Metop-A ASCAT L1 Data Record Release 2 (CF-003): User Guide

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1 INTRODUCTION

1.1 Purpose and Scope

The purpose of this document is to provide detailed information about the reprocessed Level 1B data record Release 2 from the ASCAT instrument on METOP-A (CF-003).

This document describes the data records and the methods used to produce them, and gives an overview of the quality of the data. It also provides information on obtaining the data from the EUMETSAT Data Centre.

The generation of the data record was triggered by the EU ERA-CLIM project [RD1] need for ASCAT surface winds and soil moisture fields for NWP model-based re-analysis. The level 1 data record produced in this context provides a consistent data record from which surface winds, soil moisture and other Earth surface properties important for climate monitoring and assessment, such as sea ice drift and extent, ocean fluxes and soil freeze/thaw patterns and tendencies may be derived.

1.2 Reference Documents

RD	*Document Name*	*EUMETSAT Reference*	*Available at*
[RD1]	ERA-CLIM project description		www.era-clim.eu
[RD2]	EPS Generic Product Format Specification	EPS/GGS/SPE/96167	http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=PDF_TEN_96167-EPS-GPFS&SelectionMethod=LatestReleased&Rendition=Web
[RD3]	ASCAT Level 1 Product Format Specification	EPS.MIS.SPE.97233	http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=PDF_TEN_97233-EPS-ASCAT-L1&RevisionSelectionMethod=LatestReleased&Rendition=Web
[RD4]	ASCAT Product Guide	EUM/OPS-EPS/MAN/04/0028	http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=PDF_ASCAT_PRODUCT_GUIDE&RevisionSelectionMethod=LatestReleased&Rendition=Web
[RD5]	Estimation of ASCAT-Normalised Radar Cross Section- ATBD	EUM/TSS/SPE/14/762689	To be published on the EUMETSAT web site after the CDR release review
[RD6]	ASCAT / METOP-A Reprocessed L1 Data Record Validation Report	EUM/OPS-EPS/REP/14/753112	To be published on the EUMETSAT web site after the CDR release review
[RD7]	EUMETSAT Data Centre Archive Online Ordering Application User Manual	EUM/OPS/DOC/06/0873	http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETSATDataCentre/OrderingFAQandSupport/index.html

RD	*Document Name*	*EUMETSAT Reference*	*Available at*
[RD8]	EUMETSAT DATA POLICY	-	http://www.eumetsat.int/website/home/AboutUs/LegalInformation/DataPolicy/index.html
[RD9]	ASCAT Calibration 2012	EUM/MET/TEN/12/0254	http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=PDF_ASCAT_CALIBRATION&RevisionSelectionMethod=LatestReleased&Rendition=Web
[RD10]	Product Navigator User Guide	EUM/OPS/DOC/12/680535	http://navigator.eumetsat.int/discovery/help/UserGuide_PN2.1_terraCatalog_30_EN_V2.pdf

1.3 Acronyms and Abbreviations Used in this Document

Acronym	*Meaning*
ADR	Auxiliary Data Record
ASCAT	Advanced Scatterometer
ATBD	Algorithm Theoretical Baseline Document
BUFR	Binary Universal Form for the Representation of meteorological data
CDR	Climate Data Record
CF	Climate and Forecast
CGS	Core Ground Segment
ECMWF	European Centre for Medium-Range Weather Forecasts
EPS	EUMETSAT Polar System
EQSOL	Equipment Switch-Off Line (ASCAT instrument switch-off event)
ERA-CLIM	European Re-Analysis of global Climate observations
ERF	EPS Reprocessing Facility
MPHA	Main Product Header Record
NetCDF	Network Common Data Form
NWP	Numerical Weather Prediction
NRCS	Normalised Radar Cross Section
OSI SAF	Ocean and Sea Ice Satellite Application Facility
PLSOL	Pay Load Switch-Off Line (METOP payload switch-off event)
PPF	Product Processing Facility
SZF	Sigma Zero Full-Resolution (ASCAT)
SZO	Sigma Zero Operational (ASCAT)
SZR	Sigma Zero Research (ASCAT)
UCAR	University Corporation for Atmospheric Research
WMO	World Meteorological Organisation

2 BACKGROUND

The Advanced Scatterometer (ASCAT) is a six-beam radar instrument operating at C band with vertical polarisation. Three of the beams cover a swath located on the left-hand side of the sub-satellite track and the others cover a swath located on the right-hand side. It is designed to accurately measure the surface Normalised Radar Cross-Section (NRCS), also known as backscatter or σ_0. The backscatter values can be used for the retrieval of surface wind fields over the ocean, soil moisture over land, and sea ice properties such as extent and drift.

