EUMETSAT Satellite Application Facility Scatterometer Activities

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ABSTRACT

The launch of the Advanced Scatterometer ASCAT on MetOp-A is planned on 17 July 2006. In Europe, scatterometer product development is organised through the EUMETSAT Satellite Application Facilities. Product developments are focussed on using the data for Numerical Weather Prediction and short-range weather forecasting. The former is well suited by the SeaWinds products as currently produced at KNMI at 100-km resolution (see http://www.knmi.nl/scatterometer) in preparation of the operational ASCAT production suite. For short-range forecasting or in semi-enclosed sea areas such as the Mediteranean, however, higher resolution is desirable, and both an experimental 25-km SeaWinds product is available and the Early Advanced Retransmission Service, EARS, ERS-2 product. The European Space Agency ERS-2 scatterometer KNMI product provides quasi real-time winds in the North Atlantic and European seas. It is currently provided in the ASCAT BUFR format to facilitate the development of ASCAT user interfaces. KNMI attempts to improve the spatial filtering properties of the wind retrieval by using prior information on the expected meteorological balance, e.g., favouring rotational structures in high-latitude regions. Moreover, we use solutions in all wind directions, but weighted by their inherent probability. The 2D-VAR method has the advanced filtering properties for maintaining small-scale meteorological information in SeaWinds, while reducing noise. This is tested by comparing the spatial covariance structures of the KNMI products, with those of the NOAA SeaWinds product, and, for reference, those of the NCEP model. The methodology leads towards a high-resolution scatterometer wind product. Based on these principles KNMI plans in the next phase of the SAFs to develop a 12.5-km ASCAT scatterometer wind product in the coastal zone.

1. INTRODUCTION

The all-weather capability of a scatterometer provides unique wind field products of the most intense and often cloud-covered wind phenomena, such as tropical cyclones (for example, see figure 1). As such, it has been demonstrated that scatterometer winds are useful in the prediction of tropical cyclones, e.g., Isaksen and Stoffelen (2000), and extra-tropical cyclones (Stoffelen and Beukering, 1997). At the moment the ESA ERS-2 and the NASA SeaWinds scatterometer on QuikScat provide respectively a regional real-time and a global near-real time data stream. In 2006 EUMETSAT will continue the global scatterometer mission with the ASCAT scatterometer on EPS/METOP, and will start a regional real-time ASCAT dissemination. As such, continuity of both services is likely provided to the operational meteorological community for another period of 15 years.

EUMETSAT set up Satellite Application Facilities (SAF) providing software and data products and services. KNMI is involved in the scatterometer activities of the following SAFs in preparation for ASCAT:

- Numerical Weather Prediction SAF for scatterometer software products;
- Ocean and Sea Ice SAF for scatterometer wind products; and Scatterometer Ocean Stress (SOS) products.

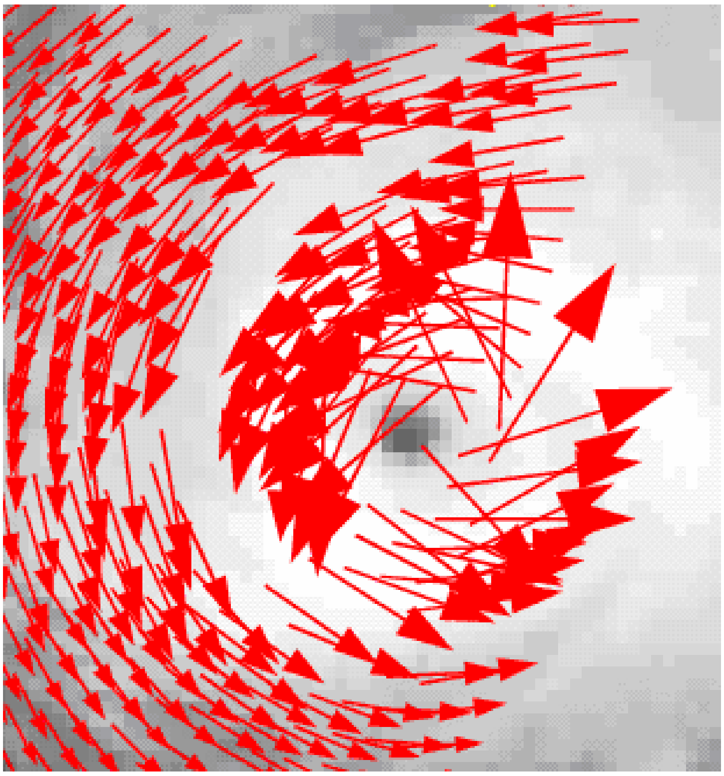

Figure 1. QuikScat 25-km wind product generated at KNMI for tropical cyclone Rita (2005), raging in the Caribbean. GOES IR cloud imagery is provided underneath for reference.

