# 發展GCE暖雨雙矩量微物理參數化方案: 理想與真實個案測試

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# Outline

# Introduction & Methodology

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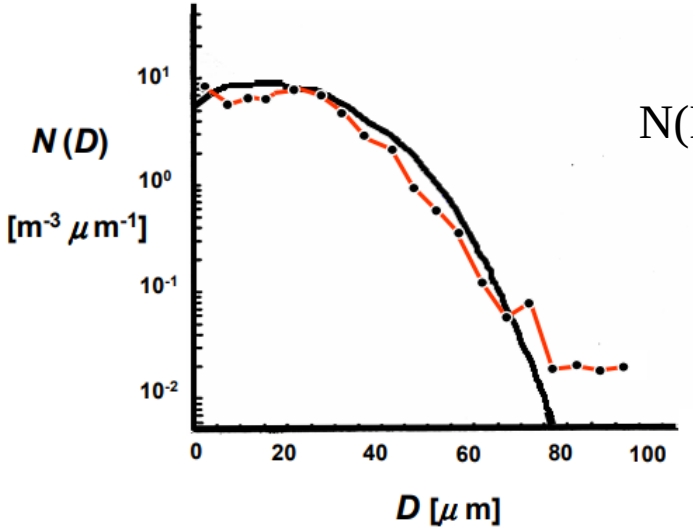
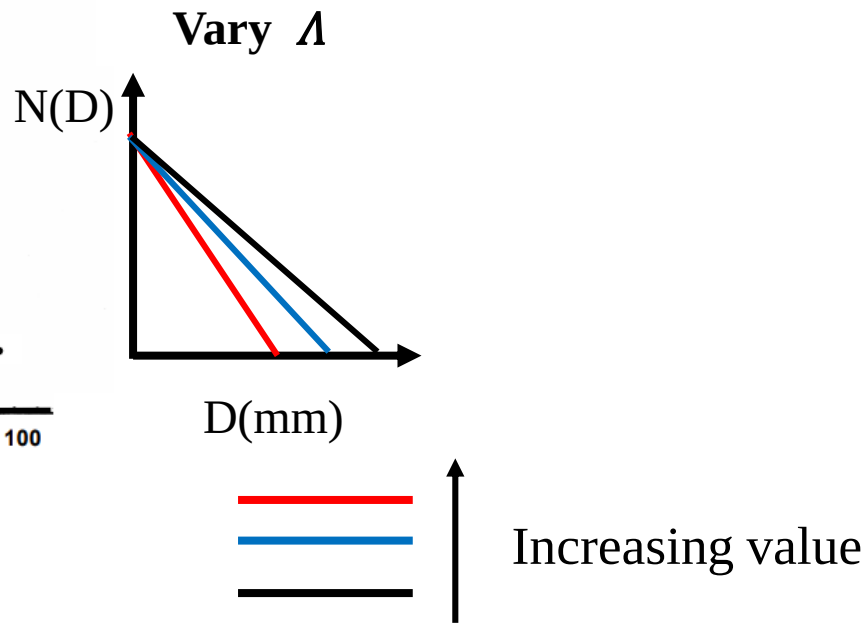
$N_0$ : *intercept* $\mu$ : *shape* $\Lambda$ : *slope*

A Multi-Moment Bulk Microphysics Scheme (Milbrandt and Yau 2004)

