



Ocean and Sea Ice SAF

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CMOD5.n - the CMOD5 GMF for neutral winds

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1 Introduction

At the OSI SAF 3rd user workshop in Amsterdam (September 2007), several users requested the OSI SAF to produce neutral winds rather than real 10m winds.

Currently, the CMOD5 Geophysical Model Function (GMF) [3] is used to retrieve ASCAT winds, but it is modified such that 0.5 m/s is added to the wind speeds. This is done since we know from ERS scatterometer wind statistics that CMOD5 winds underestimate the real 10m winds by approximately 0.5 m/s [4]. The statistical difference between the current CMOD5 + 0.5 and the CMOD5.n (neutral) winds is another 0.2 m/s in all conditions studied [2,3]. As such, the OSI SAF plans to add 0.2 m/s to their ASCAT winds by implementing CMOD5.n.

Following the above recommendation, ECMWF has fitted new CMOD5.n coefficients according to a desired CMOD5 + 0.7 m/s behaviour [2]. KNMI subsequently produced a CMOD5.n Lookup Table and tested the retrieved Maximum Likelihood Estimator (MLE) and winds against the CMOD5 + 0.7 m/s, hereafter referred to as CMOD5.7, retrieval outputs.

This report describes the validation of the CMOD5.n coefficients and shows that the winds retrieved with the new GMF closely compare to those retrieved by CMOD5.7.

1.1 References

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CMOD5.N: A C-band geophysical model function for equivalent neutral wind
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http://www.ecmwf.int/publications/library/ecpublications/_pdf/tm/501-600/tm554.pdf.
- [3] Hersbach, H., A. Stoffelen, and S. de Haan, 2007
An Improved C-band scatterometer ocean geophysical model function: CMOD5
 J. Geophys. Res., **112**, C03006. doi:10.1029/2006JC003743
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- [5] Portabella, M. and A. Stoffelen, 2006,
Scatterometer backscatter uncertainty due to wind variability
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 doi:10.1109/TGRS.2006.877952.

1.2 Abbreviations and acronyms

ASCAT	Advanced SCATterometer
AWDP	ASCAT Wind Data Processor
BUFR	Binary Universal Form for the Representation of meteorological data
ECMWF	European Centre for Medium-Range Weather Forecasts
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
ERS	European Remote Sensing satellite
GMF	Geophysical Model Function
KNMI	Royal Netherlands Meteorological Institute
MLE	Maximum Likelihood Estimator

NWP	Numerical Weather Prediction
OSI	Ocean and Sea Ice
SAF	Satellite Application Facility
WVC	Wind Vector Cell

2 Comparison of CMOD5.7 and CMOD5.n

We compared the CMOD5.n GMF to CMOD5.7. To construct CMOD5.n, we simply replaced the CMOD5 coefficients by the CMOD5.n coefficients obtained from ECMWF (see section 5) in the ASCAT Wind Data Processor (AWDP). The CMOD5.7 function is constructed by first subtracting 0.7 m/s from the wind speed v and then calculating the CMOD5 radar backscatter (σ^0) for this reduced wind speed v' . Clearly, this method does not work for wind speeds below 0.7 m/s since CMOD5 is not defined for negative wind speeds. Therefore, for wind speeds below 1 m/s the reduced wind speed was calculated as $v' = v \times 0.3$. This ensures a smooth approach to zero for low wind speeds. It can be expected however that CMOD5.7 will significantly differ from CMOD5.n for low wind speeds.

