P8

Radar-Based Nowcasting

by Combining Centroid Tracking and Motion Vector of Convective Storm

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1. INTRODUCTION

❖ Radar-based nowcasting system of KMA

- ☐ Centroid method: FAST(Fuzzy logic approach for storm tracking)
  - ➔physical properties of individual convective cell
- ☐ Area-based method: MAPLE(McGill algorithm for precipitation nowcasting by Lagrangian extrapolation)
  - ➔motion vectors over entire precipitation field

Goal:

To combine both methods by utilizing complementary characteristics. Two approaches were examined by combination of two methods for determination of future position of convective cells.

2. DATA

❖ Radar reflectivity

: CMAX(column max) of reflectivity from KMA radar network(10 radars)

❖ MAPLE

- ☐ Forecast field(reflectivity)
- ☐ Motion vector from VET※

※VET: variational echo tracking (Laroche and Zawadzki 1994)

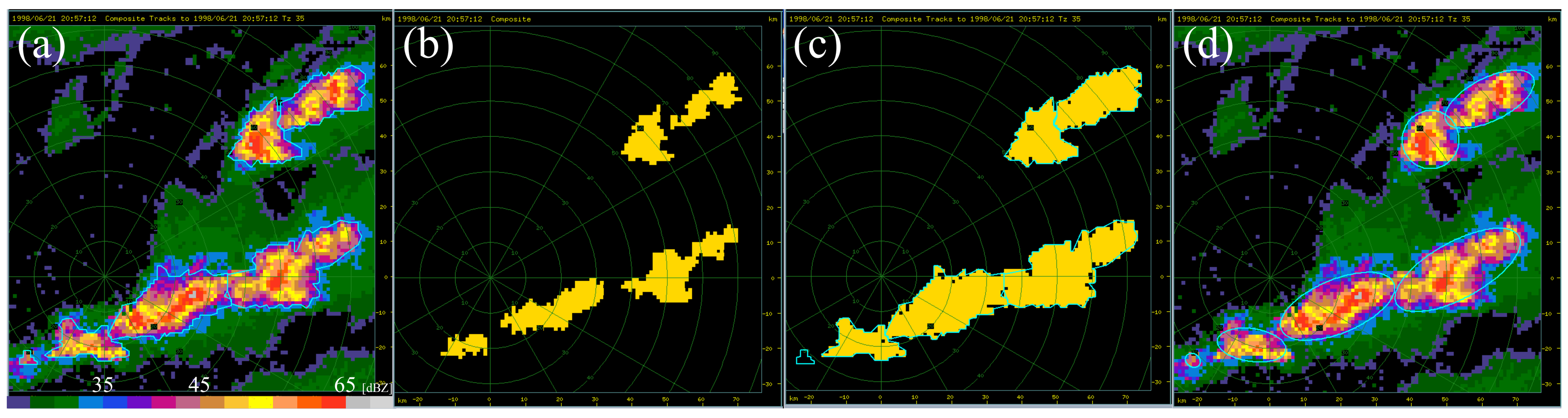
<Features of each data>

	CMAX	Forecast field	Motion vector
Size	2305x2881	1024x1024	800x800
Spatial	0.5 km	1.0 km	1.0 km
Temporal	5 min.	10 min.	10 min.

3. NOWCASTING SYSTEM IN KMA

❖ FAST

① **Identification**: Dual threshold identification(35 dBZ & 45 dBZ)



<Conceptual illustration of dual threshold identification>: (a)composite with dBZ>35, (b)significant regions with dBZ>45 , (c)significant regions grown out to 35dBZ boundary, (d)ellipse representation of storms (https://ral.ucar.edu/projects/titan/)

② **Tracking**: Based on fuzzy logic

☐ Calculate feature parameters

: speed(SPD), area change ratio(ACR), axis transformation ratio(ATR)

$$SPD_t^{m,n} = \frac{\left|\sqrt{(x_t^n - x_{t-\Delta t}^m)^2 + (y - y_{t-\Delta t}^m)^2}\right|}{\Delta t}, \quad ACR_t^{m,n} = \frac{|A_t^n - A_{t-\Delta t}^m|}{MEAN(A_t^n, A_{t-\Delta t}^m)},$$

