ASCAT SCATTEROMETER WIND DATA PROCESSING

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Abstract *- The Advanced scatterometer, ASCAT, on MetOp-A was launched on 19 October 2006 as the third wind scatterometer currently in space joining up with the ERS-2 and the SeaWinds scatterometers. Scatterometers measure the radar backscatter from wind-generated cm-size gravity-capillary waves and provide high-resolution wind vector fields over the sea with high quality. In this paper we show progress in high resolution processing and its verification, and in processing closer to the coast.*

Keywords *- high-resolution, wind, scatterometer, ASCAT, coast*

INTRODUCTION

The all-weather capability of a scatterometer provides unique wind field products of the most intense and often cloud-covered wind phenomena (for example, see figure 1). As such, it has been demonstrated that scatterometer winds are useful in the prediction of tropical cyclones [1], and extra-tropical cyclones [2]. At the moment the European METeorological SATellite organisation (EUMETSAT) ASCAT (on MetOp), the European Space Agency (ESA) ERS-2 and the National Aeronautics and Space Agency / National Oceanographic and Atmospheric Administration (NASA/NOAA) SeaWinds (on QuikSCAT) scatterometers provide a selection of regional real-time and global near-real time data streams. In addition, the Indian Space Research Organisation (ISRO) successfully launched in September 2009 the Indian Ku-band scatterometer (ISCAT), which is currently in the commissioning phase (i.e., no wind data disseminated yet). Moreover, EUMETSAT's MetOp series will guarantee the continuity of both regional and global services for another period of 10-15 years.

In Europe, scatterometer product development is organized through the EUMETSAT Satellite Application Facilities, SAF, at the Royal Netherlands Meteorological Institute (KNMI). Available scatterometer data products and wind retrieval software are summarized at www.knmi.nl/scatterometer. The SAFs attempt 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 2-Dimensional Variational Ambiguity Removal (2DVAR) method has the advanced filtering properties for maintaining small-scale meteorological information in SeaWinds, while reducing noise [3]. This is tested by comparing the spatial covariance structures of the KNMI products, with those of the NASA/NOAA SeaWinds product, and, for reference, those of Numerical Weather Prediction (NWP) models and buoys.

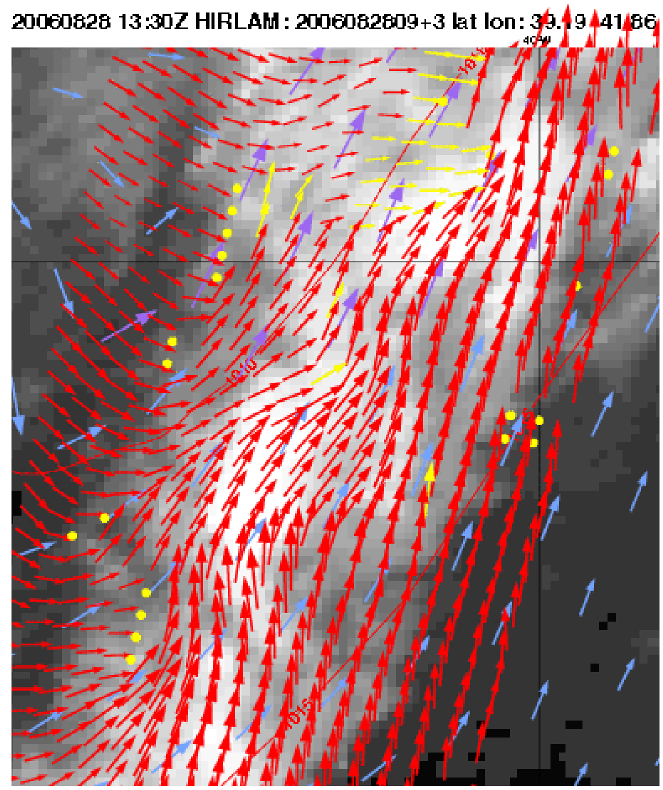

Fig. 1. ERS-2 scatterometer winds (red) on 28 August 2006 13:00 Z showing a train of atmospheric waves in the North Atlantic at 25W and 40N. Yellow arrows and dots are quality-flagged ERS-2 scatterometer cells. The blue and purple arrows depict simultaneous background Numerical Weather Prediction, NWP, model winds (KNMI HiRLAM) that generally do not resolve such weather phenomena. The METEOSAT Infra-Red background image is consistent with the scatterometer surface winds. (From www.knmi.nl/scatterometer). The missed Rossby train resulted in a bust NWP forecast the next day in the Netherlands and England. © EUMETSAT.

