Quality Control and Analyses of Disdrometer Network in Taiwan

中央氣象局雨滴譜儀觀測網資料品管與分析

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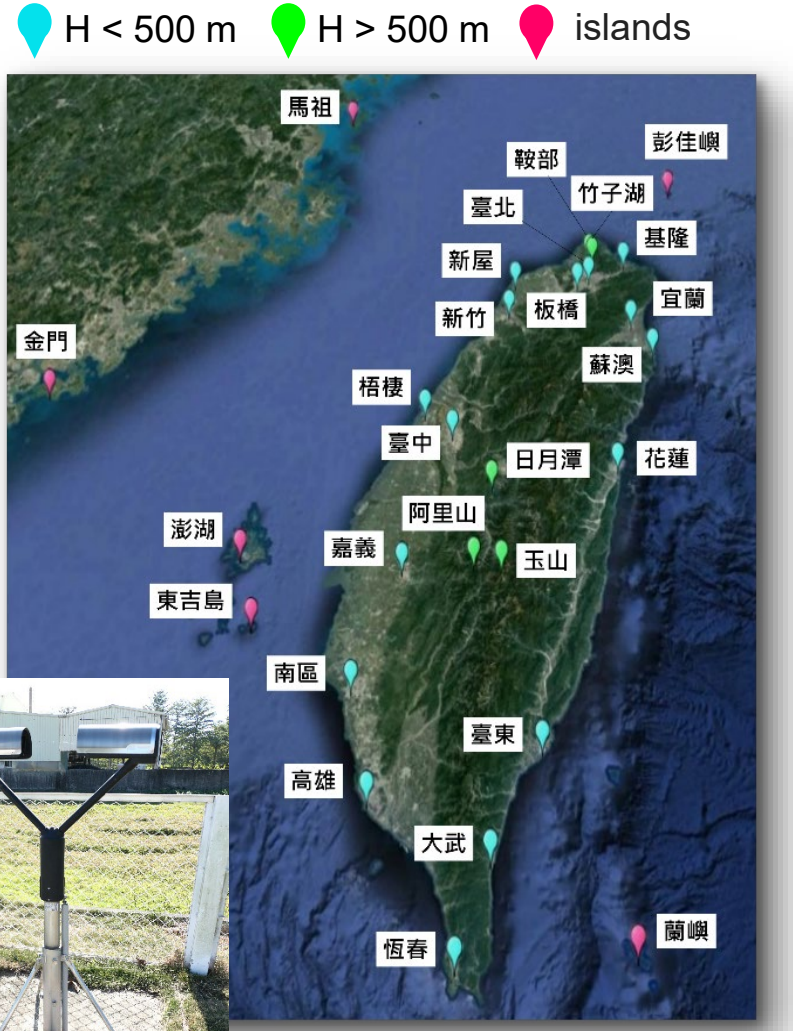
Outline

- Introduction
- Data Quality Control (QC) Method
- Analysis
- Discussion
  - ✓ strong wind
  - ✓ coastal ,offshore islands stations
- Summary and Future work

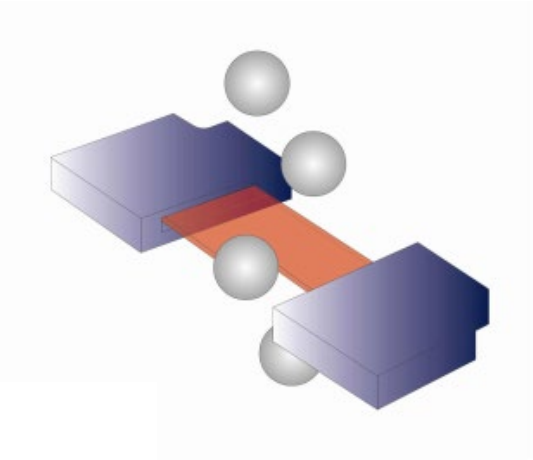
Introduction

- Drop size distribution (DSD) is widely used to improve radar quantitative precipitation estimation (QPE) and to understand the precipitation microphysics.
- **27 Parsivel²** were built in Taiwan from 2015 to 2016.
  - 16 stations : H < 500 m
  - 5 stations : H > 500 m
  - 6 stations : offshore islands
- However, ensuring a useful data quality is important before disdrometer data is applied.
- In this study, to evaluate **CWB Parsivel² data quality**, 27 Parsivel² and tipping-bucket rain gauge(TBRG) data are used to analyze from 2016 to 2018.



Parsivel² in Chiayi station →

Data Quality Control (QC) Method



Parsivel^2 : measure raindrop size and terminal velocity

- 32 particle size classes (0.062~24.5 mm)
- 32 velocity classes (0.05~20.8 m/s)

Calculate drop size distribution (DSD)

$$N(D_i) = \frac{1}{\Delta t \Delta D_i} \sum_{j=1}^{n} \frac{1}{A V t j}$$

Δt : time interval, ΔD : diameter interval,
Vt : terminal velocity, A : area, n : number of raindrops

Calculate rainfall and reflectivity by DSD

$$R = 0.6\pi \times 10^{-3} \sum_{i=1}^{n} vt(D)_i D_i^3 N(D)_i \Delta D_i$$

$$Z = \sum_{i=1}^{n} D_i^6 N(D)_i \Delta D_i$$

vt : terminal velocity, D : diameter

Data Quality Control (QC) Method

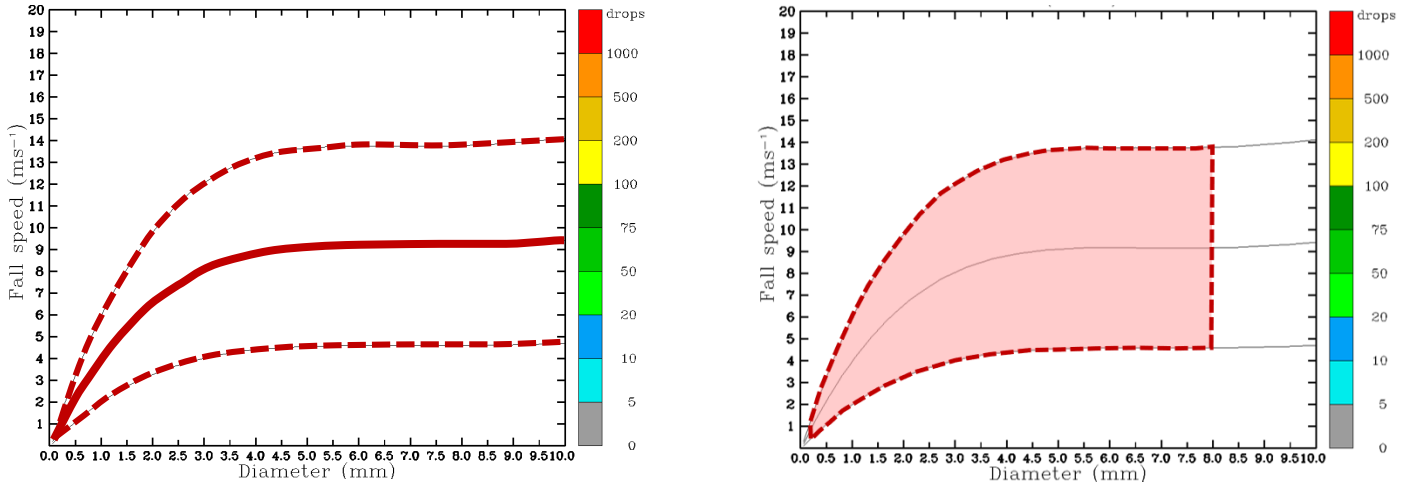
- Parsivel^2 data QC (remove unreasonable data per min.)

