# Calibration of the WindRAD Scatterometer Onboard FY-3E

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# Outline

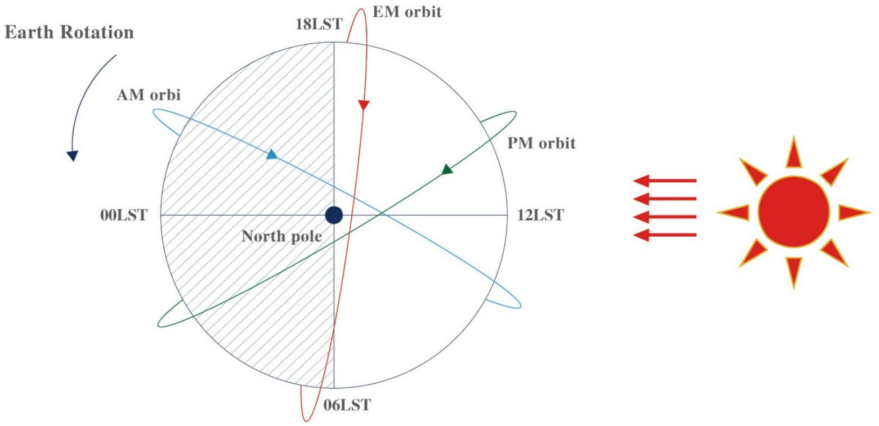
- WindRAD introduction
- Data analysis
- Calibration methods: NOC (NWP Ocean Calibration)
  HOC (Higher Order Calibration)
- Quality control
- Summary

# WindRAD Introduction

**What is WindRAD?**

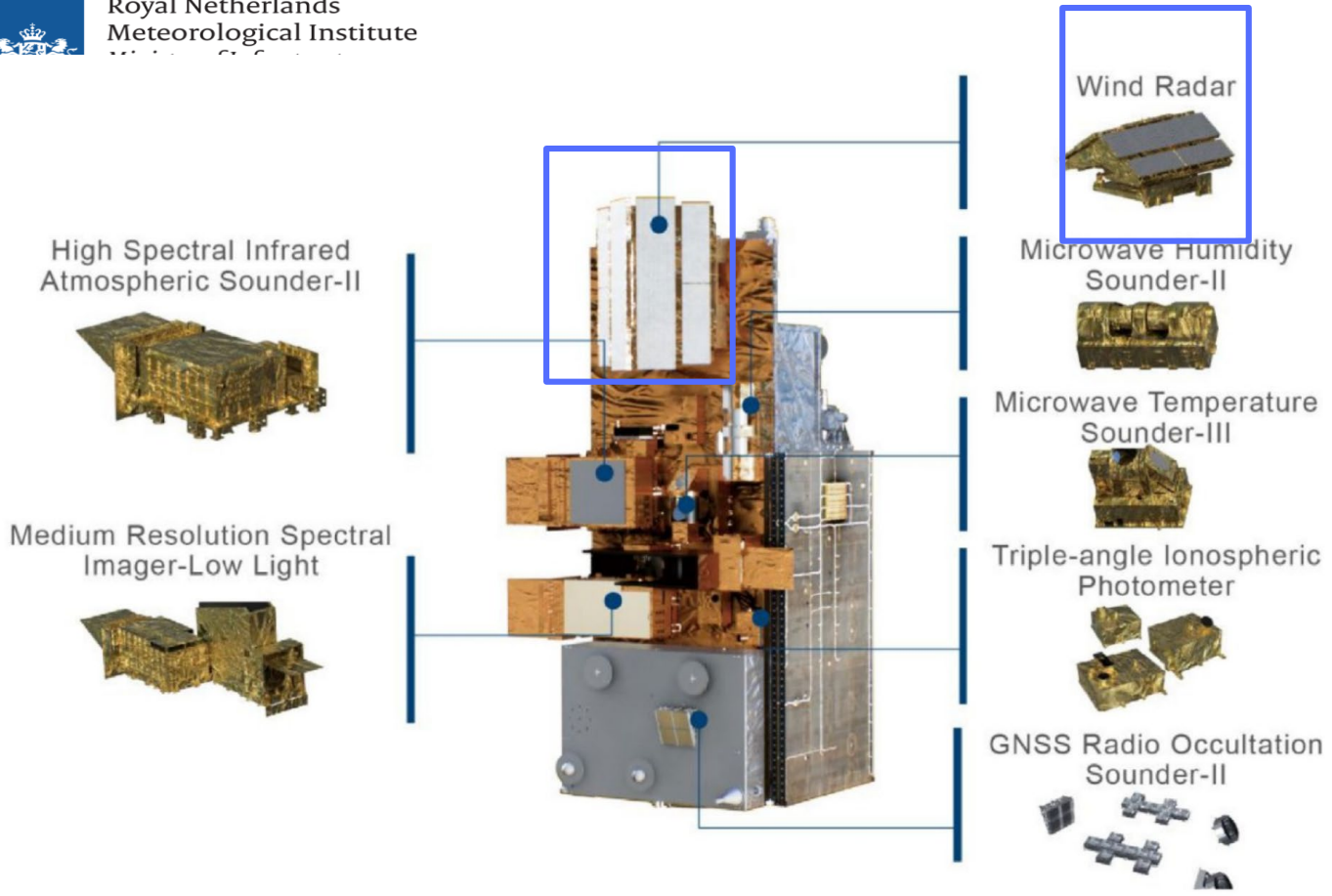
**WindRAD** is a wind scatterometer onboard **FY-3E** (Feng Yun-3E) satellite.
It was launched on 9th July 2021 by CMA (China Meteorological Administration).

*FY-3E satellite is an early-morning-orbit meteorological satellite for civil use.*



# WindRAD Introduction






- Dual frequency:

  C & Ku band
  (VV and HH)

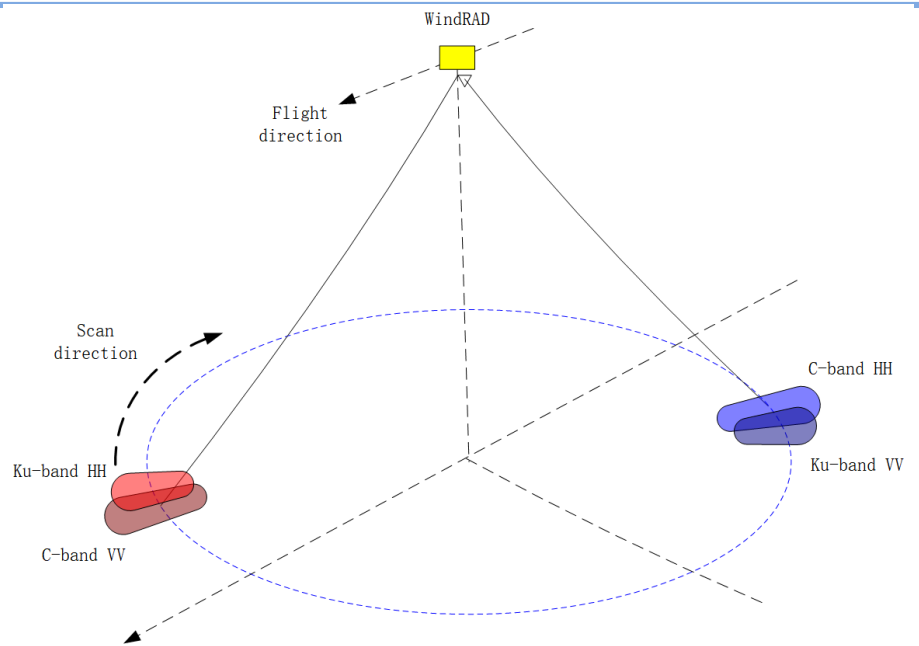
- Rotating fan-beam

## What is WindRAD?

**WindRAD** is a wind scatterometer onboard **FY-3E** satellite.

*FY-3E (FengYun-3E) satellite is an early-morning-orbit meteorological satellite for civil use.*

**WindRAD** is a **dual** frequency **rotating fan-beam** scatterometer.



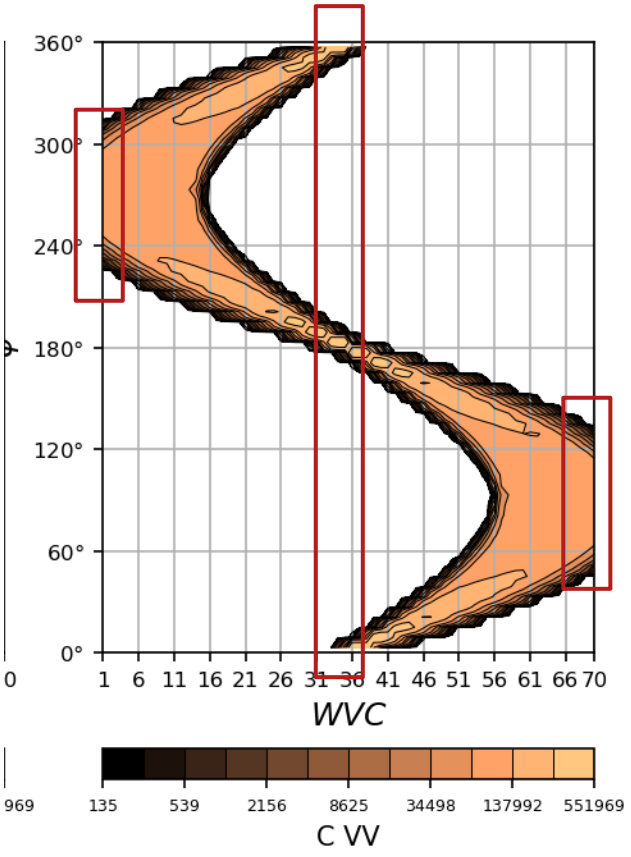

cr. Jian Shang

# Data analysis

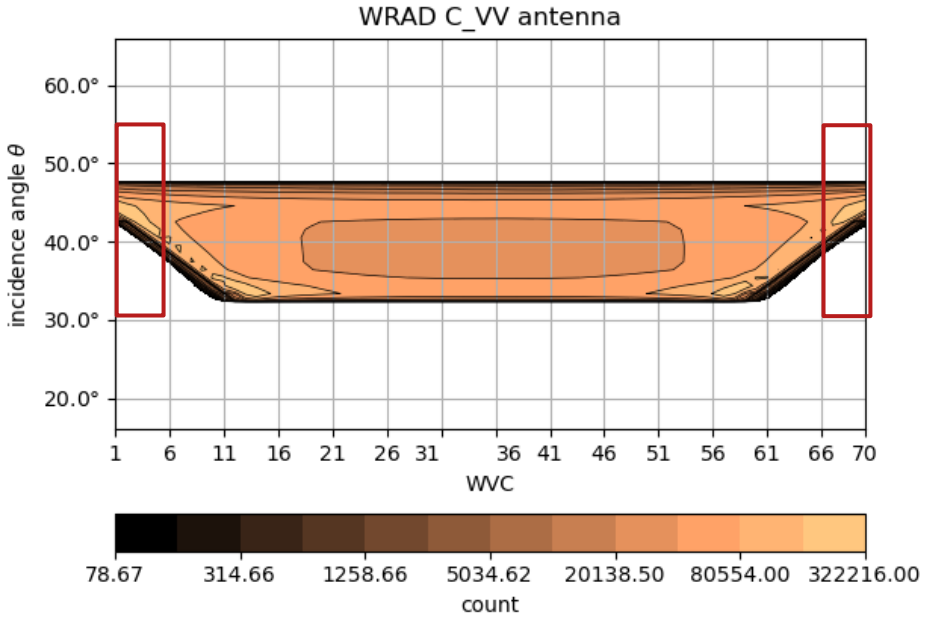
Geometries:
azimuth angle, incidence angle, sigma0 distribution

