Application to typhoon, severe weather detection and data services of GK2A

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The 12th Asia/Oceania Meteorological Satellite User’s Conference

Training event

Satellite-based Typhoon Analysis with GK2A

November 11, 2022
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Satellite Analysis Division
National Meteorological Satellite Center
Korea Meteorological Administration
Operational Structure

Radar based Analysis
Operational Forecast
Nominal: 1 forecaster 12-hr shift
Korea effect: 4 forecasters 24-hr shift

Satellite based Analysis
National Typhoon Center
Typhoon monitoring, forecasting, and report
Nominal: 1 operator 12-hr shift
Korea effect: 2 operators 24-hr shift

National Meteorological Satellite Center
Center, Intensity, Wind Radii
Nominal: 1 operator 12-hr shift
Korea effect: 2 operators 24-hr shift

Weather Radar Center
Center of the storm
Nominal: 1 operator 12-hr shift
Korea effect: 2 operators 24-hr shift
Web-based Satellite imagery Analysis System

- New user friendly web-based system for GK2A
- Using Dvorak Technique from SSEC/CIMSS
- Create own UI, DB, and intensity algorithm for ADT/SDT
- Including all available observation data
- Automated tools including finding center position, intensity, wind radii beside subjected analysis by human
- Comparisons with other agencies report and best track
Typical pattern of Typhoon near Korea

TY 1324 DANAS

Generating -> Developing -> Mature -> Weaking
1 Cb Cluster -> 2 Curved Band -> 3 CDO -> 4 EYE -> 5 SHEAR
Cloud Patterns

Unorganized Cb-cluster Pattern
Organized Cb-cluster Pattern
Low Level Cloud Vortex Pattern
SHEAR Pattern

CDO Pattern
BAND Pattern
EYE Pattern
Which imagery we can use?

2009 Typhoon MAYSAK, 2020. 09. 03. 09KST

2009 Typhoon MAYSAK, 2020. 09. 03. 01KST
Find recurving point using Water Vapor imagery

- Expect the recurving point using the distance between center of the storm and curved moisture band, CMB over GK2A Water Vapor imagery
- Normally recurving starts the distance less than 1,000km
New GK2A web-based analysis system
Web based Satellite imagery Analysis System
Tropical Cyclone Analysis

Main Window
- Data selection (time, area, type, etc)
- Layer display
- Analysis tools (palette, effect, video, contour, distribution, editing, etc)
- Phenomena (Typhoon, Flood, Cloud, Fire/Volcanic ash/Fog etc)

Secondary Window
- SDT Analysis (intensity, center position, etc)
- Automated analysis (ADT, KADT, GTS, Archer, etc)
IR based Wind Radii (15 and 25 m/s)
Additional Wind Radii

SDT Analysis : 2019 Year - FRANCISCO (1908)

Microwave

Numerical Model

MW + Model
Percentile analysis on Rain & Wind
[Example] The calculated 10%, 25%, 50%, 75%, 90% tile of precipitation and wind speed along every 1° latitude, which are estimated using MERRA-2 data for 113 historical typhoons.

- Around 28°N latitude, 90%tile is about 4.3 mm/hour for precipitation and 33 m/s for wind speed. Here the values are averaged within 200-km radius from a storm center.
- The latitude with peak value for rainfall data is 2-3° higher than wind speed.
Algorithm

Input data

Database for history TC
- MERRA-2 0.5° x 0.625°, hourly, 1980-2016
- RSMC best track Position, Max Wind 6-h, 1980-2017

Korea effective cases Lat 1°, 6-h resolution
- Average 200km radius
- Historical Database

Data for current TC
- GK2A Rainfall FD, 2km, 6.2, 7.3, 8.5, 11.2, 12.2 μm
- GK2A FD surface Wind, NWP, 3-h, 10km, grid,
- KMA TC Track for GTS Report Max Wind

Only if the TC get inside 200 km from Korea

Calculate Percentile

Rainfall/Wind speed Percentile
### Warning Thresholds

<table>
<thead>
<tr>
<th>Warning Thresholds (Possibility)</th>
<th>Types According to Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Rain-Dominant)</td>
<td>59th–81st</td>
</tr>
<tr>
<td>(Wind-Dominant)</td>
<td>57th–73rd</td>
</tr>
<tr>
<td>(Both Satisfied)</td>
<td></td>
</tr>
<tr>
<td>(Rain-Wind-Dominant)</td>
<td>Both Satisfied</td>
</tr>
</tbody>
</table>

#### Mean and std of average top cases percentile near 32N during 1980 ~ 2017

- **Mean**: 81, 74
- **Std**: 59, 57
Test Case (1913 LINGLING)

00:00 UTC Sep. 2 ~ 00:00 UTC Sep 8, 2019

GK2A PREC : Severe
GK2A WIND : Severe
GTS WIND : Severe
to warning

Rainfall and Wind effect
Case study – cont.

