Precipitation Microphysics Characteristics of Typhoon Rainbands in Continental China

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Outline

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2. Data and Methods
3. DSD Characteristics
4. Microphysical structure
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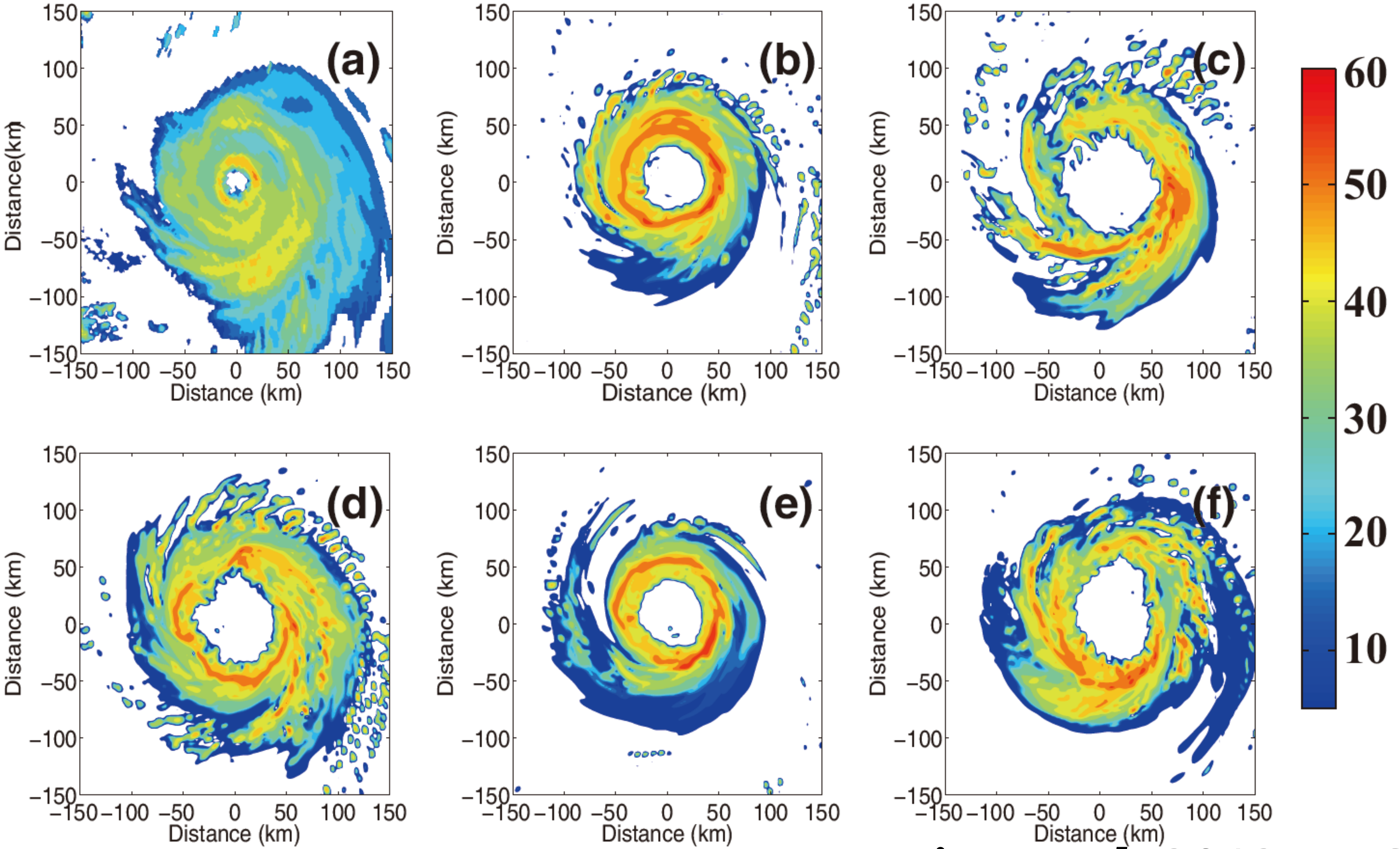
1. Background



Ming et al.,2012,JMSJ

Observation of Precipitation

Radar parameters

Reflectivity, dBZ

$$Z = \int D^6 N(D)dD$$

Differential Reflectivity, Z_{DR}

$$Z_{DR} = 10\log_{10}\left(\frac{Z_{HH}}{Z_{VV}}\right)$$

Specific Propagation Phases, K_{DP}

$$K_{DP} = \frac{180\lambda}{\pi} R_e\left\{\int_0^{D_m}\left[f_{hh}(D) - f_{vv}(D)\right]N(D)dD\right\}$$

$K_{DP} \sim D^{4.5}$

Normalized raindrop size distributions

$$N(D) = \underbrace{N_0}_{\text{Concentration}} D^{\overbrace{\mu}^{\text{Shape}}} e^{\overbrace{-\Lambda D}^{\text{Size}}}$$

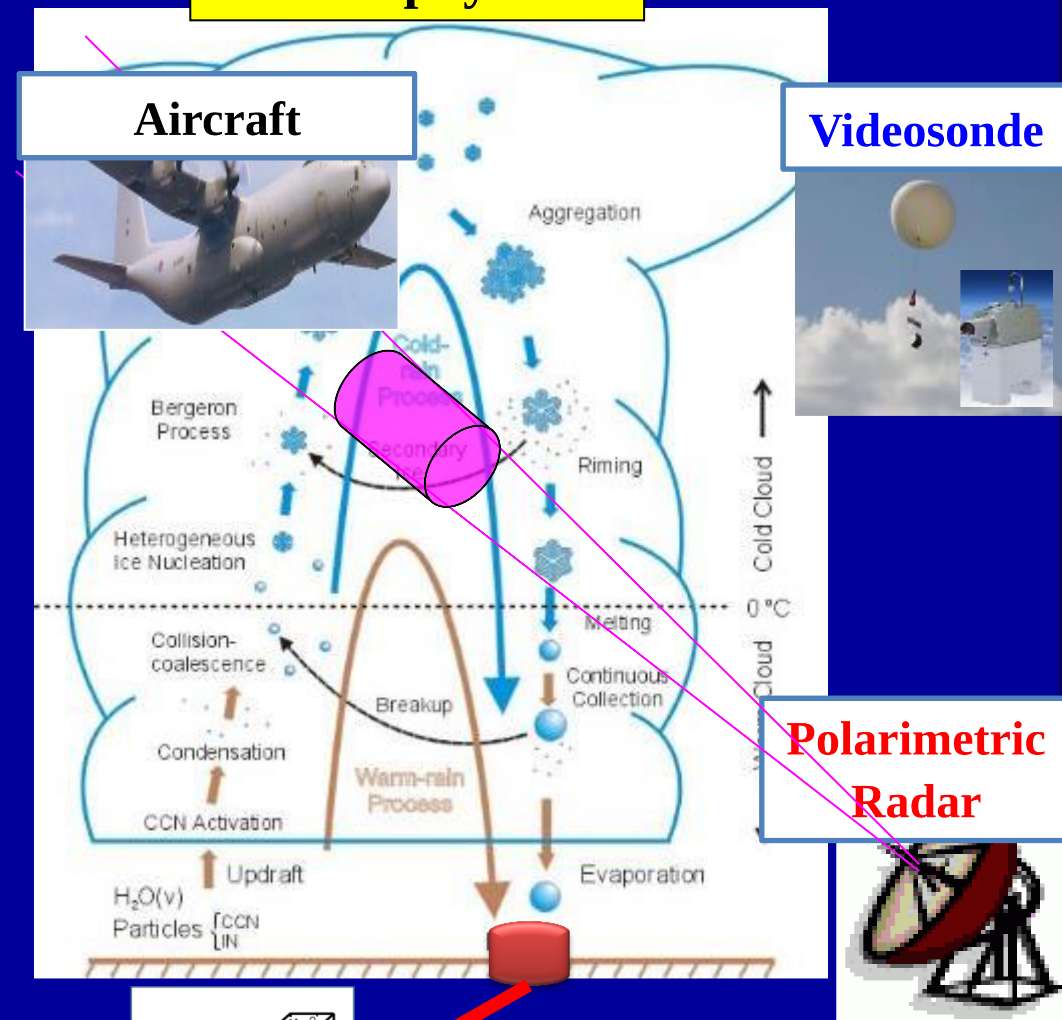
$$N_w = \frac{4^4}{\pi\rho_w}\frac{LWC}{D_m^4}$$

$[N_w] = m^{-3}mm^{-1}$

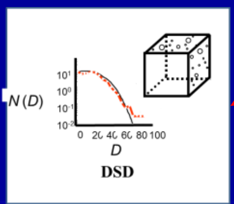
$$D_m = \frac{\int D^4 N(D)dD}{\int D^3 N(D)dD}$$

