ASCAT normalised radar backscatter at full measurement resolution

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Abstract

The Advanced SCATterometer (ASCAT) is a real aperture, vertical polarisation, C-band radar designed primarily to provide global ocean winds operationally [Figa-Saldaña et al 2002, Klaes et al 2007]. The main application of these data is the assimilation into numerical weather prediction models, but its dense coverage makes the data also extremely useful for direct use by operational weather forecasters in near real time. The basic measurement provided by the ASCAT is the Normalised Radar Cross Section (NRCS), for which other important applications have emerged in the recent years over land and sea ice areas, where it provides information on soil moisture, snow and sea ice parameters, such as ice age and drift. In particular with respect to soil moisture, ASCAT is currently used operationally in the context of data assimilation by several weather prediction centres and important steps are being taken for its specific use in hydrology applications.

Three types of NRCS products are produced at EUMETSAT. The ‘SZO’ and ‘SZR’ products contain triplets of collocated averaged NRCS values on a regular grid of nodes along and across swath. The ’SZF’ product contains geolocated NRCS values at full resolution for each of the beams. All products are distributed in near real time by EUMETSAT and are also available from the EUMETSAT Data Centre.

We describe the latest version of the SZF product, which has been enhanced to make it easier to use and more compact. It contains now a regular grid of points with a spacing of around 6.25 km, which is consistent with the grid points in the SZO and SZR products. We also present an analysis of the full resolution data, showing example results that can be obtained when it is spatially averaged for specific applications.

CONSIDERATIONS ON RE-SAMPLING AND SPATIAL RESOLUTION

In order to achieve spatial resolution and to reduce measurement noise, the ASCAT NRCS contained in the SZF product is averaged and re-sampled by using a Hamming window across and along the viewing swath, leading to the SZO and SZR products. Images of the same scene for the three different products, provided in Figure 1, illustrate the trade-off between noise and spatial resolution, where the reduction in noise comes at the price of representing less fine resolution features in the scene. The SZF product contains NRCS values on a swath-based grid with 192 nodes along the footprint of each of the three beams illuminating each swath. No re-sampling is applied, the original measurement geolocation is maintained instead, at an approximate resolution of 10x25 km.

This type of averaging window, its size and the sampling distance, have been specifically designed following Nyquist theory, in order to provide a product that can be further re-sampled without introducing spatial aliasing. In case of the SZR product, for example, a Hamming window size of 50 km provides a spatial resolution of approximately 25-34 km (depending on the distance to the nadir track) and is sampled every 12.5 km along and across the swath (Figure 2). Equally, the SZO product consists of NRCS triplets on a swath-based grid with 42 nodes spaced 25 km across and along track of approximate 50 km resolution, which is achieved with a Hamming window of size 100 km along and across swath.

