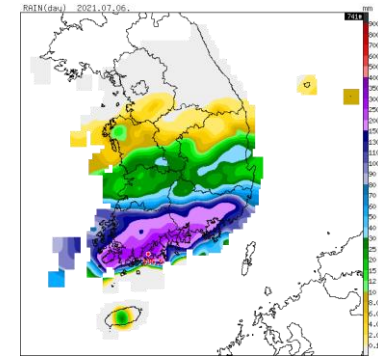


GK2A WV Profile WV(6.3, 6.9, 7.3μm) + IR (10.5μm)



335.0mm/day

2021. 07.06. 05:00KST

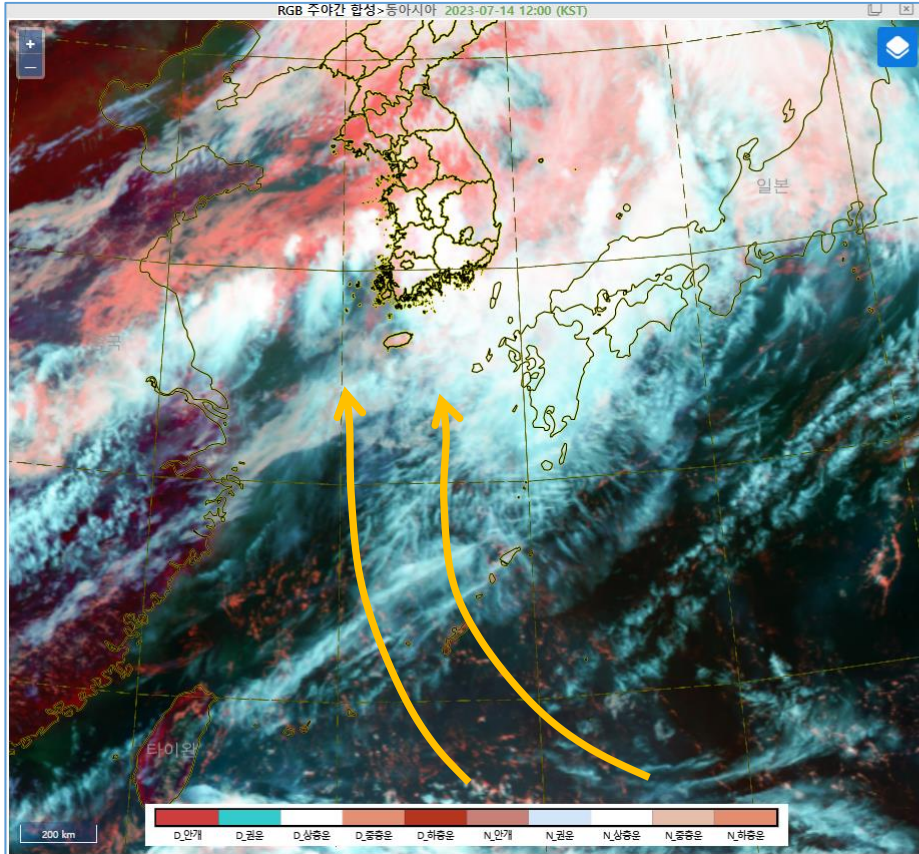


2021. 07.06. rain(day)

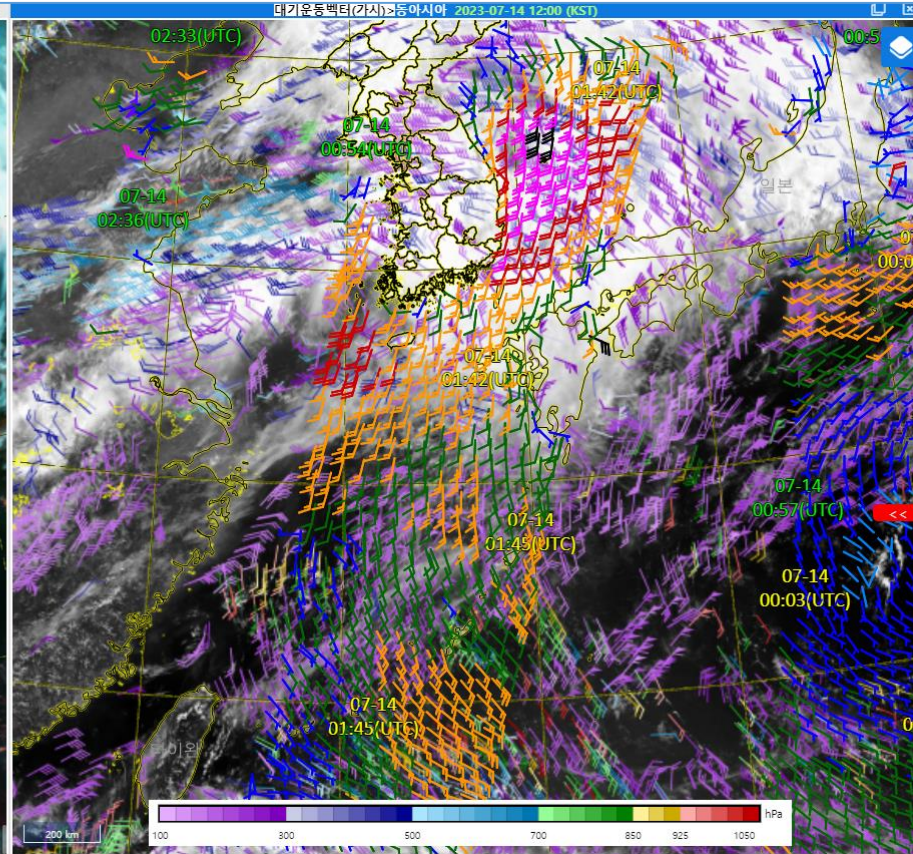
- The northern dry area southward, and the dry area at maritime tropical boundary northward
- Convective clouds develop in the compressed water vapor river between the southern & northern dry regions
- The clouds of area where WV pathway is compressed(Water vapor and infrared channels match)

⑤ Lower cumulus clouds from strong southwesterly air stream

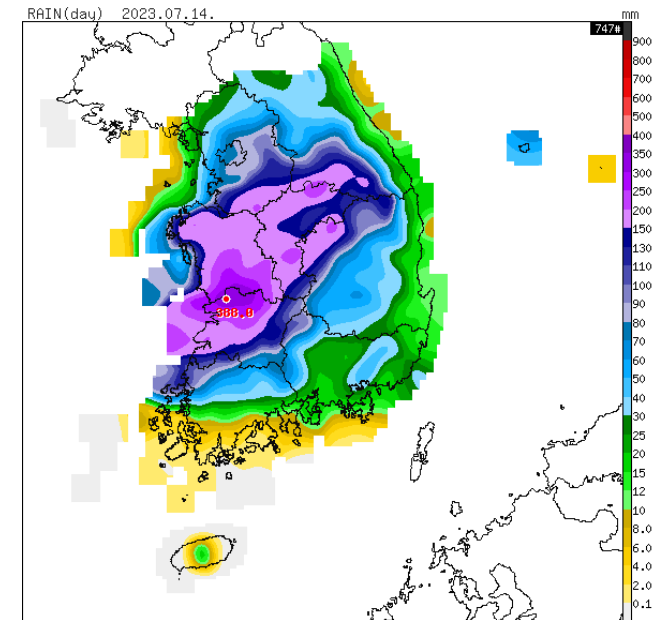
RGB day/night composite image



AMV+ Metop-B/C(ASCAT)



2023.07.14. 12:00KST

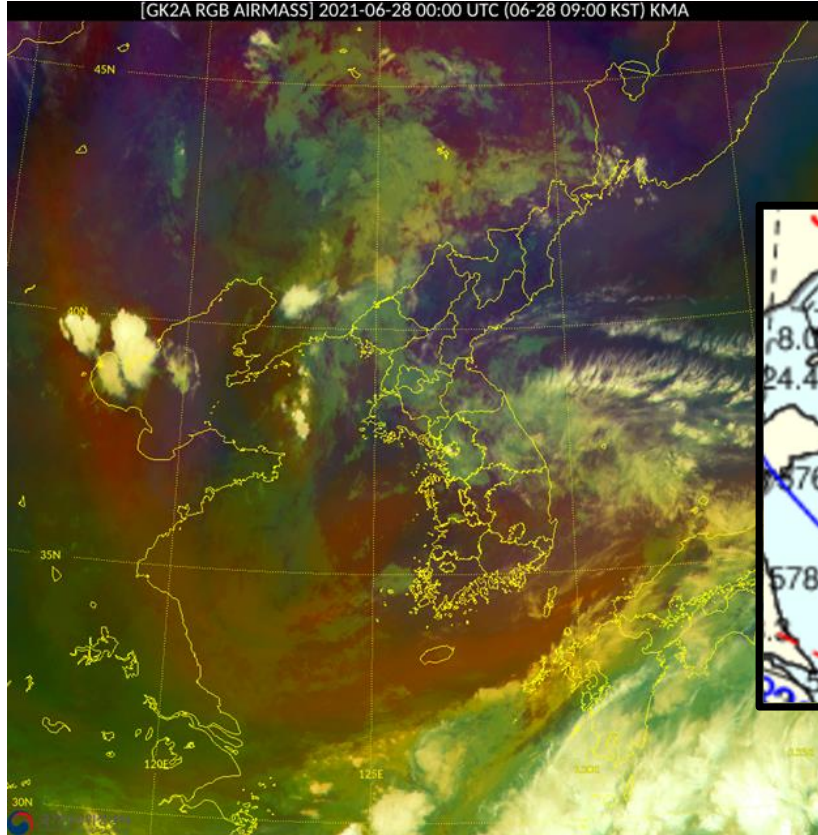


2023. 07.14. rain(day)

