Comparisons of Parsivel and MRR Disdrometer Under a Heavy Rainfall Period

Utimate C.-J. Jung and Ben J.-D. Jou

Department of Atmospheric Sciences, National Taiwan University, Taipei, Taiwan

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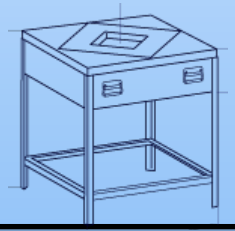
Frequently used disdrometer in Taiwan

Name	Joss-Waldvogel Disdrometer	Parsivel	2-D Video Disdrometer	Micro Rain Radar
				
Type	Impact	Optical (Scattering)	Optical (Video)	Radar
Size	H170 x W100 x D100 mm	H670 x W600 x D114 mm	H960 x W960 x D890 mm	H850 x W600 x D800 mm
Particle size	0.3 -5.0 mm	0.2 – 25 mm	Resolution < 0.17 mm	(0.2 -6.0 mm)
Particle speed	N/A	0 – 20 m/s	Error < 4%	0 – 9 m/s
Operating unit	NCU, PCCU	CWB, NTU, NCU, PCCU	NCU, (TTFRI)	NTU, PCCU

Motivation

- The additional measurements lie between radar and disdrometer could extend our understanding of the rainfall process near ground.
- If we could extract valuable DSDs' information during heavy rainfall period?
  - To understand the rainfall microphysics, improving the rainfall estimation and simulation.

Past studies have told us…

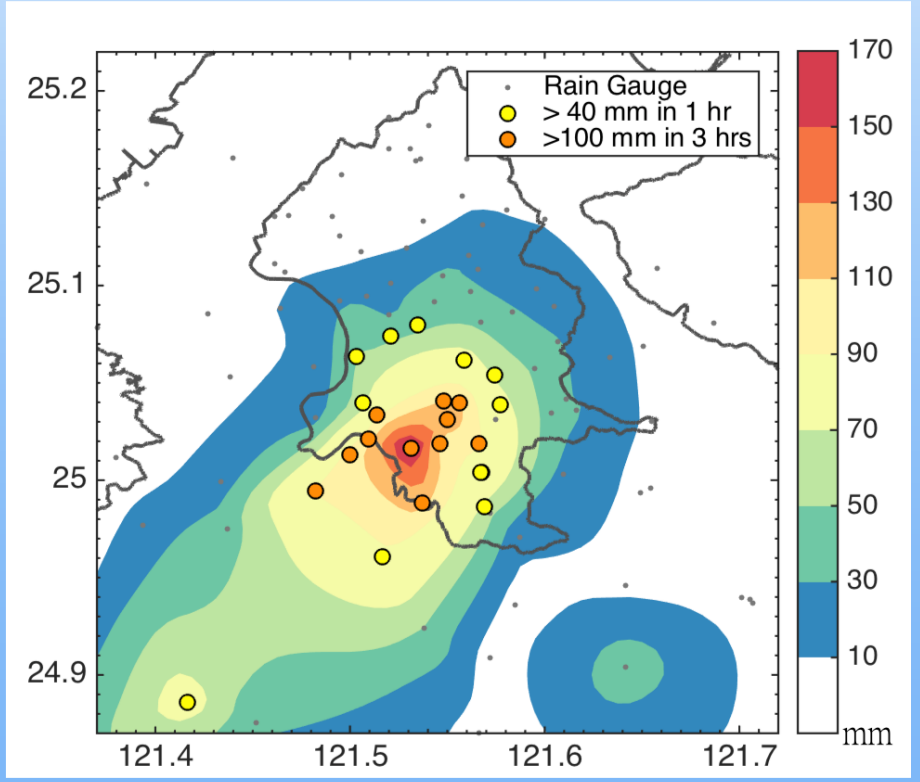
- MRR is relatively accurate due to large sampling volumes and accurate measurement of the Doppler power spectrum.
  (30 m height, Chang et al. 2020)

- MRR underestimates the rain rate and reflectivity under strong convective rain.
  (200m, Tsai and Yu, 2012; Wen et al., 2015)