# Geometries of the data as a function of WVCs

Azimuth angle



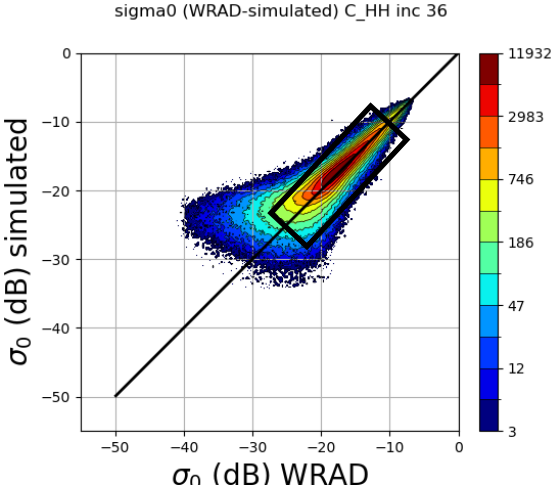
# Incidence angle

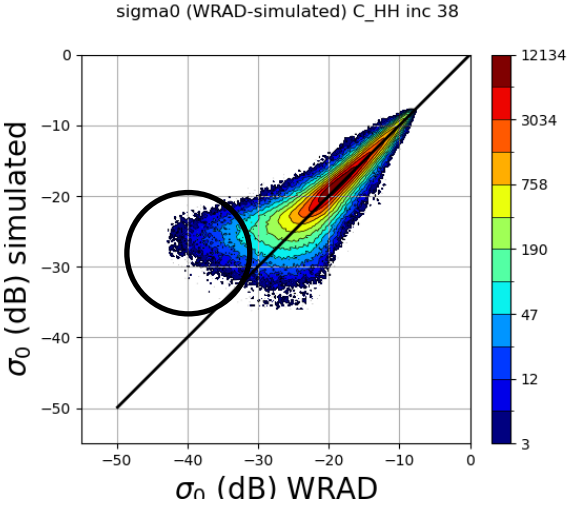


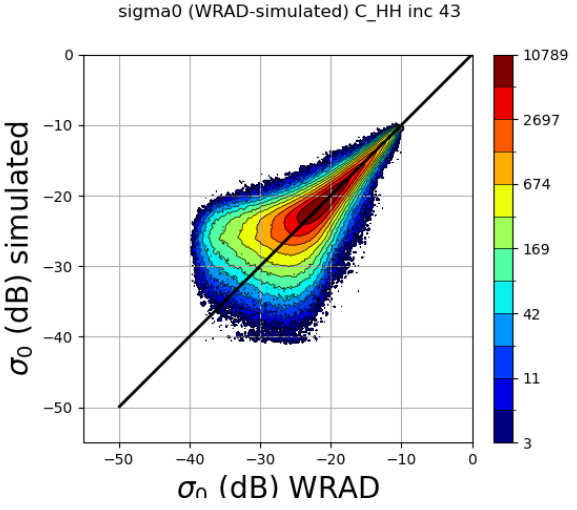
# sigma0 distribution per incidence angle



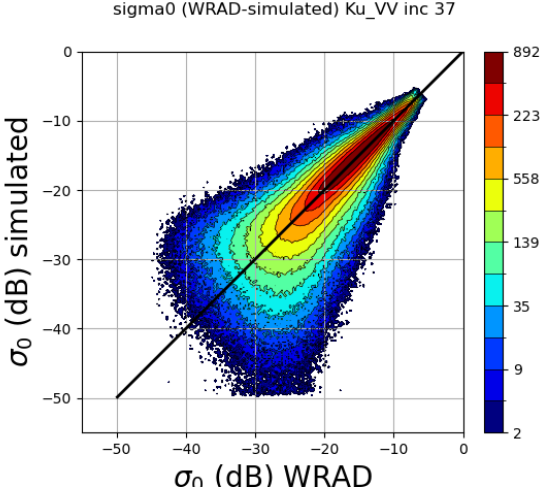
C band

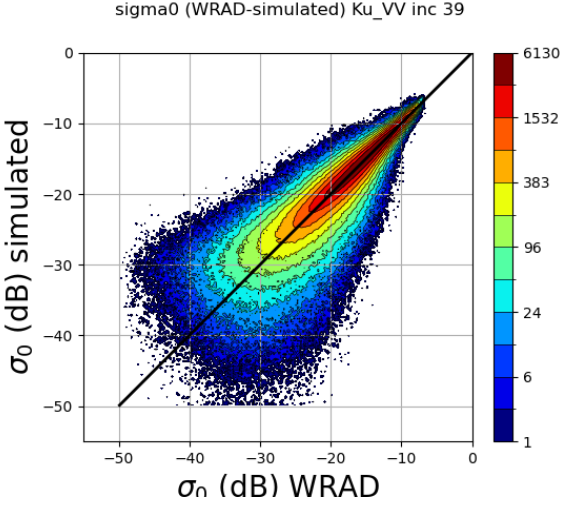


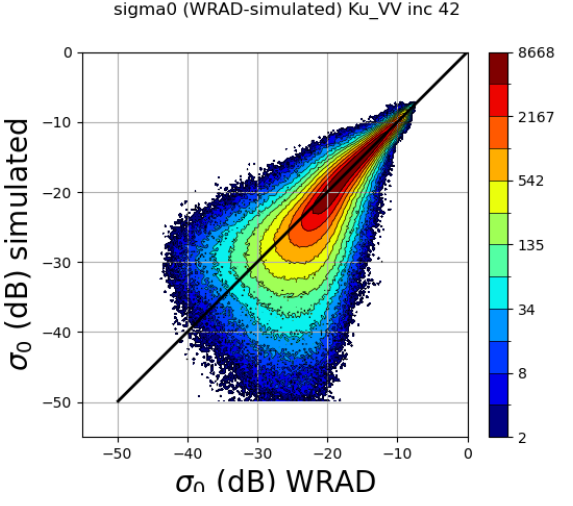




Ku band



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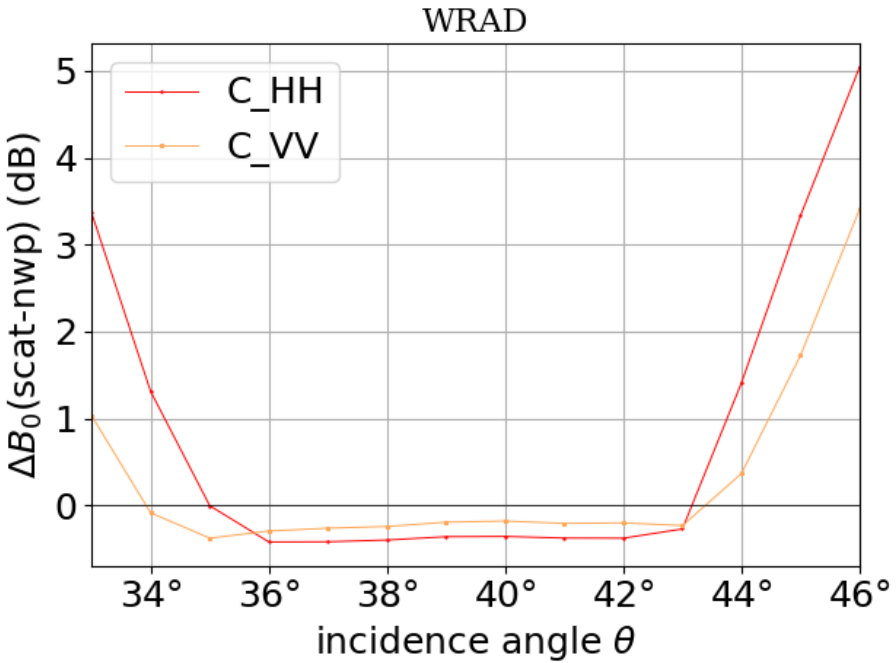
# Calibration methods

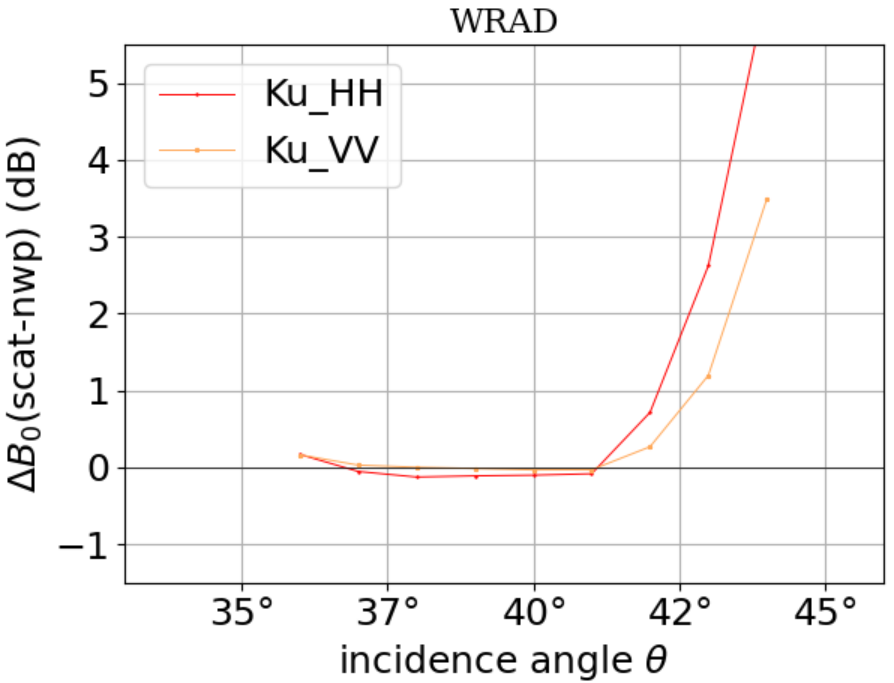
## NOC (NWP Ocean Calibration)

- For all scatterometers, there are general differences between the measured $\sigma^{\circ}$s and simulated $\sigma^{\circ}$s. These discrepancies come from instrument calibration and low-level processing, systematic, and random errors in NWP winds, as well as GMF errors.

- A well-elaborated calibration method is NWP Ocean Calibration (NOC); it is a technique to assess the difference between the measured $\sigma^{\circ}$s and simulated $\sigma^{\circ}$s from collocated NWP winds with the corresponding GMF.