Mean volume diameter

Microphysics

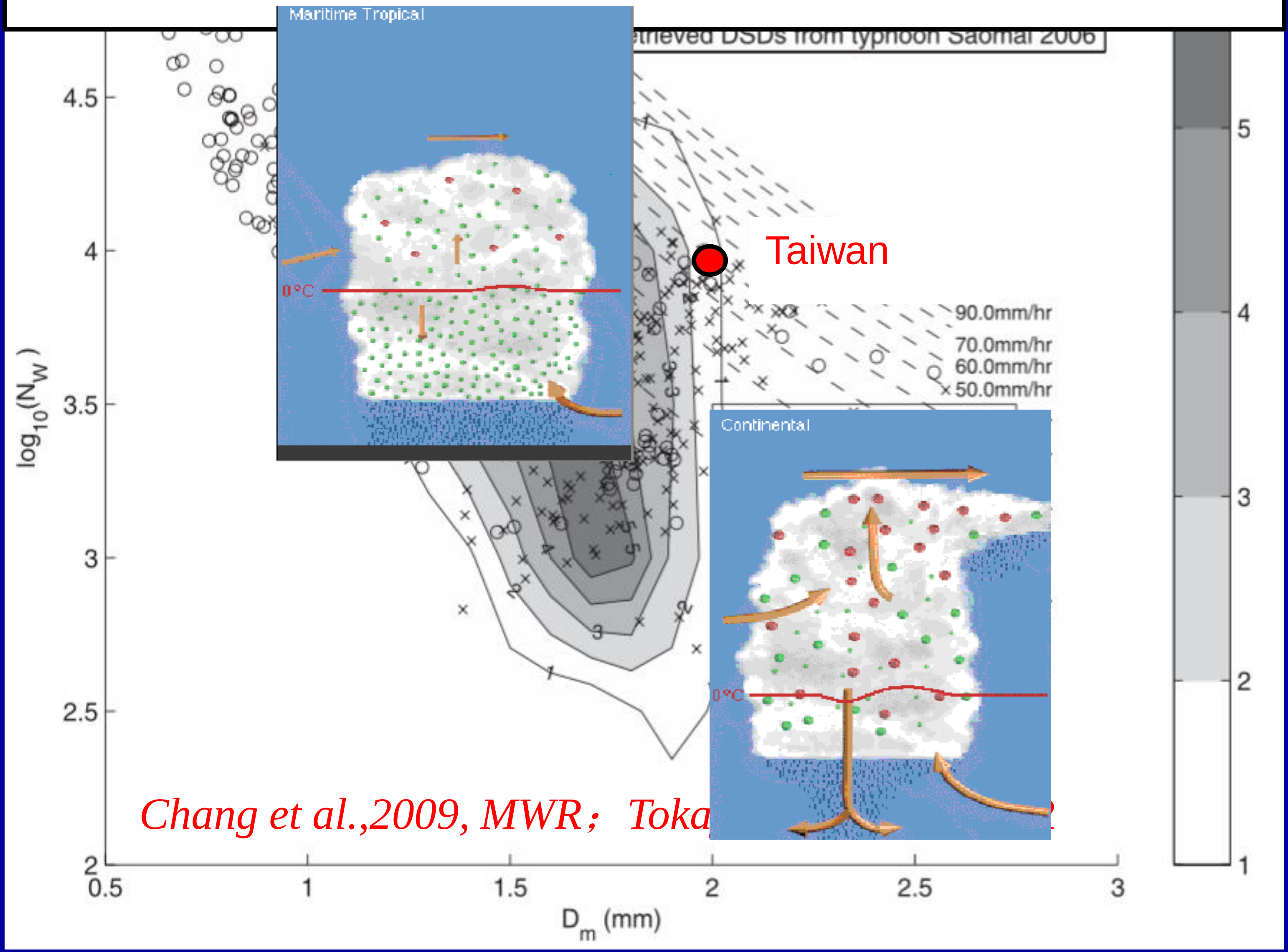


Disdrometer



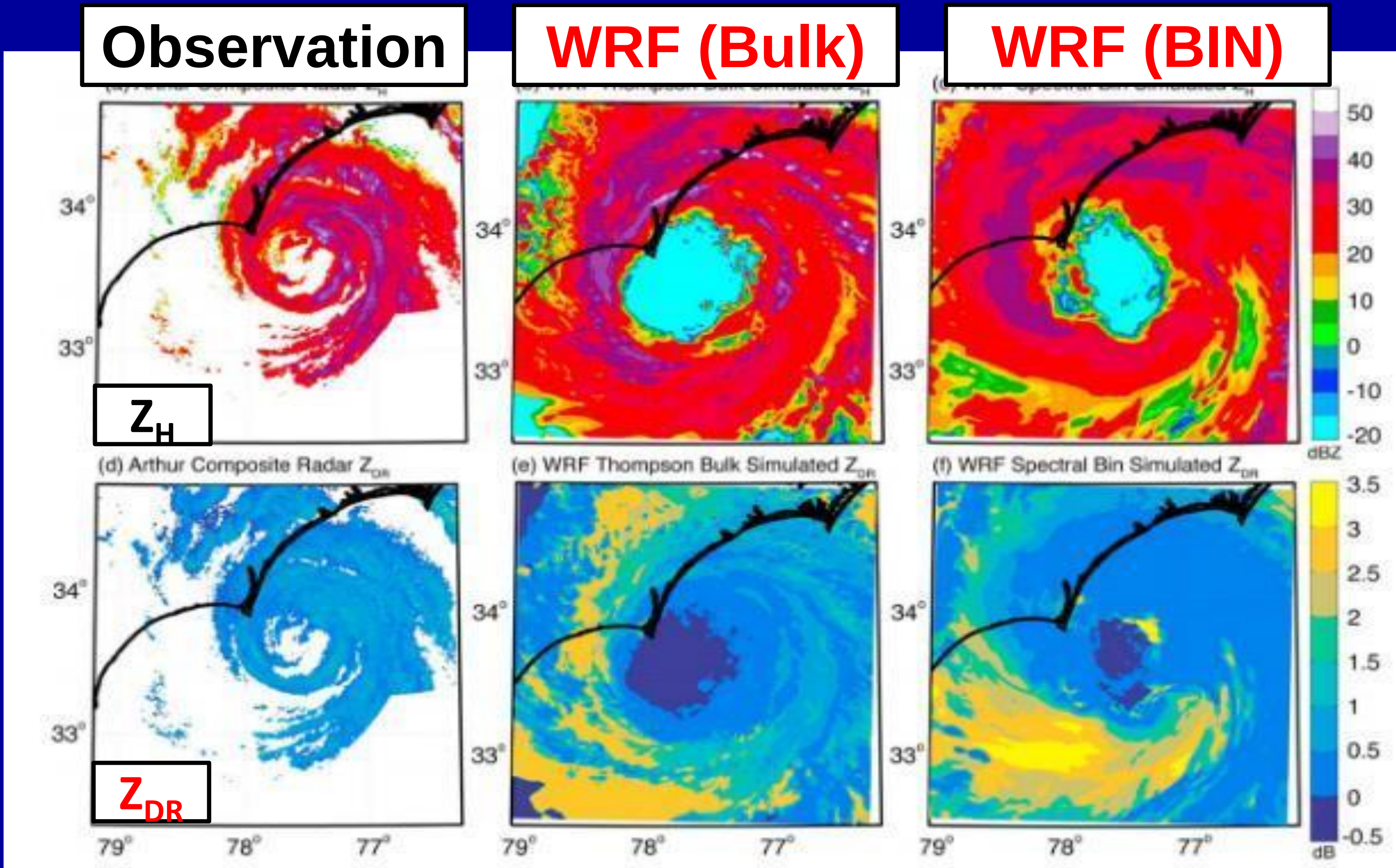
Observation of precipitation

DSD



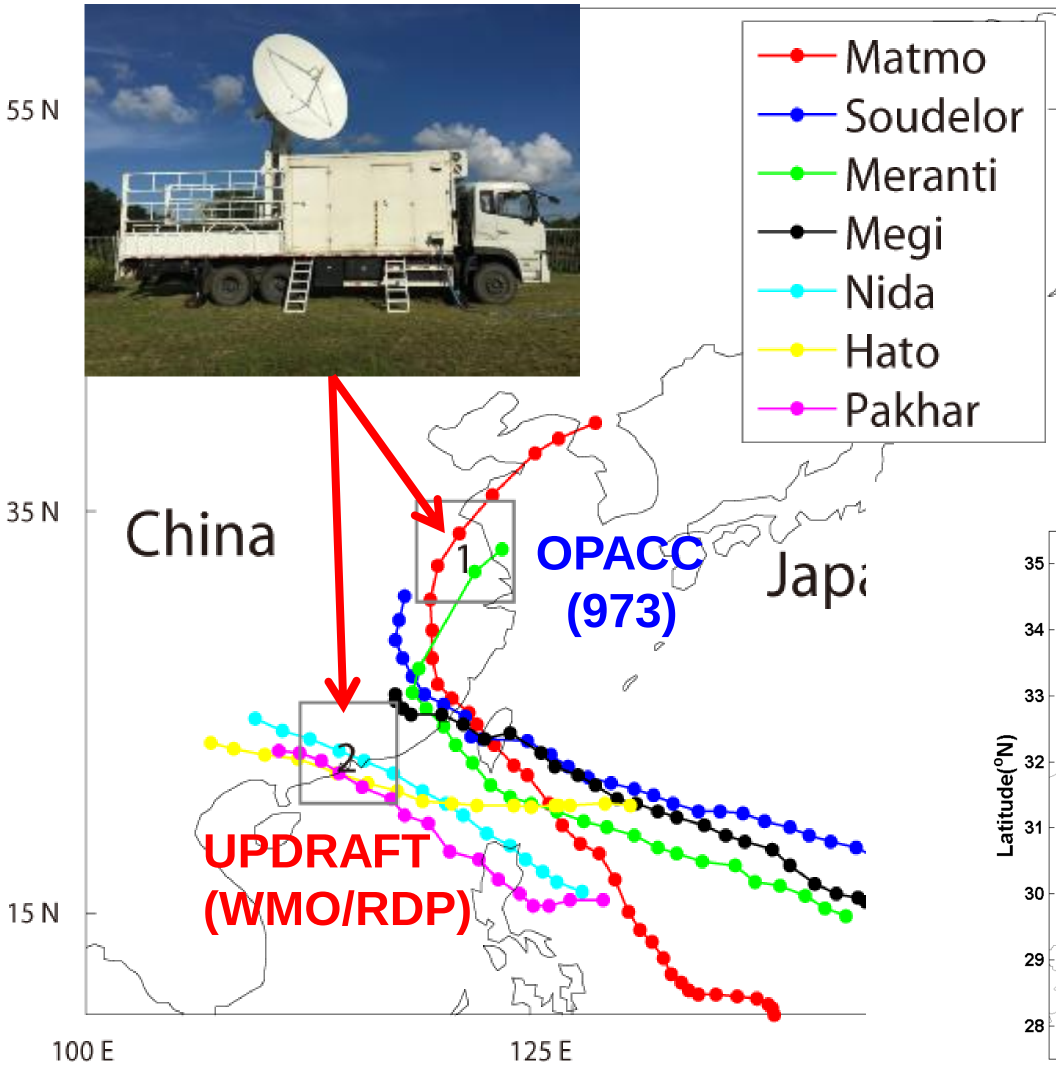
Chang et al.,2009, MWR；Toka

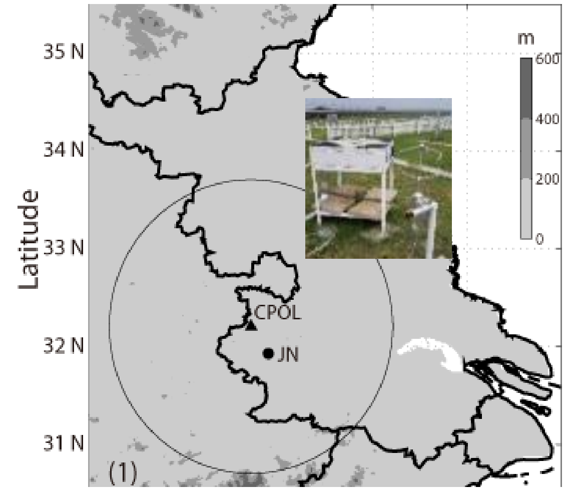
Precipitation Forecast

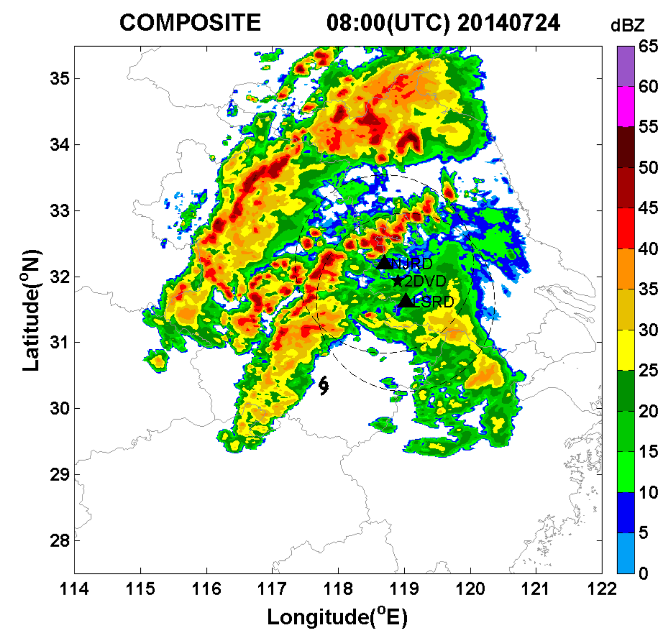


Brown et al., 2015, GRL

Motivation







Understanding the precipitation microphysics of typhoon rainband in China

2. Data and Method

- Dual-Doppler analysis (CEDRIC)