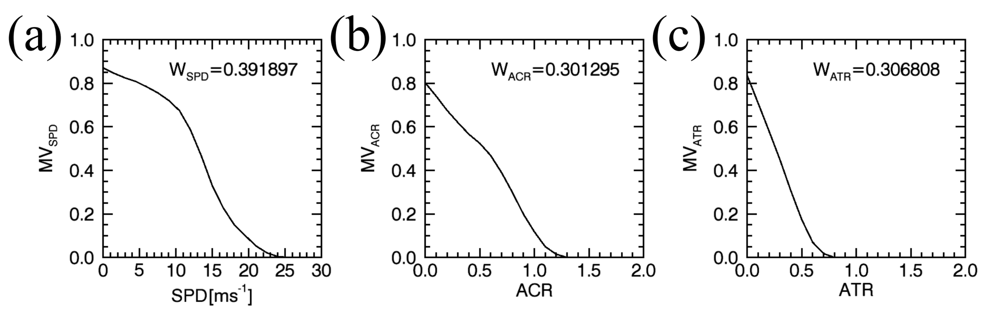
$$ATR_t^{m,n} = \frac{1}{2}\frac{|M_t^n - M_{t-\Delta t}^m|}{MEAN(M_t^n, M_{t-\Delta t}^m)} + \frac{1}{2}\frac{|N_t^n - N_{t-\Delta t}^m|}{MEAN(N_t^n, N_{t-\Delta t}^m)}$$

x, y: center of storm, (m, n): index of storm, t: time, A: area, M: major axis, N: mnior axis

☐ Calculation of total membership value of continuous storm by applying weight to each member value

$$MV_{total} = \sum_{i=1}^{3} W_i \times MV_i$$

☐ If MV_{total}>0.4, then match the two storm



<Membership function and weight of each variables. (a)SPD, (b)ACR, (c)ATR>

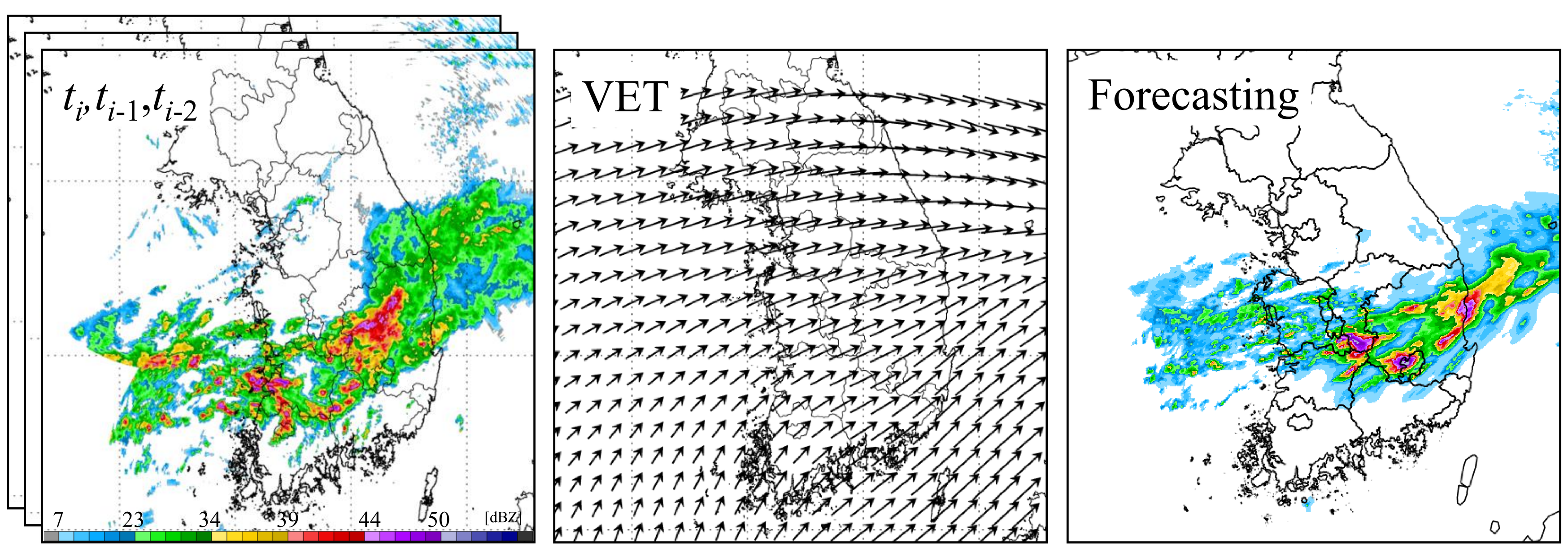
③ **Forecasting**: Using past storm track