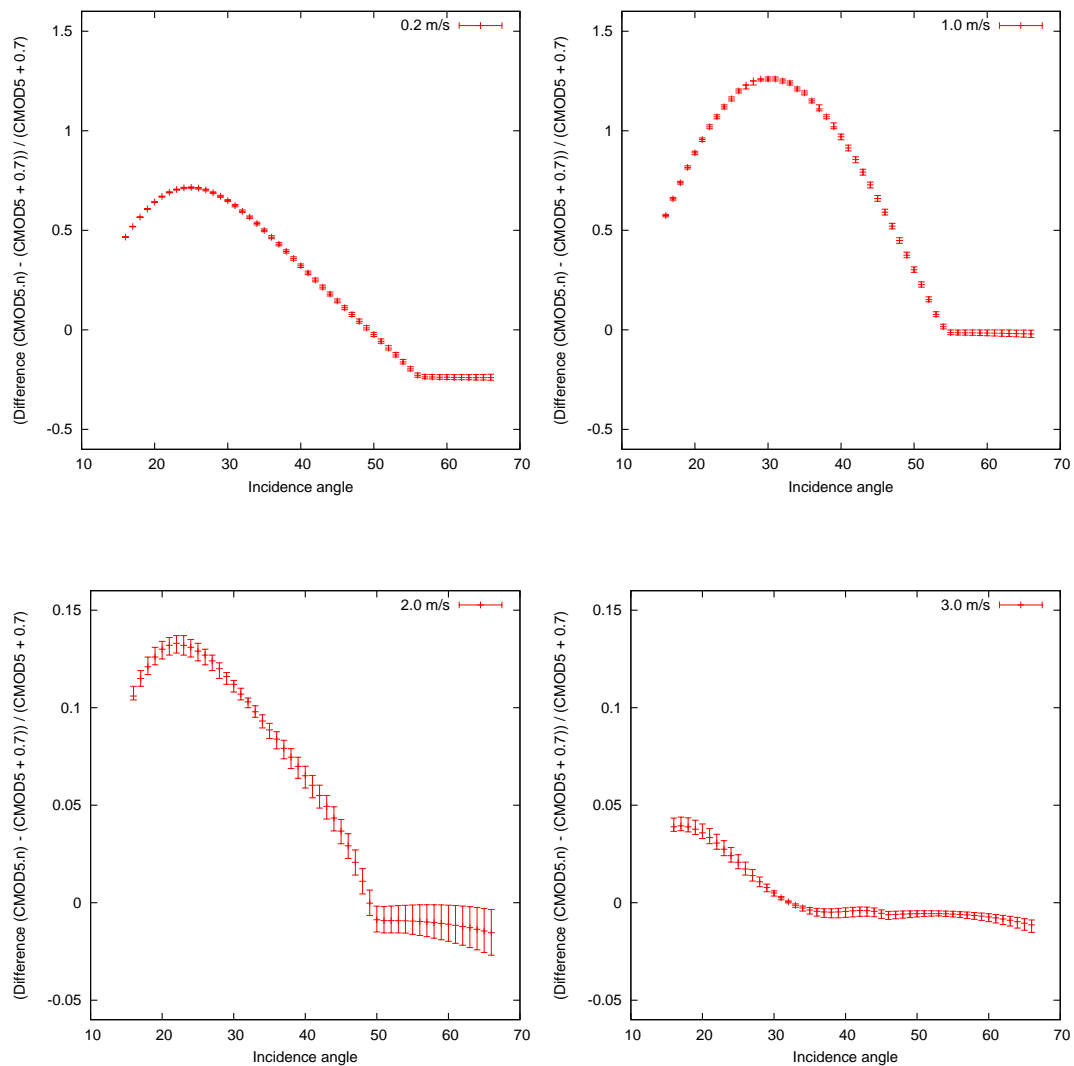


Figure 1: Plots of the difference between CMOD5.n and CMOD5.7 as a function of incidence angle for wind speeds from 0.2 to 3 m/s.

