P-16

Current Status of Convective Clouds Discrimination in NMSC/KMA

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Background

- The National Meteorological Satellite Center (NMSC) of KMA has the **Rapid Development Thunderstorms (RDT)** module developed by NWCSAF/EUMETSAT. The RDT algorithm consists of three parts: detection, tracking, and discrimination which provide information on clouds related to significant convective systems using geostationary satellite data.
- In order to optimize the use of satellite data, we adapted **Himawari-8/AHI data** to RDT module and performed the **tuning of discrimination model** by an ensemble of **logistic regression** over the Korean Peninsula.
- In addition, it improved the detection of convective clouds by **adjusting the stability index mask** based on the NWP data.

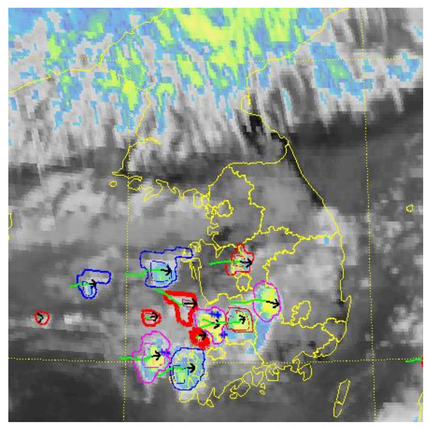
Rapid Development Thunderstorms (RDT)

- **PGE11 module(v2013) developed by NWCSAF/EUMETSAT *(Météo-France)***

- **STEP1 : Detection of cloud systems**
  - Using vertical morphology of IR10.4 BT
  - Cells(towers) are detected at each slot
  - Vertical extension: at least 6 K
- **STEP2 : Tracking**
  (in order to recognize each cell in the previous slot)
  - Analysis of cloud cells overlap: each cell of the previous slot is advected
  - Merges and splits are taken into account
  - Trends of various parameters are calculated

6.	Max_TxTmin15
7.	Max_TxTmin30
8.	Max_TxTmin45
9.	Max_TxTmin60

- **STEP3 : Discrimination (Statistical process)**
  (in order to identify convective cells)
  - Made complex by the unbalanced populations, the wide variety of scales and evolution-phases of systems
  - Highly improved by the use of a set of 6 IR-channels as predictors, by the use of NWP data
  - Very highly improved by the use of lightning data
- **STEP4 : Forecast**

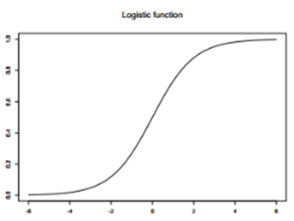


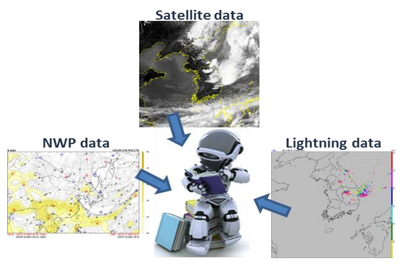
KMA RDT (2018. 8. 30. 01UTC)

- Logistic Regression

$$\mathbb{P}(Y=1|x)=\frac{\exp(\beta_0+\beta_1 x)}{1+\exp(\beta_0+\beta_1 x)}$$

$$\log\left(\frac{\mathbb{P}(Y=1|x)}{1-\mathbb{P}(Y=1|x)}\right)=\beta_0+\beta_1 x$$

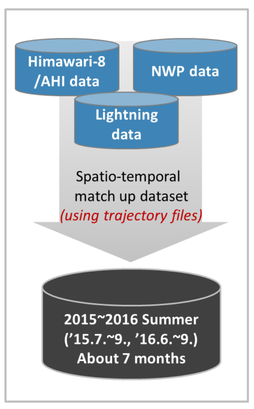


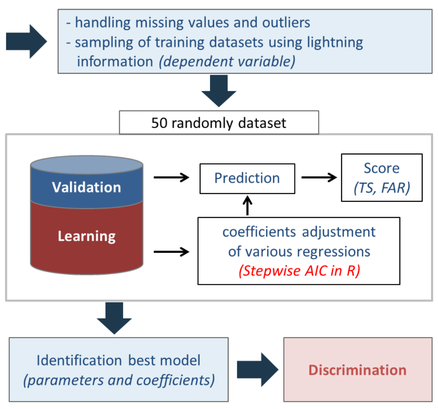


➔ As a preliminary step before applying **the GK-2A/AMI data** to the RDT module, we adapted Himawari-8/AHI data and performed the tuning of discrimination model

