Review of the NSCAT GMF in Ku-band Scatterometer Wind Retrieval

Zhixiong Wang[1], Ad Stoffelen[2], Anton Verhoef[2], Wenming Lin[1], Juhong Zou[3]

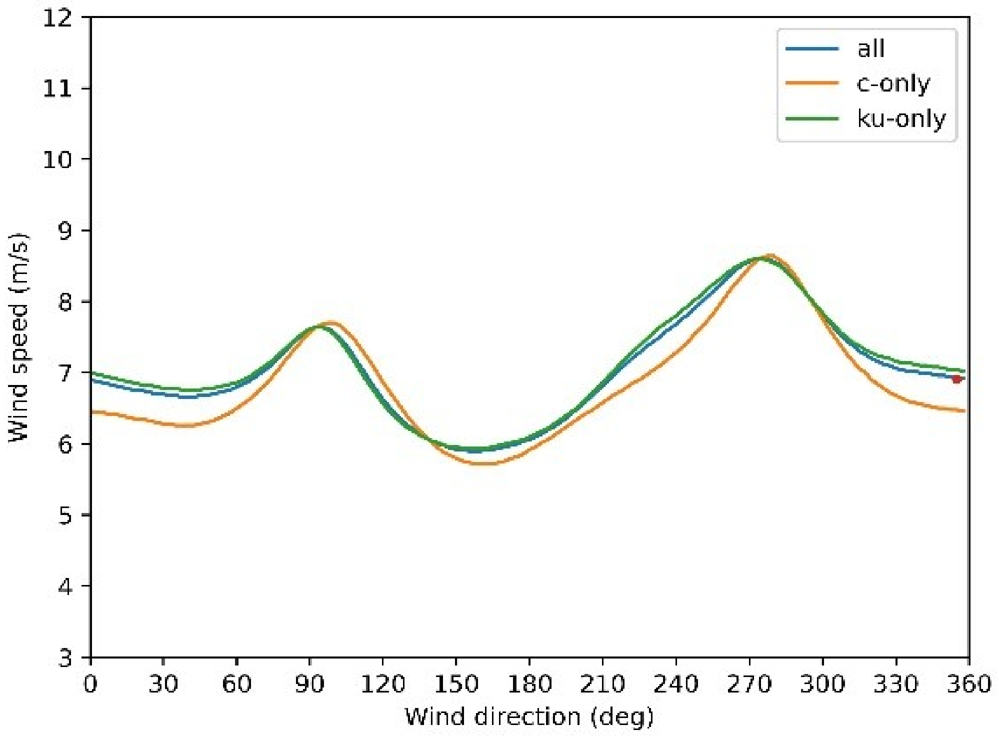
[1]Nanjing University of Information Science & Technology

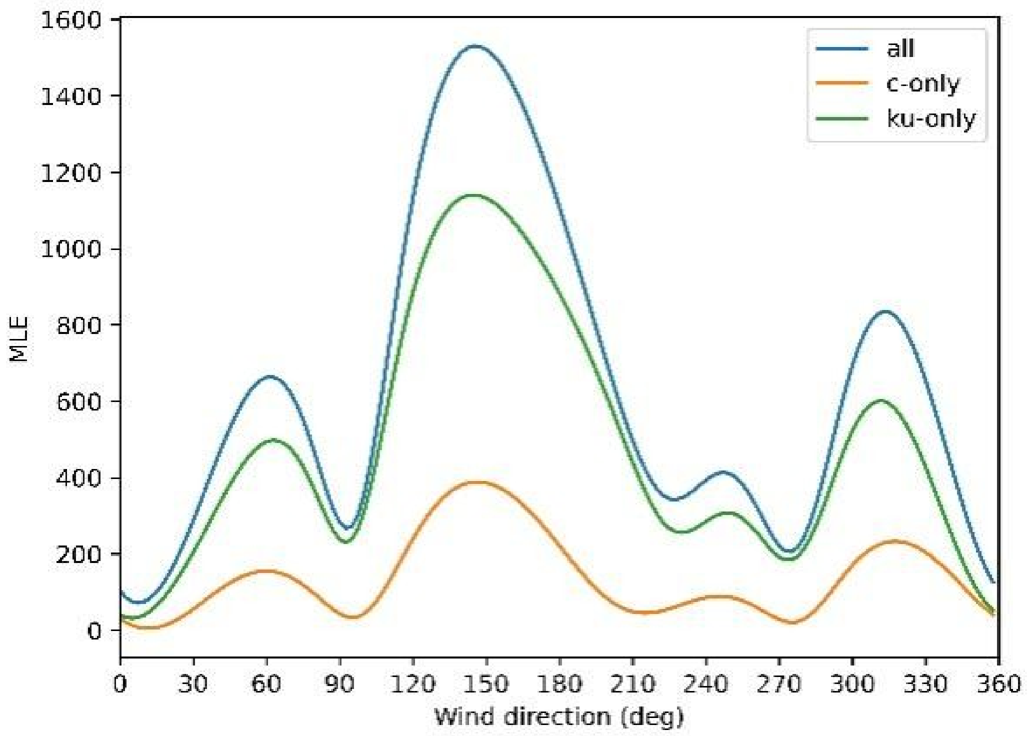
[2]Royal Netherlands Meteorological Institute

[3]National Satellite Ocean Application Service

Methodology

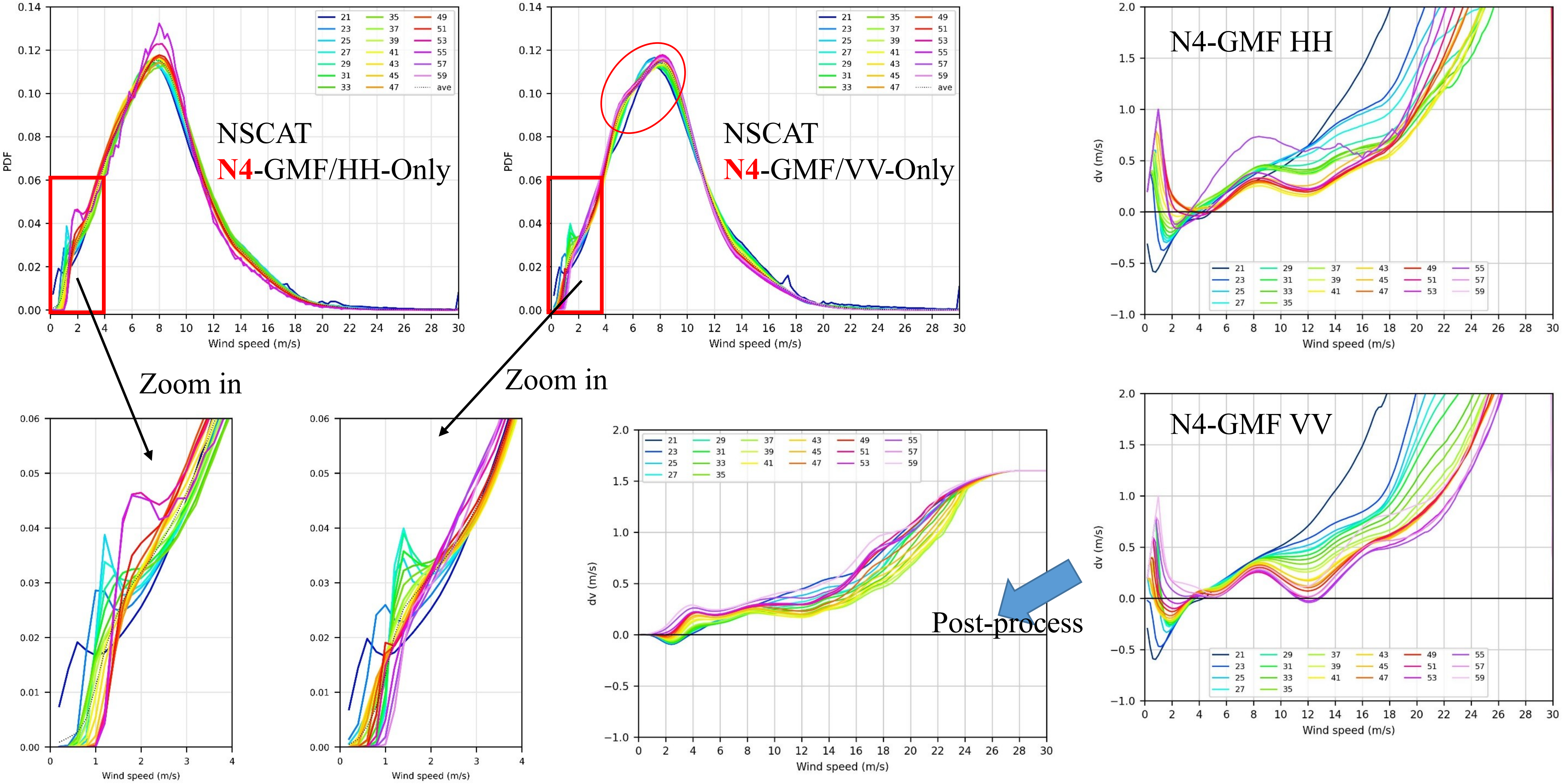
- During the wind retrieval process, we first find the "best-matched" wind speed for each potential wind direction. Subsequently, we perform wind direction ambiguity removal to select the "optimal" wind direction for each WVC.
- Once the wind direction is established for a WVC, we then examine the corresponding "best-matched" wind speed values obtained from each individual View.
- The differences between the View-specific and the WVC wind speed provide valuable insights into the **consistency** of measurements across different Views.





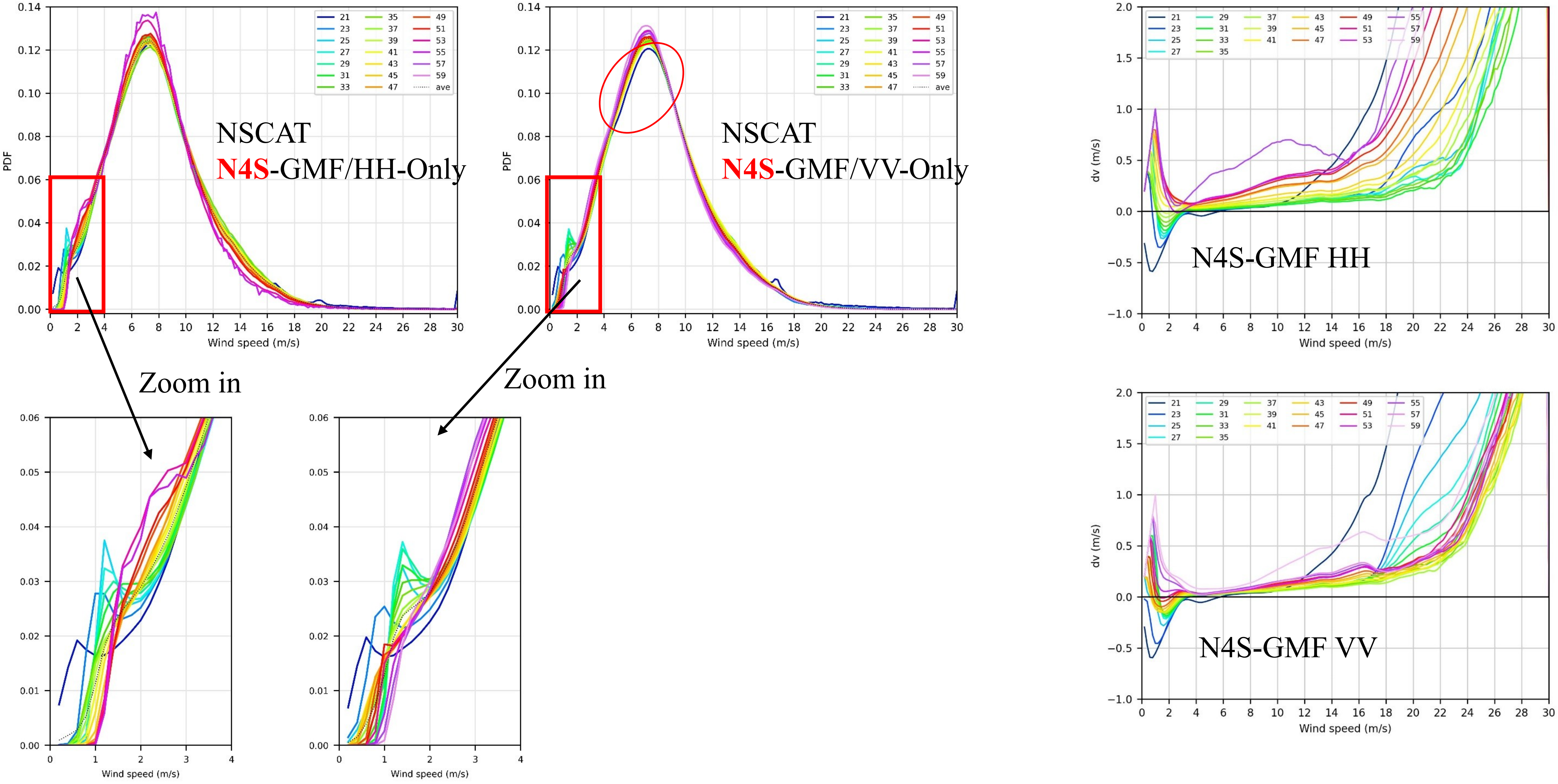
Ku-band ADEOS-1/NSCAT scatterometer winds