$$x_t = \alpha_x + \beta_x t, \qquad y_t = \alpha_y + \beta_y t$$

i: index of track

$$\alpha_x = \frac{\sum x_i}{\sum W_i} - \beta_x \frac{\sum t_i}{\sum W_i}, \qquad \beta_x = \frac{\sum x_i t_i/\sum W_i - (\sum x_i/\sum W_i)(\sum t_i/\sum W_i)}{\sum W_i t_i^2/\sum W_i - (\sum x_i/\sum W_i)(\sum t_i/\sum W_i)} \left(\because W = 0.7^{i+1}\right)$$

❖ MAPLE



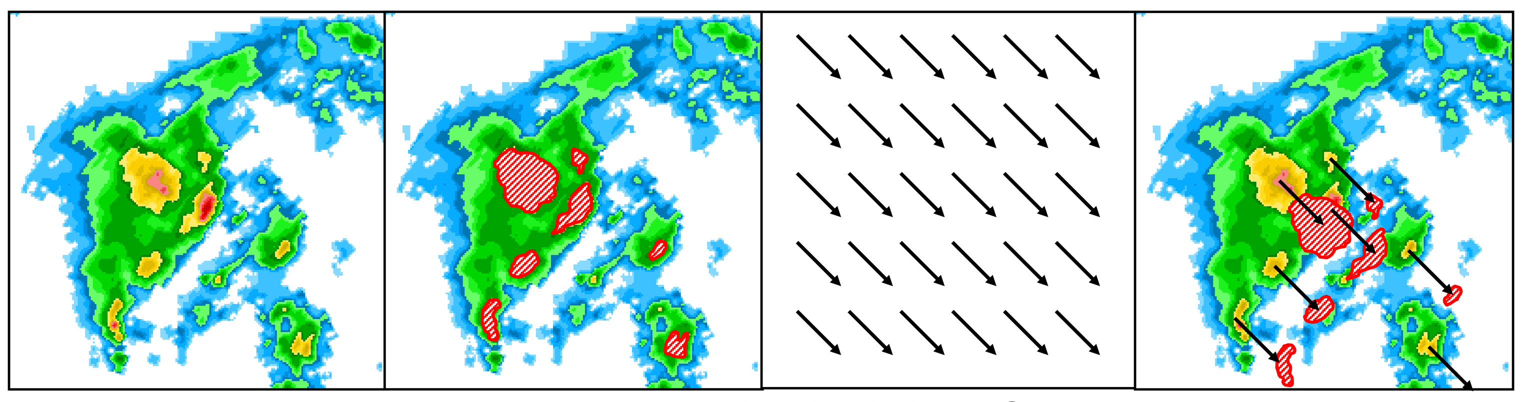
※See P9(Son et al.) for details of MAPLE

4. HOW TO COMBINE

❖ **Methodology ①: Storm identification + motion vector over storm**

➔ Future position

- ☐ Storm identification in observation field
- ☐ Calculate motion vector entire field
- ☐ Apply mean motion vector to each storm
- ☐ Forecasting future position of storm