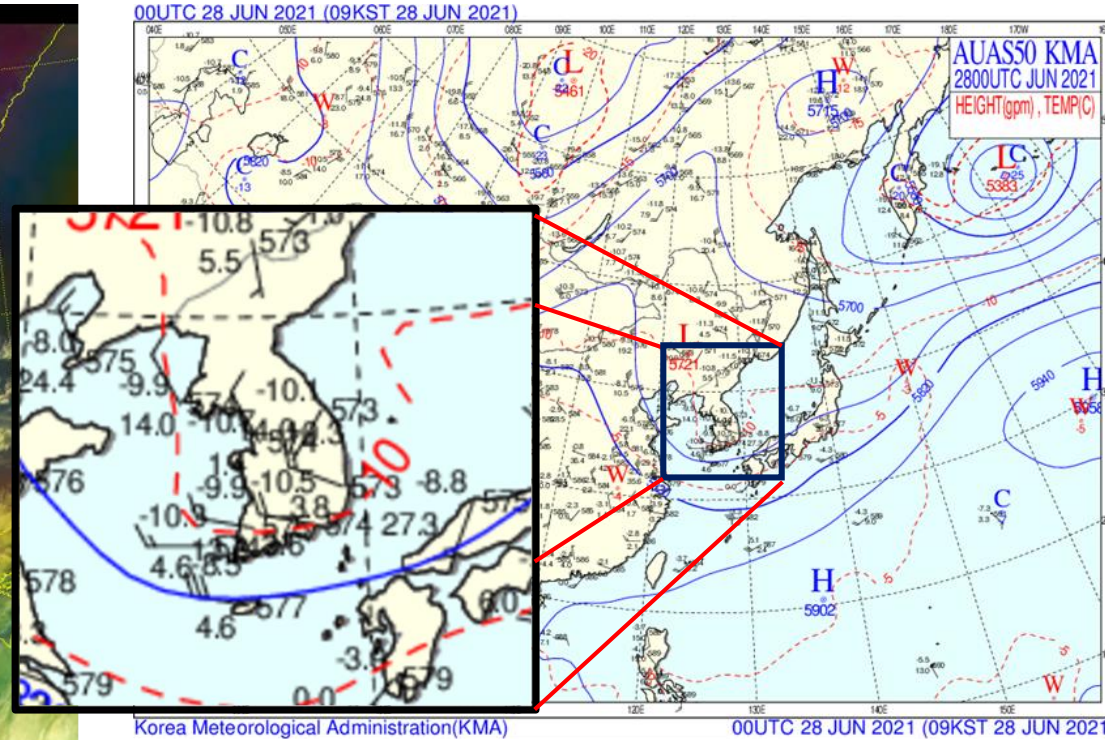
- In the RGB day/night composite image, northward of the texture shape along with the southwest wind
- In the AMV + METOP-B/C, the lower cloud moves north along with the southwest air stream over the ocean
- Around Jeju Island, detected the strong wind area(20~25knots)

⑦ Upper layer cold core

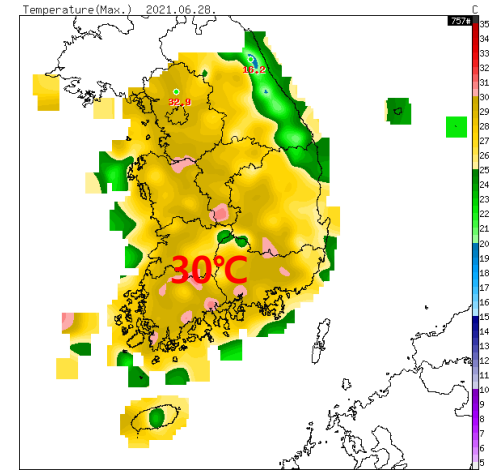
RGB Air mass



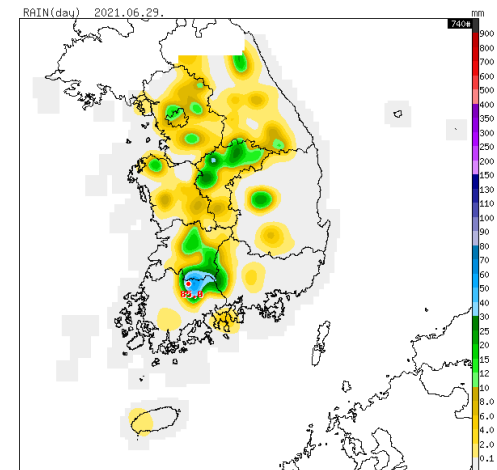
Weather chart 500hPa



2021. 06.28. 09:00KST



2021. 06.29. Temp(max)



2021. 06.29. rain(day)

- Localized heavy rain due to instability between upper and lower layer
- In the 500hPa weather chart, -10°C temperature line is distributed in Korea, on the ground showers of precipitation appear in inland areas where the maximum temperature is 30°C over

⑩ Cooling rate in the developing convective clouds lasts less than $-3^{\circ}\text{C}/10\text{minutes}$

Convective cloud monitoring and analysis (K-RDT)

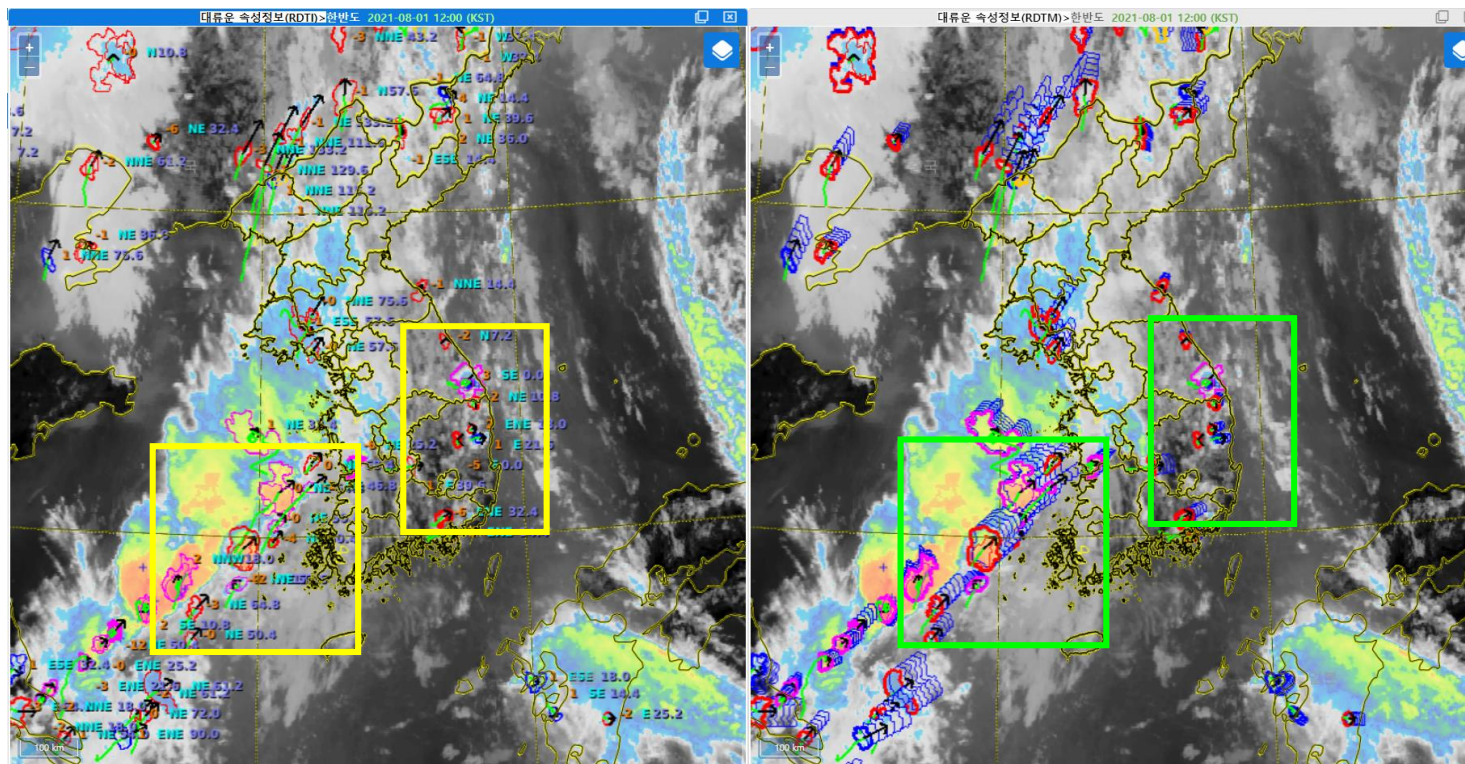
RDT (Rapid Developing Thunderstorms)

- based on NWC-SAF
- To analysis the lifecycle of thunderstorm (triggering, developing, mature, decaying, and movement pattern)

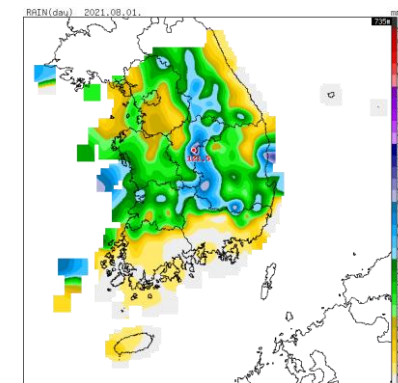
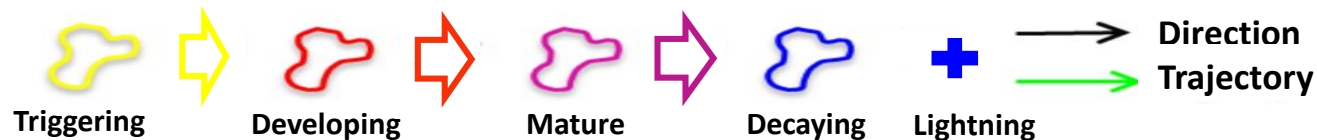
K-RDT (Koreanized RDT)