The methodology leads towards a high-resolution scatterometer wind product. Based on these principles KNMI develops in the context of the SAFs a 12.5-km ASCAT scatterometer wind product (see figure 2), later extended to the coastal zone.

Product enhancement and the preparation of wind production and user services for ASCAT on MetOp-A are the main goals of this investigation (R&D). KNMI currently processes global Ocean and Sea Ice (OSI) SAF SeaWinds 100-km and 25-km products and ASCAT 25-km and 12.5 km wind product operationally, and a mainly North Atlantic ERS-2 25-km product in quasi real-time through the EUMETSAT Advanced Retransmission Service (EARS). Moreover, at 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, 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, scientific manuscripts, and software products.

RESOLUTION VERSUS NOISE

The standard OSI SAF 100-km SeaWinds product has been developed for NWP assimilation and it is verified to compare better with independent European Centre for Medium-range Weather Forecasts (ECMWF) NWP winds than the NOAA Direction Interval Retrieval THresholding (DIRTH) product [4] and the OSI SAF 25-km product and is thus indeed suitable for NWP assimilation [5]. At higher resolutions more random wind noise is expected from SeaWinds. Noise reduction is beneficial and further progress is being made by implementing the so-called Multiple Solution Scheme (MSS). The improvement by MSS is brought by using wind vector probability information in combination with the 2DVAR background constraints on rotation and divergence [3]. 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 has been developed and is now run operationally at KNMI. Scatterometer products thus provide wind variance on scales not well analyzed by NWP models (see e.g. Figure 1). It is of interest to verify the scatterometer provided wind variance with buoy data to check the benefit of MSS.

Buoy verification statistics of the Ocean and Sea Ice SAF 25-km ASCAT, SeaWinds 25-km and SeaWinds 100-km product are provided in Table 1. Both tropical and extra-tropical moored buoys are used for one month of data. It is interesting to note that the ASCAT 25-km product compares best to both ECMWF and buoys, providing evidence of the superior quality of the ASCAT scatterometer winds. Also note that the SeaWinds 25 km (gridded) product, while supposedly at higher resolution and containing more mesoscale wind detail than the ASCAT 25-km (gridded) product (effectively at 50 km resolution), also must contain more wind error than ASCAT in order to provide worse buoy verification. Recent results (not shown) show that the ASCAT 12.5-km product (effectively at 25 km resolution) better compares to buoy data than the ASCAT 25-km product, i.e., the former contains more mesoscale detail than the latter (see [6]). Finally we note that the ECMWF model verification with the buoys is very similar to the SeaWinds 100-km product (not shown here), as may be expected from the above-presented analysis. Scatterometer data thus indeed capture mesoscale detail not resolved by NWP model analyses and forecast fields, but that verifies with buoy measurements. A more thorough validation of the current OSI SAF ASCAT and SeaWinds products can be found in [6], [7], and [8].

Table 1 Buoy verification of the Ocean and Sea Ice SAF 25-km ASCAT, SeaWinds 25-km and SeaWinds 100-km product. Both tropical and extra-tropical moored buoys are used for one month of data.

ASCAT 25		SeaWinds 25		SeaWinds 100	
SD u [m/s]	SD v [m/s]	SD u [m/s]	SD v [m/s]	SD u [m/s]	SD v [m/s]
1.76	1.79	1.84	1.83	2.19	2.00

