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Retrieval of microphysical properties of localized convective precipitation by MP-Xs and 2DVD observation
in the Tokyo Metropolitan area, Japan

(Case Study)

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Contents

- ❖ **Introduction**
- ❖ **Data and Method**
- ❖ **Results**
  - ➢ **2D Video Disdrometer data Analysis**
  - ➢ **T-matrix Scattering Simulation**
  - ➢ **Retrieval of Raindrop Size Distribution**
- ❖ **Summary and Future work**

Introduction

- Information on spatiotemporal distribution of microphysical properties of convective precipitation is important for understanding developments of convective precipitations.
- However, it has been difficult to collect three-dimensional distributions of microphysical parameters in convective precipitations quantitatively and with high spatiotemporal resolutions.
- Recently, X-band polarimetric radar and disdrometer networks were made near Tokyo metropolitan city, Japan.
  - The **X-band polarimetric radar network** provides not only drop size distribution and hydrometeor type but also kinematic properties such as wind field which is essential to understand the development of convective precipitation.
  - The **disdrometer network** can provide high temporal resolution data on hydrometeor and can be used as ground validation data for radar microphysical retrievals.

Present study

Case study to clarify microphysical properties of convective precipitation analyzing 2DVD and X-band polarimetric radar data.

Data and Method

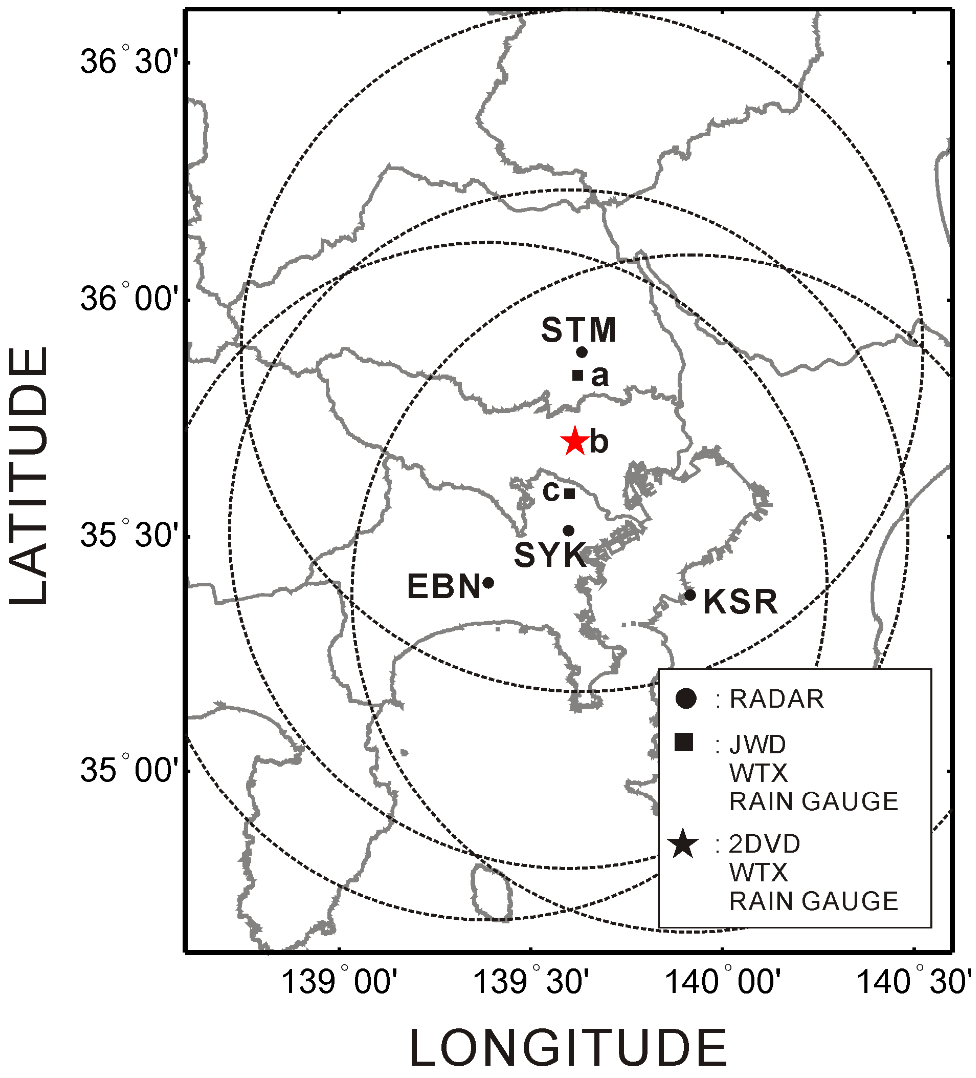


Fig 1. Observation map

❖ **Observation**

Plain area in Kanto

❖ **Instruments**

- X-band Polarimetric radar (4)
  - STM :
  - SYK :
  - EBN :
  - KSR :

< Time resolution >
1 min. surface data
5 min. volume data

- Ground observation instruments

Disdrometer : 2DVD and JWD (2)

Rain gauge (3)

Weather Transmitter (WXT)

: Temperature , Humidity, Pressure, Rain, Wind direction, and Wind Speed

- A : Nishi (JWD, Rain gauge, and WXT)
- B : Ogikubo (2DVD, Rain gauge, and WXT)
- C : Kawa (JWD, Rain gauge, and WXT)

Data and Method

❖**Two-dimensional Video Disdrometer (2DVD)**

❖ **Filtering**

During heavy rainfall, there arise problems due to "mismatched drops"

To overcome this artifact, velocity-based filter was applied (Kruger and Krajewski, 2002)

❖ Velocity –based filter

$$\left| V_{measured} - V_A \right| < 0.4 V_A$$

$$V_A = 9.65 - 10.3 \exp(-0.6 \times D)$$

V_A : formula given by Atlas et al. (1973)