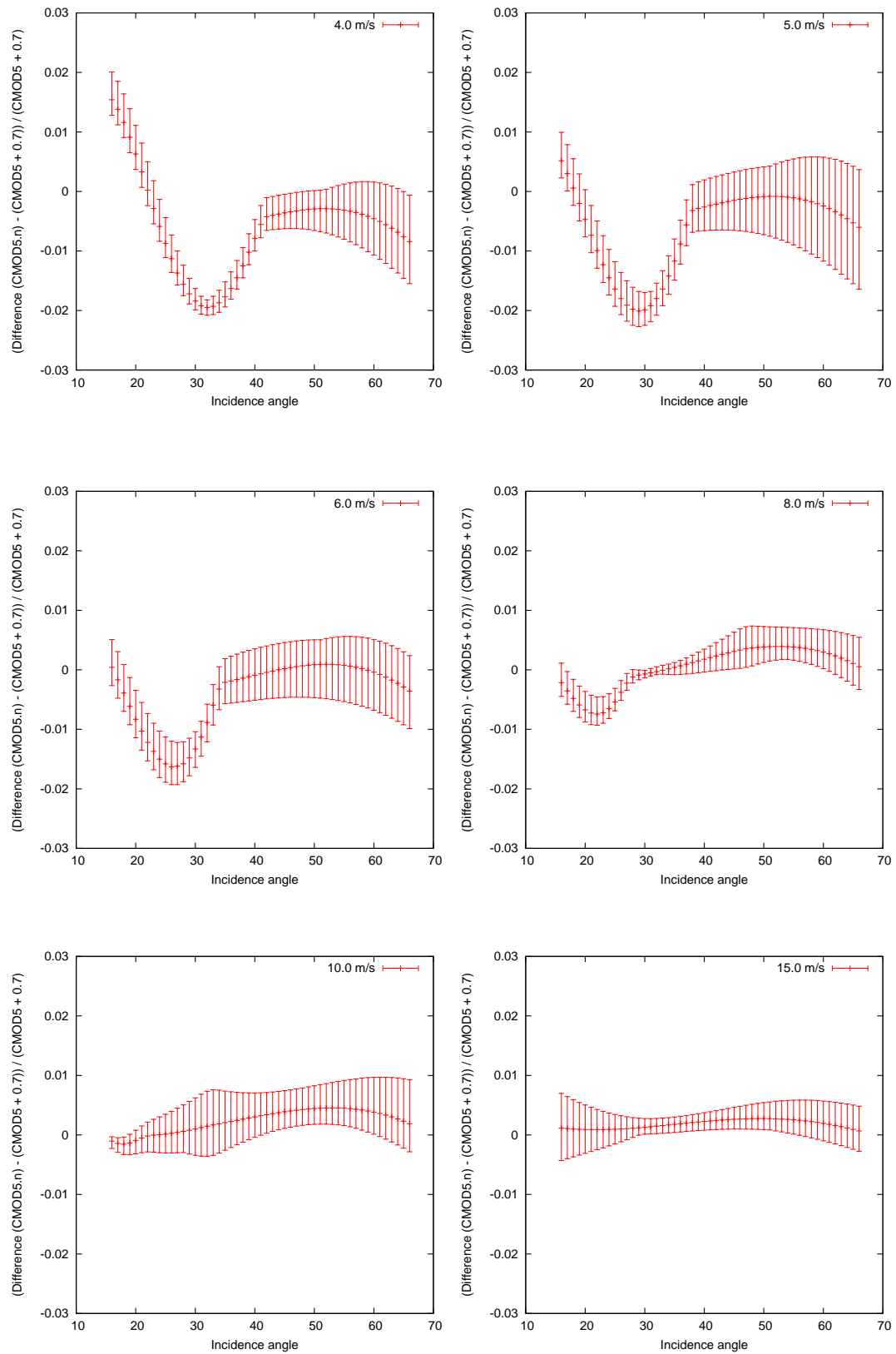


Figure 2: See Figure 1, but for wind speeds from 4 to 15 m/s.

