Ocean and Sea Ice SAF

Technical Note

SAF/OSI/CDOP/KNMI/TEC/RP/167

Stability in SeaWinds Quality Control

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Version 1.0

April 2008

DOCUMENTATION CHANGE RECORD

Reference: SAF/OSI/CDOP/KNMI/TEC/RP/167

Issue / Revision:	Date:	Change:	Description:
Version 1.0	Apr. 2008		First version.

Contents

1 Introduction

A good assessment of the information content of scatterometer winds is particularly important in order to assimilate them in weather analysis. Besides retrieval problems in cases of a confused sea state, a particularly acute problem of Ku-band scatterometry is the sensitivity to rain. Elimination of poor quality data is therefore very important for the successful use of the wind data of the SeaWinds instrument on QuikSCAT [1,2]. The process of discriminating between good and bad quality Wind Vector Cells (WVCs) winds is called Quality Control (QC).

In the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF), wind products at 100-km and 25-km resolution are made in near-real time at KNMI. The processing is done using the SeaWinds Data Processor (SDP) software package. Input to the processing are the NOAA level 2 SeaWinds data in Binary Universal Form for the Representation of meteorological data (BUFR). Until now, the KNMI QC was based on the value of the Maximum Likelihood Estimator (MLE) [1-3] in the input product from NOAA. Since this input product will change in the near future, especially with regards to the formulation of the MLE [4], it is necessary to make the QC in the OSI SAF wind products independent of the MLEs as computed by NOAA.

This report describes how the QC procedure is modified and made independent of the NOAA MLE with the aim to provide continuity in the KNMI SeaWinds wind product quality. The results of two new QC algorithms are compared with those of the old QC and it is shown that the best new QC algorithm performs even slightly better than the old one.

The JPL rain flag in the NOAA product is also used in the KNMI QC. The rain flagging will also change and part of this report is devoted to the evaluation and possible reduction of its impact on the OSI SAF wind processing.

1.1 References

[1] Portabella, M. and A. Stoffelen, 2001
Rain Detection and Quality Control of SeaWinds
J. Atm. Oceanic Technol., **18**, 7, 1171-1183.

[2] Portabella, M. and A. Stoffelen, 2002a
A comparison of KNMI Quality Control and JPL Rain Flag for SeaWinds
Canadian Journal of Remote Sensing, **28**, 3, 424-430.

[3] Portabella, M. and A. Stoffelen, 2002b
Characterization of Residual Information for SeaWinds Quality Control
IEEE Transactions on Geoscience and Remote Sensing, **40**, 12, 2747-2759

[4] Jelenak, Z. and P. Chang, 2008
Changes in NOAA/NESDIS QuikSCAT NRT Processing
To be published.

1.2 Abbreviations and acronyms

AR	Ambiguity Removal
ASCAT	Advanced SCATterometer
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

MSS	Multiple Solution Scheme
NCEP	National Centers for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
OSI	Ocean and Sea Ice
SAF	Satellite Application Facility
SDP	SeaWinds Data Processor
WVC	Wind Vector Cell

2 Quality Control methods

Quality Control is performed in several steps of the scatterometer wind processing. Before the wind inversion step, WVCs containing a significant portion of land or ice are filtered out. After that, in the wind inversion, a set of ambiguous wind vector solutions is computed using a Geophysical Model Function (GMF). The GMF is an empirical function representing the radar backscatter as a function of wind speed and direction. This report is devoted to the Quality Control procedure that is part of the wind inversion step. The Ambiguity Removal (AR) is the next step in the wind processing: in each WVC one of the ambiguous wind solutions is selected in order to obtain a consistent and unambiguous wind field. Quality Control may also be a part of the AR step in order to achieve spatial consistency.

2.1 Old QC method

The Quality Control algorithm used in the OSI SAF wind processing at KNMI is extensively described in [1] and [2]. Both the Maximum Likelihood Estimator (MLE) and the JPL rain flag present in the BUFR input from NOAA are used. The MLE is defined as:

$$\mathrm{MLE} = \frac{1}{N}\sum_{i=1}^{N}\frac{(\sigma^0_{mi}-\sigma^0_{si})^2}{K_p(\sigma^0_{mi})}$$

where N is the number of measurements, σ^0_{mi} is the backscatter measurement, σ^0_{si} is the backscatter simulated through the GMF and $K_p(\sigma^0_{mi})$ is the measurement error variance. The MLE can be interpreted as the distance between a set of radar backscatter measurements and the solution set lying on the GMF manifold in an N-dimensional space. The normalised MLE or Rn is defined as Rn = MLE/<MLE>, where <MLE> is the expected MLE value of a particular WVC number and wind solution.

In the old QC algorithm, the following steps are performed in order to assess the quality of the radar backscatter data in a WVC.