- DSD Parameter
  - Moment fitting method (Viveknandan et al., 2004)
  - Constraint-Gamma DSD Retrieval (Zhang et al., 2001)

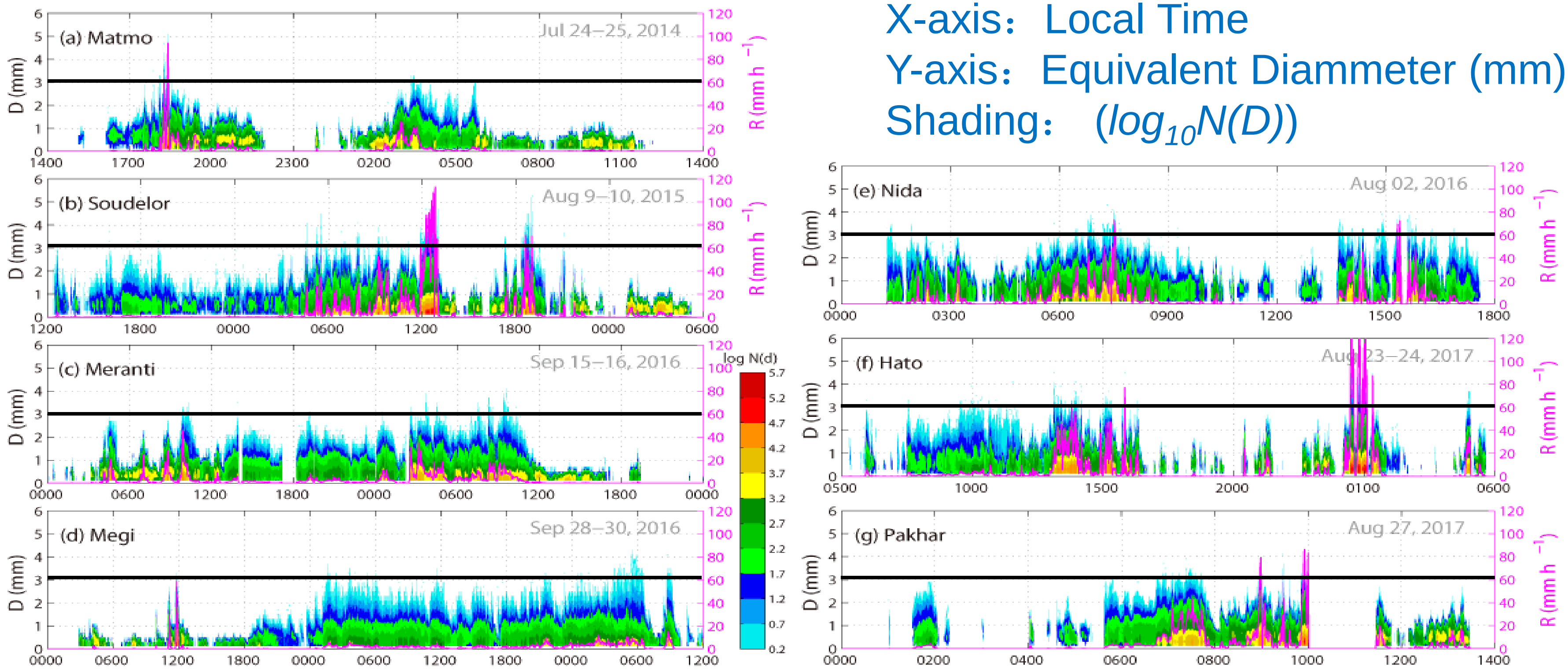
    --- Z_H & Z_{DR}
- Convective & Stratiform separation (Steiner et al., 1995)

  --- Z_H
- Liquid & Ice water content estimation (Carey and Rutledge, 2000) --- Z_H & Z_{DR}

3. DSD Characteristics

Time Series of DSDs for seven TCs

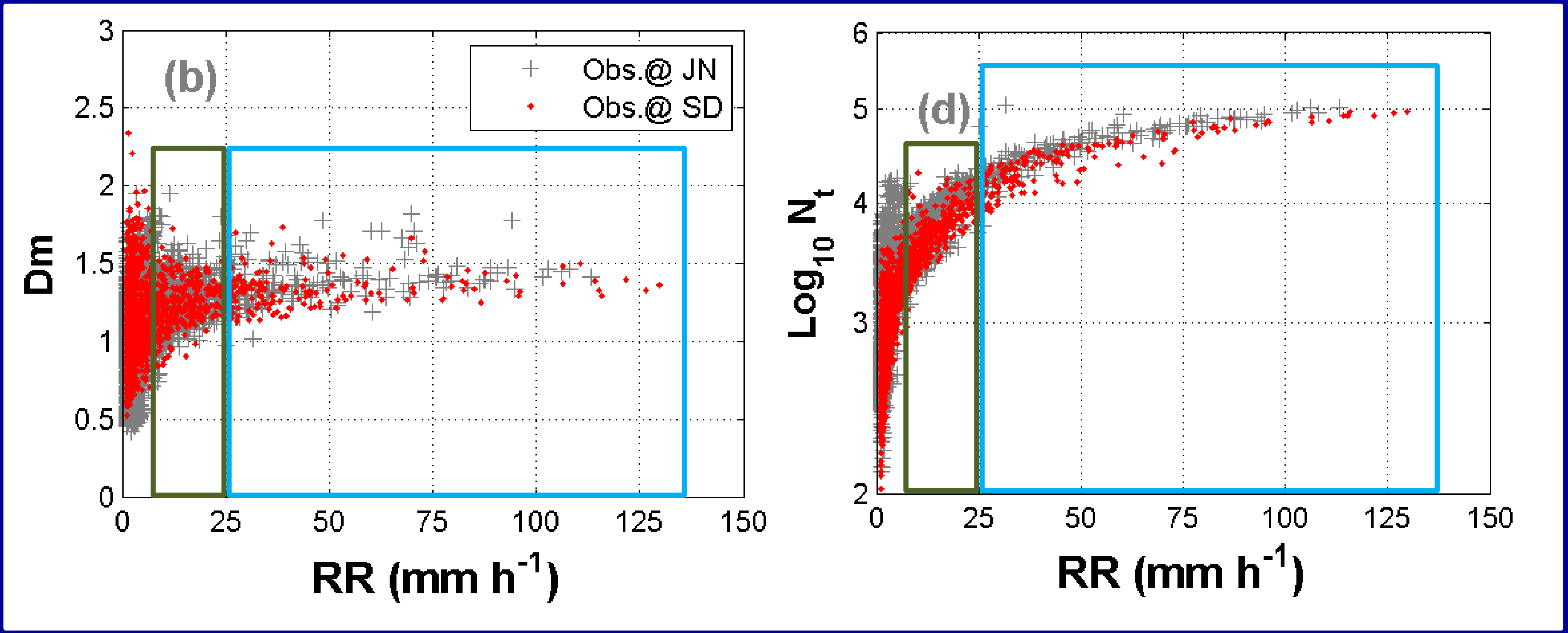
X-axis: Local Time
Y-axis: Equivalent Diammeter (mm)
Shading: ($log_{10}N(D)$)