❖ Limitation of diameter and velocity

0.2 mm ≤ Dia. ≤ 8.0 mm

Vel. ≥ 1.0 m/s (Chang et al., 2009)

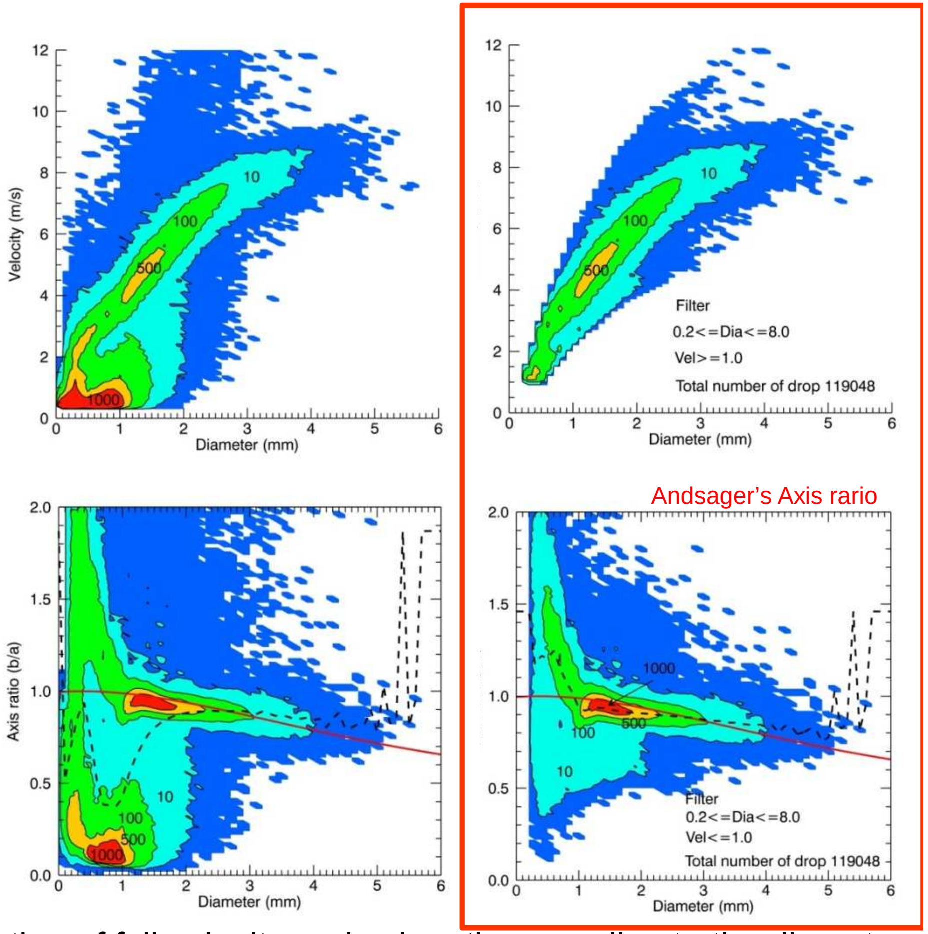


Fig. 2. Distribution of fall velocity and axis ratio according to the diameter

Data and Method

❖ **Rainfall rate**

After filtering 2DVD data, the rainfall rate was a good agreement between 2DVD and rain gauge.

Difference of total rainfall amount was about 5 %.

Rain gauge : 219 mm, 2DVD : 209 mm

❖ **Gamma distribution function** (Ulbrich, 1983)

$$N(D) = N_0 D^{\mu} \exp(-\Lambda D) = N_0 D^{\mu} \exp(-(3.67+\mu)(D/D_0))$$

Table 1. RDSD parameters using 3,4,and 6 moments method.

Parameter	Equation	Parameter	Equation
Rainfall intensity	$R = \frac{\pi}{6}\int_{D_{min}}^{D_{max}} D^3 V_f N(D)dD$	Reflectivity	$Z = \int_{D_{min}}^{D_{max}} D^6 N(D)dD$
Shape	$\mu = \frac{(8-11m)-(m^2+8m)^{1/2}}{2(m-1)}$	Median volume diameter	$D_0 = \frac{(3.67+\mu)}{\Lambda}$
Slope	$\Lambda = \frac{M_3}{M_4}(\mu+4)$	Intercept parameter	$N_0 = \frac{\Lambda^{(\mu+4)} M_3}{\Gamma(\mu+4)}$

Data and Method

❖ **Transition(T)-matrix scattering simulation**

Date : 2010.09.28 from 0200 to 0340 (UTC)
Filter : 0.2 < D < 8.0 (mm)
$|V_{(measured)} - V_{(formula)}| < 0.4\ V_{(formula)}$
Vel. > 1 m/s

Condition

Elevation : 0 °
Rain temperature : 15 °C
Andsager's axis ratio

$$a/b = 1.012 - 0.144D - 1.03D^2 \quad (1.1 \le D \le 4.4)$$

$$a/b = 1.0048 + 0.0057D - 2.628D^2 + 3.682D^3 - 1.677D^4$$

Canting angle : Gaussian distribution
Canting angle average : 0 °
Canting angle deviation : 7 °

Parameters

Reflectivity factor at horizontally (H)
Vertically (V) polarized waves (mm^6m^{-3})
Specific differential phase (deg km^{-1})
Differential reflectivity (dB)
Specific attenuation (dB Km^{-1})
Cross correlation coefficient (ρhv)
Linear depolarization ratio (LDR)
Circular polarimetric variables

2DVD Data Analysis

28th Sep. 2010

0220 ~ 0330 (UTC)