CDF Matching ➔ ΔV for GMF

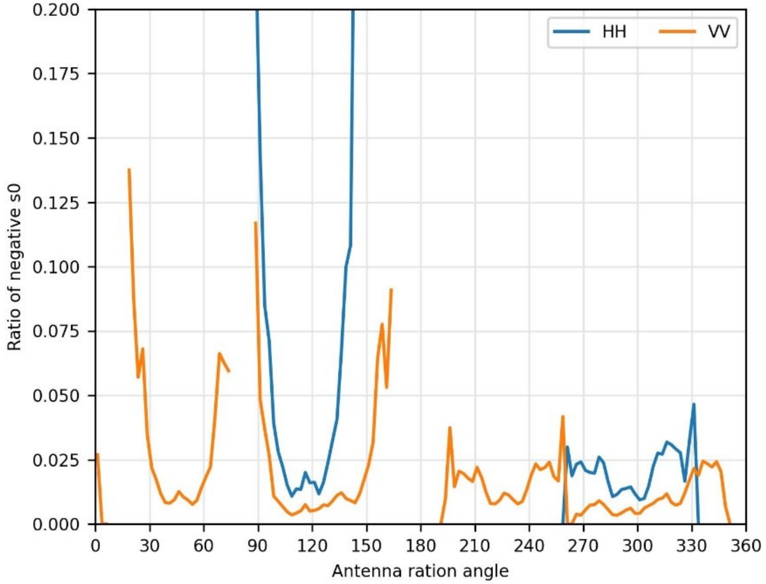


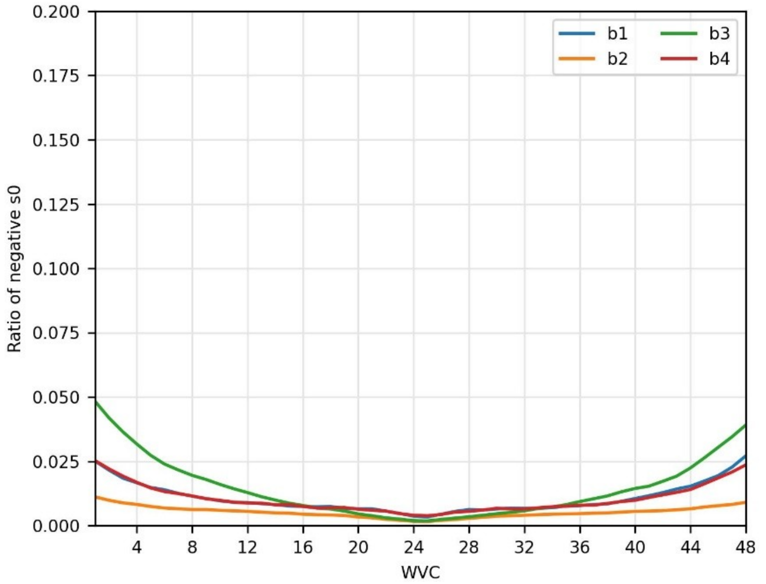
Ku-band ADEOS-1/NSCAT scatterometer winds

CDF Matching ➔ ΔV for GMF

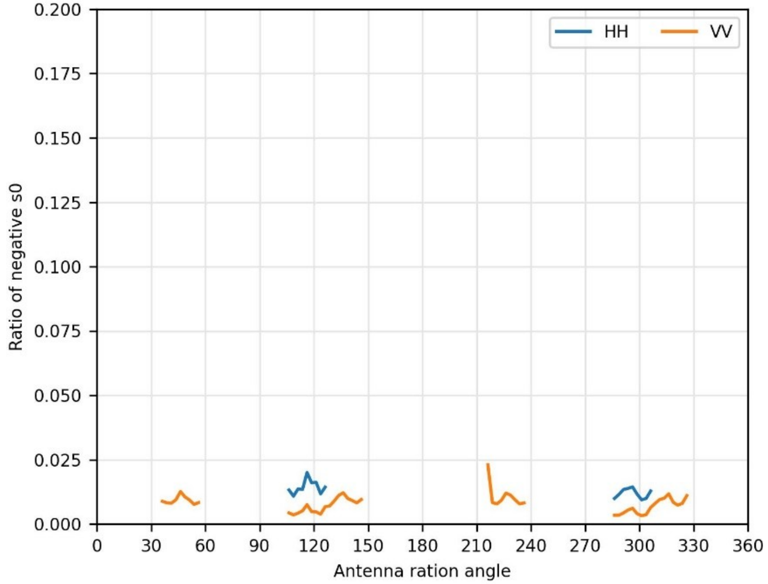


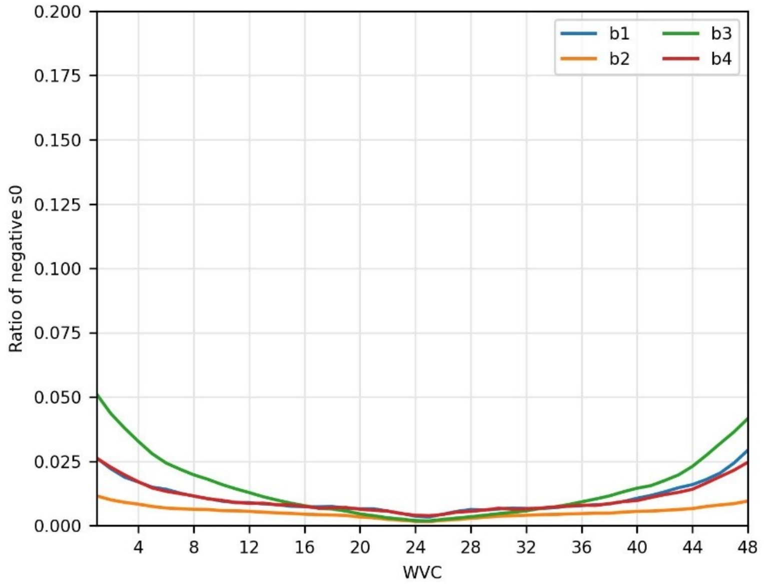
Ku-band ADEOS-1/NSCAT scatterometer winds





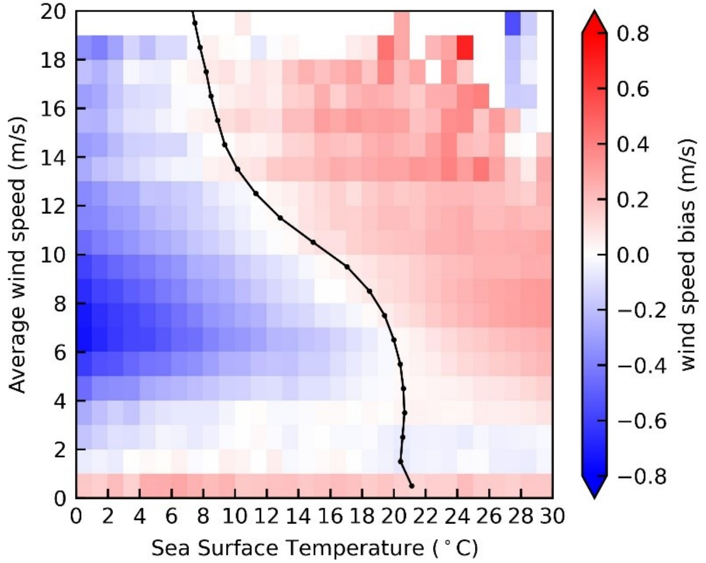
High ratio of negative Sigma0 at sidelobe,
Thus we limit the antenna azimuth for each beam