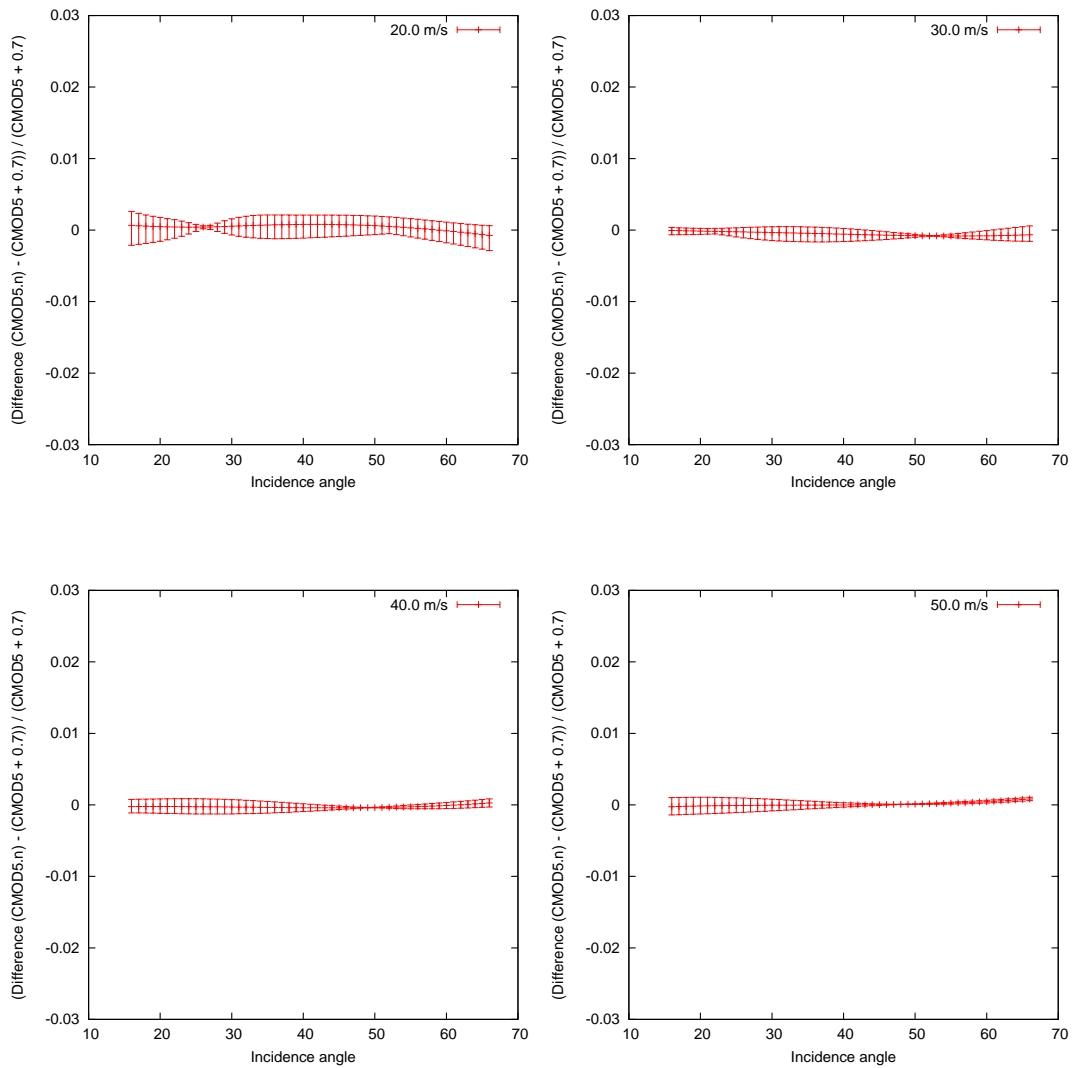
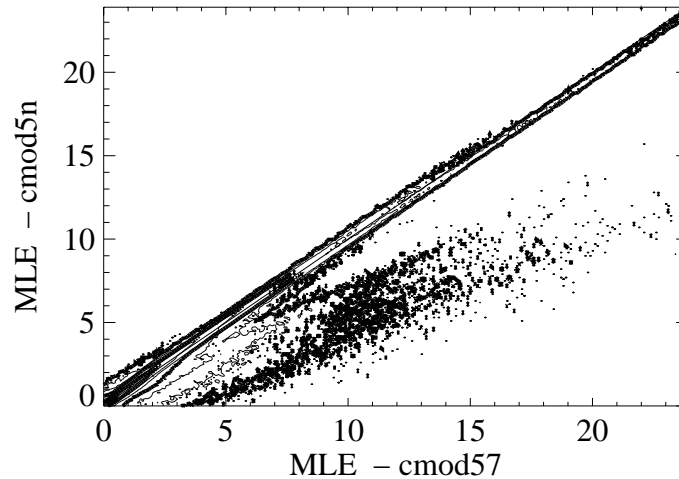


Figure 3: See Figure 1, but for wind speeds from 20 to 50 m/s.

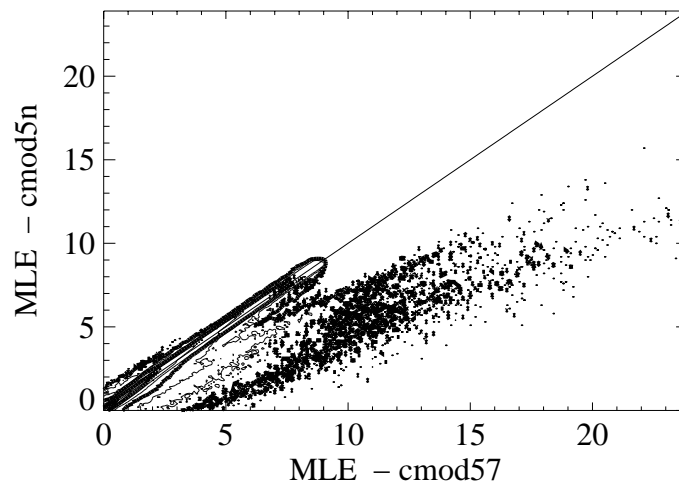
The plots in this section show the difference between the two GMFs as a function of incidence angle and wind speed. The error bars show the mean, minimum and maximum differences when scanning the wind directions for a combination of incidence angle and wind speed. The values in the plots are divided by the value of the CMOD5.7 function, i.e. they are the difference as a fraction of the GMF value. Note that the Y-axes have different scaling for wind speeds up to 3 m/s; this is where the differences are largest. For wind speeds of 4 m/s and up, the differences are smaller than 1-2% in almost all cases. These differences appear comparable to the remaining uncertainties in the GMF and smaller than the combination of instrument and geophysical noise [5].