① Define rainfall events : filter number of raindrops > 10, rainfall rate > 0.1 mmhr^{-1} (Tokay and Short 1996)

② Define reasonable raindrop sizes : 0.2 mm < D < 8 mm (Tokay et al.2013; 陳 2017)

③ Define reasonable terminal velocity : $|V(D)| < 0.5\ V(D)_{ideal}$ (Brandes et al. 2002)

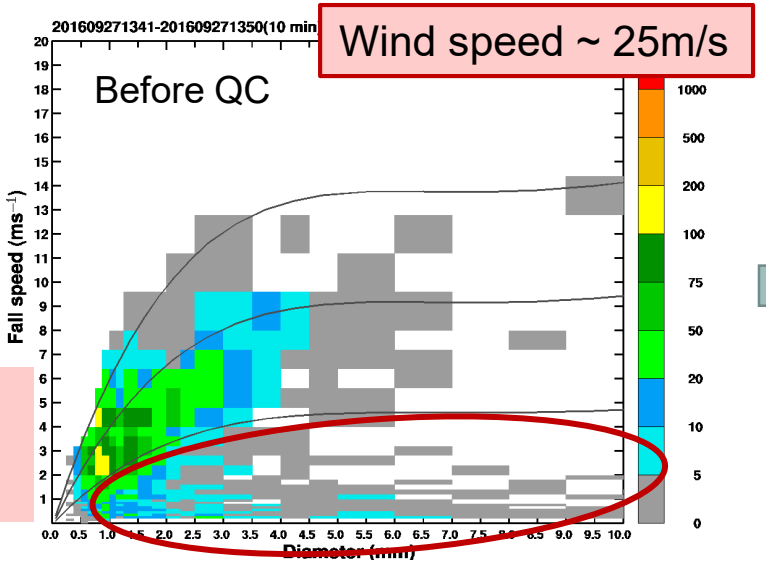
DATA is used after QC

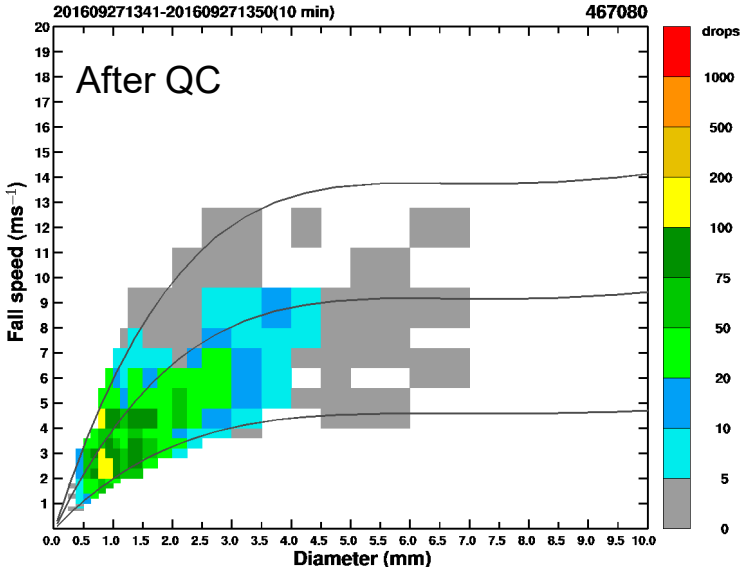


Data Quality Control (QC) Method

- 2016.09.27 meiji typhoon

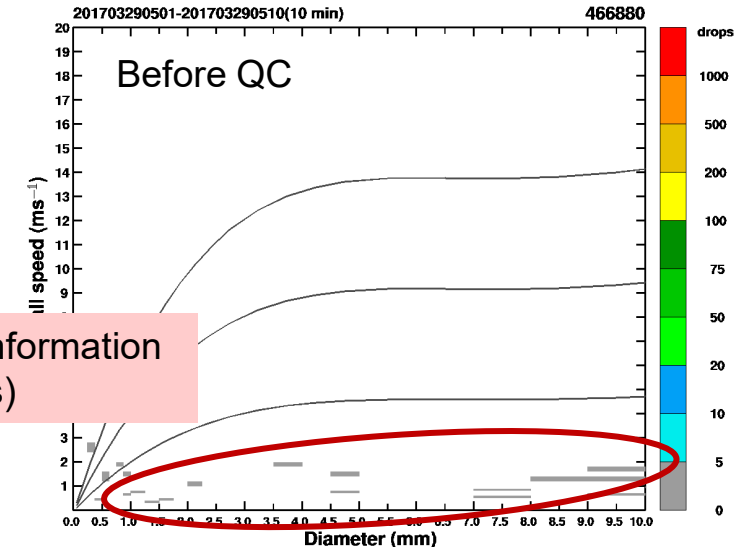
Wind speed ~ 25m/s

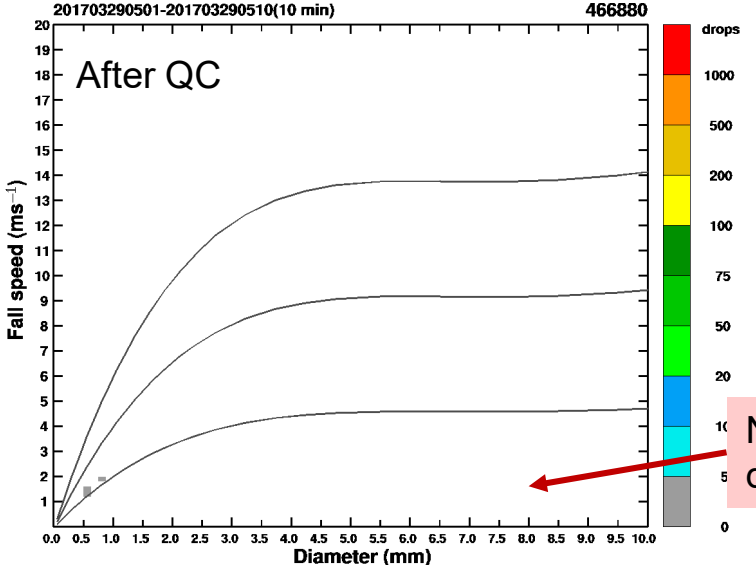




strong wind cause big raindrops, small terminal velocity data

- 2017.03.28 non-precipitation information





Non-precipitation information (ex: Insects, leaves)