Bulk method




Gamma distribution $N(D) = N_0 D^{\mu} e^{-\Lambda D}$



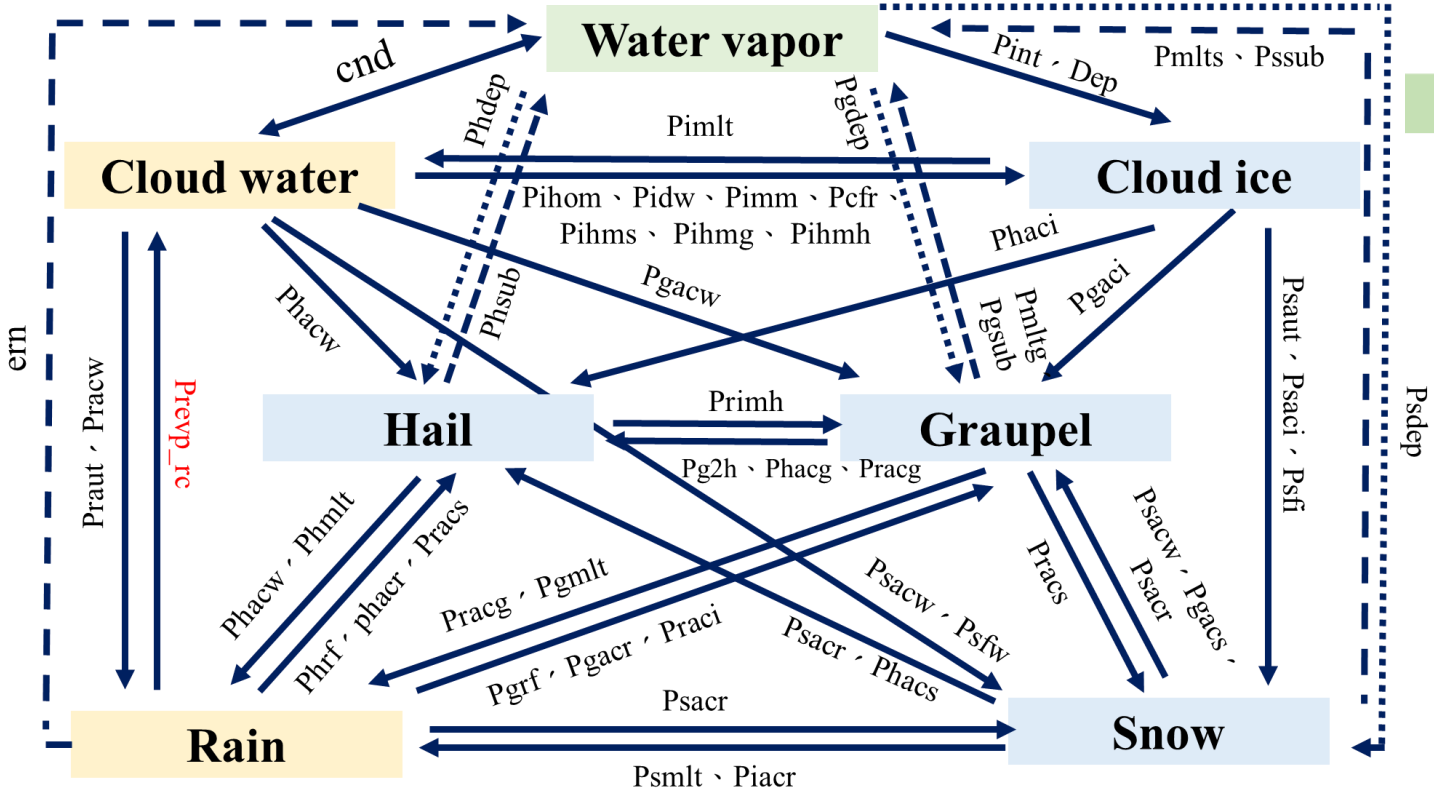

- ✓Bulk method is often used because it is more efficient than bin method.
- ✓Double-moment has greater flexibility.
- ✓In Taiwan, Goddard Cumulus Ensemble (GCE) scheme has better performance.

Turn GCE4ICE scheme into Warm-rain Double-moment

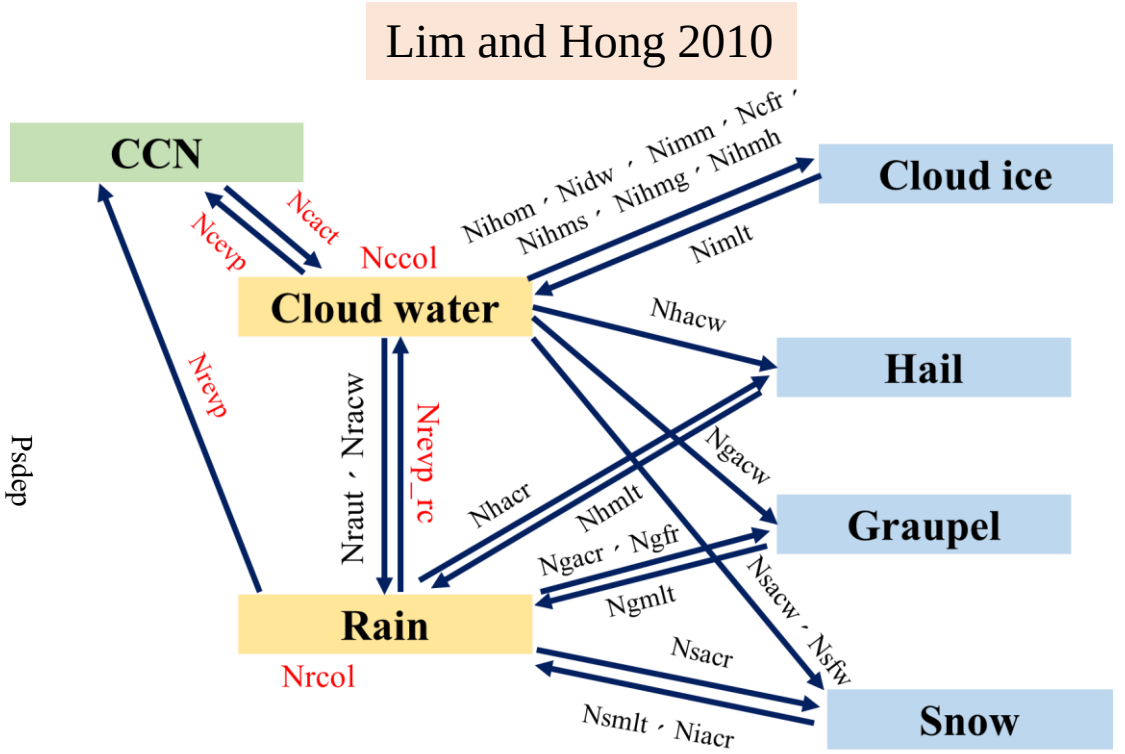
a) keep the performance of precipitation and

b) get more microphysics information of raindrop

# Introduction & Methodology




Lim and Hong 2010




**Ncact : CCN Activation**
**Prevp_rc/ Nrevp_rc : Small rain convert to cloud**
**Nrevp: Evaporation of Rain**

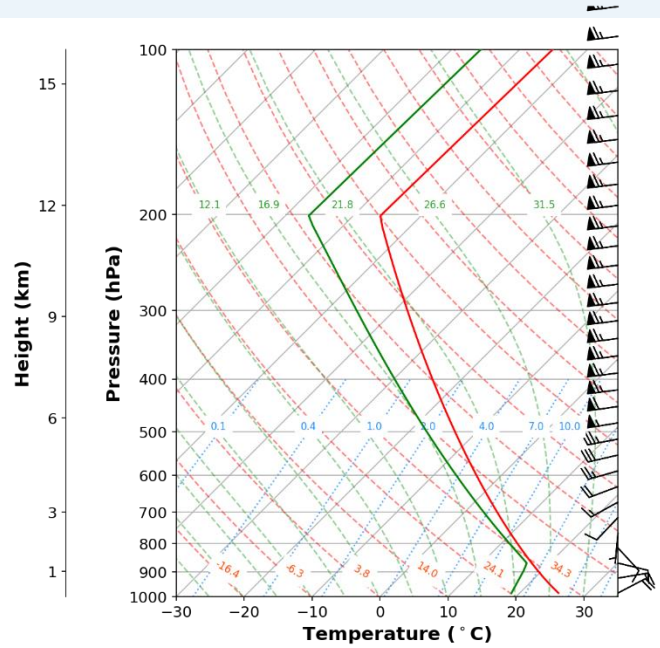
**Nccol : Self-collection of Cloud**
**Ncevp : Evaporation of cloud**
**Nrcol : Self-collection and Breakup of Rain**