3 Statistical analysis

In order to compare the quality of the retrieved ASCAT winds, eight days of data (1-8 November 2007) were reprocessed using AWDP. These are one-transponder-calibrated σ^0 values (Level 1 version 5.2.1). The data were processed twice: once with CMOD5.7 and once with CMOD5.n.



N=3788258
 mx= 0.78 my= 0.73
 m(y-x)= -0.05 s(y-x)= 0.57
 cor_xy= 0.97



N=3762771
 mx= 0.69 my= 0.65
 m(y-x)= -0.04 s(y-x)= 0.56
 cor_xy= 0.96

Figure 4: Two-dimensional histogram of the 1st rank MLE from CMOD5.n versus the 1st rank MLE from CMOD5.7 (bins of 0.1). N is the number of data; mx and my are the mean values along the x and y axis, respectively; m(y-x) and s(y-x) are the bias and the standard deviation with respect to the diagonal, respectively, and cor_xy is the correlation value between the x- and y-axis distributions. The contour lines are in logarithmic scale: each step is a factor of 3 and the lowest level (outer-most contour line) is at N/1024000 data points. The first plot shows all the data and the second only data that passed Quality Control.

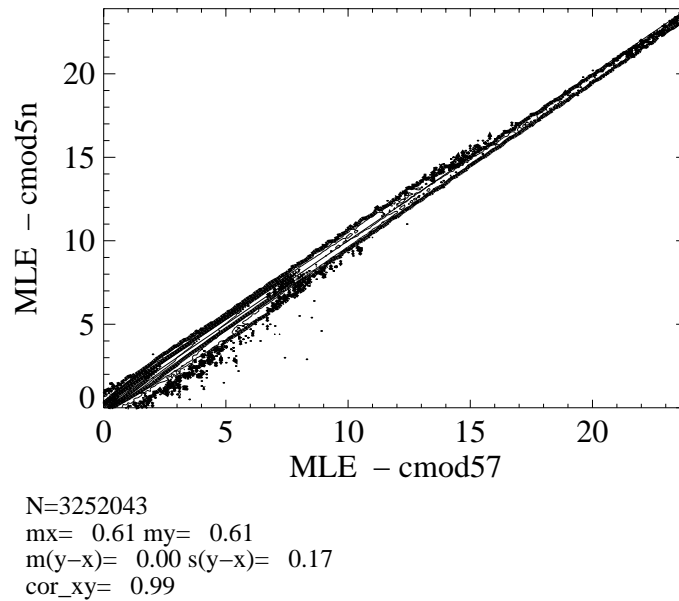


Figure 5: Same as Figure 4a, but now only the Wind Vector Cells in which the ECMWF background wind is above 4 m/s.

Figure 4 shows two-dimensional histograms of the 1st-rank MLE retrieved with CMOD5.n versus the one retrieved with CMOD5.7, for all the data (top) and for QC-passed data (bottom). Note that the plots are intentionally very detailed (the first contour line shows bins with only 3 occurrences) to underline infrequent differences. Although most of the data lay along the diagonal, a secondary accumulation is clearly visible well below the diagonal. Such accumulation is still present after QC, which indicates that it corresponds to low winds. The KNMI QC filters all MLEs above 9 for winds above 4 m/s (see the truncation of the histogram distribution along the diagonal in the bottom plot). However, for winds below 4 m/s the QC threshold is wind speed dependent to account for the occurrence of high MLE values at low winds which are not related to low quality WVCs. As such, the secondary accumulation is related to low winds. Indeed, further analysis shows that the secondary accumulation is only present for winds below 2 m/s (not shown).

Figure 5 shows the same as Figure 4a but only for WVCs in which ECMWF winds are above 4 m/s. It is clear from both the contour lines and the SD score (0.18) that the points lay very close to the diagonal, denoting a strong resemblance between CMOD5.n and CMOD5.7 GMFs.