- To adjust the parameter considering the characteristics of Korea weather pattern using GK2A (Utilization of Neural Network Technique)

Rapid Developing Thunderstorm Information(RDTI & RDTD)

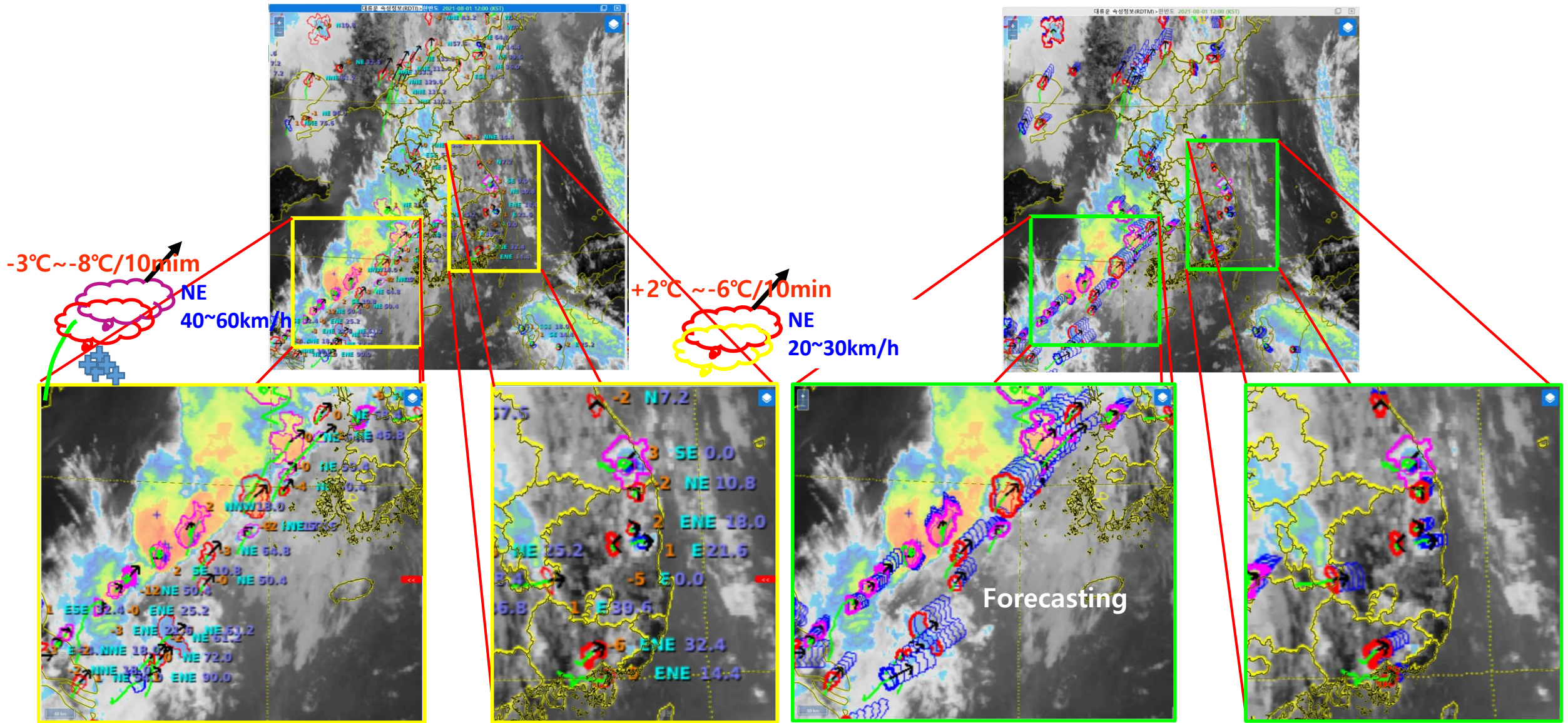


2021. 08.01. 1200KST



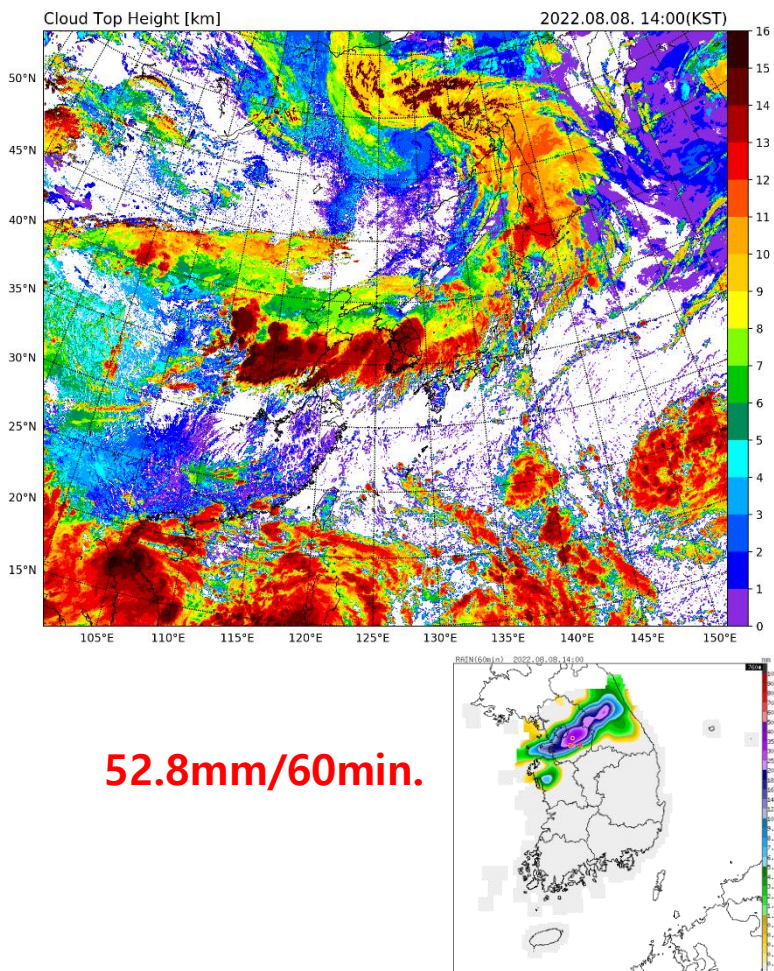
➤ Cooling rate is greater than $-3^{\circ}\text{C}/10\text{minutes}$ on the developing convective cloud

⑩ The cooling rate of the developing convective cloud lasts less than $-3^{\circ}\text{C}/10\text{minutes}$