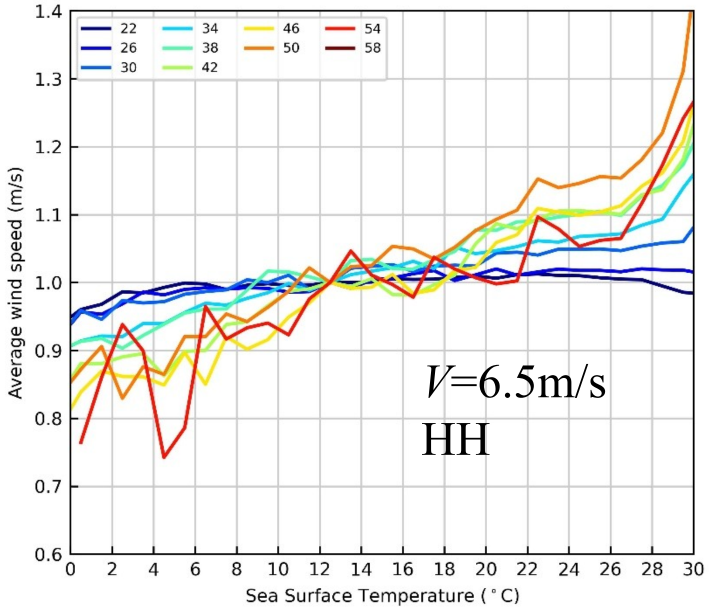


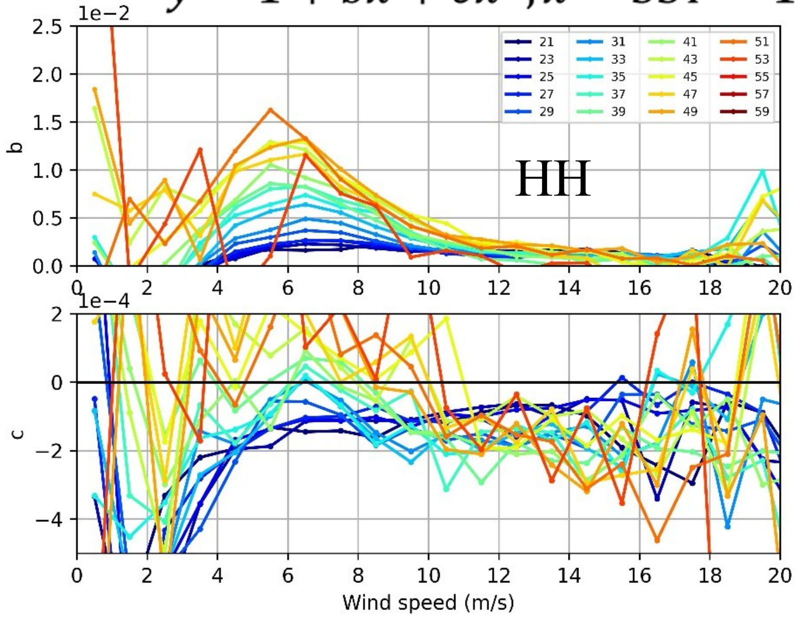


SST Effects on Ku-band ADEOS-1/NSCAT scatterometer winds

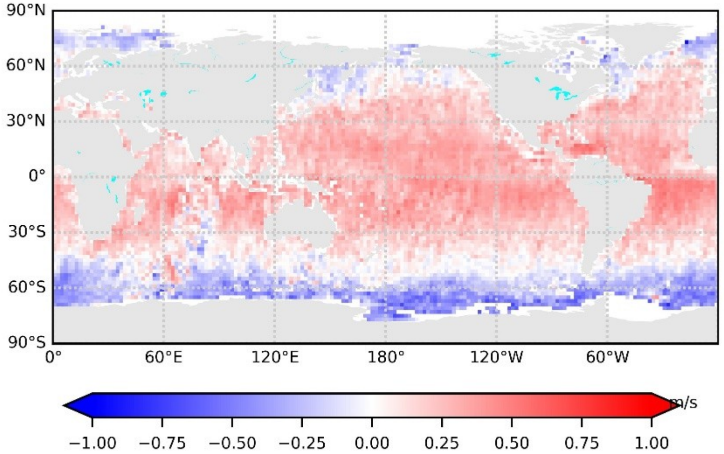
$$y = 1 + bx + cx^2, x = SST - 12.5$$

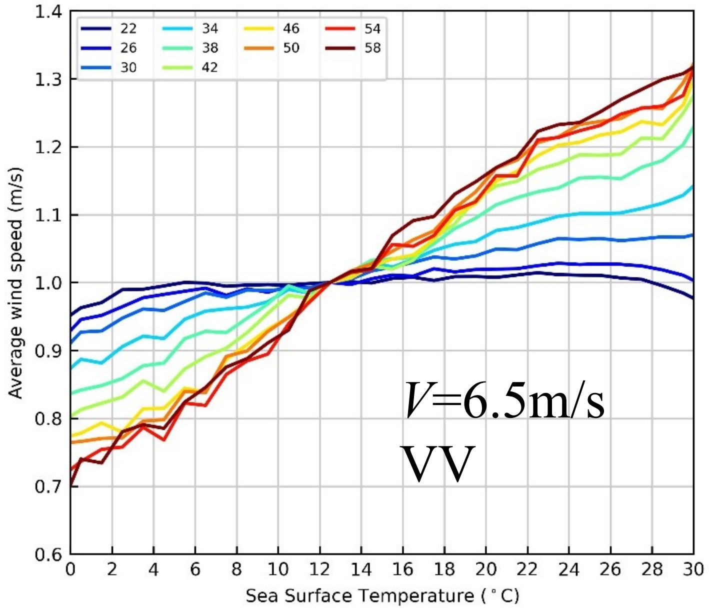




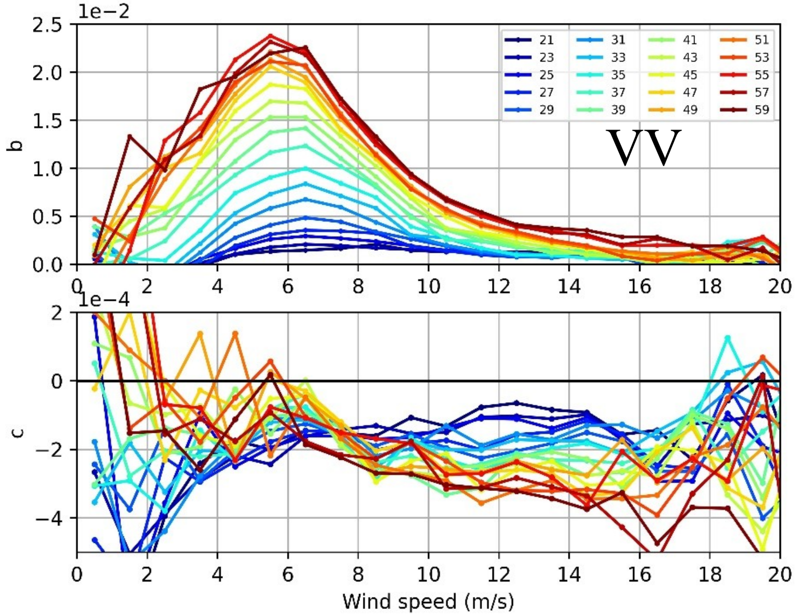


ΔV=NSCAT/N4 – ERA/SCA





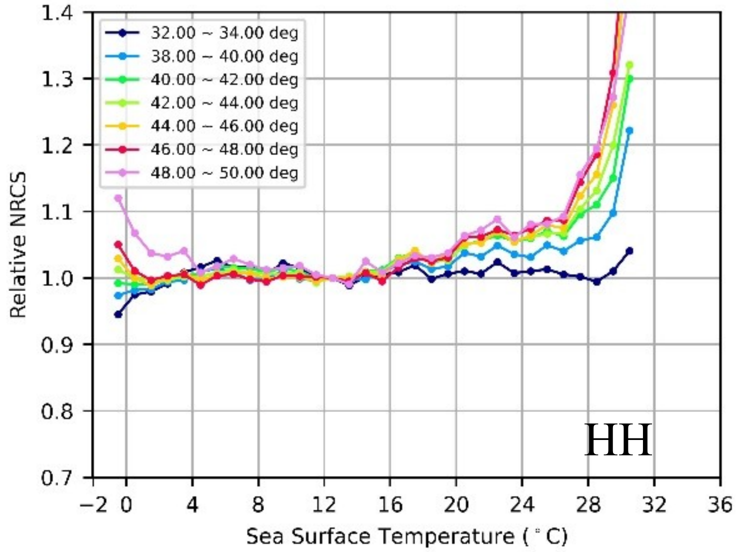
y=1+bx+cx^2, x=T-$T_{12.5}$

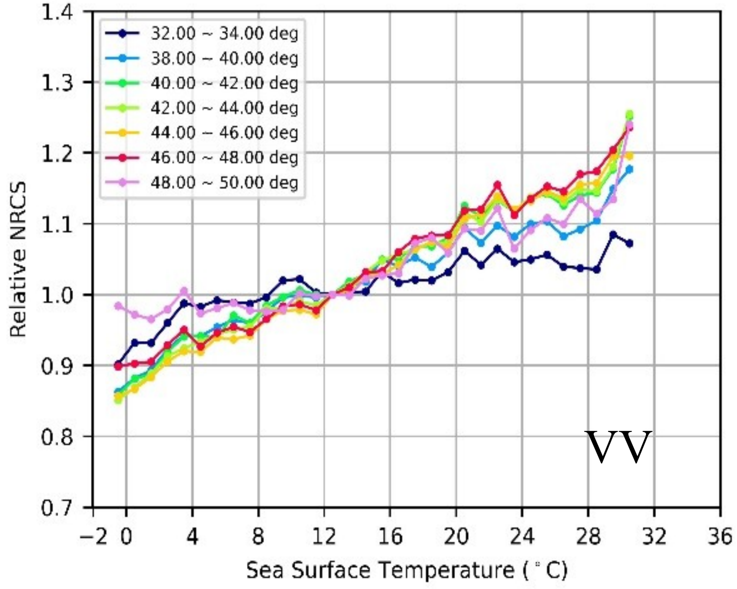


SST effects on Ku-band sigma0 measurements, for the cases of CFOSAT/SCA and FY-3E/WindRAD

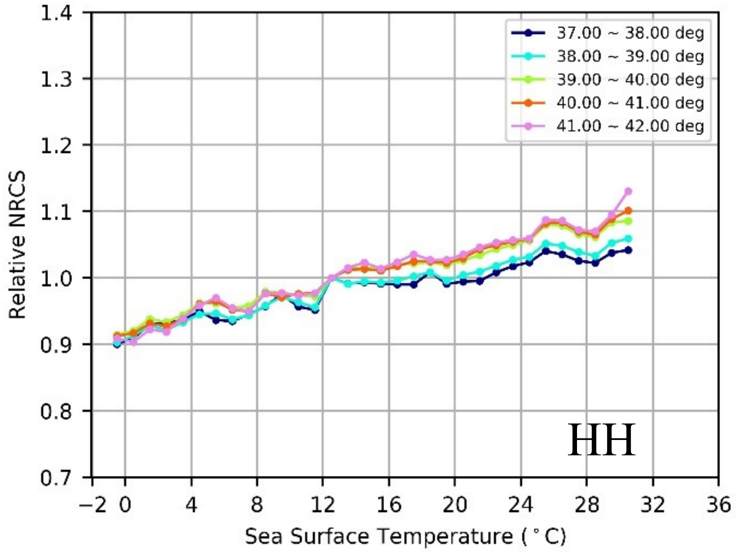
- We did **not see clear** SST effects on CFOSAT/SCA Ku-HH sigma0 measurements!
- Furthermore, SST effects on CFOSAT/SCA Ku-VV sigma0 data is **markedly weaker** than expected.

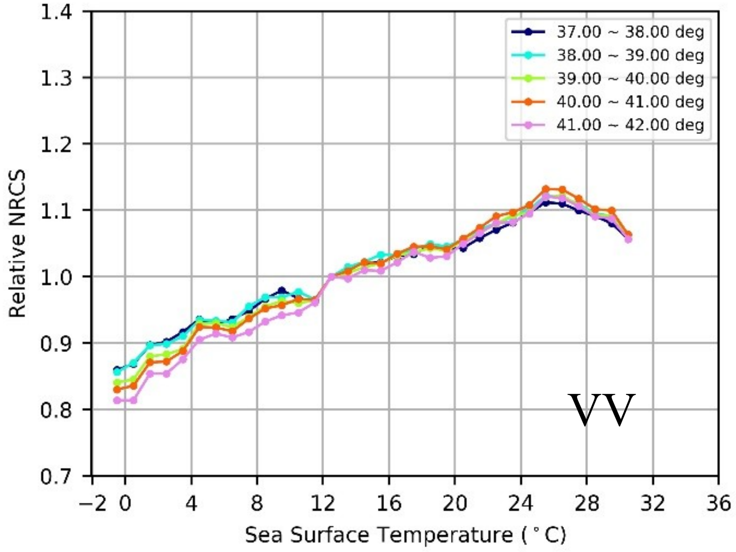
CFOSAT/SCAT





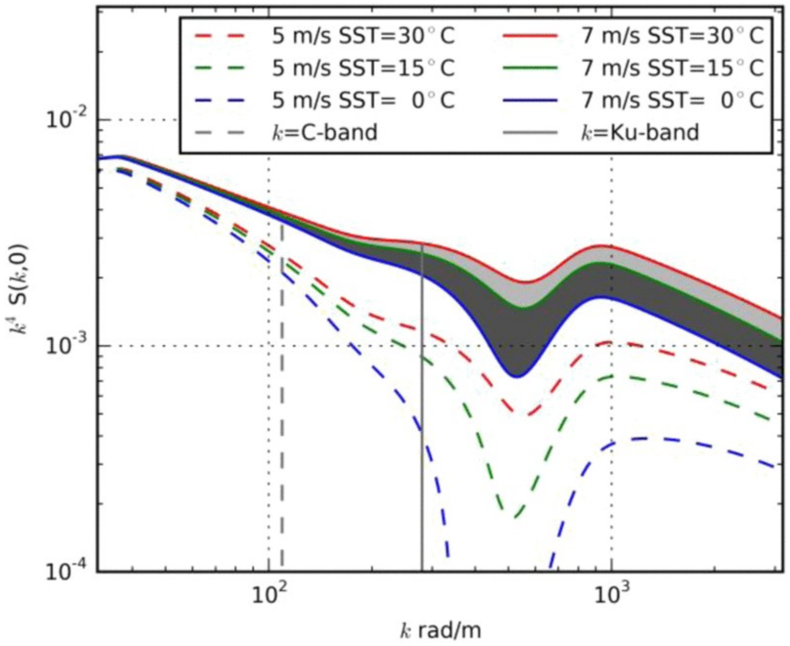
FY-3E/WindRAD-Ku



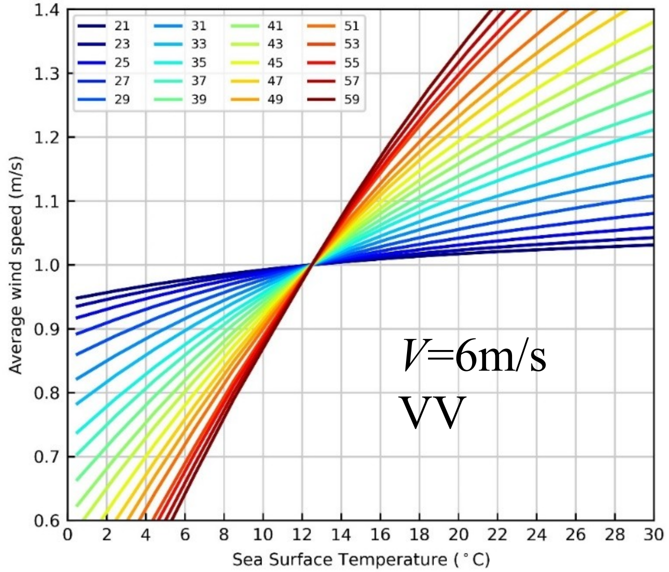


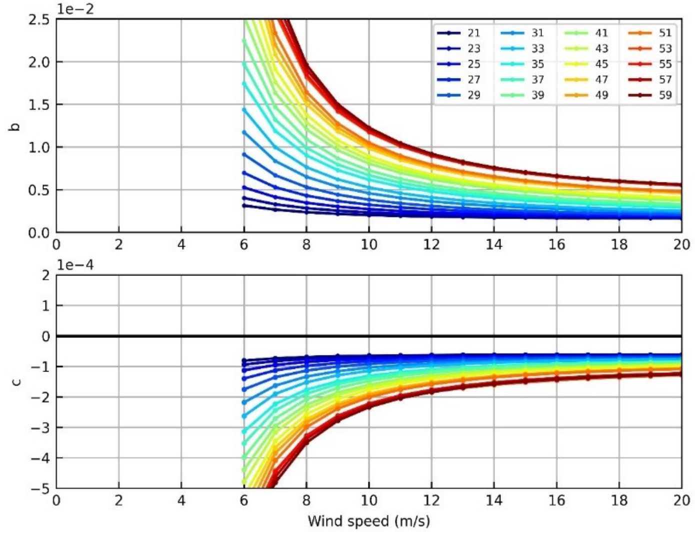
SST Effects from physics-based on

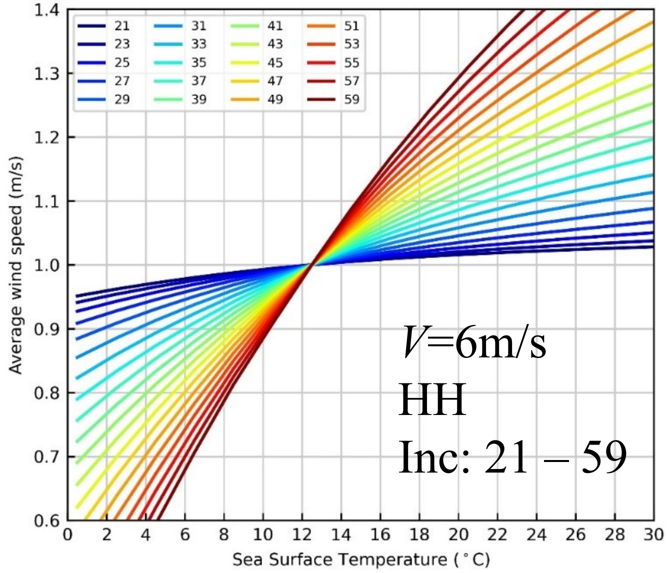
$$y = 1 + bx + cx^2, x = SST - 12.5$$

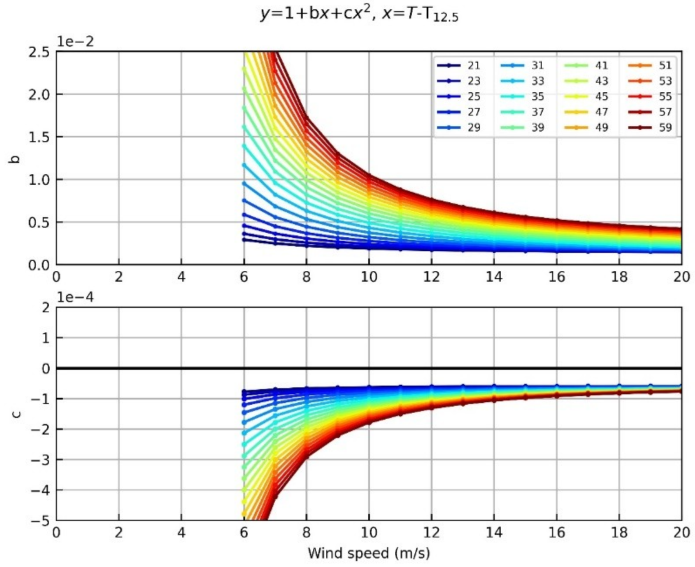


Kudryavtsev curvature spectrum for wind speed at 5 and 7 m/s, SST = 0, 15, and 30 °C in the upwind wind direction. The areas referring to 7 m/s winds are shaded to highlight the nonlinear changes between SST from 30 to 15 °C and 15 to 0 °C.

