Long-Term Assessment of the Reflectivity Biases and Wet-Radome Effect in Operational S-band Dual-Polarimetric Radar (RCWF) in northern Taiwan

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Introduction

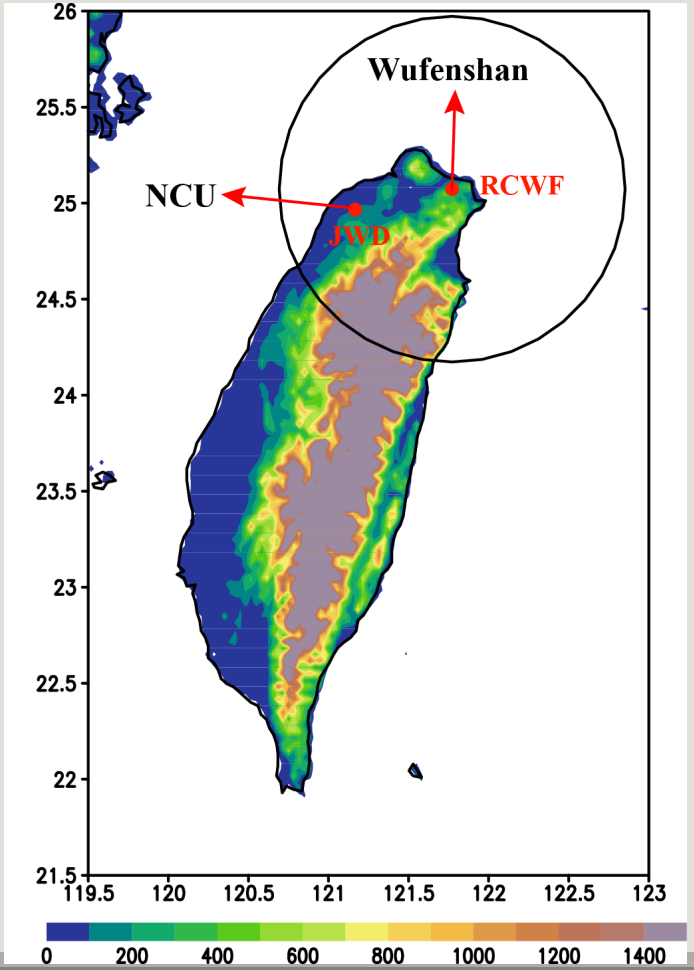
- The radar measurements → used to monitor precipitation systems & estimate the rainfall rate.
- The measurements of radar
  - **Contain errors**: non-meteorological echoes, bright band contamination, calibration biases of Z_{HH} & Z_{DR} & etc.
  - May degrade by the **attenuation, system bias, & wet-radome effect** (WRE).
- Vivekanandan et al. (2003) → 1 dB bias in Z_{HH} produces 18% bias in Z_{HH}–R relation (case NEXRAD).

Objectives

- To analyze/investigate:
  1. The calibration approach by different self-consistent methods for RCWF → accurately calibrating the Z_{HH} & Z_{DR} measurements.
  2. The long-term assessment of Z_{HH} biases from RCWF.
  3. The impacts/characteristics of WRE in RCWF.

Datasets

Datasets	Precipitation types	Periods	Avg. Temp. (°C)
RCWF (in 2017)	All	Jan – Dec	20
	Winter (DJF)	Dec – Feb	18
	Spring (MA)	Mac – Apr	20
	Mei-yu (MJ)	May – Jun	27
	Summer (JAS)	Jul – Sept	30
	Typhoon	July 28-30	30
	Autumn (ON)	Oct – Nov	24
JWD	-	2005 – 2015	-



Methods: QC steps

ρ_{HV} : Co-polar correlation coefficient.

$\Delta\Phi_{DP}^{obs}$: Twice the sum of K_{DP} (specific differential phase) over a specified range.

A_{HH} (A_{DP}) : Specific horizontal (differential) reflectivity.