00:00 UTC Sep. 2 ~ 00:00 UTC Sep 8, 2019 for 13th typhoon Lingling

GTS Wind → Severe

GK2A Wind → Severe

GK2A Rain → Severe

32°N
Application of Lower level Winds
Background

- GEO wind field
  - GK2A AMV (5 layers)
    - 925-1050 hPa, 850-925 hPa
    - 500-700 hPa, 300-500 hPa
    - 100-300 hPa
  - ocean surface wind
  - scatterometer payloaded LEO satellite
    - METOP-B, C
    - HY-2B, 2C (from 2022)
    - 2 times per day

GK2A AMV
For typhoon Namadol at 08:00 UTC Sep. 15, 2022

METOP-B,C HY-2B, 2C composite wind in 6 hours time window on Sep. 15, 2022
Full Disk Wind

- FD wind data
  - UM model data

- AMV

![Map showing wind data](image)
TC LINGLING(1913) : WIND-FD
Thank you for attention!

Next subject of severe weather detection will be continued by Senior researcher, Ok Hee Kim
Application of GK2A data for severe weather detection

2022. 11. 11.

Ok Hee KIM

KMA
I. Key points of pre-detecting signals of developing cloud with Satellite images

II. Case Analysis
1. Key points of pre-detecting signals of developing cloud
15 Key points of pre-detecting signals of developing cloud

1. Updraft area in front of the boundary of the upper dry area of mT (marine Tropical)
2. Updraft area in front of the dry area due to the trough
3. Compressed wet zone between the southern and northern dry zones
4. Warm advection with warm conveyor belt (WCB) (warm advection accompanied by low pressure)
5. Lower cumulus clouds along strong southwesterly air stream (lower jets)
6. Ci cloud as divergent in the upper strong wind zone - (in the case of lower-level convergence): upper-level divergence
7. Upper level cold core (localized heavy rain due to instability between upper and lower layers)
8. Meso-scale cyclonic clouds of upper, middle, and low level 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 °C / 10 minutes
11. Clouds thickness of 10 km or more (from the lower layer to the upper layer)
12. Heavy rainfall critical index of 30 or higher (heavy rain advisory level or higher)
13. TPW (total precipitation water) of 60mm/h or higher area
14. High instability area
15. Others: Forced rising motion due to topographic factors, duration of heavy rain clouds (moving speed less than 15 km/h), etc.
In heavy rain case, satellite analysis key point 1

1. Extension of mT upper dry area boundary and stronger dry area behind it
   - Analysis of the updraft area in front of the mT upper dry area boundary (BT -18°C) in the 7.3 WV
   - Inflow of stronger dry area (BT -11 °C or higher) behind the boundary of the mT upper dry area

* As the boundary of the upper dry area above -18°C moves northward, the closer the distance to the convective cloud, the stronger the convective cloud develops.
2. Updraft area in front of the dry intrusion due to the trough

- As the dry area accompanying the trough is strengthened, strong convective clouds are developed and strengthened in the forward direction of the dry area.
3. Compressed wet zone between the southern and northern dry zones
- The northern dry area southward, and the dry area at mT boundary northward
- Convective clouds develop in the compressed water vapor river between the southern and northern dry regions.

2020. 07. 30 09:00 KST 7.3 μm WV, 500hPa RH(NWP+Sat.)
4. Convective cloud development by warm advection in warm conveyor belt (WCB)
- 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 to Korea along with WCB from the south triggers the development of convective clouds.