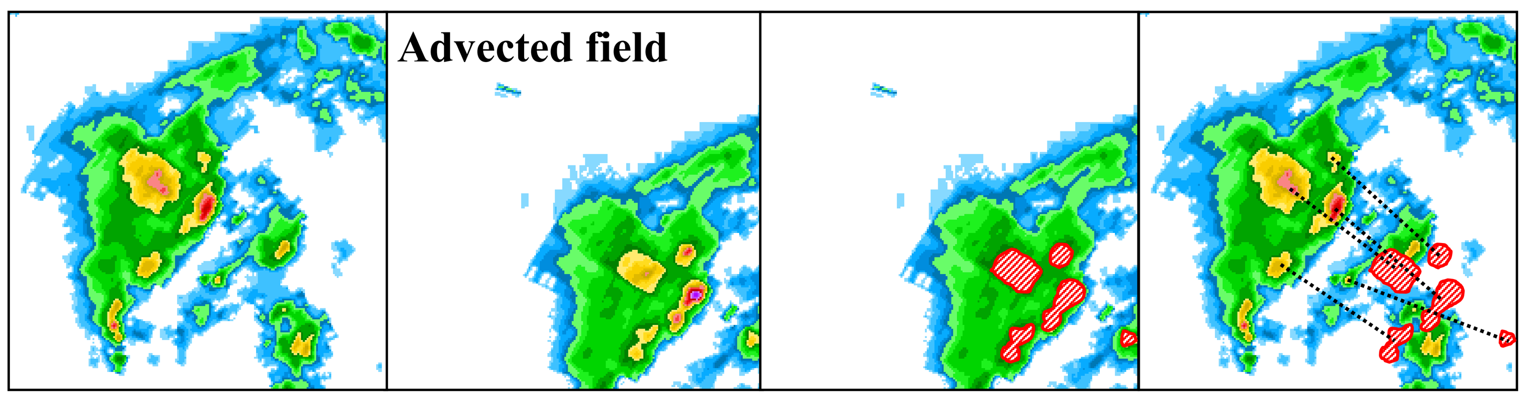


<Conceptual illustration of methodology ①>

❖ **Methodology ②: Advection by MAPLE + storm identification**

➔ Future position

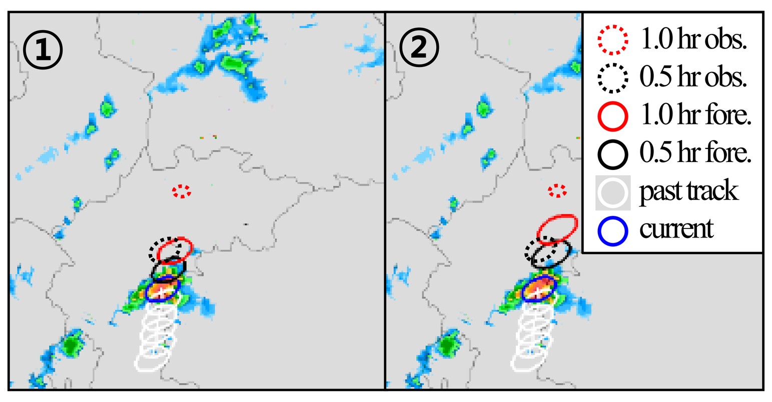
- ☐ Advection by MAPLE
- ☐ Storm identification in advected field
- ☐ Tracking storm by FAST
- ☐ Forecasting future position of storm