1. The MLE value of the selected wind that is provided by NOAA in the SeaWinds BUFR product is normalised using an <MLE> function that depends on both wind speed and WVC number (1-76). This expected MLE is a 2D function fitted to the computed mean MLEs as a function of WVC number and wind speed. See the appendix in [3].
2. The normalised MLE is compared to a wind speed dependent threshold value that has a constant value of 2 for wind speeds above 15 m/s and has a parabolic shape with a maximum of 4 at 5 m/s for wind speeds below 15 m/s. See equation 3 in [1]. When the normalised MLE exceeds the threshold, the KMNI QC flag is set.
3. In WVC numbers 29-48, the so-called nadir part of the swath, the JPL rain flag provided in the input product is taken into account as well. If in a WVC the rain flag is set, the KNMI QC flag is set. It is shown in [2] that the QC based on the NOAA MLE value is less efficient in the nadir swath, and here the evaluation of the JPL rain flag helps to improve the Quality Control.
4. In the 100-km product, a WVC is flagged if more than half of the 16 (4 x 4) underlying 25-km WVCs are flagged.

It is clear that the KNMI QC is dependent on the MLE and the rain flag in the NOAA input product. Since the algorithms used to compute these values are changed, it is necessary to change the KMNI QC algorithm as well in order to preserve a Quality Control of at least the same skill as before. The goal is to make the KNMI QC as independent as possible of the NOAA algorithms. We will evaluate the QC based on the MLE and the QC based on the JPL rain flag separately.

2.2 New QC methods

Two QC algorithms have been considered as an alternative for the NOAA MLE-based QC.

1. A QC based on the normalised MLE of the first rank solution after the KNMI wind inversion at 25 km resolution. The first rank solution is the one from the set of ambiguous wind solutions with the lowest MLE value, i.e. lying closest to the GMF. If the normalised MLE exceeds a threshold value, the WVC is flagged. This method is appealing since it is simple, it does not need any information from the NOAA wind solutions in the input product and it is very much analogous to the QC used in the ASCAT and ERS wind processing at KNMI, that also use the MLE value of the first rank wind solution.
2. A QC based on the normalised MLE of the KNMI wind solution at 25 km resolution that is closest to the NOAA selected solution. If the normalised MLE exceeds a threshold value, the WVC is flagged. This method is appealing since it is more analogous to the old QC algorithm that already has proven its skill. Portabella and Stoffelen [1] report that a QC based on the selected NOAA wind solution performs slightly better than a QC based on the first rank NOAA wind solution. Hence we expect this algorithm to perform a bit better than the one based on the first rank KNMI solution. A drawback is that we still need wind information from NOAA for the QC computations. For this QC method, a separate normalisation table containing the <MLE> surface for the KNMI solutions closest to the NOAA selected winds is necessary. This table was obtained by processing three weeks of QuikSCAT data and averaging the MLE values after KNMI inversion for each WVC number and wind speed bin. The resulting surface is shown in figure 1. Note that this surface is “filtered” in order to remove noise. For each bin, MLEs higher than 5 times the mean MLE value are rejected and with the remaining data, a new mean MLE value is computed. This process is repeated iteratively and the MLE surface appears to converge after 9 steps. After the 9 iterations, approximately 3.7% of the data is rejected. The <MLE> surface that is obtained in this way very much resembles the one based on the first rank KNMI solution, which is now used for the computation of the normalised MLE and solution probability prior to the Ambiguity Removal step of the wind processing.

Note that in both new QC methods, the same normalised MLE threshold as for the old KNMI QC (see step 2 in section 2.1) is used, despite slight differences in the normalised MLE distribution, i.e., generally higher values for the “selected” norm.

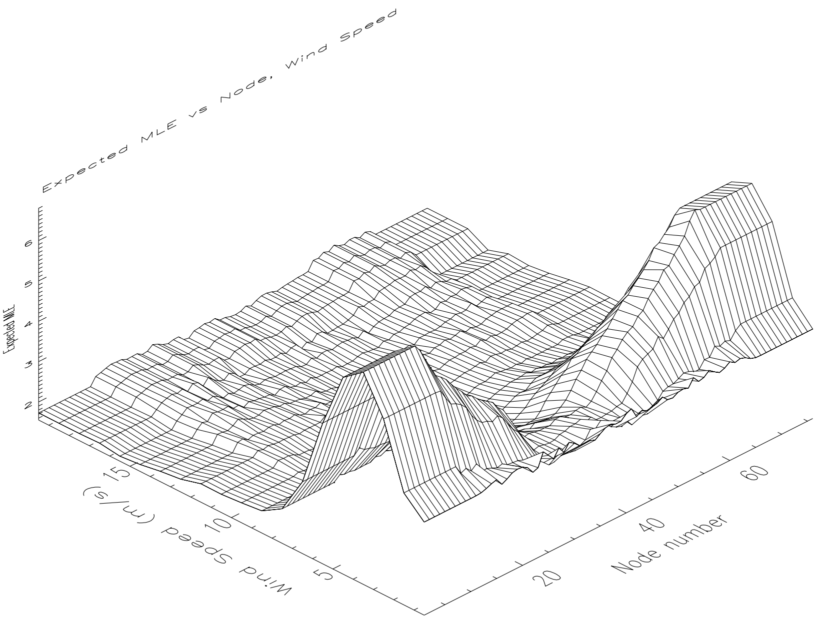

Figure 1: <MLE> surface of the KNMI wind solutions closest to the NOAA-selected winds.