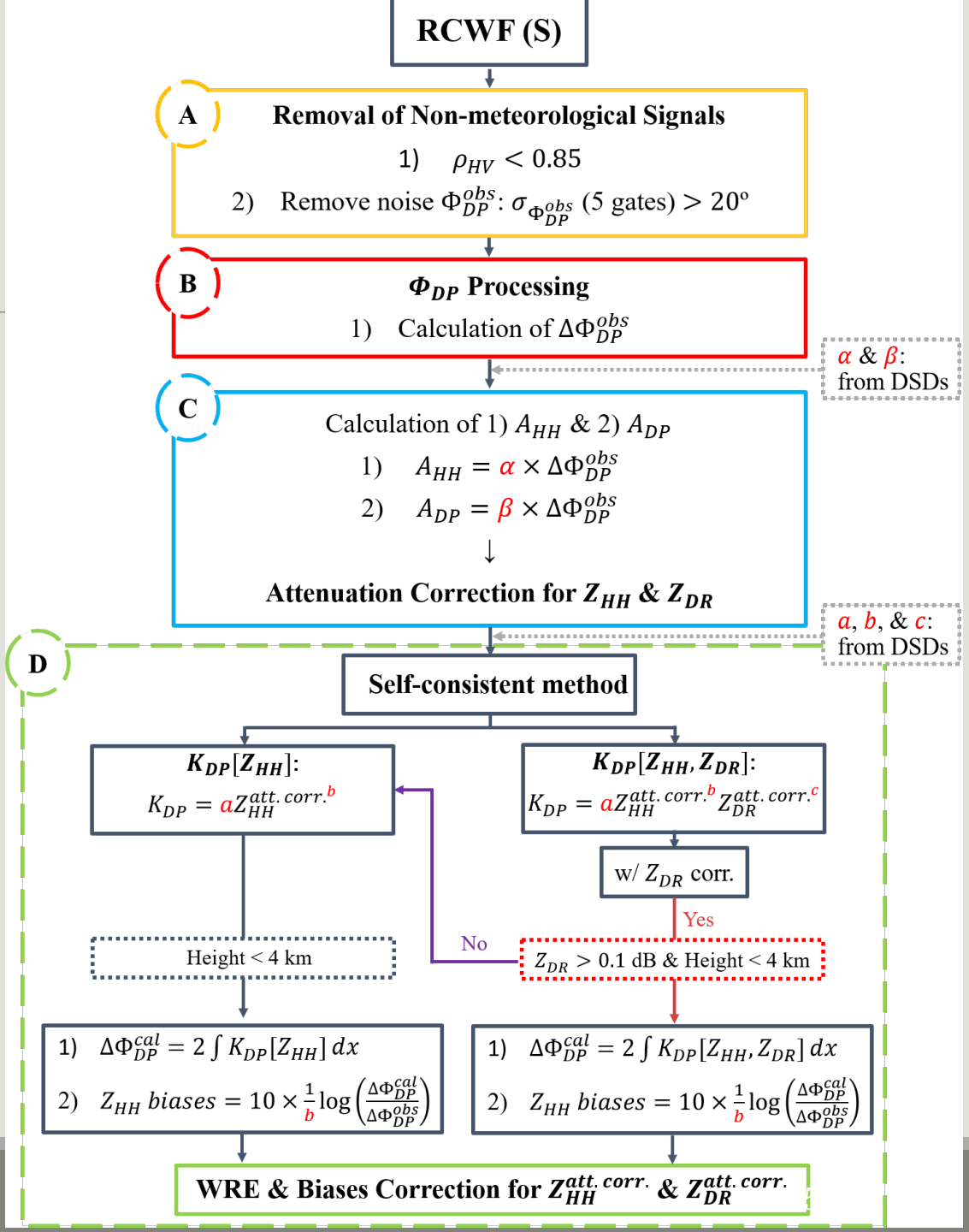
Coeffs. for α, β, a, b, & c:

- Diff. seasons & avg. temp.

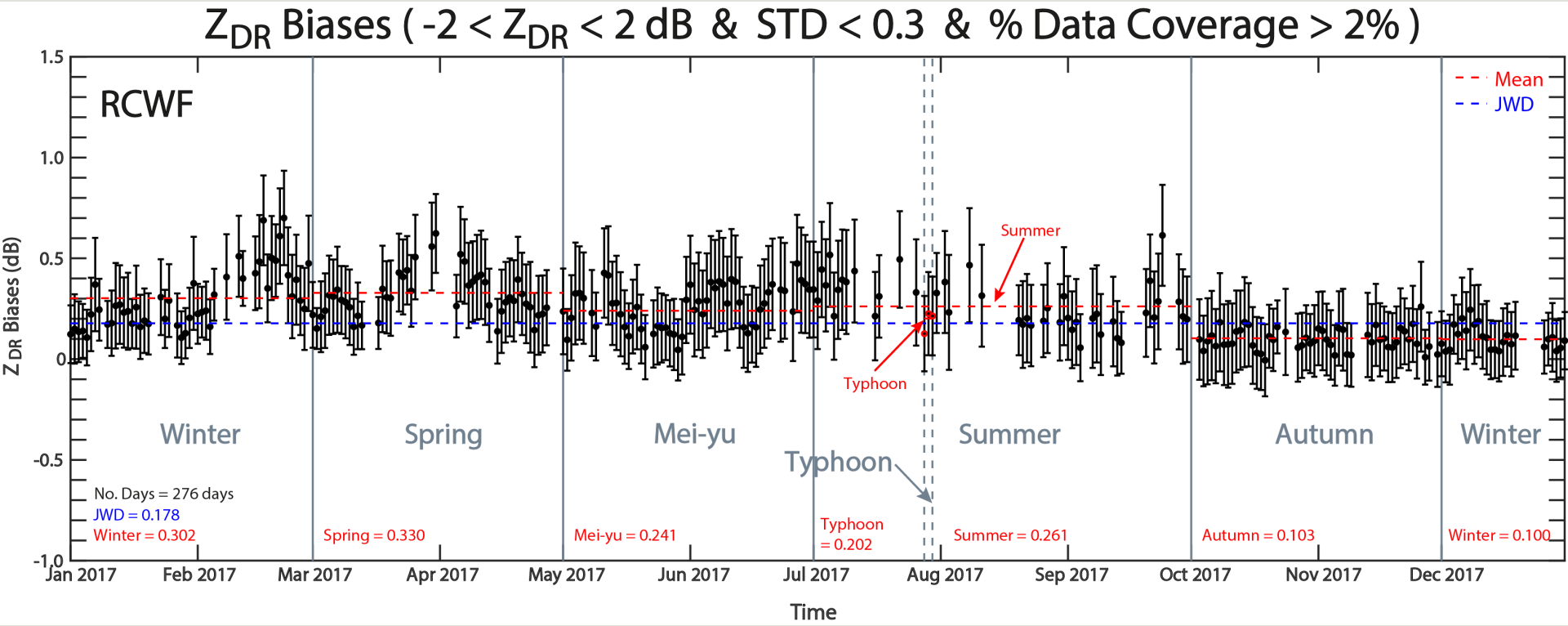
1) All 2) Season

Z_{DR} biases calculation:

1) $15 < Z_{HH} < 25$ dBZ
2) Height < 3.5 km
3) $\rho_{HV} > 0.98$
4) $\Delta\Phi_{DP}^{obs} < 15^{o}$

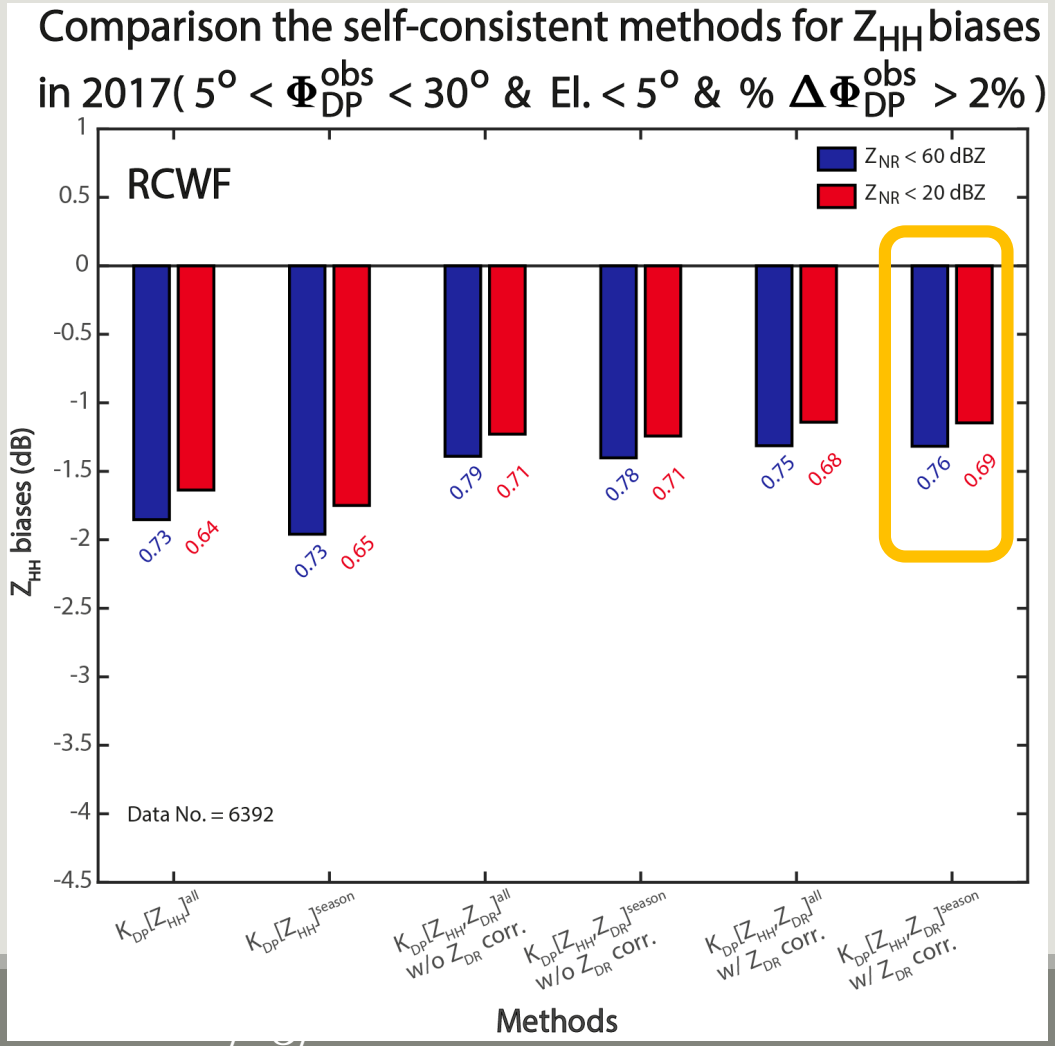


Results: Calibration of Z_{DR}



1) Z_{DR} biases → ~ consistent (**Winter** 0.12 dB, **Spring** 0.15 dB, **Mei-yu** 0.08 dB, **Summer** 0.08 dB, **Typhoon** 0.02 dB, **Autumn** -0.07 dB)

