DEVELOPMENT OF AN ASCAT COASTAL WIND PRODUCT

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ABSTRACT

Near-shore sea-surface wind field information can be important in a number of applications, such as in semi-enclosed seas and in coastal regions. The ASCAT scatterometer onboard MetOp provides (down to) 12.5-km sampled winds, which can be very useful for such applications. However, at first (soon after launch), only the 25-km sampled winds at a nominal resolution of 50 km will become operational. Because of the spatial averaging (i.e., Hamming filter) of backscatter measurements and the fixed gridding of the wind vector cell (WVC), the wind information within the first 50 km (or more) off the coast is flagged due to land/ice contamination. We propose to use level 1b full resolution (FR) backscatter data to produce 25-km sampled wind information up to 25 km off the coastline. In order to meet such goal, we plan to perform a box averaging of the FR backscatter data over a non-fixed WVC grid. Such grid will be tuned to maximize the number of land/ice decontaminated sea-surface near-shore backscatter measurements used in the processing.

1 INTRODUCTION

Local wind fields, such as land-sea breezes and katabatic wind flows strongly affect the microclimate in coastal regions. They determine to a large extent the advection and dispersion of pollutants in the atmosphere and coastal waters (by generation of local wind driven currents). Since most of the world's population lives in coastal areas and most pollutants are released into the environment near coasts, the study of these local winds is also of great relevance for environmental purposes. As such, near-shore sea-surface wind field information can be important in a number of applications, such as in semi-enclosed seas, straits, along marginal ice zones and in coastal regions.

ASCAT scatterometer observations over the ocean will provide direct estimates of the global wind vector field with a spatial nominal resolution of 50 km, a spatial sampling of 25 km and an accuracy of 3 m/s (in wind vector). The ASCAT instrument is a real aperture vertically polarised C-band radar with high radiometric stability. It has two sets of three fixed fan beam antennas, each set pointing at either side of the sub-satellite track [1] (see Fig. 1).

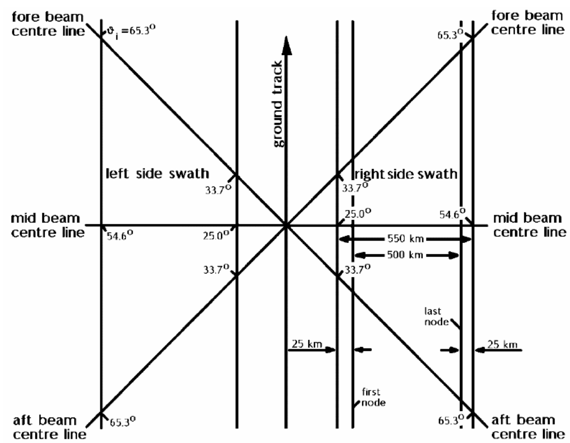

Fig. 1. ASCAT swath geometry (Fig. II.4 of [1]).

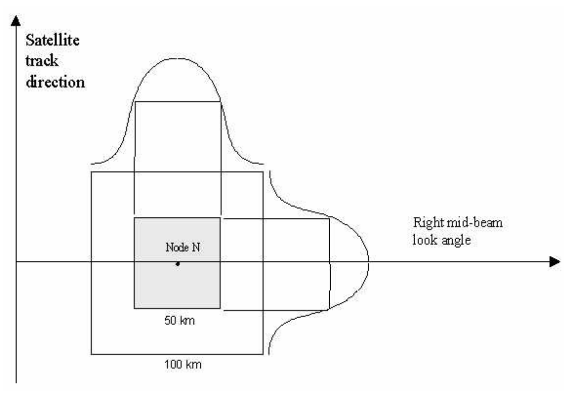

Fig. 2. Ground geometry of the spatial smoothing for σ^0 values corresponding to the right mid beam for a given node N, for the 50-km resolution product (Fig. 4a of [2]).

However, since backscatter measurements (σ^0) of up to 50 km away from each wind vector cell (WVC) center are used in the spatial averaging (see cosine weighting function in Fig. 2), WVC's within 50 km off the coast will be flagged because of land/ice contamination. The ASCAT level 2 product will also include a high-resolution 25-km research wind product, sampled every

12.5 km, which will flag wind data within 25 km off the coast. Moreover, since the WVC grid is fixed, partially contaminated WVC will also be flagged and wind data within 37.5 km (for the high-resolution product) or 75 km (for the nominal-resolution product) off the coast will often be unavailable.

In contrast with the ERS scatterometer processing, ESA will include, for the first time, a radar backscatter full resolution (FR) product, i.e., level 1b FR. The product contains the individual radar backscatter values, 256 values along each antenna beam, localised on the surface of the Earth. In such product the data are organised per position along the antenna beam and not per WVC in the swath. The sampling of individual backscatter values along-beam is of approximately 2 km for mid beams and 3 km for side beams. The FR backscatter values along every antenna beam represent footprints of about 10 km x 20 km of various shapes and orientations (see [2]).