Strong Warm advection with warm conveyor belt

2020. 07. 23. 21:00 KST RGB composite +925hPa wind

Conveyer Belt Model
5. Lower cumulus clouds along strong southwesterly air stream (lower jets) with mT extension

- In the RGB day/night composite image, northward of the texture shape along with the southwest wind
- In the AMV, the lower cloud (red series) moves north along with the southwest air stream

2020. 07. 22. 09:00 KST RGB day/night composite image, AMV(Visible)
6. Ci cloud as divergent in the upper strong wind: upper-level divergence

- 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 atmospheric motion vector

Compression of the north-south dry zone, convergence of the lower layers of the southwest and northwest

Upper level strong wind area: upper level divergence

Upper level strong winds: convective cloud development

2020. 07. 30 09:00 KST 7.3µm WV, RGB Airmass(UM 200hPa isotach), 6.3µm WV AMV
7. Upper level cold core (localized heavy rain due to instability between upper and lower layers)
- Upper level cold core over the Korea: Atmospheric instability caused by the temperature difference between the upper and lower atmospheres -> Localized heavy rainfall
- Upper cold core: Red-purple area near the center of the low-pressure in the RGB airmass image
- Convective cloud development around mountainous areas due to forced rising motion by topography and updraft area in front of dry boundary

**2021.06.28. 15:00KST**
Heavy rain case in Jeolla, Chungnam

**2021.07.19. 18:00KST**
Heavy rain case in the central region
8. Mesoscale cyclonic clouds in the middle and low level on the stationary front
- Mesoscale cyclone on the stationary front cloud band in the middle and low level, airflow converges
- 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
- As the boundary of the upper dry area of mT moves north, strong warm air with high temperature and 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.

Image: Image of a weather map showing periodic upper-level waves flow into the central region. The dry boundary moves northward. 2020.08.09 14:00KST 7.3 μm WV
In heavy rain case, satellite analysis key point 10

10. Cooling rate is greater than -3 °C / 10 minutes on the developing convective cloud
- Cooling rate is greater than -3 degrees/10 minutes
- -3~ -10 °C /10 min: strong convective cloud development
- -10~ -20 °C or more/10 min: explosively strong convective cloud development

<table>
<thead>
<tr>
<th>Cooling rate (°C/10min)</th>
<th>Stage of development</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ~ -3</td>
<td>weak</td>
<td>continuously developing</td>
</tr>
<tr>
<td>-3 ~ -6</td>
<td>moderate</td>
<td>strongly developing</td>
</tr>
<tr>
<td>-6 ~ -10</td>
<td>strong</td>
<td></td>
</tr>
<tr>
<td>-10 ~ -20</td>
<td>very strong</td>
<td>rapid development in a short time</td>
</tr>
<tr>
<td>-20 ~ more</td>
<td>explosively strong</td>
<td></td>
</tr>
</tbody>
</table>

Source: Heavy Rain Guidance Technical Note(2020)
11. Heavy rainfall with Clouds thickness of 10 km 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 10 km considering the CTH and CBH

2020.7.30. 12:00 KST heavy rainfall clouds in central region of Korea
12. **Heavy rainfall critical index: heavy rain advisory level or higher**

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

![Map 1](image1.png)  
**2022.7.13. 15:00KST**

![Map 2](image2.png)  
**2022.7.21. 00:00KST**
13. TPW (total precipitation water) of 60mm/h or higher area

- Possibility of heavy rain is very high in areas with TPW 60mm/h or more

TPW (NWP + Sat.)

2020.7.23. 09:00 KST  
2020.7.30 09:00 KST  
2020.8.2. 15:30 KST
14. Instability index: High instability area

- High probability of heavy rain cloud formation in areas with high instability

<table>
<thead>
<tr>
<th>Index</th>
<th>Applying time</th>
<th>Thunderstorm intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>weak</td>
</tr>
<tr>
<td>KI</td>
<td>Summer</td>
<td>25 ~ 30</td>
</tr>
<tr>
<td>SSI</td>
<td>All year round</td>
<td>6 ~ 3</td>
</tr>
<tr>
<td>LI</td>
<td>All year round</td>
<td>0 ~ −2</td>
</tr>
<tr>
<td>TTI</td>
<td>October to May</td>
<td>42 ~ 48</td>
</tr>
<tr>
<td>CAPE</td>
<td>April to November</td>
<td>300 ~ 500</td>
</tr>
</tbody>
</table>

KI(NWP+Sat.)  LI(NWP+Sat.)  SSI(NWP+Sat.)  TTI(NWP+Sat.)  CAPE(NWP+Sat.)