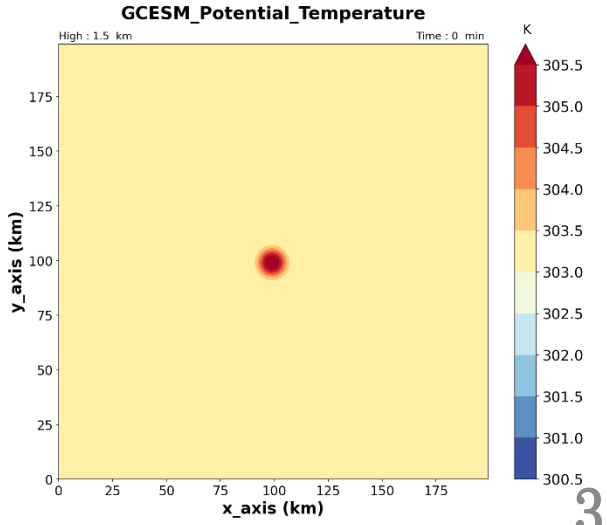
# Simulation

## I. 3D Idealized Supercell

# Simulation I --- 3D Idealized Supercell

| Model configuration | |
|---|---|
| **WRF version** | WRF4.2.1 |
| **Domain & Time step** | 200*200 & 6 s for 2h |
| **Horizontal Resolution** | 1 km |
| **Vertical levels & Model Top** | 75 levels & 25 km |
| **Rayleigh Damping** | 0.003 s-1 |
| **Initial sounding** | Case from Weisman and Klemp (1982) |
| **Thermal perturbation** | Maximum $\theta' = 3K$ with a horizontal radius of 10 km centered at a height of 1.5 km |
| **Microphysics scheme** | **GCESM(GCE4ICE)、GCEDM、WDM7** |



# Simulation I --- 3D Idealized Supercell

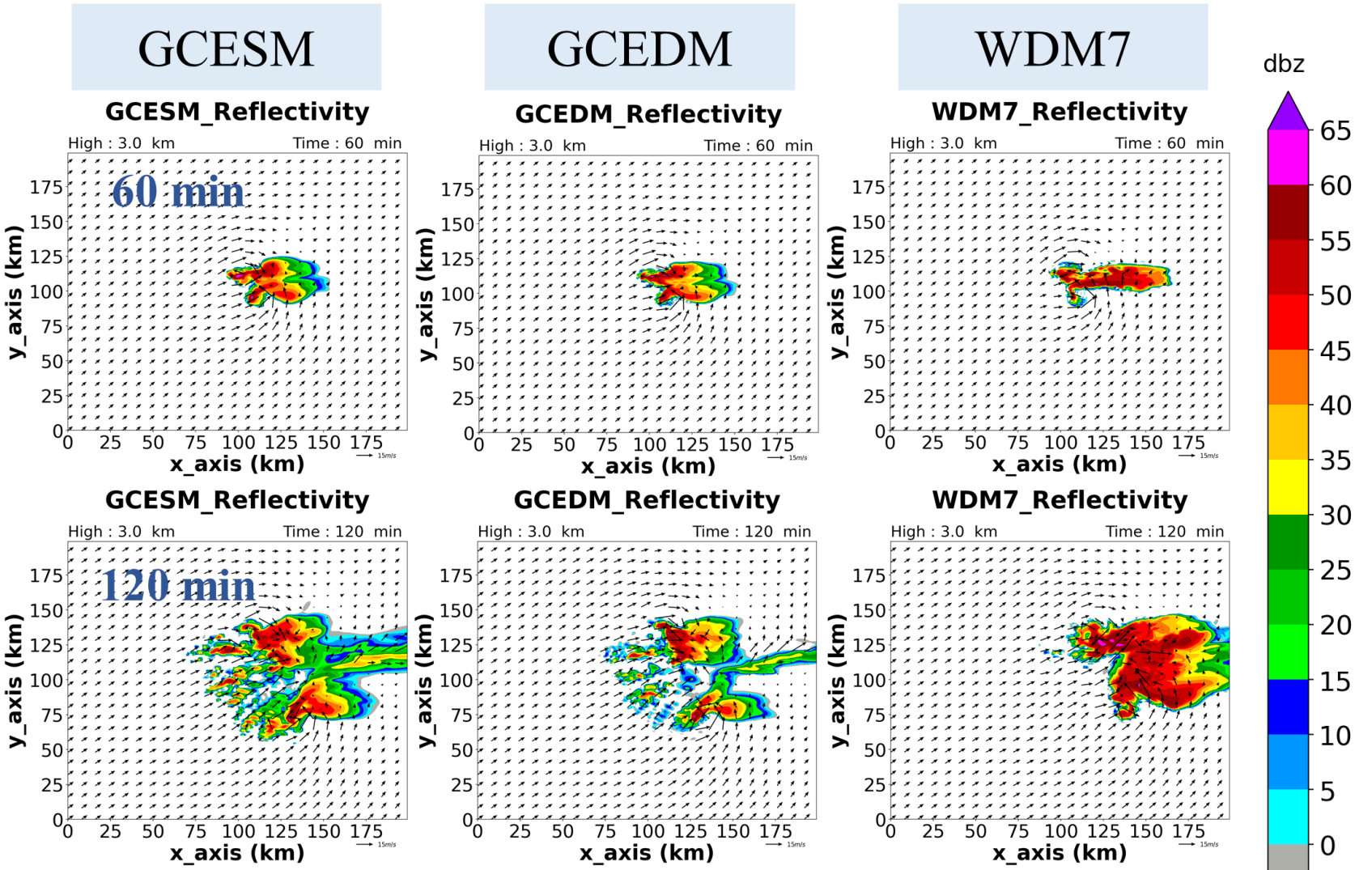
| Bulk microphysical parameterization setting | | | | | |
|---|---|---|---|---|---|
| Scheme | Prognostic | Prognostic | Constant $N_0$ | $\mu$ | Constant $\rho$ |
| DM | $q_g$ $q_h$ | $N_n$ $N_c$ $N_r$ | $N_{0s}$: 1e7 $N_{0g}$: 4e6 $N_{0h}$: 1e6 | $\mu_r$: 1 $\mu_{sgh}$: 0 | $\rho_g$: 300 $\rho_h$: 900 |
| WDM7 | | | | | |