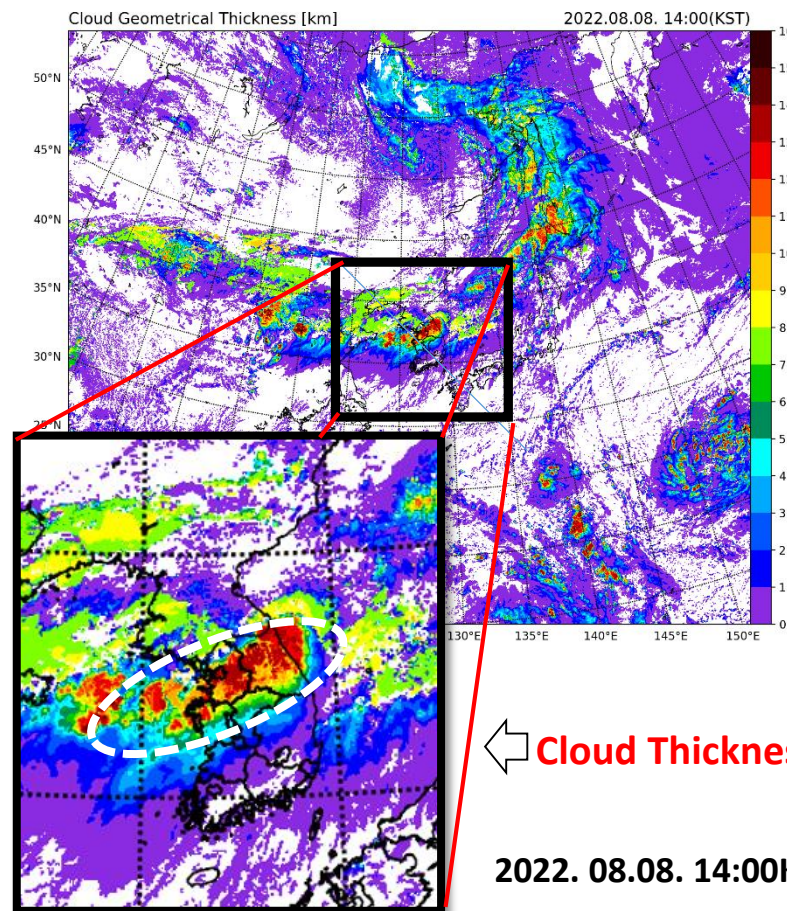


⑪ Clouds thickness of 10 km or more

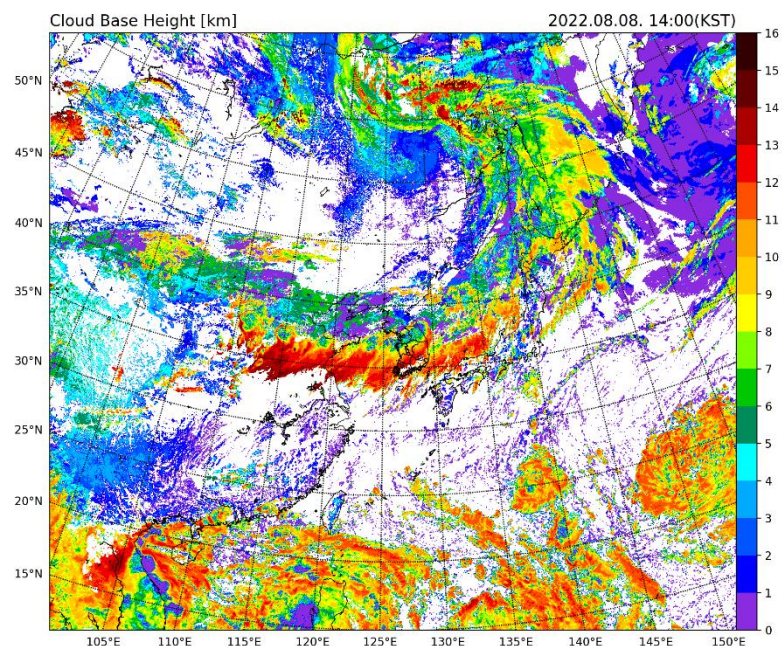
Cloud Top Height



Cloud Geometrical Thickness



Cloud Base Height



← Cloud Thickness = Cloud Top Height – Cloud Base Height

2022. 08.08. 14:00KST

- Heavy rainfall with clouds thickness of 10km or more (developed cloud from the lower layer to the upper layer)
- Strong precipitation in the densely developed cloud from the lower layer to the upper layer with a thickness of about 10km considering the CTH & CBH

Quick Guideline heavy rain

RGB day/night composite image+AWS

mT dry zone(WV 7.3 μ m) strength

Atmospheric Motion Vector

RGB air mass + 850hPa streamline(UM)

Satellite information system heavy rain quick guide



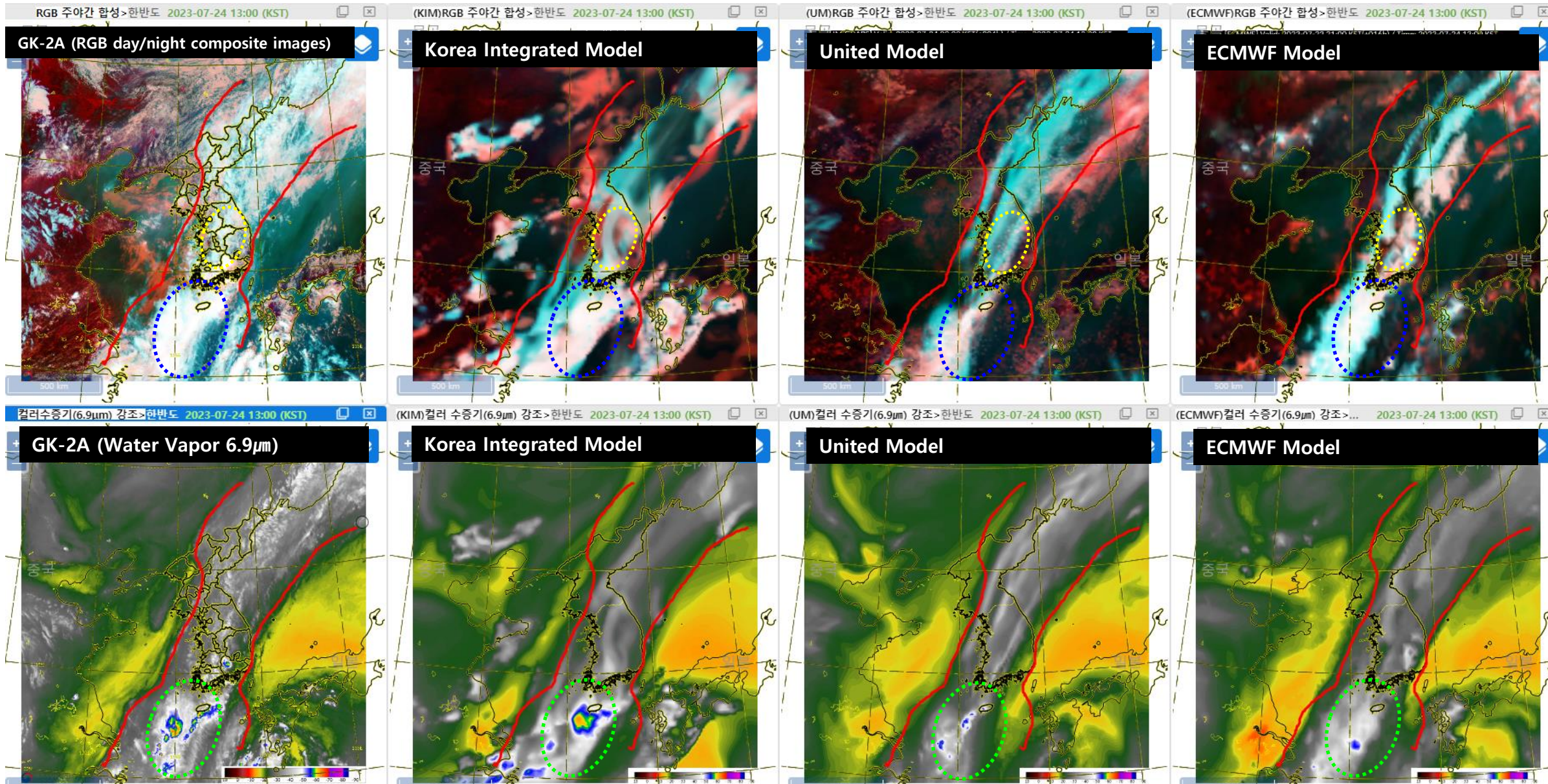
Rapid Developing Thunderstorm Information

Cloud height

Heavy rainfall Critical index

Total precipitable water(NWP)+Radar

Model Diagnosis(Cloud and Dry zone)



Summary

- NMSC/KMA has developed in detecting precursors of developing heavy rain cloud using GK-2A products and weather observation data base.
- 60 rainfall cases during 2019 to 2023 corresponding to heavy rainfall warning were surveyed. → Each case was checked by heavy rain precursors' checklist in 12 items.
- NMSC gives forecasters heavy rainfall precursor information based on the checklist and comprehensive information from relative satellite products etc.
- Diagnosis by comparing satellite images and simulated numerical models are also given to forecasters for choosing appropriate models for short-range forecasting
- For providing proper precise precursor in heavy rainfall forecasting, more active co-work between knowledge (and experience) based weather forecasts and researchers in weather satellite would be encouraged.

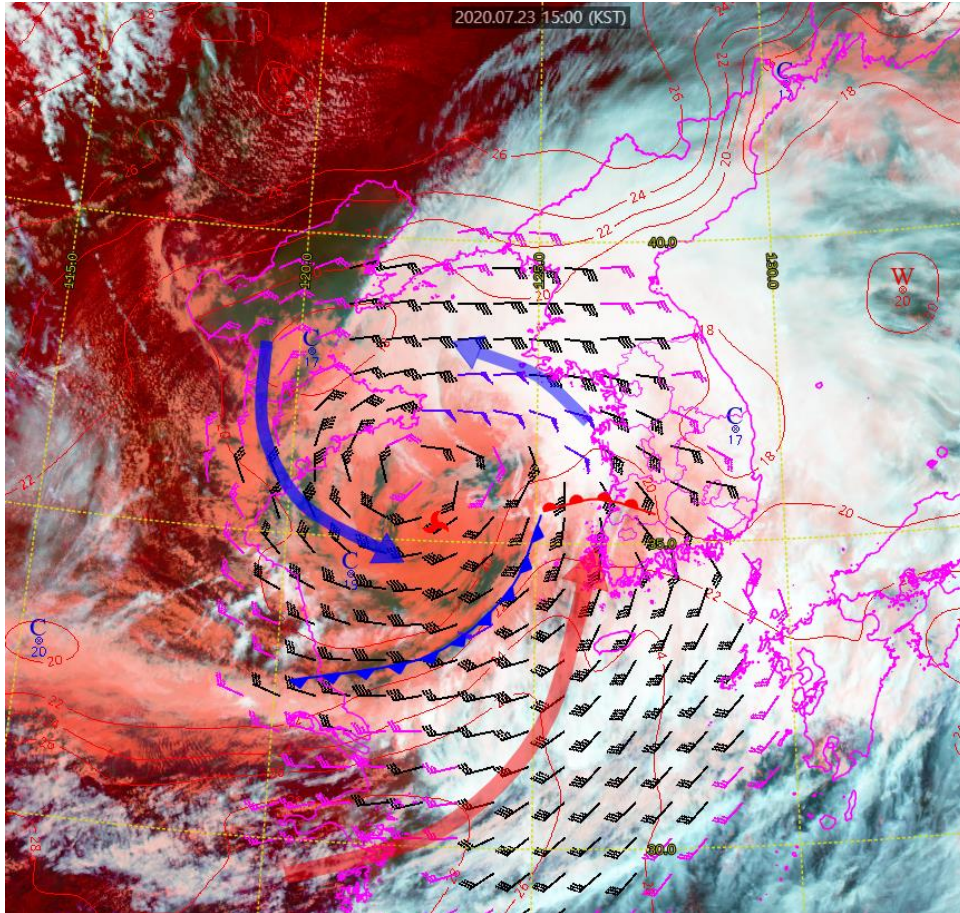
Thank you!