2020.7.30. 09:00KST
15. Others: Forced rising motion due to topographic factors, duration of heavy rain clouds (moving speed less than 15 km/h), etc.
Key points of pre-detecting signals before developing cloud

1. Updraft area in front of the boundary of the upper dry area of mT (marine Tropical)
2. Updraft area in front of the dry area due to the trough
3. Compressed wet zone between the southern and northern dry zones
4. Warm advection with warm conveyor belt (WCB) (warm advection accompanied by low pressure)
5. Lower cumulus clouds along strong southwesterly air stream (lower jets)
6. Ci cloud (jet stream) as divergent in the upper strong wind zone - (in the case of lower-level convergence): upper-level divergence
7. Upper layer cold core (localized heavy rain due to instability between upper and lower layers)
8. Medium and small-scale low-pressure rotating clouds of upper, middle, and lower layers 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 °C / 10 minutes
11. Clouds thickness of 10 km or more (from the lower layer to the upper layer)
12. Heavy rainfall critical index of 30 or higher (heavy rain advisory level or higher)
13. TPW (total precipitation water) of 60mm/h or higher area
14. High instability area
15. Others: Forced rising motion due to topographic factors, duration of heavy rain clouds (moving speed less than 15 km/h), etc.

Among the features from 1 to 13
- Heavy rain occurs when 6 or more features appear
- High probability of heavy rain when 4 or more appear
2. Case Analysis

Heavy rain case on July 30, 2020
Compressed wet zone between the southern and northern dry area

- The northern dry area southward, and the dry area at mT boundary northward
- Convective clouds develop in the compressed water vapor river between the southern and northern dry regions.
Deep convective cloud development in Daejeon

- In the lower atmosphere (850 hPa) a strong warm advection from the southwest of mT boundary into the West Sea of Korea.
- Atmospheric trough is located in the West Sea
- Due to the convergence between the southwest and northwest airstream, strong cumulonimbus clouds are developing (CTT -70 °C or less, CTH of 15 km) in Daejeon area.
Tapering Cloud types

Tapering Cloud Types

Tapering Cloud developing conditions
- Around the cyclonic center and near warm area of the stationary front
- In case of significant inflow of dry air over the warm and humid air mass in the lower layer
- In case of strong wind zone in the upper layer, strong vertical shear and upper layer divergence

F1 type: Occurs at the southern edge or center of the cloud band

(Source: from JMA)
The lower winds from the southern seas flow into the West Sea and flow into the inland of Jeolla-do of southern part of South Korea.

Convection clouds develop into inland as the warm and humid air from the southwest flow strongly into Korea.
Application products on July 30, 2020 (Daejeon) case

- Convection clouds develop strongly due to lower convergence and upper divergence
  - Thick clouds are distributed from CBH 6km to CTH 15km of the developed clouds in Daejeon (similar to the model)
  - With cooling rate of -1°C/10 minutes, clouds may gradually weaken after mature

Cloud thickness 6~13km
Cloud thickness 3km

2020. 07. 30. 09:00KST
Convection clouds develop strongly due to lower convergence and upper divergence:
- RH 90% of the lower atmosphere
- Total Precipitable Water 60mm/h or more in southern Chungcheong
- Critical Index of Heavy Rainfall is Warning and Alert level in the southern part of Chungcheong Province

2020. 07. 30. 09:00KST
The 12th Asia/Oceania Meteorological Satellite User’s Conference
Training event

Introduction to KMA’s Satellite Data Service

NMSC / KMA

Taekyu Jang
CONTENTS

I  Overview
II Weather Broadcasting Service
III Internet Service
IV Rapid Scan Service
V DCPC Service
Overview
Overview of KMA’s Satellite Data Service

Internet service
- Internet service of satellite meteorological data

Weather broadcasting Service
- Large-scale broadcast receiver (LDUS)
- Medium-scale broadcasting receiver (MDUS)
- Small-scale broadcasting receiver (SDUS)

Rapid Scan Service
- Over the Asian Pacific region (RA II and RA V)
- Every 2 minute observation with two kind of mode (fixed or tracking)

DCPC service
- Core component service of WMO WIS
Weather Broadcasting Service
01 • Weather Broadcasting Service

GK-2A Satellite 35,786Km (128.2E)

- Large-scale Data Utilization Station (LDUS)
  - Large-Scale Data Utilization Station
  - UHRIT broadcasting (high resolution Level 1B) reception
  - Utilization of commercial DVB-S2 receiver
  - Weighted/synthetic image display