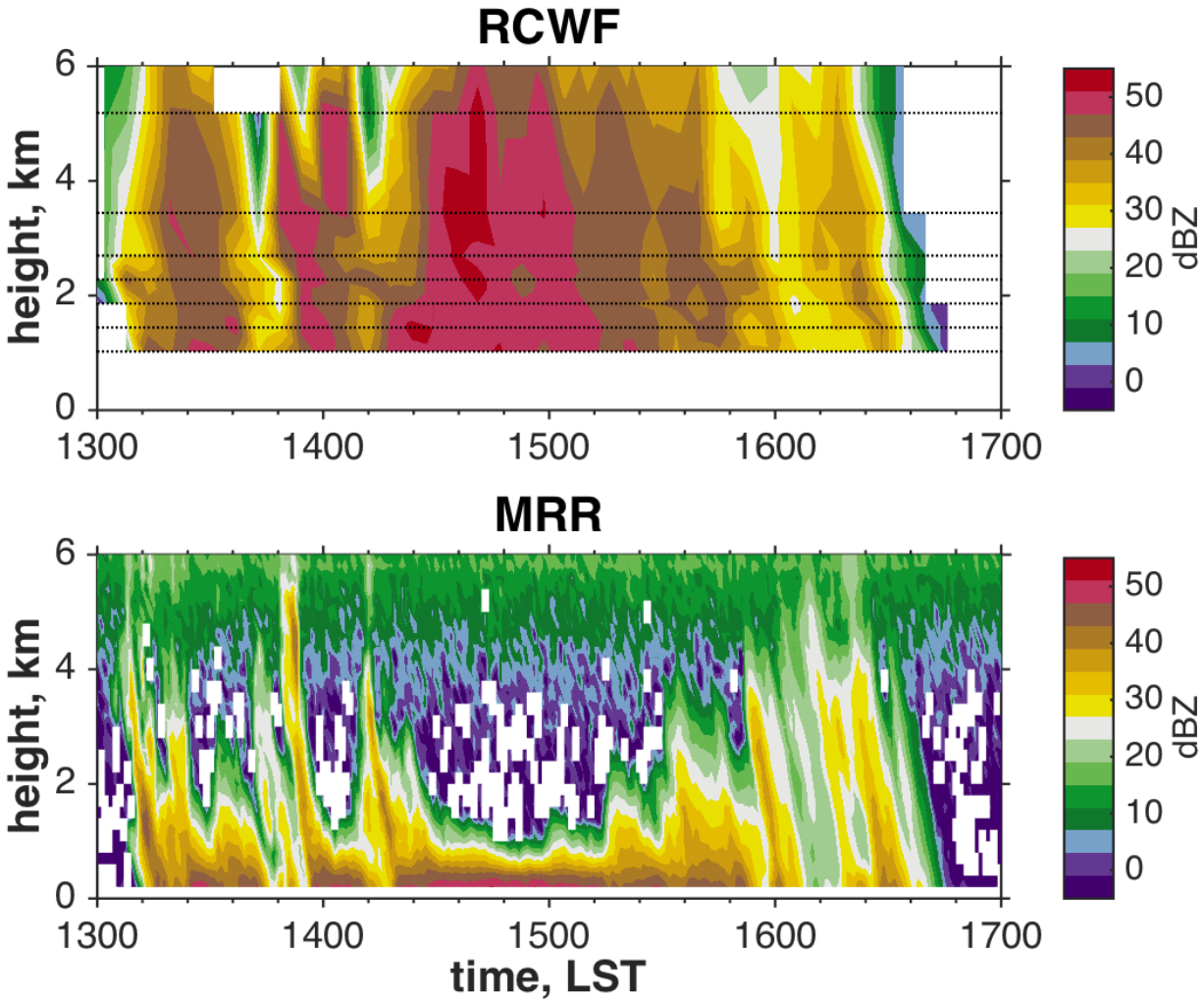
- In addition to the self-limitations of instruments, comparisons of DSDs and rainfall parameters between different instrument in various location.
  E.g. Wen et al. 2017 (Nanjing, East China);
  Adirosi et al. 2020 (Waterloo, Iowa, U.S.)

Case and rainfall

- 2015/6/14, severe afternoon thunderstorm in north Taiwan
- Both Parsivel and MRR locate at Gongguan, where the heaviest rain rate occurred.