**Make sure GCEDM keeps the rainfall features from GCESM and change microphysics characteristics**

# Result

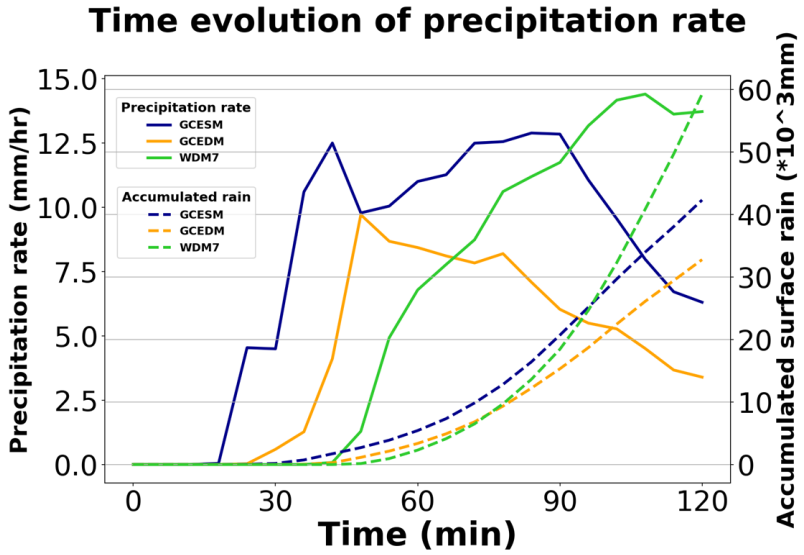
## I. 3D Idealized Supercell

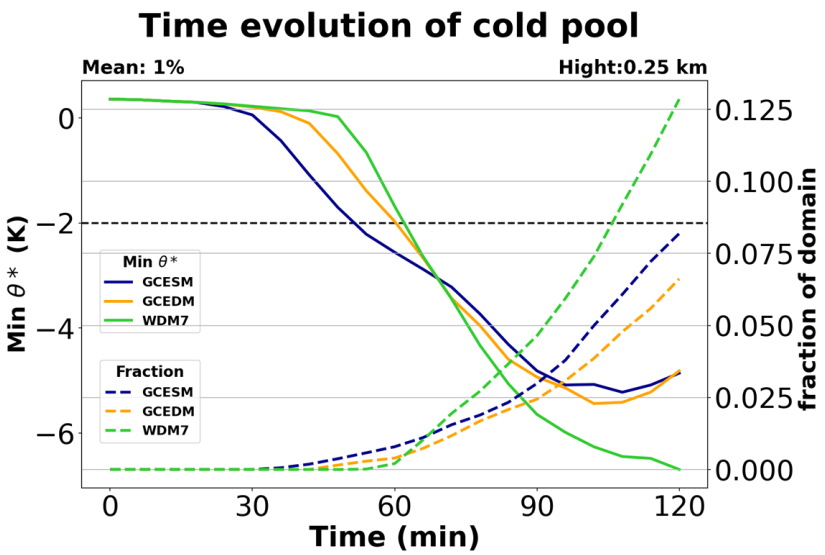
# Result I --- 3D Idealized Supercell

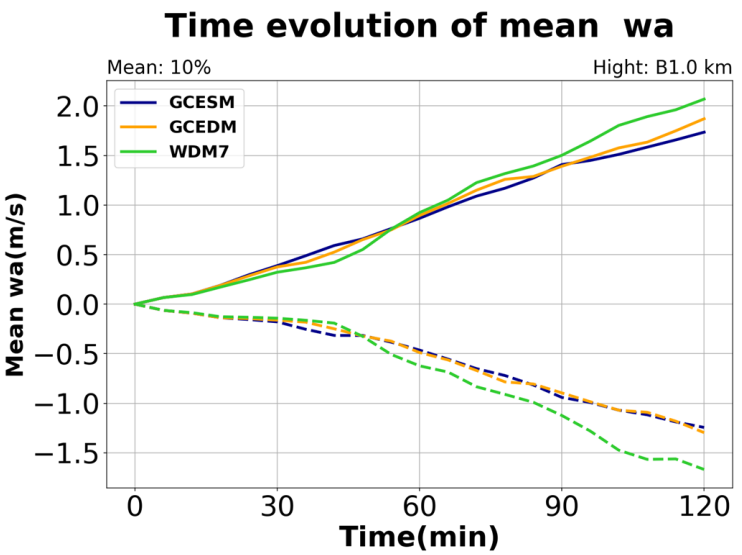



- ✓ Similar echo range and location
- ✓ Convective cell divides into two systems in GCESM and GCEDM
- ✓ WDM7 keeps strong reflectivity intensity