Non-precipitation data is removed

Analysis

- the error between Parsivel^2 and TBRG (**reference data**)

✓ NMB(normalized mean bias)

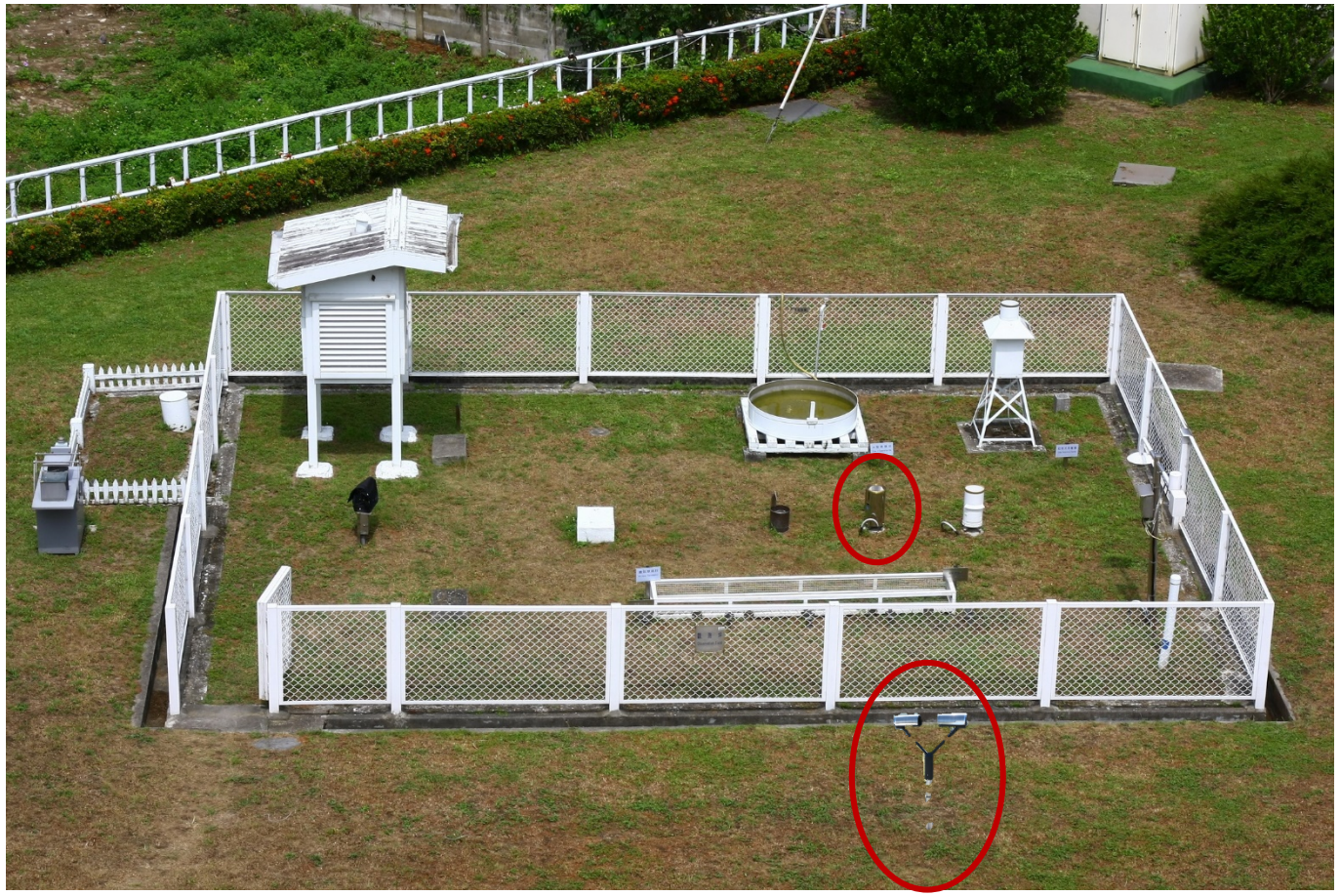
$$NMB = \frac{\sum R_{parsival} - R_{gauge}}{\sum R_{gauge}}$$

✓ RRMSE(relative root mean squarted error)

$$RRMSE = \frac{\sqrt{\sum_{i=1}^{N} \frac{\left(R_{parsival} - R_{gauge}\right)^2}{N}}}{\sqrt{\sum_{i=1}^{N} \frac{\left(R_{gauge}\right)^2}{N}}}$$

✓ CC(correlation coefficient)

$$\mathrm{CC} = \frac{covar(R_{parsival}, R_{gauge})}{\sigma_{parsivel} \times \sigma_{gauge}}$$



Analysis

- 2016-2018 27 Parsivel^2 data after QC compare to TBRG.