In Figure 2 an overview of the scatterometer wind processing package is given. Scatterometer sea surface wind research and development lies at the basis of wind product innovation:

- Input product consistency checks, quality control, rain (for SeaWinds) and ice (for ERS) screening;
- Simultaneous processing of multiple ERS-2 ground station acquisitions in order to
    - provide unique processing at all wind vector cells (WVC), i.e., avoid duplicates;
    - complete backscatter triplets by combining acquisitions of all available ground stations at each WVC;
- Spatial averaging methodologies to reduce noise and enhance quality of SeaWinds products;Inversion: computation of optimal wind solutions and associated probabilities from measurement information;
- Determination of information content; definition of observation operator; ambiguity removal (spatial filter to determine a unique wind vector field);
- Processors for real-time and archive scatterometer wind and stress products;
- Active monitoring and quality assurance methodologies (of instrument and processing); and
- Web site (visualisation) and product distribution;

Product enhancement and the preparation of wind production and user services for ASCAT on METOP are the main goals of this R&D. KNMI currently processes a global OSI SAF QuikScat 100-km product, an experimental SeaWinds 25-km product, and a North- Atlantic ERS-2 25-km product, and distributes it to the international meteorological community. Moreover, KNMI-processed ERS-2 scatterometer winds are made available in quasi real-time through the ASCAT Early Advanced Retransmission Service (EARS). Moreover, at http://www.knmi.nl/scatterometer links to the visual presentation of these products are provided, both in vector and flag presentation. Global maps of wind speed are provided over the last 22 hours (as in Figure 3), segregated in ascending and descending orbit tracks. By mouse clicks on these maps more detailed regional plots become available (as in figure 1). The link also provides documentation, papers, and software products.

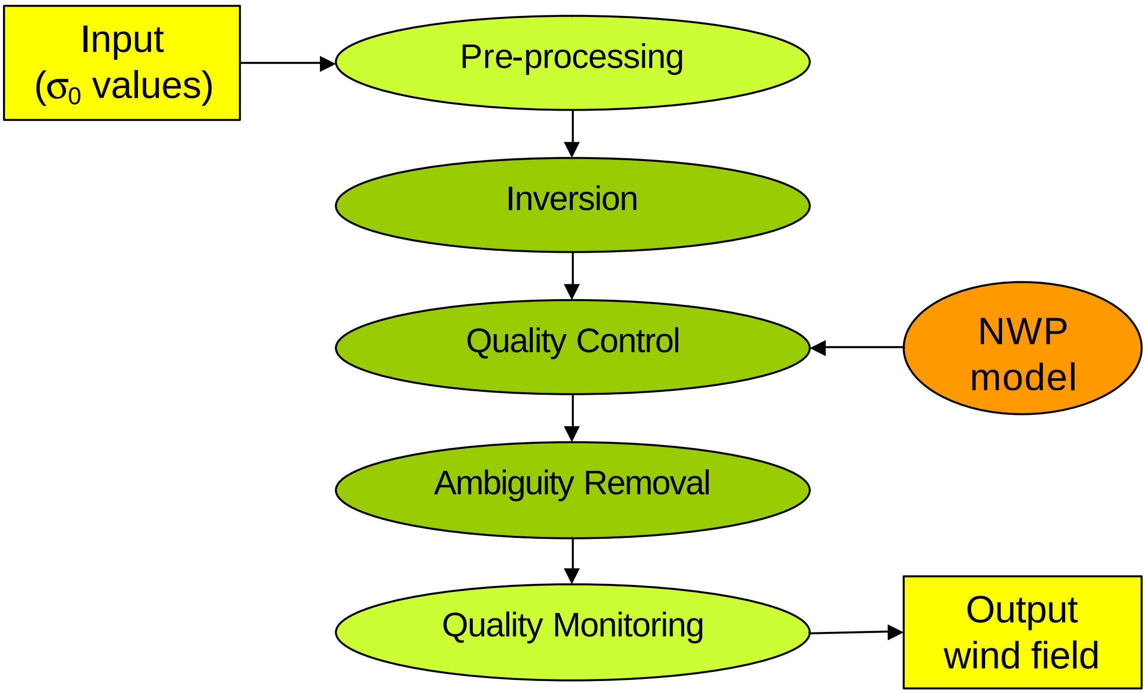

Figure 2. **Overview of scatterometer wind processing package as available at KNMI.**

