ASCAT FULL RESOLUTION BACKSCATTER PRODUCT


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ABSTRACT

We describe an improved version of the full resolution ASCAT normalised backscatter product which is more compact than the original and contains a regular grid of points to allow application driven resampling. Starting in early 2012, the new version will be distributed in near real time and will initially be used by the EUMETSAT Ocean and Sea Ice SAF to produce level 2 products containing the wind field in the vicinity of the coast.

An overview of the format and contents of the improved SZF product is given and the product size and along track spacing of the grid points are discussed. Successive rows in the grid are generated at discrete time steps from a fixed time origin which gives an average along track grid spacing of approximately 6.25 km.

Additionally, the flags in the product are described and the calculation and use of Kp values are examined.

INTRODUCTION

The Advanced Wind Scatterometer (ASCAT) is a six beam radar instrument carried on board the ESA/EUMETSAT Metop series of satellites and is designed to accurately measure surface backscatter allowing the retrieval of wind fields over the ocean [1]. The data it provides is also used by a number of other applications including sea ice monitoring and soil moisture retrieval [2], [3].

Three types of level 1b products are produced at EUMETSAT. Two of these, the SZO and SZR products, contain triplets of averaged backscatter values on a regular grid and are distributed in near real time via EUMETCAST. The third product, SZF, contains geolocated full resolution backscatter values together with incidence angles and azimuth angles and is available through the EUMETSAT Data Centre. Details of access to the Data Centre are available on the EUMETSAT home page www.eumetsat.int.

The six ASCAT antennas are operated in sequence and the received echoes are processed on board to give 256 values of received power as a function of slant range. These are averaged along-track and transmitted in an instrument source packet to the receiving station. The source packets are processed at EUMETSAT to give geolocated backscatter values (see [4] for details) which form the basis of three level 1b products:

- SZO - which contains triplets of spatially averaged backscatter with a resolution of approximately 50 km on a regular grid with approximately 25 km spacing.
- **SZR** - similar to the **SZO** except that the resolution is approximately 28 km and the grid spacing is around 12.5 km.
- **SZF** - which contains the full resolution geolocated backscatter values.

The **SZO** and **SZR** products are distributed in near real time via EUMETCAST and the **SZF** product is available from the EUMETSAT Data Centre. The format of these products is described in [5] and [6] and an example showing backscatter data taken from one of the swaths is shown in figure 1. Note that each image pixel corresponds to one backscatter measurement and hence the **SZF** image is larger than both the **SZR** and **SZO** images.

![Image of example images](image.png)

**Figure 1:** Example images of the normalised radar cross section measurements in the left mid beam from **SZO**, **SZR** and **SZF** data over Europe.

We have improved the **SZF** product to make it more compact (so that it can in future be distributed via EUMETCAST) and added grid data with a 6.25 km spacing. The grid can be sub-sampled by a factor of 2 or 4 to obtain grids similar to those in the **SZR** and **SZO** products. The improved product is more general and flexible than the original and may be of interest for applications which require full resolution data or particular types of spatial averaging.

The EUMETSAT Ocean and Sea Ice SAF is producing a level 2 coastal wind product derived from full resolution data with the wind values calculated on the grids extracted from the **SZR** products. This currently requires near real time **SZR** and **SZF** data. However, the process will be simplified in future by making use of the improved **SZF** product which contains all the necessary information.

This document gives an overview of the improved **SZF** product including the product size and grid spacing. The flags in the product are described and the behavior of the solar array flag is discussed. **Kp** values are briefly examined and information concerning a test data set and supporting documentation is given.
FORMAT OF THE IMPROVED SZF PRODUCT

The enhanced SZF product follows the generic format described in [6] and consists of a set of records. The most important of these are:

- A Main Product Header Record (MPHR) which provides information identifying the dataset, spacecraft, instrument, observation date, orbit number, etc.
- A set of Variable Internal Auxiliary Data Records (VIADR) each of which contains the latitude and longitudes for one row of points in the grid.
- A set of Measurement Data Records (MDR) containing the full resolution geolocated backscatter values derived from the individual instrument source packets.

