Outstanding issues in calibration for routine conditions

IOVWST meeting

Day 3, talk 2

Co-leads: Zhen Li (KNMI), Ad Stoffelen (KNMI), Richard Lindsley (RSS)

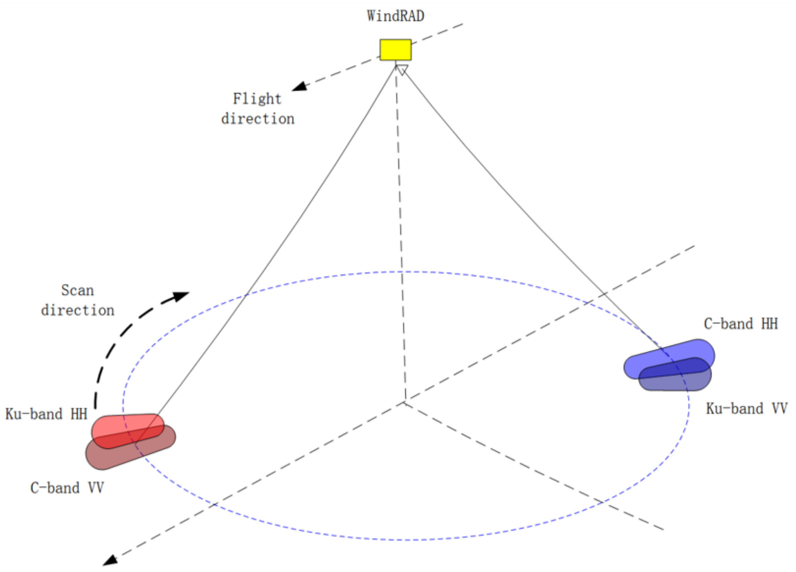
15 Nov, 2023

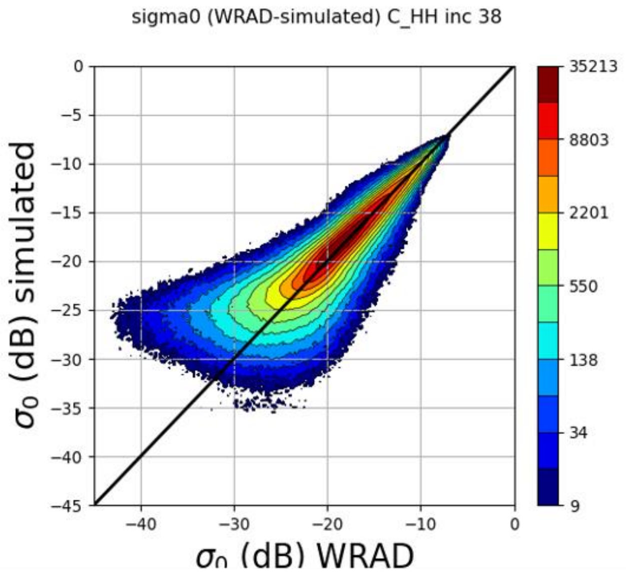
Some notions on scatterometer NRCS calibration

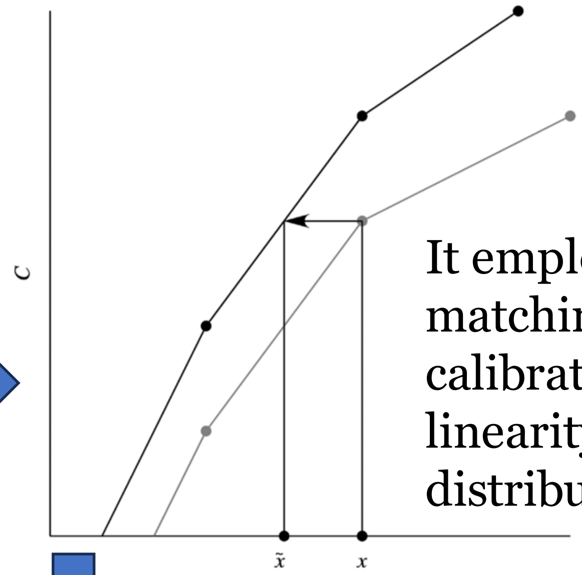
- The NRCS is a geophysical quantity and does NOT depend on instrument
- Hence, instruments may be intercalibrated to provide consistent NRCS
- Transponder calibration is difficult, hence ancillary methods are used
- Using collocated scatterometers, calibration and GMFs are being made consistent for Ku and C bands and different polarizations
- Thermo-elastic wave guide effects make antenna beam pattern gain specifications in space inaccurate and linear correction (a dB value) is needed per incidence angle
- Antenna noise floor corrections are critical for low NRCS calibration
- Rotating scatterometers may suffer from poor azimuth-angle effect compensation
- A posteriori calibration corrections are worse than the associated improvements in instrumentation and processing (though work quite well)