It is therefore concluded that, as expected, the two GMFs are very similar and only significantly differ at low winds, where CMOD5.n produces smaller MLE values than CMOD5.7 (see secondary accumulation in Figure 4), denoting that the former GMF better fits the backscatter measurements at such wind regime.

Figure 6 shows the same as Figure 4b but for KNMI-retrieved winds rather than MLEs. As it is clear from the top left plot, both GMFs produce very similar wind speeds. In terms of retrieved wind direction (top right), note that there are a few systematic differences (see accumulations that depart from the diagonal), including some 180-degree ambiguity differences (see accumulations along the 180-degree diagonals), which indicate small differences in GMF shape. Also, some wind retrieval differences at low winds can be easily seen in the wind component histograms (bottom plots). The component points perpendicular to the diagonal are 180-degree ambiguity errors. However, given the small SD scores of the different plots, it is concluded that both GMFs produce very similar wind vectors.

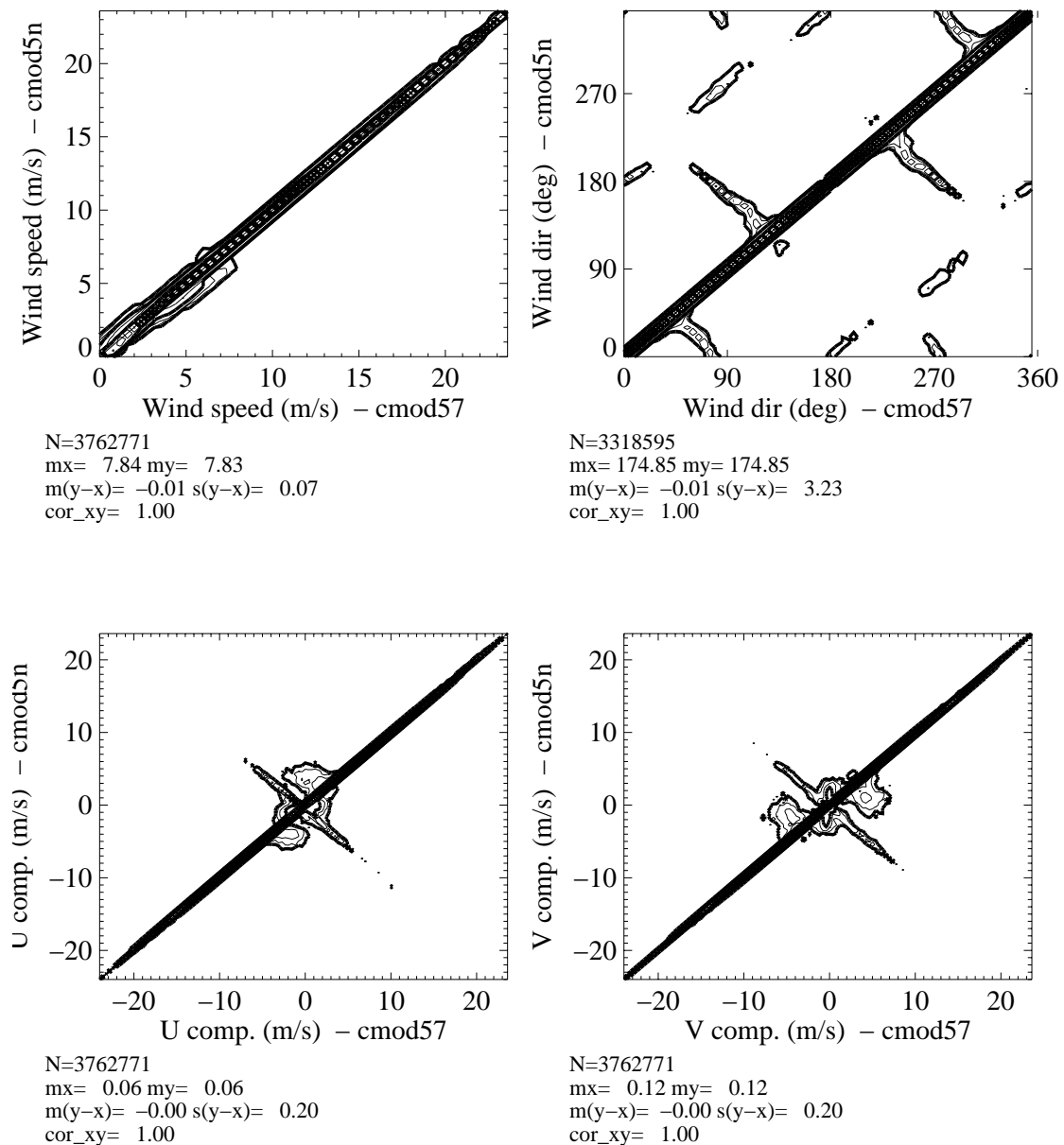


Figure 6: Same as Figure 4b, but for KNMI-retrieved winds with CMOD5.n versus KNMI-retrieved winds with CMOD5.7. The top left plot corresponds to wind speed (bins of 0.4 m/s); the top right plot to wind direction with respect to mid beam (bins of 2.5°); the bottom left plot to the wind component along the mid beam viewing angle and the bottom right plot to the perpendicular wind component (bins of 0.4 m/s for both components). The wind direction plot (top right) is computed for ECMWF winds larger than 4 m/s.

The KNMI-retrieved winds are also checked against ECMWF winds. The retrieved winds show the same Root Mean Square (RMS) difference with respect to ECMWF winds for all speed regimes, regardless of whether CMOD5.n or CMOD5.7 GMF is used. However, since CMOD5.n better fits the backscatter measurements than CMOD5.7 for very low winds, we recommend using the former for scatterometer 10-m neutral wind processing.

4 Conclusions