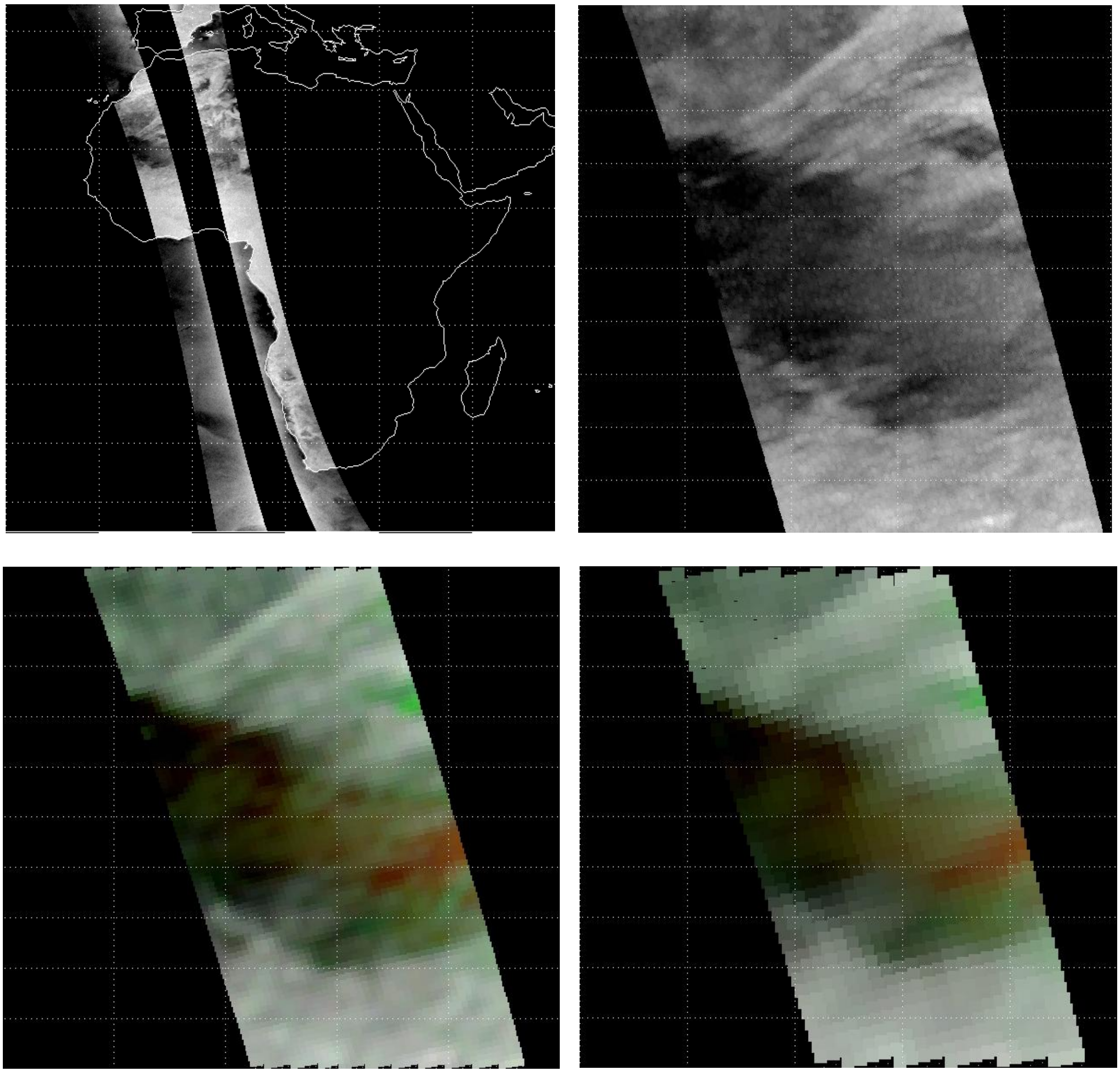

Figure 1: (top left) NRCS full resolution image (SZF) of the FORE beams during an ascending pass of ASCAT-A over the African continuent; (top right) Zoom over an area of North West Africa; (bottom left) RGB false-colour composite of the SZR product over that scene (RED=FORE, GREEN=MID, BLUE=AFT); (bottom right) Equivalent representation of the SZO product in this case.

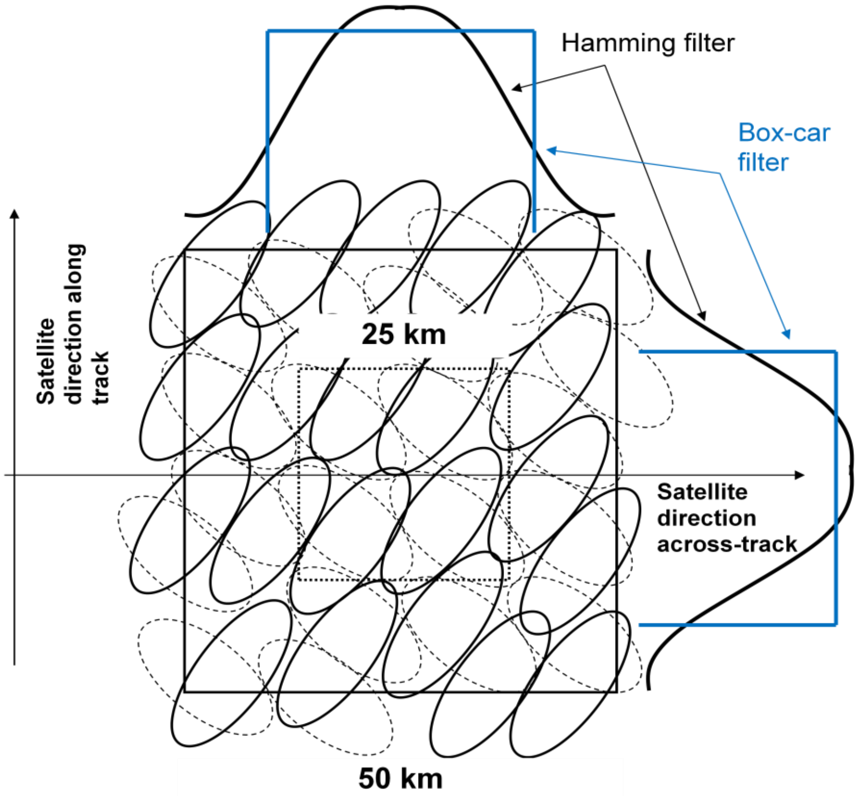

Figure 2: Schematic representation of the Hamming averaging window for the ASCAT SZR product (in black), as well as an alternative averaging window in blue, in this case a box-car (or 'top hat') window.