3 Statistical analysis

3.1 MLE-based QC

Following the approach in [1], a set of QuikSCAT data was collocated with Special Sensor Microwave Imager (SSM/I) rain data obtained from the public Remote Sensing Systems FTP server ftp.ssmi.com. Two weeks of QuikSCAT data, from 25 August to 7 September 2005, were used. Note that these are data produced with the old NOAA algorithms, but for our purpose this does not make any difference since the NOAA MLEs are not used. The NCEP 1000 mb model winds were replaced by ECMWF 10 m forecast winds, interpolated both spatially and temporally (+3h - + 15h forecast used). The SSM/I rain rates from the *F-13* and *F-14* satellites were used if they were less than 30 minutes in time and less than 0.25° in space apart from the QuikSCAT Wind Vector Cell.

In order to assess the skill of the QC algorithms, we have computed the number of accepted and rejected WVCs with their vector RMS and bias values with respect to the ECMWF background winds and segregated the results according to rain rate and swath region. The results for the old QC algorithm and the two alternative QC algorithms are shown in tables 1-3. If a QC algorithm performs well, we expect low RMS and bias values for the accepted WVCs and large RMS and bias values for the rejected WVCs. Moreover, the WVCs with high rain rates (> 6 mm/hr) should have high rejection rates since it is known that QuikSCAT is not reliable in rainy conditions. In dry conditions, we expect rejection rates of only a few percent. These rejections are mainly associated with a confused sea-state in the WVC. Note that in all these computations, the JPL rain flag evaluation (step 3 in section 2.1) was switched off.

Rain rate = 0 mm/hr									
	All WVCs (9-68)			Sweet swath (12-28, 49-65)			Nadir swath (29-48)		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	2814731			1620024			970421		
Accepted	95.57%	1.906	-0.072	95.69%	1.902	-0.050	95.50%	1.918	-0.108
Rejected	4.43%	2.636	0.461	4.31%	2.711	0.503	4.50%	2.519	0.428
0 mm/hr < Rain rate <= 6 mm/hr									
	All WVCs (9-68)			Sweet swath (12-28, 49-65)			Nadir swath (29-48)		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	127632			72599			44555		
Accepted	66.82%	3.453	1.071	64.55%	3.476	1.034	69.88%	3.442	1.144
Rejected	33.18%	4.766	2.595	35.45%	4.800	2.585	30.12%	4.628	2.538
Rain rate > 6 mm/hr									
	All WVCs (9-68)			Sweet swath (12-28, 49-65)			Nadir swath (29-48)		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	11860			7060			4014		
Accepted	22.29%	6.222	3.954	19.60%	6.178	4.057	27.11%	6.359	3.846
Rejected	77.71%	7.961	5.924	80.40%	8.050	6.067	72.89%	7.686	5.478
All Rain rates									
	All WVCs (9-68)			Sweet swath (12-28, 49-65)			Nadir swath (29-48)		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	2954223			1699683			1018990		
Accepted	94.04%	1.980	-0.033	94.04%	1.974	-0.015	94.11%	1.996	-0.063
Rejected	5.96%	3.700	1.260	5.96%	3.815	1.344	5.89%	3.505	1.145

Table 1: Accepted and rejected WVCs using Quality Control based on the MLE of the selected NOAA solution ("old method") for different SSM/I rain regimes. RMS and bias values are in m/s with respect to ECMWF forecast winds.

If we first compare the results of Table 2 to those of Table 1, we see that the QC skill in table 1 is slightly better. If we compare the accepted and the rejected rain-free WVCs, the RMS value increases from 1.906 to 2.636 in Table 1, whereas it only increases from 1.934 to 2.513 in Table 2. That is, the accepted WVCs in Table 1 have a lower RMS value than the accepted WVCs in Table 2, whereas the rejected WVCs in Table 1 have a higher RMS value than the rejected WVCs in Table 2. Hence, the algorithm used in Table 1 better discerns good quality WVC winds (low RMS values) from bad quality winds (high RMS values). If we look at the wind speed biases, we find similar behaviour; in Table 1 there is a better bias discrimination between rejected and accepted WVCs.

Also note that the rejection rate for rain-free WVCs is lower in Table 1 (4.43%) than in Table 2 (4.95%). Hence, in Table 1, we not only have better discrimination in terms of RMS and bias, but also a larger fraction of the good quality WVCs is kept. This is according to expectations, since the "rank-1" norm is smaller than the "selected" norm, and thus the "rank-1" normalised MLE larger than the "selected" normalised MLE.

However, if we look at the results for rainy WVCs (rain rate > 6 mm/hr), the results are better in Table 2. Here we see a larger rejection rate (79.38% versus 77.71%).