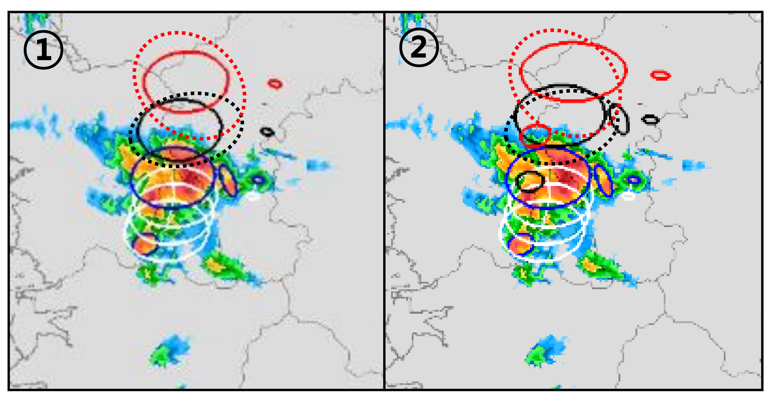
<Conceptual illustration of methodology ②>

5. RESULT

❖ **Case I: Isolated storm**



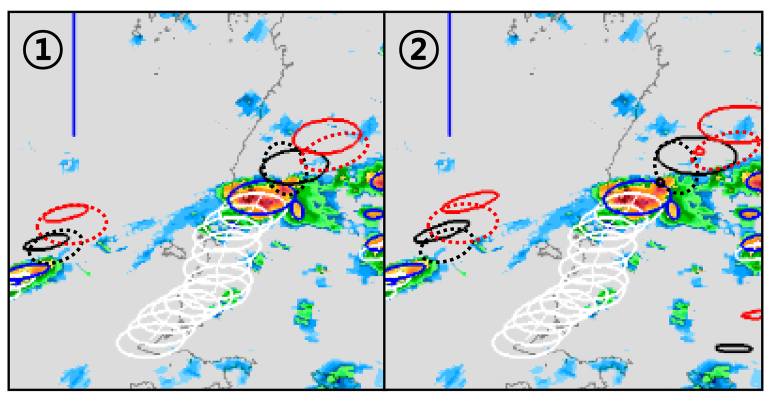
<Case 1: 0740LST 25 Aug 18>



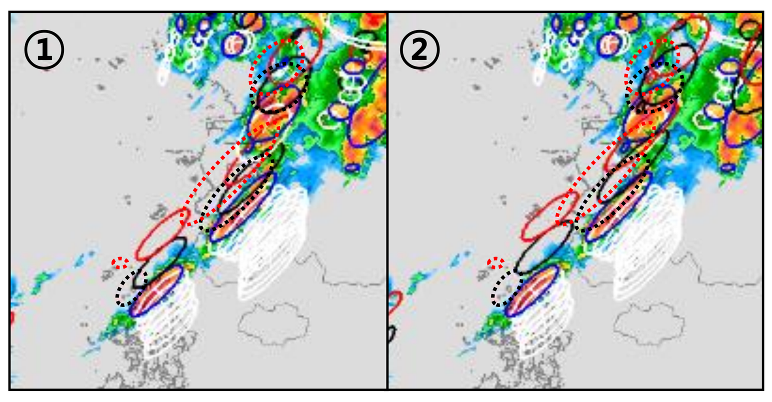
<Case 2: 0150LST 26 Aug 18>

- ✓ Both method similar in direction of forecasting, but some different in position of storm
- ✓ The main difference between both method was caused by motion vector

❖ **Case II: Storm associated with mesocyclone system**



<Case 3: 0400LST 26 Aug 18>



<Case 4: 1020LST 26 Aug 18>

- ✓ 2nd method forecast a small storm of the future(but usually merged)
- ✓ Both methods exhibited the same error when the direction of the wind suddenly changed at the front line

6. SUMMARY & FUTURE WORKS

- ❖ To combine two radar-based nowcasting method by utilizing complementary characteristics, two approaches were examined: "identification + motion vector", "advected + identification"
- ❖ Two types of cases(isolated, systematic) were used for analysis and qualitative verification was performed. In case of isolated, both method similar in direction of forecasting. In case of systematic, both methods show the same error when the direction of the wind suddenly changed at the front line.
- ❖ In the future, quantitative verification will be conducted

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