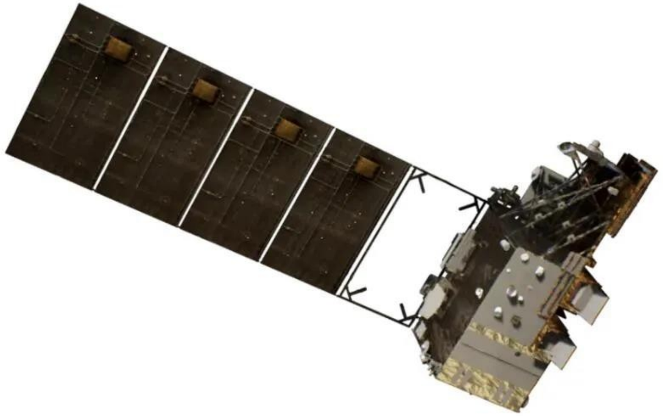


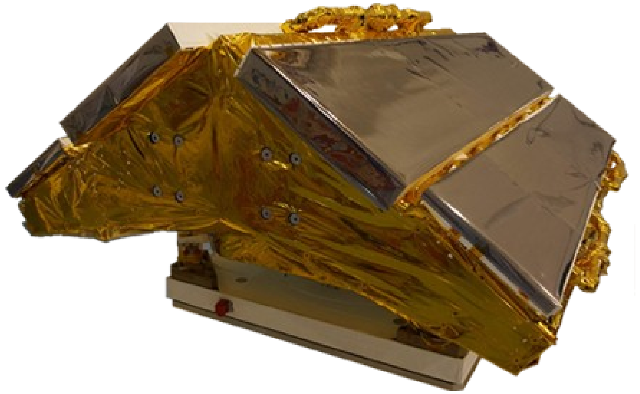






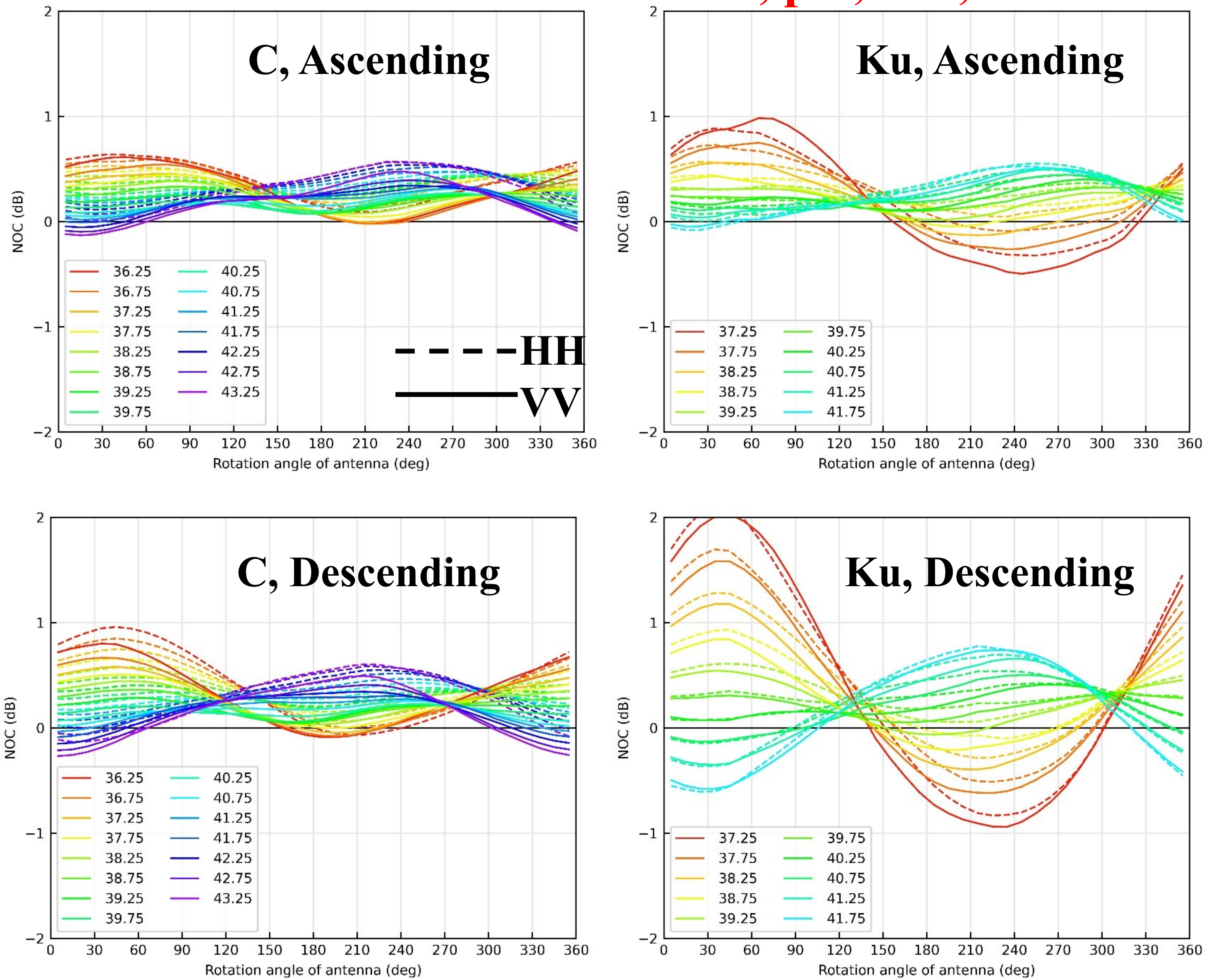
Sea surface winds retrieval from the FY-3E/WindRAD



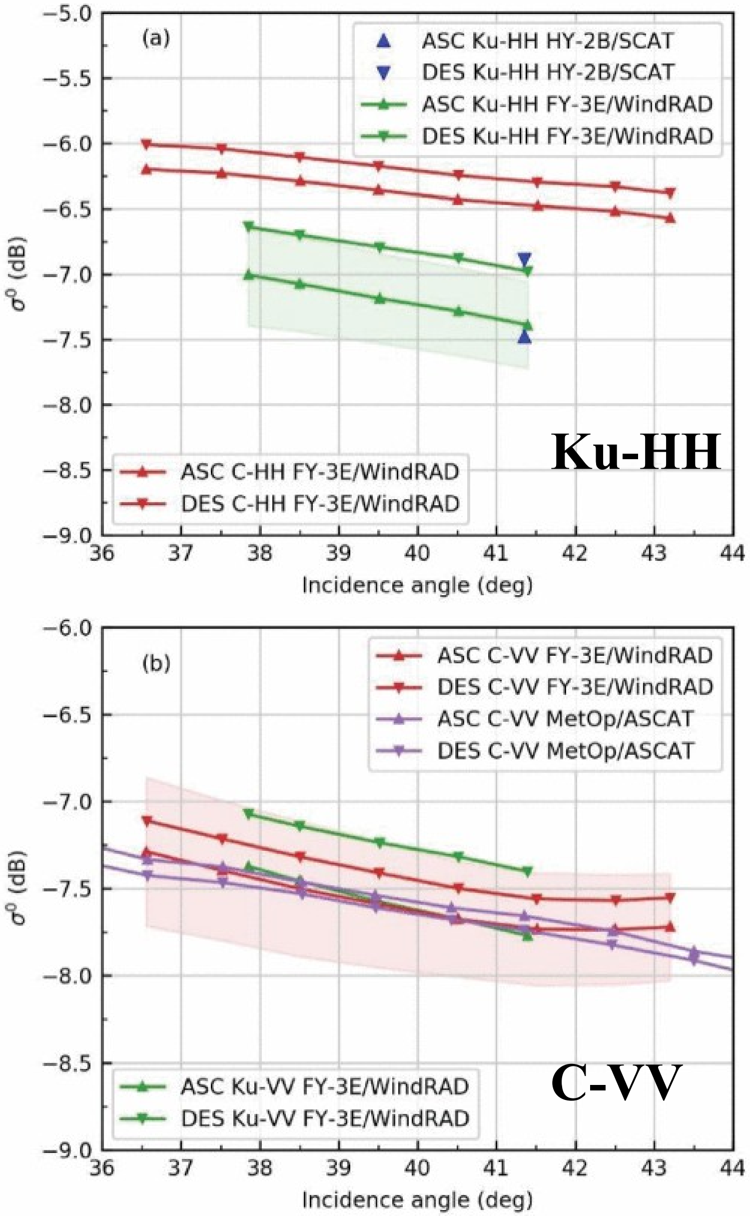


Cal/Val of WindRAD sigma0 data

NOC results <band, pol, inc., ant. >

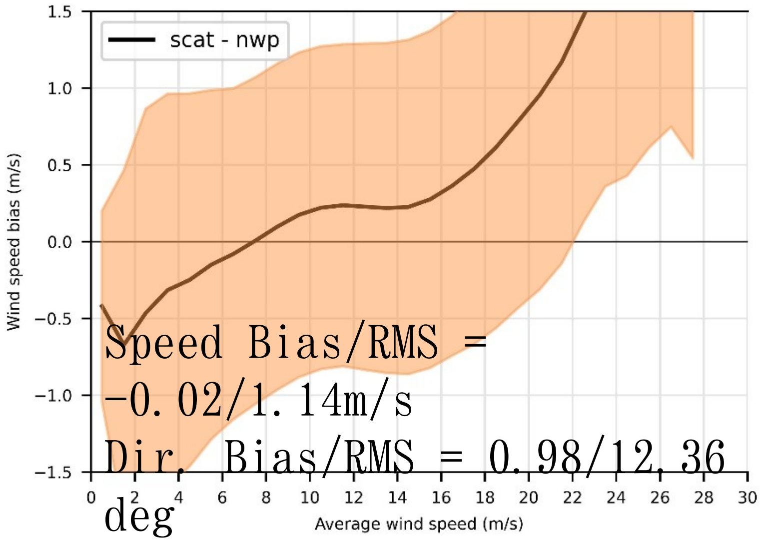


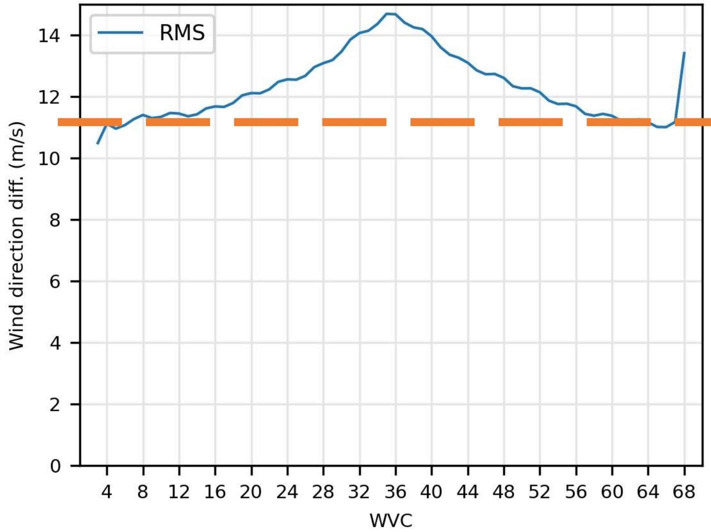
Amazon rainforest



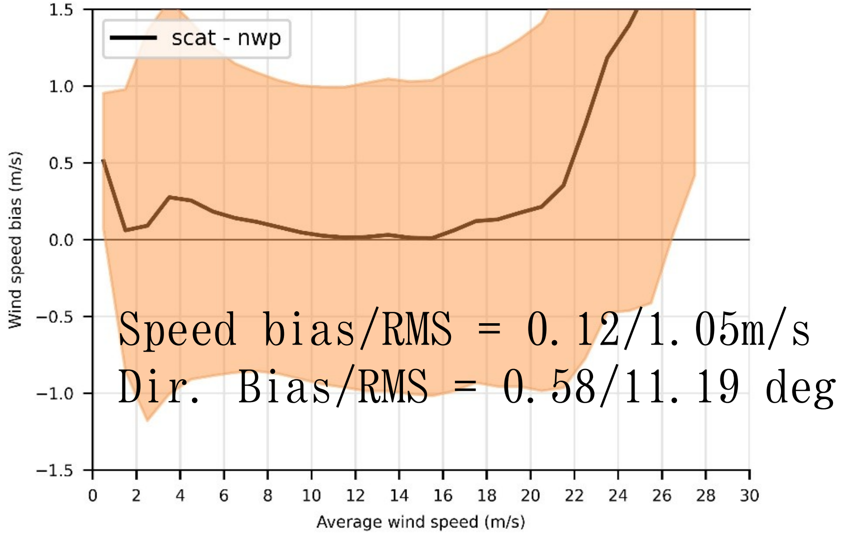
2.3 Error characteristics of WindRAD wind products (old version)