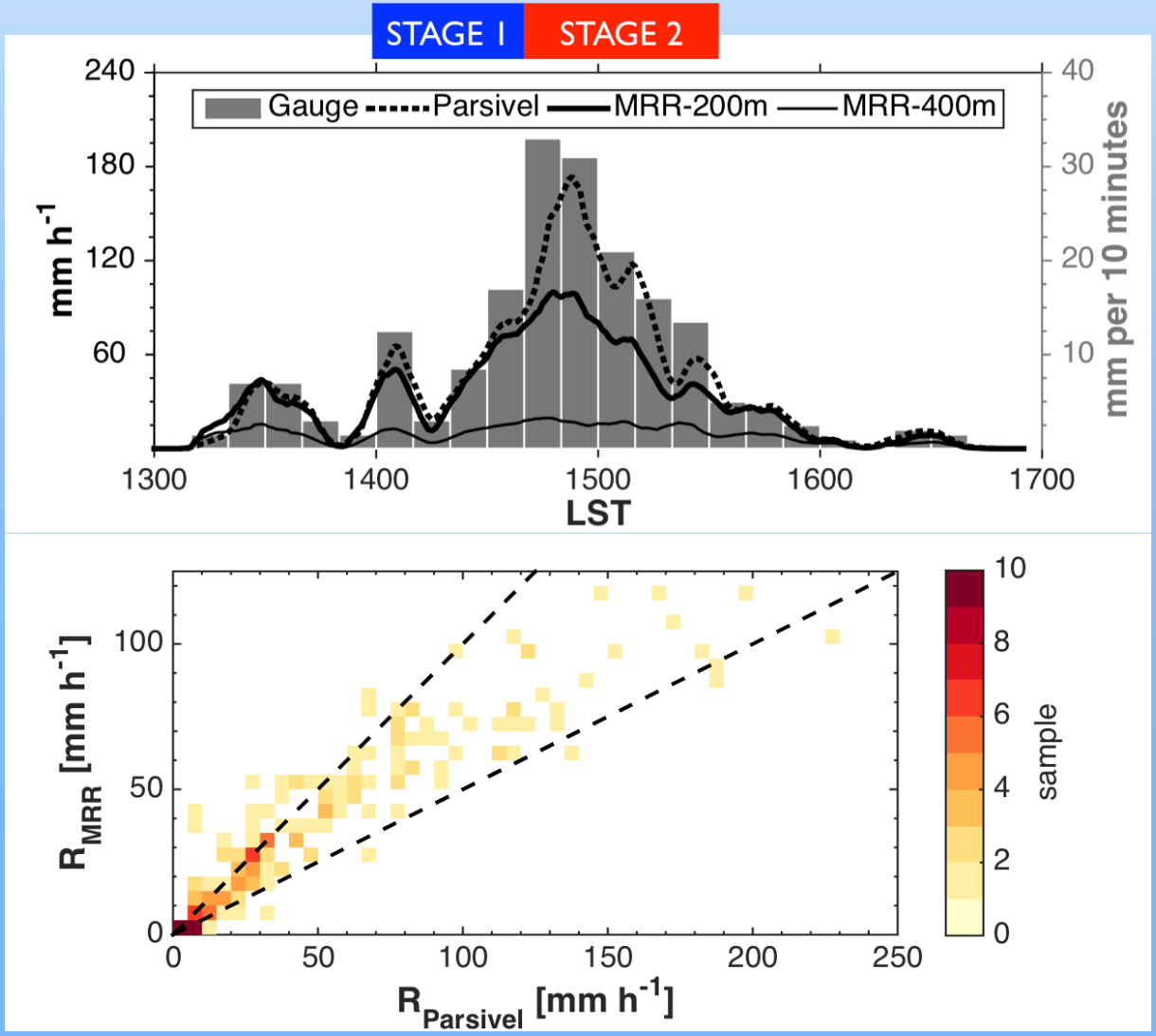
Vertical structure of the rainfall



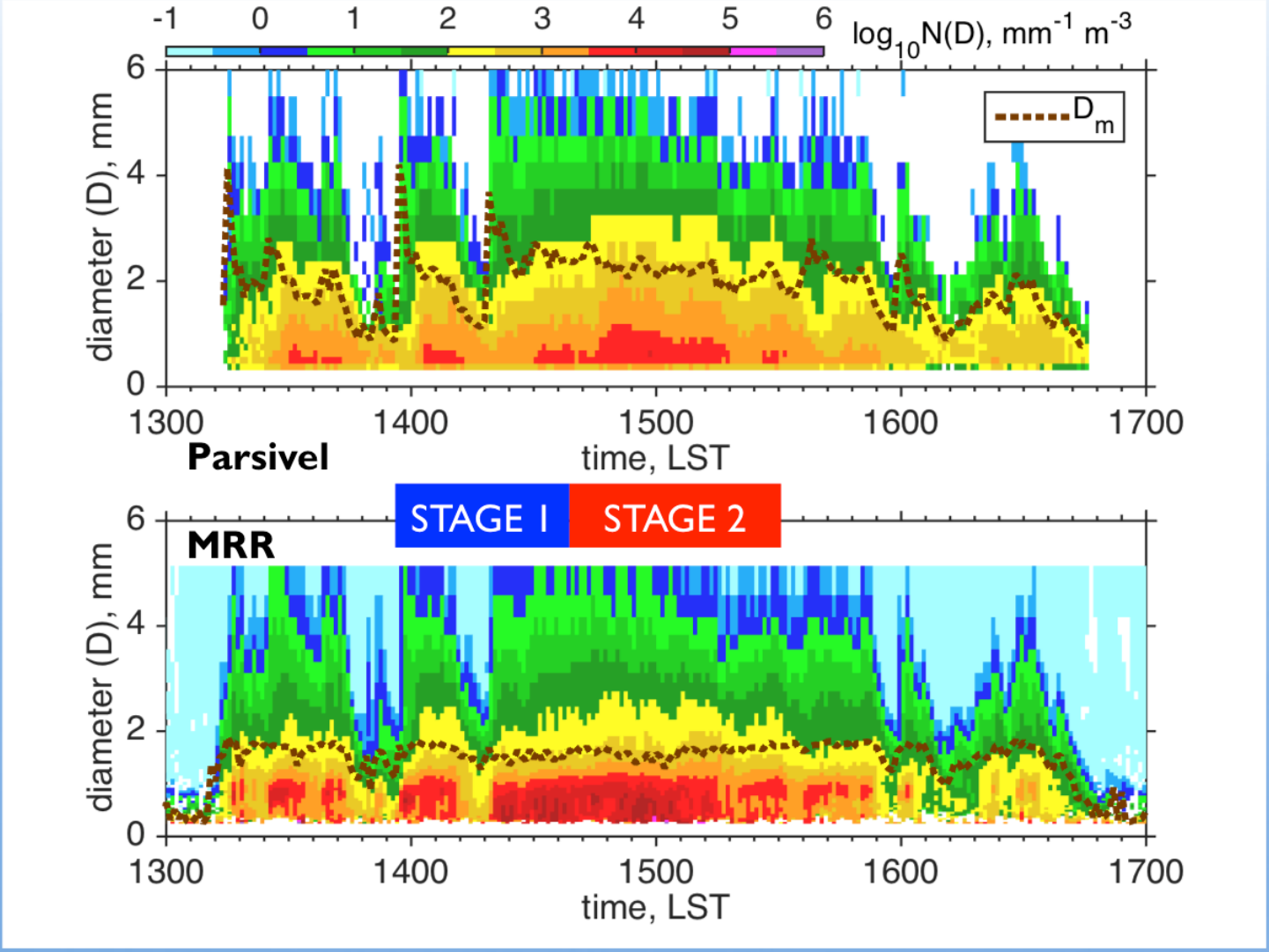