# Result I --- 3D Idealized Supercell



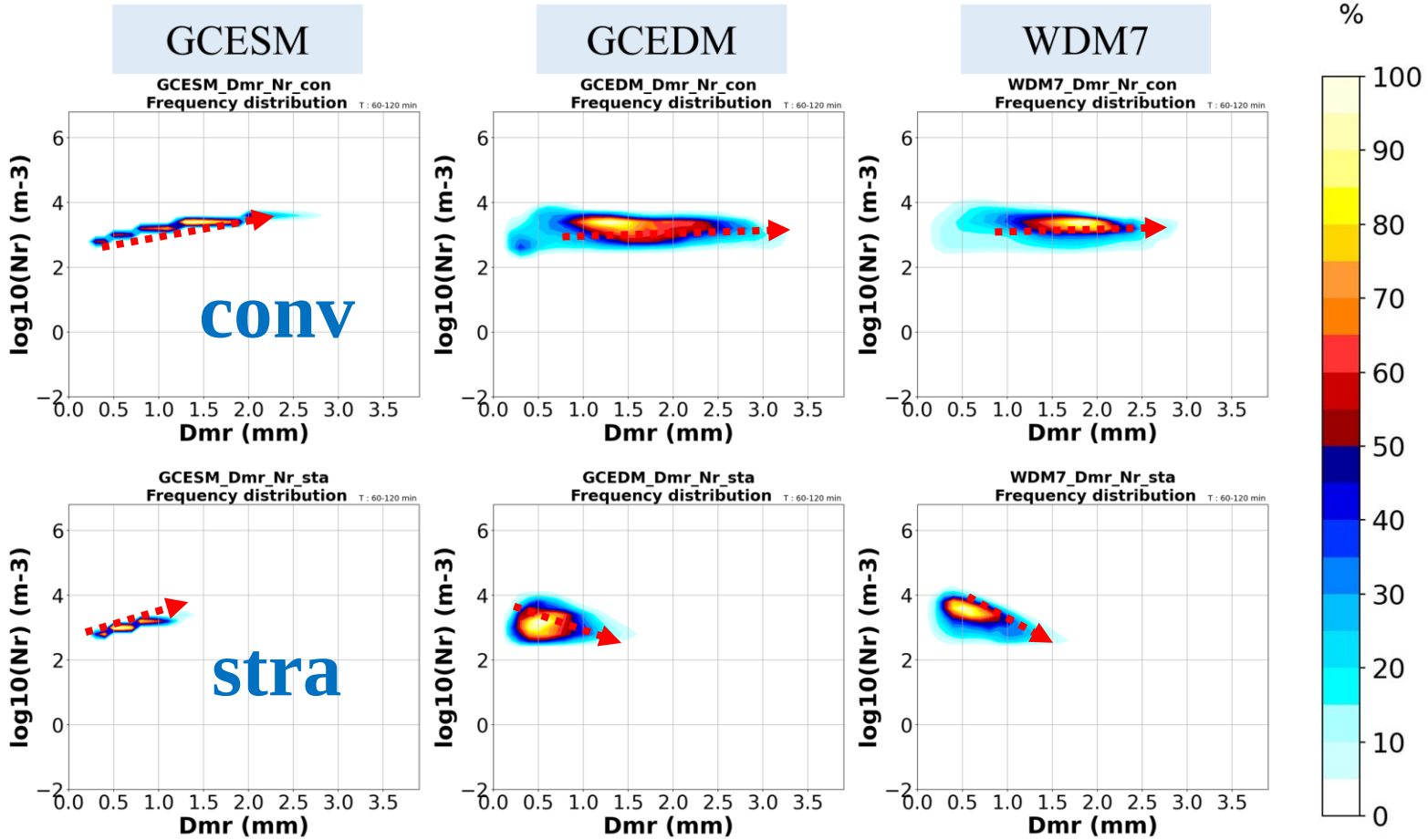

- ✓ Variety of rainfall rate in GCEDM is similar to GCESM.
- ✓ Intensity and range of cold pool are also close.
- ✓ Dynamic performances of GCE schemes are consistent.

➢ **GCEDM maintains the features of precipitation from GCESM**

# Result I --- 3D Idealized supercell

## Frequency distribution of Nr and Dmr

60 – 120 min




$N_r$ ：*rain number concentration*

Dmr ：*mean – weighted diameter of raindrop*

✓The distributions in two systems of GCEDM are close to WDM7

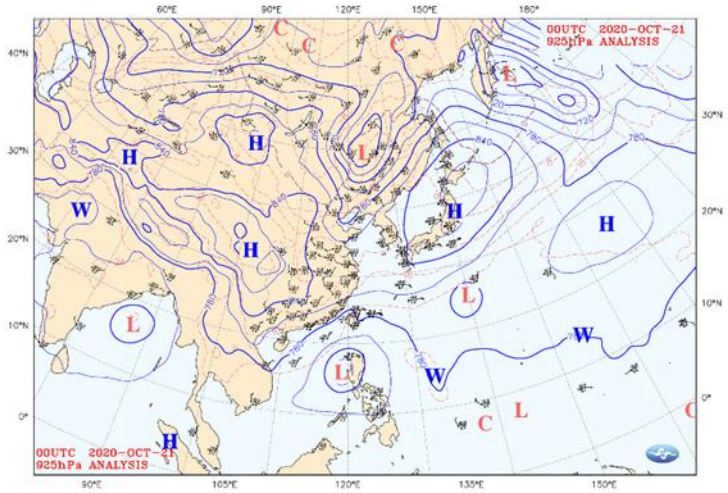
➢ **Raindrop characteristics in GCEDM become flexible following to WDM7**

# Simulation

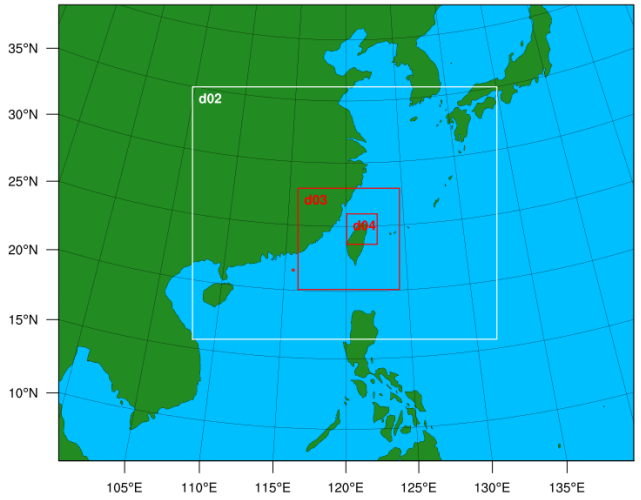
## II. Real Case

# Simulation II --- Real Case

| Model configuration | | | | |
|---|---|---|---|---|
| **WRF version** | WRF4.2.1 | | | |
| **Start time** | 2020-10-21 00 UTC | | | |
| **End time** | 2020-10-22 00 UTC | | | |
| **Domain** | D01 | D02 | D03 | D04 |
| **Horizontal resolution** | 27 km | 9 km | 3km | 1km |
| **Time step** | 90 s | 30s | 10s | 10/3s |
| **Vertical level** | 52 levels form surface to 10 hpa | | | |
| **Initial and boundary condition** | **NCEP FNL ($1^\circ \times 1^\circ$)** | | | |
| **Microphysics scheme** | **GCESM、GCEDM** | | | |