# NOC as a function of incidence angle (NOCinc)



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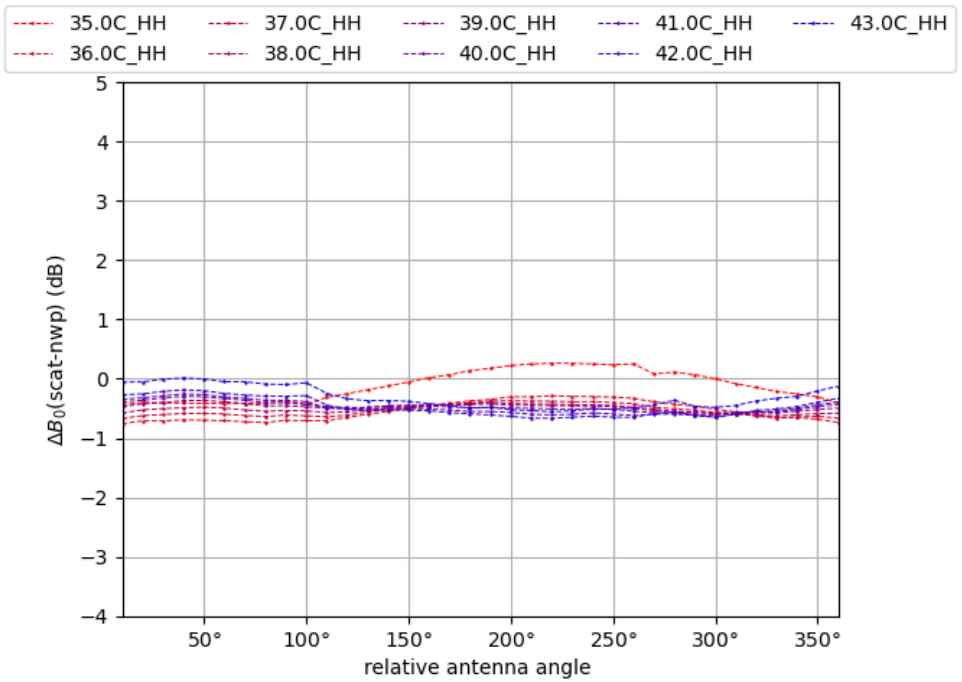
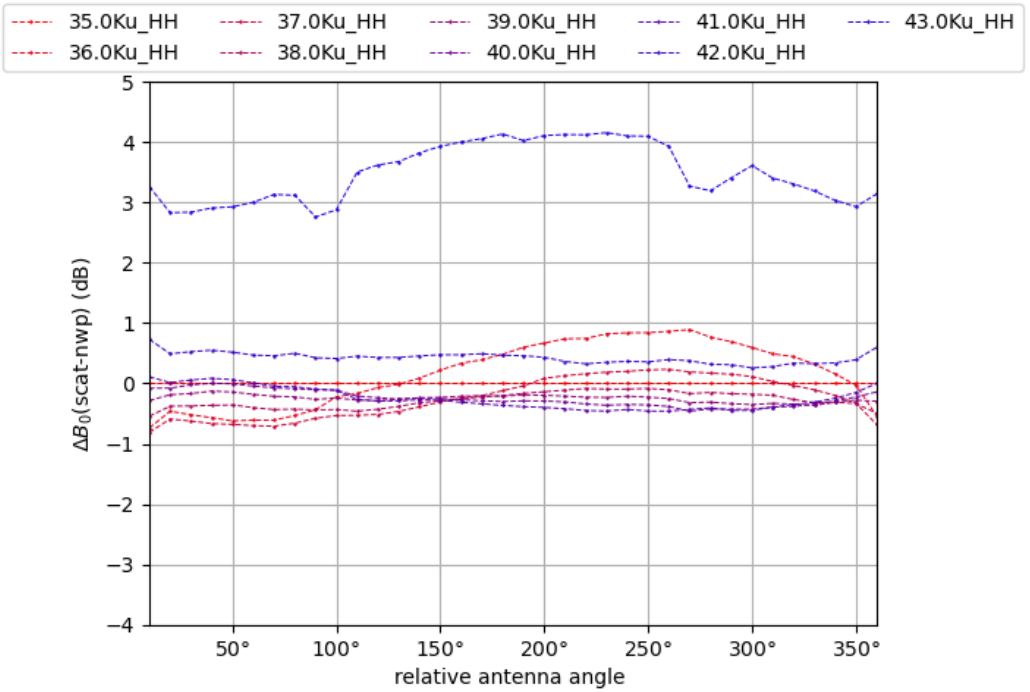
# NOC as a function of incidence angle and relative antenna angle (NOCant)

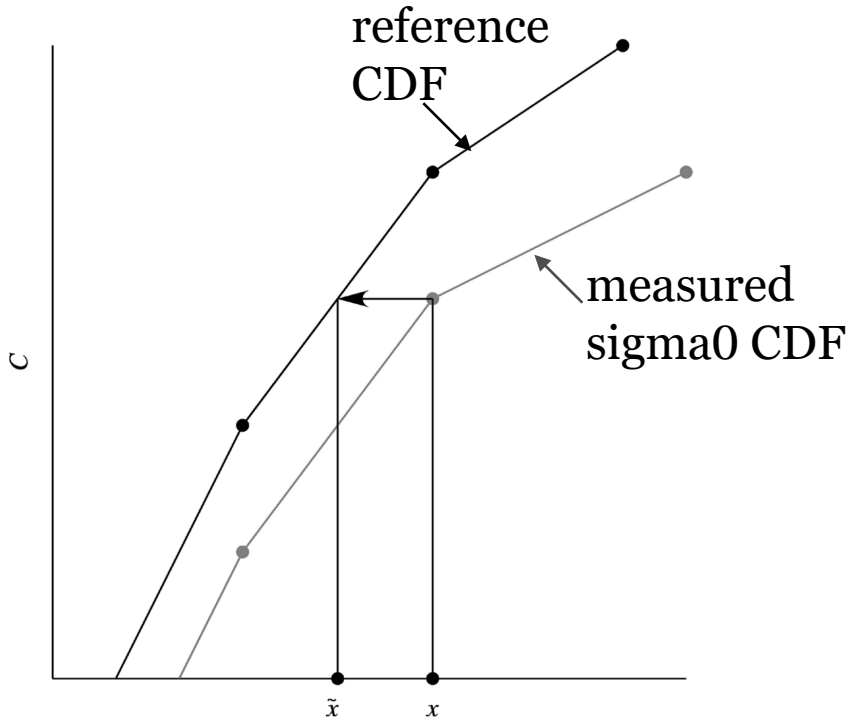


# HOC (Higher Order Calibration)

What is **HOC**:

It employs CDF* matching technique to calibrate the non-linearity in the sigma0 distribution




* CDF: Cumulative Distribution Function

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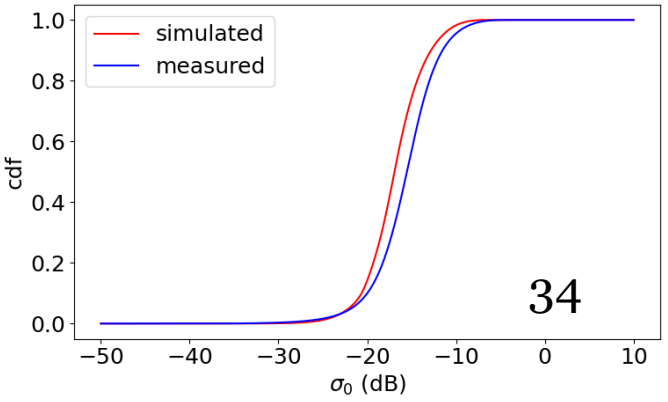
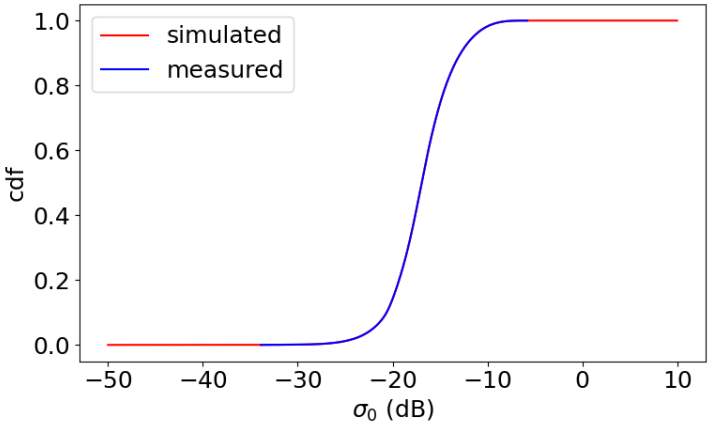
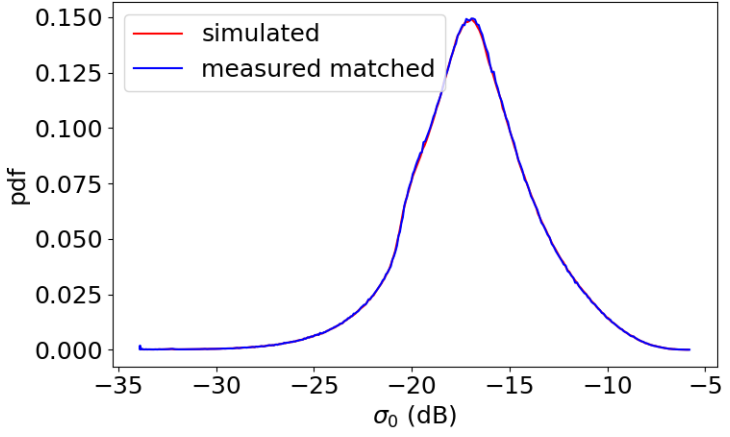
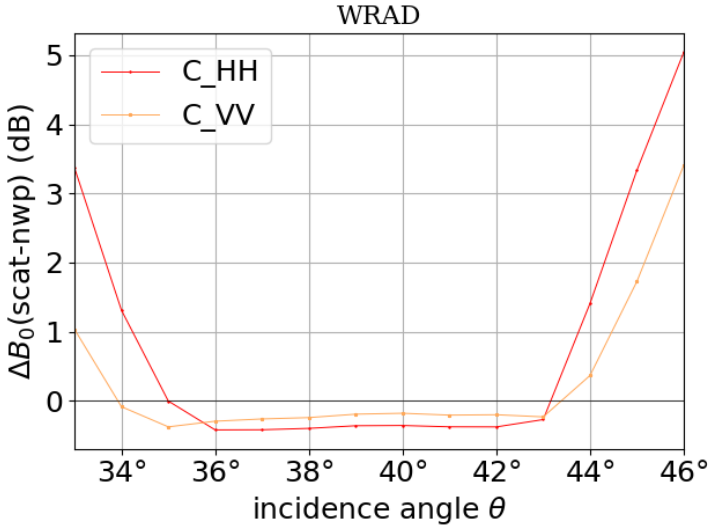
# C-band