Methodology

- Tuning of discrimination models



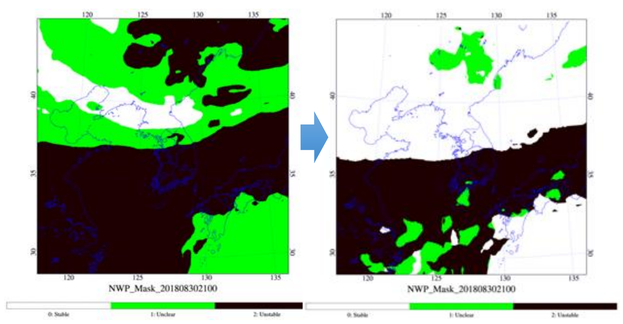


- Input data
  Himawari-8/AHI (2 km, every 10 min.),
  ➔ IR10.4, IR12.3, IR3.9, WV6.2, WV7.3, IR8.6
  + Unified Model (KMA oper.)
  for NWP convective mask
- 6 Category (same as PGE11),
  6 Depth, 1 Mode (full configuration)
  = 36 models (Logistic Regression)
- 111 Discriminating parameters
  (because of time depths and additional channel)

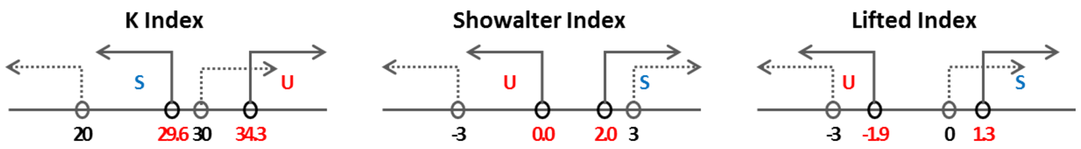
- In order to optimize the convective mask, we adjusted thresholds of stability indices (K Index, Showalter Index, Lifted Index) based on the NWP data

- NWP convective mask (RDT v2013)
  - Unstable : **KI > 30** or **SSI < -3** or **LI < -3**
  - Stable : **KI < 20** and **SSI > 3** or **LI > 0**

- Comparison of Lightning occurrence and stability indices over the Korean Peninsula
  - Data: Ground lightning data(KMA), stability indices(KI, SSI, LI) of PGE11 from NWP data(UM)
  - Period: 2016~2018 JJA (9 months)
    ➔ within 5 km radius, ±5 min. (nearest)



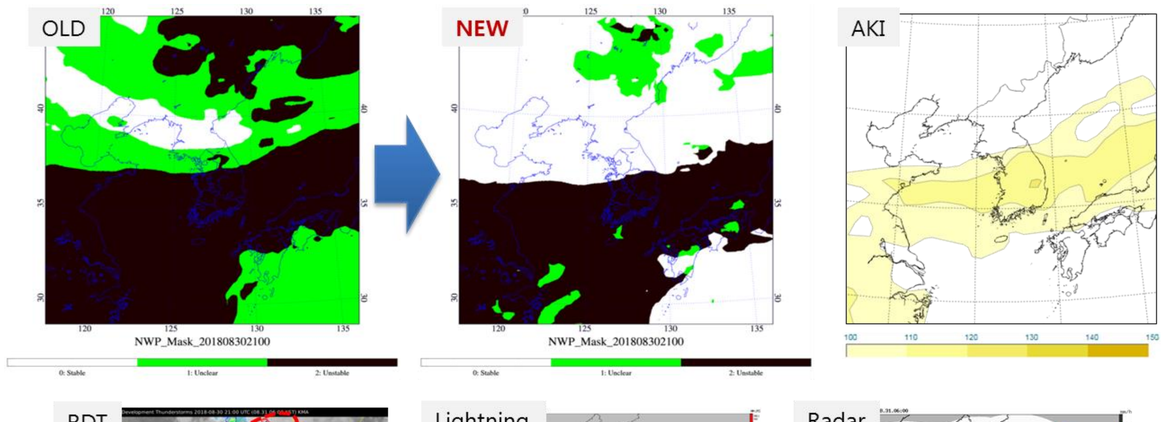
	Min.	Lower whisker	Q1	Median / Mean	Q3	Upper whisker	Max.
KI	-3.618	**29.593**	**34.298**	36.204 / 35.701	37.435	42.091	43.181
SSI	-5.558	-3.534	-1.425	-0.599 / -0.698	**-0.019**	**2.090**	14.987
LI	-6.623	-6.623	-4.058	-2.957 / -2.833	**-1.917**	**1.294**	11.555