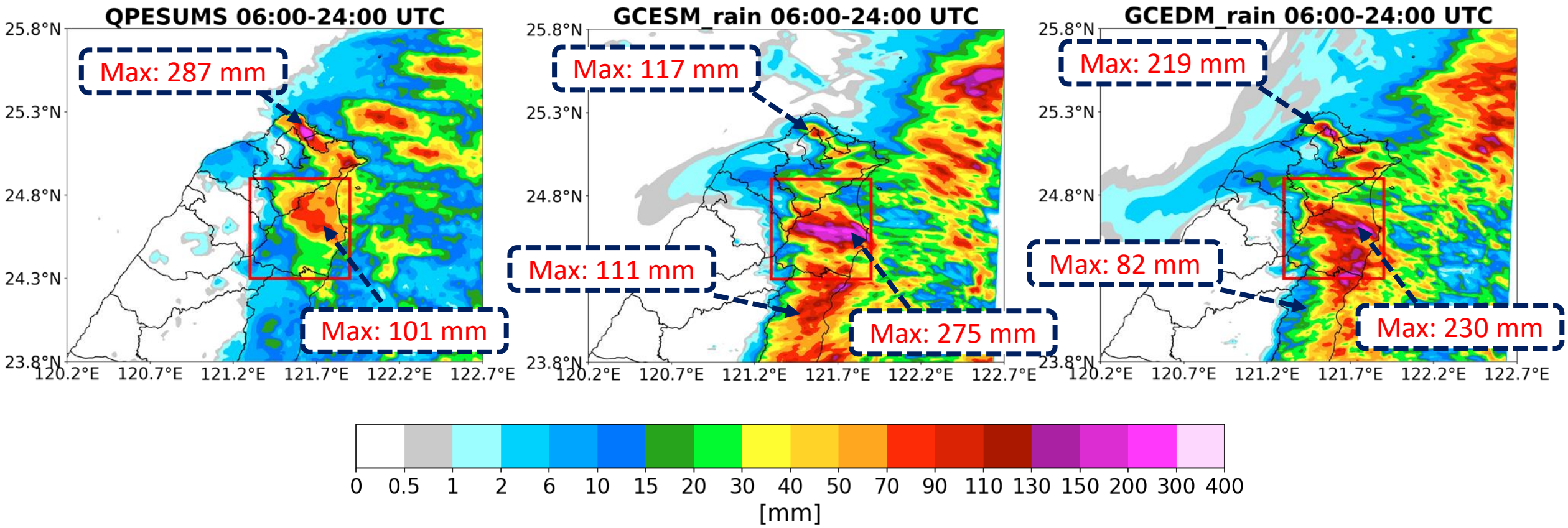

WPS Domain Configuration



# Result

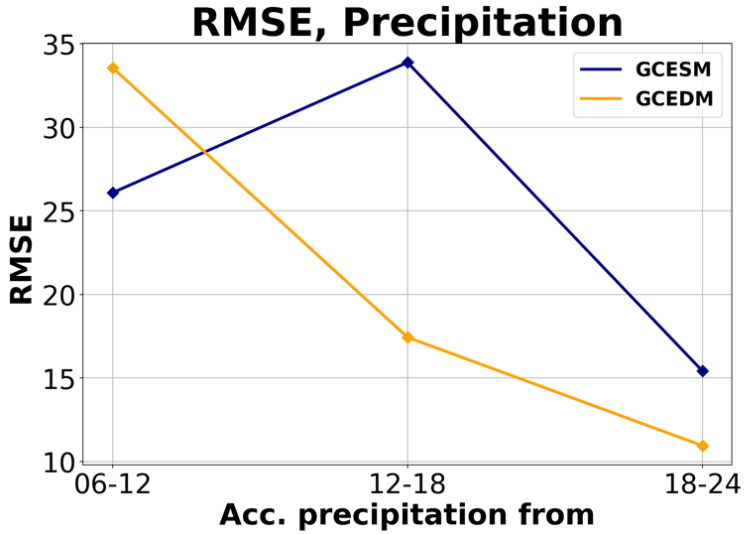
## II. Real Case

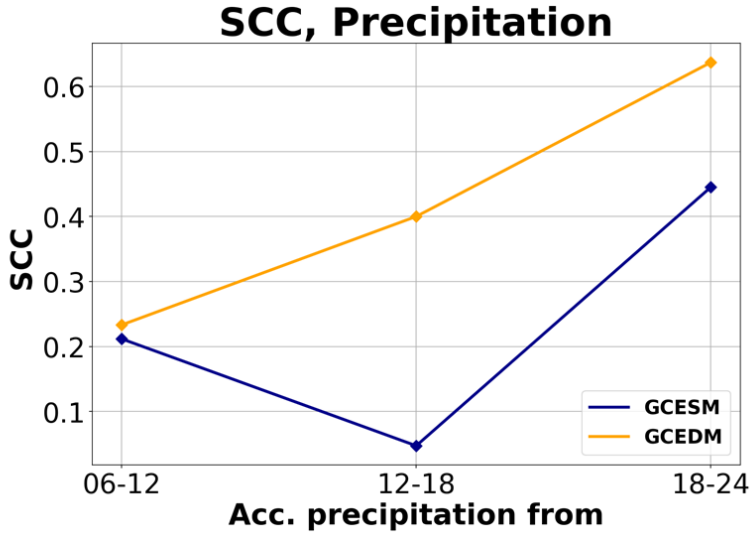
# Result II --- Real Case

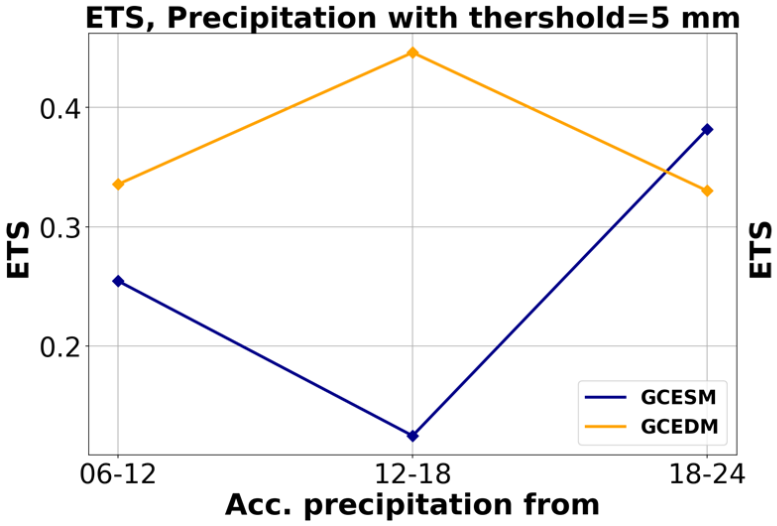


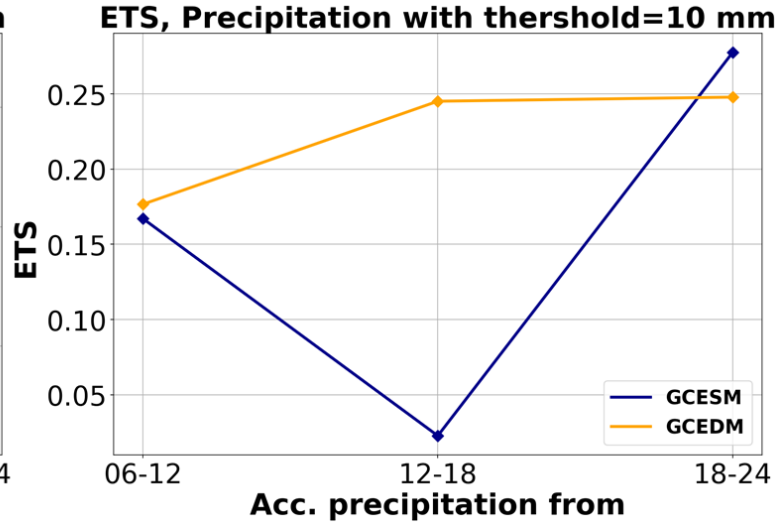

✓ **GCEDM improves overestimate** precipitation in **GCESM**

# Result II --- Real Case




## Yilan rainfall area

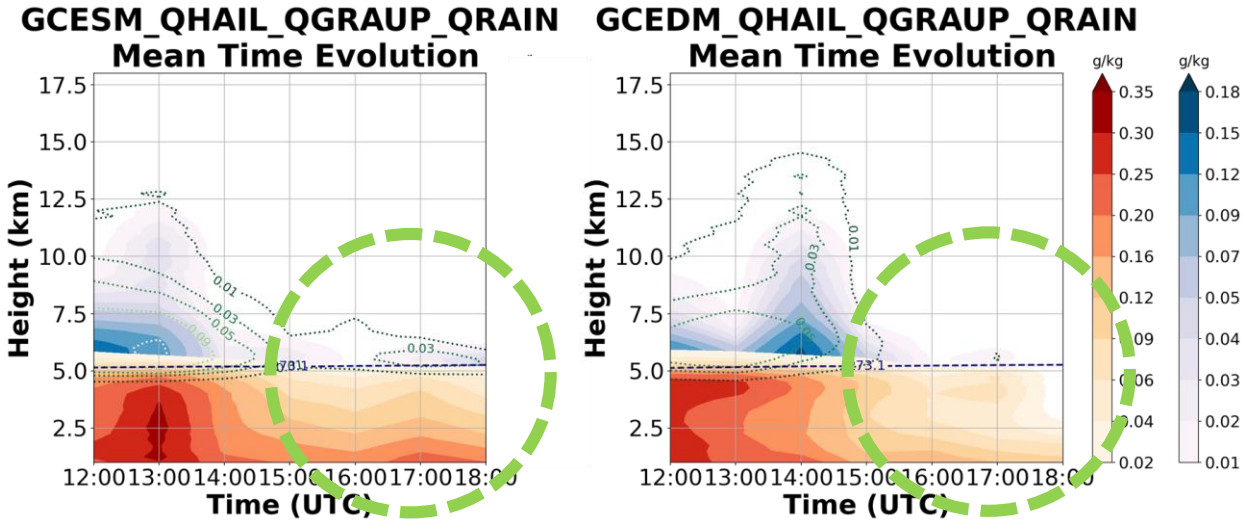