✓Majority of raindrops less than 3mm
✓High concentration of small raindrops

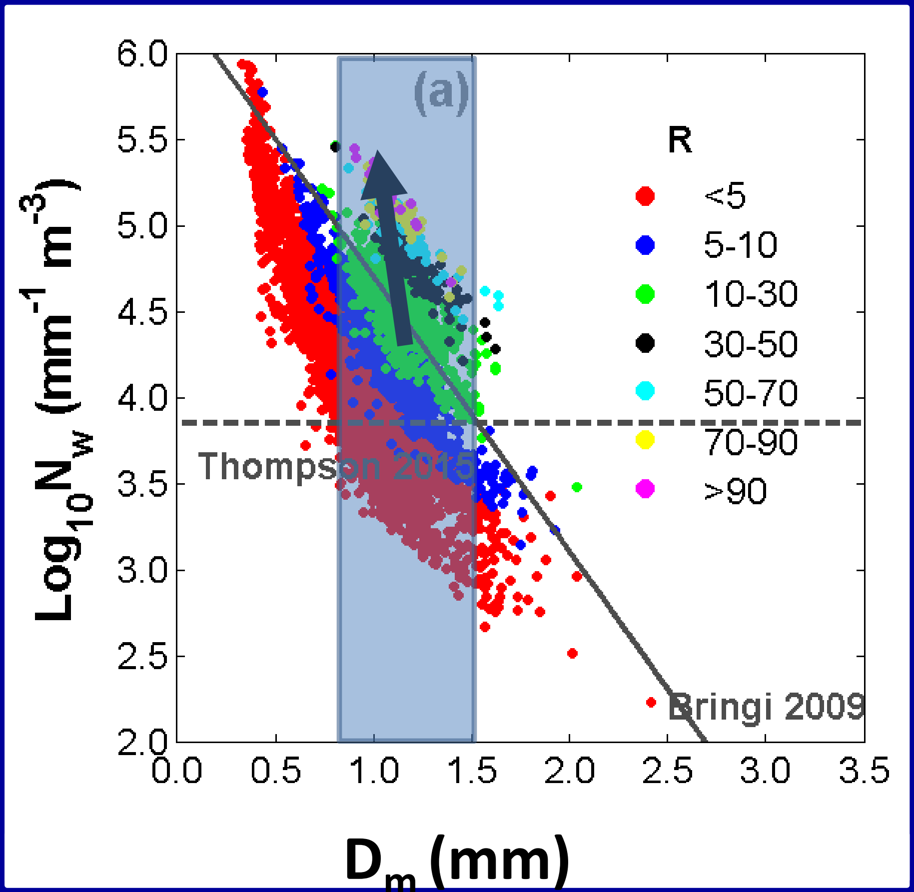
Wen and Zhao, 2017, JGR (Under Review)

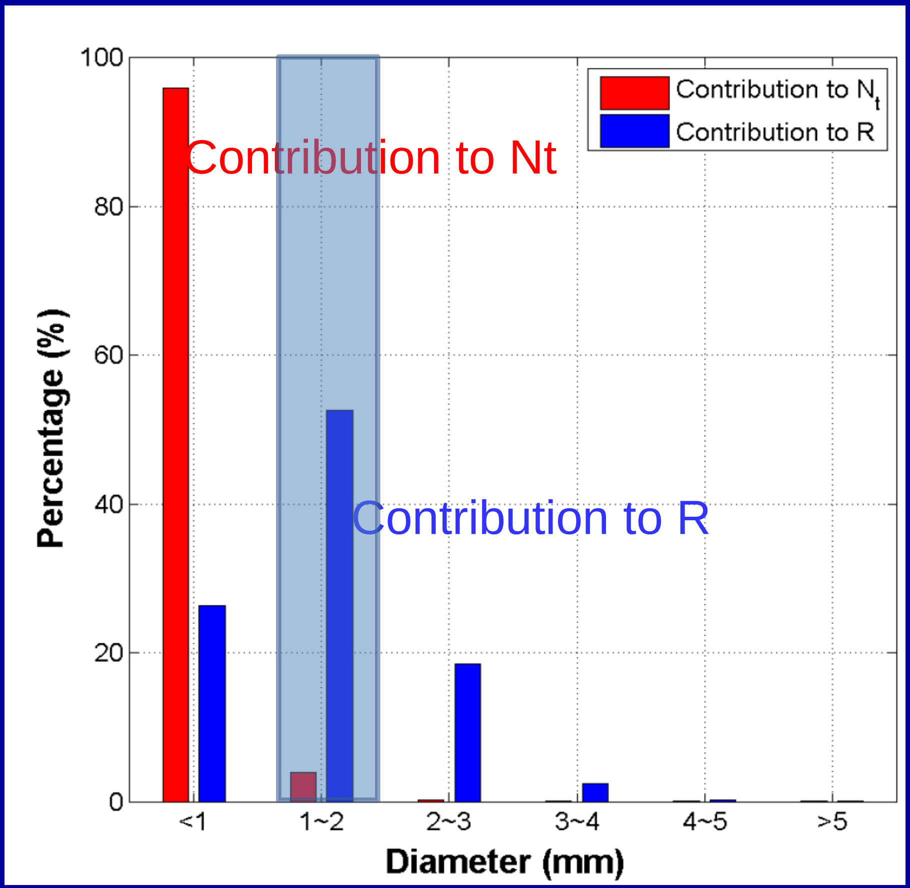
3. DSD Characteristics



- **The differences in the computed parameters of these seven typhoons in South and East China are negligible.**
- **Both *Dm* and *Nt* increase with an increase in the rain rate. *Dm values stay at about 1.5 mm when R > 25 mmh^{-1}***

3. DSD Characteristics

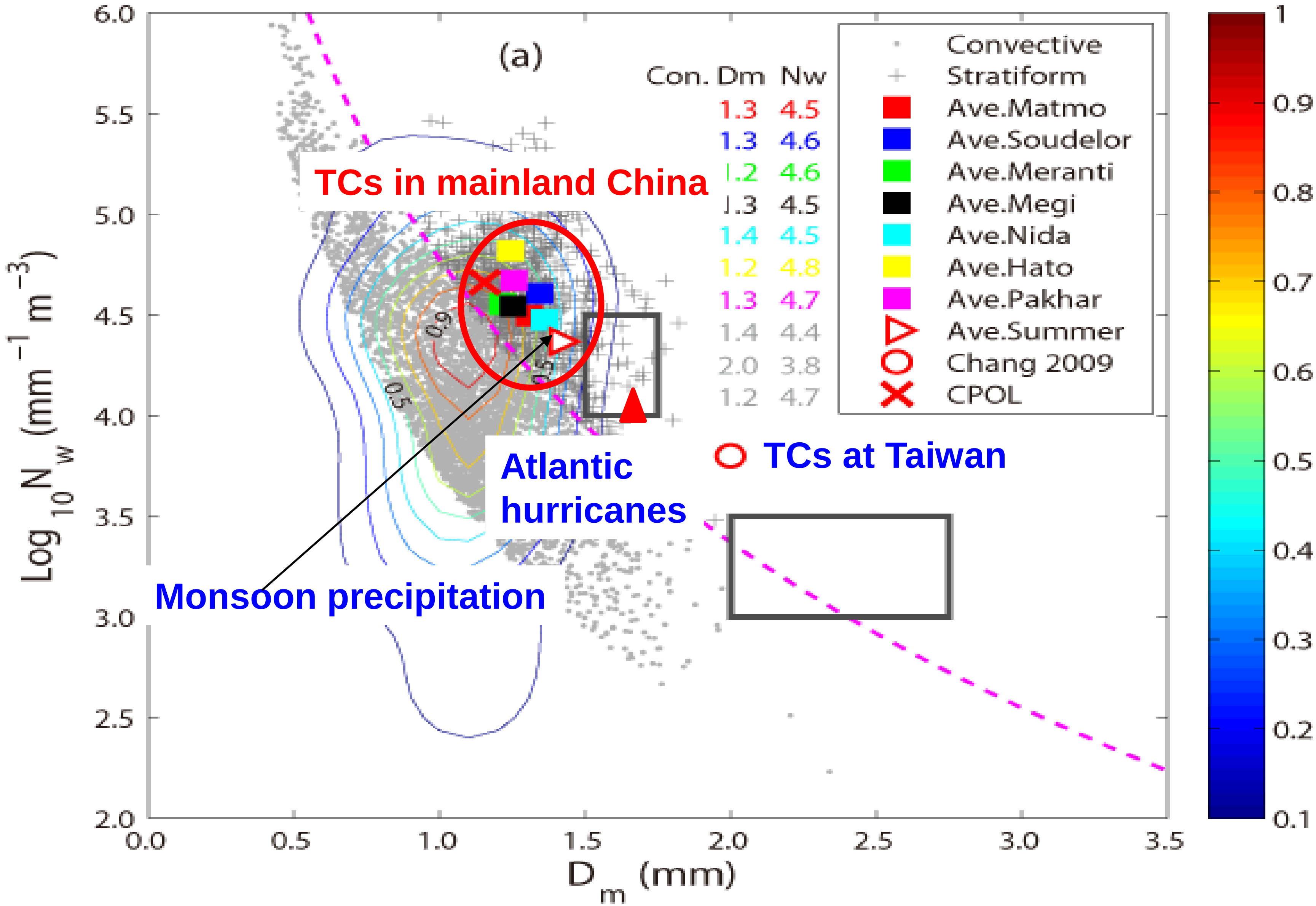




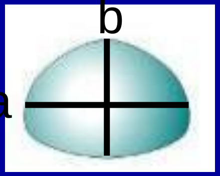
The distributions of the two parameters become narrower as *R* increases.