Higher Order Calibration (HOC) for non-linear distribution in Sigma0s

Zhen Li[1], Ad Stoffelen[1], Anton Verhoef[1], Zhixiong Wang[2], Jian Shang[3], Honggang Yin[3]
KNMI[1], NUIST[2], CMA[3]







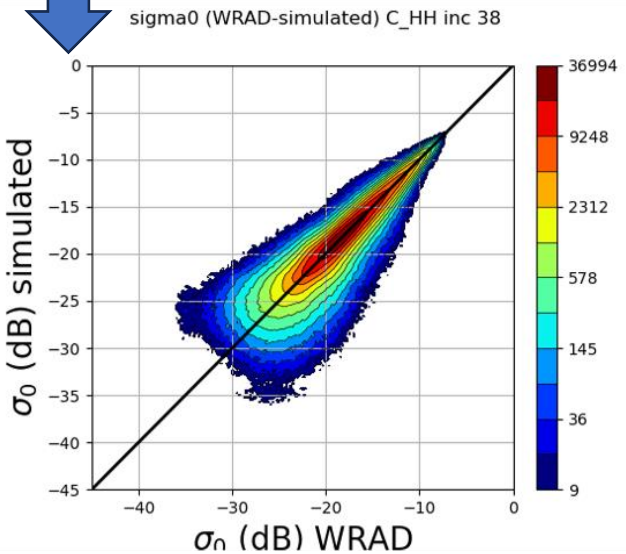
It employs CDF matching technique to calibrate the non-linearity in the sigma0 distribution

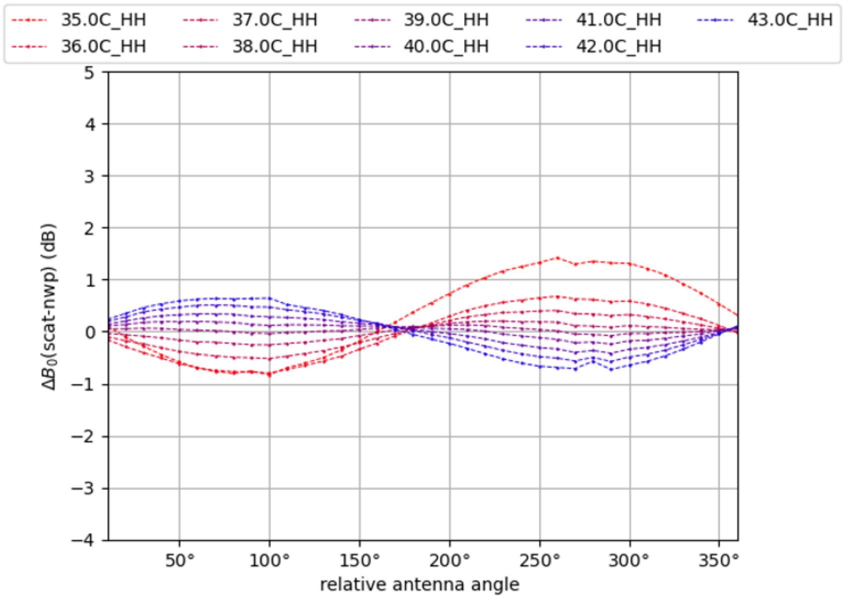
There are two issues in needed of calibration:

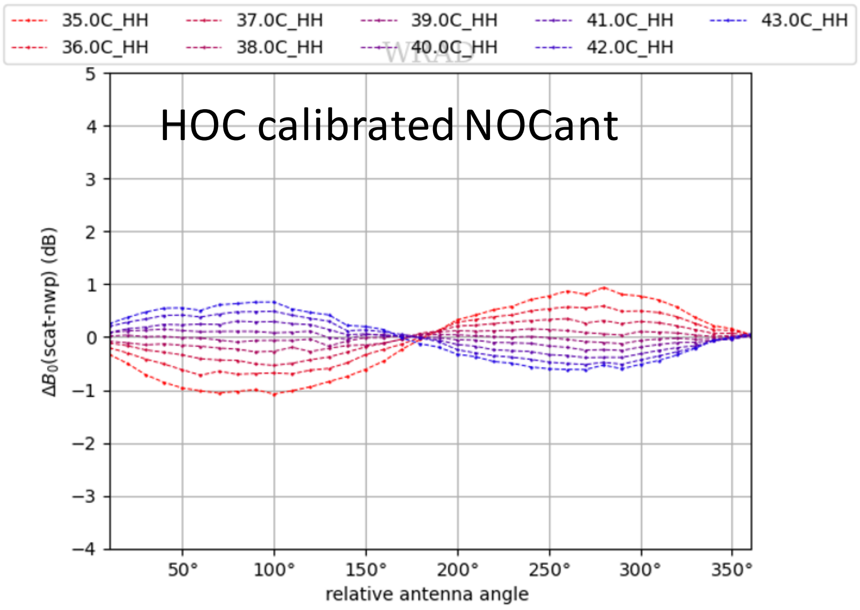
- The ridge off the diagonal, usually => **NOC**
- The non-linearity at the low sigma0 values => **HOC**

NOTE:

- HOC can remove the incidence angle dependency, which is NOC as a function of incidence angle and the non-linearity.
- HOC cannot remove the azimuth angle dependency, which is introduced by rotating and level-0 processing.

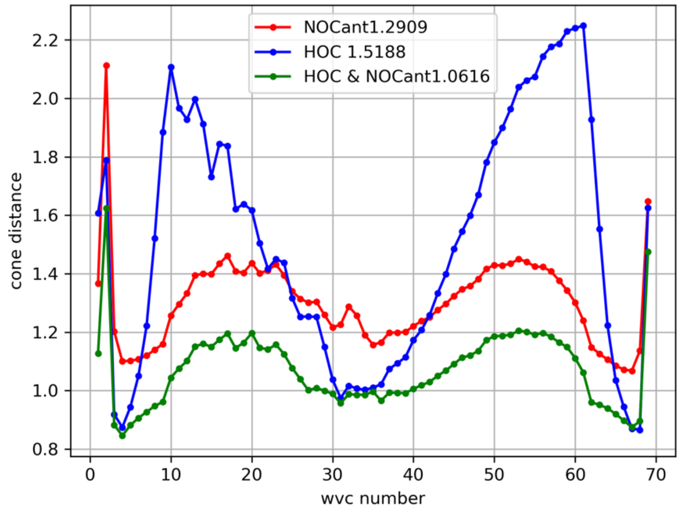






NOCant: NOC as a function of incidence angle and relative azimuth angle.

Use the combination of **HOC&NOCant** can remove the non-linearity, incidence angle dependency and azimuth angle dependency => achieve optimal wind result.