Rainfall intensity

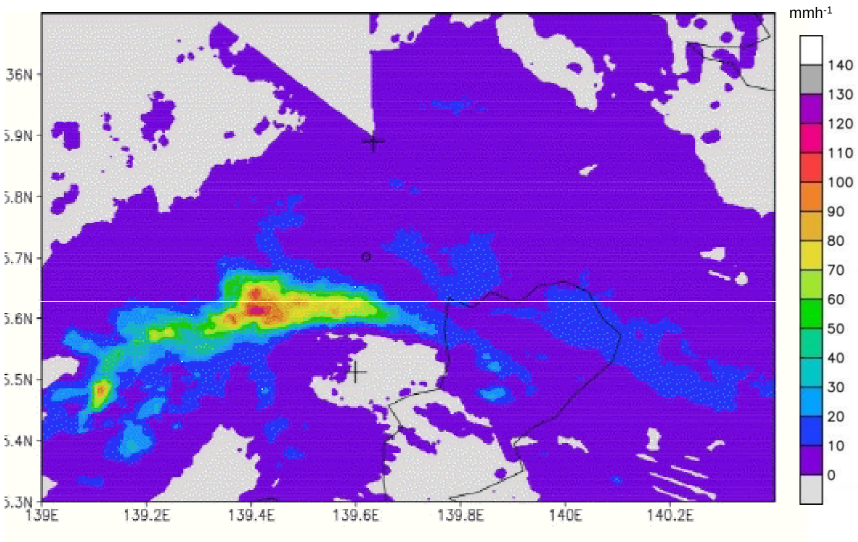


Fig. 3. Animation of rainfall intensity distribution

Accumulated rainfall amount

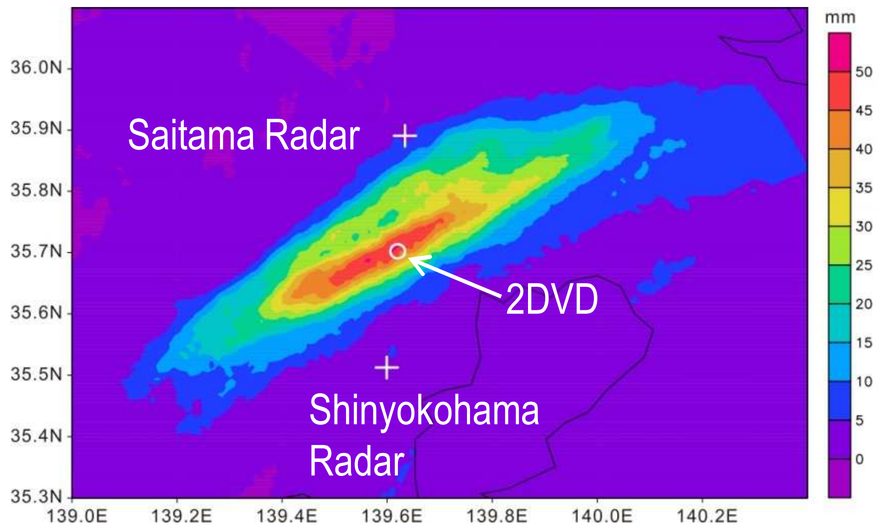


Fig. 4. Distribution of accumulated rainfall rate

- The selected case is localized convective system, which was passed over the 2DVD site from 0220 to 0330 on 28th Sep. 2010.
- Maximum accumulated rainfall amount was recorded at 2DVD site about 50 mm.