- Medium-scale Data Utilization Station (MDUS)
  - Medium-Scale Data Utilization Station
  - HRIT broadcasting reception
  - Application of SDR (SW demodulation/decoding) technology
  - Backward compatibility with COMS broadcasting receivers

- Small-scale Data Utilization Station (SDUS)
  - Small-Scale Data Utilization Station
  - LRIT broadcasting reception
  - Application of SDR (SW demodulation/decoding) technology
  - Building the low-cost system (application of omni-directional antenna)

Non-stop weather broadcasting service

- LRIT (Low Rate Information Transmission)
- HRIT (High Rate Information Transmission)
- UHRIT (Ultra High Rate Information Transmission)
02 • Weather Broadcasting Service

Small-sized broadcasting receiver is a low-priced terminal which can be easily installed on a ship, and provides service for an extensive area.

LRIT Service

- Frequency Band: L-band
- Transmission Rate: ≥ 8kbps
- Broadcasting Information: Weather FAX replaceable Image and Text (Satellite Image, Weather Information, and Daily Climate Map, etc.)
- Providing service with the same specification as COMS Satellite LRIT service (frequency, Information transfer rate, and transmission specification, etc.) (Difference at Transmission Rate)

Small-scale Data Utilization Station (SDUS)

- Main Function: Reception of LRIT Broadcasting, Displaying and Management of Received Data
- Configuration: Small Antenna/LNB, A/D Converter, and Mini-PC
- Implementing demodulator/decoder with S/W (adopting SDR concept)
- Providing Service through Personal Smartphone
Internet Service
Various types of satellite meteorological datasets is shared
Currently, 16 countries are using the real time ftp service.
04 • Internet Service

The website of the National Meteorological Satellite Center

GK2A Satellite Images – shows the various satellite images and informations for the GK2A
GK2A Data Services – data download, service request(open api, rapid scan)
The website of the National Meteorological Satellite Center
Various satellite meteorological data services (such as searching, displaying, or downloading) can be provided on the data website of the National Meteorological Satellite Center.

1. Display of the search list of satellite meteorological data
2. Request
3. Status is displayed, such as “Being Prepared” or “Download Possible”
4. HTTP download service is provided

Satellite, area, data type, and period selected by user
Select data list, format, and request final order
Preparation status to be able to download satellite meteorological data
Download of Satellite meteorological data

Customized satellite data service allowing the users to select a kind of satellite, area, data type, period, and data format
07 • Internet Service

The website of the National Meteorological Satellite Center

Open API – Open Application Programming Interface
– API Key-based System (need registration)
08 • Internet Service

Procedure of Open API Service

- Sign up to homepage
- Request issue key from manager by e-mail (Required attachment: ID of homepage)
- Manager OpenAPI application examine
- Program operating
- Use the key to create a URL in user page
- Manager reply

Open API – Open Application Programming Interface
- API Key-based System (need registration)
The usage of Open API service is continuously increasing.
09 • Internet Service

Software support page
- Data Processing Tool, Manual, Sample code/data
- SRF(Spectral Response Function)
- lat/lon coordinate data(GEOS, LCC)/(NetCDF, Ascii, Bin)

Software

Program
- Customized Imagery Processing Tool (Windows Logo) : gk2a_sat_win_center_20200220.zip
- Customized Imagery Processing Tool (Linux Logo) : gk2a_sat_linux_center_20200220.zip
- GK2A Medium-scale Data Utilization for weather forecast data (MDUS) S/W (Linux Logo) : mdus_sw.zip

Description

Sample
Rapid Scan Service
01 • Rapid Scan Service

Over the Asian Pacific region (RA II and RA V)

- Provide significant improvements in the real-time monitoring of hazardous weather such as Typhoon, thunderstorm and dust events
- Users can submit official request form defining specific measurement area via rapid scan request webpage (http://datasvc.nmsc.kma.go.kr/datasvc/html/special/specialReqMain.do)
- The number of joined countries is 7.
Rapid Scan Target Observation

Typhoon HAISHEN
2020. 9. 4. 06 ~ 09 UTC
(VI006, every 2 min., 0.5km)
DCPC Service
05

**DCPC NMSC**

Data Collection or Production Center (WIS Core Components)

- Metadata search
- Basic data (Level1b), product data (Level2)
Thank you