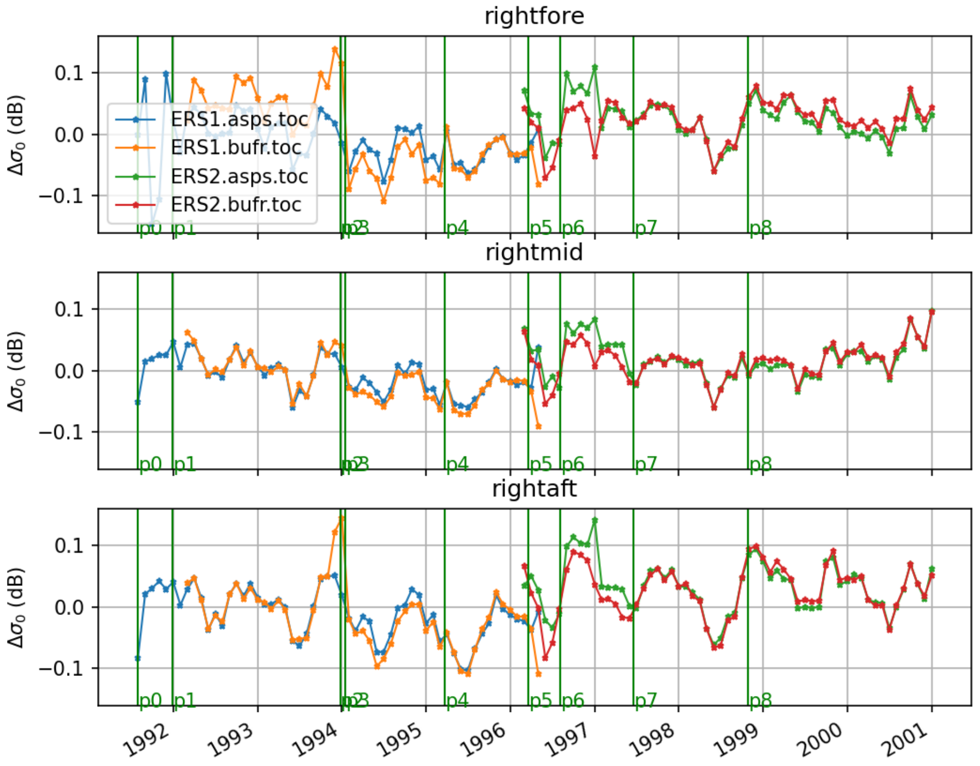
The MLE (cone distance) is a metric to measure the quality of the retrieval. It reveals how well the measurements fit the GMF (Geophysical Model Function), the lower the better. The combination of HOC&NOCant gives the best fit to the GMF.

* Li, Z.; Stoffelen, A.; Verhoef, A.; Wang, Z.; Shang, J.; Yin, H. *Atmospheric Measurement Techniques, (2023), 4769-4783, 16(20)*

Calibration of the ERS scatterometer wind product with NOC and Cone Metrics

KNMI Jeroen Verspeek, Ad Stoffelen, Anton Verhoef

- The ERS1/ERS2 wind product will be reprocessed over their entire life span
- Two datasets for ERS are available, ASPS and BUFR operational data. They partly overlap and partly complement each other.
- Beam pattern corrections were applied for level1b (operational BUFR data), noise floor, offset and NOC/cone metrics.
- The quality of both derived wind products are compared and assessed.
- NWP ocean calibration (NOC) is used for NRCS monitoring and cone metrics as “absolute” NRCS calibration method.
- Time series show daily and seasonal variations in the wind speed bias, but they appear to be very stable over the long term.



Cross-Calibration Modeling

The idea behind the cross-calibration model is that on the calibration area, the difference in reported σ_0 from two scatterometers can be represented reasonably well by

$$\sigma_{Scatt1} - \sigma_{Scatt2} = C_{Calibration} + C_{Area}$$

The goal of the model is to predict C_{Area} so that $C_{Calibration}$ can be isolated.

Using formulas for volume backscattering, we model calibration offset due to the physical properties of the area using the predicted σ_0 values given by

$$\sigma_0(\theta_i, f) = V(\theta_i, p, v_i) + S(\theta_i, H_{RMS}, L_{Corr}) + A(\theta_a).$$

The formula has volume, surface, and azimuth components, each calculated using parameters including incidence and azimuth angle, particle radius, ice volume fraction, and surface RMS height and correlation length.