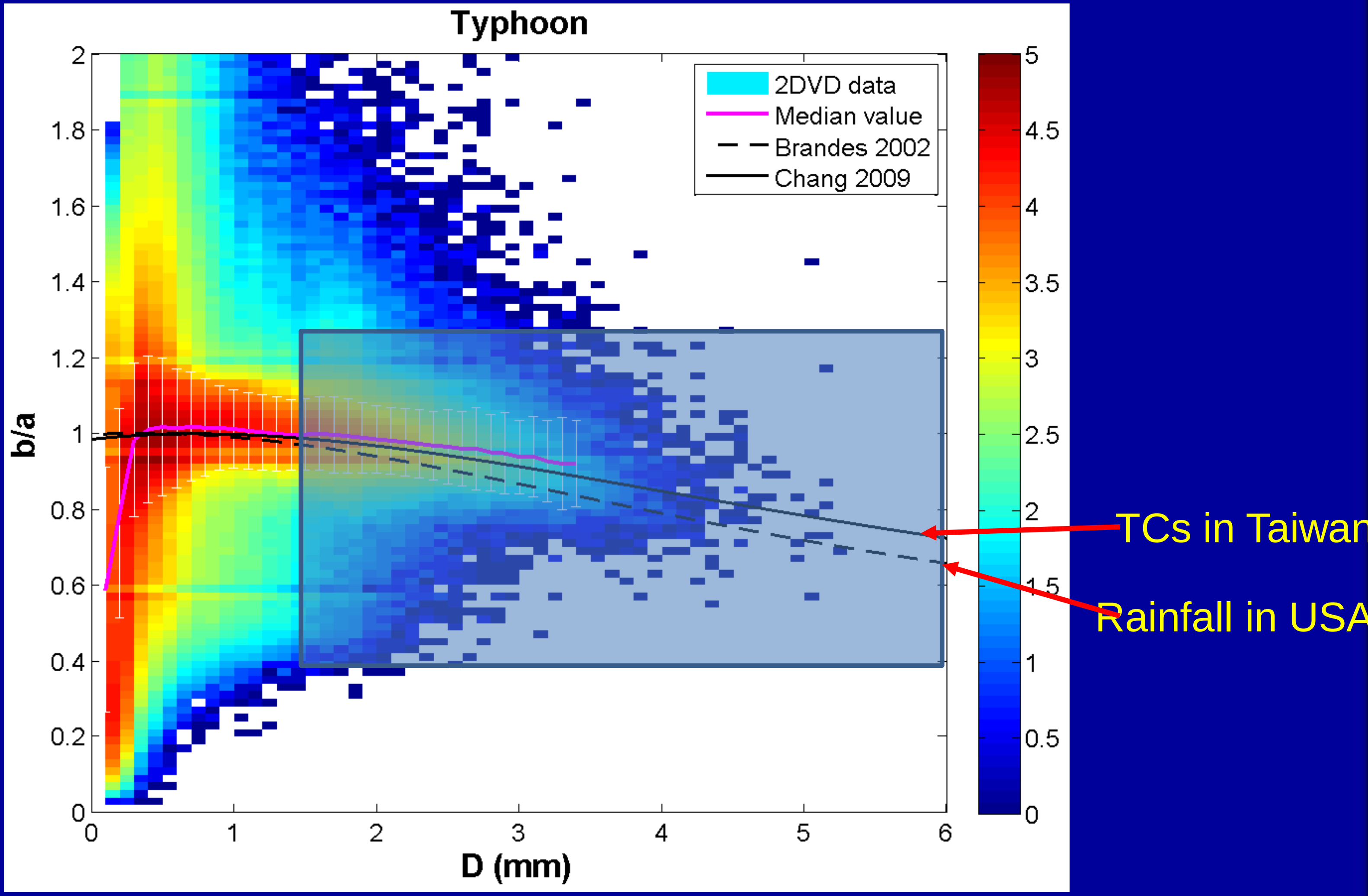
The contribution to total rainfall from the drops at 1~2 mm in diameter is 52.6% .