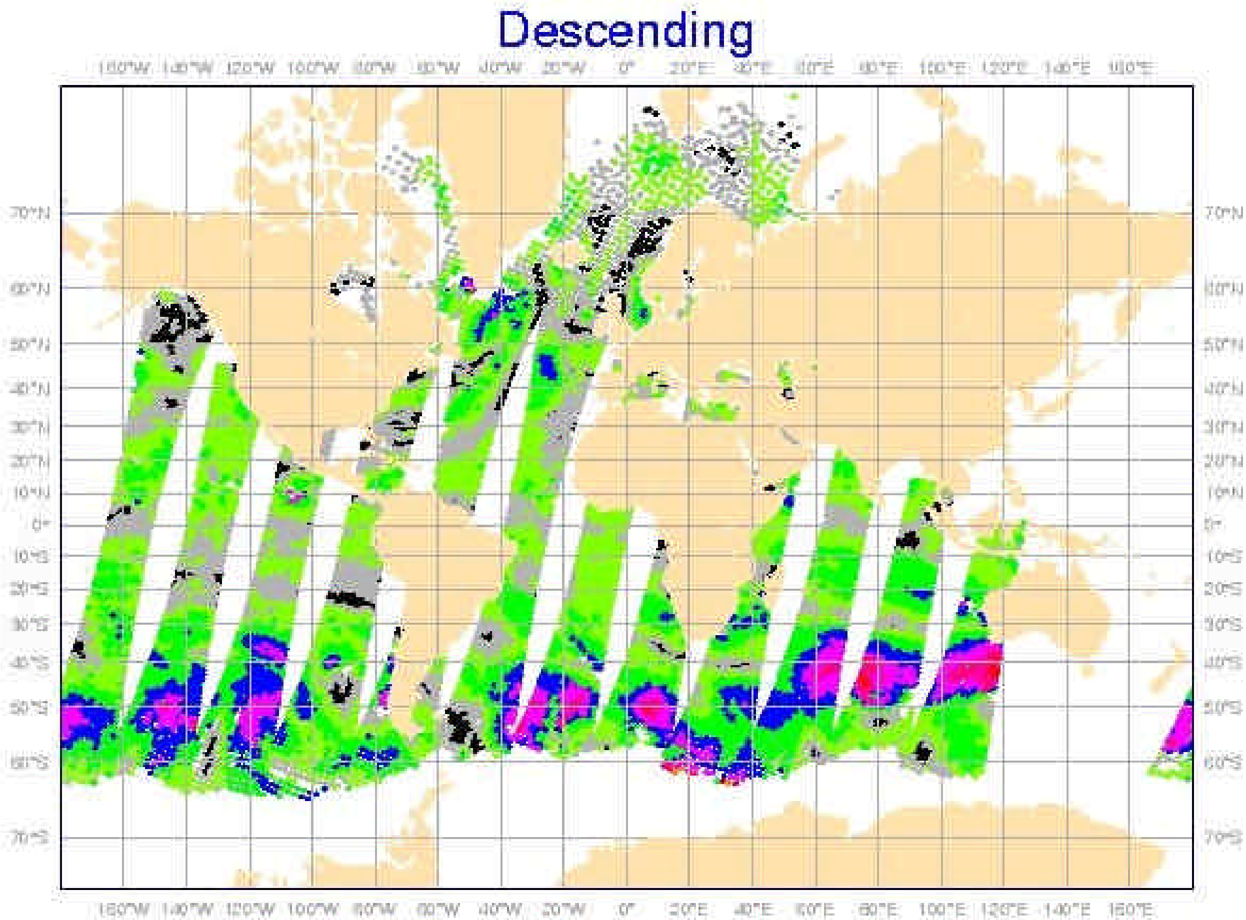

Figure 3. **Overview of QuikScat SeaWinds 100-km wind speeds (coloured) as generated at KNMI.**