Red error : NMB < -30%, RRMSE < -35%, CC < 0.9

		NMB	RRMSE	CC			NMB	RRMSE	CC
平地測站(北)	基隆	-0.191	0.271	0.952	山區	竹子湖	**-0.349**	**0.377**	0.96
	台北	-0.147	0.171	0.983		鞍部	-0.2	0.262	0.961
	板橋	-0.126	0.18	0.979		玉山			
	新屋	-0.263	0.286	0.961		新阿里山	-0.269	0.446	0.864
	新竹	-0.278	0.284	0.976		日月潭	-0.142	0.317	0.923
平地測站(中.南)	梧棲	-0.194	0.25	0.964	離島	馬祖	-0.266	0.27	0.965
	台中	-0.06	0.219	0.973		彭佳嶼	**-0.417**	**0.447**	0.899
	嘉義	-0.051	0.218	0.964		金門	**-0.326**	**0.373**	0.933
	南區	0.061	0.232	0.966		澎湖	0.022	0.366	0.901
	高雄	-0.094	0.216	0.967		東吉島	**0.646**	**1.165**	**0.675**
	恆春	-0.154	0.228	0.969		蘭嶼	**-0.355**	**0.48**	0.842
平地測站(東)	宜蘭	**0.93**	**2.130**	**0.568**					
	蘇澳	-0.026	0.229	0.96					
	花蓮	-0.054	0.179	0.977					
	台東	**-0.334**	**0.354**	0.967					
	大武	**-0.386**	**0.425**	0.944					

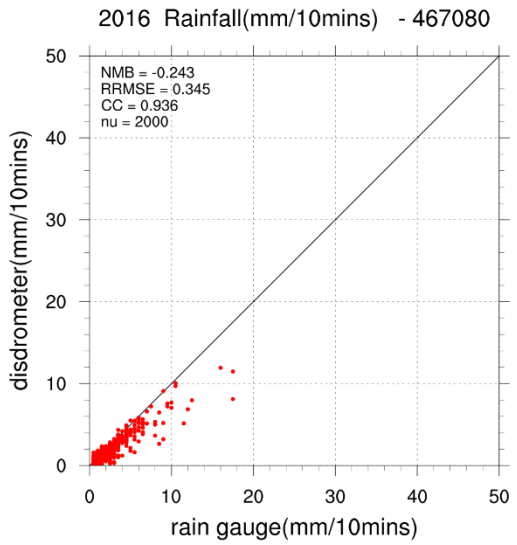
- Parsivel^2 has an underestimation in the most of 27 stations
- slightly underestimate over the low altitude stations
- severely underestimate in the mountain and islands
- 宜蘭、東吉島 abnormally overestimate

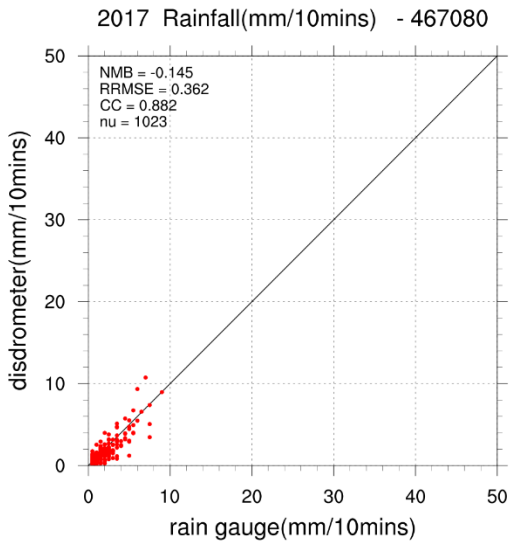
→ because of the abnormal data in 2018, 2016

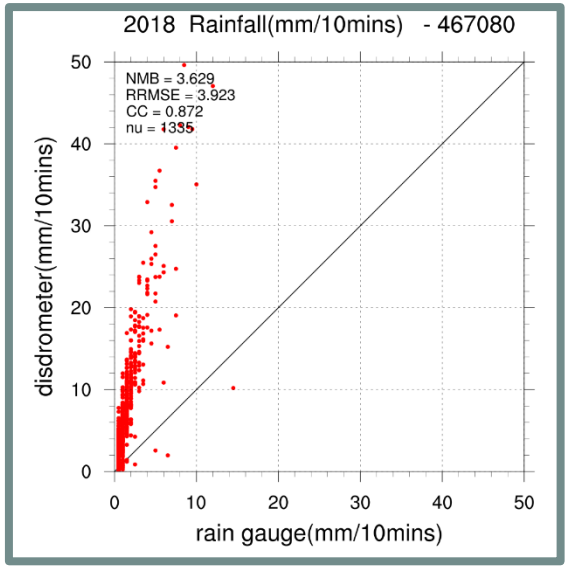
Analysis

- data quality of 2016-2018 宜蘭、東吉島 station.