2DVD Data Analysis

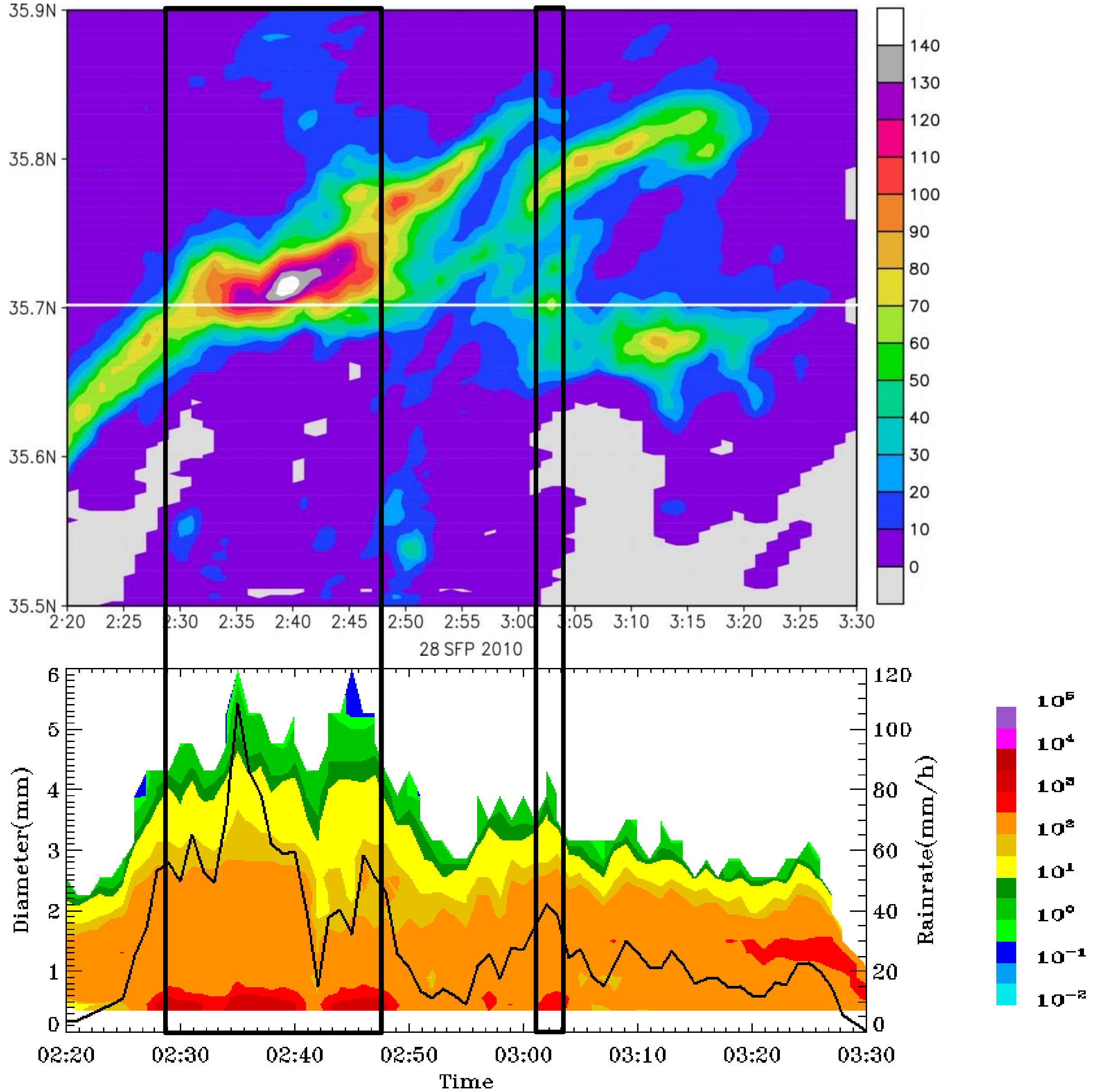


Fig. 5. Time series of distribution of rainfall rate along latitude (upper) and number density of raindrops with rainfall rate measured by 2DVD(bottom)