Rain rate = 0 mm/hr									
	All WVCs (9-68)			**Sweet swath (12-28, 49-65)**			**Nadir swath (29-48)**		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	2814731			1620024			970421		
Accepted	95.05%	1.934	-0.061	95.13%	1.933	-0.038	95.13%	1.940	-0.099
Rejected	4.95%	2.513	0.220	4.87%	2.531	0.214	4.87%	2.498	0.276
0 mm/hr < Rain rate <= 6 mm/hr									
	All WVCs (9-68)			**Sweet swath (12-28, 49-65)**			**Nadir swath (29-48)**		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	127632			72599			44555		
Accepted	70.83%	3.650	1.185	71.00%	3.639	1.133	69.97%	3.681	1.311
Rejected	29.17%	5.057	2.871	29.00%	5.122	2.901	30.03%	4.913	2.800
Rain rate > 6 mm/hr									
	All WVCs (9-68)			**Sweet swath (12-28, 49-65)**			**Nadir swath (29-48)**		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	11860			7060			4014		
Accepted	20.62%	6.853	4.221	18.87%	6.698	4.170	24.41%	7.149	4.418
Rejected	79.38%	8.210	6.176	81.13%	8.276	6.250	75.59%	7.999	5.963
All Rain rates									
	All WVCs (9-68)			**Sweet swath (12-28, 49-65)**			**Nadir swath (29-48)**		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	2954223			1699683			1018990		
Accepted	93.70%	2.023	-0.017	93.78%	2.019	0.003	93.75%	2.032	-0.048
Rejected	6.30%	3.641	1.052	6.22%	3.704	1.076	6.25%	3.571	1.077

Table 2: Same as Table 1 but for Quality Control based on the MLE of the first rank KNMI solution.

If we compare the results in Table 3 to those in Table 1, it appears that the skill of both algorithms is comparable. In the rain-free case, the RMS difference between accepted and rejected WVCs (1.916 versus 2.710) is higher as compared to Table 1 (1.906 versus 2.636), but the bias difference in Table 3 (-0.065 versus 0.391) is lower than in Table 1 (-0.072 versus 0.461). The rejection rate is a bit lower in Table 3 (4.22% versus 4.43% in Table 1). We conclude that the skill in Table 3 is a bit better, although the differences are marginal.

The QC skill for the rainy WVCs is slightly better in Table 3 (77.84% rejection rate) than in Table 1 (77.71% rejection rate), but here the differences are quite small, as well.

In all tables, the QC skill in the sweet swath is better than in the nadir swath. Especially in the rainy WVCs (rain rate > 6 mm/hr) we see higher rejection rates in the sweet swath in all tables. In the rain free WVCs, we see a generally higher RMS value difference in the sweet swath when comparing accepted and rejected WVCs, although in Table 2 the difference is small. In terms of wind speed bias value differences (rain free WVCs), the sweet and nadir swaths show comparable results in all three tables.

Rain rate = 0 mm/hr									
	All WVCs (9-68)			**Sweet swath (12-28, 49-65)**			**Nadir swath (29-48)**		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	2814731			1620024			970421		
Accepted	95.78%	1.916	-0.065	95.89%	1.909	-0.044	95.87%	1.936	-0.099
Rejected	4.22%	2.710	0.391	4.11%	2.770	0.413	4.13%	2.628	0.397
0 mm/hr < Rain rate <= 6 mm/hr									
	All WVCs (9-68)			**Sweet swath (12-28, 49-65)**			**Nadir swath (29-48)**		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	127632			72599			44555		
Accepted	64.96%	3.635	1.139	62.91%	3.606	1.053	68.65%	3.725	1.333
Rejected	35.04%	4.919	2.714	37.09%	4.908	2.658	31.35%	4.919	2.790
Rain rate > 6 mm/hr									
	All WVCs (9-68)			**Sweet swath (12-28, 49-65)**			**Nadir swath (29-48)**		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	11860			7060			4014		
Accepted	22.16%	7.089	4.412	19.83%	6.991	4.316	27.68%	7.257	4.680
Rejected	77.84%	8.303	6.229	80.17%	8.345	6.289	72.32%	8.163	6.055
All Rain rates									
	All WVCs (9-68)			**Sweet swath (12-28, 49-65)**			**Nadir swath (29-48)**		
		RMS	bias		RMS	bias		RMS	bias
Nr. of WVCs	2954223			1699683			1018990		
Accepted	94.15%	2.000	-0.025	94.17%	1.988	-0.009	94.41%	2.031	-0.048
Rejected	5.85%	3.873	1.305	5.83%	3.958	1.359	5.59%	3.767	1.272

Table 3: Same as Table 1 but for Quality Control based on the MLE of the KNMI solution closest to the selected NOAA solution.

We conclude that the QC algorithm in Table 2 performs not as good as the old QC, although the algorithm still is useable. The QC algorithm in Table 3 has the same or a slightly better skill than the old QC approach and is good enough to succeed the old algorithm. In the remainder of this report we will refer to this QC algorithm (algorithm 2 in section 2.2) as the “new” QC method.

3.2 Influence of JPL rain flag

The new QuikSCAT data from NOAA will include not only a new MLE formulation but also a new JPL rain flag [4]. The new rain flagging algorithm is less conservative than the old one, i.e. it flags less WVCs. We tested the influence of the old versus the new JPL rain flag by processing old and new NOAA data over the same period: 8 January 2008 1:10 UTC to 11 January 2008 1:33 UTC. The NOAA data produced with the new algorithm were kindly provided to KNMI parallel to the operational QuikSCAT data stream. Since the KNMI QC uses the JPL rain flag only in the nadir part of the swath, only this part was considered (WVCs 29-48), see Table 4.

Note that the number of wind containing WVCs is different for the old and new NOAA products (709543 vs. 704896, a difference of 0.66%). We looked into this issue more closely and found out that it is caused by changes in the NOAA land and ice flagging between the old and new data – land or ice flagged WVCs are not processed by SDP. We assume that this difference only marginally contributes to the bias and RMS values in Table 4.