Results: Calibration of Z_{HH}

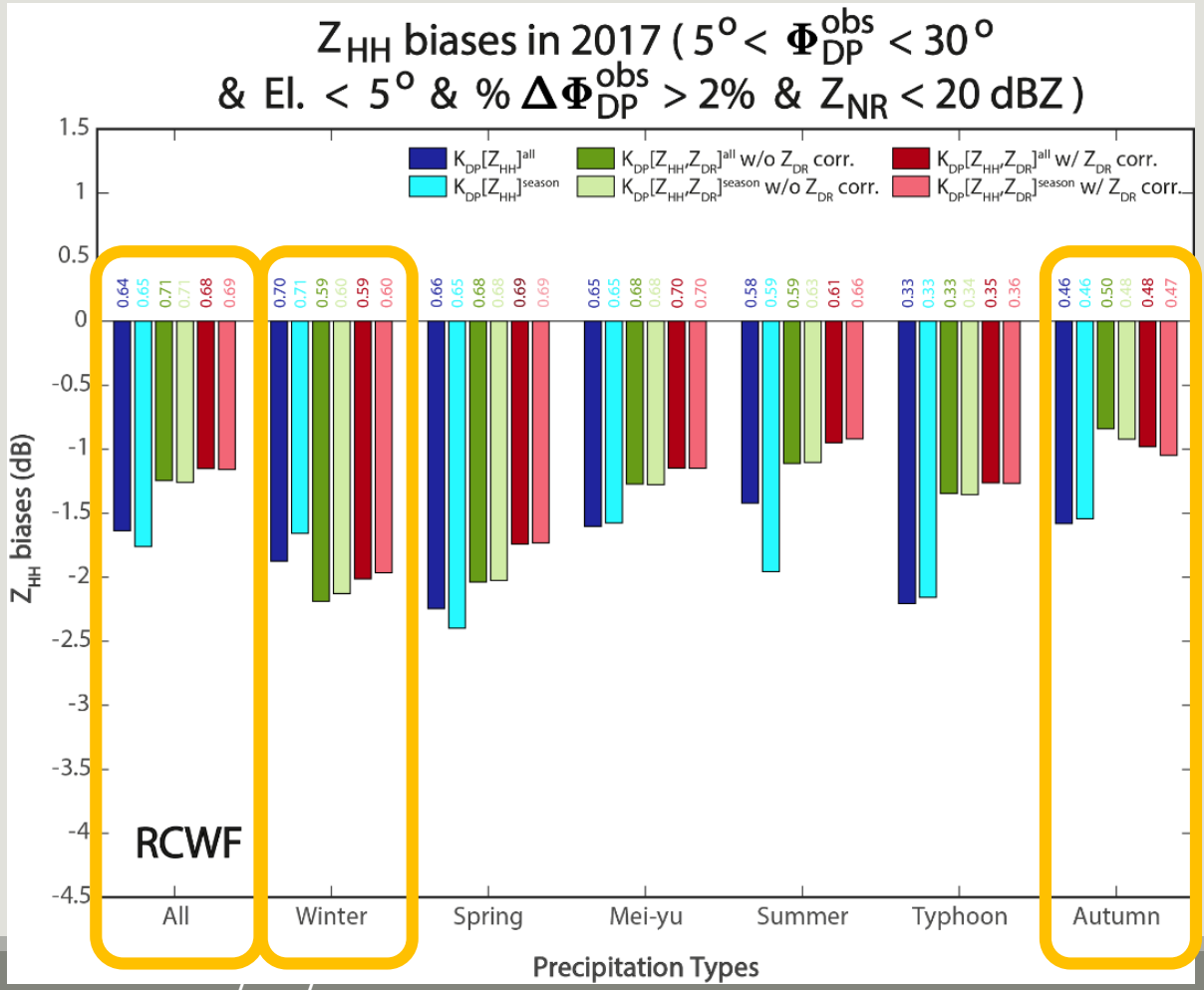


Z_{NR} : Near-radar reflectivity within 10 km

El. : Elevation angles

1) Z_{NR} > 20 dBZ for all methods showed higher mean bias → WRE
2) STD for all methods is similar ~0.7
3) $K_{DP}[Z_{HH}, Z_{DR}]^{season}$ w/ Z_{DR} corr. has lowest mean bias → best methods to calibrate the Z_{HH}

Results: Calibration of Z_{HH}



Systematic biases

1) $K_{DP}[Z_{HH}, Z_{DR}]^{season}$ w/ Z_{DR} corr. has **lowest** mean **bias** except for Winter & Autumn.