An ASCAT instrument is carried on each of the EUMETSAT METOP satellite series. The ASCAT carried by the METOP-A satellite (ASCAT-A) has been operational since 2007 and the ASCAT on board the METOP-B satellite (ASCAT-B) became operational in 2013. A third ASCAT will be carried on the METOP-C satellite.

EUMETSAT participated in the European re-analysis of global climate observations (ERA-CLIM) project [RD1]. The project aimed at the preparation of consistent input data records from different observing systems and their use in data assimilation systems for a new global atmospheric reanalysis for the satellite era. This effort required the generation of consistent Climate Data Records (CDR) from satellite data and the application of the best available approaches for instrument calibration.

One of EUMETSAT's contributions to the ERA-CLIM project was the generation of a homogeneous and consistent ASCAT-A Level 1 data record that has been produced employing the EUMETSAT reprocessing facility. The available data record covers the period of 1 January 2007 to 31 March 2014.

Section 0 describes the structure and content of the data record. Section 5 gives the details of how it was produced. The characteristics of the data are described in Section 6. Information about how the data can be obtained from the EUMETSAT Data Centre is provided in Section 7.

3 DATA RECORD OVERVIEW

General	Data record name	Metop-A ASCAT L1 Data Record Release 2 (CF-003).
	Data record reference	ASCAT GDS L1B XXX CDR_R02 (XXX=SZO, SZR or SZF)
	Data record digital identifier	(Will be added after introduction at EUMETSAT Data Centre)
	Data record short description	Reprocessed data from the Advanced Scatterometer (ASCAT) on METOP-A
	Record type	ASCAT-A NRCS FCDR
	Period covered	1 Jan 2007 – 31 Mar 2014.
	Content	NRCS data (dB), state of the art ASCAT Level 1 operational processor PPF v9.1.3
	Generation frequency	Specific data record generation with a repeat cycle of approximately 3 years
Instrument	Instrument name	Advanced Scatterometer on METOP-A (ASCAT-A).
	Instrument description	Six-beam C-band scatterometer with three beams covering a swath on the left hand side of the satellite track and three beams covering a swath on the right hand side.
Data	Input data	ASCAT Level 0 data, METOP-A Orbit State Vector prediction files, antenna gain calibration mode, instrument and processor characterisation and land/sea mask. ASCAT NTB files and ASCAT L1A files are intermediate output/input data and not distributed.
	Output data	ASCA_SZO, ASCA_SZR, ASCA_SZF (EUMETSAT Data Centre product identifier)
	Format	The data is in the native EPS format. The SZO and SZR products are also provided in BUFR and NetCDF formats (Climate and Forecast conventions used).
Access	EUMETSAT Data Centre	The data set is available from EUMETSAT Data Centre (https://eoportal.eumetsat.int/).
	Delivery	• ftp push • html download • physical media.
Coverage	Spatial	Global (ocean and land), sampling: • ASCA_SZR on 12.5 km, ASCA_SZO on 25 km spacing swath grid • ASCA_SZF on measurement sampling pattern (i.e. full resolution)
	Temporal	Continuous, full ASCAT-A mission: Jan 2007 – Mar 2014
Resolution	Horizontal	• ASCA_SZR 25-30 km, ASCA_SZO 50 km • ASCA_SZF approximately 10 km × 25 km
	Vertical	n/a (surface parameter)
	Temporal	14.2 orbits per day