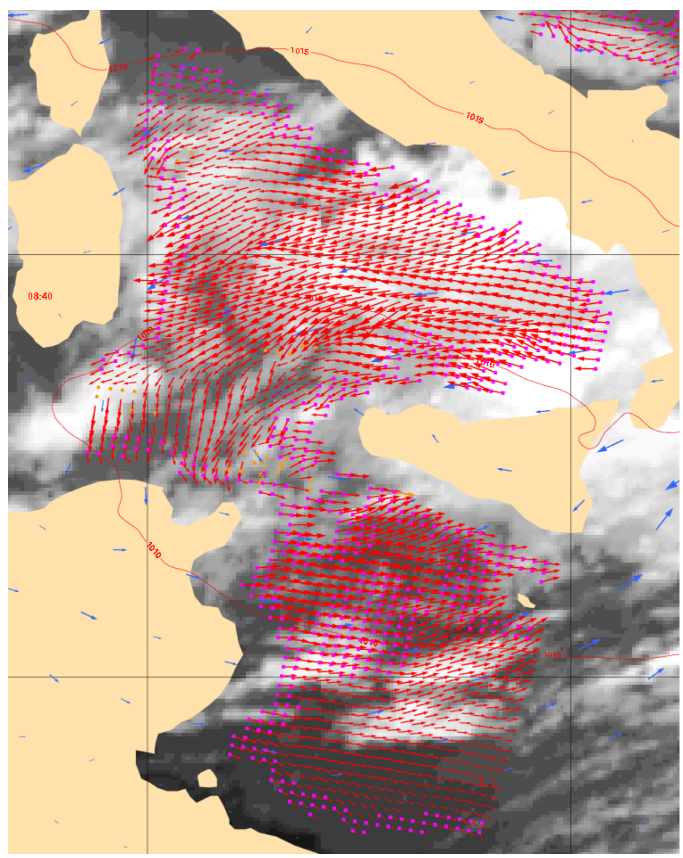

Fig. 2: Operational ASCAT 12.5-km wind product generated at KNMI on top of collocated GOES IR cloud imagery underneath. Centered at 37N, 12E, on 15 October 2009 at 08:30 Z.

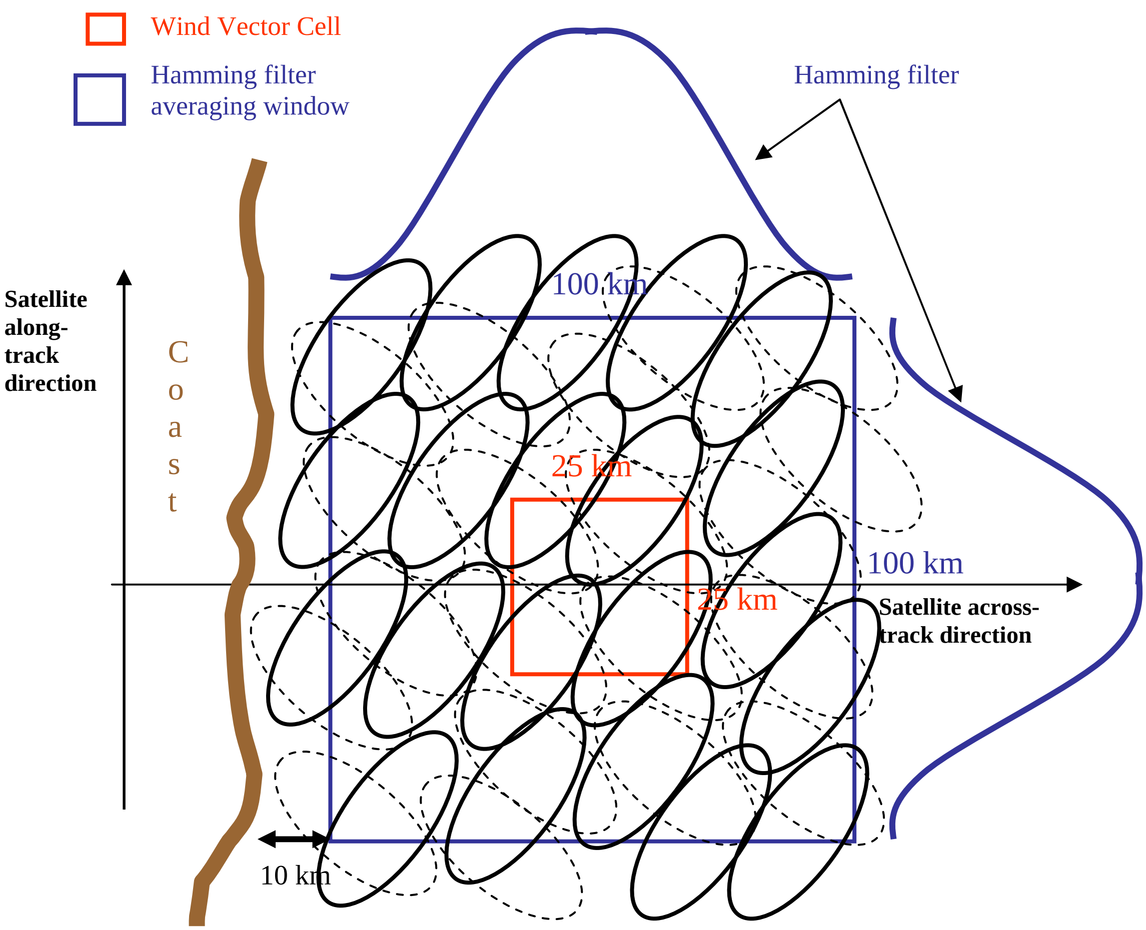

Fig. 3. Depiction of the application of a Hamming filter in the ASCAT backscatter processing.