The upper part of Table 4 confirms that there is not much difference between the old QC method (based on the NOAA MLE of the selected NOAA solution) and the new QC method (based on the KNMI MLE of the KNMI solution closest to the selected NOAA wind). We find somewhat higher rejection rates as compared to those in Table 1 and Table 3 (look at the 'Nadir swath' / 'All Rain rates' part of Table 1 and Table 3). Higher rejection rates are indeed expected since in Table 4 the JPL rain flag is taken into account – rain flagged WVCs are rejected in Table 4, but not in the previous section.

Old NOAA product						
	Old QC method			**New QC method**		
		RMS	bias		RMS	bias
Nr. of WVCs	709543			709543		
Accepted	90.93%	1.943	-0.281	91.16%	1.948	-0.280
Rejected	9.07%	3.301	0.965	8.84%	3.361	0.983
New NOAA product						
	New QC method			**New QC method, lower MLE threshold**		
		RMS	bias		RMS	bias
Nr. of WVCs	704896			704896		
Accepted	92.92%	1.984	-0.254	90.86%	1.973	-0.257
Rejected	7.08%	3.428	1.017	9.14%	3.186	0.737

Table 4: Accepted and rejected WVCs using old and new KNMI QC and old and new NOAA products. Only the nadir region of the swath (WVCs 29-48) is considered. RMS and bias values are in m/s with respect to ECMWF forecast winds.

If we compare the upper right part and the lower left part in Table 4, we can see the influence of the old versus the new JPL rain flag. It is clear that the rejection rate is lower with the new, more relaxed, JPL rain flag (7.08% vs. 8.84%). It is also clear that the RMS and bias values of the accepted WVCs are slightly higher in the bottom left part of the table. This indicates that a little more bad quality WVCs are not rain flagged with the new JPL algorithm and in this way we loose some skill in the Quality Control.

In order to investigate whether we can compensate for the loss of skill in the Quality Control due to the more relaxed JPL rain flagging, we tried to raise the rejection rates of the new NOAA product and bring them to the same values as they had with the old NOAA product. This was done by reducing the MLE threshold in the nadir swath (see step 2 in section 2.1). It appears that if we multiply the threshold by 0.85, we obtain a rejection rate that is comparable to the rejection rate obtained with the old NOAA data. The results are in the lower right part of Table 4 and should be compared to the upper right part of this table: the rejection rate is nearly identical now (9.14% vs. 8.84%). It is clear, however, that the skill of the QC in the lower right part of the table is worse: we see higher RMS and bias values for the accepted WVCs, and lower RMS and bias values for the rejected WVCs when we compare with the upper right part. We can also compare the lower right and left parts of Table 4. The RMS value of the extra WVCs that are rejected in the lower right part (9.14% - 7.08% = 2.06%) can be calculated as $\sqrt{(9.14 \times 3.186^2 - 7.08 \times 3.428^2)/2.06} = 2.155$ m/s. Hence, the RMS value of the extra rejected WVCs is only slightly higher than the RMS value of the accepted WVCs (1.973 m/s) and these are still of reasonably good quality.

Clearly, lowering the MLE threshold does not help to improve the skill of the Quality Control.

3.3 Effect on 100-km product

Until now, we have only considered the changes in the 25-km OSI SAF SeaWinds product. It is important however to look at the 100-km product, as well. The influence of the new MLE-based KNMI Quality Control and the new JPL rain flag on the 100-km product was evaluated using the same data set of three days as was used in section 3.2. Note that in a 100-km WVC no winds are calculated if more than half of the 16 (4 x 4) underlying 25-km WVCs are flagged. Hence, it is not possible to compute RMS and bias values for rejected winds. The statistics of the accepted WVCs are shown in Table 5. The same subdivision as in Table 4 is used in this table.

Old NOAA product						
	Old QC method			**New QC method**		
	Nr. of WVCs	RMS	bias	Nr. of WVCs	RMS	bias
Accepted	41383	2.265	-0.034	41517	2.264	-0.037
New NOAA product						
	New QC method			**New QC method, lower MLE threshold**		
	Nr. of WVCs	RMS	bias	Nr. of WVCs	RMS	bias
Accepted	42107	2.356	0.001	41870	2.336	-0.009

Table 5: Accepted 100-km WVCs using old and new KNMI QC and old and new NOAA products. Only the nadir region of the swath (WVCs 8-12) is considered. RMS and bias values are in m/s with respect to ECMWF forecast winds.

From the top left and top right parts of Table 5 it is clear that (like in the 25-km product) the results of the old and new QC methods are very similar. If we compare the top right and bottom left parts of the table (old versus new JPL rain flag), we see that a higher number of WVCs is accepted, resulting in a small increase of the RMS and bias values. The increases are even smaller here than those obtained for the 25-km product.

Finally, if we compare the bottom right part with the bottom left part of Table 5 (MLE threshold reduced to 0.85 times its original value), we see a reduction of the number of accepted WVCs, but almost no improvement in the RMS and bias values.

These results are very similar to those obtained with the 25-km product in the previous section and we conclude that the old and new MLE-based QC methods yield comparable results. The influence of the JPL rain flag on the 100-km product is even smaller when we compare to the 25-km product.