2. QUIKSCAT PRODUCTS

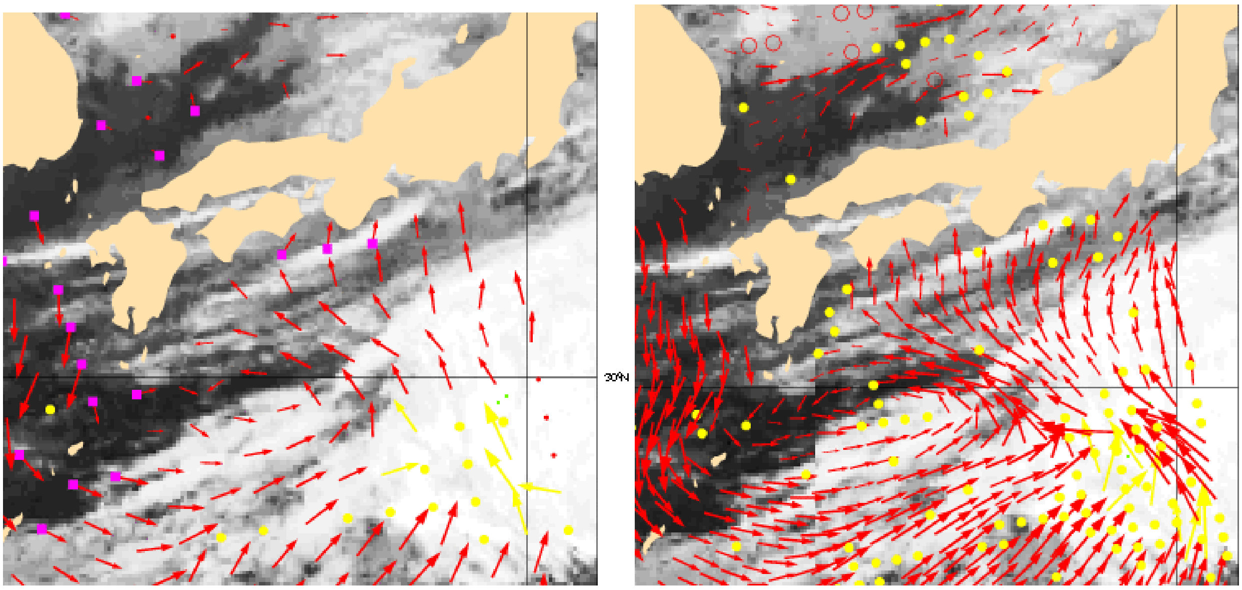

Figure 4. QuikScat 100-km (left) and corresponding 25-km (right) wind product generated at KNMI. GOES IR cloud imagery is provided underneath for reference.

The standard KNMI 100-km QuikScat product has been developed for NWP assimilation and it is verified to compare better with independent ECMWF NWP winds and is thus suitable for NWP assimilation (Portabella, 2002). At lower resolutions more random wind noise is expected from SeaWinds. The use of the KNMI 100-km product in NWP provides generally positive or neutral impact, depending on the study period. Further noise reduction and QC is believed to be beneficial for NWP impact and further progress is being made by implementing the so-called Multiple Solution Scheme (MSS) as presented at the 7th IWW. The improvement is brought by using wind vector probability information in combination with the 2D-VAR background constraints on rotation and divergence (Portabella and Stoffelen, 2003). We further note that the improved verification of MSS is mainly due to the reduction of occasional erratic noise; coherent mesoscale structures remain present and become more visible due to the noise reduction.

Based on this experience a 25-km MSS SeaWinds product was developed and is now operated experimentally at KNMI (see www.knmi.nl/scatterometer). In figure 4 the MSS 25-km product is shown on the right. It is clear that important mesoscale details, potentially useful for short range weather forecasting and nowcasting, are added. Figure 5 shows an example of the product in the tropical region. The finding at 100-km resolution for MSS that the 2D-VAR NWP background winds, NCEP winds at 1000 mb, have a relatively small influence on the product appears also valid at 25 km. This needs to be further validated however.