Byunghyun Song, DongSu Kim, OkHee Kim



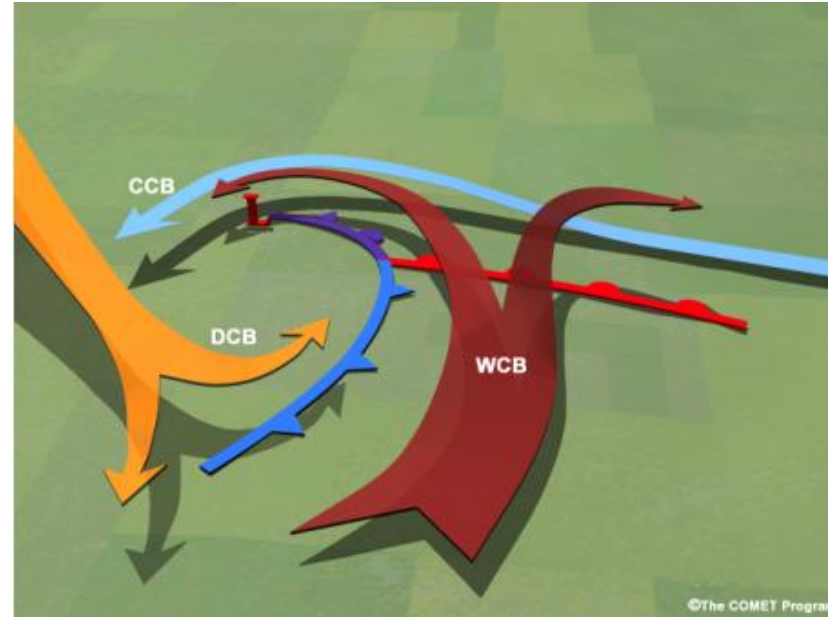
④ Warm advection accompanied by Low pressure in warm conveyor belt

RGB day/night composite image + 850hPa wind vector

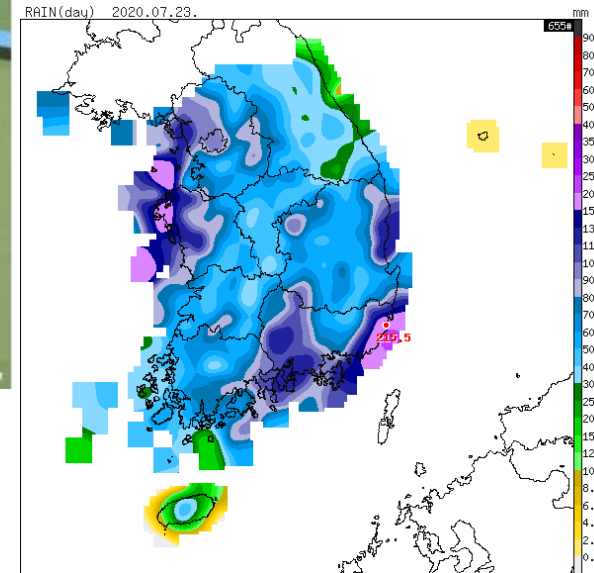


2020. 07.23. 15:00KST

Warm Conveyor Belt



DCB : Dry conveyor belt
WCB : Warm conveyor belt
CCB : Cold conveyor belt

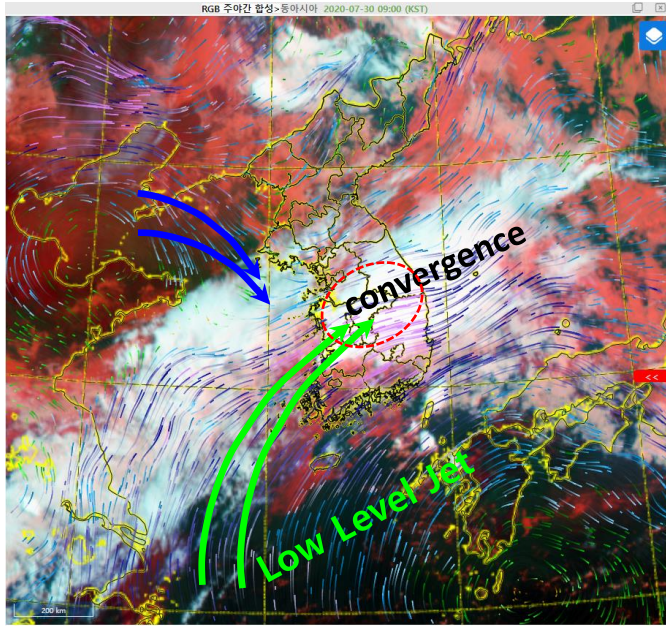


2020. 07.23. rain(day)

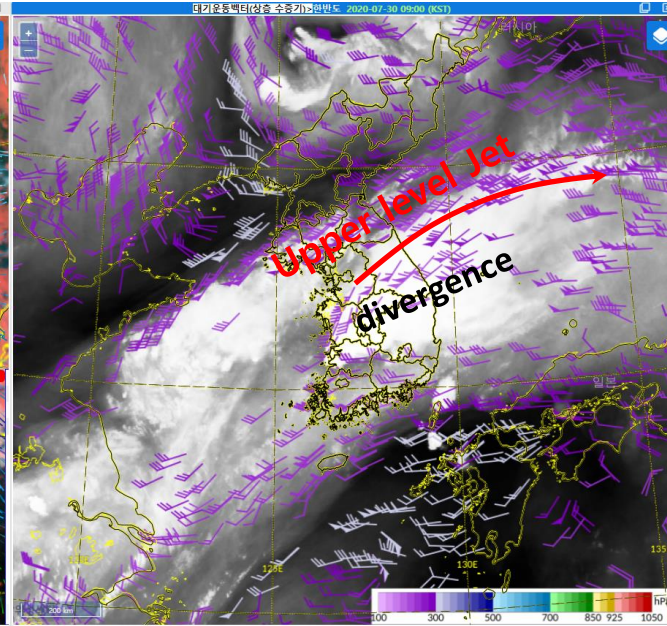
- DCB is formed in the southwest of the Low pressure center, WCB is formed in the southeast, and CCB is formed in the northeast
- Continuous warm advection and humid air into Korea along with WCB from the south triggers the development of convective clouds

⑥ Cirrus cloud as divergent in the upper strong wind zone

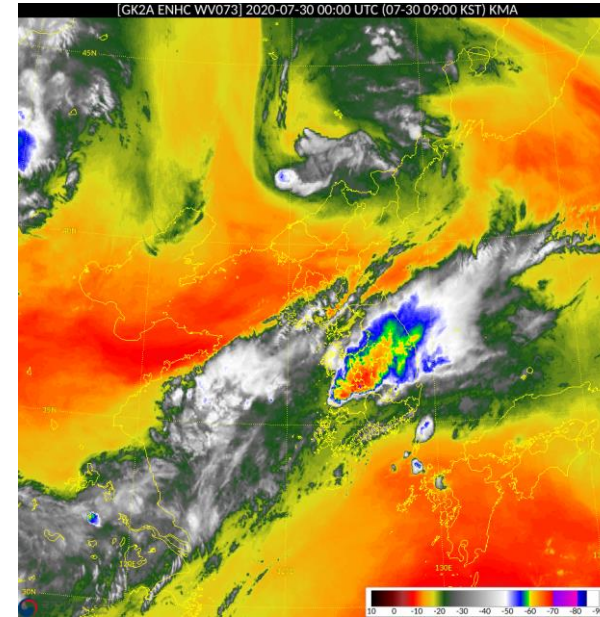
RGB day/night composite + Streamline(850hPa)



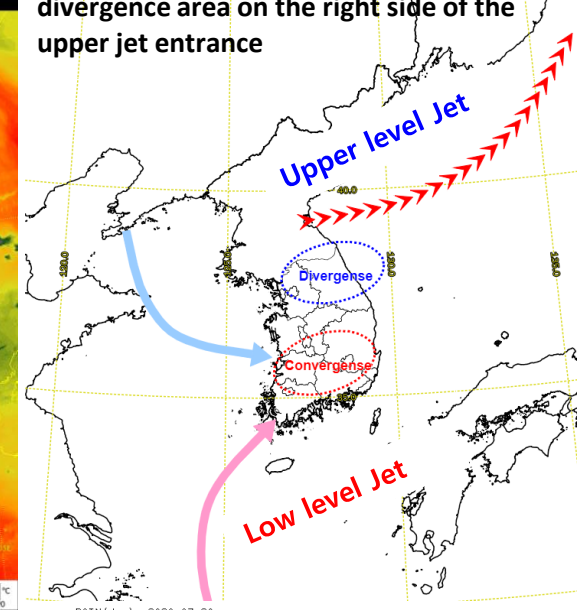
AMV



WV(7.3μm)

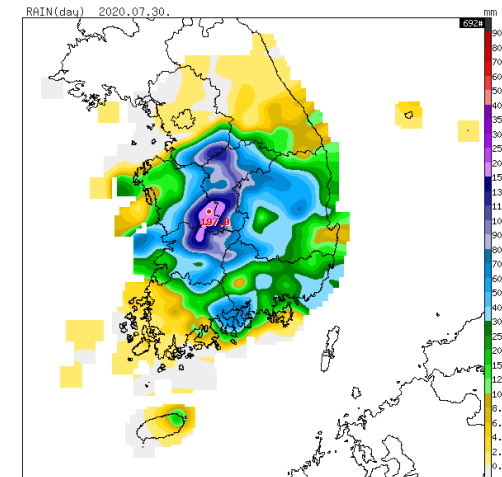


Connecting to the lower jet at the divergence area on the right side of the upper jet entrance