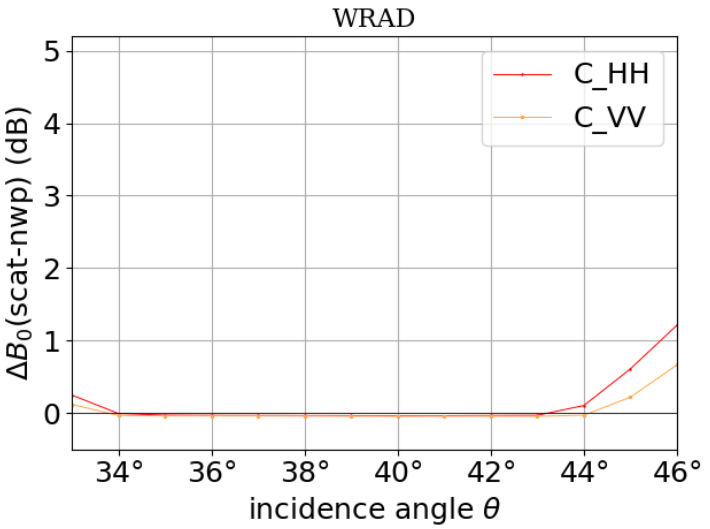


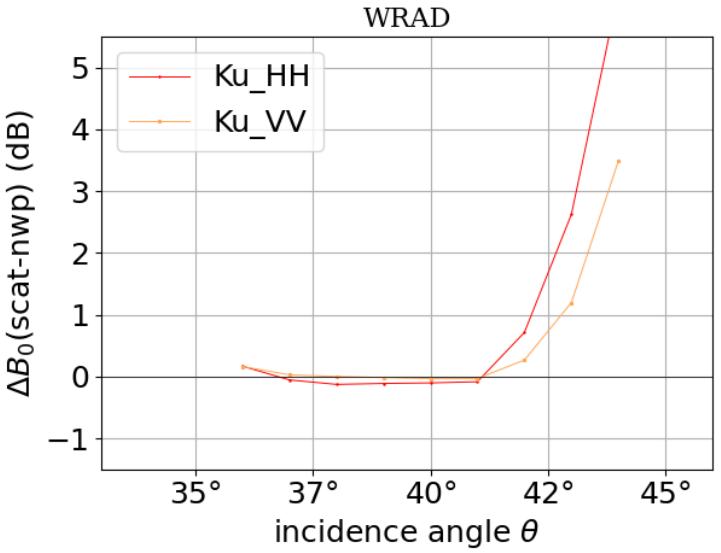



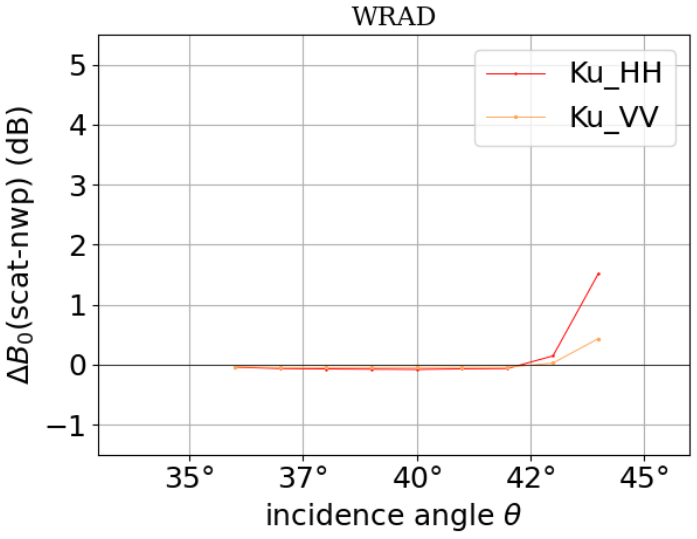



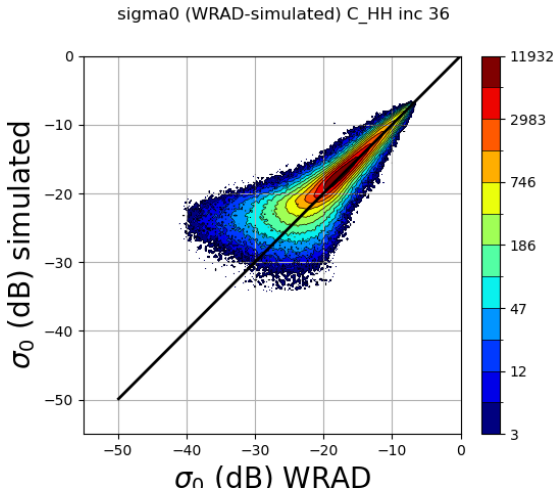
# Combine HOC and NOCinc

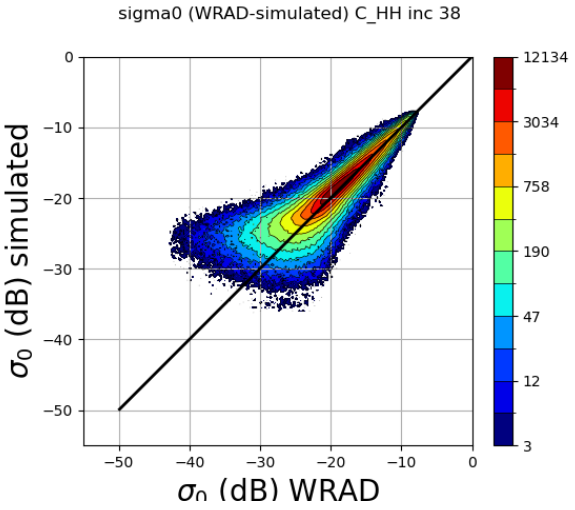


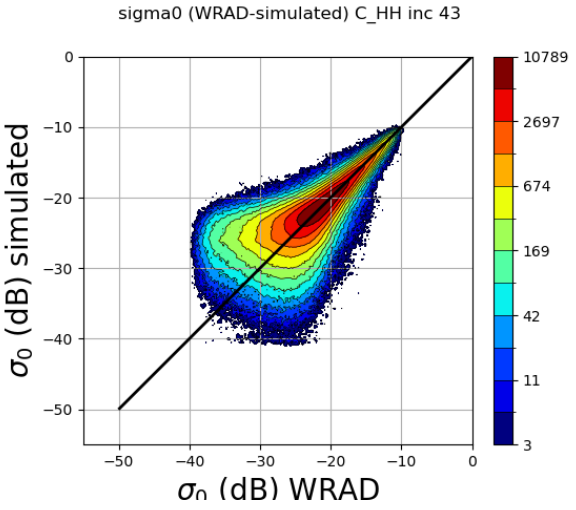



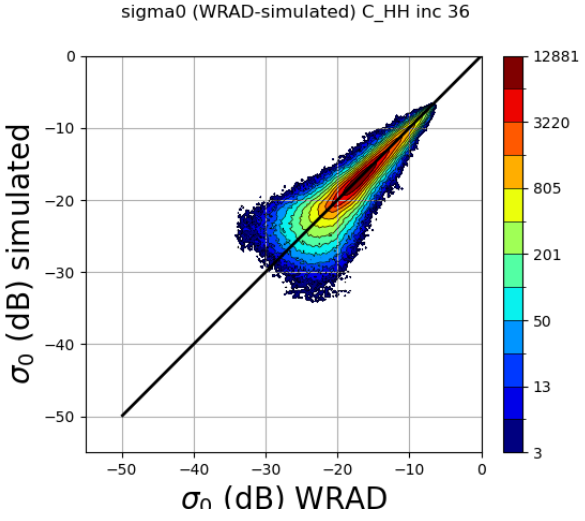



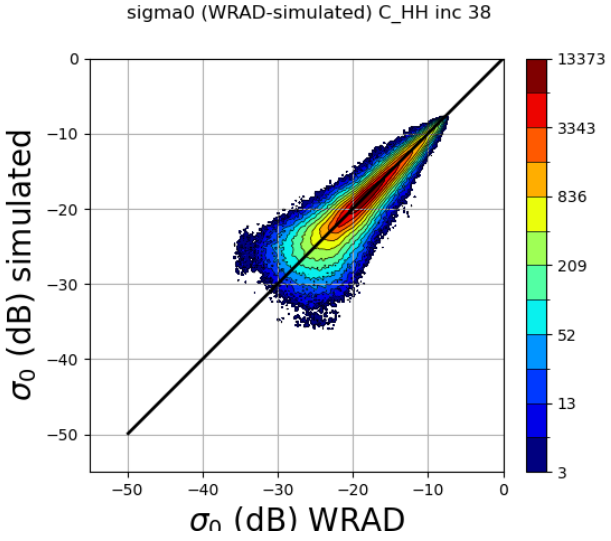



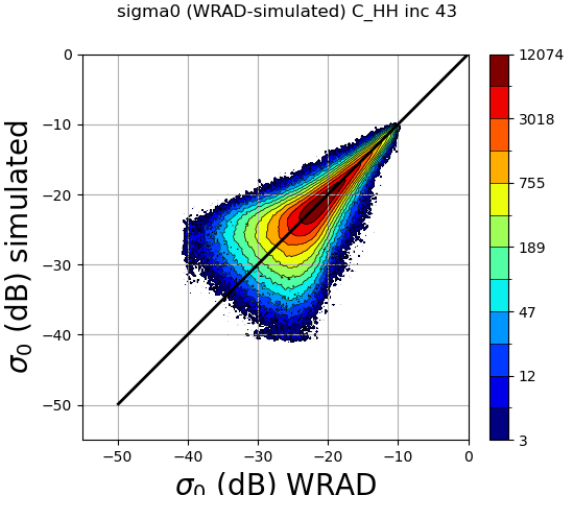

sigma0 (WRAD-simulated) C_HH inc 36
σ0 (dB) simulated
σn (dB) WRAD
11932
2983
746
186
47
12
3


sigma0 (WRAD-simulated) C_HH inc 38
σ0 (dB) simulated
σn (dB) WRAD
12134
3034
758
190
47
12
3


sigma0 (WRAD-simulated) C_HH inc 43
σ0 (dB) simulated
σn (dB) WRAD
10789
2697
674
169
42
11
3


sigma0 (WRAD-simulated) C_HH inc 36
σ0 (dB) simulated
σn (dB) WRAD
12881
3220
805
201
50
13
3


sigma0 (WRAD-simulated) C_HH inc 38
σ0 (dB) simulated
σn (dB) WRAD
13373
3343
836
209
52
13
3


sigma0 (WRAD-simulated) C_HH inc 43
σ0 (dB) simulated
σn (dB) WRAD
12074
3018
755
189
47
12
3

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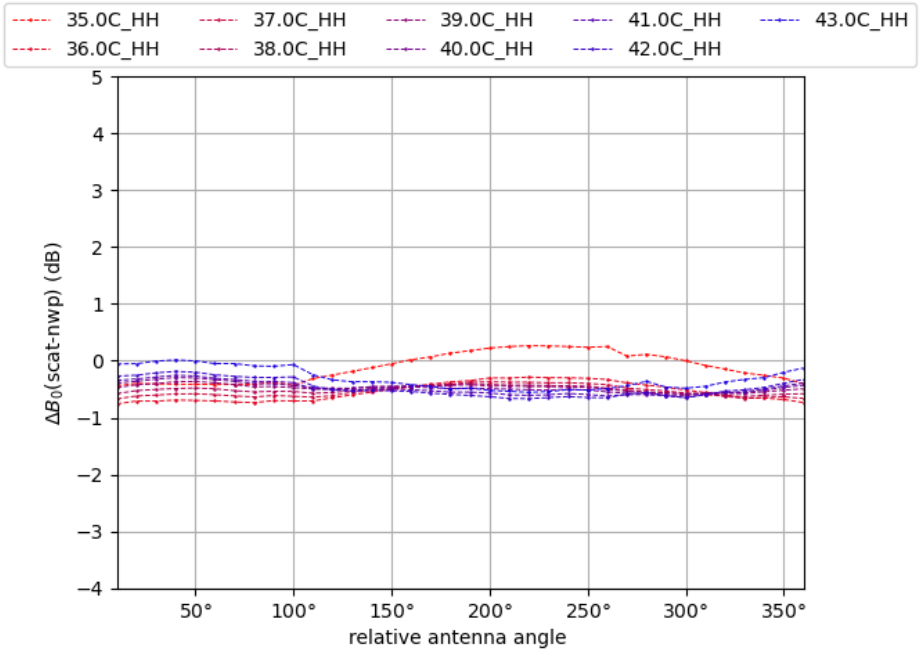
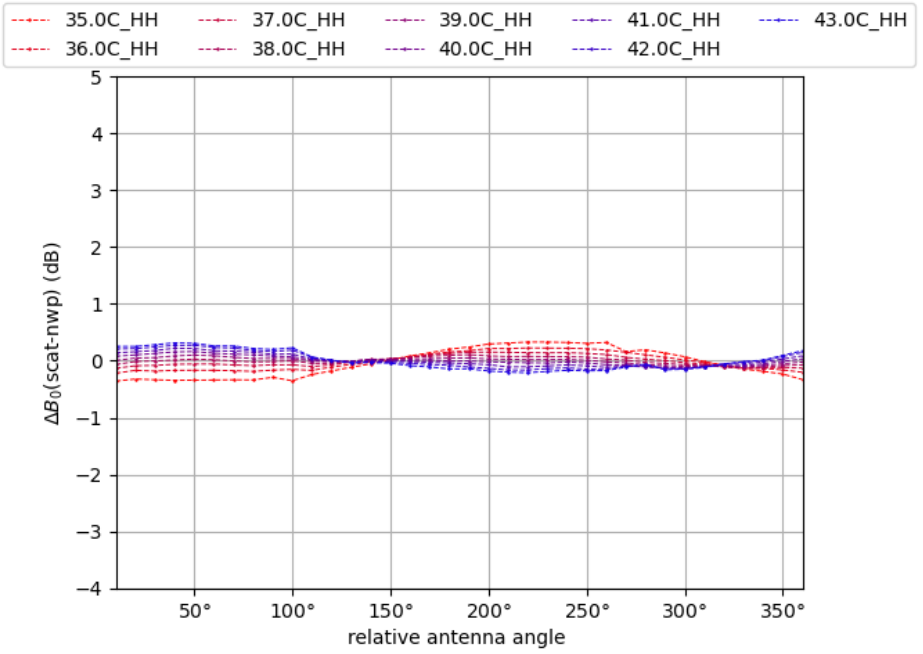
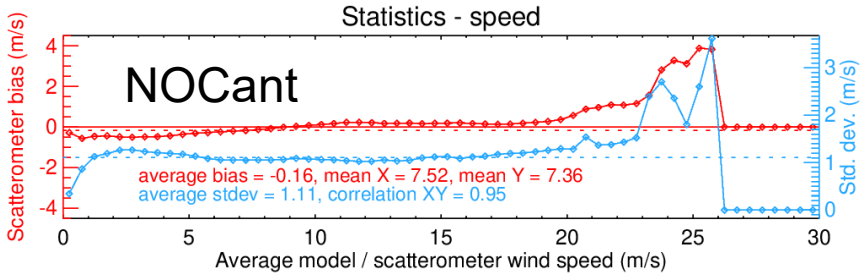
# Combine HOC and NOCant

