Identification and Tracking of Convective Cells in 3D Reflectivity Mosaic from Weather Radar Network

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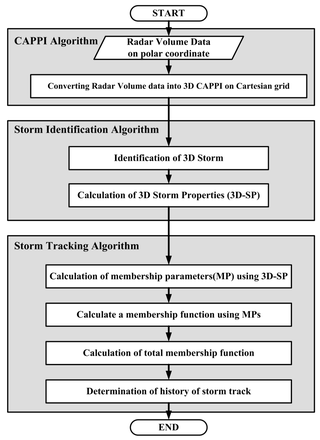
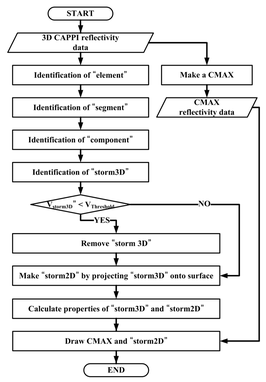
Introduction

- Identification and tracking of convective storms using high resolution weather radar data are essential elements of monitoring and warning of severe weather
- Automatic monitoring and warning systems such as TITAN (Dixon and Wiener, 1993) and SCIT (Johnson et al., 1998) have been recently utilized for practical forecasting operation

➔ **While the previous tracking algorithms use the subjective cost function or the advection vector determined by human experts, an objective algorithm is developed using fuzzy logic in the current study**



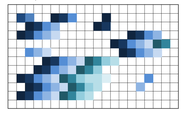
Identification algorithm



Element

- A grid point (x, y, z) above reflectivity threshold (e.g. 35dBZ)

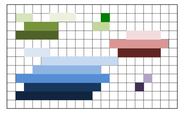
EX) 84 Elements



Segment

- Group of consecutive Elements along x-axis on each x-y plane of 3D CAPPI

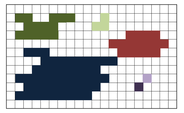
EX) 17 Segments



Component

- Group of consecutive Segments along y-axis on each x-y plane of 3D CAPPI

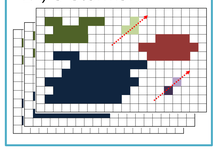
EX) 5 Components



Storm3D

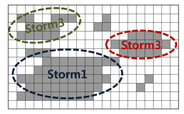
- Group of consecutive Components along z-axis of 3D CAPPI
- filter out small storms using volume threshold (e.g. 50km^3)

EX) 3 Storm3D

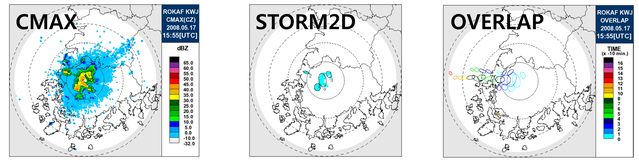


Storm2D

- Projected Storm3D onto x-y surface
- Storm is represented by ellipse



Identification products



21 storm properties

1) Storm ID, 2) Center latitude, 3) Center longitude,
4) Center height 5) Volume 6) Area 7) Top 8) Base ..... etc.

➔ **These properties are used to construct fuzzy membership function and weights**

Development of fuzzy algorithm for tracking

Four Fuzzy Parameters

Speed[SPD]

$$SPD_t^{mn} = \frac{|\sqrt{(x_t^n - x_{t-\Delta t}^m)^2 - (y_t^n - y_{t-\Delta t}^m)^2}|}{\Delta t}$$

Difference of Mean Reflectivity [DMR]

$$DMR_t^{mn} = |Z_t^n - Z_{t-\Delta t}^m|$$

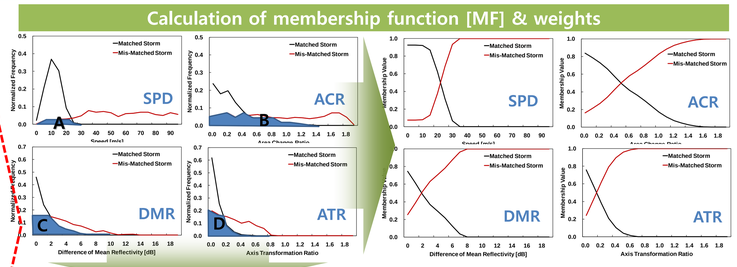
Area Change Ratio [ACR]

$$ACR_t^{mn} = \frac{|A_t^n - A_{t-\Delta t}^m|}{avg(A_t^n, A_{t-\Delta t}^m)}$$

Axis Transformation Ratio [ATR]

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

Calculation of membership function [MF] & weights

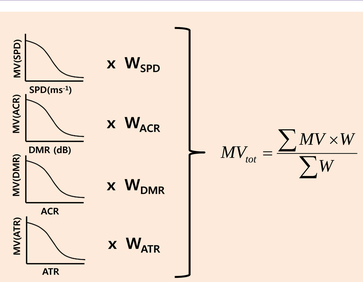


$$W_{SPD} = \frac{1}{AT} \quad W_{ACR} = \frac{1}{BT} \quad W_{DMR} = \frac{1}{CT} \quad W_{ATR} = \frac{1}{DT}$$

$$T = \frac{1}{A} + \frac{1}{B} + \frac{1}{C} + \frac{1}{D}$$

Variables	Weightings(W_i)
SPD	0.60
ACR	0.15
DMR	0.11
ATR	0.14

Fuzzy Classifier



$$MV_{tot} = \frac{\sum MV \times W}{\sum W}$$

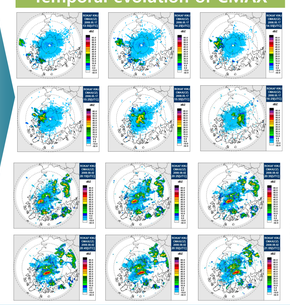
If MV_{tot} >= $MV_{threshold}$, same storm and tracking