2DVD Data Analysis

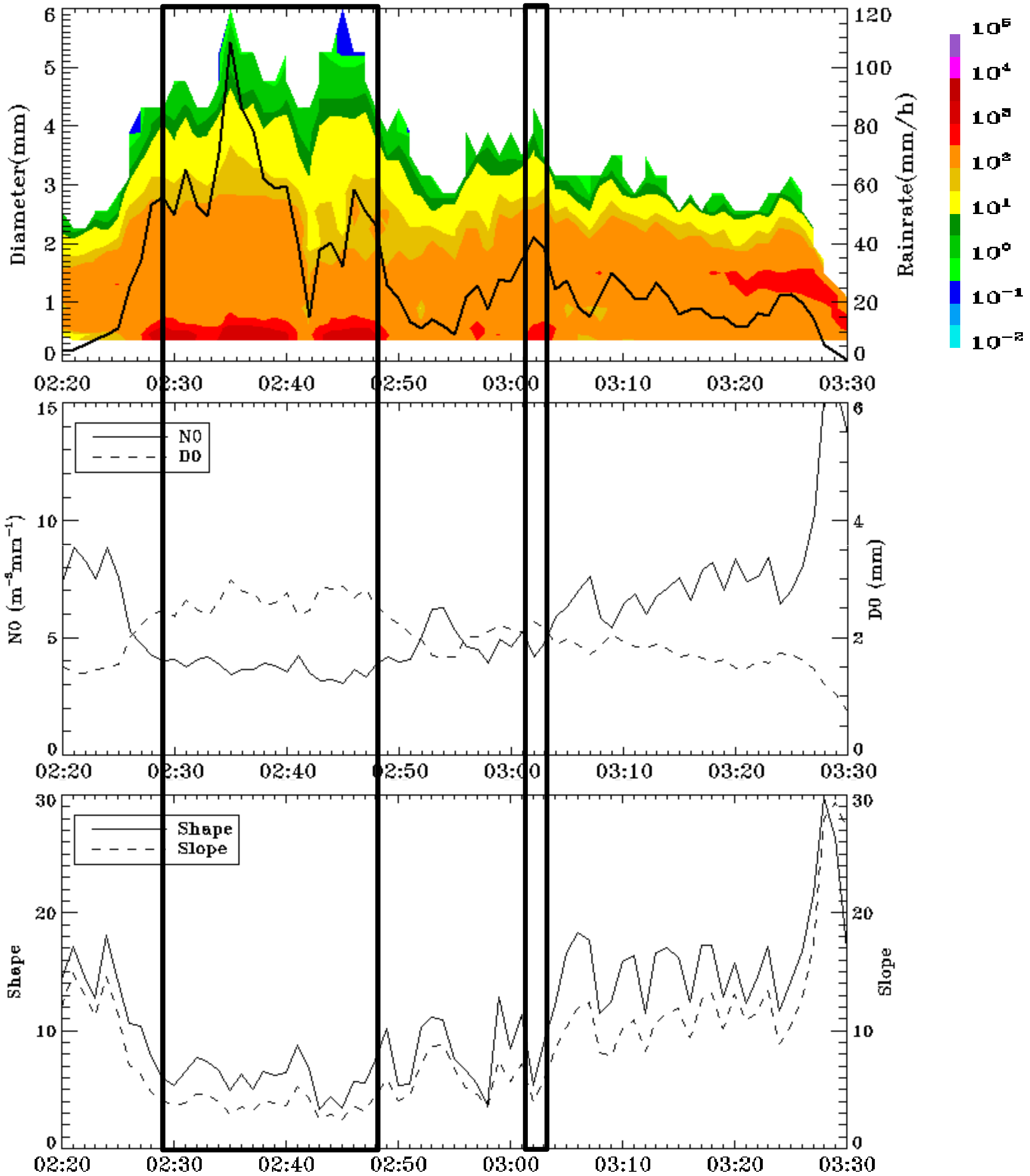
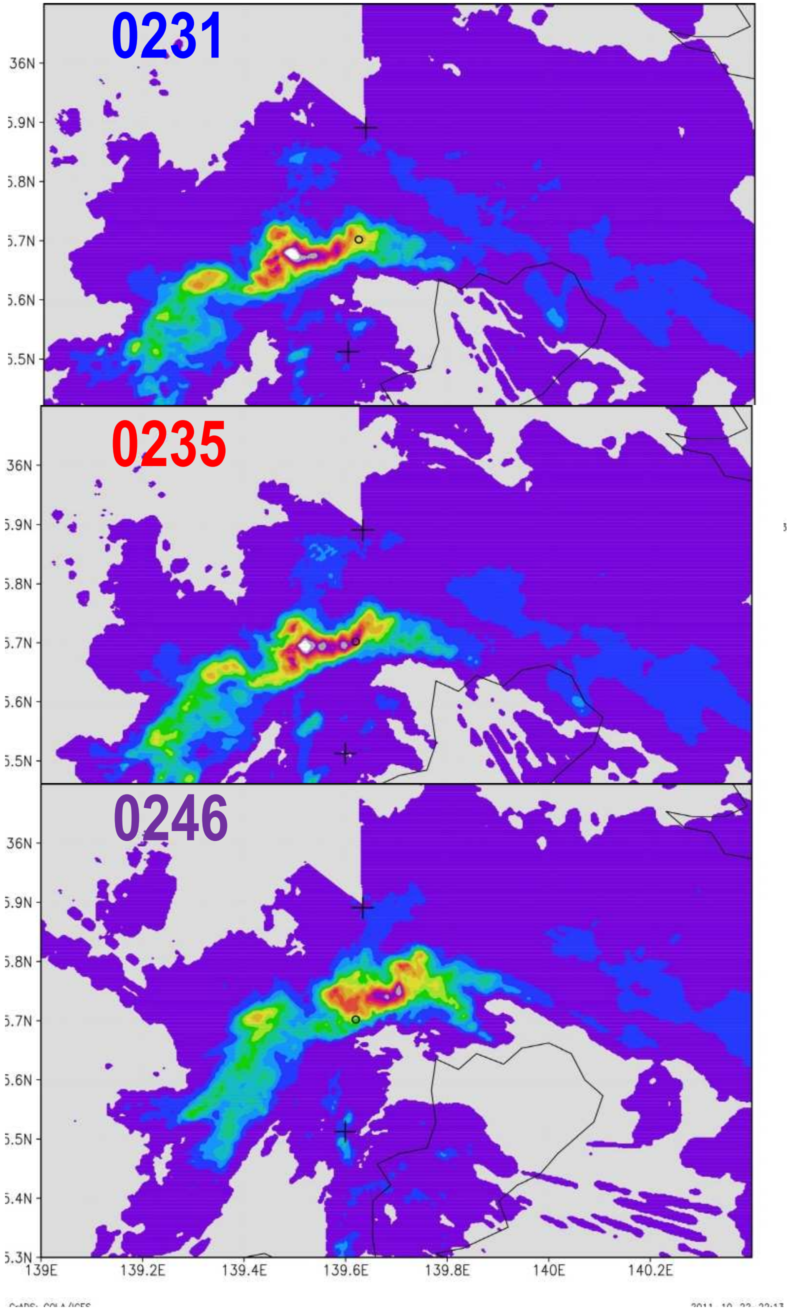
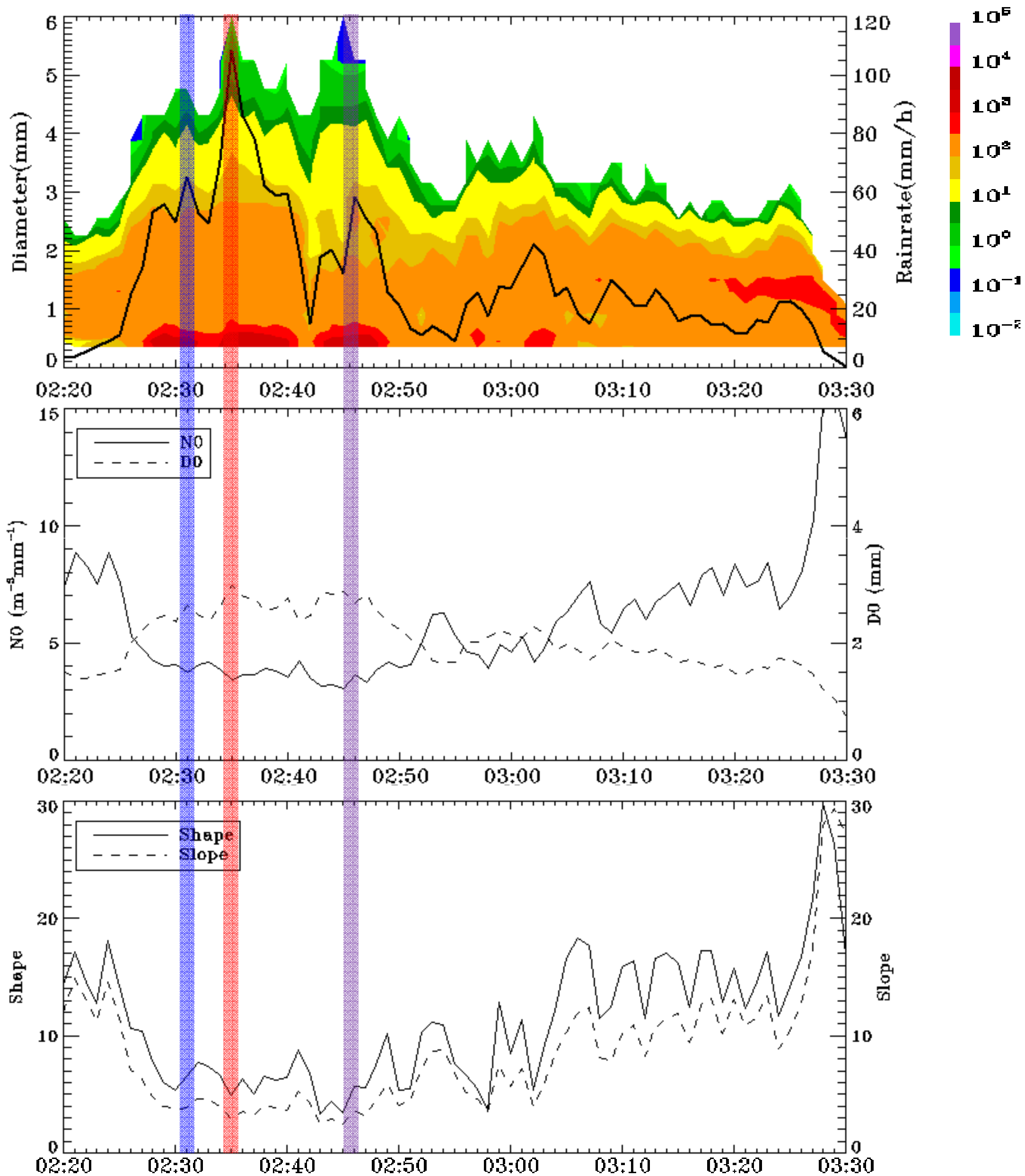