Users requested the provision of 10m neutral winds at the 3rd OSI SAF User Workshop instead of real 10m winds, following an extended triple collocation study by KNMI and, independently, by ECMWF. Subsequently, CMOD5 has been adapted to neutral winds in two different ways. A simple way is to subtract 0.7 m/s to any wind that is presented to the CMOD5 function during the wind retrieval process, called CMOD5.7 here. A more elegant way to algorithmically implement 10m neutral wind retrieval is to adopt the CMOD5 GMF coefficients to fit CMOD5.7, called CMOD5.n here. In this technical report the equivalence of CMOD5.7 and CMOD5.n is shown.

The noted differences stay within the uncertainties due to the GMF and the instrumental plus geophysical noise estimates. The highest relative differences occur for very low wind speeds, where these differences are geophysically least meaningful and where CMOD5.7 was artificially modified for inversion purposes (below 1 m/s). Further note that CMOD5 GMF errors at low winds were noted in [5]. The CMOD5.n residual appears somewhat lower than the CMOD5.7 residual for very low winds, indicating a better compatibility with the measurement triplets of CMOD5.n.

We recommend the implementation of CMOD5.n in the OSI SAF processing chain.

5 Appendix: CMOD5 and CMOD5.n coefficients

The CMOD5 Geophysical Model Function gives the radar backscatter (σ^0) as a function of wind speed v , incidence angle Θ and azimuth angle φ with respect to beam pointing. The construction of the CMOD5 function is described in detail in the appendix of [1]. Here, we only provide the coefficients necessary to construct the function, both for CMOD5 and for CMOD5.n [2].

Coefficient	Value (CMOD5)	Value (CMOD5.n)	Coefficient	Value (CMOD5)	Value (CMOD5.n)
C ₁	-0.688	-0.6878	C ₁₅	0.007	0.0066
C ₂	-0.793	-0.7957	C ₁₆	0.33	0.3222
C ₃	0.338	0.338	C ₁₇	0.012	0.012
C ₄	-0.173	-0.1728	C ₁₈	22.0	22.7
C ₅	0.0	0.0	C ₁₉	1.95	2.0813
C ₆	0.004	0.004	C ₂₀	3.0	3.0
C ₇	0.111	0.1103	C ₂₁	8.39	8.3659
C ₈	0.0162	0.0159	C ₂₂	-3.44	-3.3428
C ₉	6.34	6.7329	C ₂₃	1.36	1.3236
C ₁₀	2.57	2.7713	C ₂₄	5.35	6.2437
C ₁₁	-2.18	-2.2885	C ₂₅	1.99	2.3893
C ₁₂	0.4	0.4971	C ₂₆	0.29	0.3249
C ₁₃	-0.6	-0.725	C ₂₇	3.80	4.159
C ₁₄	0.045	0.045	C ₂₈	1.53	1.693

Table 1: Coefficients used to build CMOD5 (from [1]) or CMOD5.n.