Physical Content	Principal physical quantity provided in data set	Normalized radar cross section (NRCS) of the Earth surface together with measurement time, location (latitude and longitude) and geometrical information (incidence and azimuth angles). This is provided in two main forms: 1. Individual NRCS measurements at full instrument resolution, and 2. Spatially-averaged NRCS measurements from the fore, mid and aft beams on a regular grid of points in the left-hand and right-hand swaths.	
	Physical description of data record	Approximately 35,000 files for each of the following product types 1. Level 1B SZO: Spatially-averaged NRCS triplets on a 25 km spacing swath grid with approximately 50 km resolution. 2. Level 1B SZR: Spatially-averaged NRCS triplets on a 12.5 km spacing swath grid with approximately 25 km – 30 km resolution. 3. Level 1B SZF: Full-resolution NRCS measurements. Each file contains data covering one data acquisition dump over Svalbard (approximately 101 minutes). The product sizes are approximately 170 Mb (SZF), 30 Mb (SZR) and 7 Mb (SZO).	
Uncertainty target	Accuracy	• Absolute and inter-beam: 0.1 dB • Relative (with regard to int. angle): p2p variations of antenna patterns within 0.1 dB	Ensured by transponder calibration and validated over global ocean, rainforest and sea ice
	Precision	Radiometric resolution: 4%	Validated over rainforest and ocean
	Stability	0.1 dB over 5 years	Validated with respect to rainforest backscatter, CMOD5 and ocean measurement
Data record characteristics	1. The data is continuous over the seven-year period apart from a few minor instrument and satellite outages; 2. Monitoring and validation over the rainforest and ocean shows that the data has a high and consistent quality over the entire time period; 3. Data quantity and quality is reduced slightly in the vicinity of Turkey due to routine calibration activities of four times per month and four calibration campaigns with a span of one to three times per day for a period of two to three months; 4. Radio frequency interference from ground has been observed to influence the ASCAT backscatter measurements. This is infrequent (generally every two or three months) and lasts for a short period (approximately 40 seconds). The summary quality flag for spatially-averaged backscatter does not take into account the reduced number of samples occurring near data gaps. Users of the SZO and SZR products should check the field containing the number of samples used in the re-sampling, as well as the quality flag.		

4 PRODUCT DEFINITION

This section gives an overview of the data record, covering file sizes, contents, formats and file names.

4.1 Physical Structure

The data set covers the period of 1 January 2007 to 31 March 2014 and consists of approximately 35,000 files for each of the following product types:

- Level 1B (SZO);
- Level 1B (SZR);
- Level 1B (SZF).

Each file is based on the data obtained during one download from the satellite to the ground receiving station at Svalbard, Norway. This takes place once per satellite orbit. Each file is generally 101 minutes long with the data starting and ending at the edge of the Svalbard ground station coverage time. This is shown in Figure 1. As of June 2011, some files are composed of data acquired at the McMurdo ground station in Antarctica and completed with the remaining data acquired at Svalbard. As of December 2013, most of the 14 orbits per day have been composed of data acquired at McMurdo for the first half, and Svalbard for the second half of each orbit.

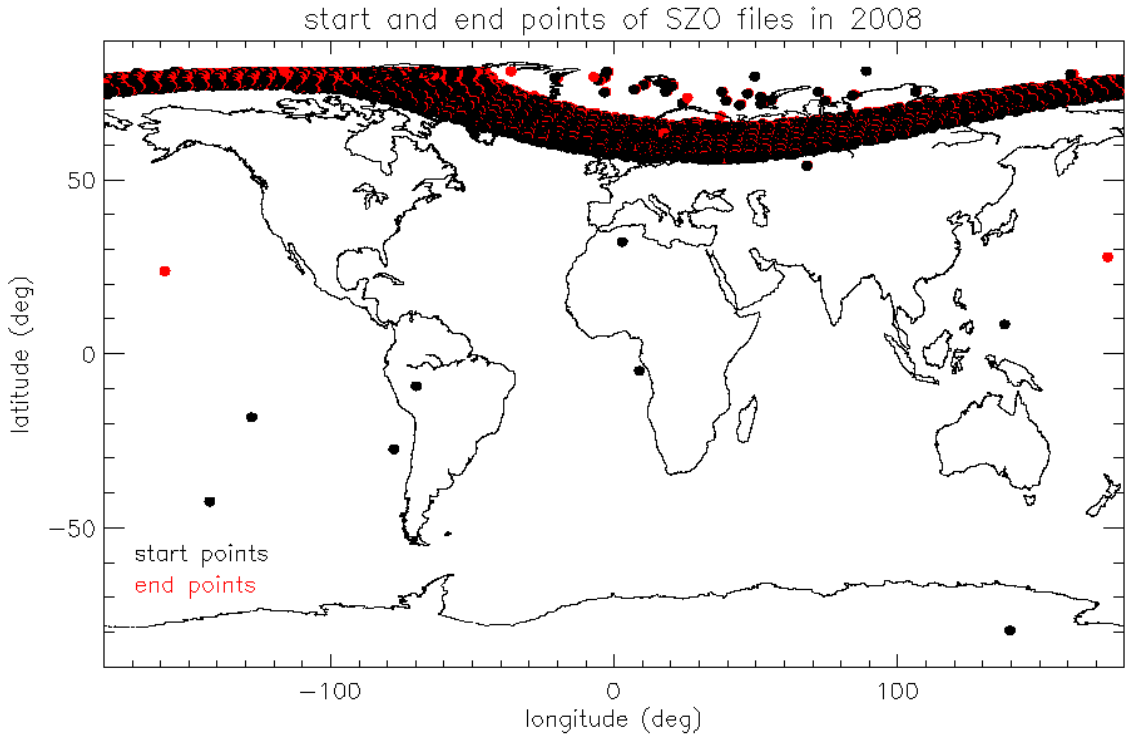

Figure 1. Approximate start and end points of the of the ASCAT SZO products. Start points are in black and the end points are in red.