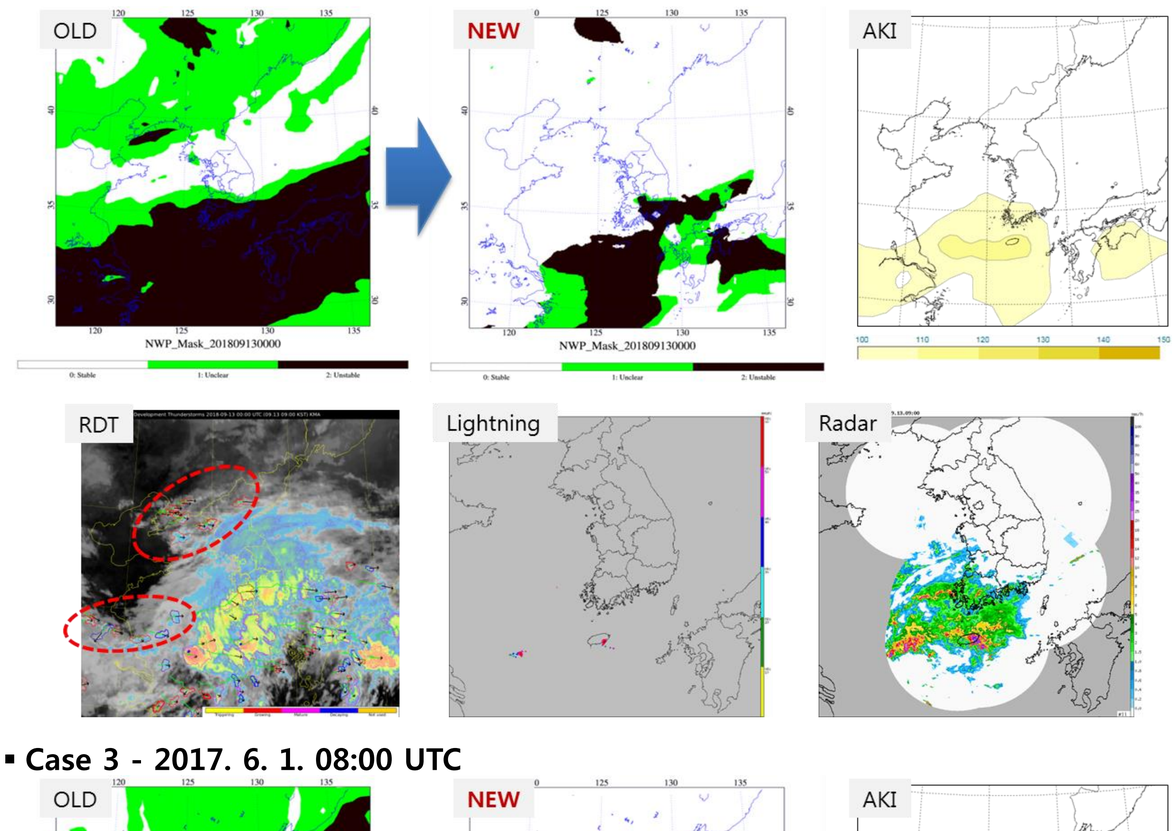
➔ To optimize for the Korean Peninsula and its surrounding region, We performed the tuning of discrimination model using logistic regression. Also, the quartiles (Q1 or Q3) and whiskers for each stability index are used as new thresholds of the NWP convection mask as a filter of stable area.