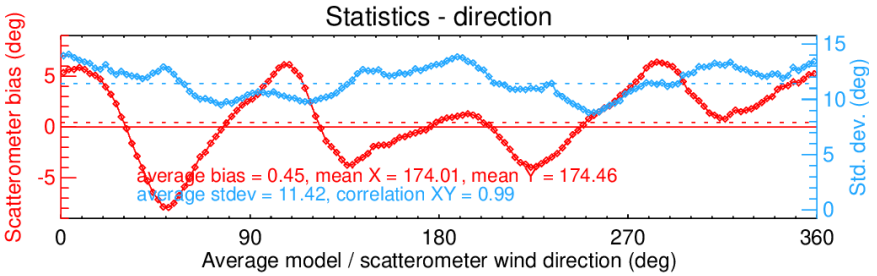


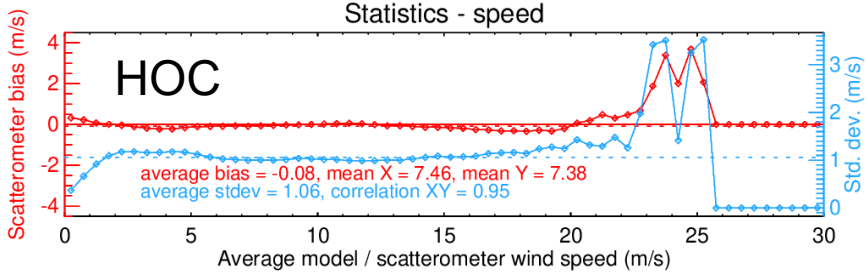



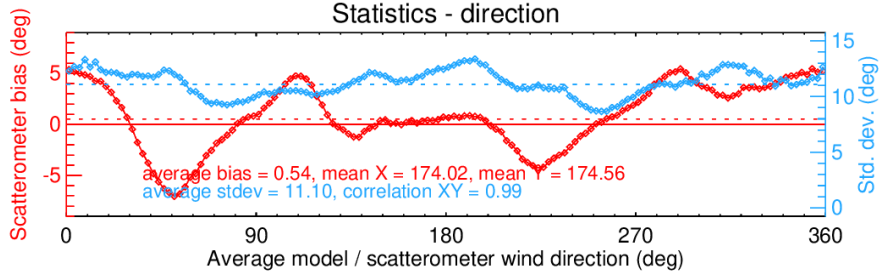
# C-band

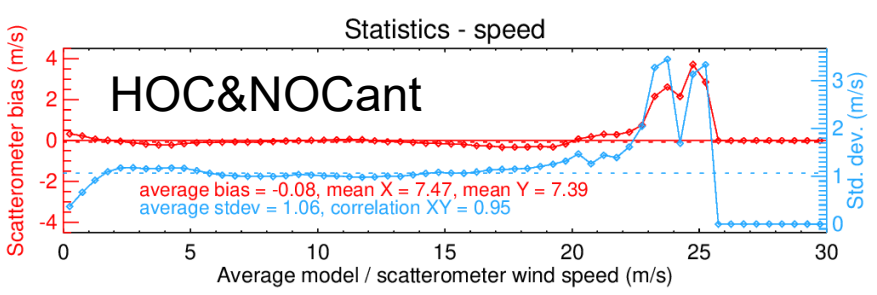
## Calibration methods

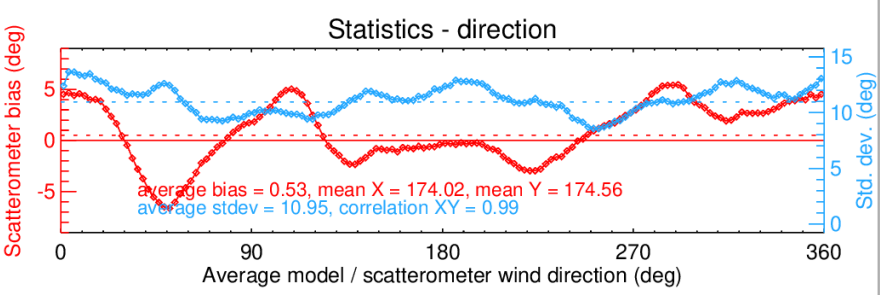


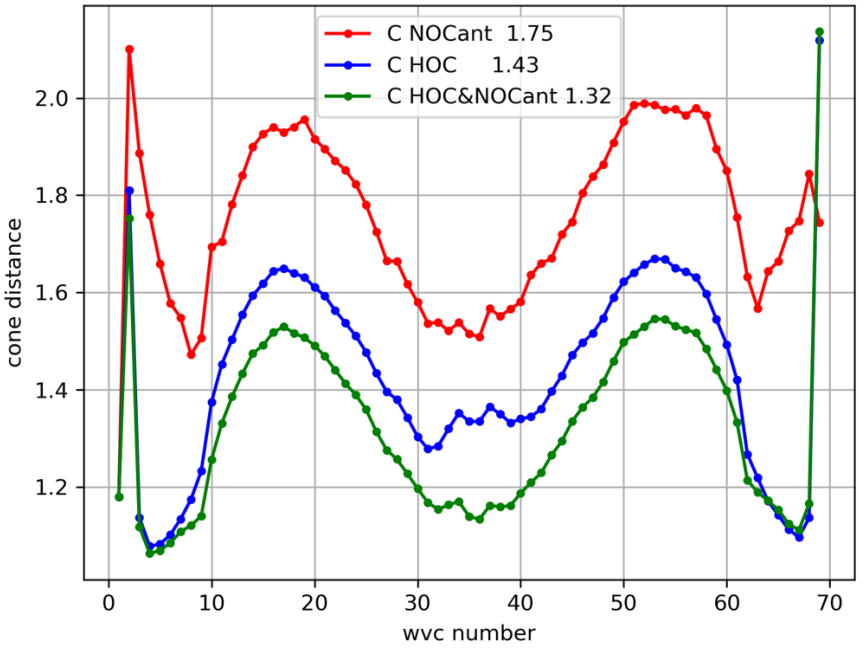



# Cone distance metric (C-band)



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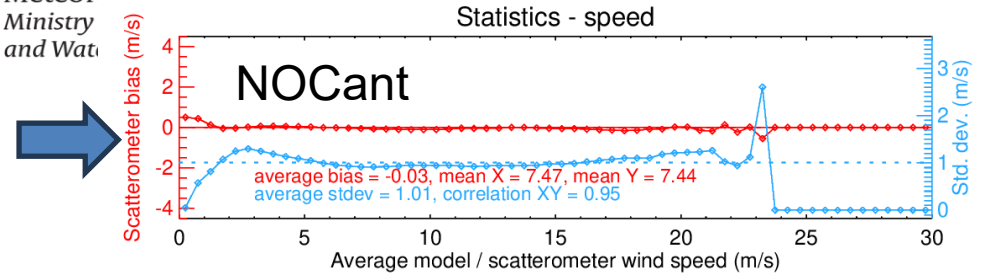
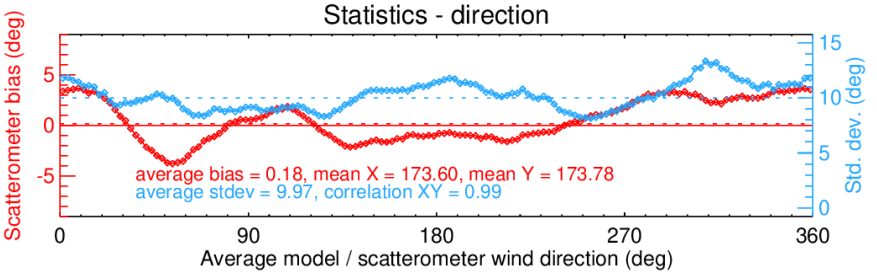
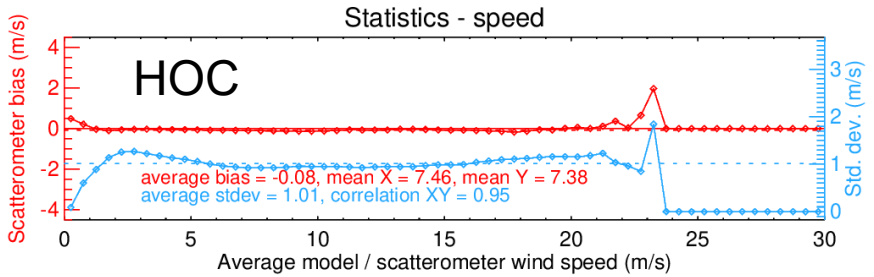
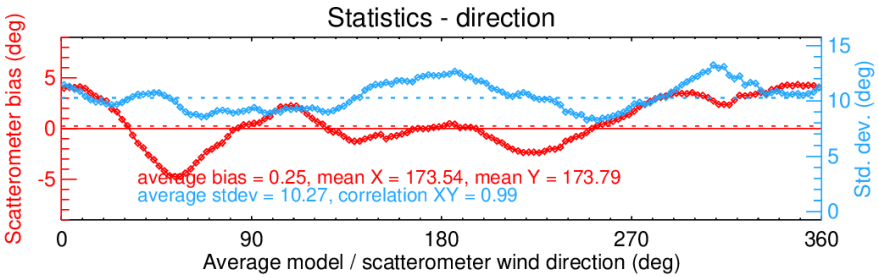
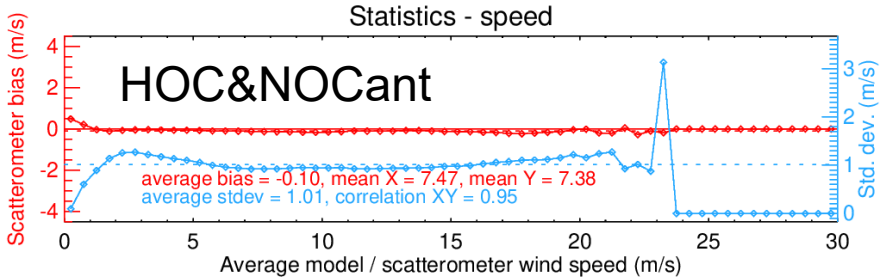
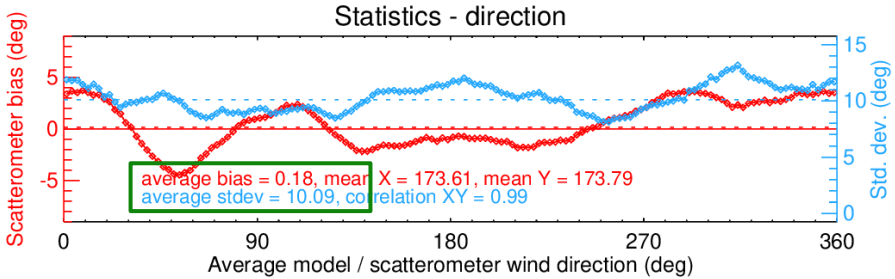