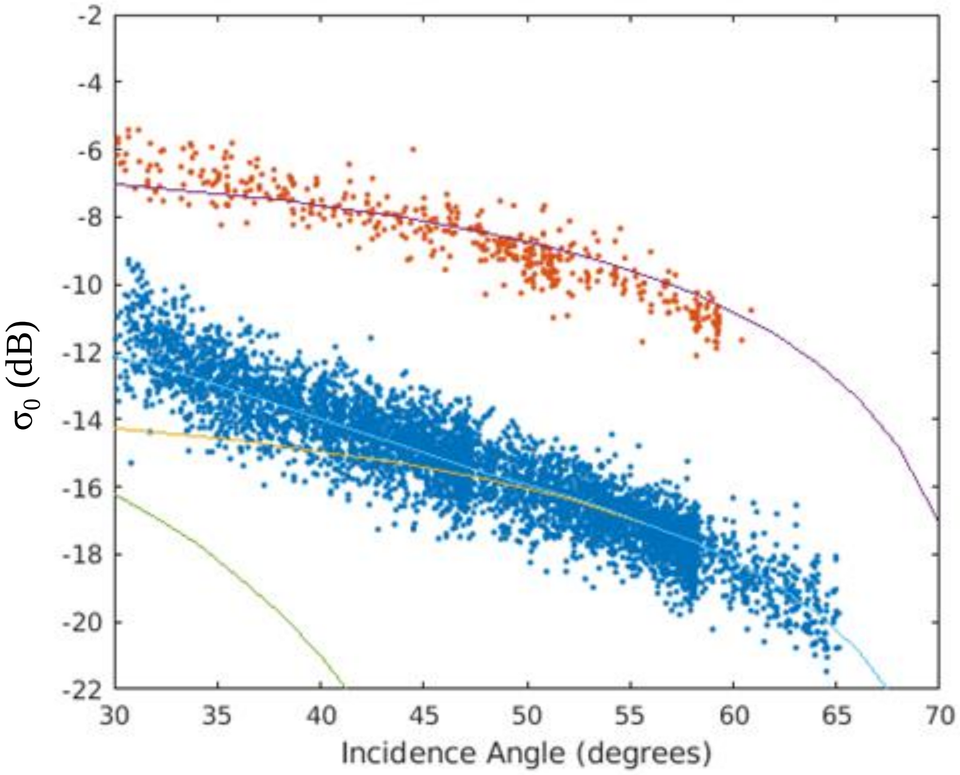
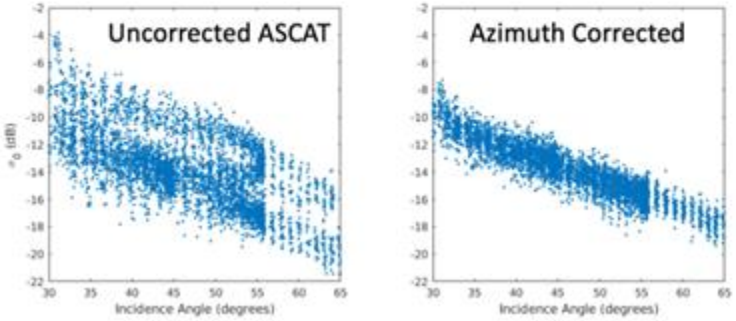


Figure 1. Plot of ASCAT (blue) and NSCAT (red) data points with the modeled NSCAT (purple) and ASCAT (light blue) fit lines. ASCAT surface (green) and volume (yellow) components are also depicted