If MV_{tot} < $Mv_{threshold}$, different storm

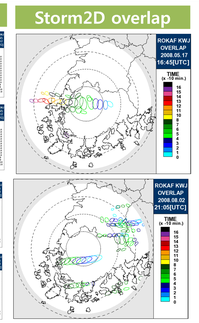
Storm tracking results from a single radar

Case	Period (UTC)
1	1355 – 1645 17 May 2008
2	1955 – 2105 02 Aug 2008

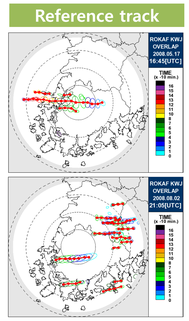
Temporal evolution of CMAX



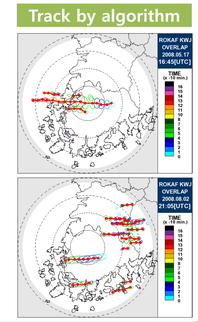
Storm2D overlap



Reference track



Track by algorithm



Tracking algorithm on radar mosaic

Limitation of cell tracking using a single radar

- No tracking of whole lifecycle of storm due to short coverage of radar
- No detection of storm at the cone of silence and beam blockage areas
- Inaccurate storm properties due to beam broadening effect at far range

➔ **Reflectivity mosaic can alleviate above limitations**

Issue in radar reflectivity mosaic

- Discrepancy of radar reflectivity among radar network and absolute calibration
- Beam blockage

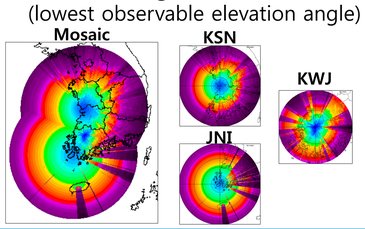
Reflectivity calibration

❖ **Characteristics of three radars**

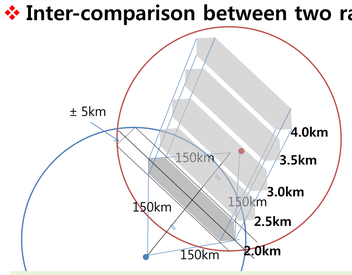
	JNI	KSN	KWJ
Band	S-band	S-band	C-band
Range[km]	240	240	120
P_{peak}[kW]	750	750	250

- JNI were absolutely calibrated by disdrometer measurements
- Beam blockage simulation using DEM with horizontal resolution of 3"

❖ **Beam blockage**
(lowest observable elevation angle)



❖ **Inter-comparison between two radar**

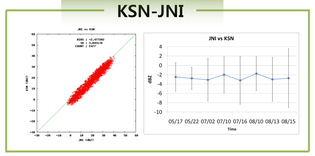


Characteristics of comparison area

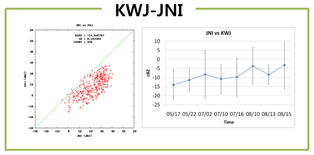
1) Horizontal range
: ± 5km at the equidistant point from radar
2) 150km range from radar
3) 2 km ≤ height ≤ 4 km
4) Vertical resolution : 0.5km
5) Reflectivity in beam blockage area are excluded

JNI : -3.0 dB
KSN : -5.62 dB
KWJ : -14.14 dB

KSN-JNI



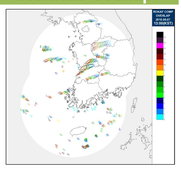
KWJ-JNI



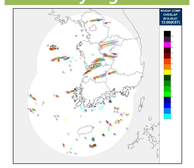
Storm tracking results from reflectivity mosaic of radar network

Case	Period (LST)
1	0920 – 2350 07 June 2010
2	1500 – 2200 30 June 2010

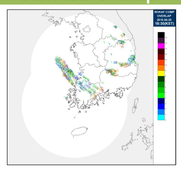
Storm2D overlap



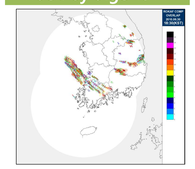
Track by algorithm



Storm2D overlap



Track by algorithm



Summary and conclusion

- Identification algorithm and objective tracking of convective cells have been developed in the present study.
- The developed algorithm properly identified and tracked cells compared with references using a single radar and mosaic of radar network.
- The algorithm may provide useful short-term forecasting or nowcasting capability of convective cells and provide the statistical characteristics of severe weather.

Reference

Dixon, M. J., and G. Wiener, 1993: TITAN: Thunderstorm identification, tracking, analysis, and nowcasting-A radar-based methodology. *J. Atmos. Oceanic Technol.*, **10**, 785-797.
Johnson, J. T., P. L. Mackeen, A. Witt, E. D. Mitchell, G. Stumpf, M. D. Eilts, and K. W. Thomas, 1998: The Storm cell identification and tracking algorithm: An enhanced WSR-88D algorithm. *Wea. Forecasting*, **13**, 263-276.

Acknowledgment

This study was financially supported by the Construction Technology Innovation Program(08-Tech-Inovation-F01) through the Research Center of Flood Defence Technology for Next Generation in Korea Institute of Construction & Transportation Technology Evaluation and Planning(KICTEP) of Ministry of Land, Transport and Maritime Affairs(MLTM).