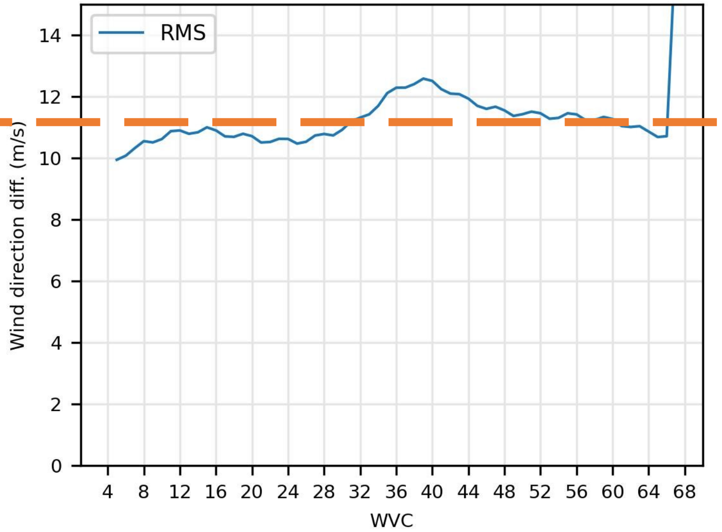
C-only



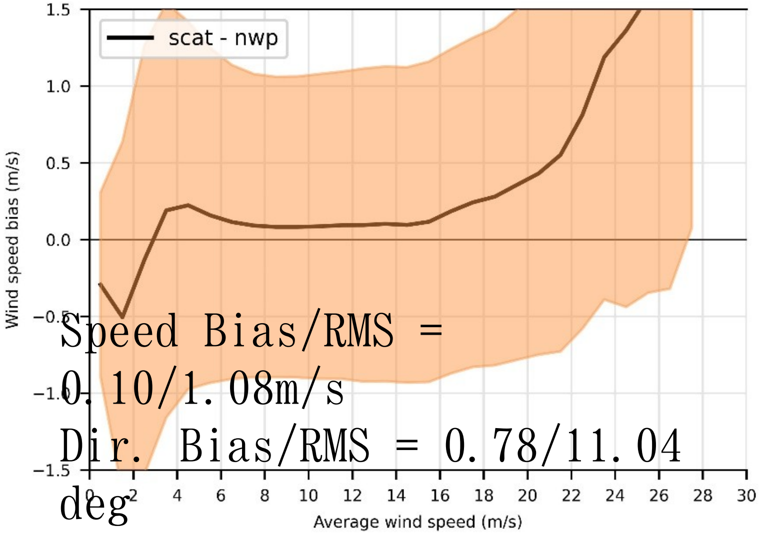


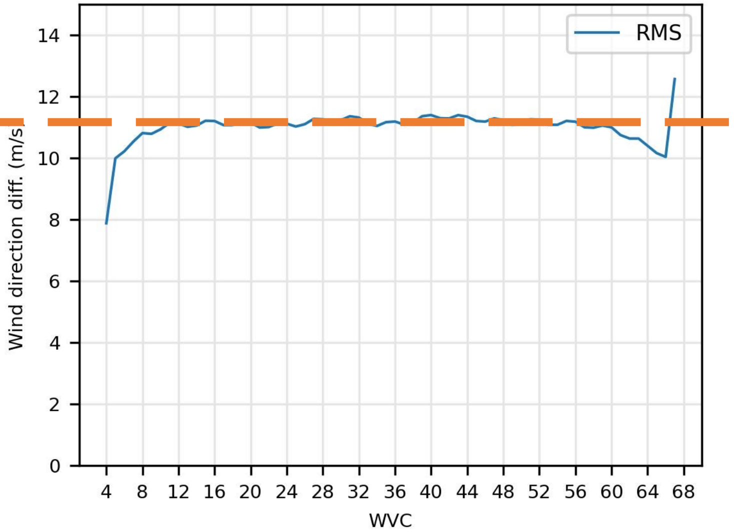
Ku-only



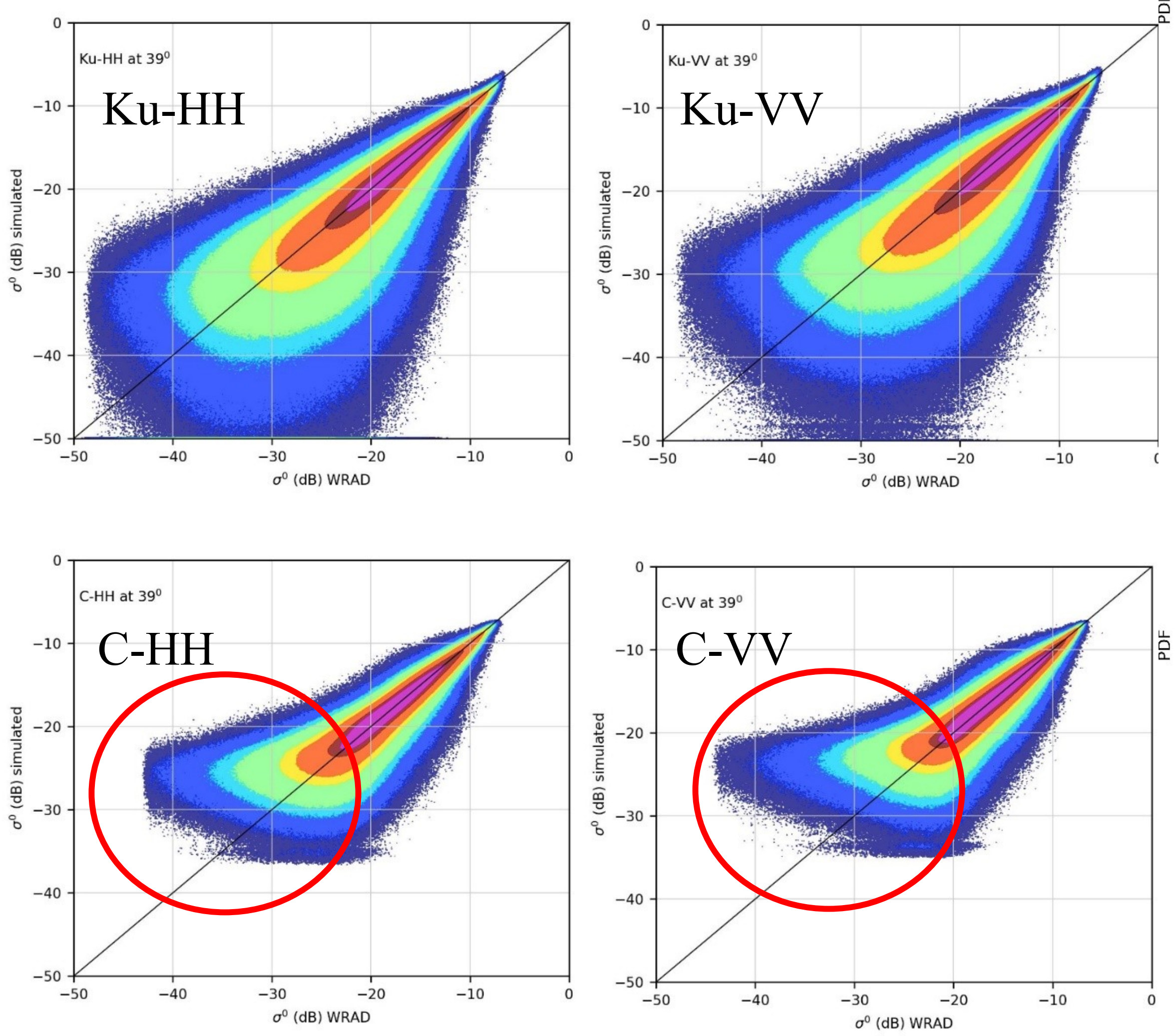


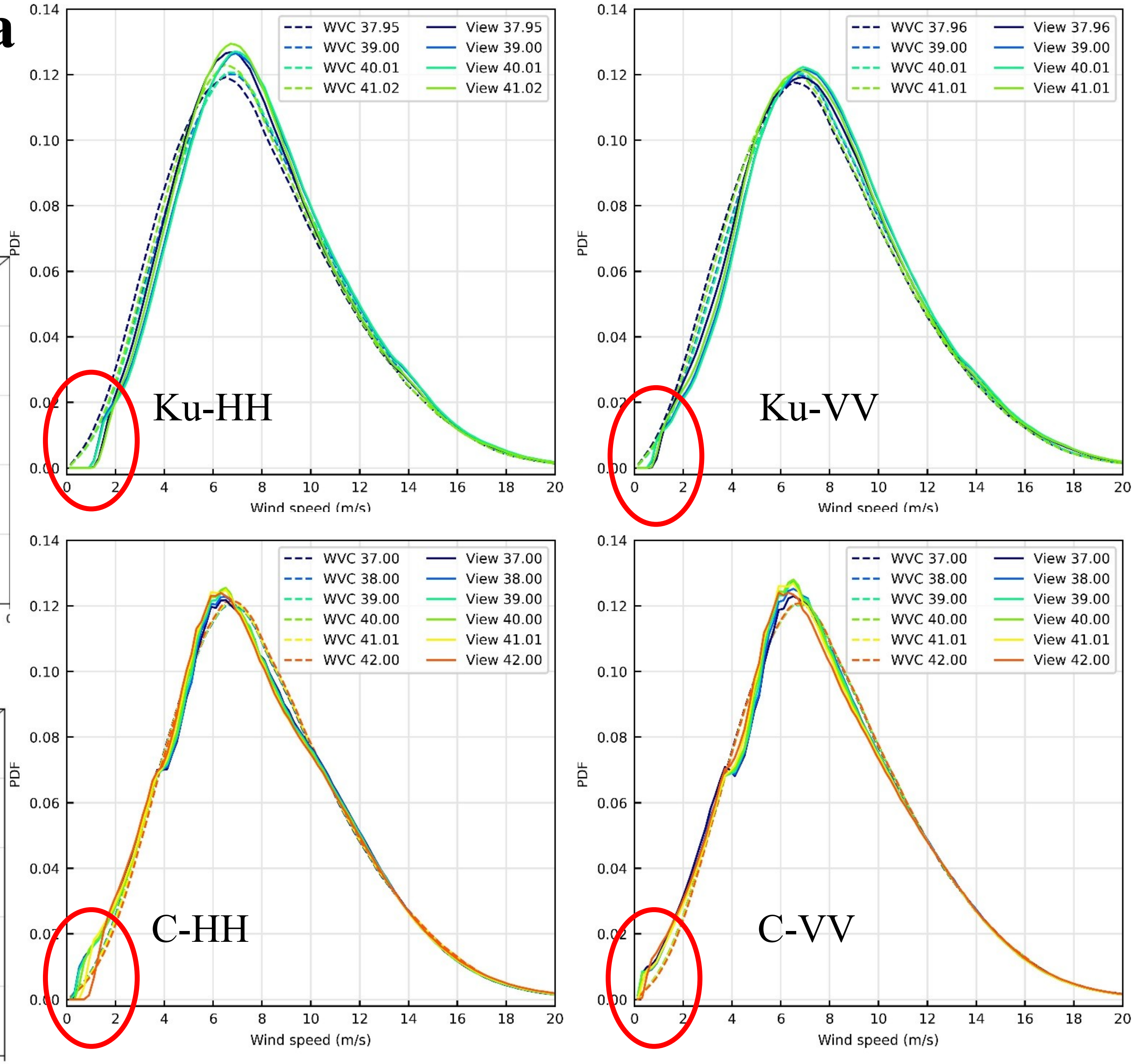
C & Ku





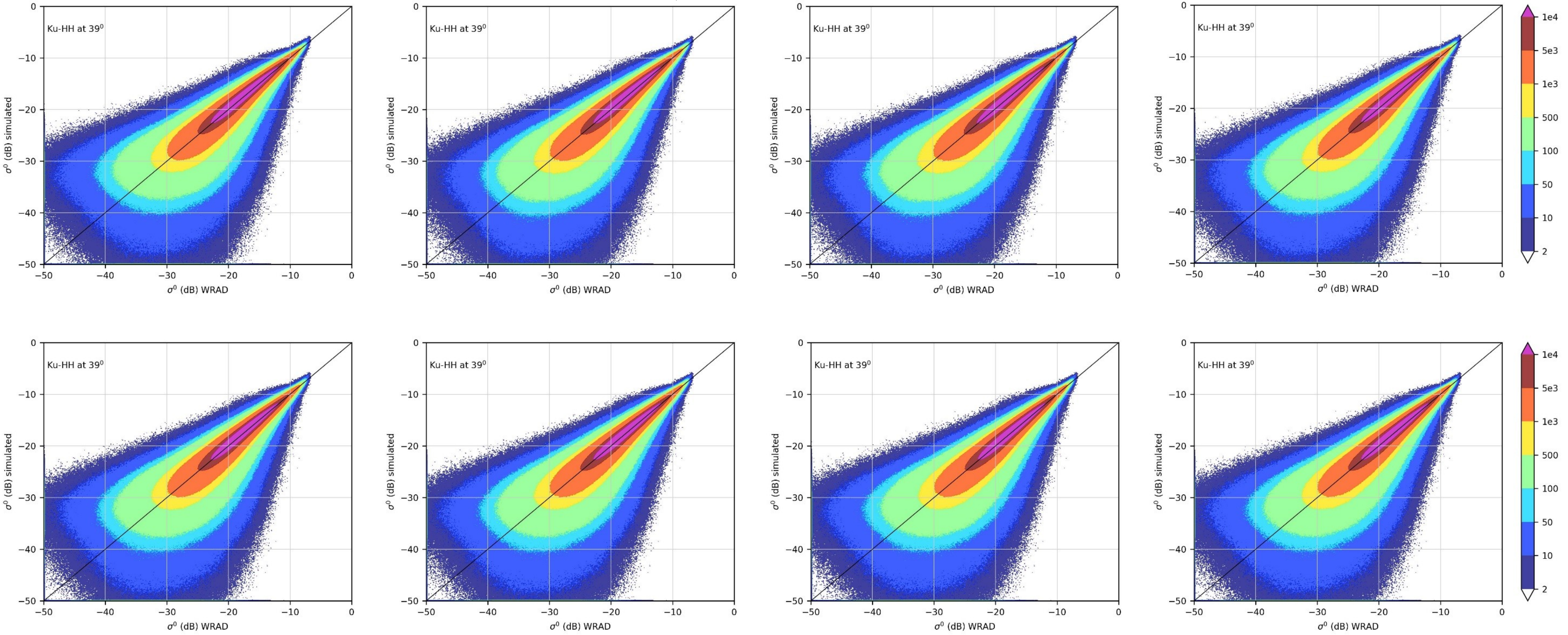
Cal/Val of WindRAD sigma0 data





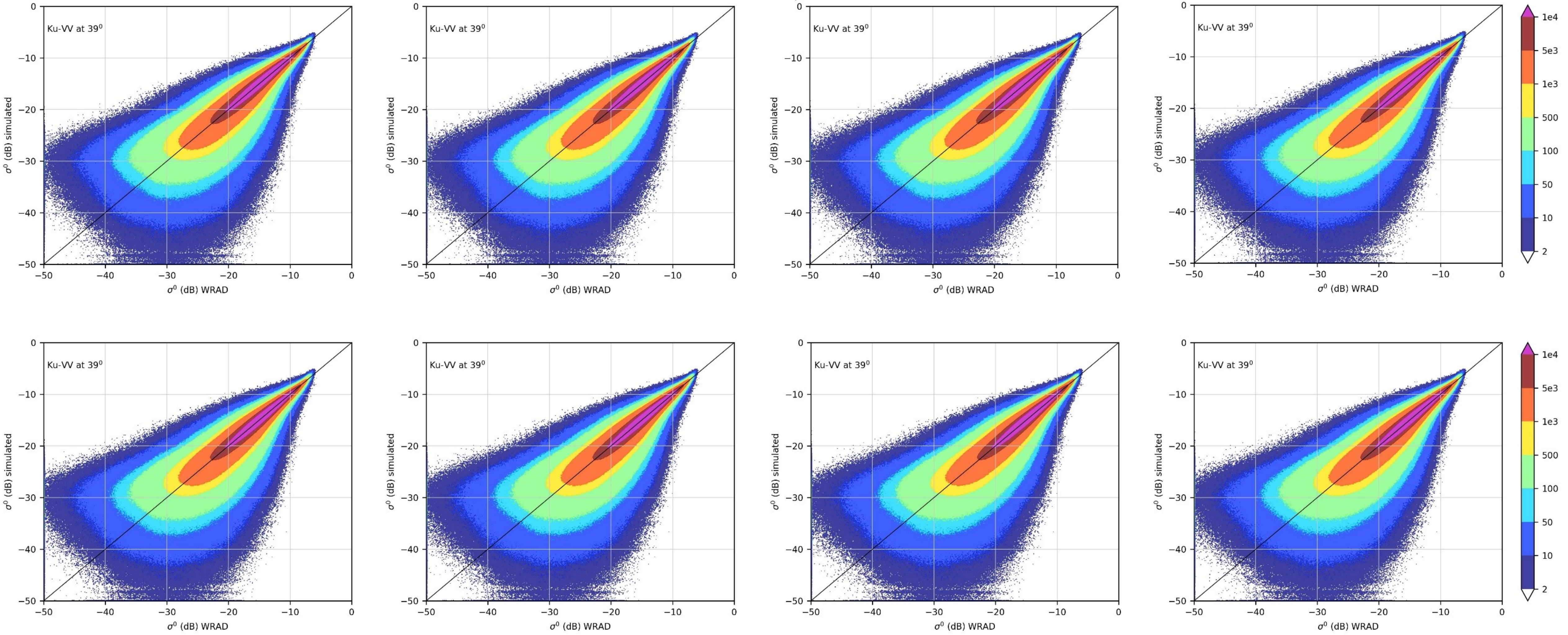
Cal/Val of WindRAD sigma0 data

Ku-HH, s0 = s0 – 0.00001*i

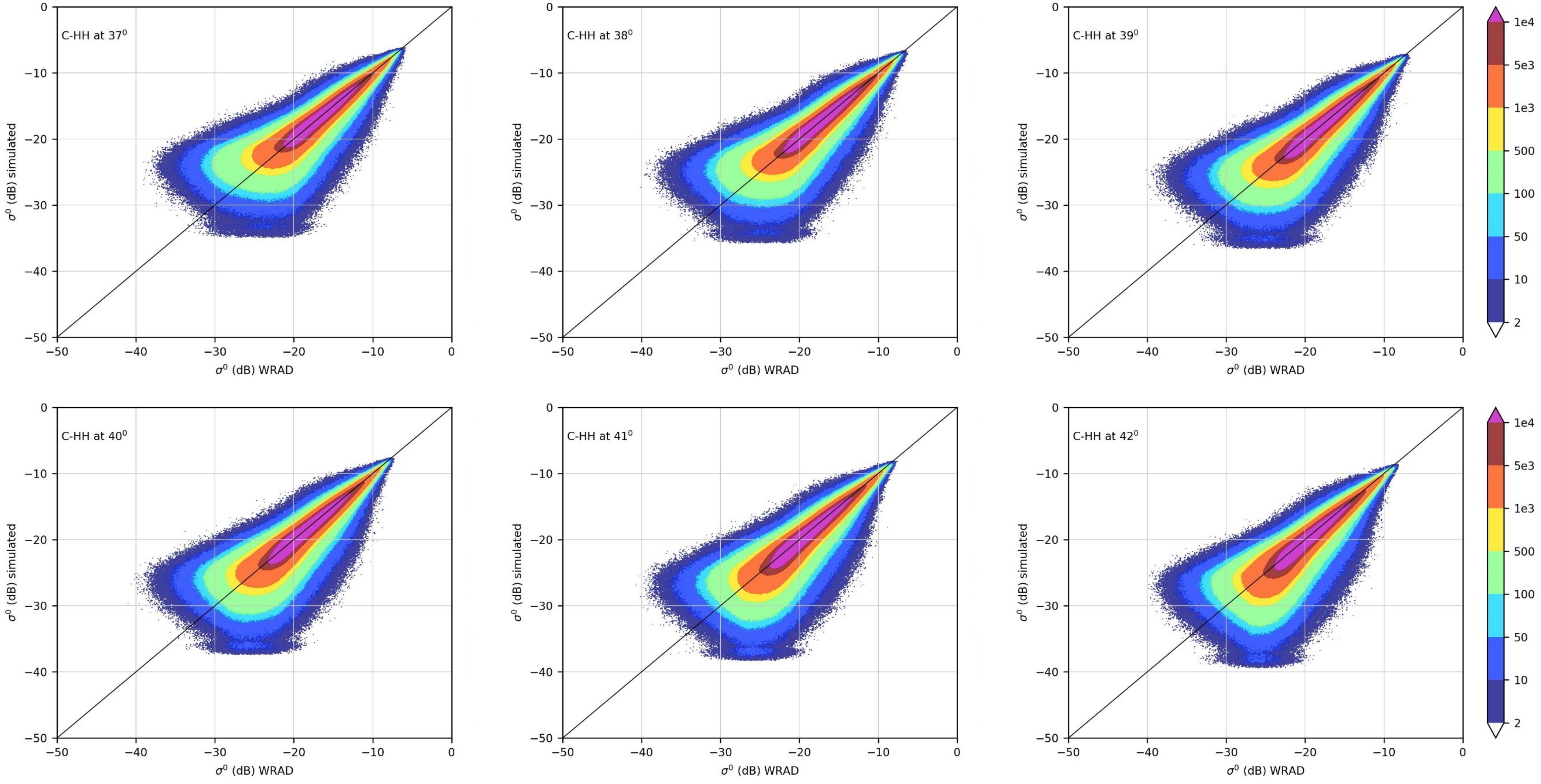


Cal/Val of WindRAD sigma0 data