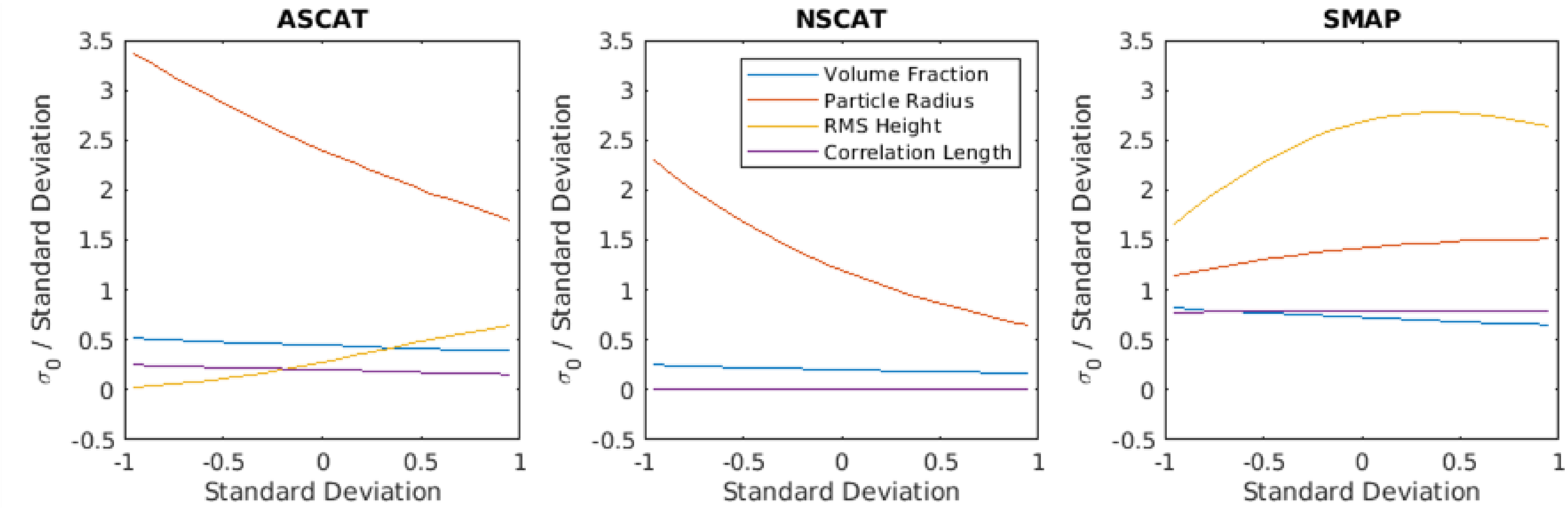


An Analysis of Antarctica as a Target for First Order Cross-Calibration Between NSCAT, SMAP, and ASCAT
Porter and Long, 2023

Model Sensitivity

Figure 2. shows the sensitivity of the model. Because the units for each parameter differ, we define the sensitivity of the model with respect to a parameter as the derivative of modeled σ_0 with respect to the standard deviation of that parameter. Shown in the figure are the sensitivity values up to ± 1 standard deviation away from the estimated value for the parameter.

The values used in the model for each of these parameters are estimates, so this sensitivity analysis is an important tool for evaluating the model's accuracy.



Using scatterometer observations to correct for persistent biases in modelled ocean surface winds

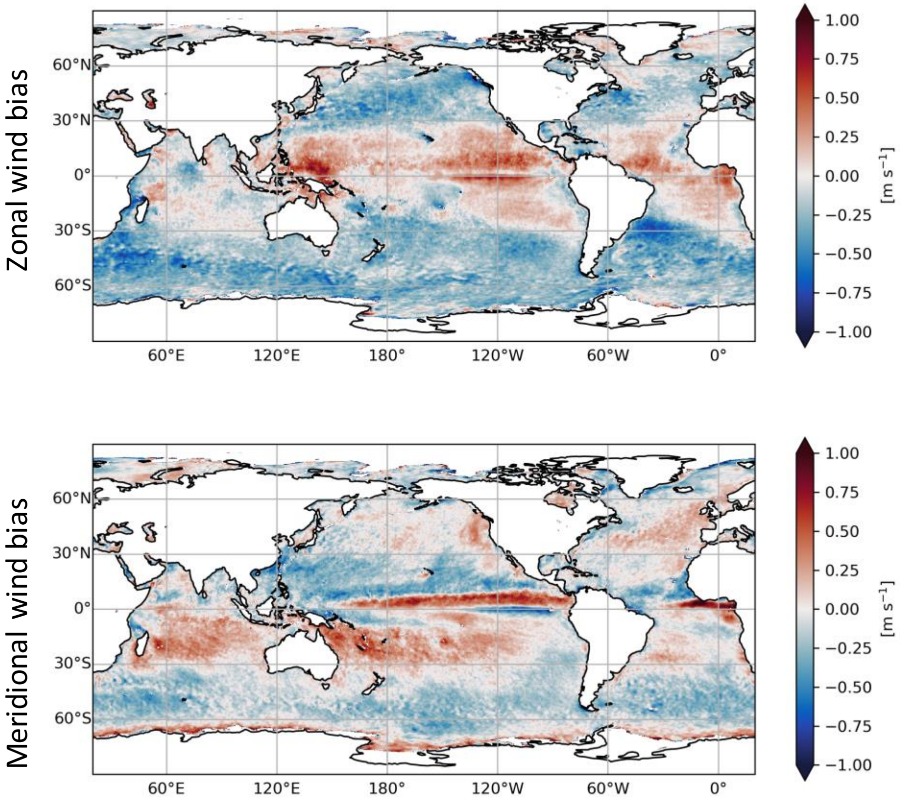
Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management