By replacing the Hamming filter (i.e., cosine weighting function in Fig. 2) averaging with a simple box (i.e., constant weighting function) averaging, we can produce 25-km sampled winds, which, in contrast with the 25-km sampled (nominal-resolution) level 2 product (nominally up to 75 km off the coast), will provide sea-surface wind information up to 25 km off the coastline, at 35- to 40-km resolution. Moreover, by using a non-fixed WVC grid, we can maximize the number of wind observations at such short distance off the coast.

According to the Numerical Weather Prediction (NWP) and Ocean & Sea Ice (OSI) Satellite Application Facilities (SAFs) plans, the ASCAT nominal-resolution level 2 product will become operational right after the Calibration/Validation (Cal/Val) period (early 2007), whereas the high-resolution level 2 product will not become operational before 2009. As such, the aim of this project is to develop a (40-km resolution) coastal wind product, which will be the basis for the future development (within the OSI SAF) of a high-resolution coastal wind product.

2 WORK PLAN

The project will be conducted on the basis of 6 work packages (WP), which are described below. We anticipate that it will be conducted in collaboration with EUMETSAT and the OSI SAF in particular.

- WP-1 focuses on the land/ice masking of the FR backscatter measurements. First, a reading software for the ASCAT level 1b FR product will be developed. Then, we will study the best strategy for the land/ice masking of the FR backscatter values. As such, we will examine the land flag contained in level 1b FR to determine whether it is accurate enough for our purposes. We anticipate that ice flagging is more complex and will be taken up by the OSI SAF. We will concentrate our efforts on the land masking (ice contamination is avoidable by using the OSI SAF ice screening) as a first step to show the validity of the coastal wind product. The accuracy of the land masking will be tested using backscatter information. A progress report, showing the results for land flagging, will be delivered by the end of WP-1.
- WP-2 is dedicated to the WVC definition. ASCAT nominal-resolution product uses a fixed WVC grid with a spatial sampling of 25 km x 25 km, along and across the satellite track. We plan to use the WVC grid, which optimizes the use of near-shore triplets in the processing. As such, we will study two different options: (a) a (local) regular grid, based on the level 2 25-km sampled grid, and (b) an irregular grid based on the coastline in the 25 km template.
- WP-3 focuses on the backscatter spatial averaging. Once the WVC is defined, all the FR backscatter measurements located inside every WVC are averaged beam-wise in order to produce the 25-km sampled triplets (i.e., averaged fore, mid, and aft beams). Since every FR backscatter has a WVC-dependent signal-to-noise ratio of about 1 and the goal is to achieve a signal-to-noise ratio of at least 0.05 or 5% (requirements for the nominal-resolution product), we need at least 400 FR measurements (for each beam) in order to get a usable triplet. Therefore, the definition of the WVC (WP-2) is expected to be revisited in order to meet the objective of signal-to-noise ratio of 0.05. As such, the results on WP-2 and WP-3 will be delivered together in a midterm report by the end of WP-3.
- WP-4 is dedicated to the development of a wind retrieval procedure. For such purpose, we will adapt the Royal Dutch Meteorological Institute (KNMI) ASCAT wind data processor (AWDP) to our coastal product characteristics. As such, the work in this WP will focus in adapting the processor to the new WVC grid definition.
- WP-5 is dedicated to the validation of the coastal wind product. For such purpose, we will collocate our wind product with both ASCAT level 2 nominal-resolution (25-km sampled) winds and European Centre for Medium-range Weather Forecast (ECMWF) winds. Collocations with the ASCAT level 2 product will be somewhat off the coast but they will provide very valuable information on the consistency of the coastal product. On the other hand, collocations with ECMWF will provide an indication of the general quality of the product. In coastal regions,

meteorological phenomena such as land-sea breezes or katabatic flows are usually better depicted by high-resolution regional models than by mesoscale global models like ECMWF. As such, collocations with the High Resolution Limited Area Model (HIRLAM) output will also be used in the validation of the coastal wind product. The HIRLAM runs will cover the European Atlantic coasts as well as semi-enclosed seas such as the Mediterranean and the Baltic. A final report including all WPs will be delivered at the end of WP-5.

3 SCHEDULE

The project will last 24 months and consists of three phases:

- Phase 1 will include WP-1 and start at approximately t0, i.e., as soon as the commissioning phase ends and the calibrated and validated data are available. It is expected to last 6 months, thus ending at t0 + 6 months.
- Phase 2 will start at the end of phase 1, i.e., t0 + 6 months. Since WP-2 and WP-3 interact with one another, both are included in phase 2. The latter will last 12 months, thus ending at t0 + 18 months.
- Phase 3 will start at the end of phase 2, i.e., t0 + 18 months, and includes WP-4 and WP-5. It is expected to last 6 months, thus ending at t0 + 24 months.

4 DISCUSSION

As seen in Fig. 2, the Hamming filter uses backscatter information from neighbouring WVCs in the averaging. This in turn will lead to some correlation between the retrieved winds from neighbouring cells. On the other hand, one can perform box averaging only with the backscatter information inside each WVC and therefore avoid wind correlation. The box averaging however produces noisier triplets than the Hamming filter (less backscatter measurements are used in the former averaging), and therefore potentially noisier retrieved winds.