COASTAL SCATTEROMETER PRODUCTS

Another new development for the ASCAT scatterometer is in the development of a coastal product. Figure 3 depicts the spatial ASCAT processing. The projected scatterometer fan beams of approximate 20 km width are along the long axis cut into pieces of approximate 10 km length. The remaining footprints thus have typical dimensions of 10 by 20 km with a main orientation across the beam, as represented by the elliptical shapes in figure 3. Currently, these backscatter measurements are collected over a hamming window extending over 100 km (50 km spatial resolution). It may be clear that near the coast land contamination will be probable due to the extent of the hamming filter, since land or coastal returns are generally high relative to the ocean returns. In the context of the NWP SAF visiting scientist scheme, KNMI built a prototype ASCAT Wind Data Processor (AWDP) based on a box-average spatial averaging scheme, i.e., the coastal AWDP. In a box average, much closer distances to the coast can be achieved than with the Hamming window (see Figure 4). The next step will be in the tuning and verification of the coastal processor with NWP and buoy data. Some first results can be found in [9].

OUTLOOK

Scatterometers provide accurate and spatially consistent near-surface wind information [10]. The OSI SAF ASCAT product proves to be of unprecedented accuracy as compared to other scatterometer products. 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 www.knmi.nl/scatterometer for the ASCAT, 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. The authors will provide more information on request.

Improvements in geophysical modeling are being pursued and a change of the SAF product definition to 10-m equivalent neutral winds [11] was recently implemented in the ASCAT and ERS operational processing. Moreover, KNMI participates in the NOAA hurricane hunter air campaign to provide ASCAT underflights with the IWRAP instrument. ASCAT winds for the northern hemisphere ascending tracks are being made available within 35 minutes through the EARS programme. KNMI is involved in the GMES MCS MyOcean consortium with the ambition to provide, together with IFREMER, gridded mesoscale wind forcing with an hourly frequency.

The ISRO scatterometer (ISCAT) orbit at 12 LST nicely complements SeaWinds at 6 LST and ASCAT at 9:30 LST, and will be a very useful complement for providing temporally-resolved eddy-scale ocean winds. Global NRT backscatter (L2A) products would be greatly appreciated from ISRO to aid in a timely exploitation of the instrument and its data.

ACKNOWLEDGEMENTS

We greatly acknowledge EUMETSAT for providing the grants to develop the scatterometer data and software services in the context of the SAF network and the EARS project.

REFERENCES

[1] L. Isaksen and A. Stoffelen, "ERS Scatterometer Wind Data Impact on ECMWF's Tropical Cyclone Forecasts," *IEEE Trans. on Geoscience and Rem. Sens.* 38 (4) pp. 1885-1892, 2000.

[2] A. Stoffelen and P. Van Beukering, "Implementation of improved ERS scatterometer data processing and its impact on HIRLAM short range weather forecasts," *Report NRSP-2/97-06*, Beleidscomissie Remote Sensing, The Netherlands, 1997.

[3] J. Vogelzang, A. Stoffelen, A. Verhoef, J. de Vries and H. Bonekamp, "Validation of two-dimensional variational ambiguity removal on SeaWinds scatterometer data," *J. Atm. Oceanic Technol.*, 7, 26, 1229-1245, doi:10.1175/2008JTECHA1232.1, 2009.

[4] JPL, "QuikSCAT science data product user's manual, version 2.2.," *Jet Propulsion Laboratory D-12985*, pp. 89., 2001.

[5] M. Portabella and A. Stoffelen, "A probabilistic approach for SeaWinds data assimilation," *Quart. J. R. Met. Soc.* 130, pp. 127-159, 2004.

[6] A. Verhoef and A. Stoffelen, "Validation of ASCAT 12.5 km winds.," R*eport for the EUMETSAT OSI SAF*, SAF/OSI/CDOP/KNMI/TEC/RP/147, available at www.knmi.nl/scatterometer/publications/, 2009.