Institut de Ciències del Mar

Copernicus Marine Service

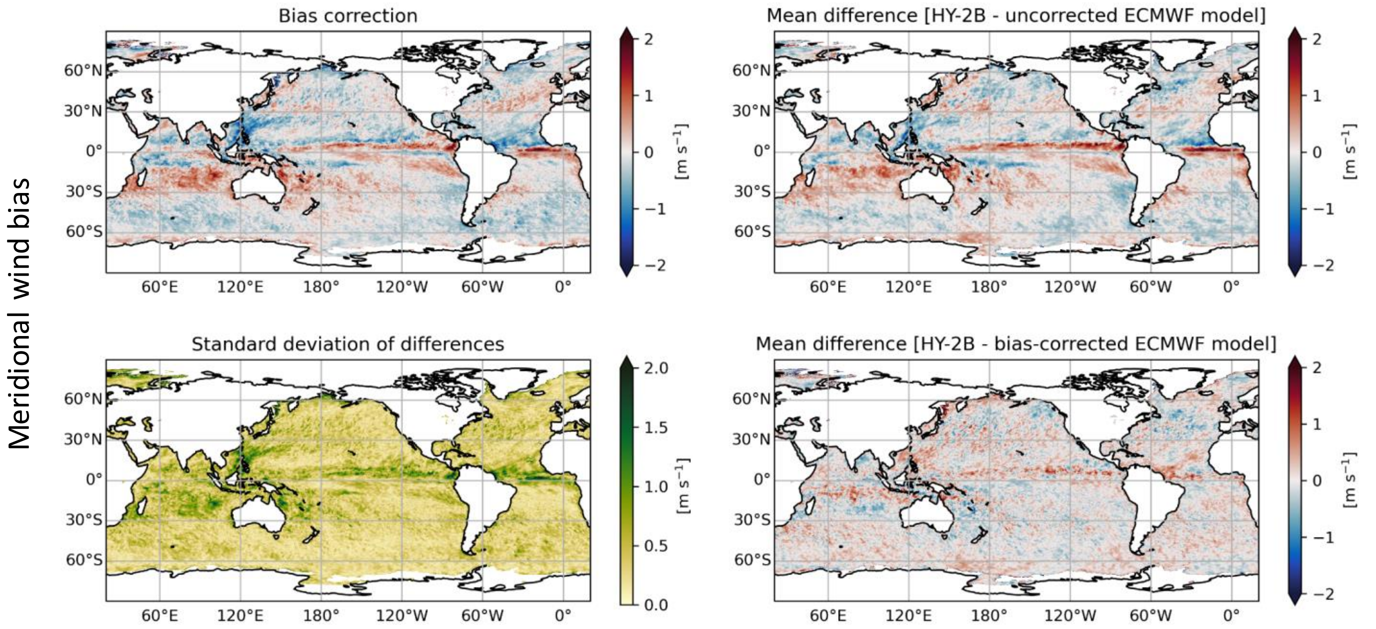
Rianne Giesen, Ad Stoffelen, Ana Trindade, Marcos Portabella and Anton Verhoef

Metop-B ASCAT – ECMWF OPS [2022]



Annually averaged scatterometer-model differences display substantial systematic biases

20-day bias correction (Metop-B/C ASCAT – ECMWF ERA5)



- We use 20-day averaged scatterometer-model differences to produce corrected hourly ECMWF model fields
- Comparison with independent HY-2B HSCAT (different time of day) shows that biases are removed effectively

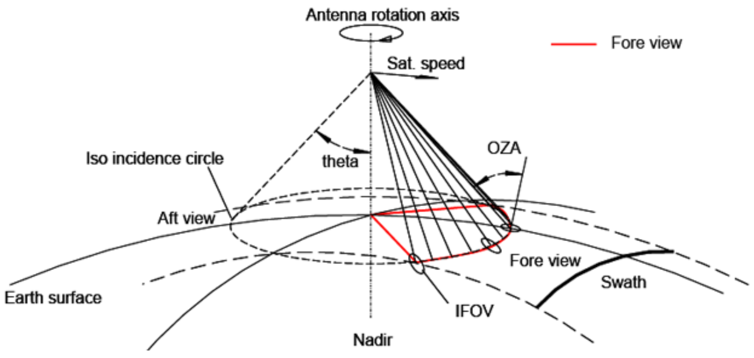
Belmonte Rivas, M. and A. Stoffelen (2019): *Characterizing ERA-Interim and ERA5 surface wind biases using ASCAT*, Ocean Sci., 15, 831–852, doi: 10.5194/os-15-831-2019.