Serious attenuation

Applicable in the lowest level

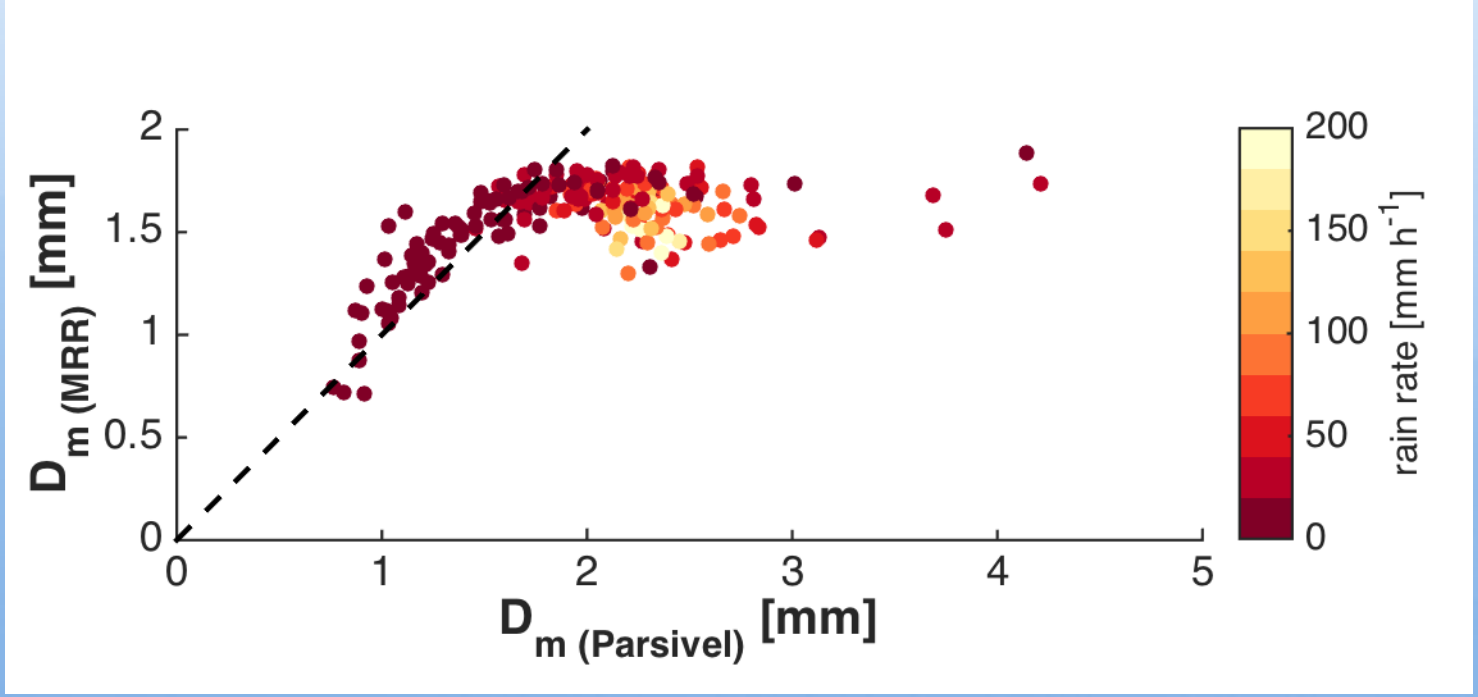