[7] J. Vogelzang, Stoffelen, A., Belmonte,M., Portabella, M., Verhoef, A, and Verspeek, J., "Quality of high resolution ASCAT wind fields," *Proc. of the 2008 EUMETSAT Meteorological Satellite Conference*, EUMETSAT P.52, Darmstadt, Germany, 8-12 September, 2008. (P)

[8] J. Vogelzang, Stoffelen, A., Belmonte, M., Portabella, M., Verhoef, A, and Verspeek, J., "The SeaWinds data processor," *Proc. of the 2008 EUMETSAT Meteorological Satellite Conference*, EUMETSAT P.52, Darmstadt, Germany, 8-12 September, 2008.

[9] M. Portabella, A. Verhoef, and A. Stoffelen, "Contribution to the development of a high-resolution ASCAT coastal wind product.," *Visiting Scientist report for the EUMETSAT NWP SAF*, NWPSAF-KN-VS-007, available at www.knmi.nl/scatterometer/publications/, 2008.

[10] A. Stoffelen, "Scatterometer applications in the European Seas. Remote Sensing of the European Seas," V. Barale and M. Gade, eds., Springer, 269-282., 2008.

[11] M. Portabella and A. Stoffelen, "On scatterometer ocean stress," *J. Atm. and Ocean Techn.*, vol. 26, pp. 368-382, doi::10.1175/2008JTECHO578.12009.

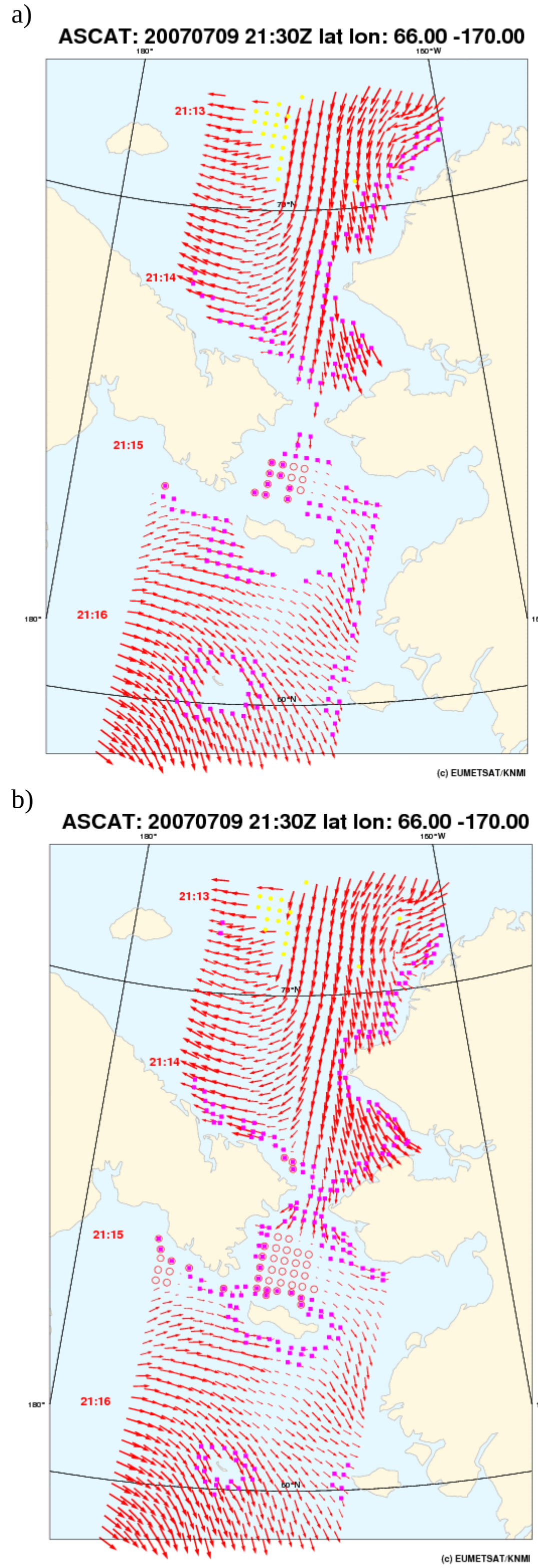

Fig. 4: ASCAT L2 wind field (a) and ASCAT coastal wind field (b). The circles represent winds below 0.5 m/s. The purple squares correspond to WVCs where the land flag is set.