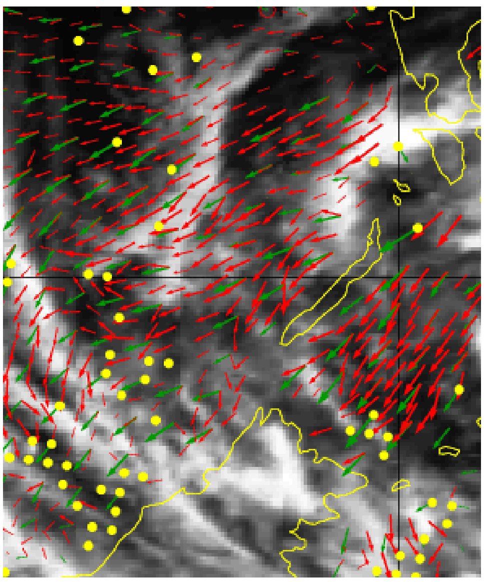

Figure 5. QuikScat 25-km (red) wind product generated at KNMI on top of the background NCEP 1000-mb winds (green) used in 2D-VAR. GOES IR cloud imagery is provided underneath for reference.

3. INCREASED SPATIAL RESOLUTION AND NOISE

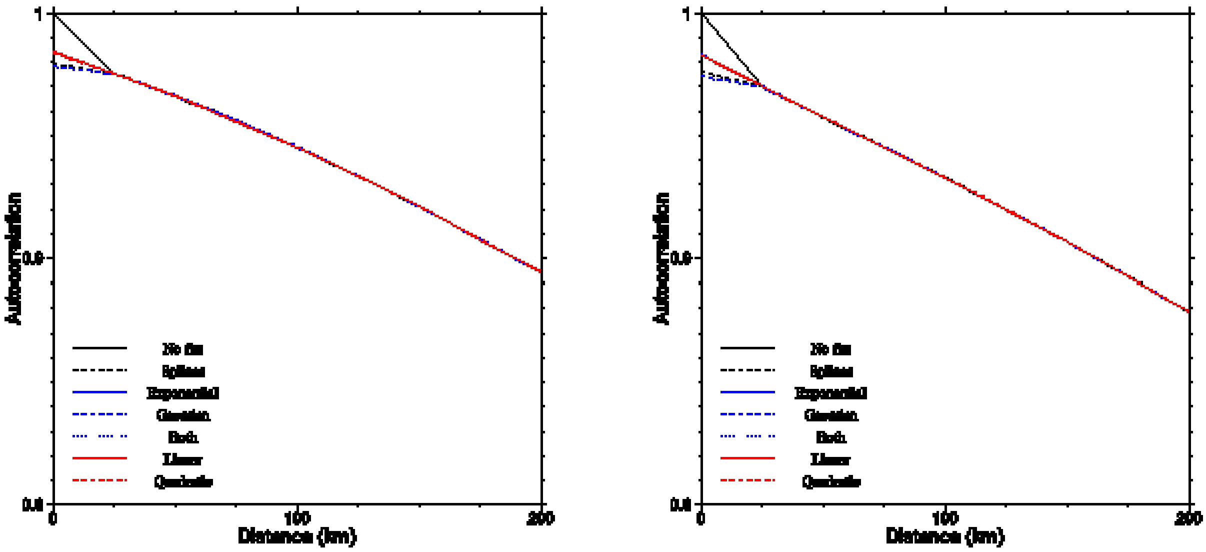

Figure 6. The autocorrelation near the distance separation origin for the 25-km SeaWinds wind speed components u (left) and v (right) after the noise peak has been removed using various techniques as indicated in the legend.

Figure 6 shows autocorrelation spectra for the wind components of a 25-km wind product where MSS has not been used. Various extrapolations to the origin were tested to estimate the random noise in the wind data. If the linear or quadratic fits are used (red) a plausible extrapolation is achieved and the random noise is estimated as about 2% of the total wind component variance.

