ON HIGH RESOLUTION COASTAL WINDS

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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:

SAF, EUMETSAT, scatterometer, wind

1. 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 (Isaksen and Stoffelen, 2000), and extra-tropical cyclones (Stoffelen and van Beukering, 1997). At the moment the European organisation for the exploitation of Meteorological Satellites (EUMETSAT) ASCAT on MetOp-A, the European Space Agency (ESA) scatterometer on ERS-2 and the National Aeoronautics and Space Agency / National Oceanographic and Atmospheric Administration (NASA/NOAA) SeaWinds scatterometer on QuikScat provide a selection of regional real-time and global near-real time data streams. In addition, in 2008 the Indian Space Research Organisation (ISRO) will launch an Indian Ku-band scatterometer (ISCAT). Continuity of scatterometer services is likely provided for another period of 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., favoring 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. 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.

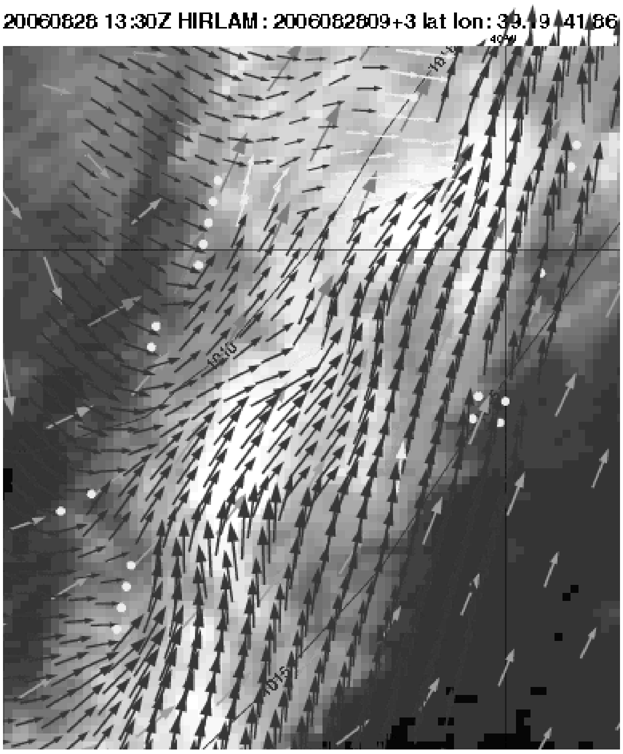

Figure 1:
ERS-2 scatterometer winds (black) on 28 August 2006 13:00 Z showing a train of atmospheric waves in the North Atlantic at 25W and 40N. Light arrows and dots are quality-flagged ERS-2 scatterometer cells. The grey arrows depict simultaneous background Numerical Weather Prediction, NWP, model winds (KNMI HiRLAM) that generally do not resolve such weather phenomena. The METEOSAT Infra-Red background image is consistent with the scatterometer surface winds. (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 QuikScat 100-km and 25-km products operationally, a global pre-operational ASCAT OSI SAF 25-km wind product, 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.

2. RESOLUTION VERSUS NOISE

The standard OSI SAF 100-km QuikScat product has been developed for NWP assimilation and is verified to compare better with independent European Centre for