4.2 Product Contents

The product types are the same as those produced from the operational processing of ASCAT data in the EPS ground segment. An in-depth description of the ASCAT products can be found in [RD4] and only a brief summary of the main geophysical content is provided in this document. The geophysical content in the products has been obtained using the algorithms described in [RD5]

The Level 1B SZF products contain individual backscatter measurements at the full instrument resolution together with their associated geometrical information (incidence angle, azimuth angles, latitude and longitude). They also contain a reference swath-based latitude/longitude grid with 6.25 km spacing along-track and across-track. This facilitates user-driven customization of the re-sampling, as well as collocation of data from the different beams.

The Level 1B SZR products contain backscatter triplets produced by re-sampling the full resolution backscatter from the fore, mid, and aft beams at selected points on the Earth's surface. This re-sampling is done on a swath-based grid at 12.5 km spacing along-track and across-track. The use of a weighted averaging window in the re-sampling (in this case a Hamming filter) gives a horizontal resolution of 25–30 km, depending on beam and across-track position.

The Level 1B SZO products also contain backscatter triplets produced by spatially averaging full resolution backscatter from the fore, mid, and aft beams at selected points on the Earth's surface. In this case, the swath grid is at 25 km spacing and the re-sampling (also a Hamming filter) gives a resolution of approximately 50 km.

4.3 Product Formats, File Names and Sizes

All products are available in EPS native format. The Level 1B SZO and SZR products are also available in Network Common Data Form (NetCDF) and in the Binary Universal Form for the Representation of meteorological data (BUFR) format. All formats are described in detail in [RD4], but a summary of the relevant structure and metadata is given here.

4.3.1 EPS Native Format

The output of the data processing is in the EPS native data format, which is a generic binary format used for all instruments and products from the EPS. This is described in [RD2] and consists of a sequence of binary records of varying types. The type of records, and the order they appear in the product are as follows:

Main Product Header Record (MPHR)
Provides information identifying the data, spacecraft, instrument, observation date, orbit number, and other data.

Secondary Product Header Record (SPHR)
Provides product related information such as quality indicators or summary data.

Internal Pointer Record (IPR)
Identifies the remaining records in the product and their location in the file.

Auxiliary Data Records (ADR)
Provides auxiliary data that are applicable to the data in the product.

Measurement Data Records (MDR)
Contains instrument measurements along with associated geolocation and quality information.

The formats of the ADR and MDR are specific to each instrument and product and are given for the ASCAT products in [RD3].

The MPHR in each product contains the following information related to the data set identification and configuration:

Tag	*Value*
INSTRUMENT_ID	ASCA
SPACECRAFT_ID	M02
PROCESSING_CENTRE	ERF1
PROCESSOR_MAJOR_VERSION	9
PROCESSOR_MINOR_VERSION	1
FORMAT_MAJOR_VERSION	12
FORMAT_MINOR_VERSION	0
PROCESSING_MODE	R
DISPOSITION_MODE	O

Table 1: Metadata identifying the data set, corresponding to the EPS Native format.

Note: M02 in the SPACECRAFT_ID field indicates the second METOP flight model, which was renamed METOP-A after launch. The PROCESSING_MODE and DISPOSITION_MODE are set to "R" and "O" for files in the reprocessed data set.

Furthermore, the ADR 'VIADR-VER' records the configuration of processor and instrument characterisation, as well as the Level 1B calibration.

Tag	*Value*
XCL_VERSION1.2	2.4 before (11.09.2009 12:00)
XCL_VERSION1.2	2.3 after (11.09.2009 12:00)

Table 2: Metadata identifying the calibration version, corresponding to the EPS Native format.

The filenames follow the generic convention used by the EPS. Each file name identifies the instrument, the product type, product level, METOP satellite, start and stop times of the data contained in the file, together with information about the processing (the disposition and processing mode and the time at which the product was produced).