Result

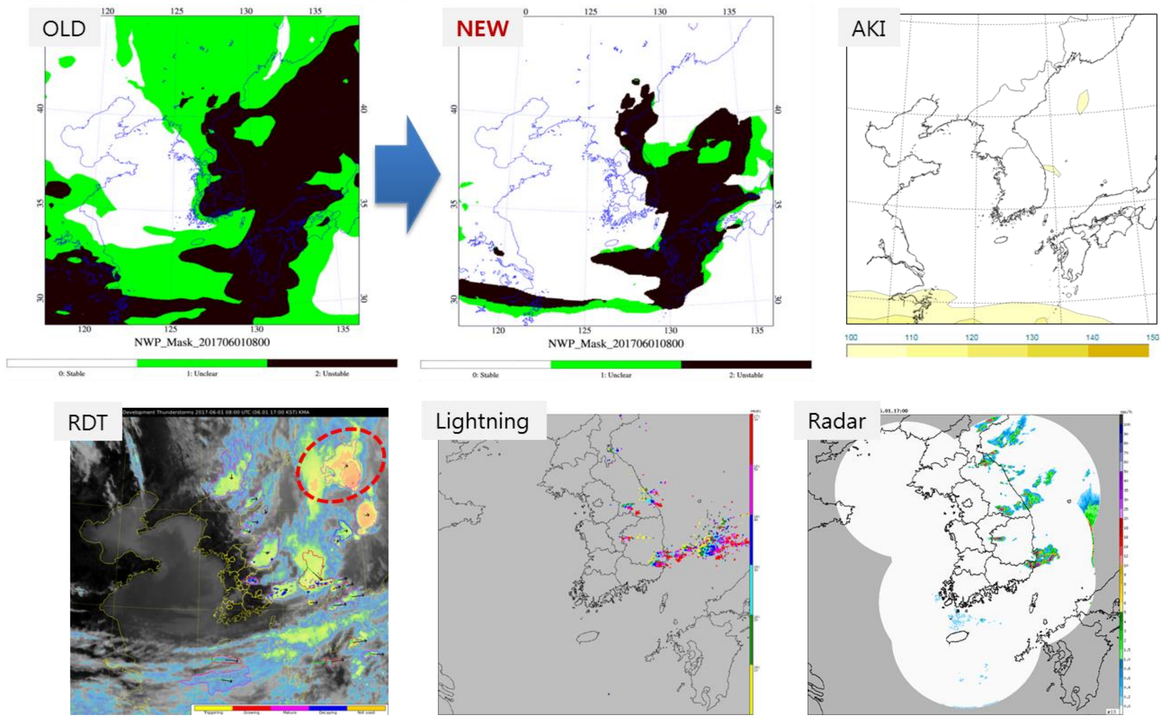
- **Case 1 - 2018. 8. 30. 21:00 UTC**



- **Case 2 - 2018. 9. 13. 00:10 UTC**



- **Case 3 - 2017. 6. 1. 08:00 UTC**



➔ As a result of applying the new thresholds of NWP convective mask, Non-convective clouds(without lightning activity) can be excluded in stable regions.

➔ With the exception of some cases, the new NWP mask represents a spatial distribution similar to the Advanced Korean-unstable Index (AKI) used in the KMA. ***(Additional stability index?)***

Summary

- The discrimination skill of RDT algorithm was improved (POD ~75%, severe lightning). Also, False alarm reduced by the use of new thresholds of the NWP convective mask. However, the RDT product still overestimates convective cells compare to radar reflectivity(dBZ) and ground truth.
- For the future work, we plan to improve the RDT algorithm using **rapid scan data** of GK-2A (every 2 min.). Also, we want to apply various machine learning methods using radar data and geo-satellite visible channel data.

- *NWCSAF/EUMETSAT, 2013: Algorithm Theoretical Basis Document for "Rapid Development Thunderstorms" (RDT-PGE11 v3.0)*
- ***This research was supported by "The Development of Satellite Data Utilization and Operation Supportive Technology" of the NMSC/KMA.***