Comparison of rainfall



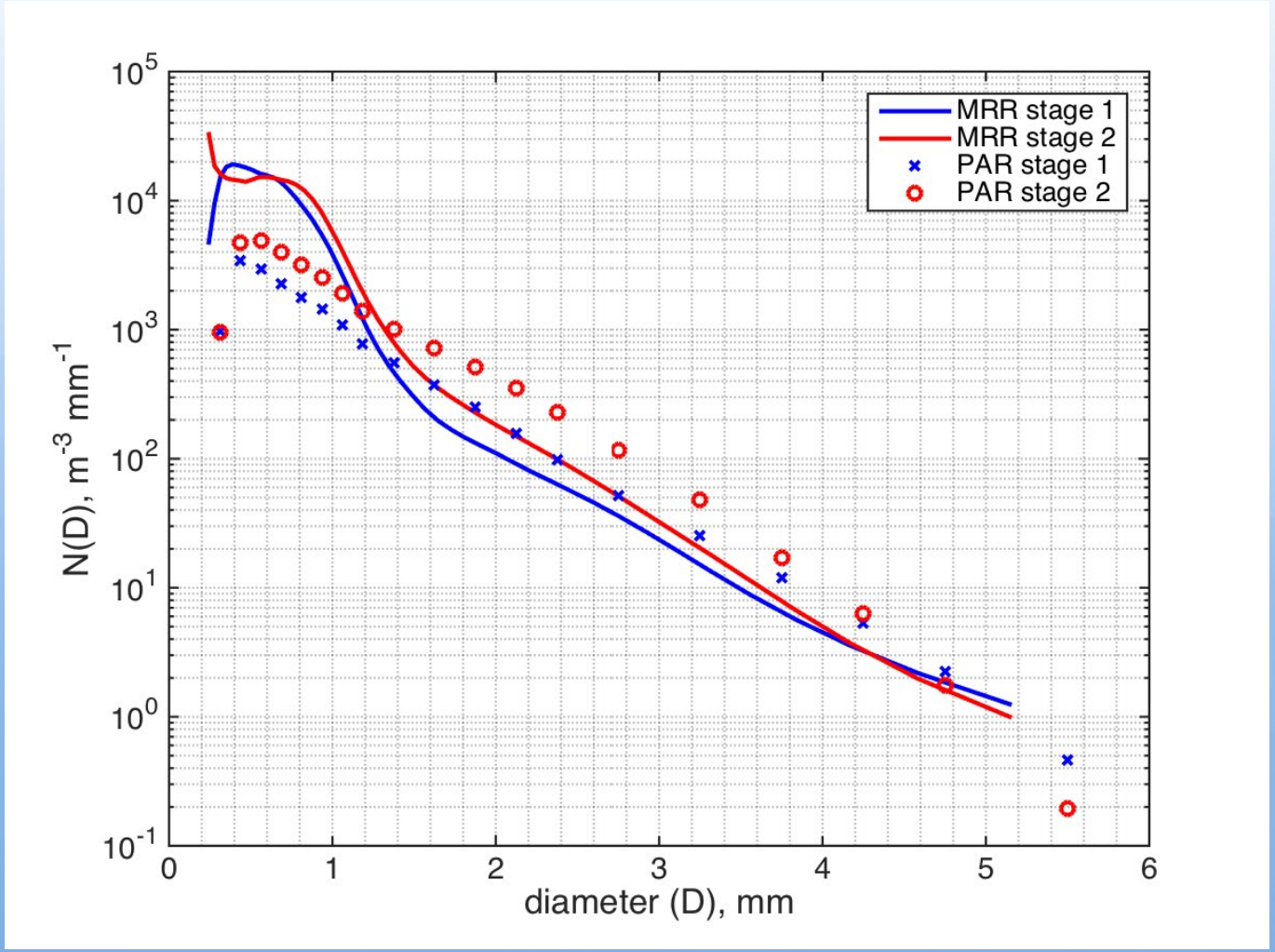
Measurement error increase with rain rate