3. DSD Characteristics



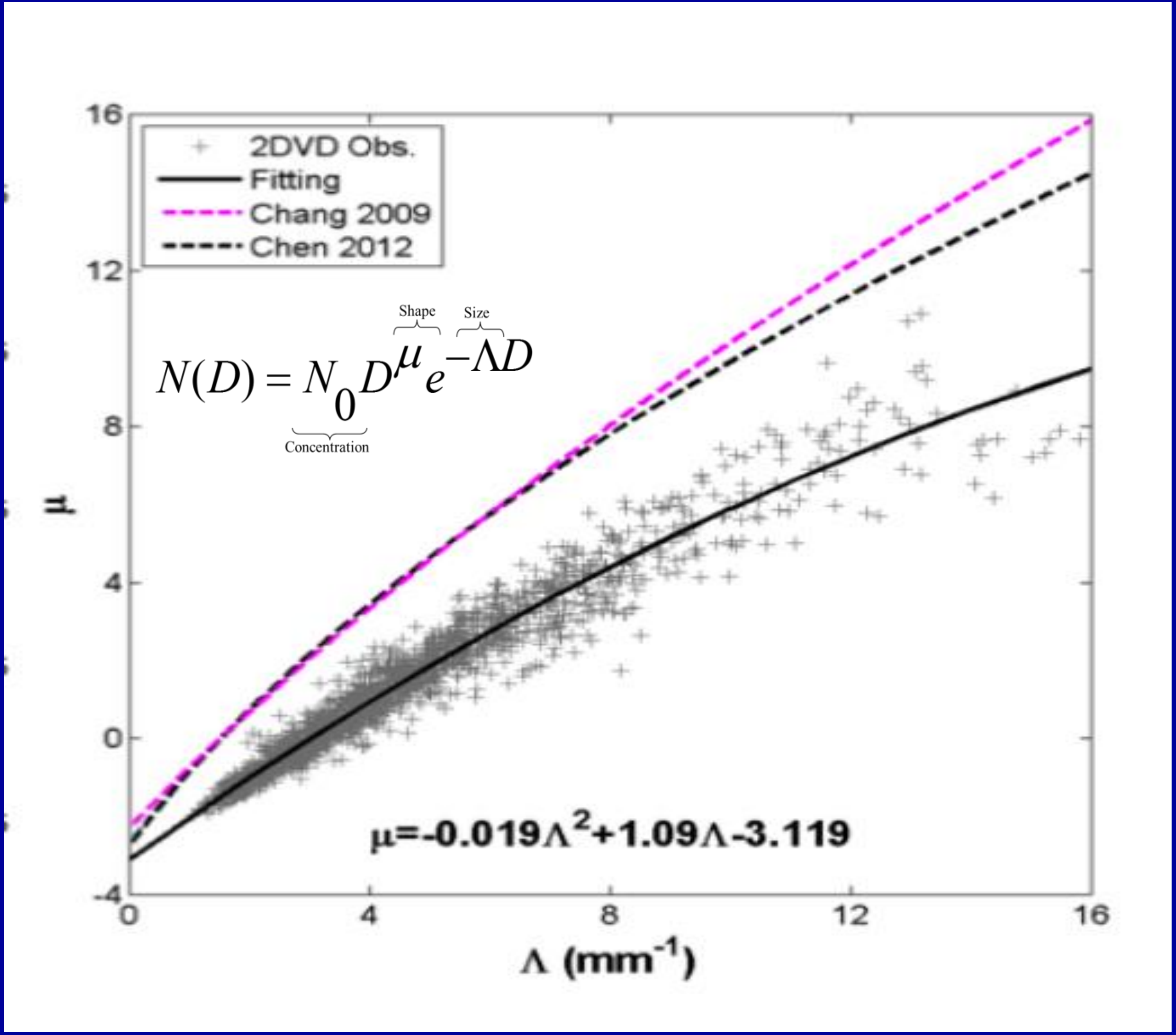
3. Drop Shape Relation



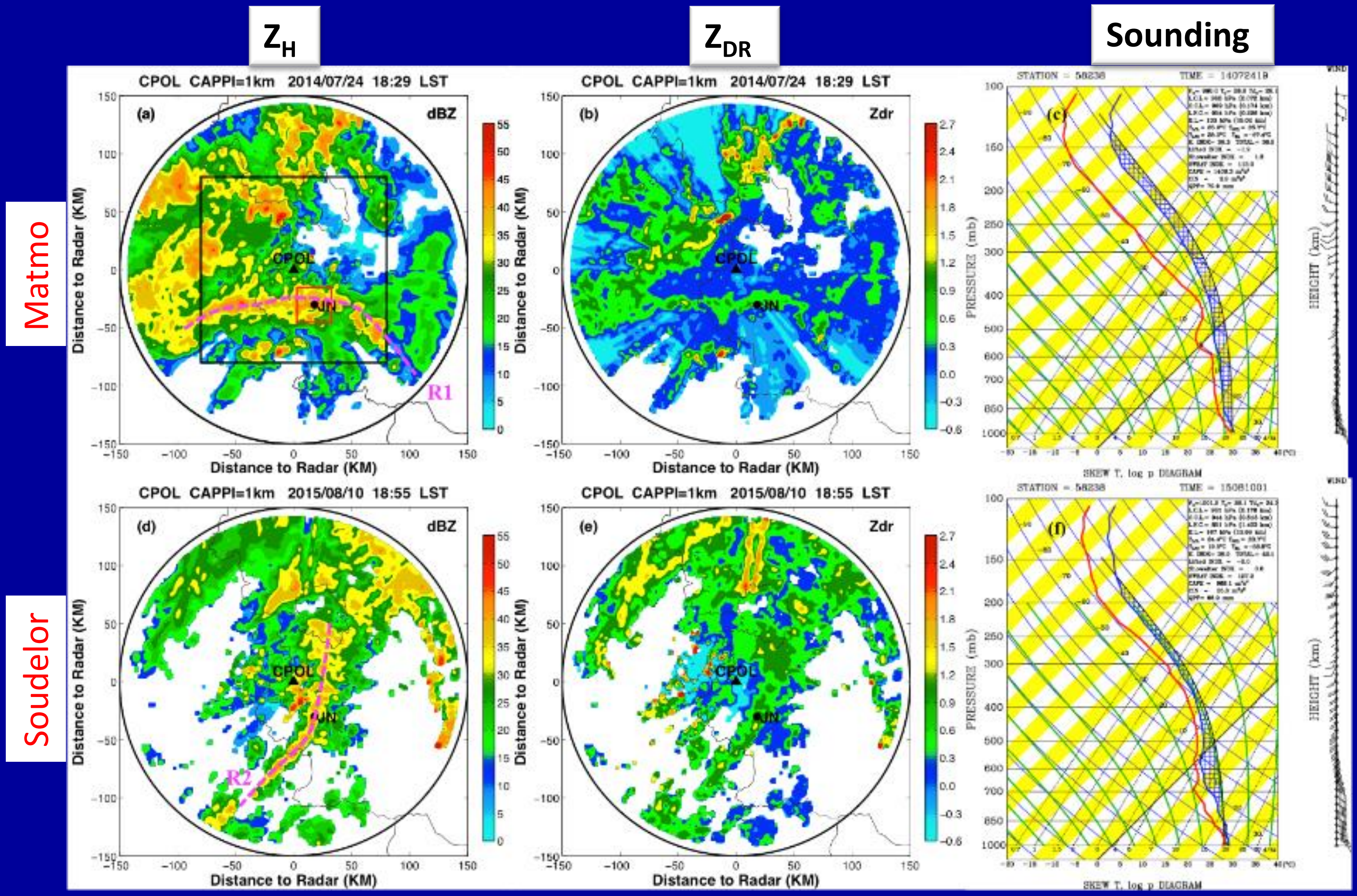


- The DSR is more spherical for D>1.5 mm

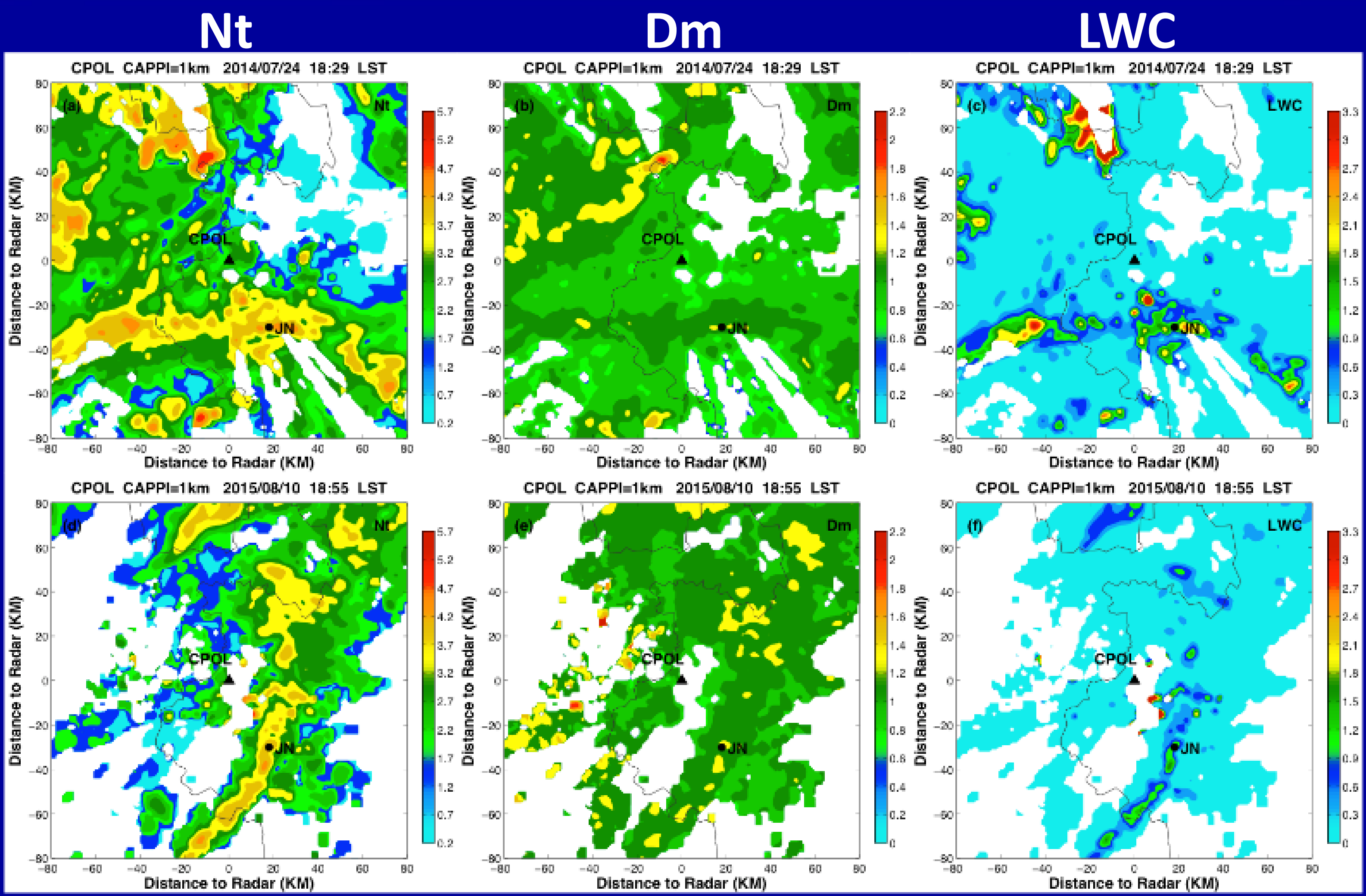
3. u-Λ Relation



4. Microphysical Structure

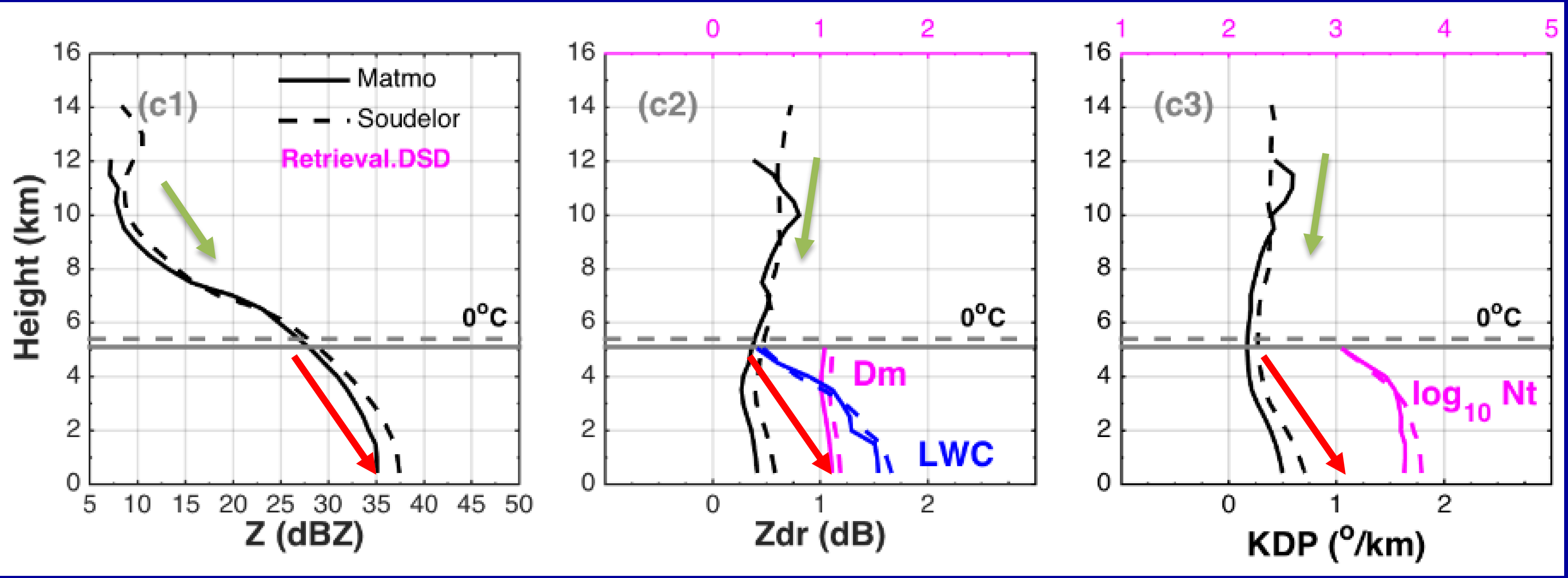


4. Radar Derived DSDs



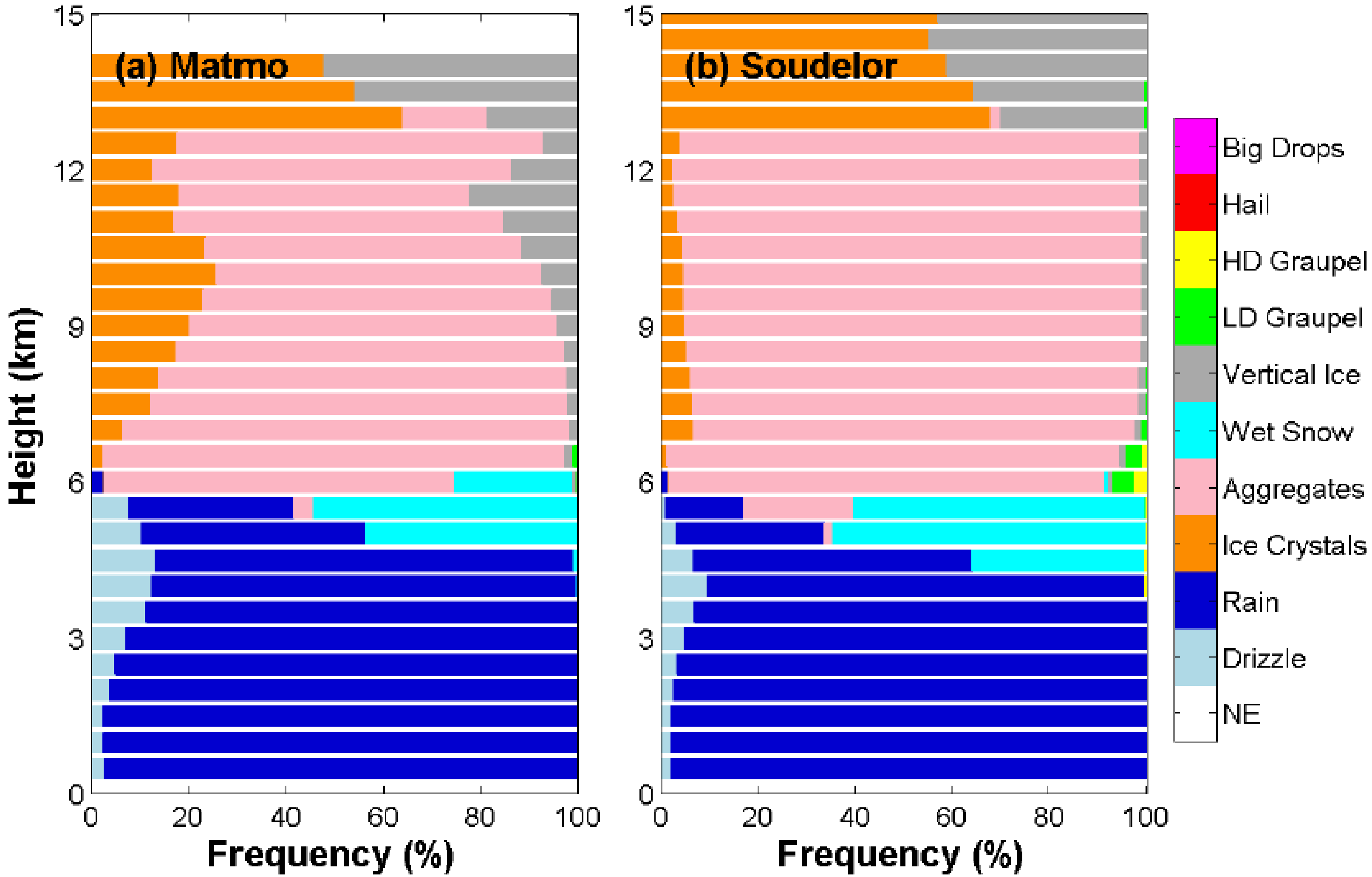
The *Dm* values show a more inhomogeneous distribution and mostly around 1-1.4mm. A higher Z_H value usually corresponds to a higher *Nt and LWC*.