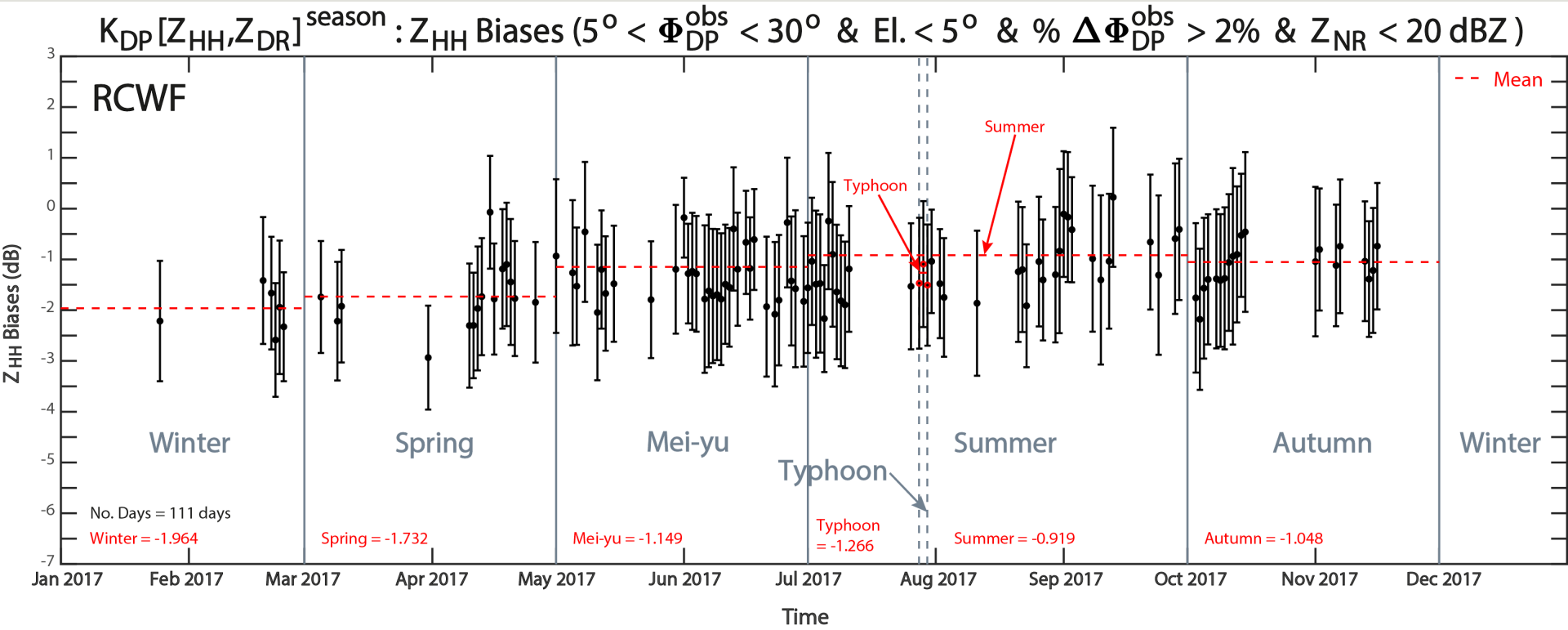
2) **All:**

$K_{DP}[Z_{HH}, Z_{DR}]^{season}$ w/ Z_{DR} corr. → calibrate **well** among 6 different methods.

Dark: Coeffs. → All

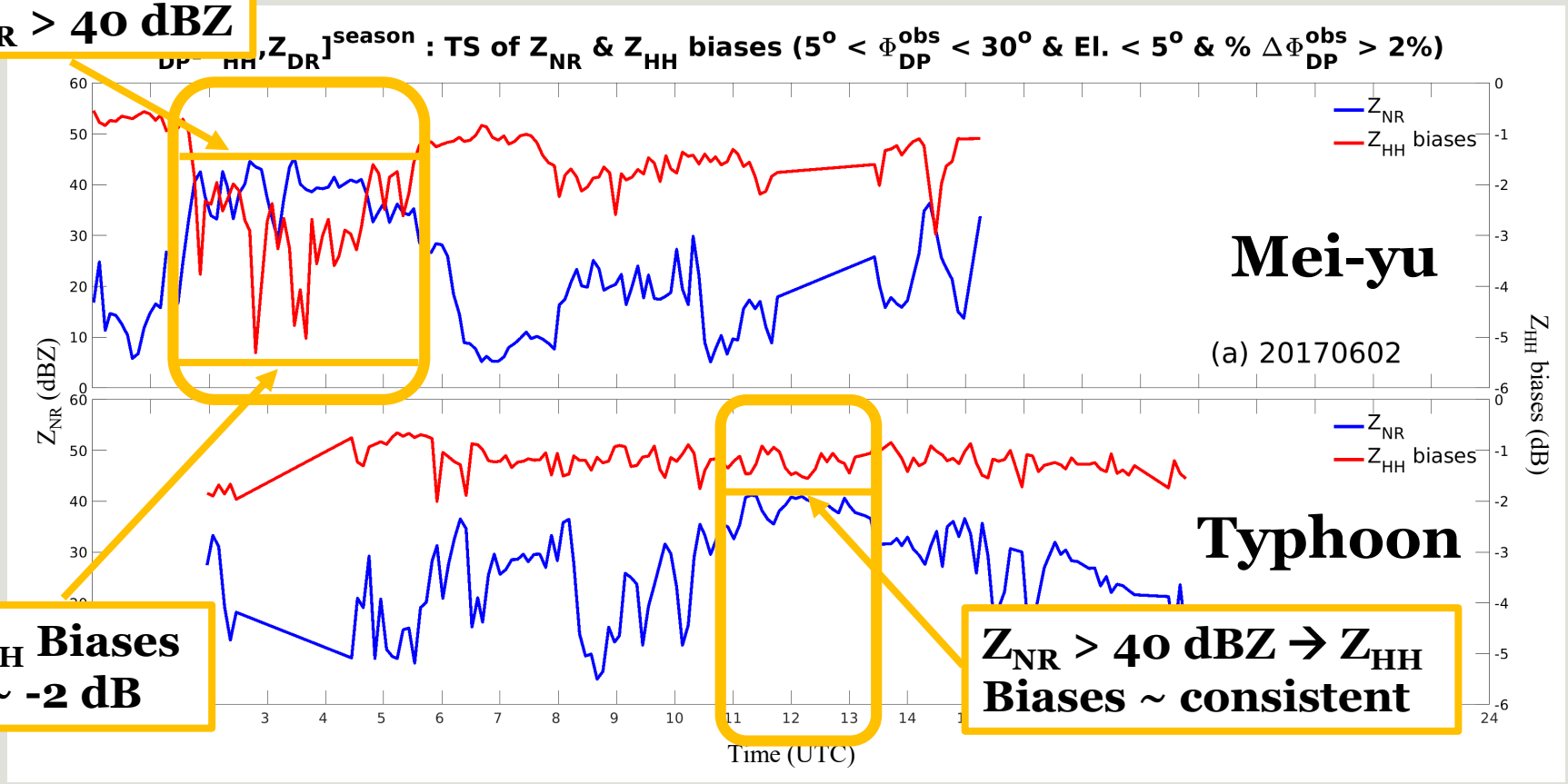
Light: Coeffs. → Season

Results: Calibration of Z_{HH}



1) Z_{HH} biases → ~ consistent (**Winter** -1.96 dB, **Spring** -1.73 dB, **Mei-yu** -1.15 dB, **Summer** -1.23 dB, **Typhoon** -0.92 dB, **Autumn** -1.05 dB)