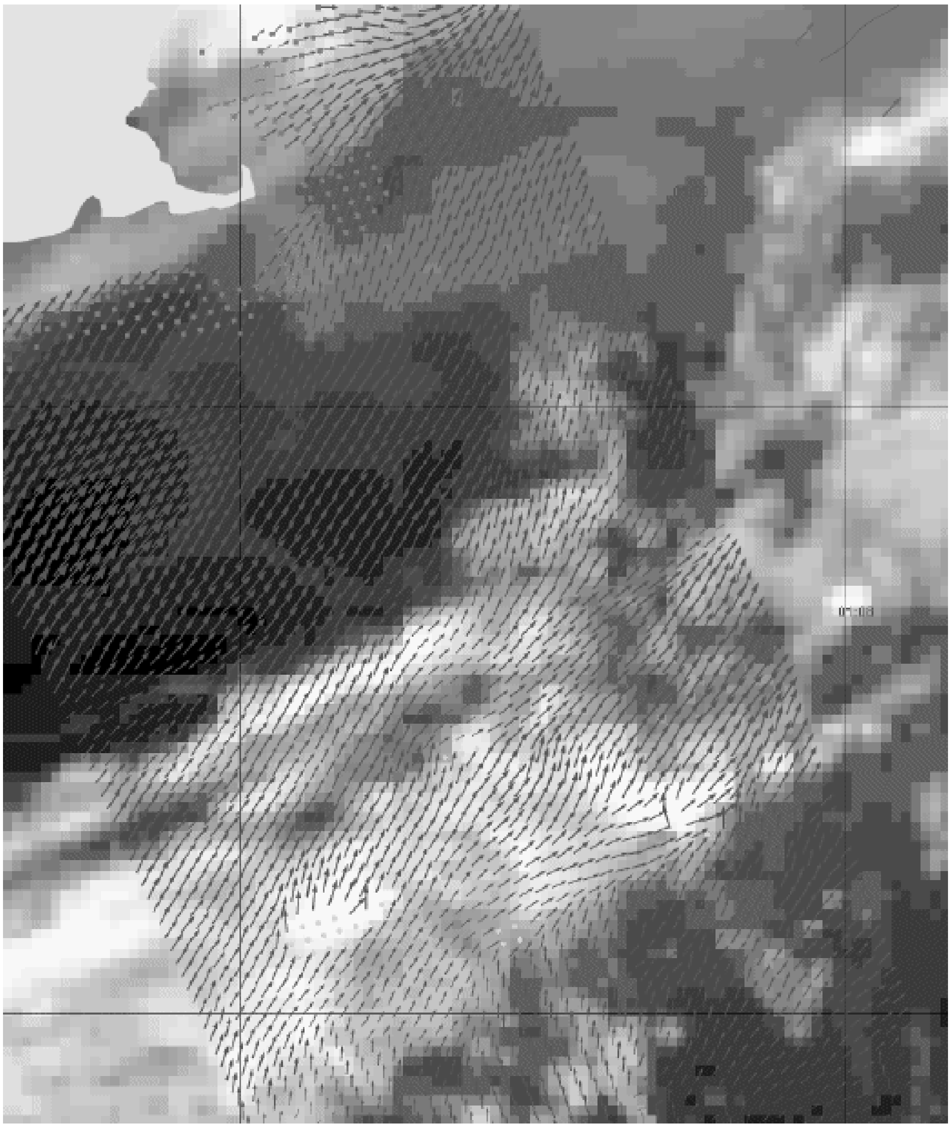

Figure 2: Experimental ASCAT 12.5-km wind product generated at KNMI on top of collocated GOES IR cloud imagery underneath. Centered at 38N, 68W, on 4 July 2008 00:30 Z.

Medium-range Weather Forecasts (ECMWF) NWP winds than the NOAA Direction Interval Retrieval with Threshold nudging (DIRTH; Stiles, 1999) product and the OSI SAF 25-km product and is thus indeed suitable for NWP assimilation (Portabella and Stoffelen, 2004). 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 (Portabella and Stoffelen, 2004). 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 operated operationally at KNMI (2008). 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 OSI SAF 25-km ASCAT, SeaWinds 25-km and SeaWinds 100-km product are provided in Stoffelen (2008a or b??). The ASCAT 25-km product compares best to ECMWF while it compares best of all products to the buoys as well, providing evidence of the superior quality of the ASCAT scatterometer winds. The ASCAT 25-km winds are effectively at 50 km resolution and it is interesting to note that the SeaWinds 25 km product, while supposedly at higher resolution and containing more mesoscale wind detail, also must contain more wind error than ASCAT in order to provide worse buoy verification. The error is presumably due to residual rain (Portabella and Stoffelen, 2001). Finally, Stoffelen (2008a or b?) notes that the ECMWF model verification with the buoys is very similar to the SeaWinds 100-km product, thus confirming its relatively poor resolution over the oceans. Scatterometer data thus indeed capture mesoscale detail not determined by NWP model analyses and forecast fields, but that verifies with buoy measurements.