The filename format for the various products is given in Table 3 below. Each filename is 96 characters long.

Level (type)	*Filename*
Level 1b (SZO)	ASCA_SZO_1B_M02_[start time]_[stop time]_R_O_[processing time]
Level 1b (SZR)	ASCA_SZR_1B_M02_[start time]_[stop time]_R_O_[processing time]
Level 1b (SZF)	ASCA_SZF_1B_M02_[start time]_[stop time]_R_O_[processing time]

Table 3: File names identifying the data set, corresponding to the EPS Native format.

The approximate size of the files of each product type is as follows:

Level 1b SZF	170 Mb
Level 1b SZR	30 Mb
Level 1b SZO	7 Mb

The size of the complete reprocessed data set for each year is given in Table 4.

	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*Total*
Level 1b (SZO)	32	32	33	33	32	33	33	9	**237**
Level 1b (SZR)	123	125	127	127	126	127	127	32	**914**
Level 1b (SZF)	771	789	799	797	792	802	792	197	**5739**
Total sizes (GB)	**926**	**946**	**959**	**957**	**950**	**962**	**952**	**238**	**6890**

Table 4: Size of the data set (in GB) corresponding to the EPS Native format.

4.3.2 About the NetCDF Format

NetCDF is a machine-independent, self-describing, binary data format standard for exchanging scientific data. Level 1B SZO and SZR products are provided in this NetCDF format. The project homepage is hosted by the Unidata program at the University Corporation for Atmospheric Research (UCAR). They are also the chief source of NetCDF software, standards development, updates etc. The format is an open standard. All NetCDF data sets developed at EUMETSAT use NetCDF v.4 in the Classic Data Model. Climate and Forecast (CF) conventions have been applied where applicable.

The data format is *self-describing*. Self-describing data contains a header which describes the layout of the rest of the file, in particular the data arrays, as well as arbitrary file metadata in the form of name/value attributes.

Table 5 lists global attributes that allow for identification of this specific data set as well as the Level 1B calibration used:

Global attribute	*Value*
platform_long_name	METOP-A
Sensor	ASCA
processing_centre	ERF1
processor_major_version	9
product_minor_version	1
format_major_version	12
format_minor_version	0
instrument_calibration_version	2.4 before 11.09.2009 12:00 2.3 after 11.09.2009 12:00

Table 5: Metadata identifying the data set, corresponding to the NetCDF format.

The World Meteorological Organization (WMO) file-naming conventions are used to name the NetCDF data files. Each file name identifies the originating and processing centres, contents type, instrument, spacecraft, start sensing time, orbit number and product level and type. These conventions are shown in Table 6.

Note: For product type, SZO is represented by the tag *250*, while SZR uses *125*.

Level (type)	*Filename*
Level 1b (SZO)	W_XX-EUMETSAT-Darmstadt,SURFACE+SATELLITE,METOPA+ASCAT_C_EUMP_[start sensing time]_[orbit]_eps_o_250_l1.nc
Level 1b (SZR)	W_XX-EUMETSAT-Darmstadt,SURFACE+SATELLITE,METOPA+ASCAT_C_EUMP_[start sensing time]_[orbit]_eps_o_125_l1.nc

Table 6: File names identifying the data set, corresponding to the NetCDF format.

The approximate size of the files of each product type is as follows:

Level 1b SZR	28 Mb
Level 1b SZO	7 Mb

The size of the complete data record in NetCDF format is given in Table 7.

	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*Total*
Level 1b (SZO)	32	32	33	33	33	33	33	9	**238**
Level 1b (SZR)	123	125	126	126	126	127	127	32	**912**
Total sizes (GB)	**155**	**157**	**159**	**159**	**159**	**160**	**160**	**41**	**1150**

Table 7: Size in GBs of the data set corresponding to the NetCDF format.

4.3.3 BUFR Format Description

The Level 1B SZO and SZR products are also available in the WMO Binary Universal Form for the Representation of meteorological data (BUFR) format. BUFR is a binary code designed to represent any meteorological dataset that employs a continuous binary stream. For the operational data, the sequence descriptor for ASCAT data is 3-12-061. Bulletin headers are IESXii—ii is from 01 to 10 for the 25 km data, and 11 to 99 for the 12.5 km data. The originating station is EUMP.

In Section 4 of the BUFR code, the *Identification of originating/generating Sub-centre* field (descriptor 001034) allows identification of this data set with a value of two. In the current ASCAT sequence descriptor, there is no field to identify the Level 1B calibration.