Each VIADR contains 81 points across the left swath and 81 points across the right swath with a fixed spacing of 6.25 km. This compares to the grids in the SZO and SZR products which have 21 and 41 points across each swath with a fixed spacing of 25 and 12.5 km respectively.

Each MDR contains a fixed number of backscatter values (currently 192) together with the associated latitudes, longitudes, incidence angles and azimuth angles.

Figure 2 shows an example of the grid and backscatter latitudes and longitudes extracted from an improved SZF product containing three minutes of data. Note that the fore and aft beam data do not coincide exactly with the grid given in the product but are displaced slightly.

![Figure 2: Latitude and longitudes in 3 minutes of data showing the location of the backscatter values in each beam and the grid points in the left and right hand swaths.](image)

Along Track Grid Spacing

Successive grid rows in the SZO/SZR products are derived from an initial satellite position by finding successive positions where the sub-satellite points are 25/12.5 km apart. Actual along track spacing varies slightly around this value depending satellite height and the incidence angle. However, the generation of the first reference line of nodes according to this scheme is directly related to the start of the input raw data flow because the processor is data driven. In other words different processor facilities started at different times use a different initial satellite position and hence produce products...
with slightly offset grids. This makes processor cross validation slightly complex.

To overcome this problem, the grid rows in the enhanced SZF product are generated at discrete time steps from a fixed time origin. This allows an average grid spacing of approximately 6.25 km while ensuring that different processor runs produce the same grids regardless of the start sensing time of the input data.

Figure 3 shows the along track grid spacing in the left hand swath at near, mid and far range during a typical orbit. This indicates that the along track spacing varies between approximately 6.03 and 6.3 km around an orbit. Figure 4 shows the along track grid spacing for the right hand swath at near, mid and far range. This behaves similarly, varying between 6.07 and 6.27 km.

**Figure 3:** Typical along track grid spacing at near, mid and far range in the left hand swath.

**Figure 4:** Typical along track grid spacing for near, mid and far range in the right hand swath.
Product Size

Typical SZO, SZR and SZF product sizes for a full orbit of data (approx 100 minutes) are 6.5, 25 and 300 megabytes respectively. One orbit of data in an improved SZF product consists of approximately 6,400 VIADR and 44,000 MDR and as each VIADR has a size of approximately 1.3 kb and each MDR has a size of approximately 3 kb this gives a total product size of around 150 Mb. Hence the improved SZF product is around 50% smaller than the product it replaces.

Note that the files transmitted via EUMETCAST cover 3 minute segments of the orbit and will have a size of about 4.5 Mb for the improved SZF product.

FLAGS

The processing algorithms detailed in [4] set a number of flags to indicate non-nominal conditions that may affect the quality of the data. The flags that apply to all the data in an MDR are:

- **fhrx** - the ASCAT across swath filter response is estimated using a set of noise measurements. If some of these are missing or corrupt then the estimate of the filter response will be less accurate. This flag is set if the number of noise values used during processing was less than 95% of nominal.
- **vhrx** - this flag is set if the number of noise values used to calculate the filter response was less than 80% of nominal.
- **fpgp** - the power gain product used during processing is an estimate obtained from a rolling average of the values contained within individual instrument source packets. If some of these are missing or corrupt then the estimate of the power gain product will be less accurate. This flag is set if the number of values used during processing was less than 95% of nominal.
- **vpgp** - this flag is set if the number of values used to calculate the power gain product was less than 80% of nominal.
- **fman** - this flag is set if the information in the orbit state vector file indicates that a maneuver is taking place.
- **forb** - this flag is set if the actual orbit height of the satellite differs from the height used to calculate the normalization (calibration) coefficients.
- **fatt** - set if the information in the orbit state vector file indicates that the satellite is not in yaw steering mode.
- **fcfg** - set if the ASCAT configuration in the instrument source packets differs from the configuration assumed during processing.
- **fosv** - set if the orbit state vector file is missing. In this situation the fatt and fman flags cannot be determined.
- **ftel** - set if telemetry data is missing.
- **ftool** - set if telemetry data is outside normal limits.
- **fnoise** - set if the noise data required for processing is missing and an interpolated value has been used instead.