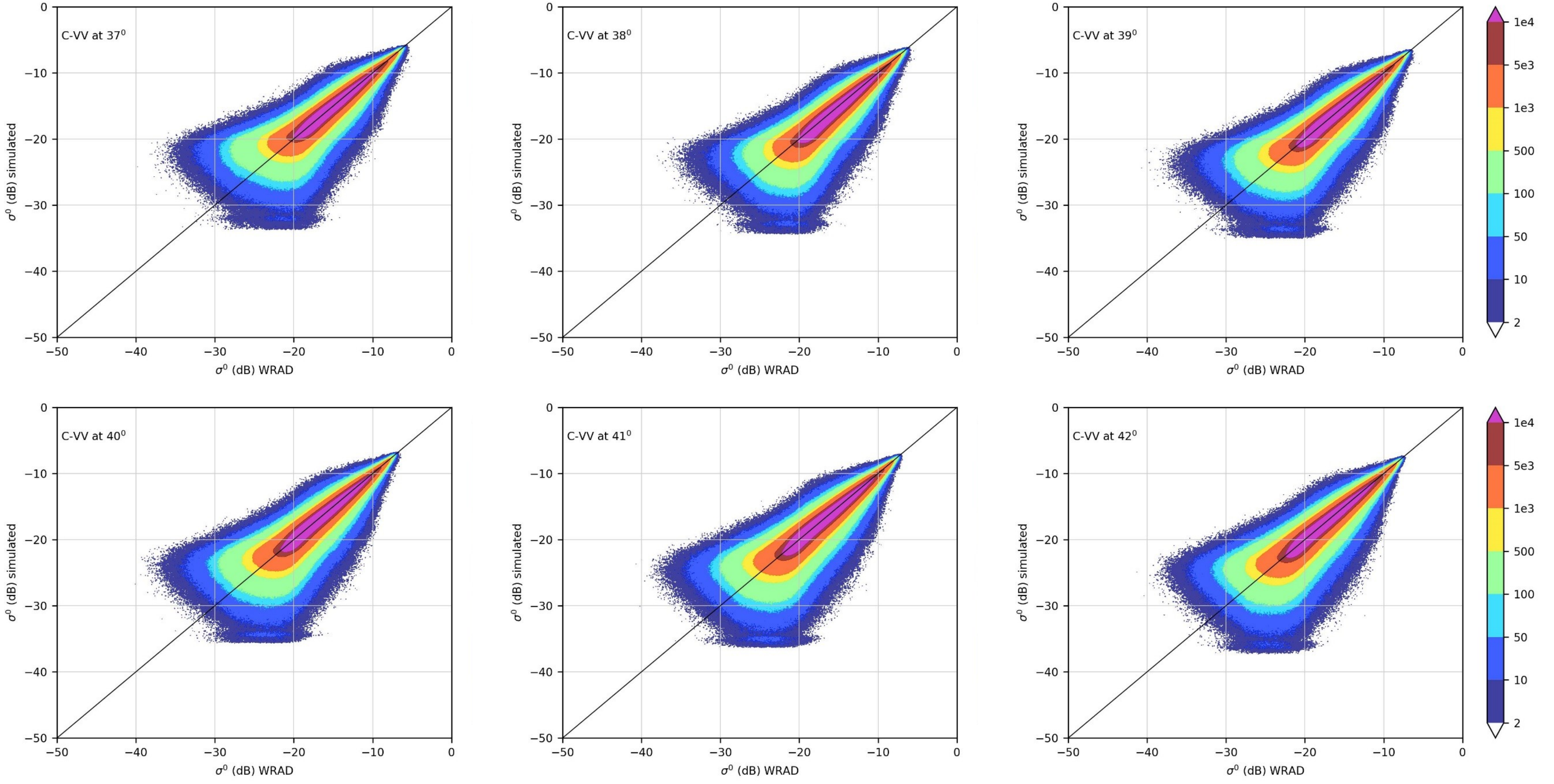
Ku-VV, s0 = s0 – 0.00001*i



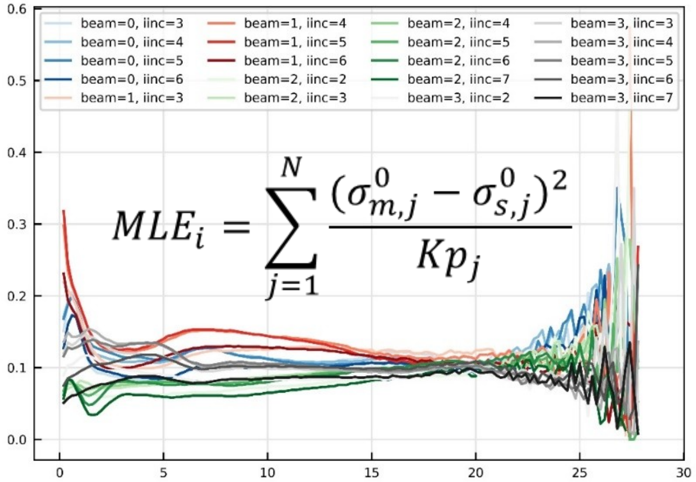
C-HH, s0 = s0 +[0.001+ $(\theta - 37)$*0.0002)*Random



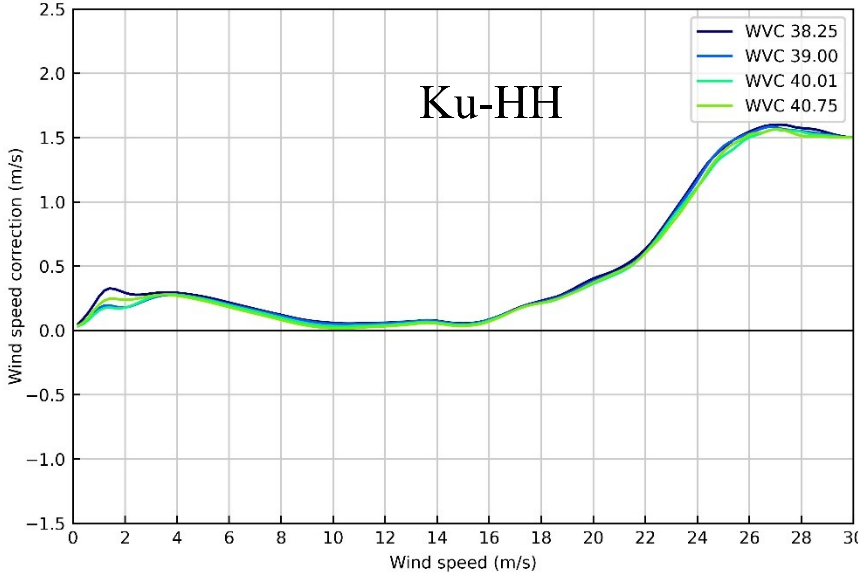
C-VV, s0 = s0 +0.0018*Random

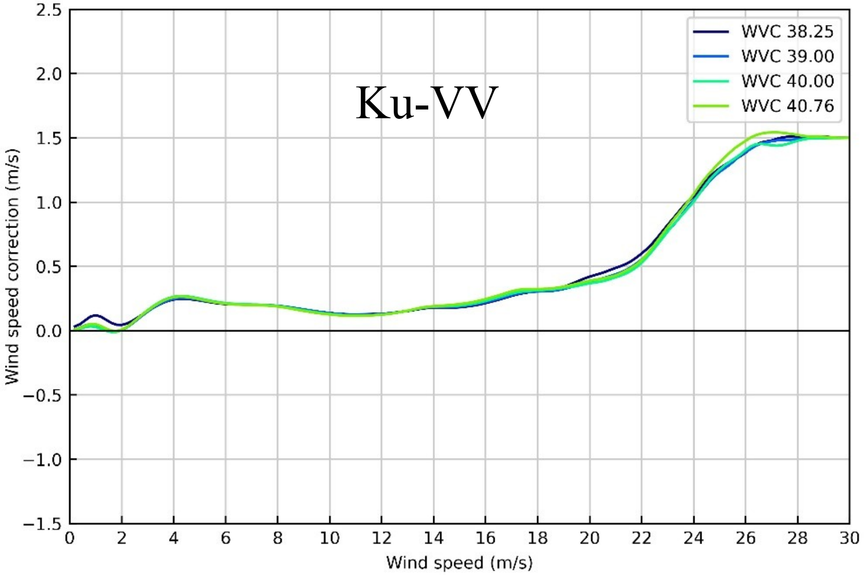


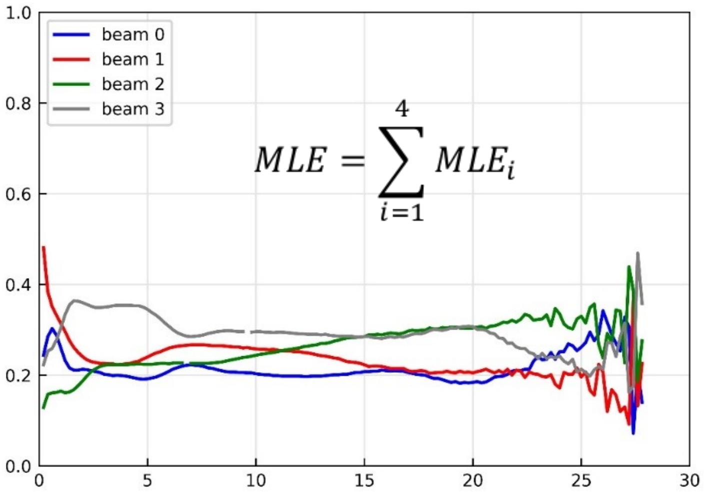
Adapt GMFs to further improve consistencies among four beams



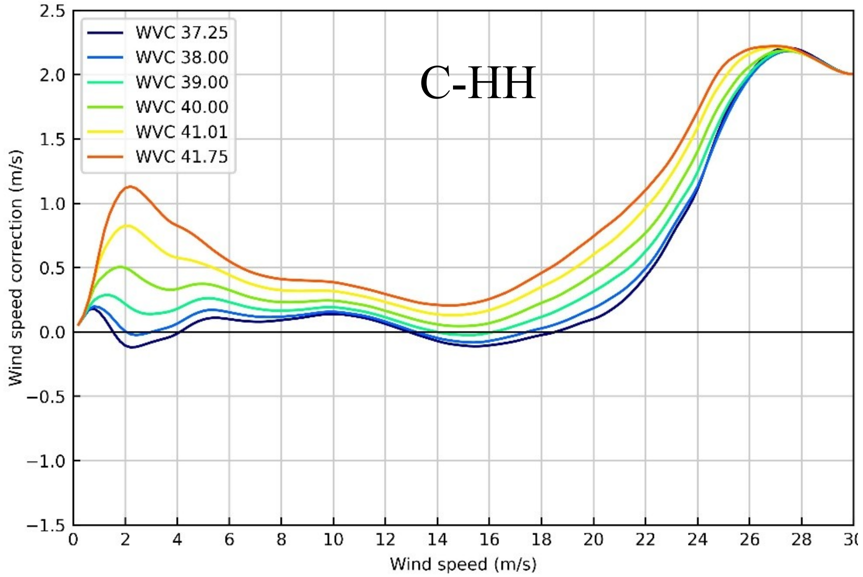
$$MLE_i = \sum_{j=1}^{N} \frac{(\sigma^0_{m,j} - \sigma^0_{s,j})^2}{Kp_j}$$