宜蘭

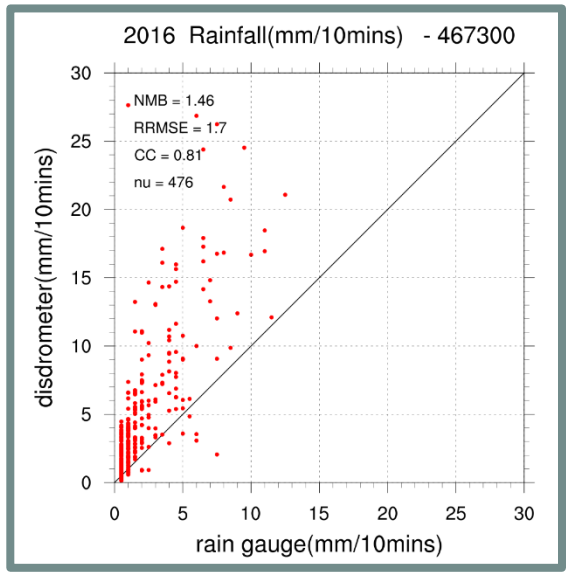


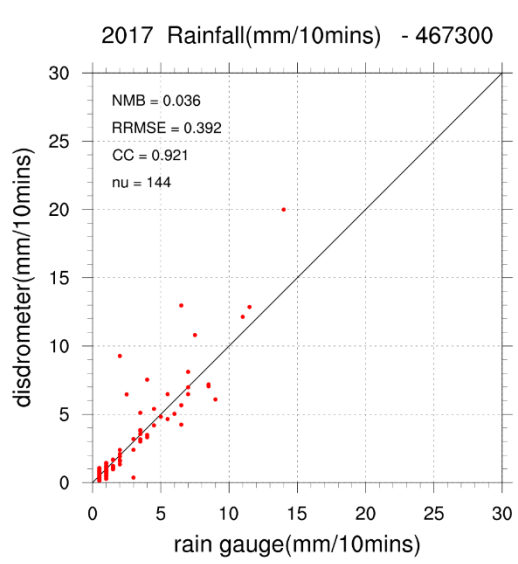


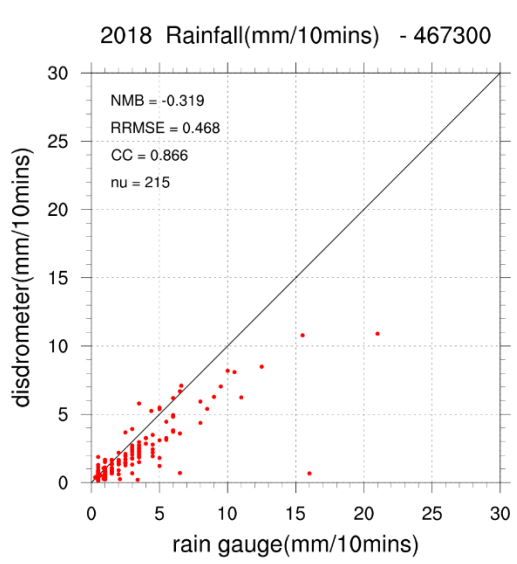


Parsivel^2 rainfall **6 times** higher than TBRG in 2018

東吉島

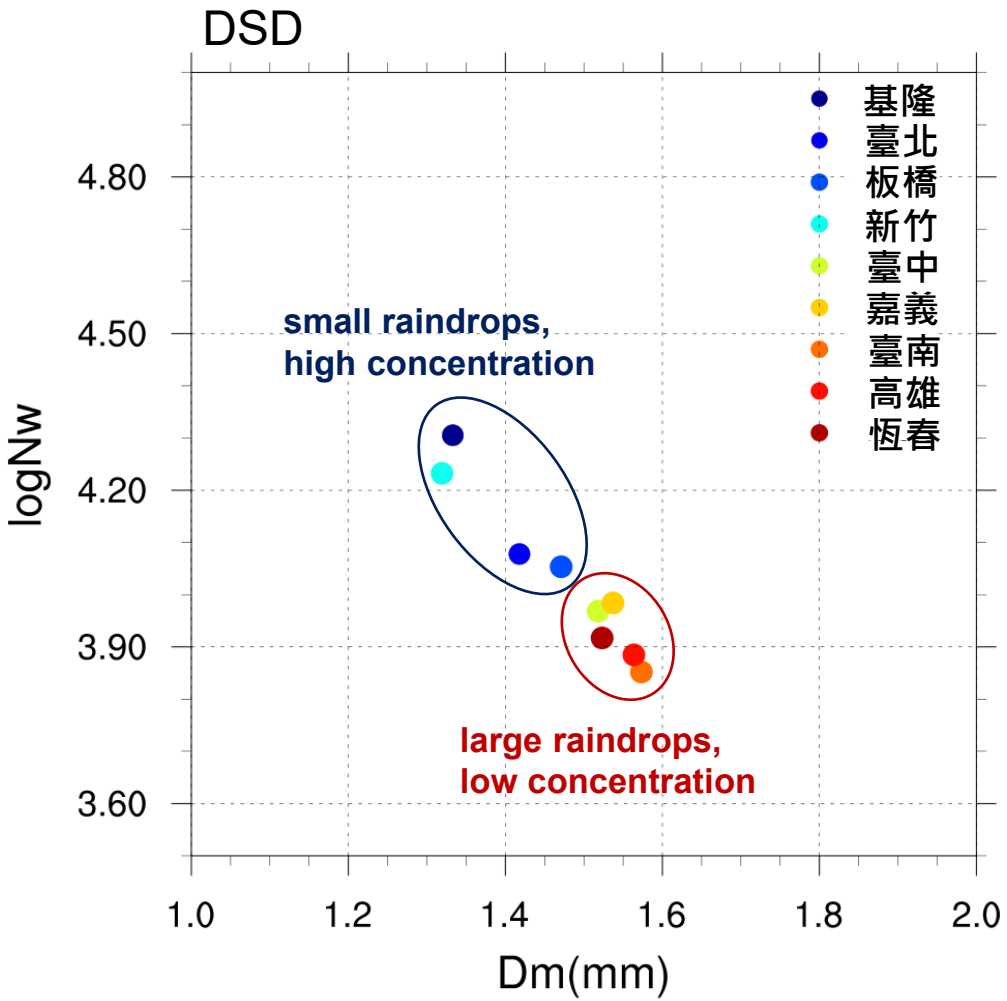


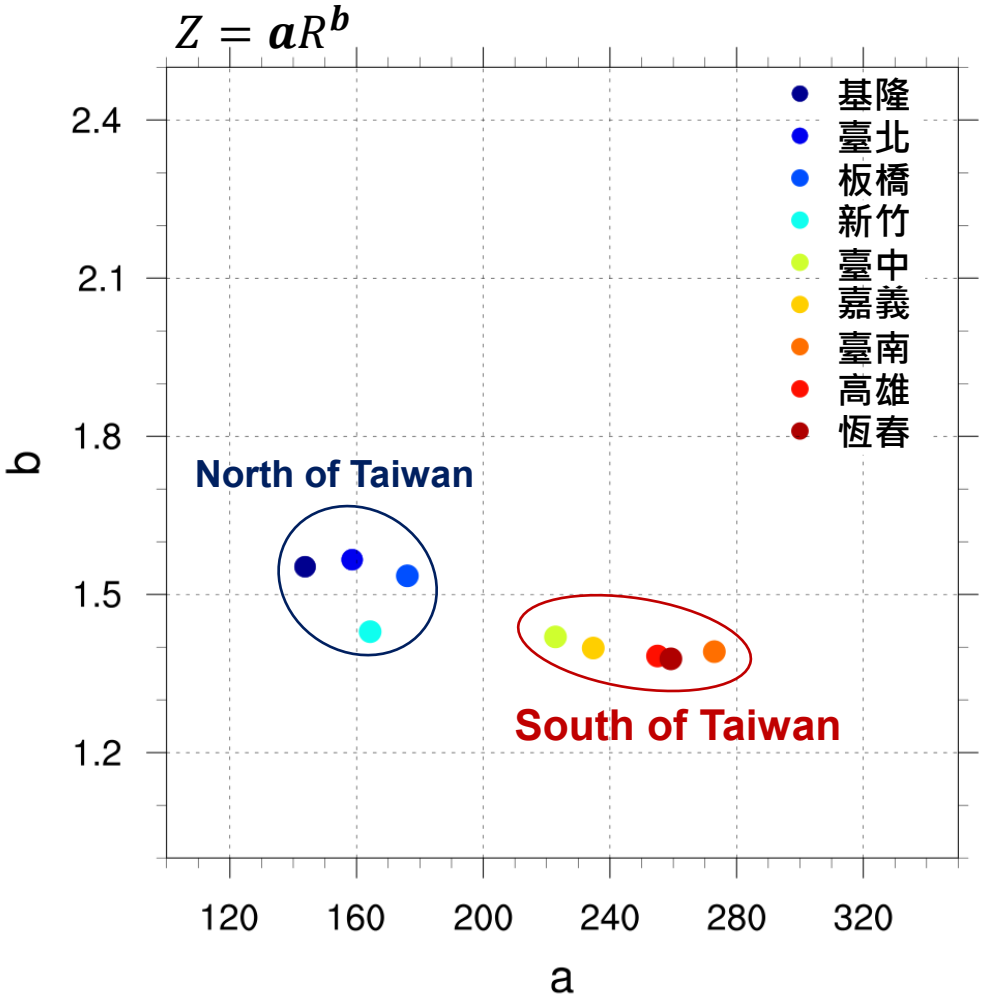


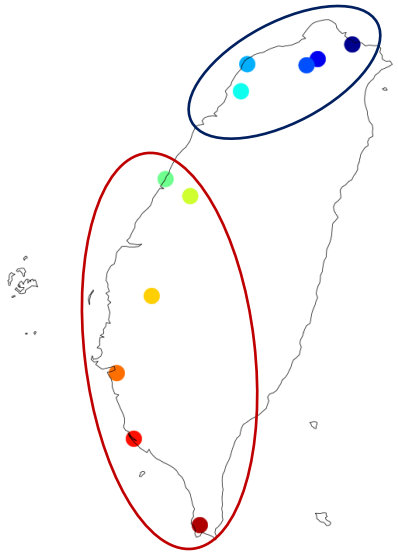


Parsivel^2 rainfall **3 times** higher than TBRG in 2016

Analysis The differance of north and south Taiwan



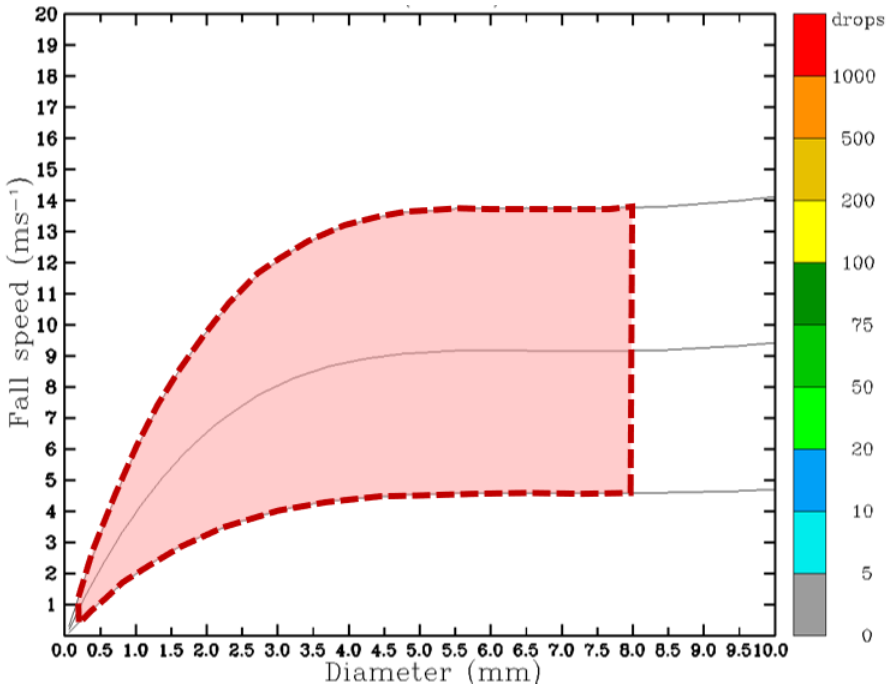