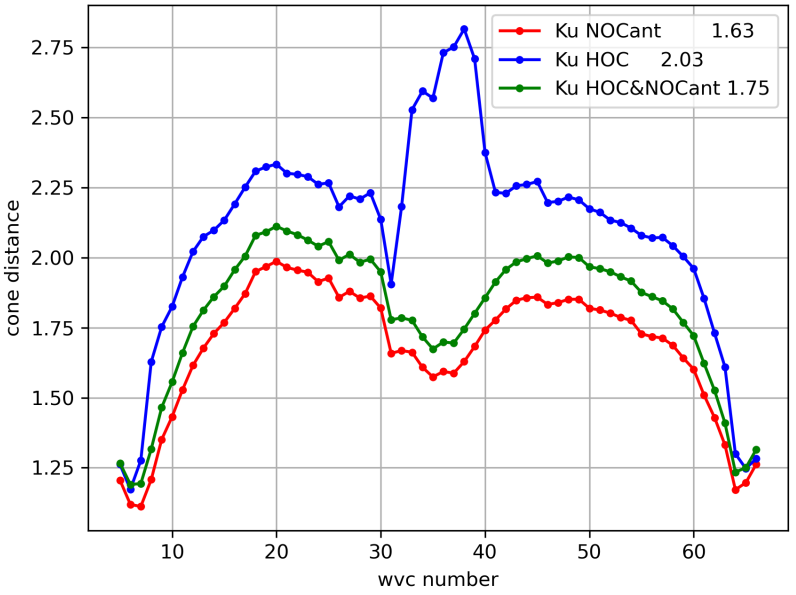



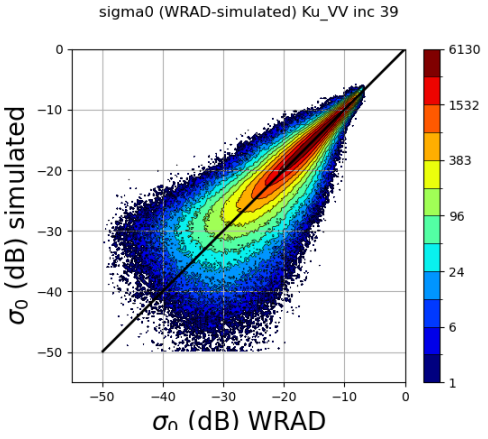



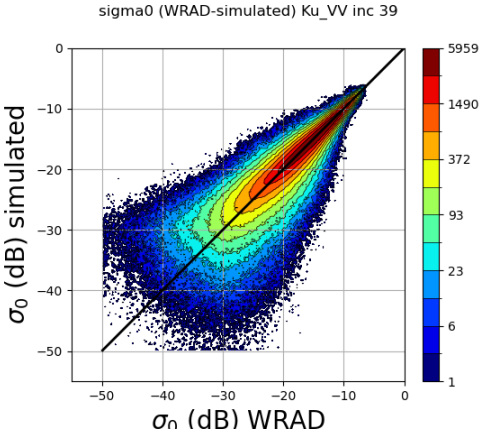




Ku NOCant 1.63
Ku HOC 2.03
Ku HOC&NOCant 1.75
cone distance
wvc number


sigma0 (WRAD-simulated) Ku_VV inc 39
σ0 (dB) simulated
σn (dB) WRAD

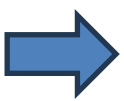
HOC

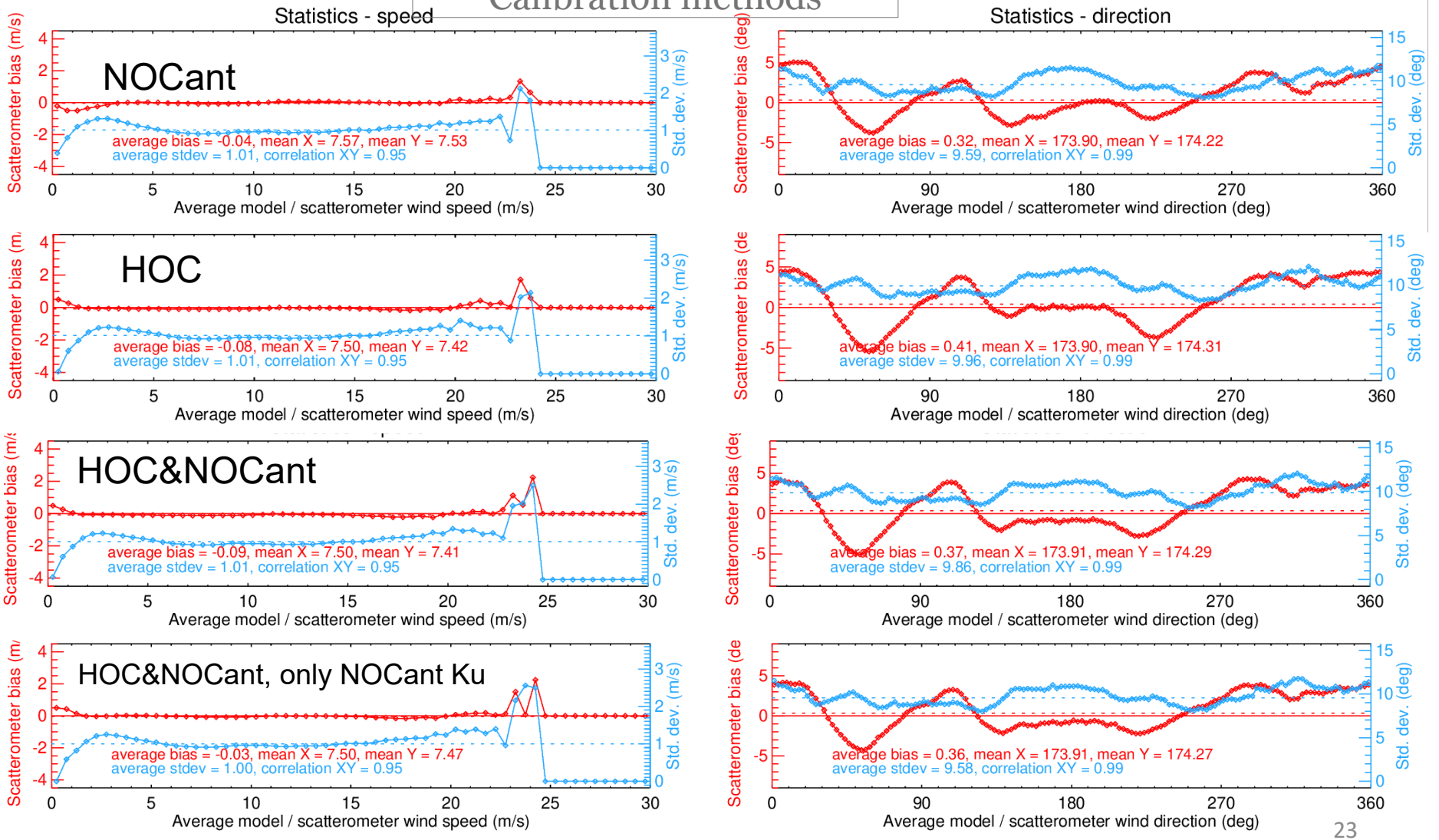

sigma0 (WRAD-simulated) Ku_VV inc 39
σ0 (dB) simulated
σn (dB) WRAD

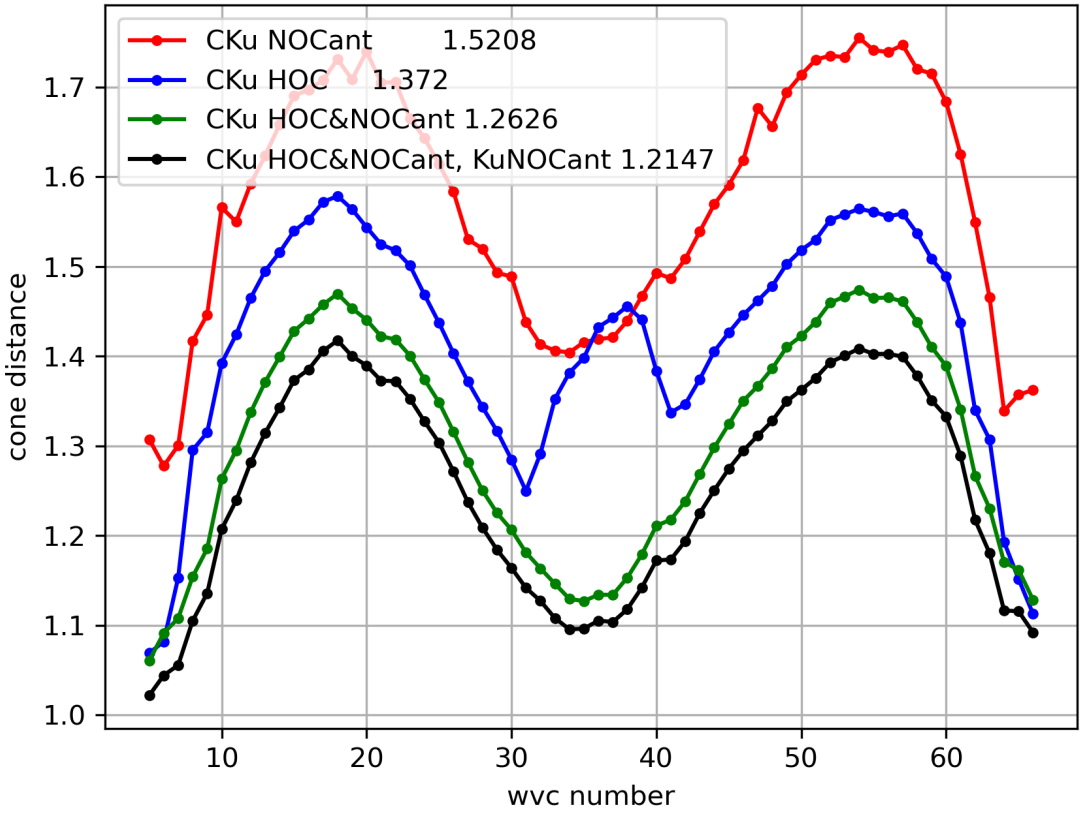
# Calibration methods



C&Ku

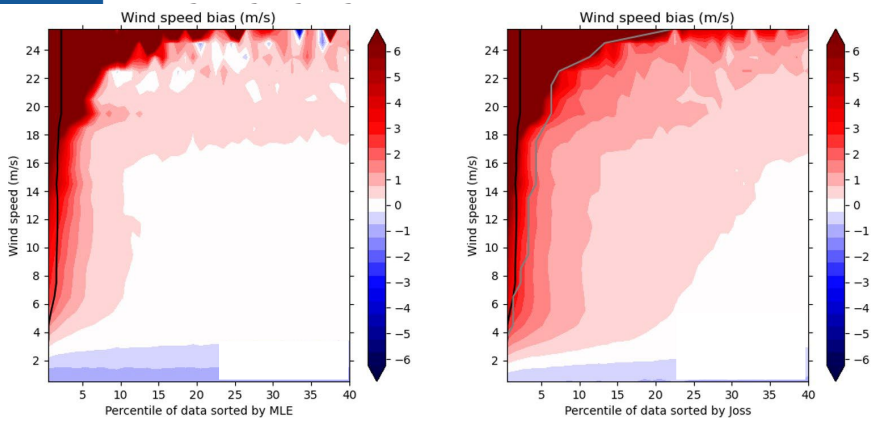