Fig. 6. Time series of parameters, intercept parameter N_0, median diameter D_0, shape, and slope

2DVD Data Analysis





2DVD Data Analysis

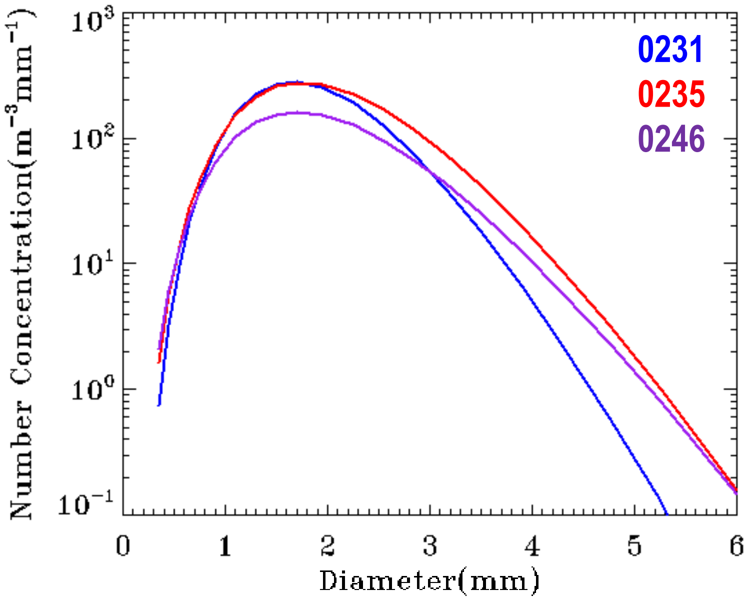
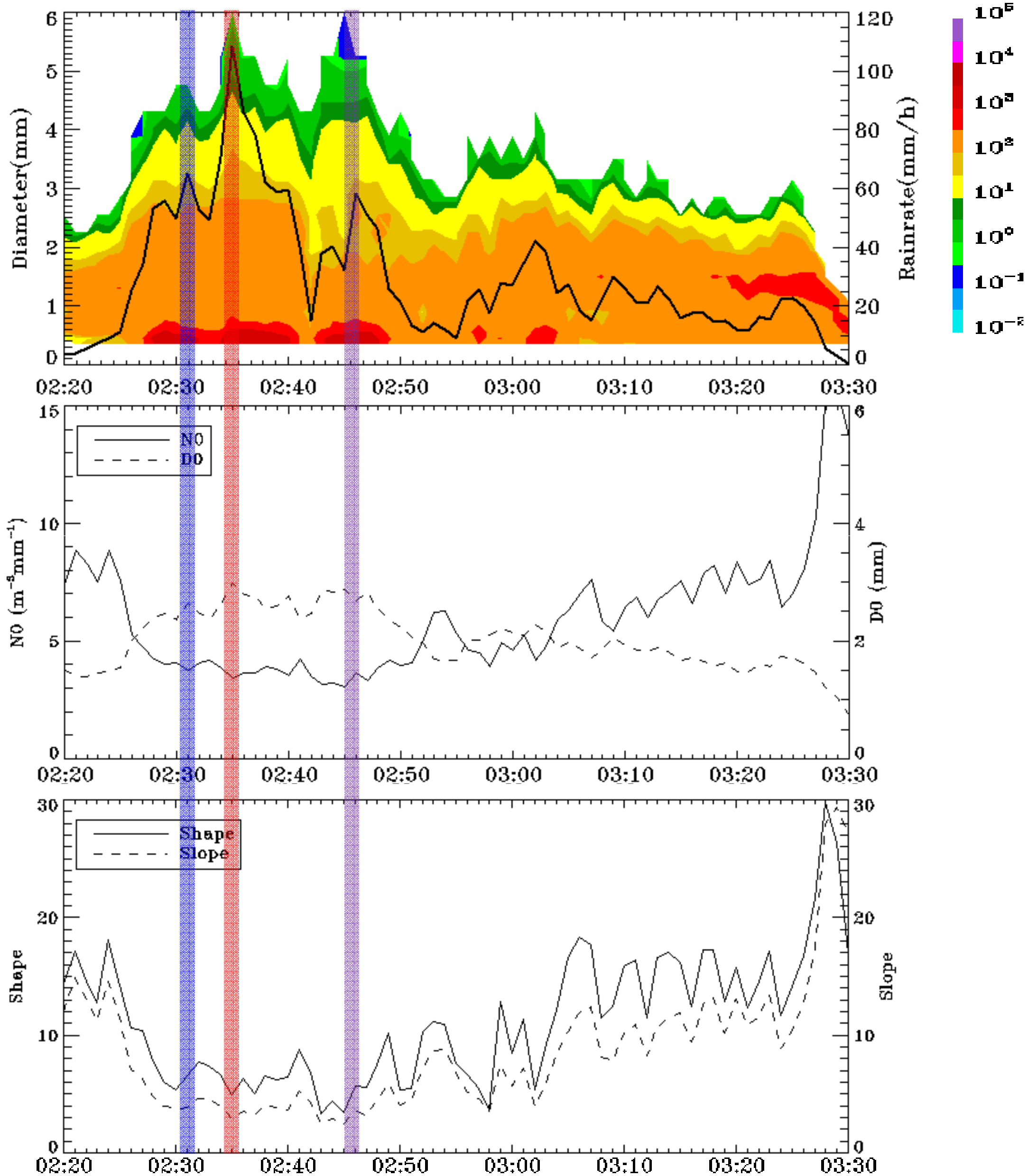