These flags are rarely set during normal operations. Two other flags are produced which apply to individual values in the MDR. These are:

- **fland** - this flag is set if the latitude and longitude of the backscatter measurement lies over land.
- **fsol** - set if the backscatter measurement may be affected by reflections from the solar array.

When the solar array on the Metop satellite is in a particular orientation it may reflect back part of the signal from the left fore antenna. This can occur in descending passes over the equator. The flag is set in about 0.8% of all backscatter values and figure 5 shows the typical position on the Earth of the
flagged backscatter values. However, there have been no reports of any obvious difference in quality between flagged and non-flagged backscatter values and hence the effect of the solar array reflections seems to be negligible.

![location of nodes with fsol set](image)

**Figure 5:** Plots showing the location of the backscatter values whose solar array flag is set during a typical month.

If data quality is of overriding importance then all data which has any flags set should be discarded. For normal purposes, where minor degradation in the data is acceptable, then data which has one or more of the fhrx, fpkp, fnoise and fsol flags set and no other flags set can be used.

**Kp VALUES**

The error in spatially averaged backscatter values can be estimated and is given in SZO/SZR products in the form of

\[
Kp = \frac{\text{error\_estimate}}{\text{mean\_backscatter}}.
\]

If the data in the SZF product is used to calculate a spatially averaged backscatter then the Kp values can be calculated using the algorithms given in [7]. This takes into account the correlations that exist in the full resolution data caused by processing on board the ASCAT instrument.

Kp is related to the standard deviation of the backscatter in the spatial averaging region and may contain useful geophysical information. As an example, figure 6 shows the Kp values from SZR data over the Arctic from the period 2011/03/18 to 2011/04/07. The Kp values over sea ice are not uniform but show a large scale spatial variation that may be related to ice type and small scale variations that may be related to physical features in the ice. This may provide additional information to assist established techniques for classifying ice type or ice edge.

Figure 7 shows images of mean $\sigma_0$ (upper) and Kp (lower) over Arctic sea ice at -116.3° longitude, 80.1° latitude obtained by averaging 7 days of ASCAT SZR data beginning on 2011/03/18, 2011/03/22 and 2011/03/26. The features in sea ice Kp are more obvious than features in backscatter and appear to be slowly changing position. Hence Kp may provide additional information that could assist algorithms for tracking the movement of sea ice.
Figure 6: Mean Kp in the Arctic region obtained from SZR data over the period 2011/03/18 to 2011/04/07.

Figure 7: Snapshots of mean $\alpha_0$ (upper images) and Kp (lower images) over Arctic sea ice obtained by averaging 7 days of ASCAT SZR data beginning on 2011/03/18, 2011/03/22 and 2011/03/26 at -116.3° longitude, 80.1° latitude.

FURTHER INFORMATION AND TEST DATA

The reference documents [4], [5] and [6], which specify the format of the existing level 1b products and the processing algorithms, are available from the EUMETSAT website:

www.eumetsat.int/Home/Main/DataProducts/Resources/index.htm

A test data set containing the improved SZF product and a document describing full details of its format are available via anonymous login from the EUMETSAT ftp server:
ftp.eumetsat.int/pub/EUM/out/MET/anderson/szf.tgz

The operational implementation of the improved SZF product is expected in early 2012. Note that after a period of validation of the new format by users, the format description as given above may vary slightly from the final implementation.

REFERENCES