1. The measured size is limited at about 5 mm for MRR.
2. MRR contain number density smaller than order of 10^{-1}, but not for Parsivel.
3. MRR shows obviously much more small particle (< 1 mm) than Parsivel.
4. The mean diameter D_m shows very different distribution of these two instruments.



- The D_m of MRR never exceeds 2 mm, meanwhile the Parsivel often shows D_m > 2 mm.
  Before the time of heavier rainfall (≧ 20 mm h^{-1}), the D_m of Parsivel even exceeds 3 mm.



- The breakup process could result the high concentration of small drops, but meanwhile the ongoing coalescence process could maintain the concentration of medium drops.

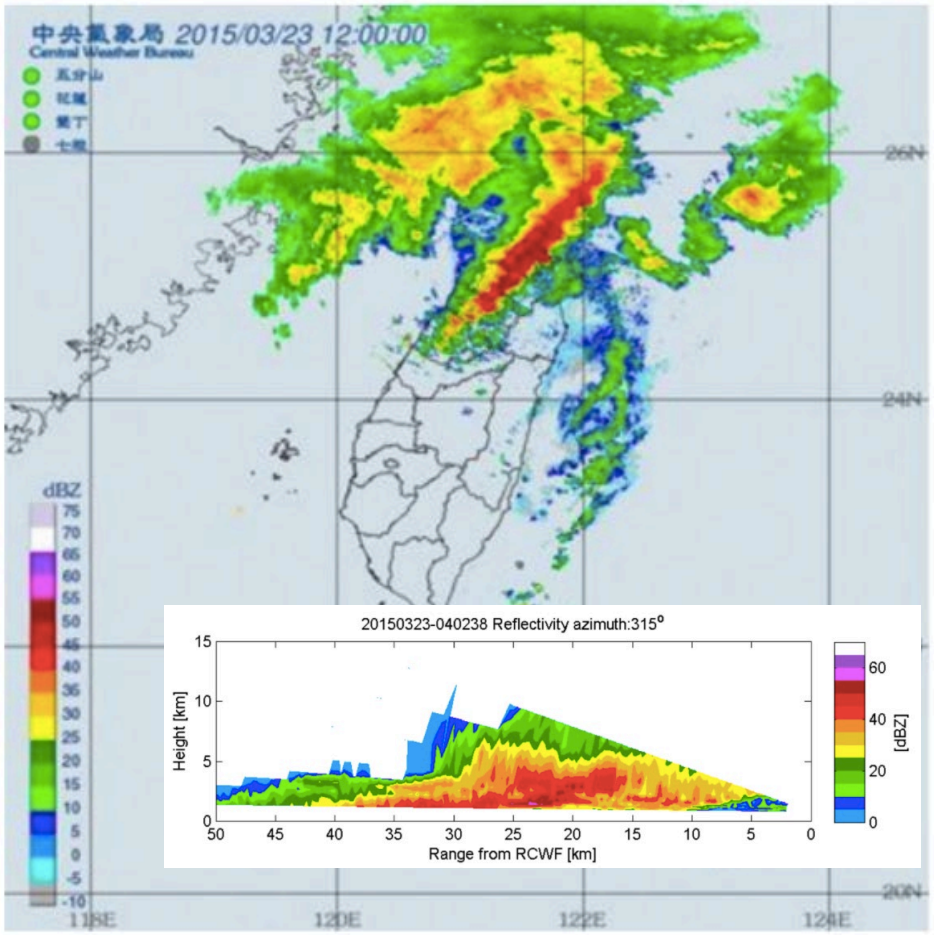
- MRR shows higher N(D) of smaller drops but seriously underestimates the rain rate.
- Reasonable speculation is that the DSDs measured by MRR should contain more big drops.