Global ocean hourly reprocessed sea surface wind and stress from scatterometer and model. *E.U. Copernicus Marine Service Information (CMEMS). Marine Data Store (MDS).* DOI: 10.48670/moi-00185

Radiometric Wind Retrieval for MWI

Sisma Samuel, Anton Verhoef, Ad Stoffelen (KNMI)

EUMETSAT OSI SAF



conically scanning MWI- viewing geometry

MWI frequency 18GHz – 183GHz (26 channels)

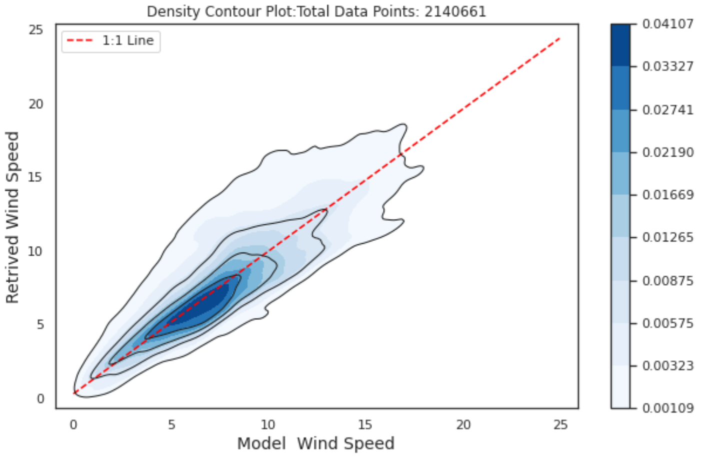
Retrieval of windspeed for future Microwave Wind Imager.

Currently using SSMIS Brightness temperature from channels- 19V&H,22V, 37V&H GHz

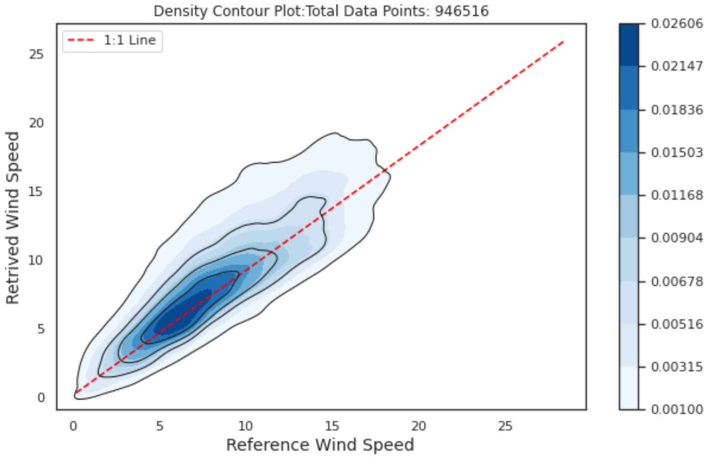
Work is in progress……

Retrieval based on data from SSMIS-F16, F17, F18

Comparison with ERA5 windspeed



Windspeed collocated with RapidScat



Discussion points for outstanding issues in calibration for routine conditions:

- Consistency of different GMFs: e.g. NSCAT-4DS, NSCAT-4HY2, what is the optimal reference ?
- Calibration methods: NOC (incidence or/and azimuth dependency, cone metric), HOC (non-linearity).

  Instruments have their own attributes, which need to be treated differently and carefully.
- Using scatterometer observations to correct for persistent biases in modelled ocean surface winds (Rianne, day 1 talk 1).
- Intercalibration: the differences between remotely sensed wind products and NWP wind products (day 2 talk 3)
- Rain quality control: MLE, Joss (Xu et al., 2020), Bayesian methods, possibly also ML method (Xu et al., 2021).
- Triple, quadruple, quintuple collocation analysis for the consistency of all scatterometers, giving confidence of the wind data quality (Vogelzang et al., 2021 and 2022).
- Intercalibration with passive winds: e.g., SSMI, WindSat, MWI (Microwave Imager) or CIMR winds (Dinnat et al., 2023).
- Cone metrics for Ku-band pencil-beam scatterometers?