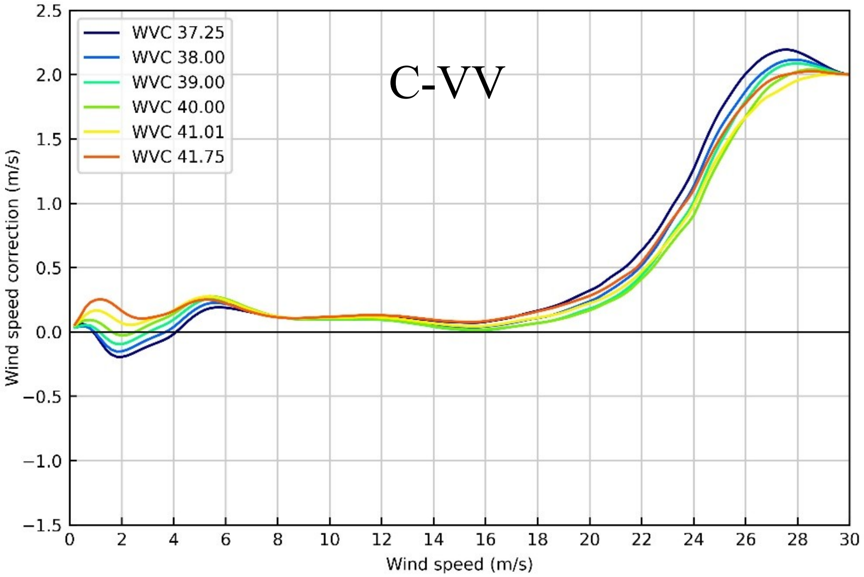




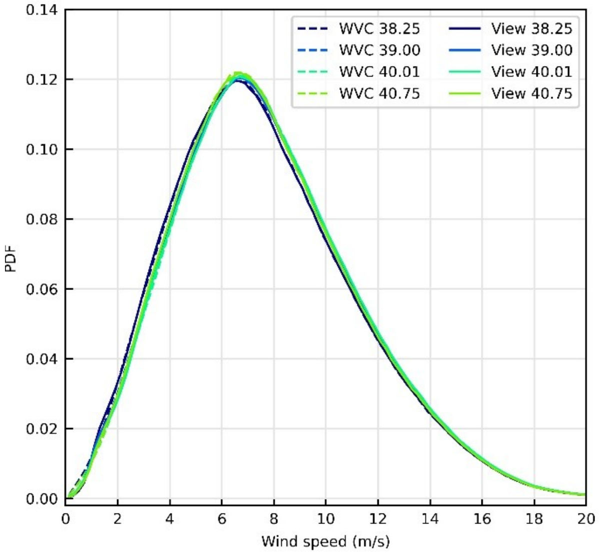


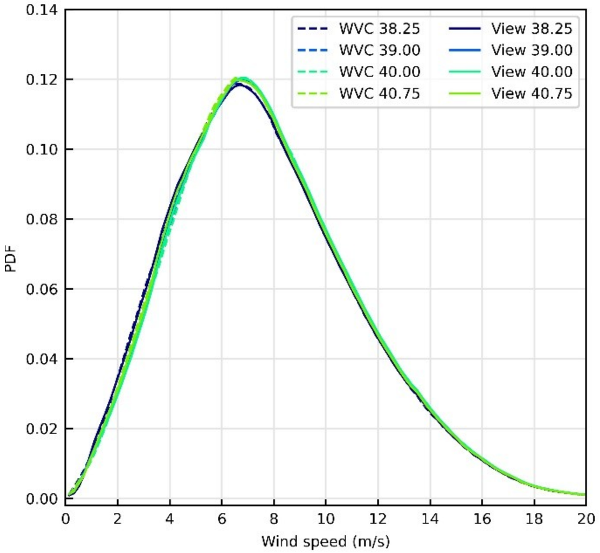
$$MLE = \sum_{i=1}^{4} MLE_i$$

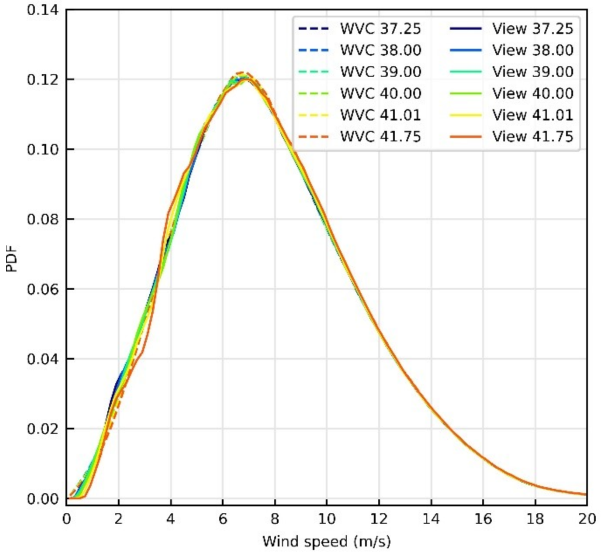


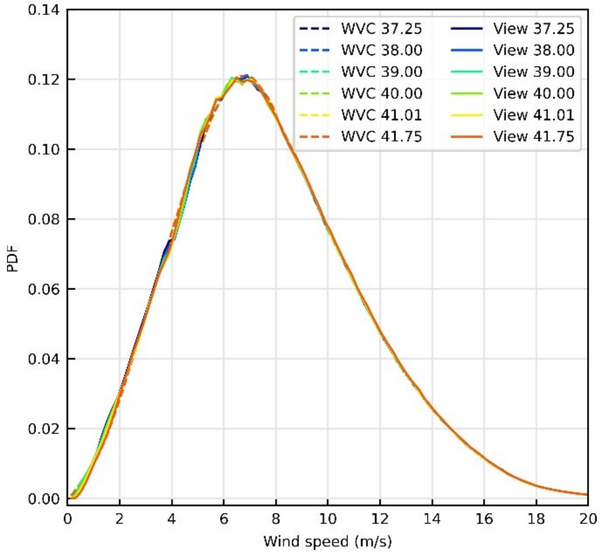


New WindRAD winds

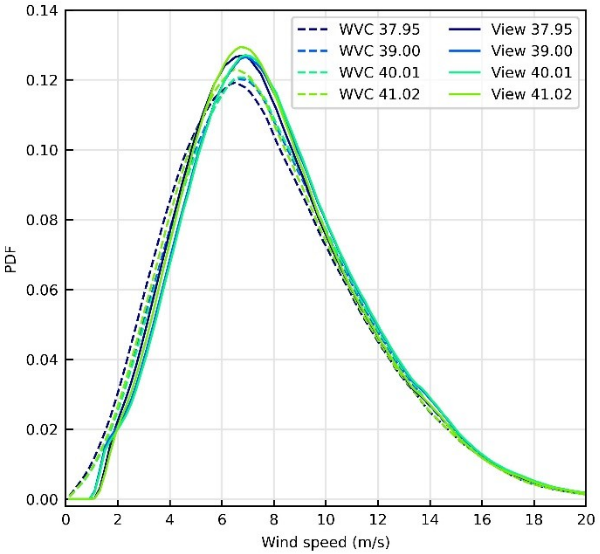


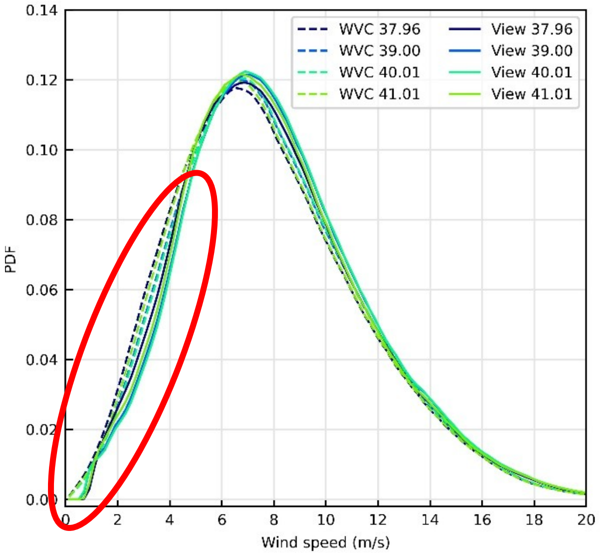


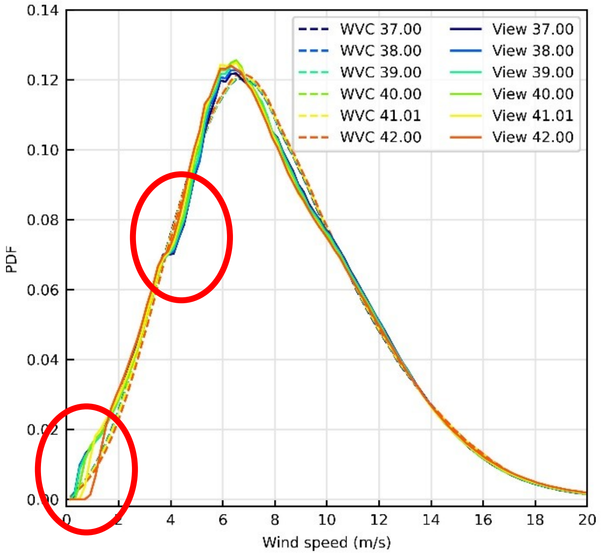


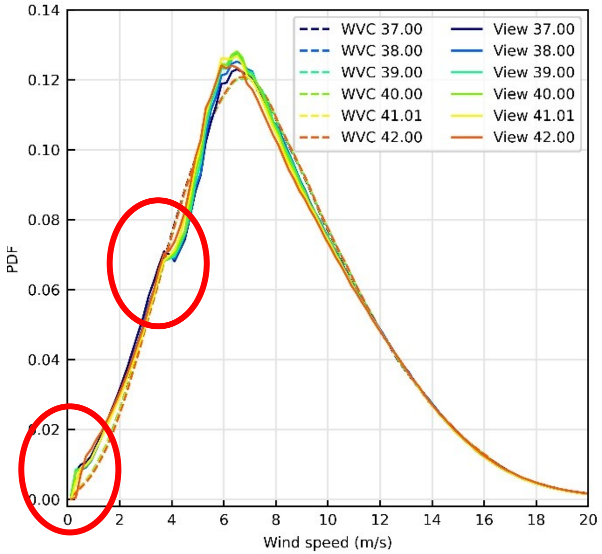


Ku-HH Ku-VV C-HH C-VV

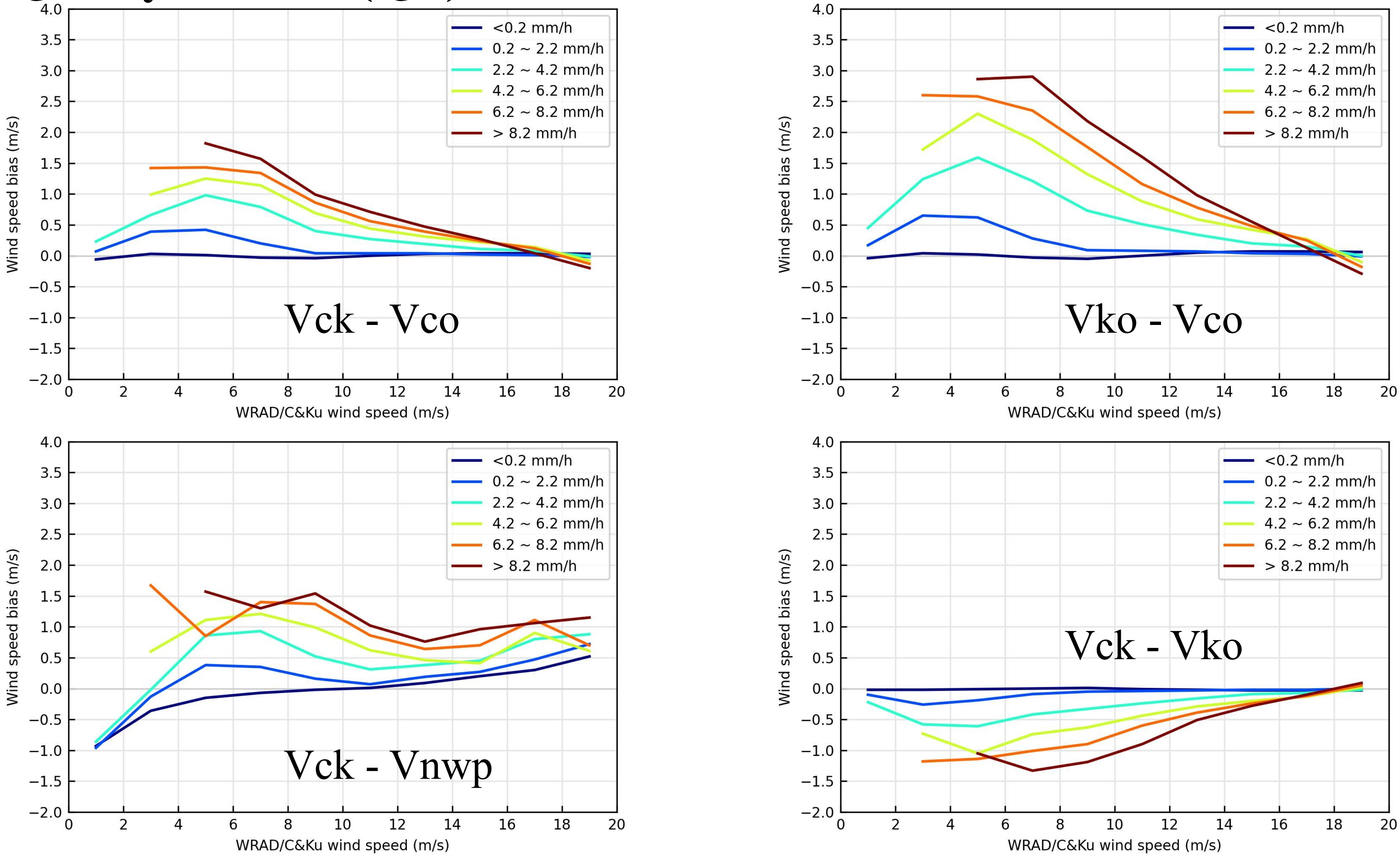




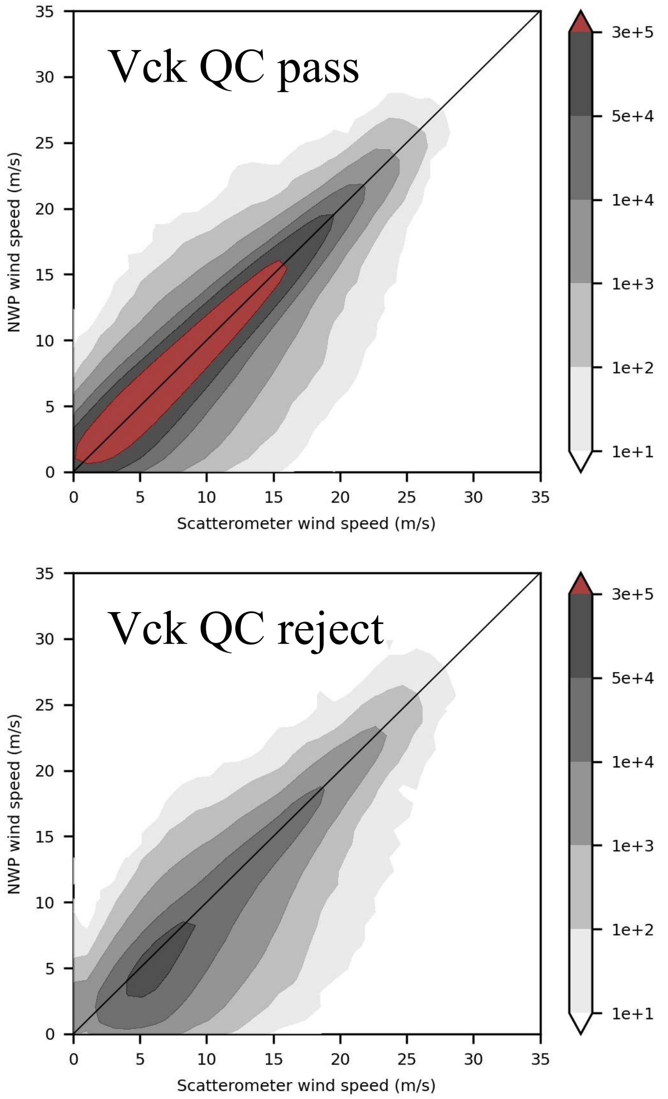




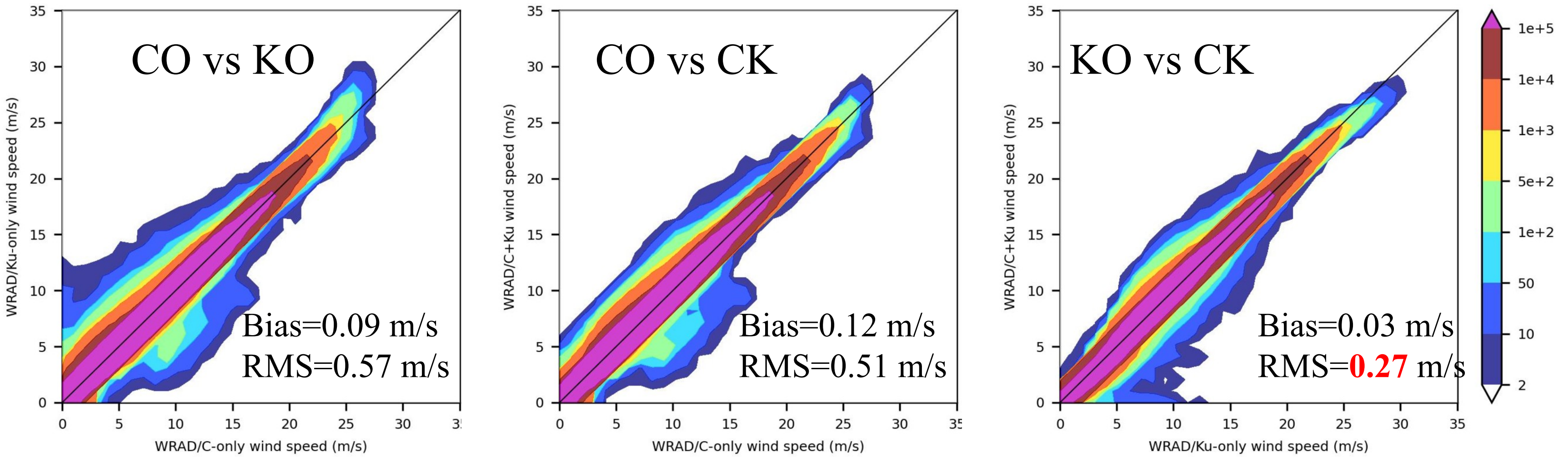
Quality Control (QC) of WindRAD winds: Rain effects



Quality Control (QC) of WindRAD winds



QC method	Ratio of QC passed	Ref. winds	Wind speed Bias(m/s)	Wind speed SD(m/s)	Speed RMS	Direction RMS
Fixed ratio	93.9%	NWP	-0.07	1.06	1.06 m/s	10.87°
$\|\Delta V\| > 0.6$ m/s	91.9%		−0. 06	1.07	1.07 m/s	10.99°
$\|\Delta V\| > 1.2$ m/s	96.2%		-0.05	1.09	1.09 m/s	11.13°
$\|\Delta V\| > 1.8$ m/s	96.7%		-0.05	1.09	1.10 m/s	11.21°



Summary

- At very low wind speeds (<2 m/s), there is a clear discrepancy between measured and simulated sigma0 values. This may be related to the internal calibration of scatterometer data, i.e., noise subtraction. **Is it feasible to develop an open-source L1B processor capable of handling data from all spaceborne scatterometers?**
- Further refinement of the incidence angle and wind speed dependencies is needed for NSCAT-series GMF.
- Incidence angle dependence of SST effects on Ku-band sigma0 measurements needs further study.