4 Case study

In order to compare the old and new QC methods synoptically, we compared the QuikSCAT wind field using the old and new NOAA algorithms and the old and new KNMI QC methods. The new KNMI QC method implies both the new MLE-based QC and the evaluation of the JPL rain flag in the nadir part of the swath. For illustration purposes we here present a case from 8 January 2008 around 3:00 UTC.

Figure 2 shows the 25-km resolution wind field over the Indian Ocean (south of Madagascar) using data with the old NOAA algorithm and using the old KNMI QC. Red arrows denote valid wind vectors; yellow dots denote WVCs for which the KNMI QC flag is set. Yellow arrows denote WVCs for which the Variational Quality Control flag is set. This is part of the Ambiguity Removal step and not relevant in this context. Also shown in the picture is a Meteosat 7 Infrared image from 3:00 UTC.

Several regions are marked in figure 2 where a large part of the WVCs is QC flagged: south and near the centre of the cyclonic structure (region 1), east of the centre of the cyclonic structure (region 2), near 45° South and 54° East (region 3) and near 32° South and 57° East (region 4).

Figure 3 shows the SDP QuikSCAT wind field using the old NOAA input files, but the new KNMI QC. It appears that the flagged regions are a bit smaller in this figure, especially in region 1. Still, the wind vectors that are present in figure 3 but not in figure 2 appear to be quite consistent and in this sense, the new QC is beneficial since it flags less WVCs of good quality. It is also clear that the new KNMI Quality Control flags less scattered WVCs in regions where the wind field is smooth and no rain is present; see for example the top left part of figure 3 where less scattered yellow dots are present as compared to figure 2.

Figure 4 shows the SDP QuikSCAT wind field using the new NOAA input files and the new KNMI QC. Hence, figures 3 and 4 show the difference between the old and the new JPL rain flag (although only used in the nadir swath). There seems to be not much influence in regions 1, 3 and 4, but in region 2, there are almost no WVCs flagged anymore. This is consistent with what was reported in [4]: in the new NOAA QuikSCAT product, the rain flagging of data has been reduced from 4.2% to ~1.8% of the WVCs. The wind vectors in region 2 in figure 4 seem to be consistent and of good quality, so in this sense the new rain flagging is successful in the reduction of the apparent false alarm rate. It is remarkable though that the new rain flag algorithm flags quite some WVCs in a low wind and apparently cloud-free area near 25° South and 51° East (region 5 in figure 4).