Fig. 7. Gamma DSD distribution

Table 2 Comparison of DSD parameters

Time	0231	0235	0246
R	64.93	108.49	58.35
D_0	2.64	2.97	2.68
N_0	5822	2846	4276
μ	6.49	4.84	5.68
Λ	3.85	2.89	3.49



T-matrix scattering simulation

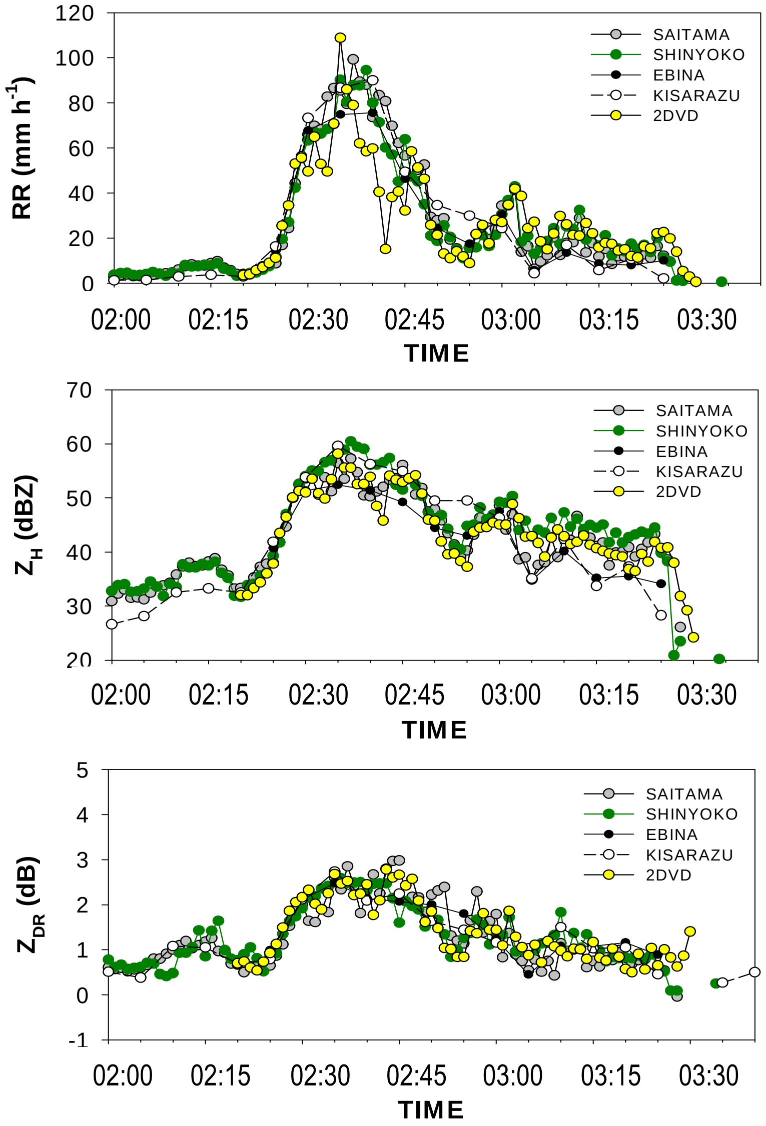


Fig. 8. Comparison of radar parameters between T-mat. using 2DVD data and X-Pol. Radar data. (a) rainfall intensity, (b) reflectivity, and (c) differential reflectivity