4. Vertical Structure

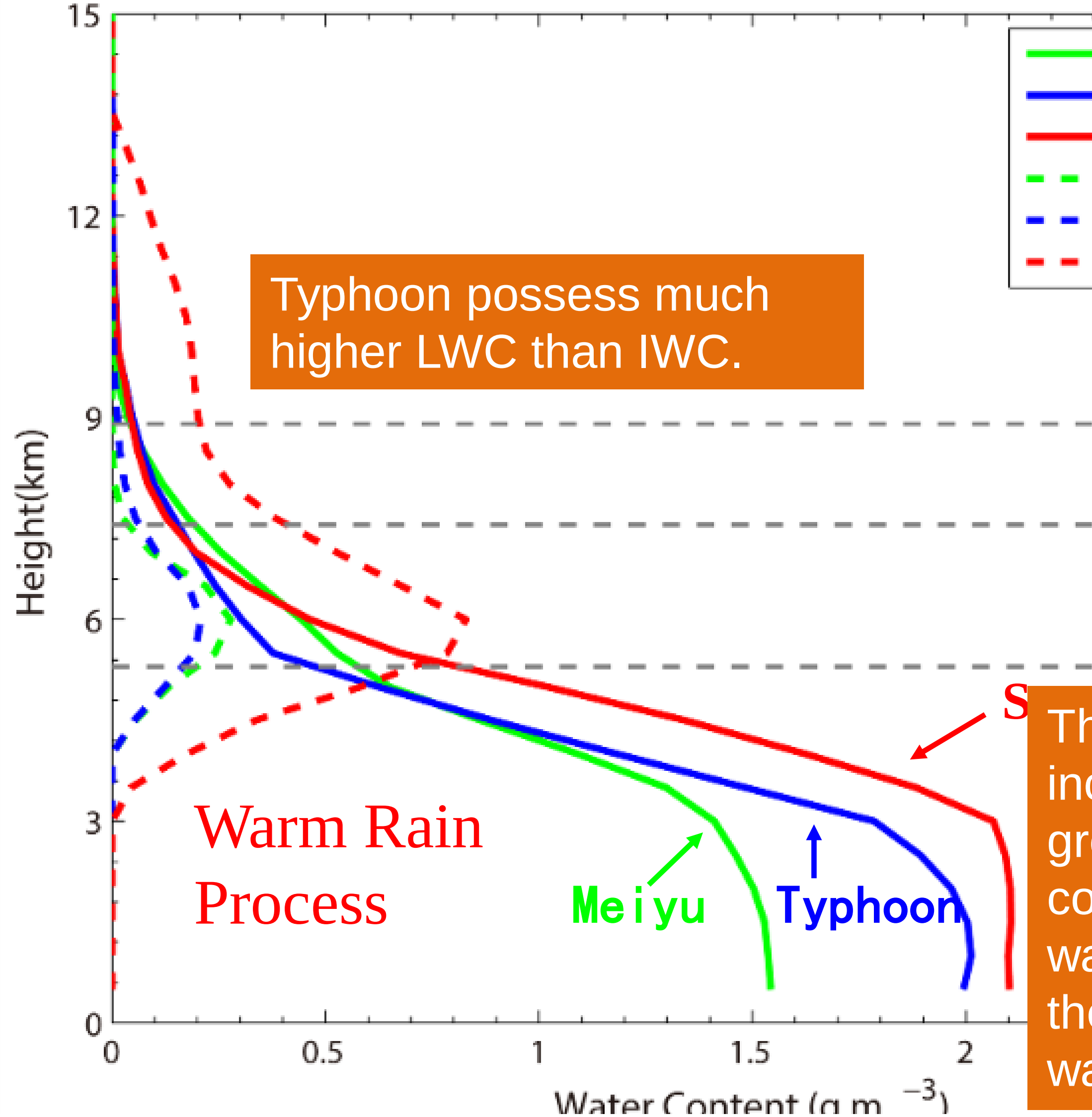


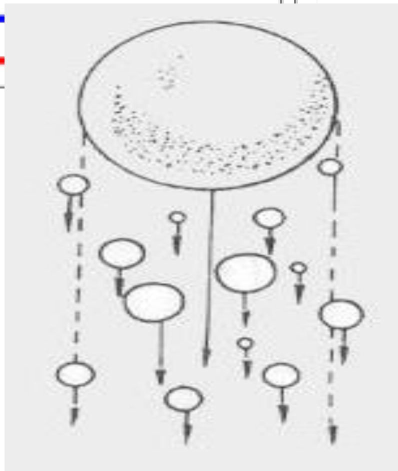
The averaged profiles of Z_H, Z_{DR} and K_{DP} downward to the ground, indicating the processes of collision coalescence and/or the accretion of cloud water by raindrops.

4. Microphysical Structure



4. Microphysical Process



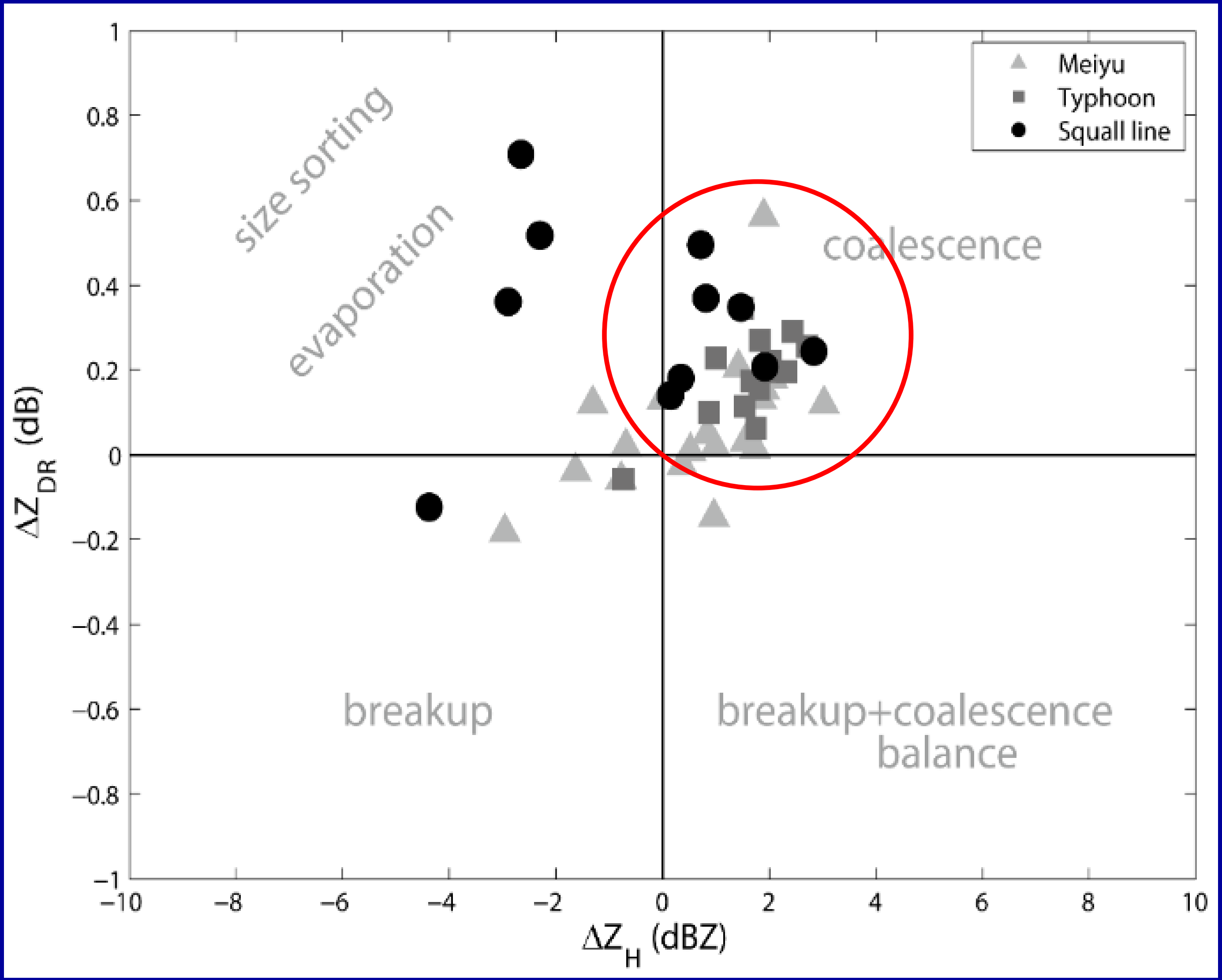


Typhoon possess much higher LWC than IWC.

The liquid water content increases rapidly toward ground, indicating the conversion from cloud water into rainwater by the accretion of cloud water by raindrops.