Reference [3] shows that there are efficient ways to reduce the noise and maintain the geophysical information from relatively noisy backscatter measurements.

Due to the non-linear relationship between the backscatter measurements and the wind and to the measurement errors, scatterometer wind inversion does not lead to a unique solution but rather to a set of few ambiguous solutions at each WVC location (e.g., see [4] and [5]). A spatial filter, which uses additional background information (generally NWP output) in combination with meteorologically consistent spatial filter functions, can be applied to remove the ambiguity, e.g., median filter [6], variational analysis type of filter [7]). In particular, a variational analysis ambiguity removal (AR) filter, such as 2D-Var [7], is able to keep most of the meteorological information and, at the same time, remove most of the noise [3]. Fig. 3 shows a meteorological case where the scatterometer retrieved wind field is produced with two different AR procedures: a median filter (Fig. 3a) and 2D-Var (Fig. 3b). The latter shows smoother (see bottom left part of the plot) and more meteorologically consistent (see cold front air flow in the middle left part of the plot realistically depicted by Fig. 3b) winds than the former.

We anticipate that in order to get as close as possible to the coastline some (25 km x 25 km) WVCs may contain a small number of backscatter measurements. In order to reduce the signal-to-noise in the averaged backscatter (at least to 0.05), we may allow some backscatter measurements from neighbouring WVCs in the box averaging and therefore some correlation in the resulting wind field. This will in turn result in 35- to 40-km resolution winds. In this work we do not seek for a non-correlated wind product but rather for useful and extended coastal wind product.

Once the high-resolution ASCAT level 2 product is operational, the same procedure as proposed in this paper can be used to develop a high-resolution coastal product, which will provide 12.5-km sampled wind information up to 15 km off the coast, at 15- to 20-km resolution.

ACKNOWLEDGMENTS

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a) b)

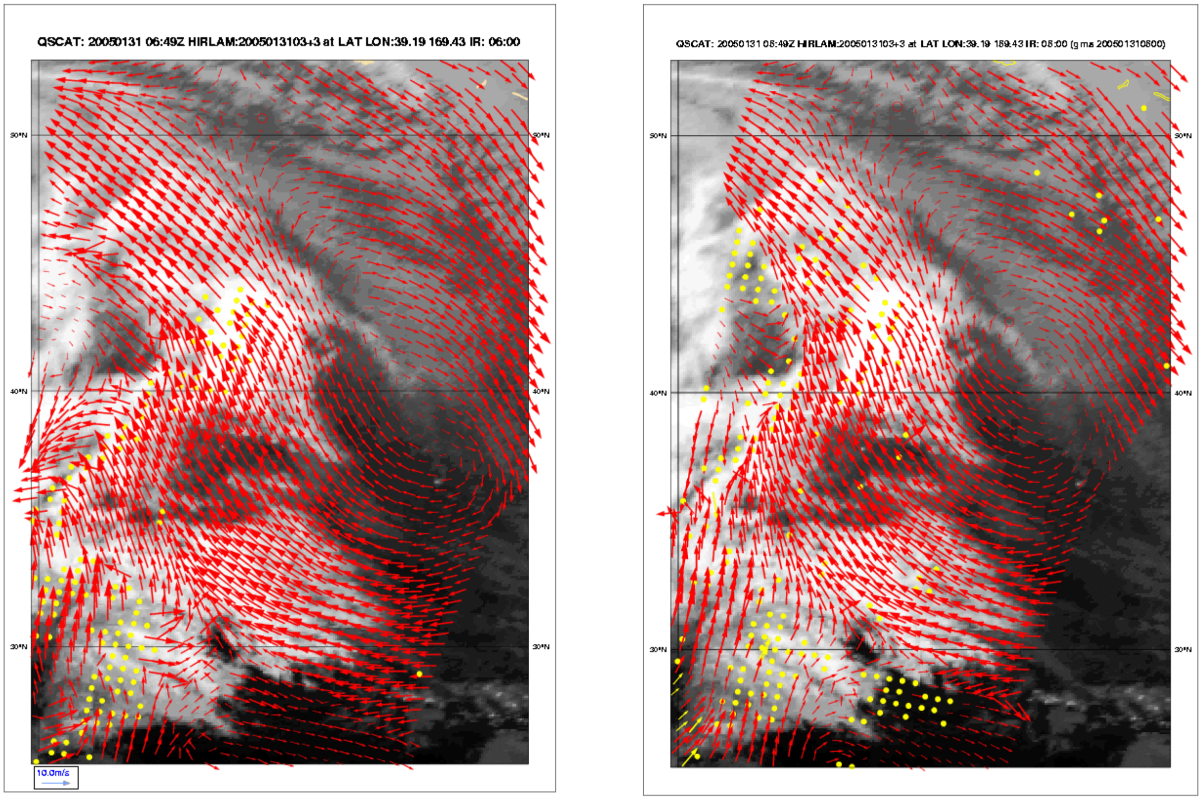

Fig. 3. SeaWinds scatterometer retrieved wind field, using a median filter AR (a) and the 2D-Var AR (b). For more examples, visit http://www.knmi.nl/scatterometer

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