$$\text{RMSE} = \sqrt{\frac{\sum(S-O)^2}{N}} \quad \text{SCC} = \frac{\sum(S-\tilde{S})(O-\tilde{O})}{\sqrt{\sum(S-\tilde{S})^2}\sqrt{\sum(O-\tilde{O})^2}}$$

$$\text{ETS} = \frac{Hit - R}{Hit + False + Miss - R}$$

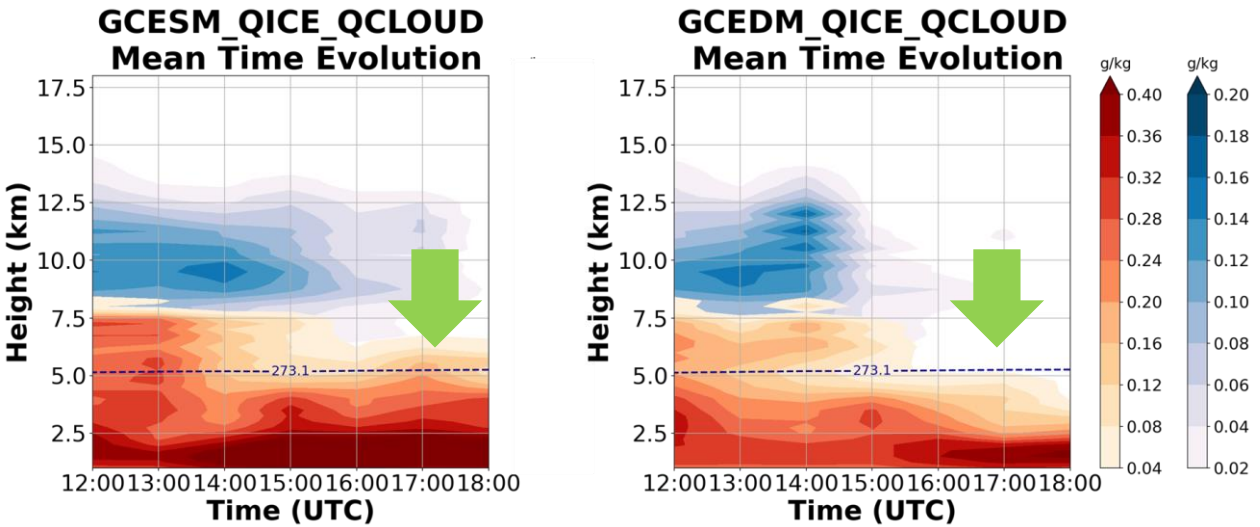
$$\text{R} = \frac{(Hit + False) * (Hit + Miss)}{Total\ grids}$$

✓ **GCEDM improves rainfall performance** very much in 12-18 UTC.