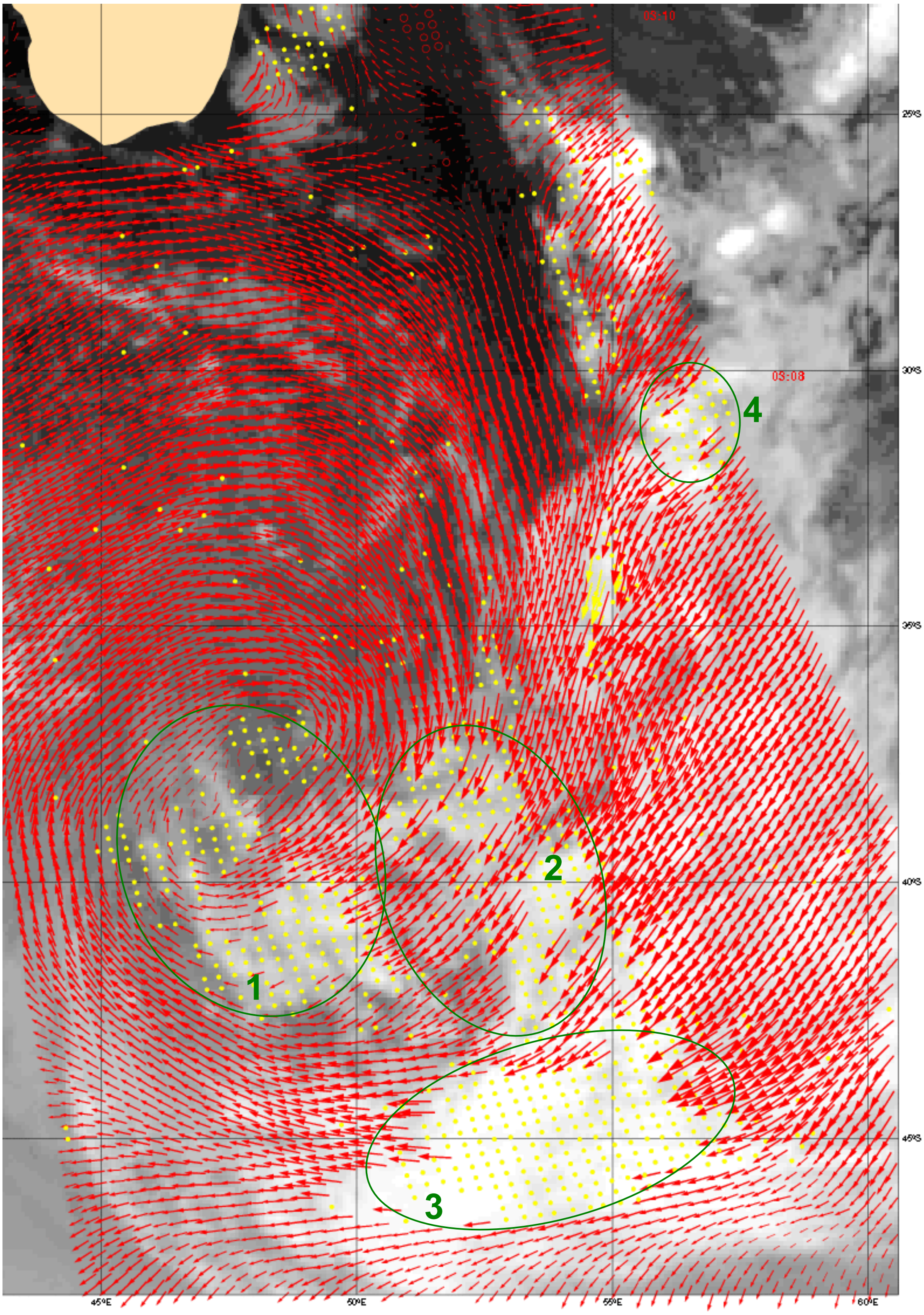

Figure 2: SDP QuikSCAT wind field from 8 January 2008, 3:00 UTC, using old NOAA input data and made with old KNMI QC.

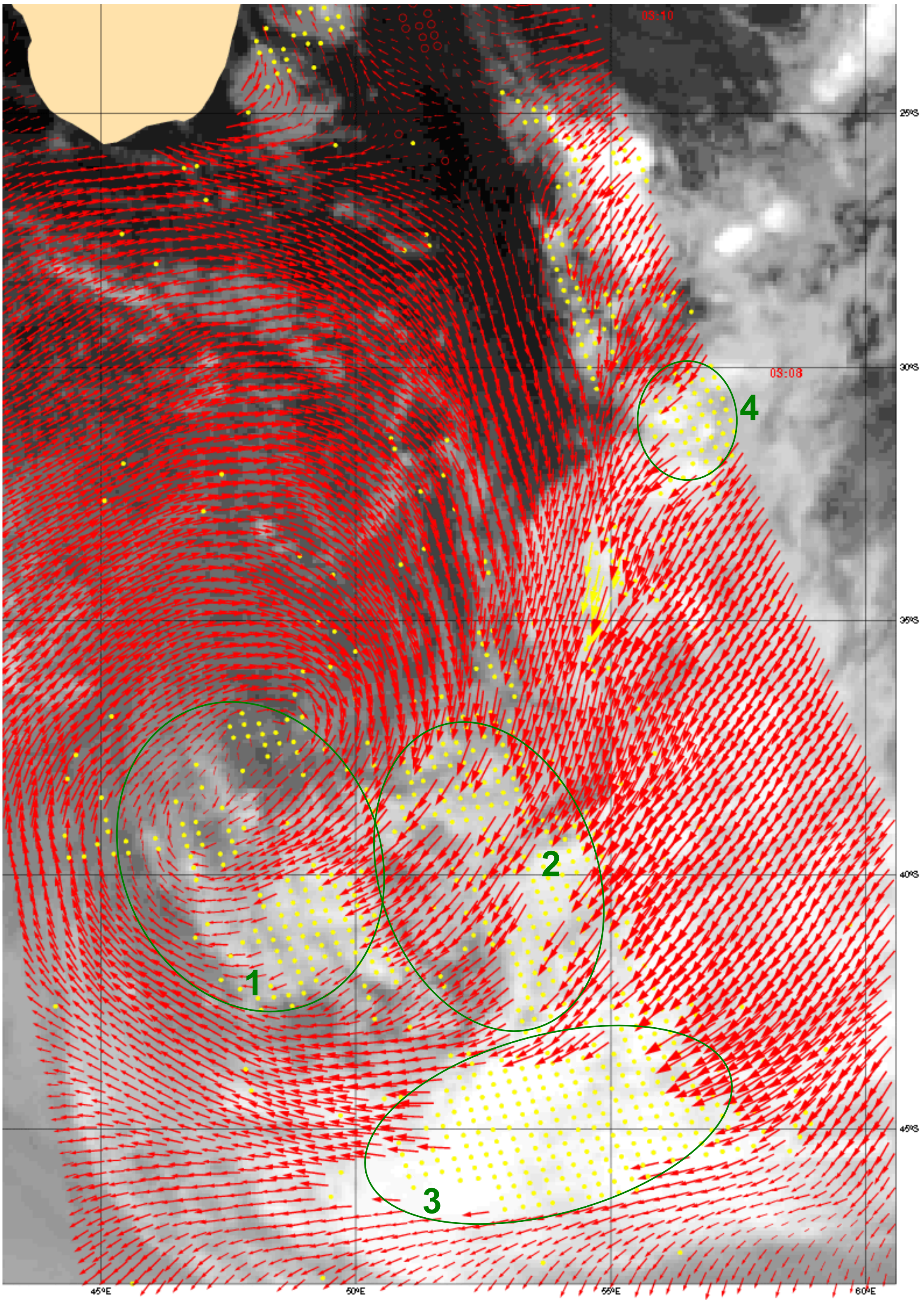

Figure 3: SDP QuikSCAT wind field from 8 January 2008, 3:00 UTC, using old NOAA input data and made with new KNMI QC.