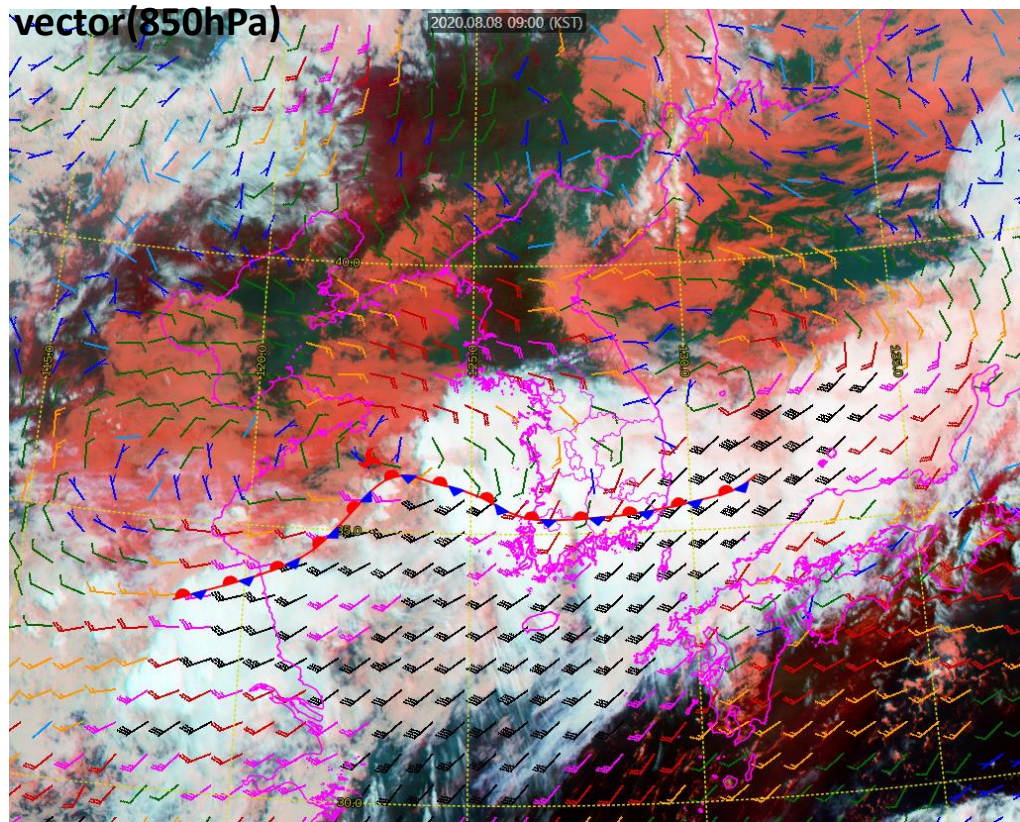
2020. 07.30. 09:00KST

- Convergence of the lower layers in the compressed water vapor passage between the north-south dry zone
- Convective clouds develop due to upper layers divergence as strong winds with the upper layers
- Confirmation of strong winds in the area of convective cloud development in the upper AMV

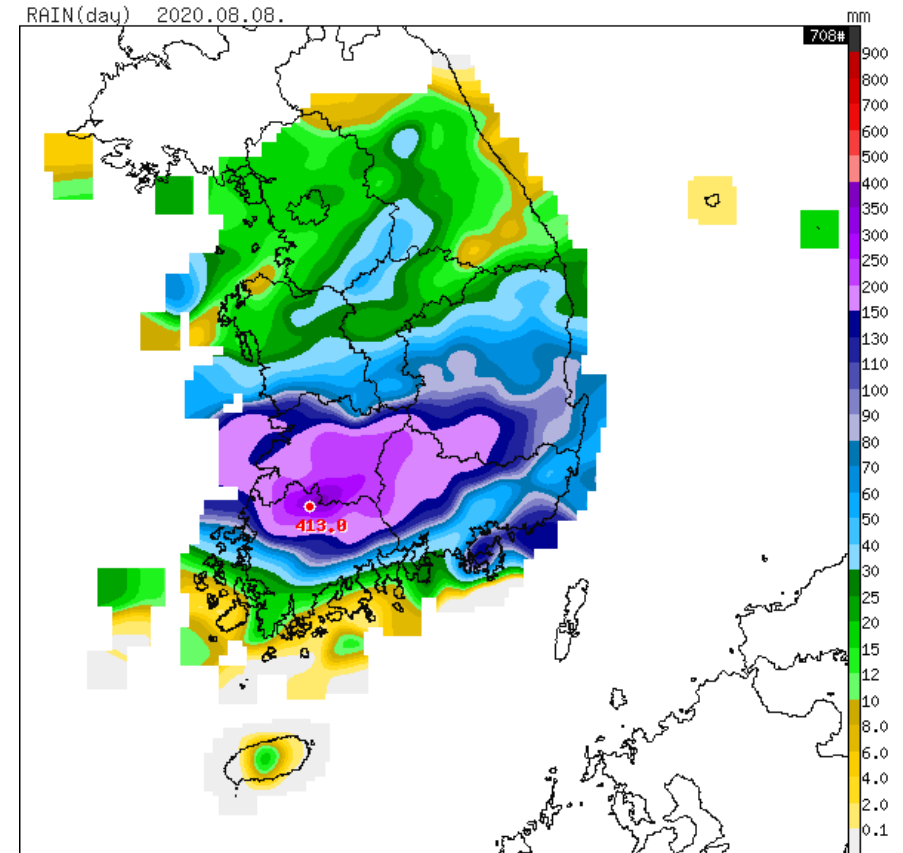


⑧ Meso-scale system on the stationary front

RGB day/night composite image + Wind



2022. 08.08. 09:00KST

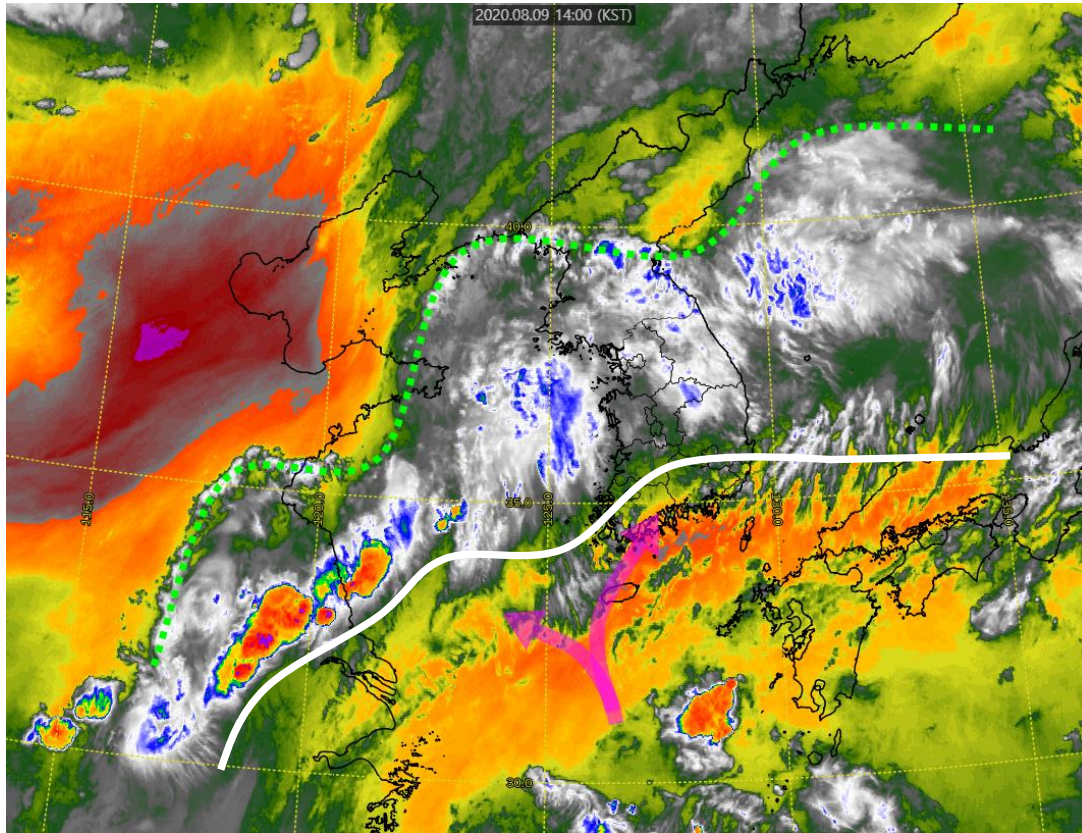


2022. 08.08. rain(day)