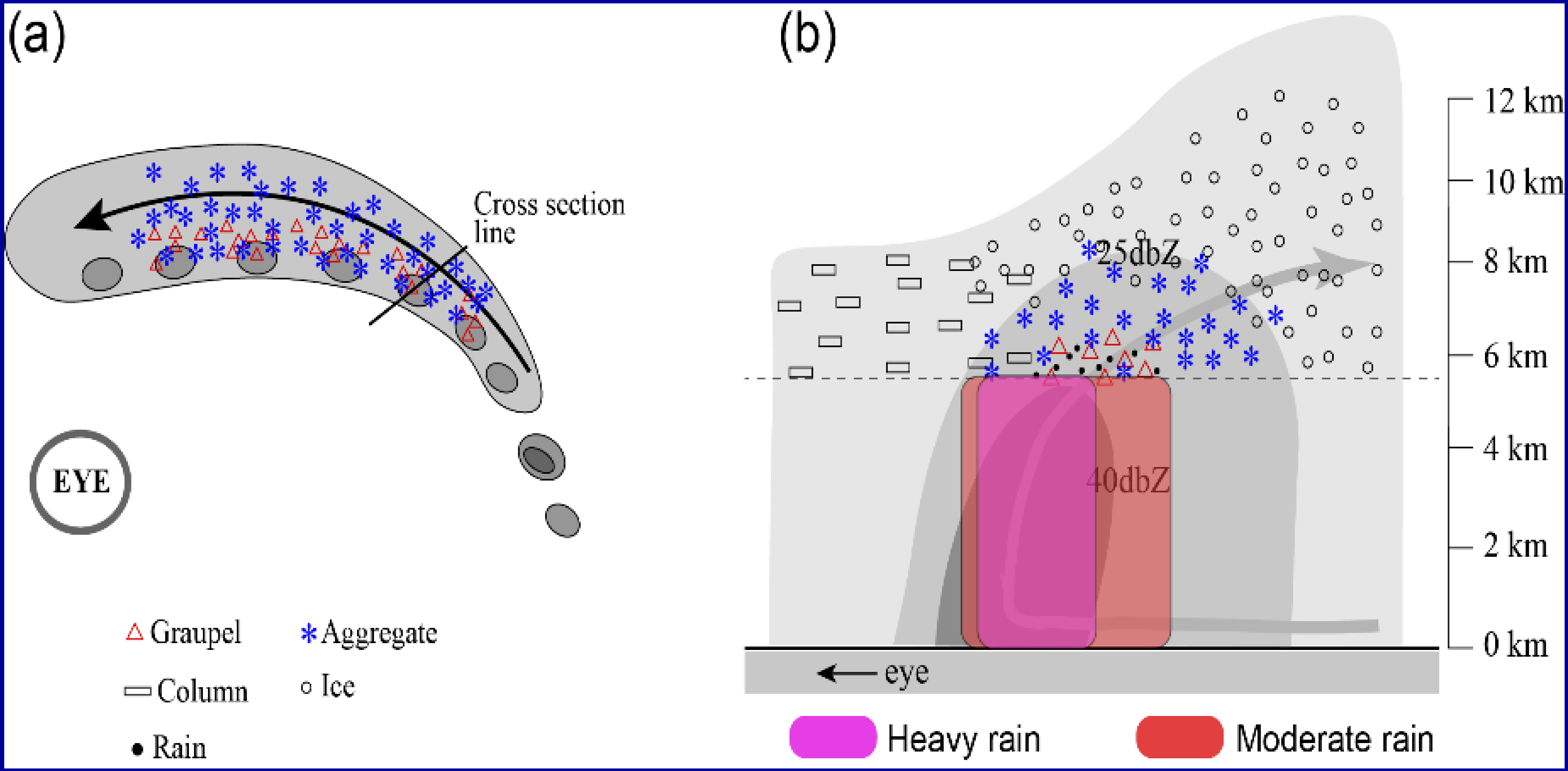
Wang and Zhao, 2016, JGR ; Chen and Zhao,2017,JHM (Under Review)

4. Microphysical Process



The changes in Z_{DR} and Z_H over a 3-km layer (0.5 – 3.5 km)

4. Microphysical Process



The inner rainband microphysics of Matmo (2014)

Wang and Zhao et al.,2018, JGR (Under Review)

4. Microphysical Process

AGU Spotlight

Reading Raindrops: Microphysics in Typhoon Matmo

Quantitative predictions about tropical storms require an understanding of even their smallest physical processes. A new study observes unusual microphysics in 2014's Typhoon Matmo.

SOURCE: *Journal of Geophysical Research: Atmospheres*

Typhoon Matmo, pictured here approaching Taiwan in July 2014, demonstrated microphysical processes different from those of other apparently similar tropical storms, including an abundance of small raindrops. Credit: NASA

By Leah Crane 9 December 2016

When tropical cyclones pass over the land, they can be disastrous to coastal areas. Scientists can paint a fairly accurate picture of cyclones' trajectories and intensities, but their ability to quantitatively predict the heavy rainfall that accompanies these storms is less advanced. The quantitative forecasts require a more precise understanding of the physics of tropical cyclones, down to the size of a single raindrop.

In a new study, Wang et al. used relatively new observational methods to examine microphysical processes in a typhoon's rainband, the line of heavy showers—generated by temperature differences—that spirals in toward the storm's center and gives a hurricane its distinctive whorl shape.

Precipitation Microphysics Characteristics of a Typhoon Matmo (2014) Rainband after Landfall over Eastern China based on Polarimetric Radar Observations

Editors' Highlight

Radar has been used to study dynamical structures of tropical cyclones for many years. The recent development of particle identification retrieval from observations of S-band polarimetric Doppler radars opens a door to document microphysical characteristics of tropical cyclones. This study uses this new observing technology to advance our understanding of tropical cyclones. The authors observed microphysical processes in a landfalling typhoon that are distinct from other types of marine deep convection. This and other similar investigations on microphysical properties of tropical cyclones provide invaluable information for validating and developing numerical models.

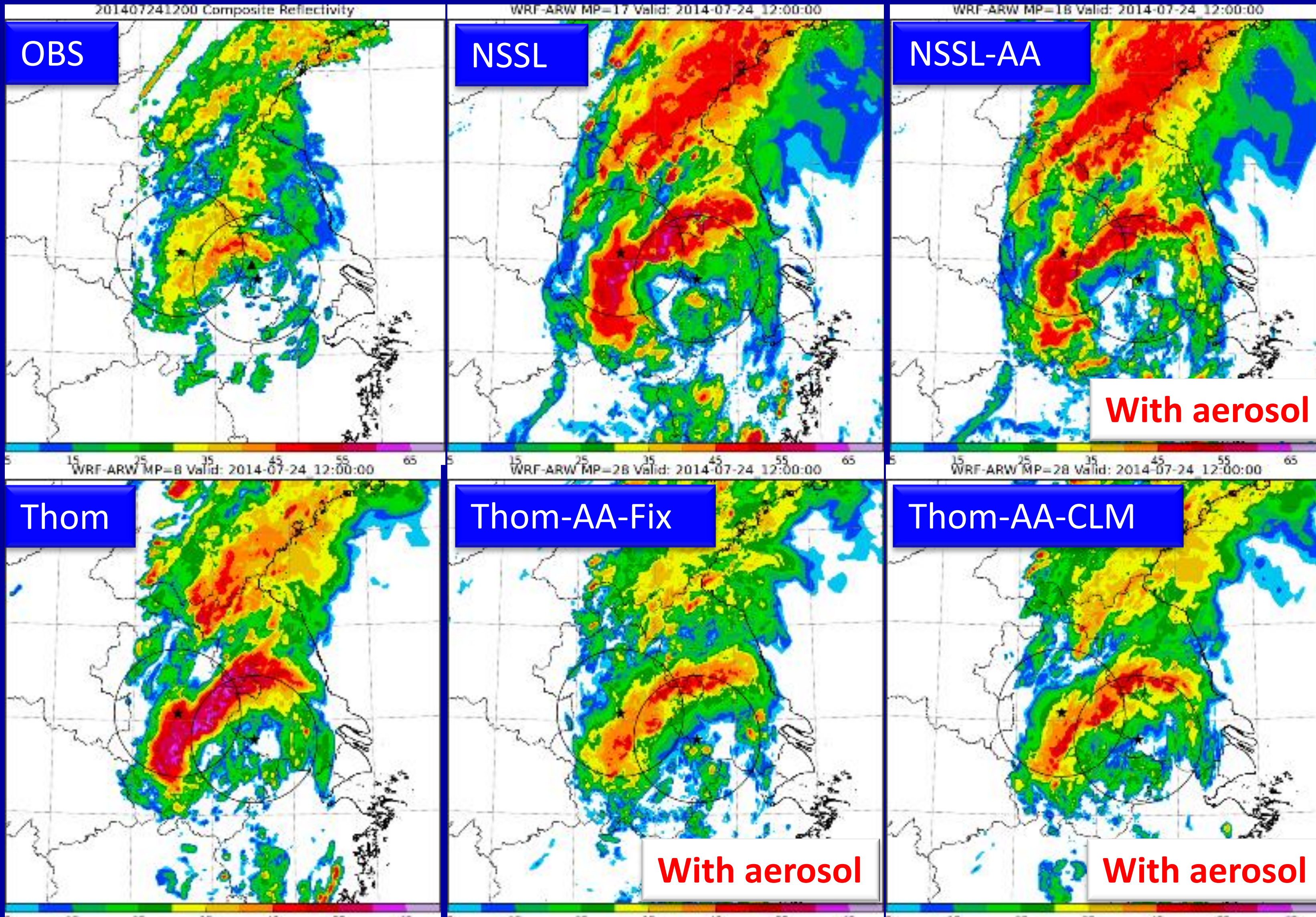
https://eos.org/research-spotlights/reading-raindrops-microphysics-in-typhoon-matmo

Crane, L. (2016), Reading raindrops: Microphysics in Typhoon Matmo, Eos, 97, doi:10.1029/2016EO063821. Published on 09 December 2016.

5. Summary

- The differences in the computed DSD parameters of typhoons in South China coastal region and East China are negligible. The differences of DSDs become narrower as rainfall intensity increases. The increase of raindrop concentration plays a crucial role in the intensification of heavy rainfall.
- The small and midsize drops jointly dominate typhoon rainfall in China, and show a higher (lower) raindrop concentration (diameter) compared to that of maritime convective, typhoons in Taiwan, Atlantic tropical cyclones, and summer rainfall in East China.
- Warm rain processes (conversion of cloud water into rainwater via accretion process) dominate the formation and evolution of typhoon rainfall in China.

5. Future Study



Thank You！

Questions?