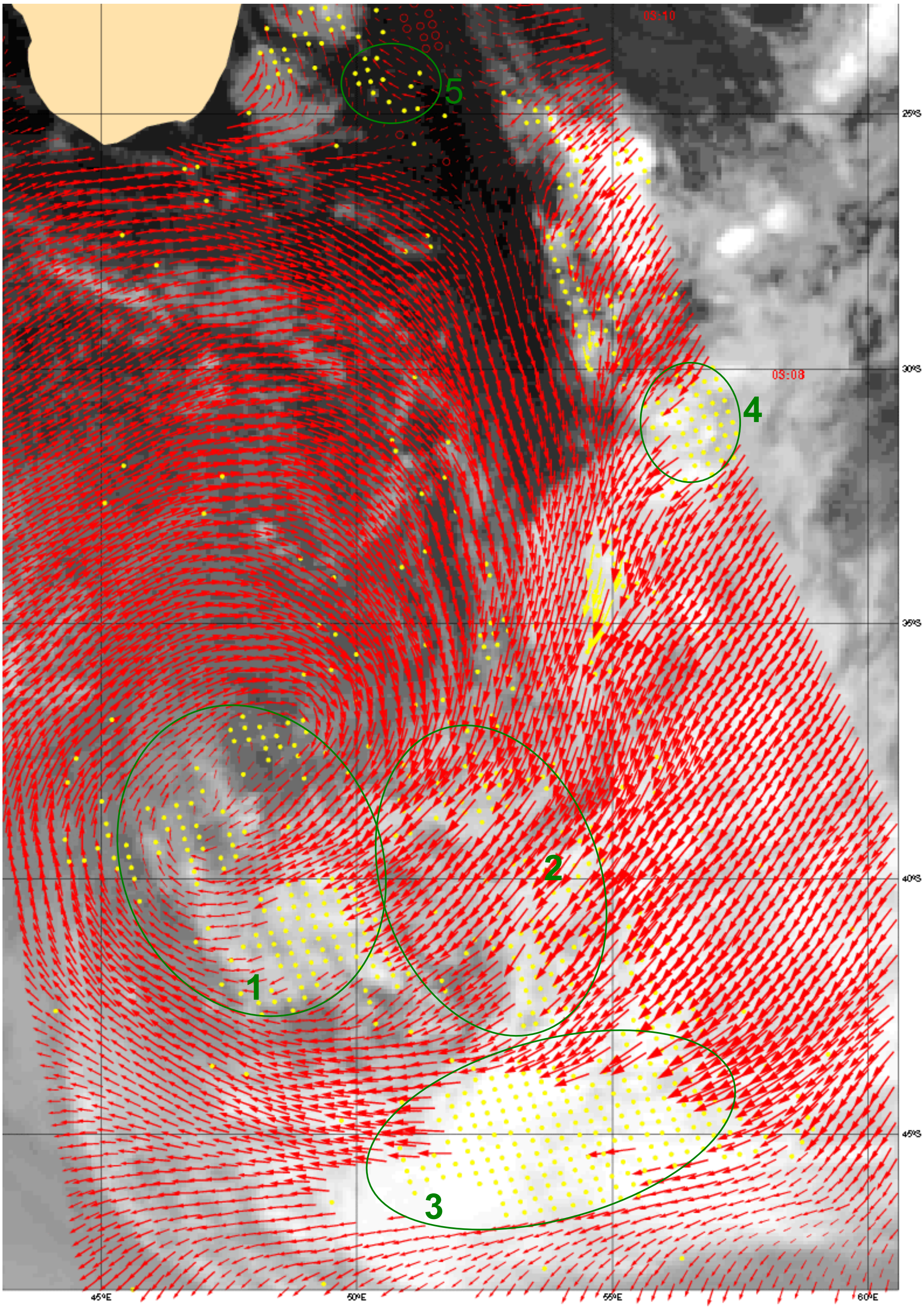

Figure 4: DP wind field from 8 January 2008, 3:00 UTC, using new NOAA input data and made with new KNMI QC.

5 Conclusions

From the statistical analyses and the case studies in the previous chapters we can draw some conclusions for the Quality Control of the OSI SAF QuikSCAT wind processing at KNMI.

The KNMI QC algorithm 2 presented in section 2.2 offers a good alternative for the old QC that was based on the MLE values as computed by NOAA. Although it still somewhat relies on NOAA wind data in the input BUFR product, it does not need NOAA MLE values any more. The new KNMI QC algorithm has at least the same skill as the old one.

The use of the JPL rain flag in the nadir swath is part of the KNMI wind processing. Since the new rain flagging is less conservative, less WVCs will be flagged and some more WVCs will probably incorrectly pass the Quality Control. Since NOAA will stop producing the data using the old rain flag algorithm, this aspect is not easily tackled. However, the KNMI QC already filters most of the rainy WVCs and the wind vectors that pass both KNMI QC and JPL rain flagging seem to be consistent and of at least reasonable quality (see section 4). This is confirmed by the analysis of their RMS and bias values in section 3.2.

Finally, the OSI SAF SeaWinds products remain of similar quality and the changes in the NOAA processing will only have very limited influence on the OSI SAF wind products, both at 25-km and 100-km resolution.