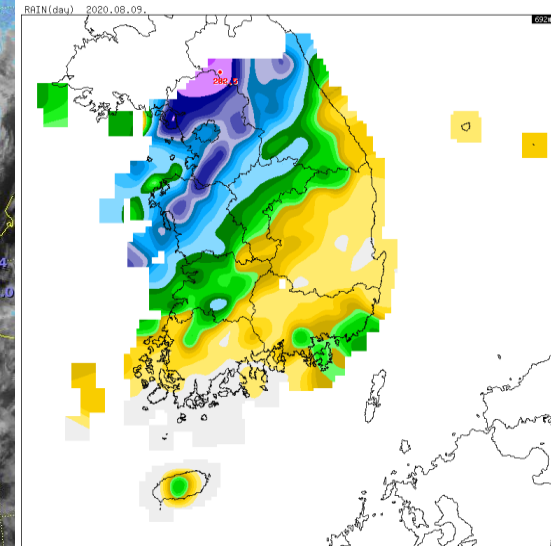
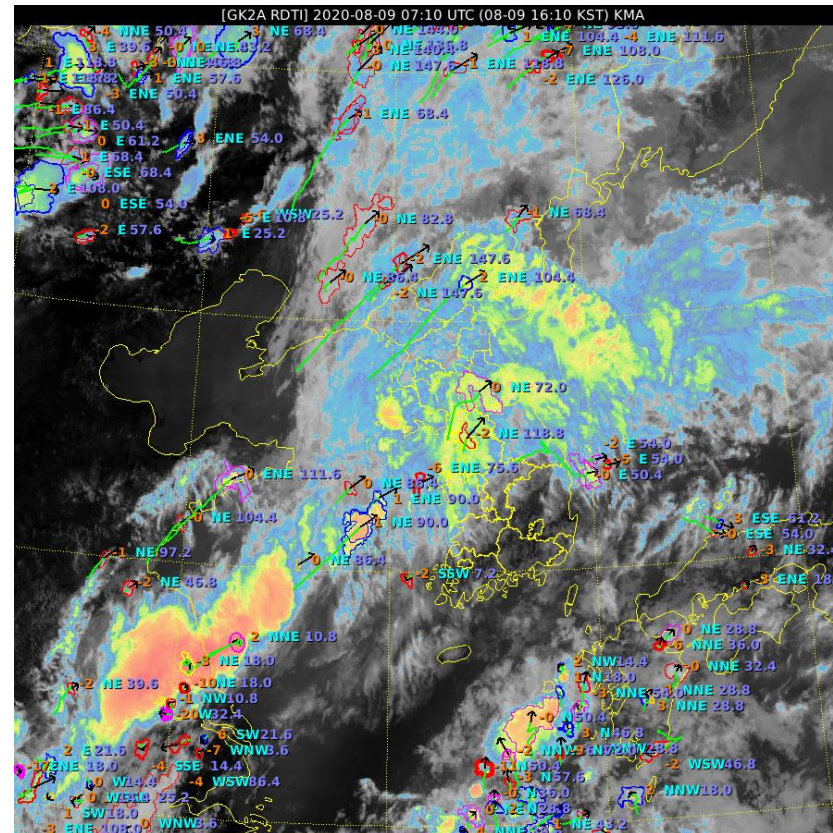
- Mesoscale system clouds developing on the stationary front
- Strong southwesterly airflow into Korea from the southeast of low pressure (strong low level jet stream)

⑨ Periodic upper-level wave inflow on the stationary front

Water vapor(7.3 μm) color



Rapid Development Thunderstorm(RDT)

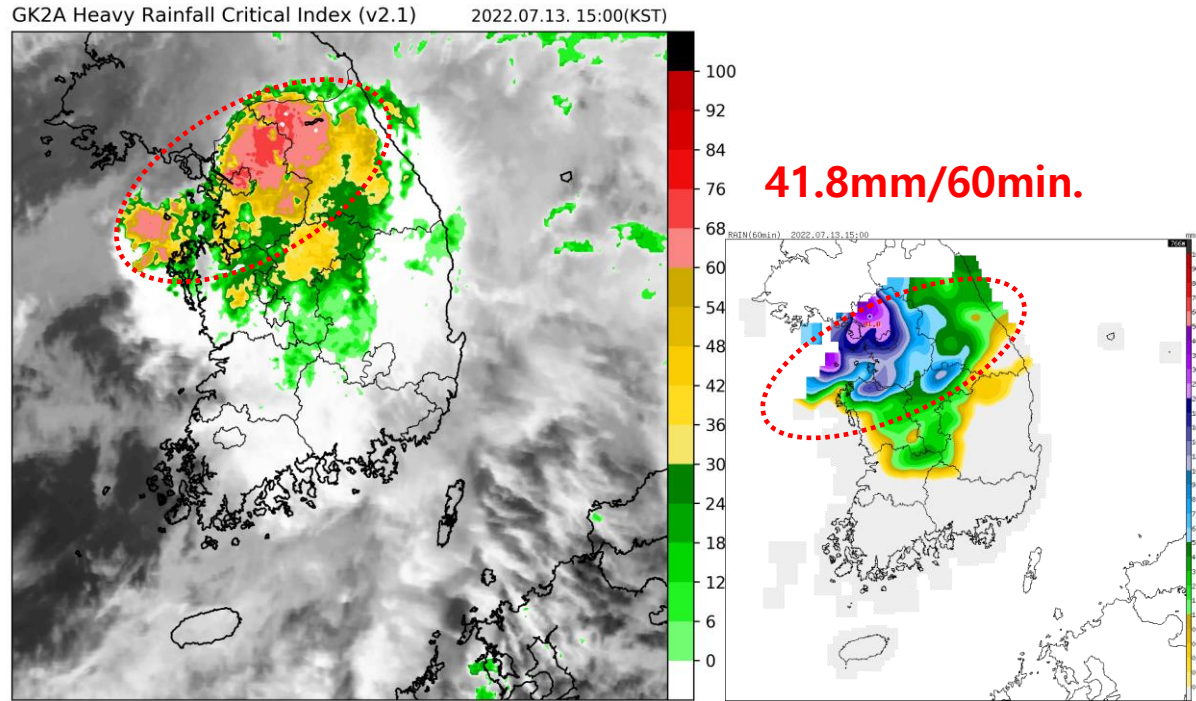


2020. 08.09. 14:00KST

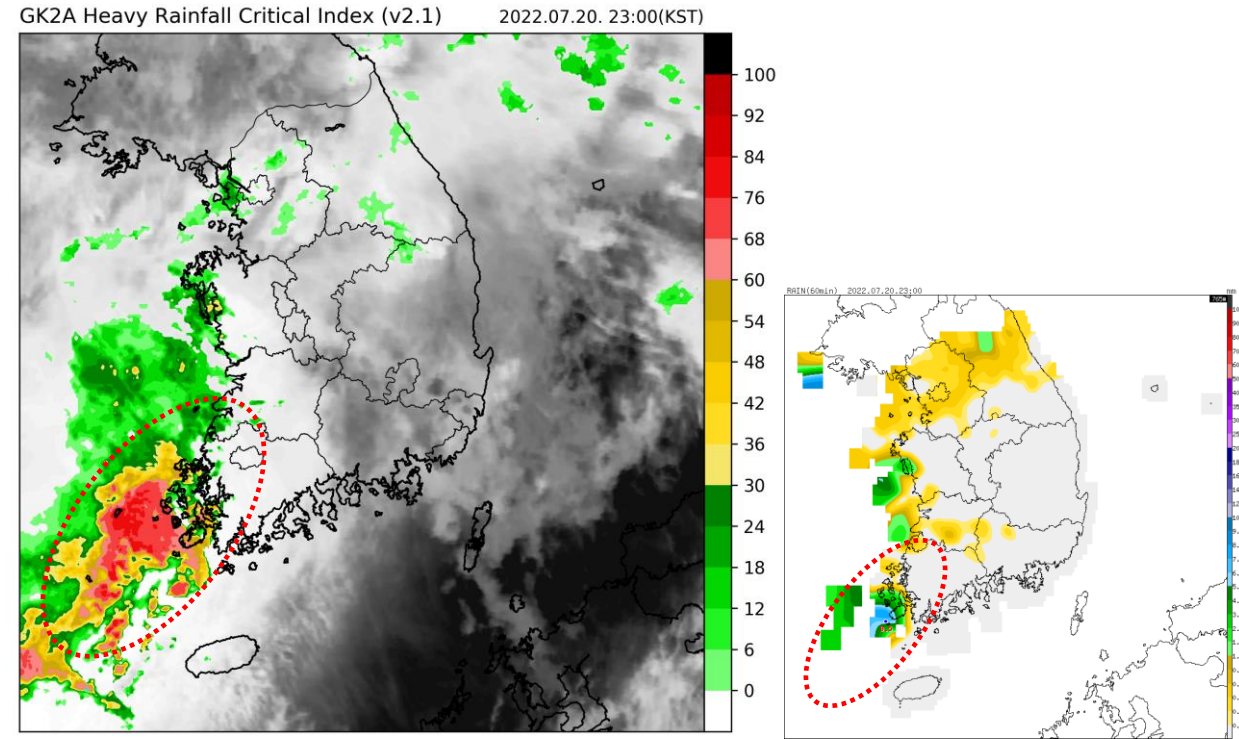
2022. 08.09. rain(day)

- As the boundary of the upper dry area of mT moves north, strong warm air with high temperature & humidity flows into Korea.
- On the stationary front in Korea, the upper wave periodically passes, and the dry air penetrate between the upper waves, and the convective clouds develop