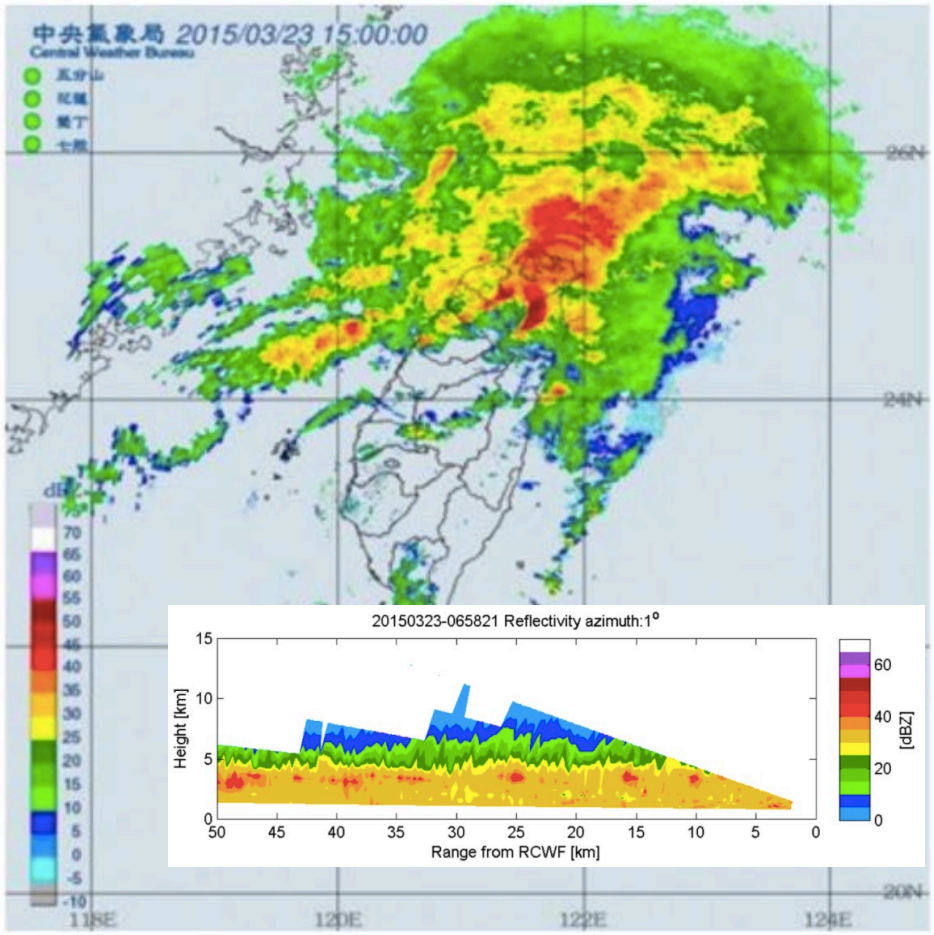
Discussions

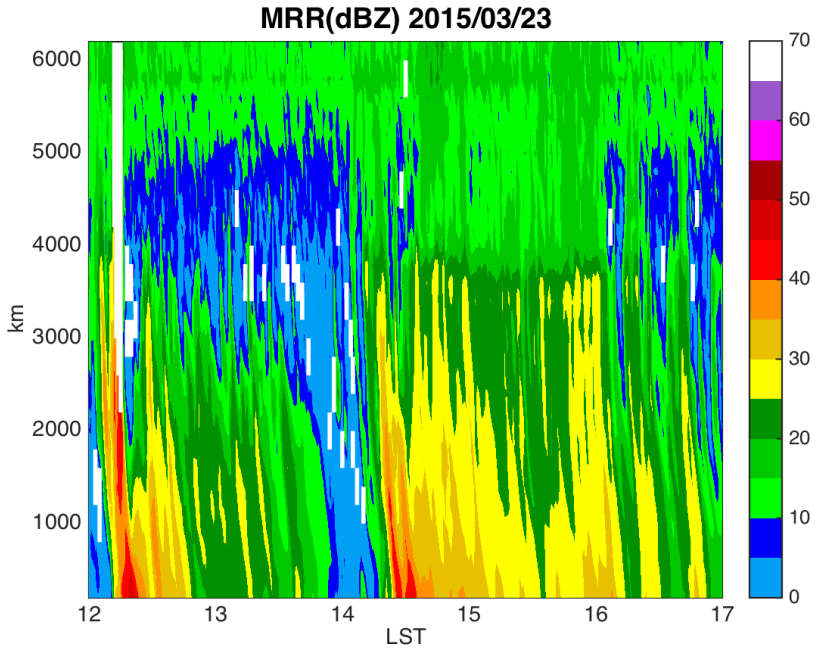
- The highest and only available data of MRR is the gate of 200 m because of the increasing attenuation with height.
- The maximum measurable Doppler frequency would decrease number of big drops (> 5 mm), so that MRR cannot show its advantage of large sampling volume (Chang et al. 2020).
- Finer gate resolution should be considered for MRR to observe the convective rainfall, so that there could be chance to correct its own measurements at higher level.