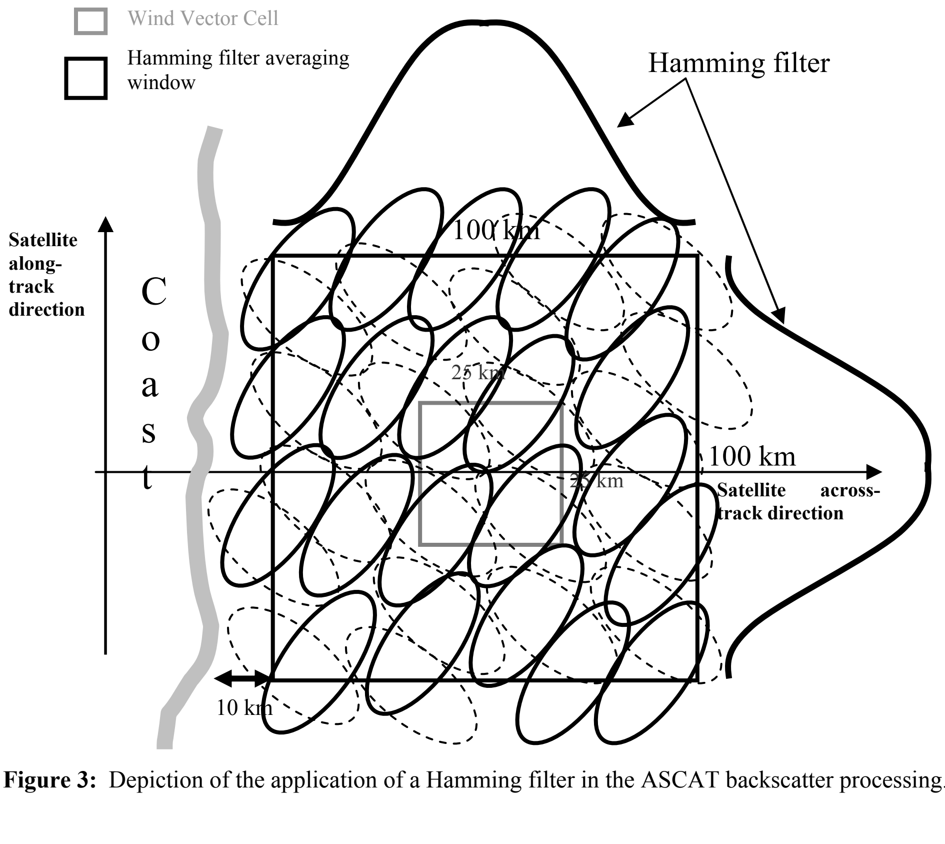

Figure 3: Depiction of the application of a Hamming filter in the ASCAT backscatter processing.

3. COASTAL SCATTEROMETER PRODUCTS

Another new development for the ASCAT scatterometer will be in the production of coastal winds. Figure 3 depicts the spatial ASCAT processing. The projected scatterometer fan beams of approximate 20 km width are cut along the long axis into pieces of approximately 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 processor based on a box-average spatial averaging scheme. In a box average much closer distances to the coast may be achieved for the same spatial resolution as compared with the Hamming window processing. The next step will be in the tuning and verification of the coastal processor with NWP and buoy data.

4. OUTLOOK

Scatterometers provide accurate and spatially consistent near-surface wind information (Stoffelen, 2008a). 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, SeaWinds 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

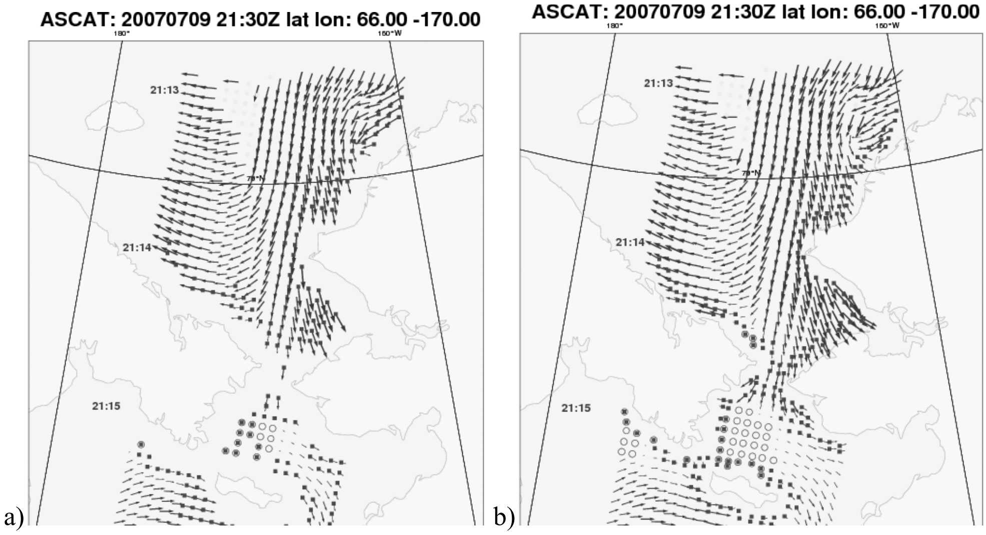

Figure 4: (a) ASCAT L2 wind field and (b) ASCAT coastal wind field. The circles represent winds below 0.5 m/s. The squares correspond to WVCs where the land flag is set.

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 is being made (Portabella and Stoffelen, 2008). KNMI participates in the NOAA hurricane hunter air campaign to provide ASCAT underflights with the radar Imaging Wind and Rain Airborne Profiler (IWRAP) for mutual comparison. ASCAT winds for the northern hemisphere ascending tracks are being made available within 35 minutes through the EARS programme.

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