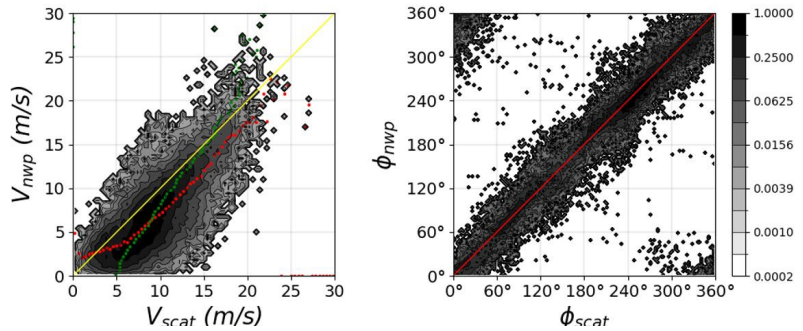


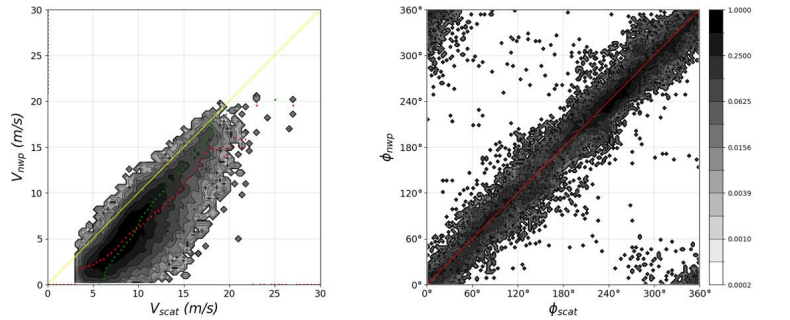

CKu NOCant 1.5208
CKu HOC 1.372
CKu HOC&NOCant 1.2626
CKu HOC&NOCant, KuNOCant 1.2147
cone distance
wvc number
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
10
20
30
40
50
60

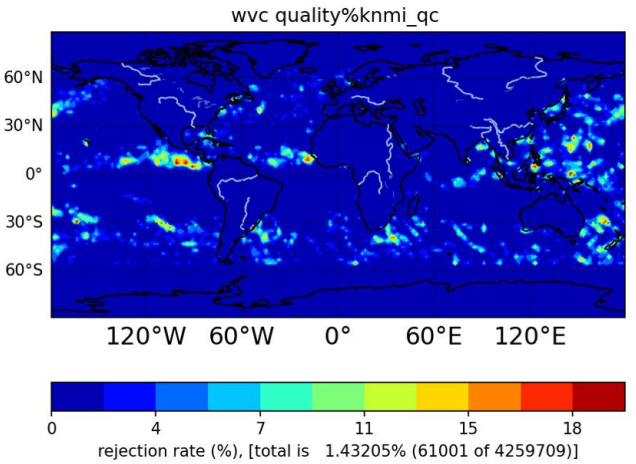
# Preliminary result on Quality Control

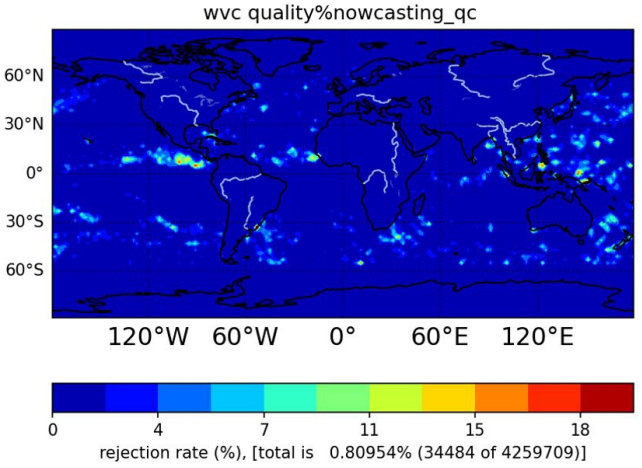
# Ku band, mixQC



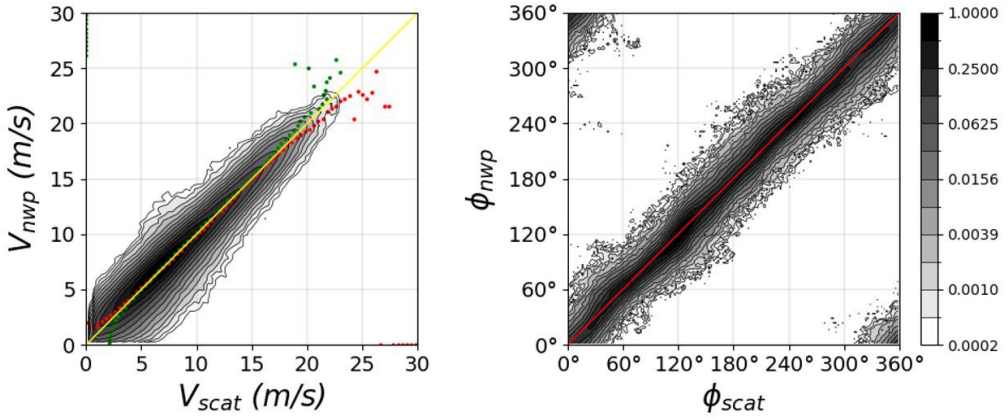



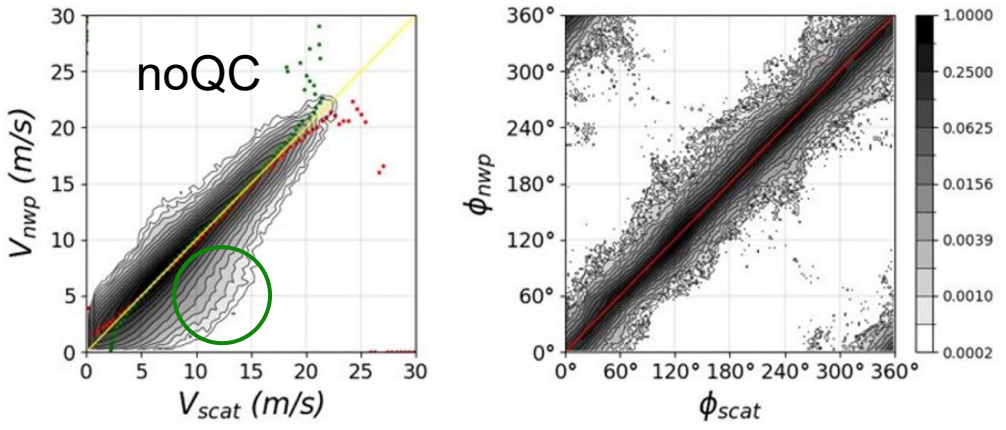



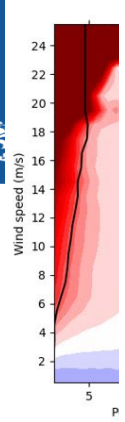

* Xu et al., 2020 (Joss method)