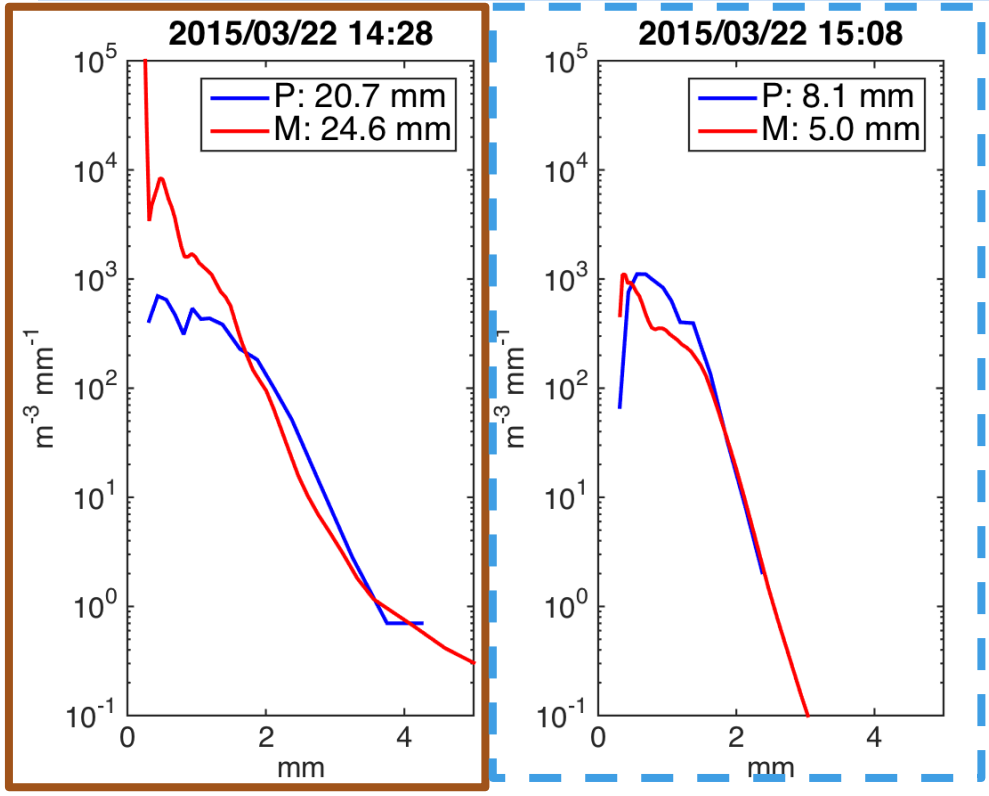
Case of not much intensive rain

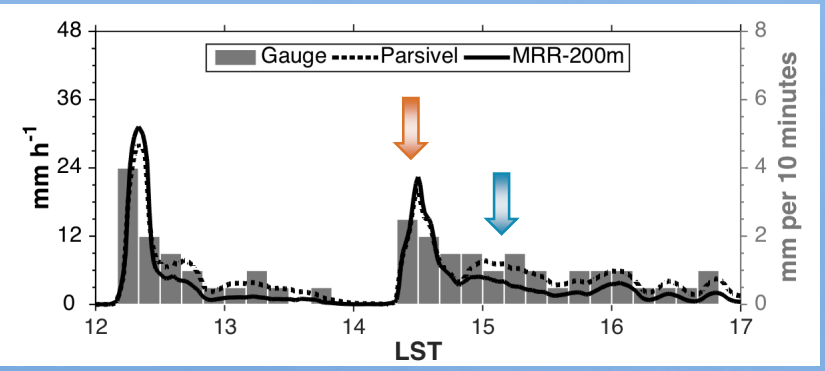
- 2015/3/23, frontal squall line, ~ 50 mm/day











- At the time of heaviest rain rate,
  MRR shows higher N(D) of small drops and higher rain rate than Parsivel.
- After the first rain shaft, MRR lake if the mid-size drops and underestimate the rain rate.

Conclusions

- MRR and Parsivel shows the increasing number concentrations with increasing rain rate.
- The Dm of MRR scarcely exceeds 2 mm, and it directly limits the rain rate derived by MRR especially during heavy rainfall.
- For the heavier rainfall (especially for > 20 mm h^{-1}), uncertainty increases for the intercomparison between these instruments.

- The authors would recommend to continue the deployment of the collocated disdrometers, rain gauge and radar coverage.
  Much finer gate resolution of MRR would increases its applicability during heavy rainfall.

Thanks for your attention.