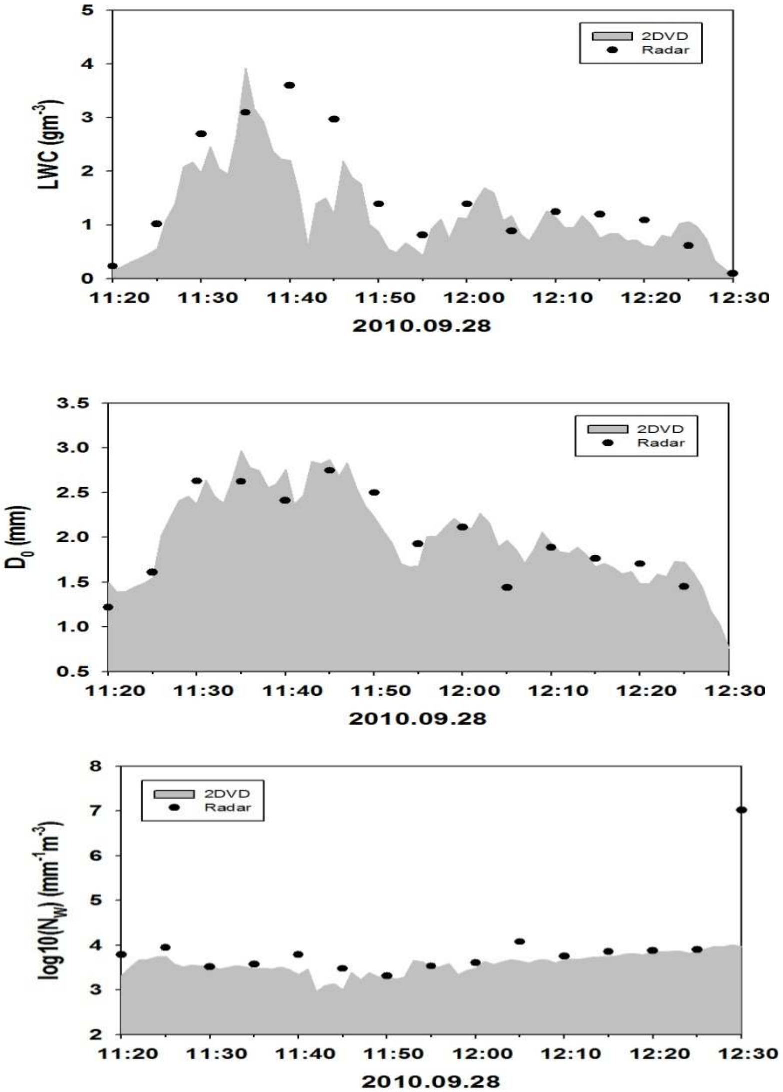


Fig. 9. Comparison of DSD parameters calculated by 2DVD and retrieved by X-Pol. Radar data. (a) LWC, (b) D_0 and (c) N_W

Retrieval of Raindrop Size Distribution

❖ **D_0-Zdr relation (Kim et al., 2010)**

$$D_0 = 0.77 Z_{DR} + 0.79$$

❖ **N_w retrieval (Kim et al., 2010)**

$$N_W = \frac{3.67^4}{\pi \rho_w} \left(\frac{W}{D_0^4} \right) \qquad W(Z_H, K_{DP}) = \begin{cases} \alpha_1 Z_H^{\beta_1} & \text{for } Z_H \le 35 \text{ dBZ or } K_{DP} \le 0.3^{\cdot} \text{ km}^{-1} \\ \alpha_2 K_{DP}^{\beta_2} & \text{otherwise} \end{cases}$$

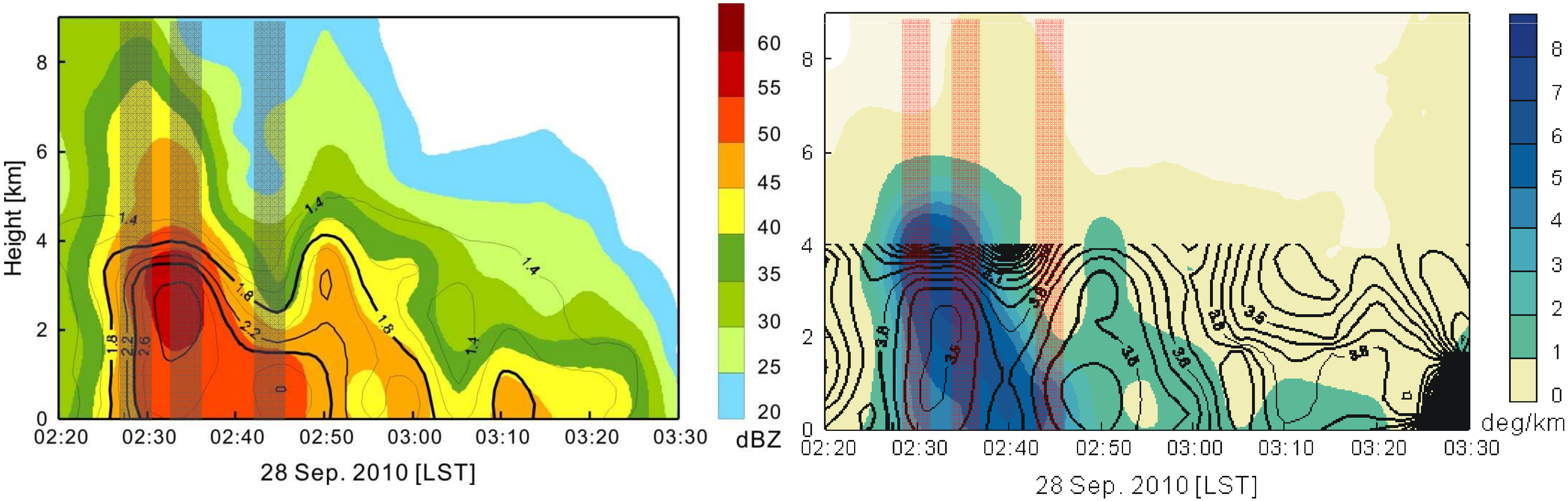


Fig. 10. Time-Height distribution of (a) Z_H (shaded), D_0 (contour) and (b) K_{DP} (shaded), N_W (contour).

Summary and Future work

- **Summary**
  - Localized convective precipitation on Sep. 28th, 2010 was studied.
  - According to position of convective precipitation, **different microphysical processes and properties were appeared**.
    - Large drop ($D \geq 5$mm) appeared and the number of middle drop ($2 \leq D \leq 3$ mm) decreased when the system passed though the 2DVD.
  - **T-matrix scattering simulation using calibrated 2DVD data** was coincided with **X-Pol. radar data** (R,Z and Zdr).
  - Retrieval of **3-dimensional raindrop size distribution** using X-Pol. radar data.
    - D_0 shows an inverse relation with N_W.
    - On the first and second peak containing many middle drop, the height of Z_H (> 50 dBZ) extended over 4 km.
    - On the second and third peak including large drop, the large K_{DP} (> 4) touched ground.

- **Future work**
  - Analysis the various convective precipitation cases and statistical analysis of microphysical characteristics
  - <u>Identify the 3-dimensional structure of microphysical properties in localized convective precipitation</u>

Thank You :D