- DSD observed in the north of Taiwan is different from the south of Taiwan.
  The difference is also investigated in Z-R relationship.

Discussion

- In this study, **Ratio** is used to evaluate Parsivel^2 data quality

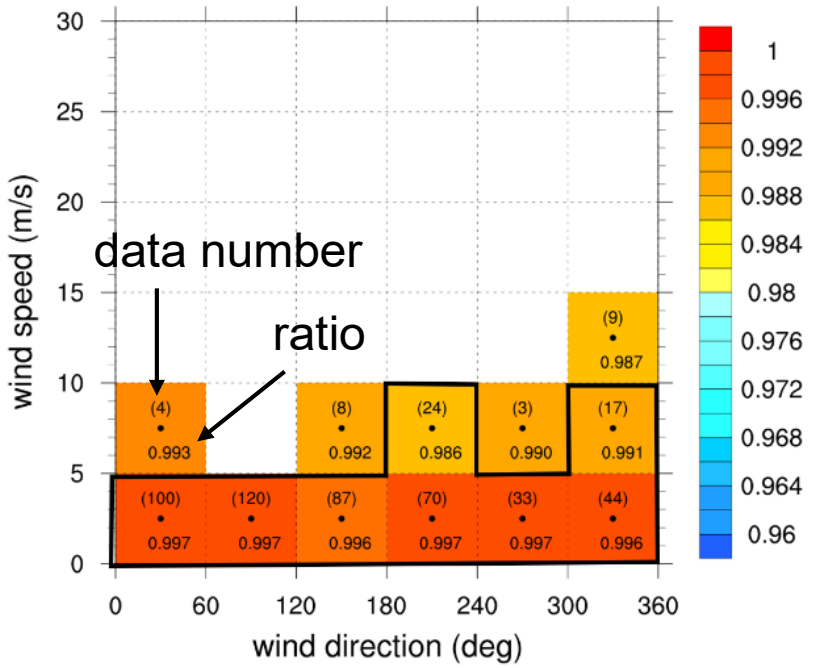


$$\text{Ratio} = \frac{\text{raindrops number after QC}(\textit{red dotted line})}{\text{raindrops number before QC}}$$

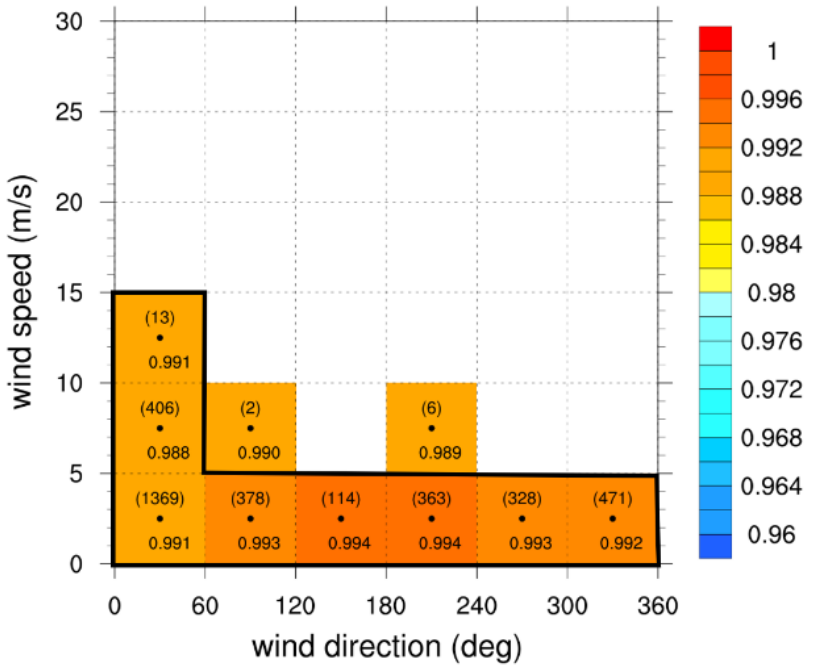
- ✓ Ratio = 1, no data is removed
- ✓ Ratio = 0 , all data is removed