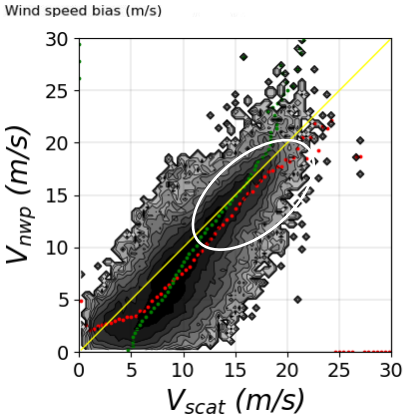
# Quality Control

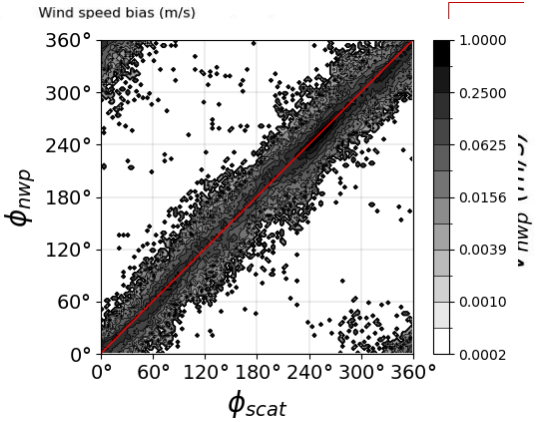


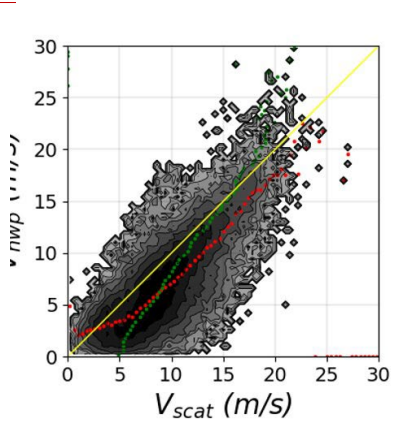


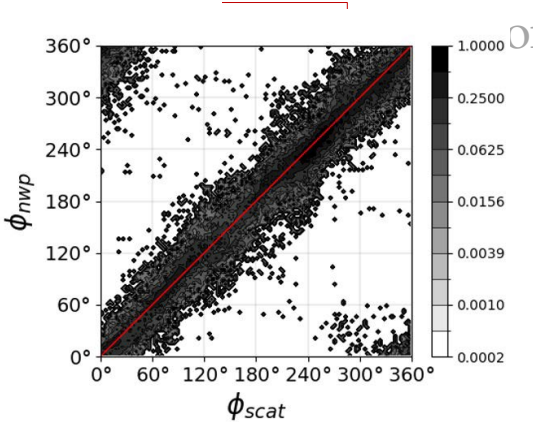



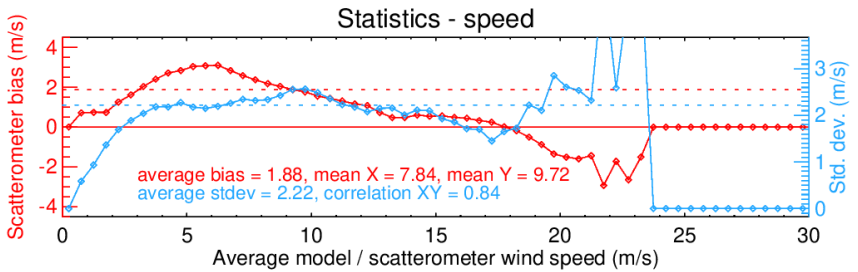


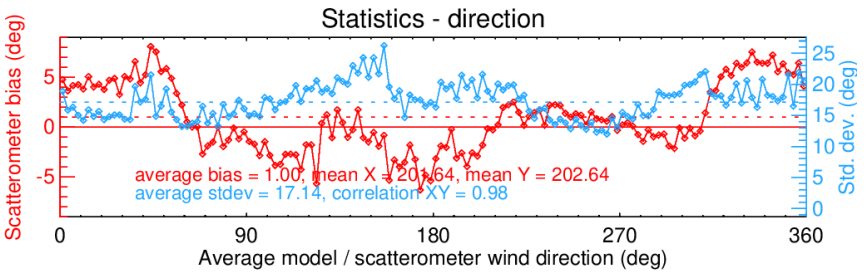



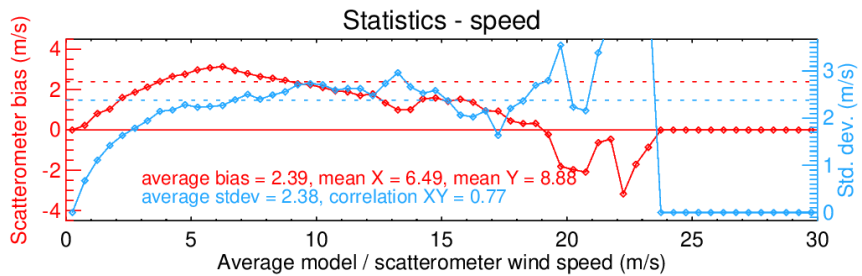



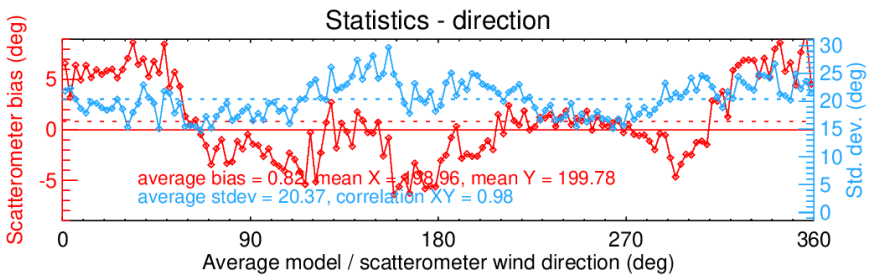




ScatSat-1/OSCAT mix qc rejection rate ~ 3.9%,Joss only ~ 2.6%

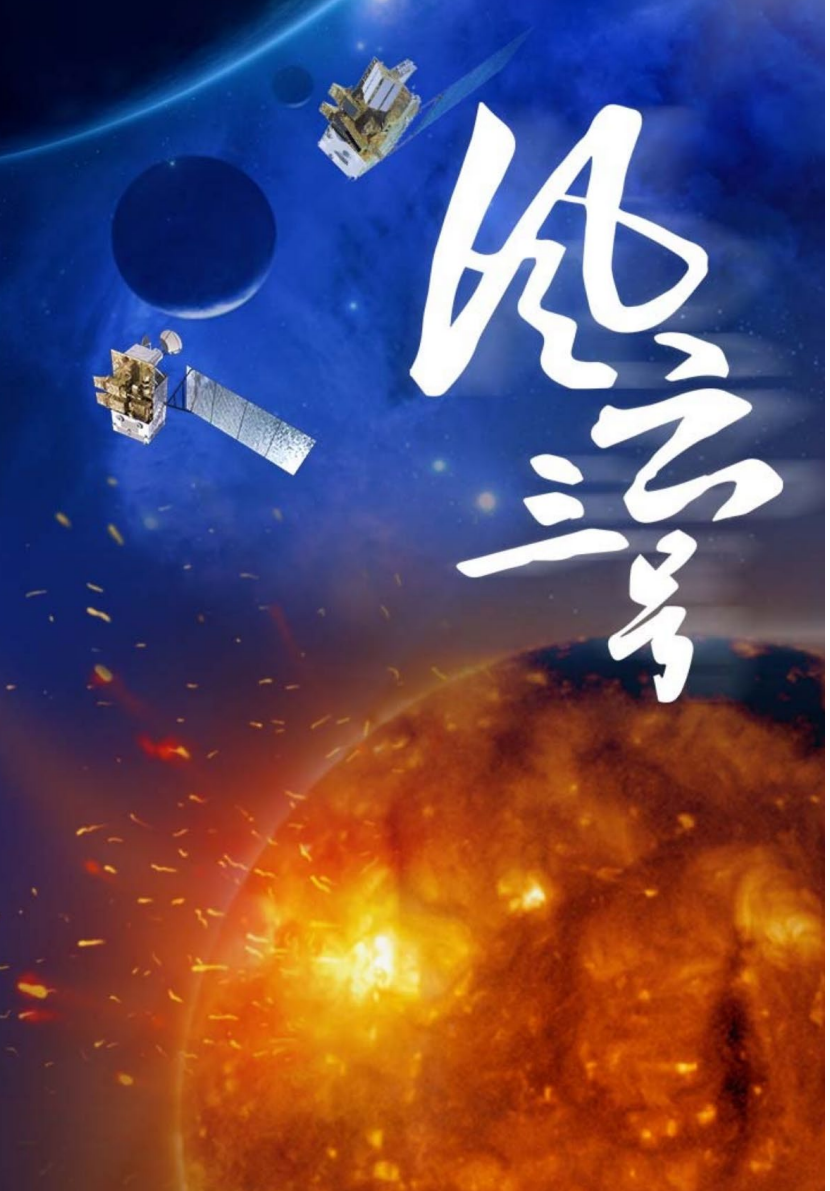
Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure*
*and Water Management*

# Summary

- WindRAD is the first dual-frequency rotating fan-beam scatterometer in orbit.
- HOC calibrates the incidence angle dependency and non-linearity in the sigma0 distribution, and NOCant calibrates the azimuth angle dependency caused by the rotating feature.
- The combined channel calibration is optimal with C-band (HOC&NOCant), Ku-band (NOCant only).
- Quality control: much lower rejection rate comparing to the other Ku band pencil-beam.

1. Li, Z.; Verhoef, A.; Stoffelen, A.; Shang, J.; Dou, F. First Results from the WindRAD Scatterometer on Board FY-3E: Data Analysis, Calibration and Wind Retrieval Evaluation. Remote Sens. 2023, 15, 2087. https://doi.org/10.3390/rs15082087

2. Li, Z.; Stoffelen, A.; Verhoef, A.; Wang, Z.; Shang, J.; Yin, H. Higher-Order Calibration on WindRAD scatterometer winds. AMT, 2023, 16(20), 4769-4783. https://doi.org/10.5194/amt-16-4769-2023

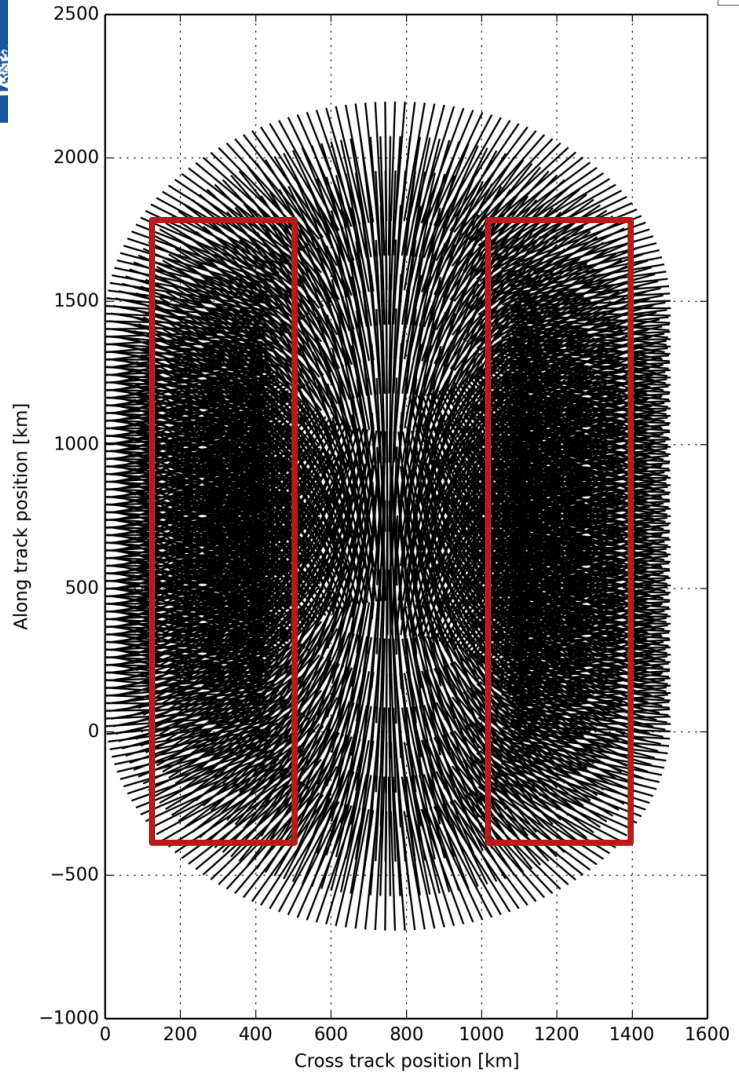


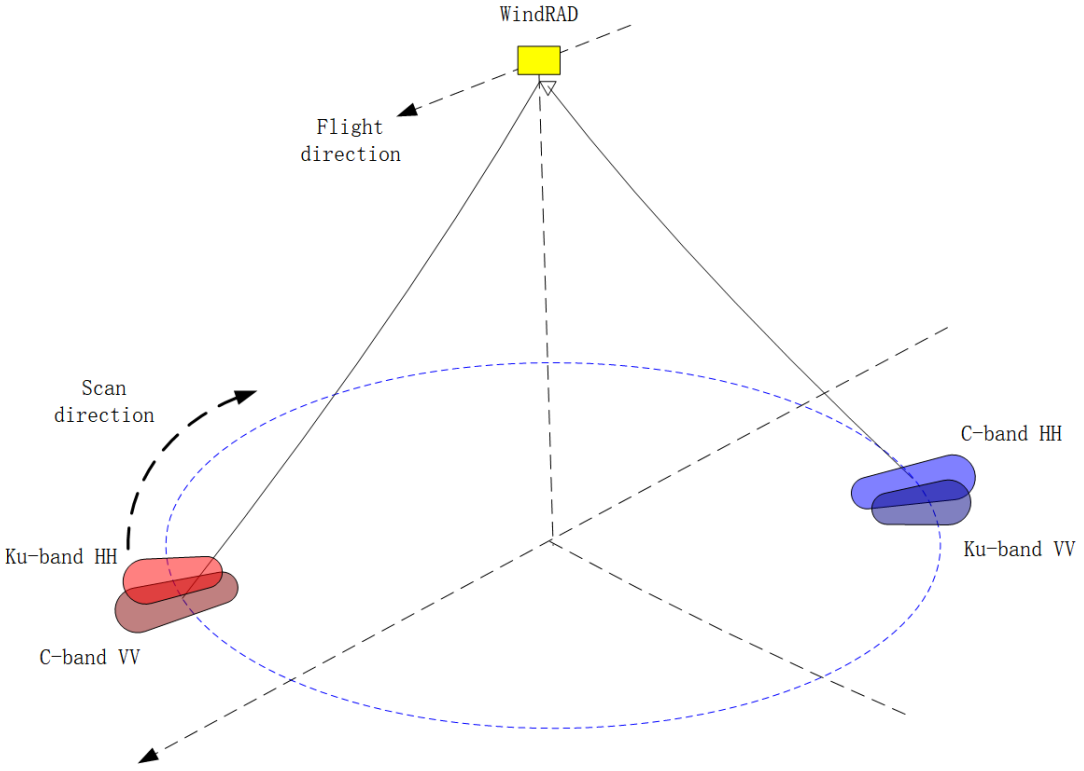
Thank you for listening, questions?

zhen.li@knmi.nl



Picture credit from CMA


2500
2000
1500
1000
500
0
−500
−1000
Along track position [km]
0
200
400
600
800
1000
1200
1400
1600
Cross track position [km]


WindRAD
Flight direction
Scan direction
C-band HH
Ku-band VV
Ku-band HH
C-band VV