- WRAD provides good opportunity to study rain effects on C and Ku band sigma0 measurements and retrieved winds.

Extra slides

2.1 C-HH GMF for WindRAD wind retrievals

Procedure of building GMF for C-band HH:

Eq. (1):

$$z_p(\theta, V, \phi) = B_0^p(\theta, V)\underbrace{\left[1 + B_1^p(\theta, V) * \cos(\phi) + B_2^p(\theta, V) * \cos(2\phi)\right]}_{\text{Wind direction dependency}}$$

Wind speed dependency

Eq. (2):

$$z = (\sigma^0)^{0.625}$$

$$\boxed{z = \left(B_0^p(\theta, V)\left[1 + B_1^p(\theta, V) * \cos(\phi) + B_2^p(\theta, V) * \cos(2\phi)\right]\right)^{1.6}}$$

Eq. (3):

$$\mathrm{PR} = \frac{\sigma_{\mathrm{VV}}^0}{\sigma_{\mathrm{HH}}^0} = \frac{B_0^{\mathrm{VV}}(\theta, V)}{B_0^{\mathrm{HH}}(\theta, V)}$$

Step 0: s0 -> z using Eq. (2)

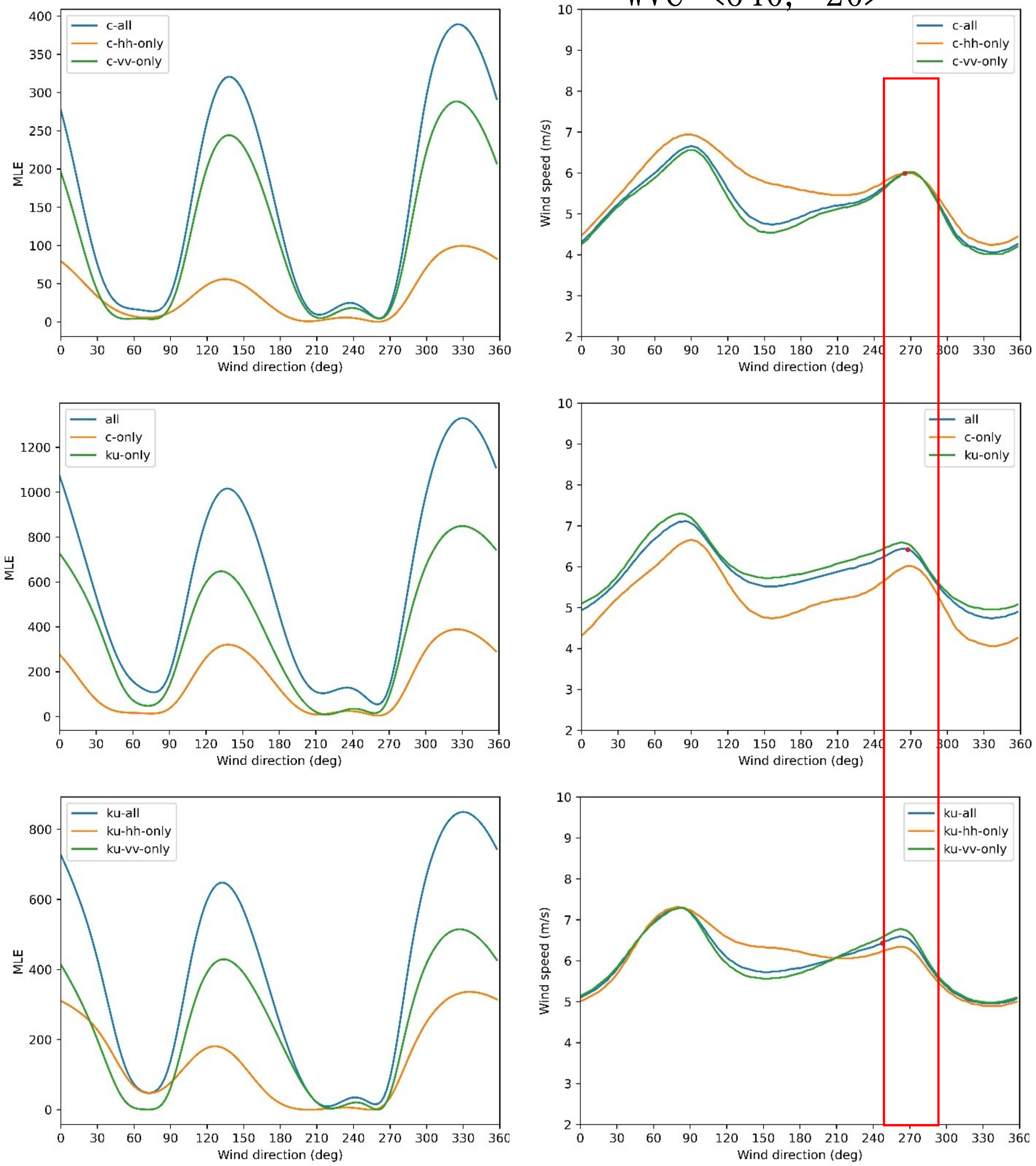
Step 1: Derivation of wind direction dependency for each $(\boldsymbol{\theta}, \boldsymbol{V})$;

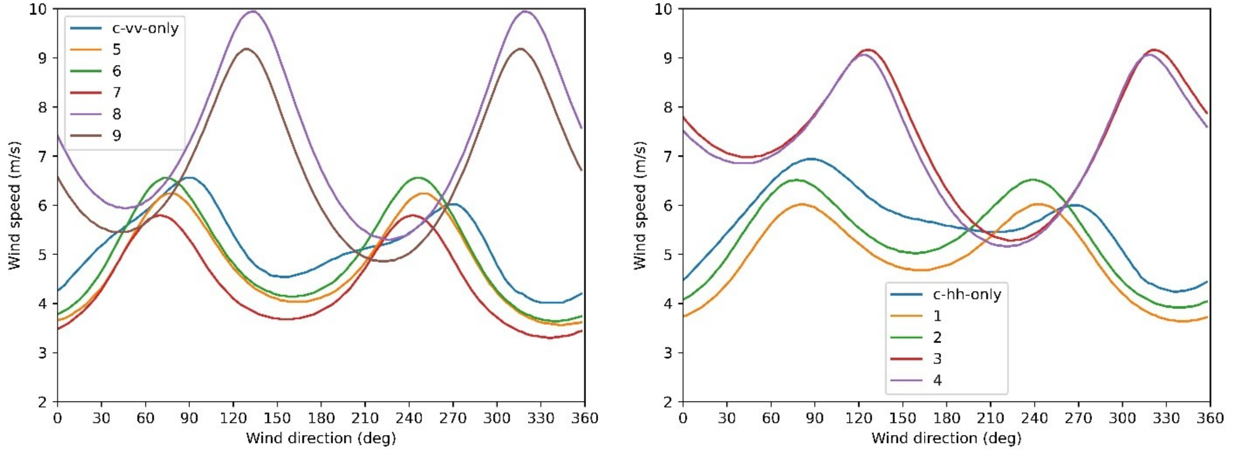
Step 2: Derivation of wind speed dependency; this can be done via PR $(\boldsymbol{\theta}, \boldsymbol{V})$.

Step 3: CMOD7_HH = CMOD7_VV + PR + wind direction dependency

Step 4: s0 -> Z

WVC <640, 20>






```
arr_inc = np.array([ 41.060, 38.040, 39.210, 42.190, 42.530,
39.550, 36.510, 37.700, 40.720, 39.560, 40.700, 41.060,
38.130, 39.210])
arr_azi = np.array([341.990, 338.380, 224.160, 220.850,
343.540, 340.280, 336.290, 226.080, 222.430, 340.270, 222.430,
341.980, 338.370, 224.160])
arr_pol = np.array([2,2,2,2,3,3,3,3,3, 0,0,1,1,1])
wspd_ck, c, ku, nwp = 6.42, 5.99, 6.43, 5.81
wdir_ck, c, ku, nwp = 267.5, 265.0, 247.5, 259.7
```