Discussion strong wind

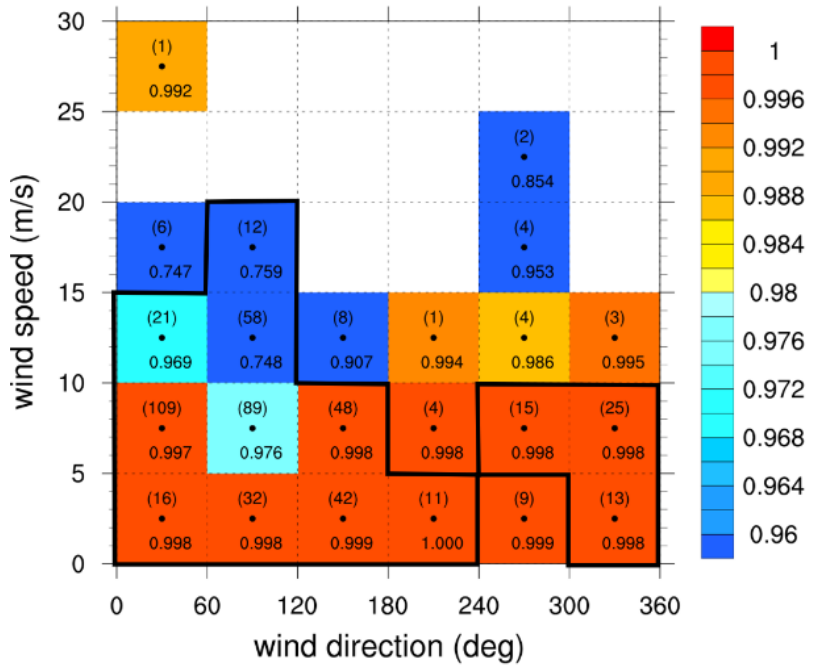
高雄



竹子湖



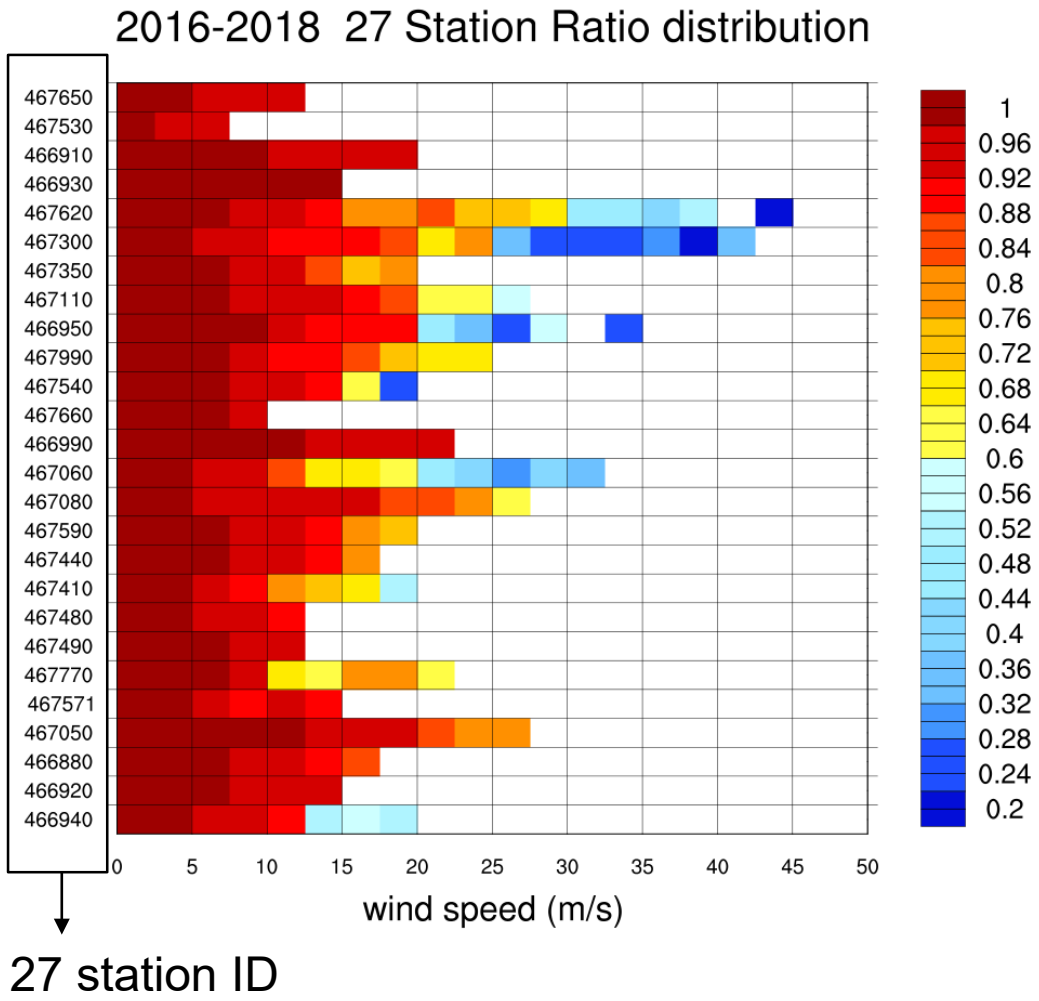
彭佳嶼



- strong wind speed, ratio decrease
- 彭佳嶼 station : when wind speed is greater than 15 m/s, Ratio is about 0.7 .