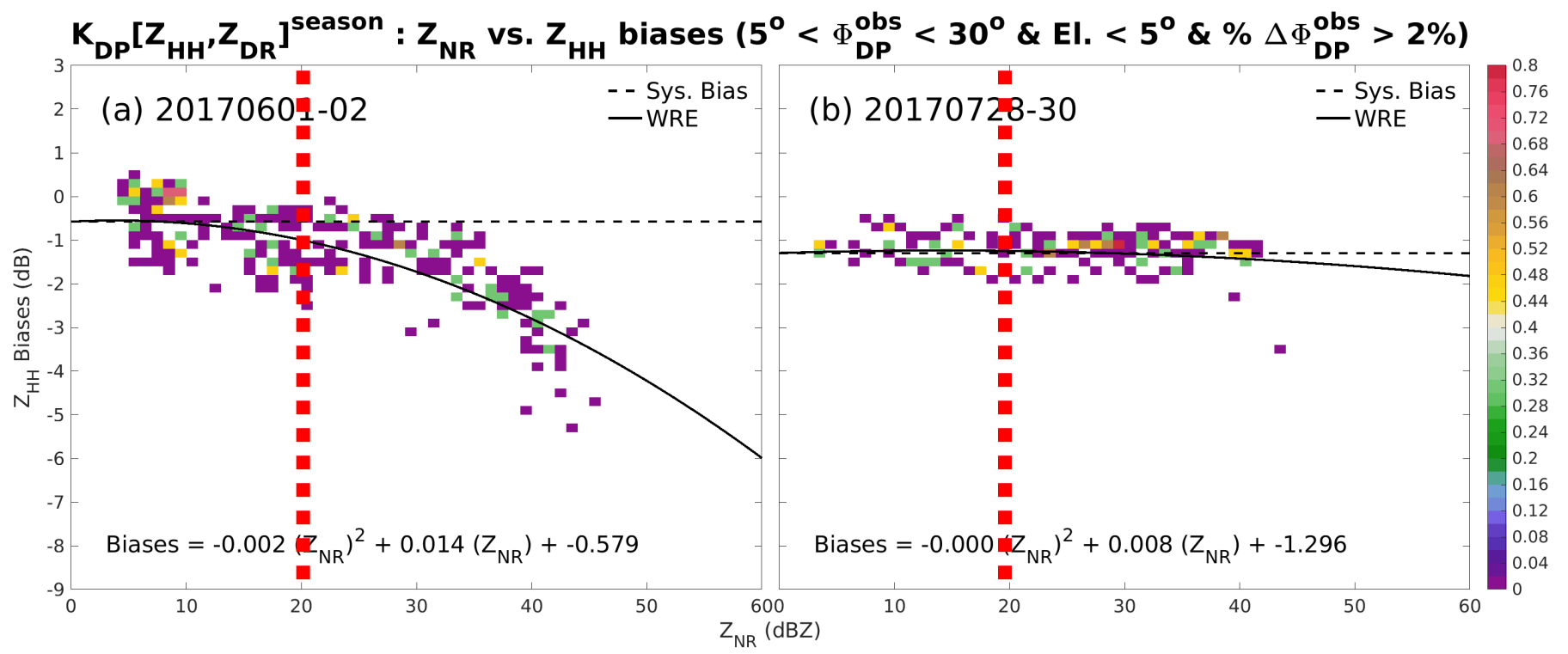
Results: WRE Studies



Results: WRE Studies

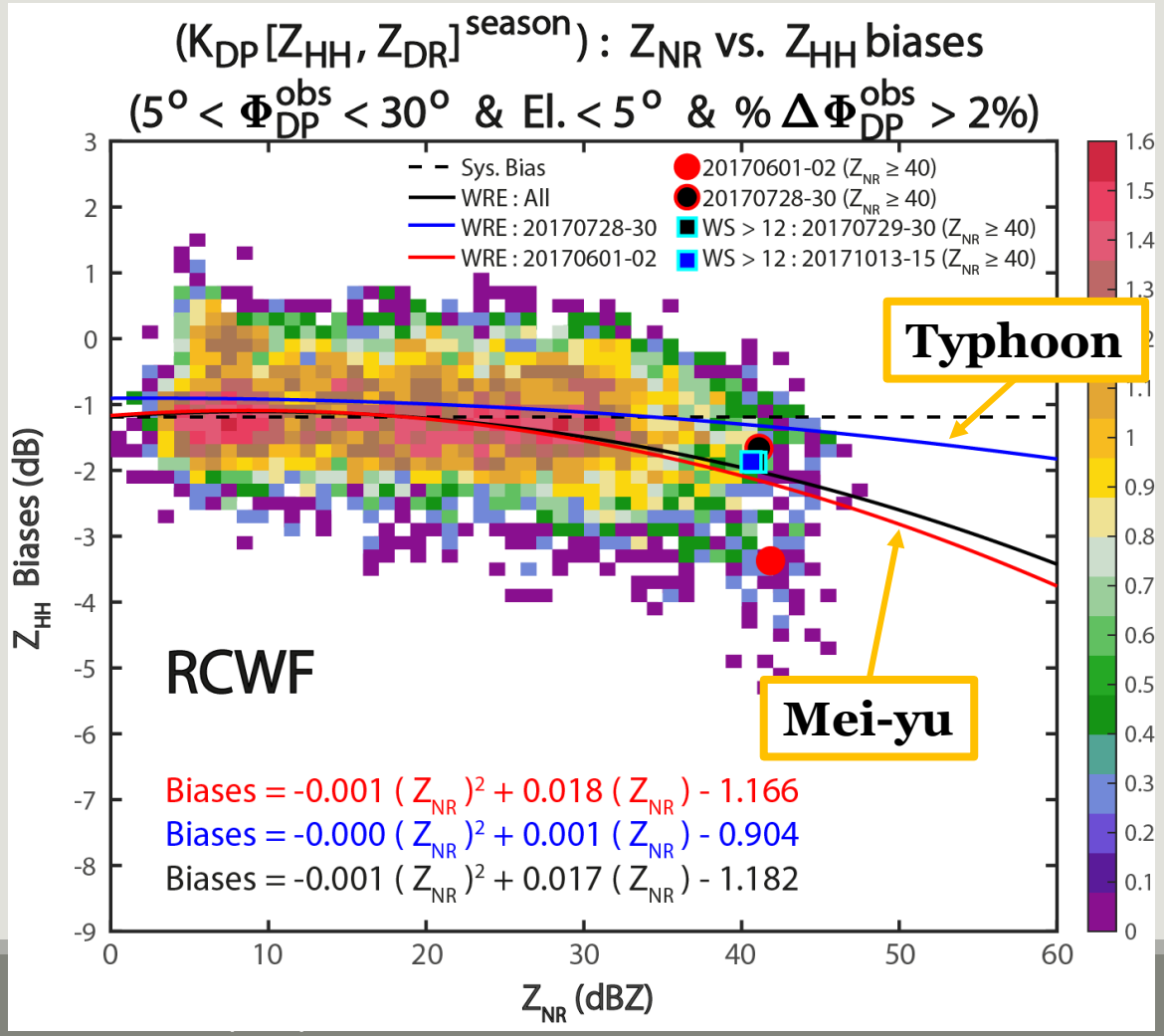
Mei-yu

Typhoon



Wind Speed (WS) → factors that influences the WRE ?

Results: WRE Studies