DESCRIPTION AND FEATURES OF THE SZF PRODUCT

Figure 1 shows the potential of using as much as possible of the original resolution of the measurements, for applications where the noise reduction is not as critical as for wind retrieval, or for cases where a different averaging approach (in time, for example, rather than in space) could achieve noise reduction without compromising the spatial resolution. In order to allow the exploration of this potential, EUMETSAT is now providing a new SZF product, which includes a number of important features:

- Provision of a swath-based grid of 6.25 km spacing to facilitate user-customized re-sampling
- Compact format and small size, allowing its dissemination in Near Real Time
- Currently only available in native binary format, but netCDF format is expected in early 2014.

An additional feature currently being prototyped is the provision of a new land flag indicating the fraction of the full resolution Field Of View contaminated by land, with the purpose of better exploiting the data in coastal regions.

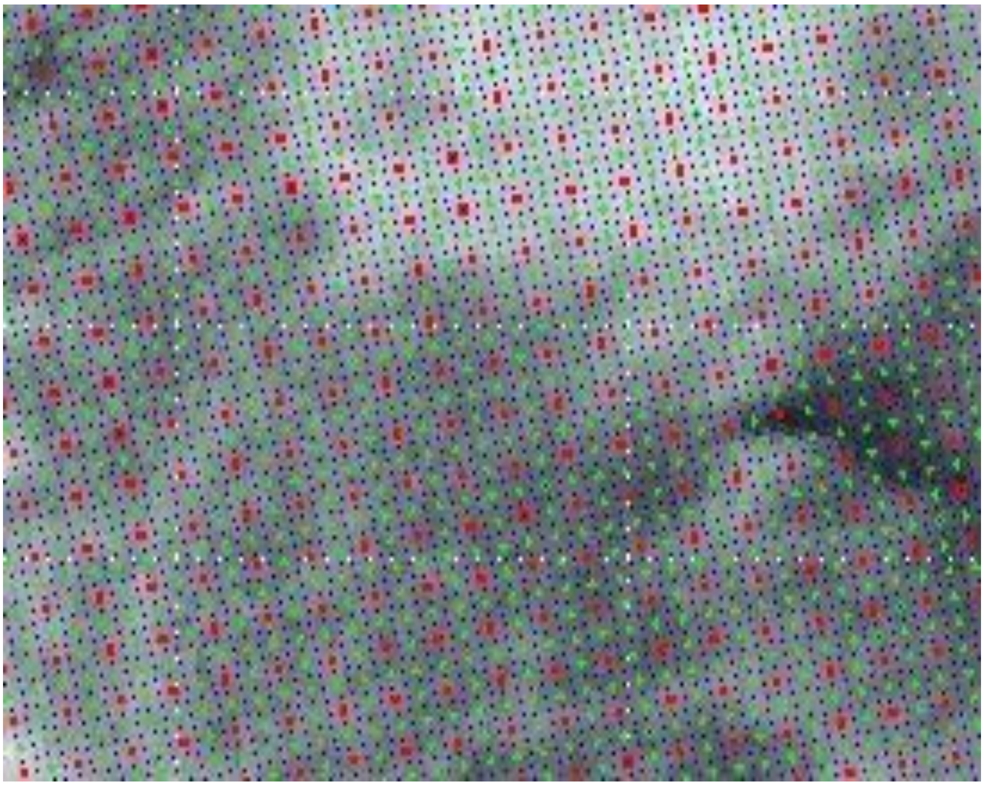

Figure 3 : Auxiliary 6.25 km swath grid included in the SZF product (blue), superimposed to the full resolution NRCS and to the 12.5 km SZR grid (green) and the 25 km SZO grid (red), respectively.