Discussion strong wind

- Statistics of Parsivel^2 data from 2016 to 2018.
- ratio decrease when wind speed increase
- wind speed > 10 m/s, ratio < 0.7

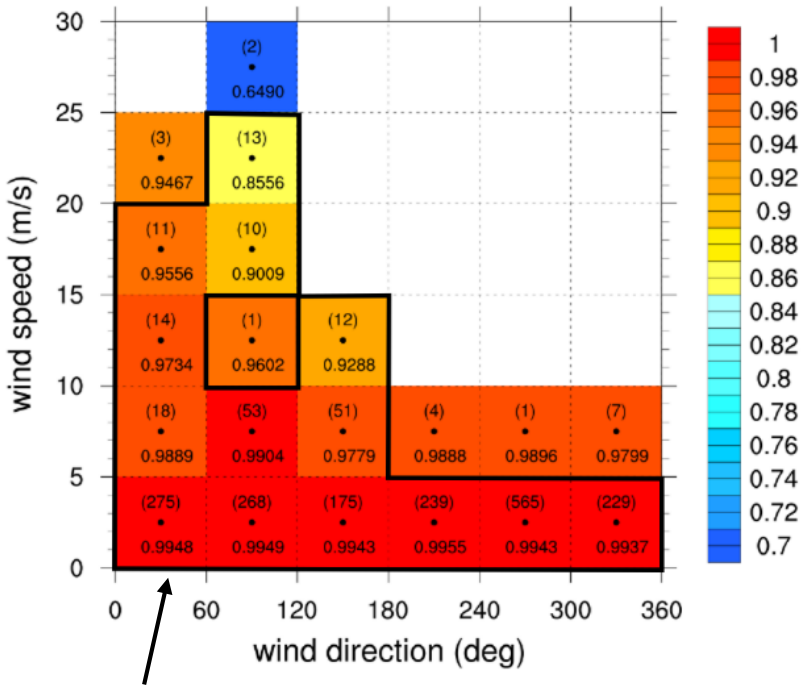


Discussion coastal ,offshore islands stations

- Parsivel² locate in the coastal or offshore islands. Ratio decrease over time.

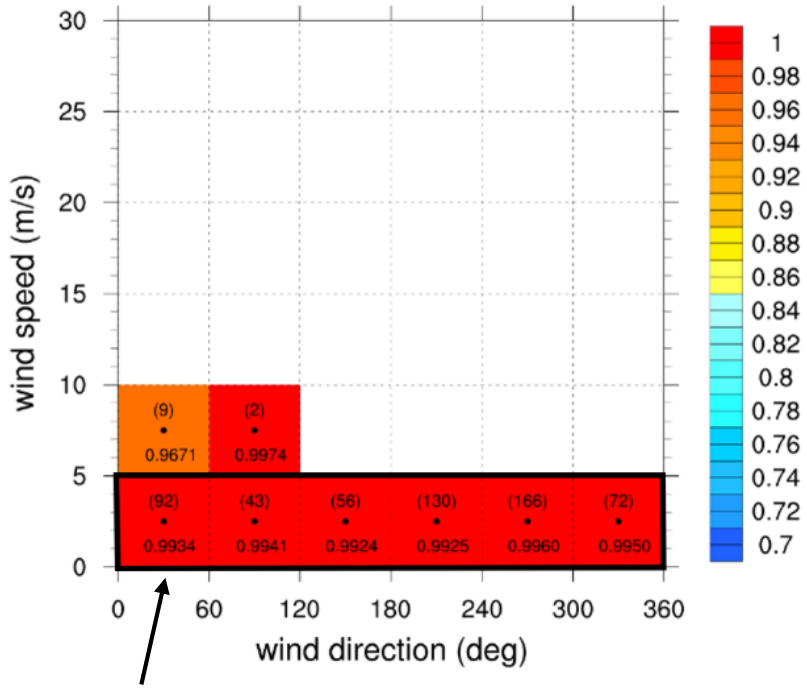
宜蘭

2016



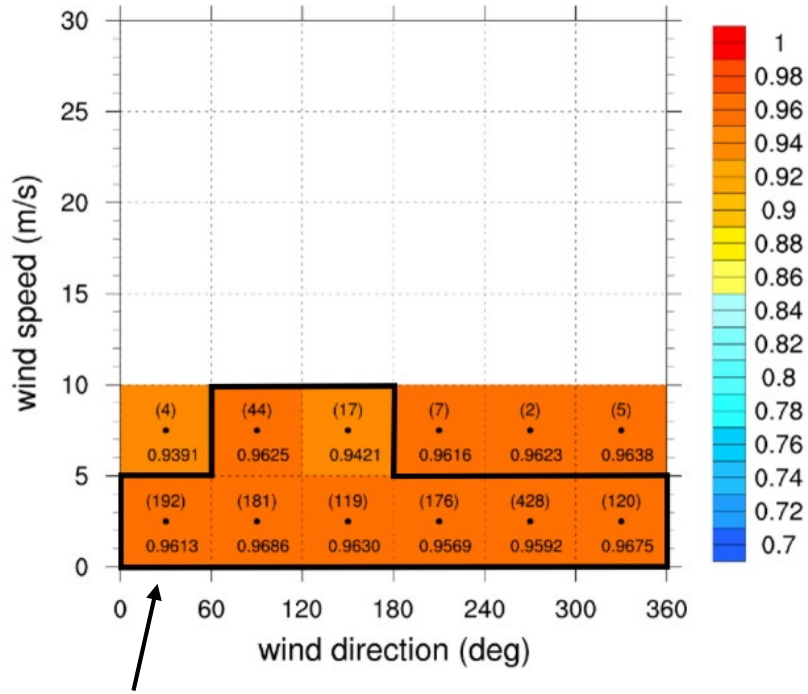
Ratio ~ 0.994

2017



Ratio ~ 0.993

2018



Ratio ~ 0.961

- The same situation is found in 蘇澳 and 金門 station.
- High humidity and coastal wind may influence the accuracy of instrument(Parsivel²), so regular maintenance is necessary.

Summary

- Based on the comparison between Parsivel^2 and TBRG rainfall from 2016 to 2018, underestimations were found in the most of 27 Parsivel^2 stations, especially in the mountainous and offshore areas and islands.
- Ratios of data volume after QC to before QC decrease as wind speed increase. Besides, ratios could be less than 0.7 when wind speed larger than 10 m/s.
- It is necessary to frequently maintain Parsivel^2 because its accuracy of observation could be affected by surrounding environment, such as humidity.

Future work

- To calibrate the underestimations at each Parsivel^2 station by using the methodology proposed by Chang et al.(2020).

$$\boldsymbol{N(D)^{corrected}} = \boldsymbol{N(D)^{obs}} \times 10^{\left(\frac{mean\ bias}{10}\right)}$$

- To quantify the errors caused by strong winds by using a large amount of Parsivel^2 data.

END