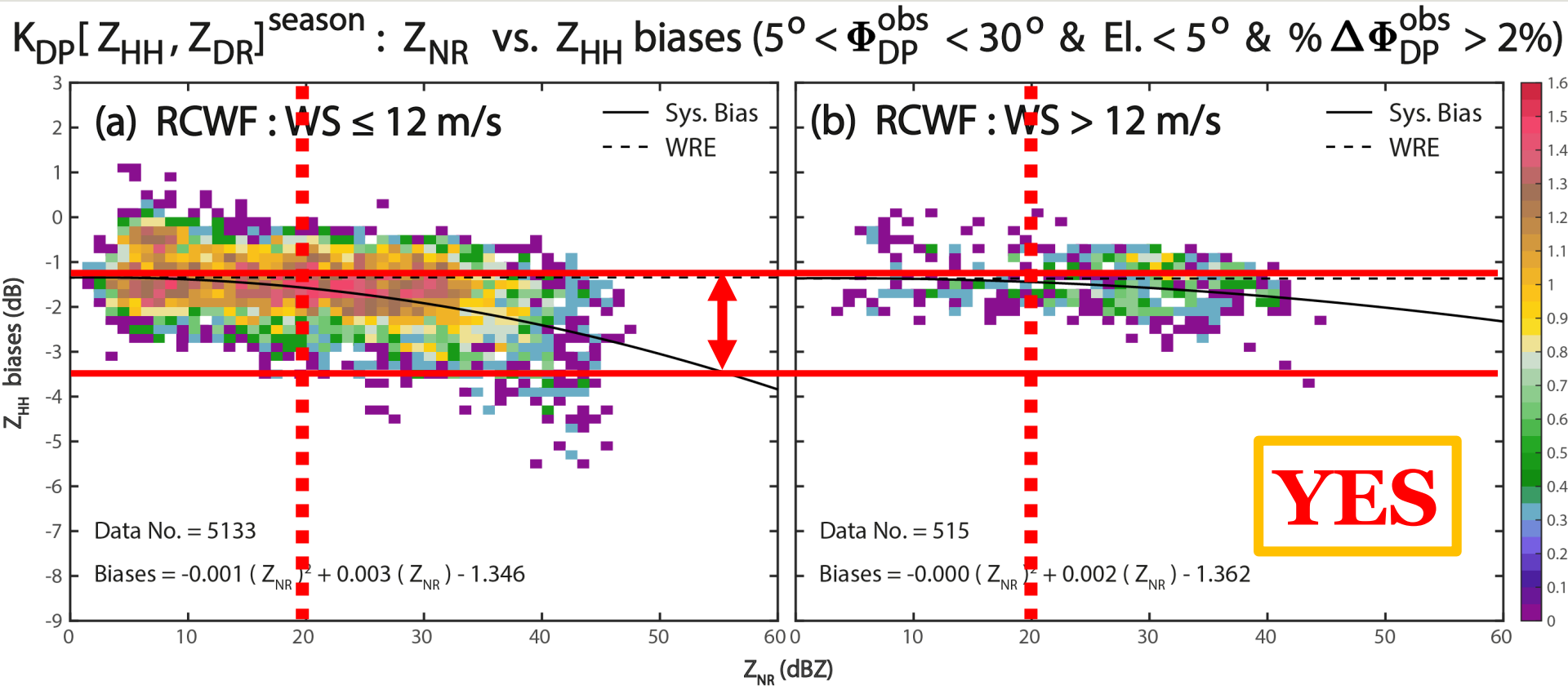


1) The WRE → quadratic poly-fitted eq.
2) Typhoon case (20170728-30) has smaller mean bias than Meiyu case (20170601-02)
3) Case 20171013-15 (WS > 12 m/s) showed similar result with typhoon case
4) WRE → affected by WS