FIELD	DESCRIPTION
UTC_LOCALISATION	UTC time associated to the echo data (localisation time T_0)
SAT_TRACK_AZI	Azimuth angle bearing (range: 0 to 360) of nadir track velocity
AS_DES_PASS	Ascending/descending pass indicator
BEAM_NUMBER	Antenna Beam number
SIGMA0_FULL	Full-resolution sigma_0 values
INC_ANGLE_FULL	Full-resolution incidence angle values
AZI_ANGLE_FULL	Azimuth angle of the up-wind direction for a given antenna beam (range: -180 to +180, where minus is west and plus is east with respect to North)
LATITUDE_FULL	Latitude (-90 to 90 deg)
LONGITUDE_FULL	Longitude (0 to 360 deg)
LAND_FRAC	Estimation of the land fraction in the measurement footprint (currently under prototyping)
FLAGFIELD_RF1	Flag field related to the quality of raw echo corrections
FLAGFIELD_RF2	Flag field related to the quality of raw echo corrections
FLAGFIELD_PL	Flag field related to the knowledge of the platform orbit/attitude
FLAGFIELD_GEN1	Processing and summary flags
FLAGFIELD_GEN2	192-dimension flags , including surface type, solar array interference and the sign of the backscatter value

Table 1: List of fields in the new ASCAT SZF product.

POTENTIAL AND USE EXAMPLES OF THE SZF PRODUCT

It has been shown over ocean [Vogelzang et al 2011] that equivalent measurement noise and effective resolution of the SZR product are obtained if the NRCS is averaged using a Box-car filter of around 30 km of diameter, instead of a Hamming window of an approximate size of 50 km. This new averaging approach has the advantage of providing valid wind retrievals closer to the coast, as shown in Figure 4. Additionally, it has been found to produce winds which better correlate with surface current variability in the mesoscale [Plagge et al 2012].

A similar approach needs to be assessed for data over land, where a higher variability of the surface NRCS can clearly be observed in the SZF image in Figure 1 and indicates a good potential for the exploration of alternative re-sampling techniques towards increased resolution of soil moisture estimates.

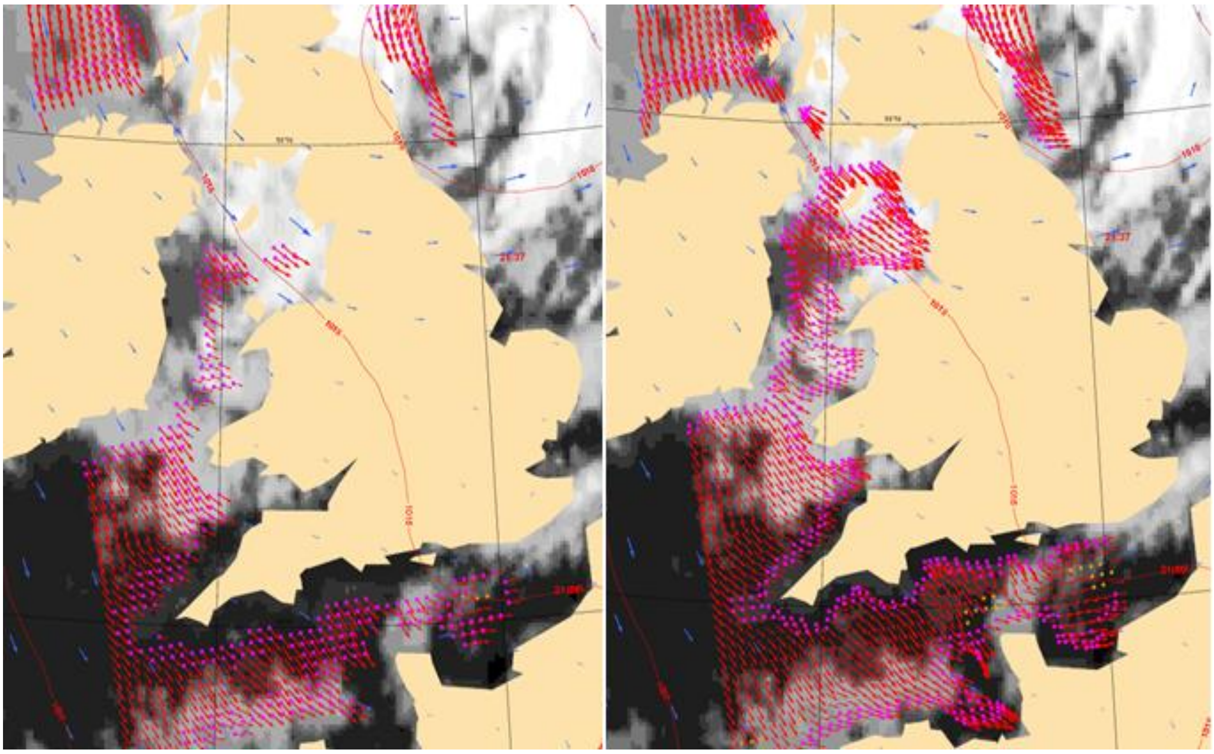

Figure 4: Winds derived from the SZR product (left) and those derived from the box-car spatially averaged NRCS, (right) also known as 'coastal winds'. Courtesy of the Ocean and Sea Ice Satellite applications Facility (OSI SAF).