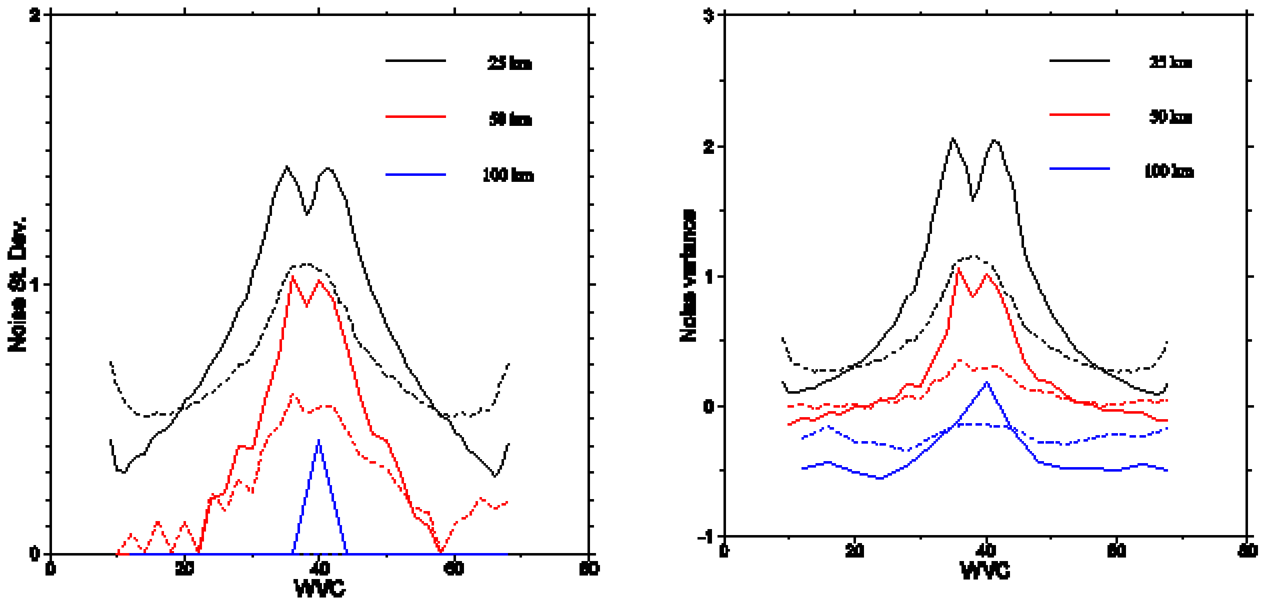

Figure 7. Standard deviation (left) and variance (right) of the noise level in the SDP wind speed components u (solid curves) and v (dashed curves) at various resolutions.

Figure 7 shows an analysis of the autocovariance intercept for different KNMI SeaWinds products that were produced without MSS. It confirms the choice for a 100-km wind product if random wind component noise is to be taken minimum. The 25-km and, to a lesser extend, the 50-km products appear very noisy in the SeaWinds nadir region.

Figure 8 shows the effect of MSS on the 25-km product. It clearly removes the random noise in the wind product, while plots like in figures 4 and 5 indicate that the relevant mesoscale flow is kept. This is now further verified in spatial wind spectral analyses and extended wind validation.