⑫ Heavy rainfall critical index of 30 or higher



2022. 07.13. 15:00KST



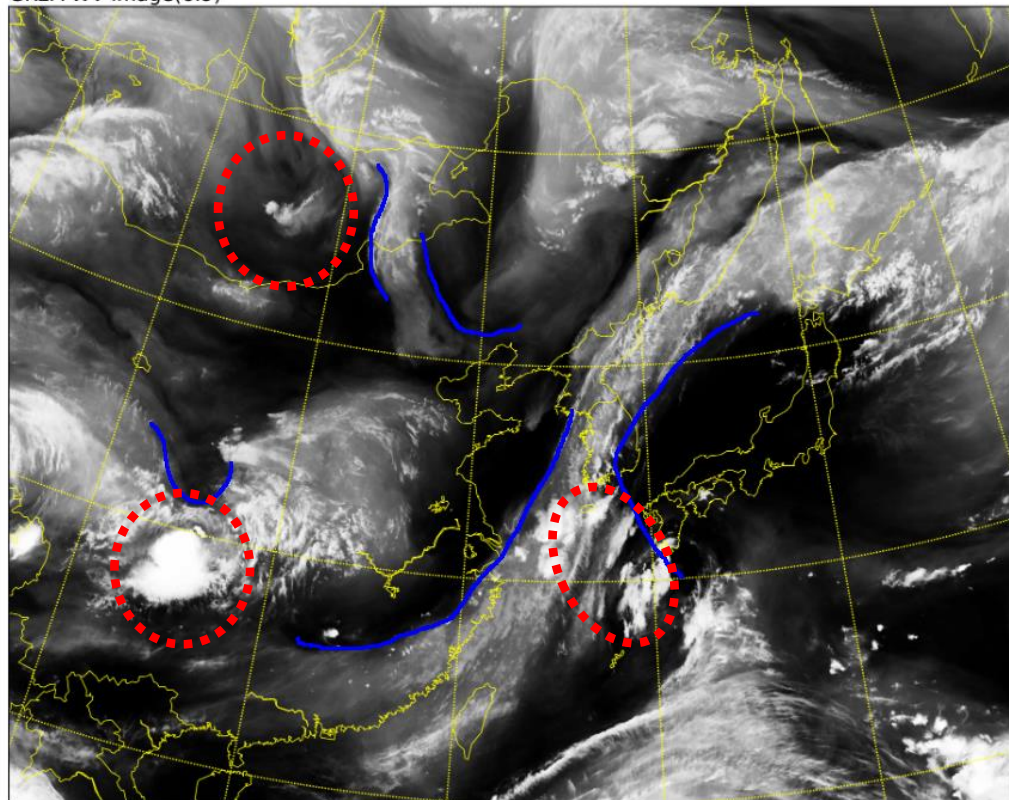
2022. 07.20. 23:00KST

➤ Heavy rainfall critical index of 30 (heavy rain advisory level) or higher

Model Diagnosis (Phase difference)

WV(6.9 μ m)

GK2A WV Image(6.9)



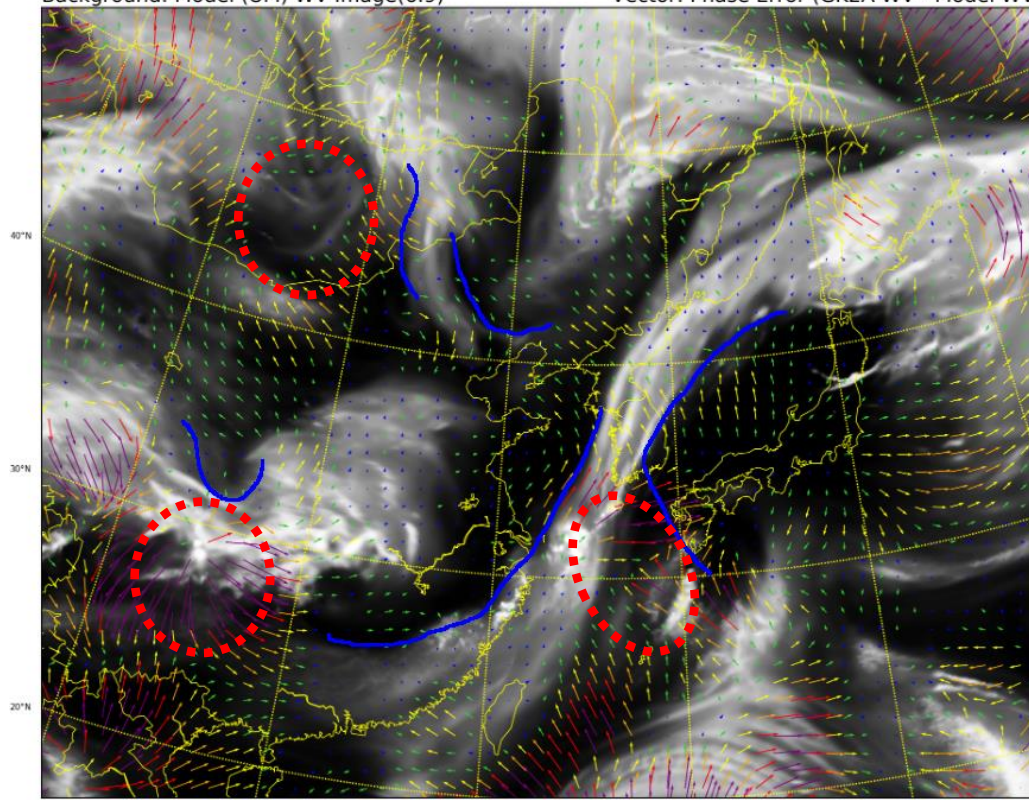
Korea Meteorological Administration (KMA)

VALID: 03UTC 24 Jul 2023 (+ 03h)
12KST 24 Jul 2023 (+ 03h)

UM Model WV(6.9 μ m) phase difference

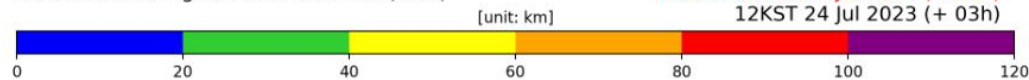
Background: Model (UM) WV Image(6.9)

Vector: Phase Error (GK2A WV - Model WV)



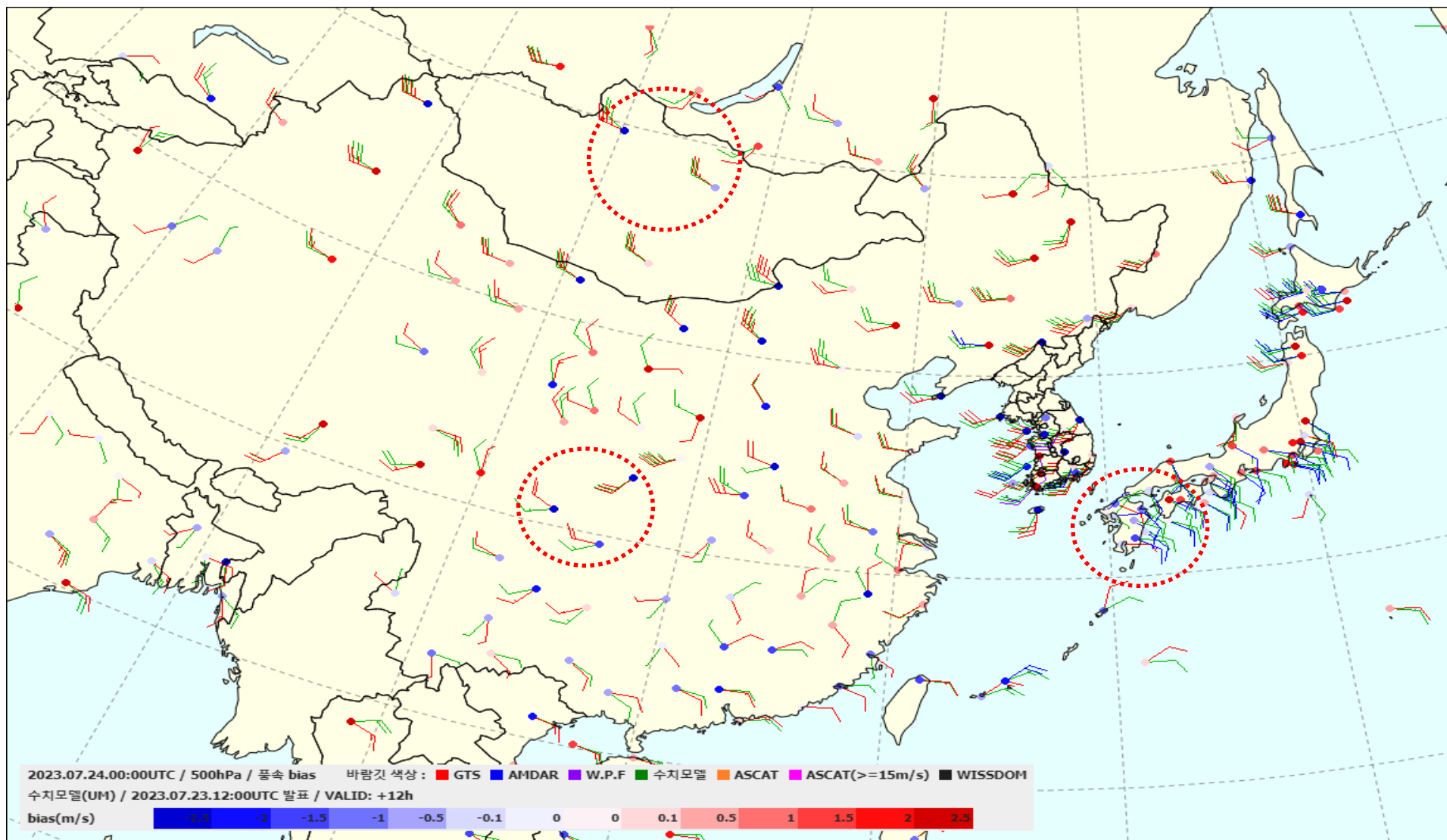
Korea Meteorological Administration (KMA)

VALID: 03UTC 24 Jul 2023 (+ 03h)
12KST 24 Jul 2023 (+ 03h)



GK2A WV – Model WV

Model Diagnosis (Phase difference)



GTS 500hPa Wind vector
vs
UM Model

blue color means
Observation data are greater
than model

Wind vector Bias : Forecast – Observation