Mei-yu : 20170601-02
Typhoon : 20170728-30
WS > 12 : 20171013-15

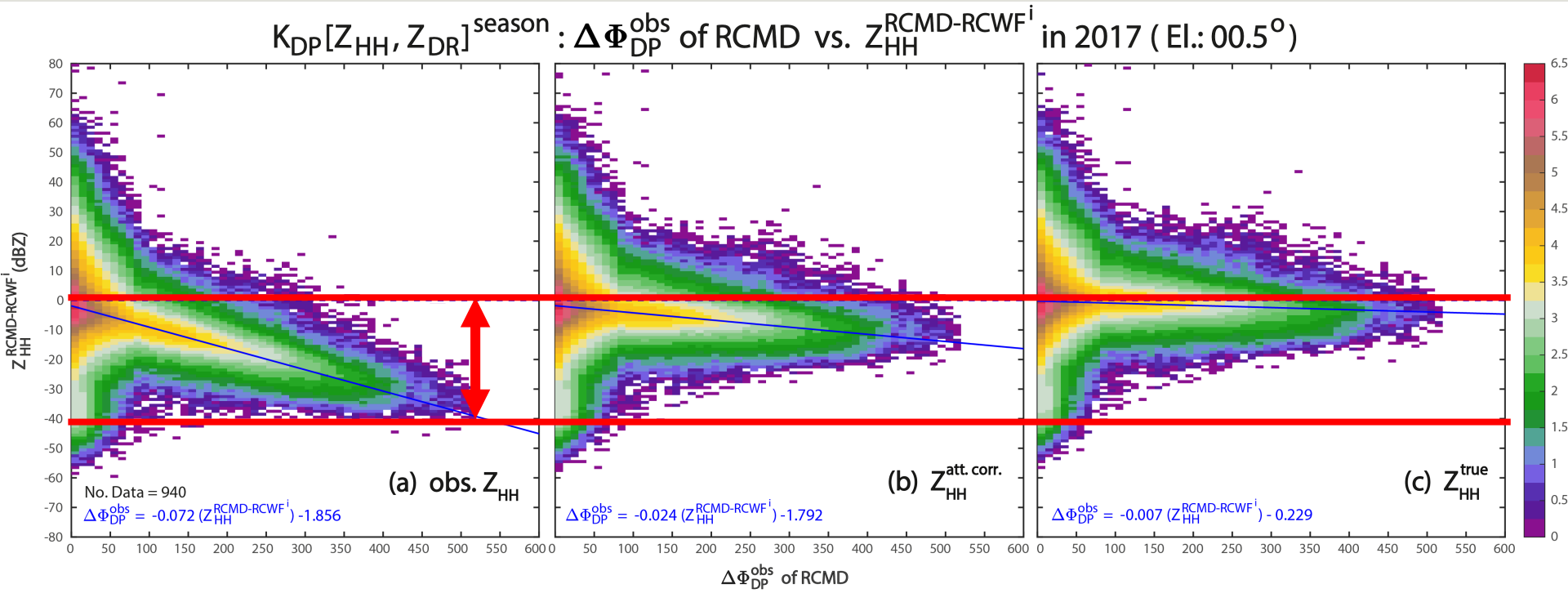
Results: WRE Studies

Wind Speed (WS) → factors that influences the WRE ?



Results: Validation with RCMD

Obs. Z_{HH} | **Obs. Z_{HH} + A_{HH}** | **Obs. Z_{HH} + A_{HH} + [Z_{HH} sys. biases + WRE]**



Z_{HH} biases → -1.86 dB ⟶ -1.79 dB ⟶ -0.23 dB

Conclusions

- Calibration for Z_{HH} & Z_{DR} → **Important!**
  - Z_{HH} & Z_{DR} → affected by WRE, systematic, & attenuation biases
  - Systematic biases → consistent (~ -1.2 dB)
- Among the 6 diff. self-consistent methods: K_{DP} $[Z_{HH}, Z_{DR}]^{season}$ w/ Z_{DR} corr. → calibrated well the results
- WRE:
  - Additional underestimations in Z_{HH} up to 6 dB
  - WS → factor to influence the WRE
  - Z_{DR} → influence the WRE

Manuscript: Long-Term Assessment of the Reflectivity Biases and Wet-Radome Effect in Collocated Operational S- and C-band Dual-Polarimetric Radars in northern Taiwan (in prep.)

Thanks for listening!

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Methods: Coeffs. from NCU JWD

Precipitation types [Avg. Temp. (°C)]	$A_{HH} = \alpha K_{DP}$	$A_{HH} = \beta K_{DP}$	$K_{DP} = aZ_{HH}^{b}$		$K_{DP} = aZ_{HH}^{b}bZ_{DR}^{c}$		
	α (x 10^{-2})	β (x 10^{-3})	a (x 10^{-5})	b (x 10^{-1})	a (x 10^{-5})	b	c (x 10^{-1})
All [20]	1.97	2.30	5.52	8.94	1.85	1.01	-5.76
Winter (DJF) [18]	2.70	2.30	5.12	9.06	1.84	1.01	-4.94
Spring (MA) [20]	2.09	2.30	5.76	8.86	1.80	1.01	-5.73
Mei-yu (MJ) [27]	2.09	2.00	5.54	8.95	1.83	1.01	-5.84
Summer (JAS) [30]	1.54	1.90	6.37	8.69	1.88	1.01	-6.39
Typhoon [30]	1.55	1.80	5.51	8.96	1.92	1.00	-5.83
Autumn (ON) [24]	1.89	2.10	5.49	8.96	1.96	1.00	-5.20