# Result II --- Real Case




**Blue : Hail ；Green：Graupel；Red : Rain**




**Blue : Ice ；Red : Cloud**

## Yilan rainfall area

✓ In **16 to 18** UTC：

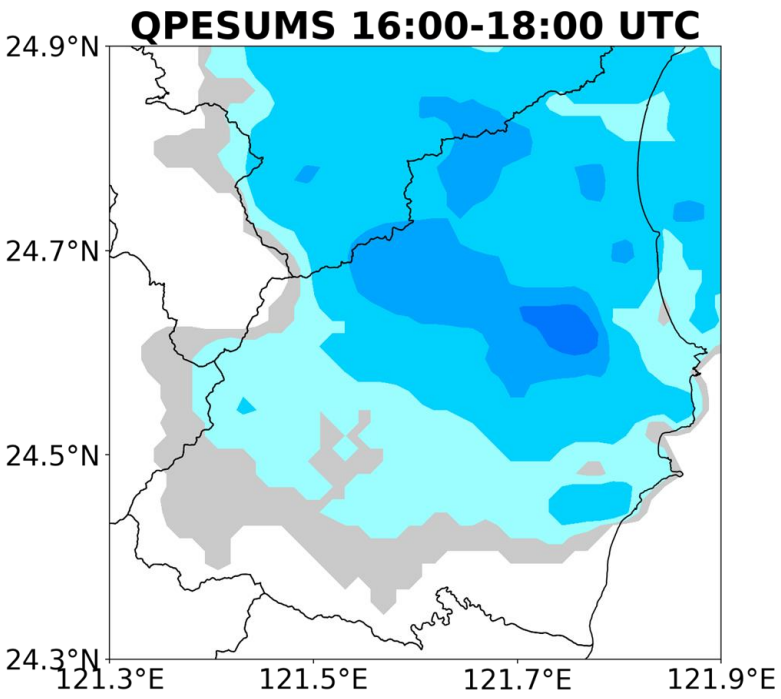
a) Less hail and graupel exist in both GCE schemes

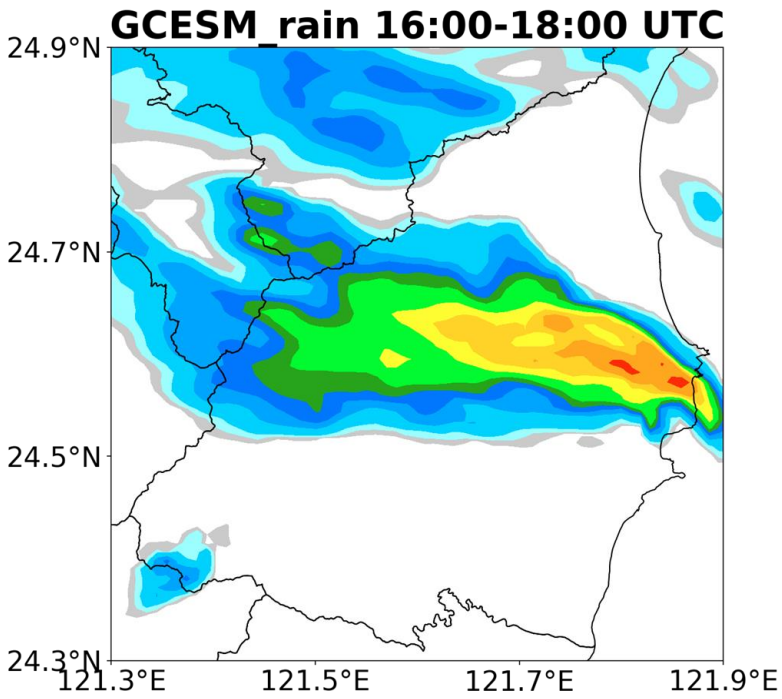
b) More cloud water, less cloud ice

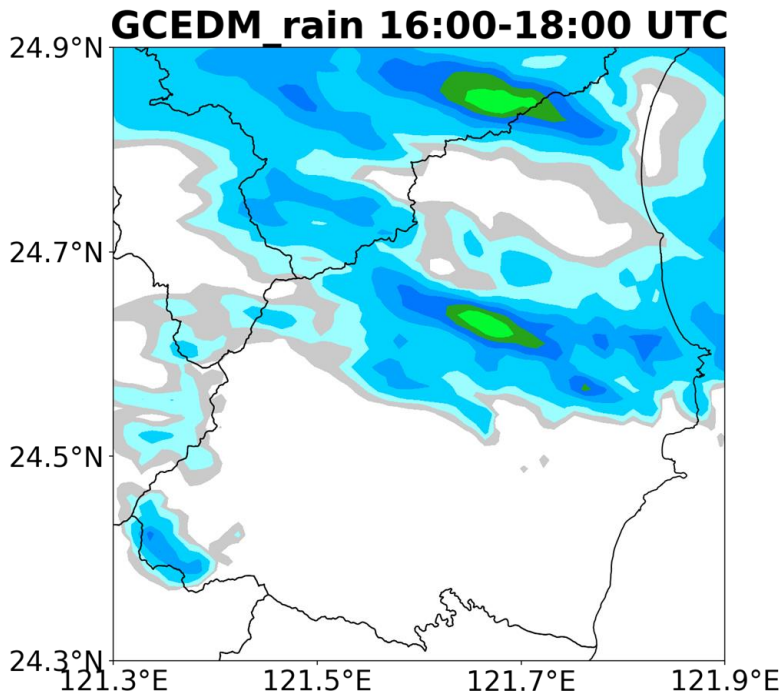
➢ **warm-rain process dominate**

# Result II --- Real Case

## 16-18 UTC




- **GCEDM not only improves overestimate,**
  **but also makes rainfall location closer to observation**

# Summary

# Summary

◆**This study tries to turn GCE4ICE single-moment scheme into warm-rain double-moment scheme following Lim and Hong (2010)：**

✓ **With 3D idealized supercell, we confirm**

- ➢ **GCEDM keeps the characteristics of precipitation in GCESM.**
- ➢ **The features of rain droplet in GCEDM become various successfully.**

✓ **In 20201021 real case study**

- ➢ **GCEDM shows much better forecast ability, especially when warm-rain situation.**

# Thank you for listening