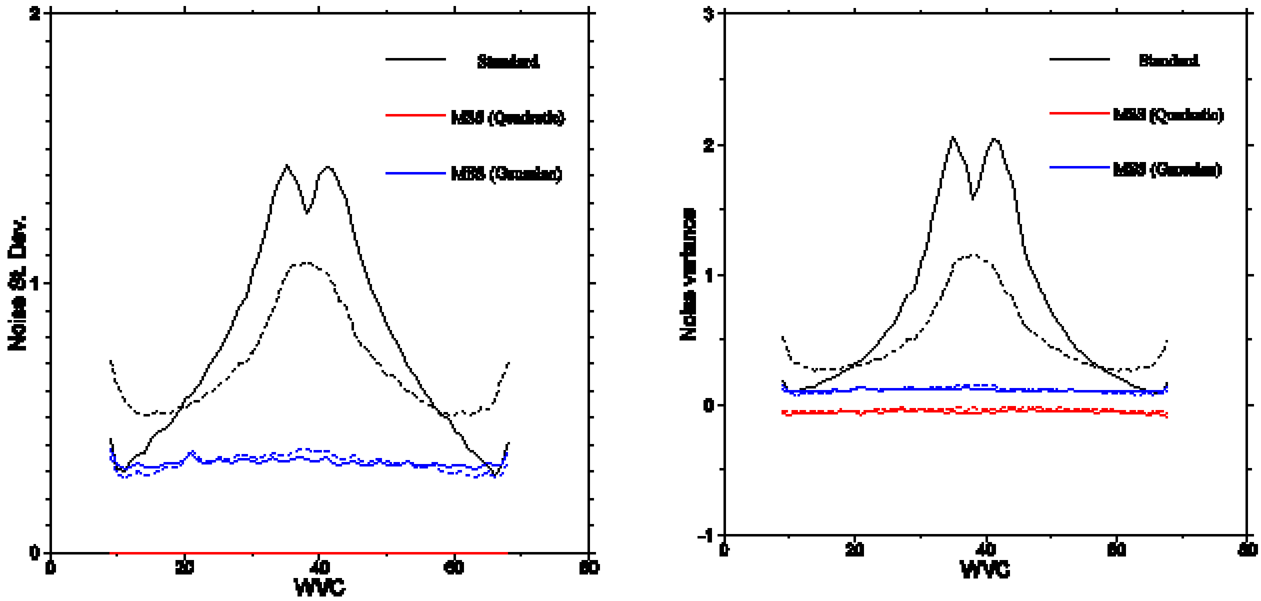

Figure 8. Standard deviation (left) and variance (right) of the noise level in the SeaWinds 25-km wind components u (solid curves) and v (dashed curves) for the standard four-solution scheme (black curves) and the MSS (blue and red curves). The red curves were obtained using quadratic extrapolation to assess the noise peak height; the blue curves using a Gaussian fit (see figure 6).

4. OUTLOOK

KNMI developed a spatial filtering method that fully exploits the information obtained by scatterometer wind retrieval (Portabella and Stoffelen, 2003) and which is meteorologically balanced, called MSS. Given the beneficial working of MSS, an increase in the resolution of the QuikScat wind retrieval is being experimented. It will be verified spatially by correlation analyses and against in situ observations. KNMI welcomes potential users and testers of this product, whom should contact the author.

Scatterometers provide accurate and spatially consistent near-surface wind information. Hardware permitting, there will be a continuous series of scatterometers with at times ideal coverage of the ocean surface wind for the first two decades of this century. EUMETSAT provides user services in collaboration with KNMI, where these are now being set up and freely available at http://www.knmi.nl/scatterometer for the QuikScat and ERS-2 scatterometers. Near-real time FTP products or software can be obtained after registration. Moreover, a visiting scientist scheme is funded in order to support the development programme and the use of the KNMI services. Again, the authors will provide more information on request.

EUMETSAT's ASCAT is planned for launch on the 17th of July. KNMI is making plans for the EUMETSAT SAFs to provide wind and wind stress products with main innovations in spatial resolution and in the coastal zone. Extended calibration and validation activities will be ongoing.

5. REFERENCES

ATLAS, R., and R.N. HOFFMAN (2000), The Use of Satellite Surface Wind Data to Improve Weather Analysis and Forecasting, in Satellites, Oceanography, and Society, edited by D. Halpern, Elsevier Oceanography Series 63, Elsevier Science, Amsterdam, the Netherlands, ISBN 0-444-50501-6.

ECMWF (2004) European Centre for Medium-range Weather Forecast, http://www.ecmwf.int

EUMETSAT Satellite Application Facilities (SAF) (2004), http://www.eumetsat.de/saf

HiRLAM (2004) High-Resolution Limited Area Model, http://hirlam.knmi.nl

ISAKSEN, Lars, and Ad STOFFELEN, (2000) “ERS-Scatterometer Wind Data Impact on ECMWF’s Tropical Cyclone Forecasts”, IEEE-Transactions on Geoscience and Remote Sensing (special issue on Emerging Scatterometer Applications) **38** (4), pp. 1885-1892.

KNMI (2004) http://www.knmi.nl/scatterometer

PORTABELLA, Marcos, and Ad STOFFELEN, (2001) Rain detection and quality control of SeaWinds. *J. Atm. and Ocean Techn*. ***18*** *(7)*, pp. 1171-1183.

PORTABELLA, Marcos, and Ad STOFFELEN, (2003) A probabilistic approach for SeaWinds data assimilation,” *Quart. J. R. Met. Soc.* ***130***, pp. 127-159.

SEAWINDS (2004)
Instrument: http://winds.jpl.nasa.gov/missions/quikscat/quikindex.html
Archive data: http://podaac.jpl.nasa.gov/quikscat
Near-real time data: http://manati.wwb.noaa.gov/quikscat

STOFFELEN, Ad, (2000) A generic approach for assimilating scatterometer winds, proc. ECMWF seminar 4-8 Sept. 2000, available from http://www.knmi.nl/scatterometer/seawinds/pdf/ECMWF_seminar00.pdf.

STOFFELEN, Ad, Aart VOORRIPS, and John DE VRIES, (2000) Towards the Real-Time Use of QuikScat Winds, BCRS project report, available from KNMI.

STOFFELEN, Ad, and Paul VAN BEUKERING, (1997) The impact of improved scatterometer winds on HIRLAM analyses and forecasts, BCRS study contract 1.1OP-04, report published by BCRS, Delft, The Netherlands, and HIRLAM technical report #31, published by IMET, Dublin, Ireland. Available from KNMI.