Furthermore, it can be seen in Figure 5 that higher winds are visible on the wind climatology, as a result of processing data contaminated with corner reflector signals (such as ships). This happens because the wind retrieval quality control discards contaminated triplets, which most often occur in low wind situations, which results in higher wind climatology for areas along the major shipping routes and major harbours. This suggests potential in the removal of these spurious NRCS signals, through their identification at SZF level and successful removal before re-sampling of the NRCS. Again here, there is also potential in successfully applying this method over land surfaces in areas of dense population, hence improving the quality of the soil moisture signal.

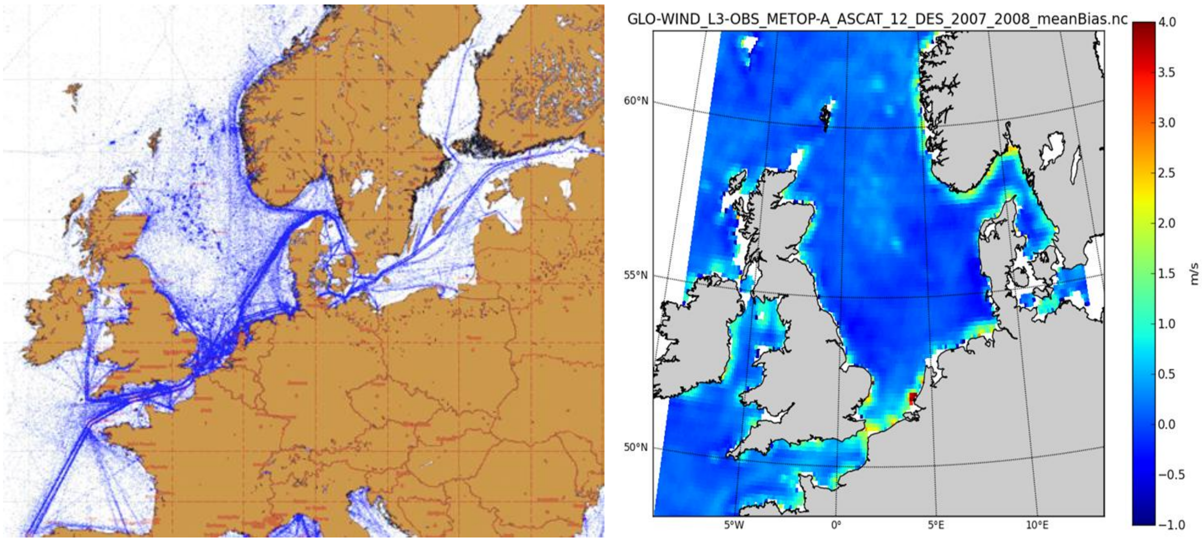

Figure 5: (left) Synoptic view of European shipping routes derived using seven years of radar data from ESA's Envisat satellite http://www.esa.int/Our_Activities/Observing_the_Earth/Envisat/ESA_map_reveals_European_shipping_routes_like_never_before ; (right) Wind bias w.r.t. ECMWF winds of ASCAT Level 3 wind data, provided by KNMI in the context of MyOcean and derived from the OSI SAF box-car filtered NRCS.

SUMMARY AND CONCLUSIONS

ASCAT NRCS measurements in full resolution are re-sampled, in order to collocate the data from the three beams and to reduce noise, which comes at the cost of spatial resolution. The current approach for re-sampling uses Hamming averaging windows and follows Nyquist theory, in order to allow further re-sampling of the data without introducing aliasing.

Other techniques have been successfully employed for specific applications, leading for example to the availability of winds much nearer the coast, and as a consequence the potential of making the SZF product available in near real time has been recognised by EUMETSAT, as a means to facilitate the exploration of optimum application-specific NRCS averaging techniques.

This new SZF product includes a number of features to facilitate this task, namely a reference swath grid pattern, a compact format and its planned availability in netCDF.

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