WMO File Naming Conventions are used also to name the BUFR datasets as shown in Table 8

Level (type)	*Filename*
Level 1b (SZO)	W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPA+ASCAT_C_EUMP_ [start sensing time]_[orbit]_eps_o_250_l1.bufr
Level 1b (SZR)	W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPA+ASCAT_C_EUMP_ [start sensing time]_[orbit]_eps_o_125_l1.bufr

Table 8: File names identifying the data set, corresponding to the BUFR format.

Note: This is the same naming convention as for the NRT product, so you cannot distinguish the BUFR files belonging to this data record from the NRT BUFR files. An update of the BUFR conversion software is planned to be able to reflect the *cdr* nature of these files.

The size of the complete data record in BUFR format is given in the table below.

	2007	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*Total*
Level 1b (SZO)	8.88	9.07	9.18	9.16	9.11	9.20	9.13	2.29	**66.02**
Level 1b (SZR)	33.5	34.2	34.6	34.6	34.4	34.7	34.6	8.7	**249.3**
Total sizes (GB)	42.38	43.27	43.78	43.76	43.51	43.90	43.73	10.99	**315.3**

Table 9: Size (in GBs) of the data set corresponding to the BUFR format.

5 PRODUCT GENERATION

This section gives an overview of how the data record was produced and describes the used input and auxiliary data, the processing software and the setup of the reprocessing facility.

5.1 Input Data

The instrument source packets from the ASCAT-A are downloaded once every orbit to the Svalbard receiving station and transmitted to the EUMETSAT Data Centre. In the EPS ground segment, these packets are pre-pended with UTC time information and saved in the form of level 0 products containing around 101 minutes of data: this corresponds to one data dump. The ground segment uses Level 0 products to produce operational, near-real-time Level 1A and 1B products. All of these products are archived at the EUMETSAT Data Centre.

For this effort, Level 0 ASCAT-A data was obtained from the EUMETSAT Data Centre for the period 1 January 2007 to 31 March 2014. Note that ASCAT-A was officially commissioned on 1 March 2007; hence, ASCAT-A prior to this date is flagged as “commissioning”. However, this flag relates to the formal completion of the METOP-A commissioning activities and not necessarily to the quality of the raw data. Our validation of raw data from early 2007 has shown a very stable instrument, performing at the level of the rest of 2007, so it was decided to include this period in the data record.

Note: Some ASCAT-A instrument source packets from 2007 were only processed into Level 0 files using a backlogged processing mode during 2008, i.e. due to ground segments issues some data from 2007 were not processed directly upon reception, but later in 2008. This results in a higher number of Level 1 files in the data record, when compared to the operational data also available from the EUMETSAT Data Centre.

5.2 Auxiliary Data

The auxiliary data consists of four elements: orbit state vectors, calibration information, instrument parameter files and processing parameter files. Each of these is described in the sections that follow.

5.2.1 Orbit State Vectors

The Flight Dynamics Facility at EUMETSAT releases orbit state vector prediction files daily. These files contain the predicted METOP-A state vector (time, position and velocity) for each ascending crossing of the Earth’s equatorial plane for the following three next days.

The information in these files is recorded in the MPHR of the Level 0 products. Information from the Level 0 MPHR or from the orbit state vector files is used during the operational processing to estimate the satellite position and velocity at any point around the orbit.

5.2.2 Calibration

The general approach for the characterisation of the ASCAT antennae gain is based on the use of ground transponders. By carrying out periodic calibration measurement campaigns of two to four months, the data collected by ASCAT from the transponders is used to estimate the in-flight gain pattern and pointing bias of each antenna, representative of that period. The campaigns carried out so far for ASCAT-A are represented in Figure 2 as yellow diamonds and referred to as EC-2007, EC-2010 and EC-2012. A comparison with the first and reference characterisation (EC-2007) allows determining whether the antennae gain has significantly changed and an update in the antennae characterisation may be introduced in the operational processing chain. This is illustrated also in Figure 2 by the blue line, which represents the calibration stability of the operational ASCAT-A record.

In particular, note that a change in the product radiometric accuracy was detected during the routine product quality monitoring in 2009 for the mid-left beam. This is 0.1 dB in backscatter, and is represented by the jump to a thin blue line in Figure 2. This is also independently confirmed by EC-2010: a gain of 0.05 dB, represented by the smaller yellow diamond in EC-2010. After this confirmation, the antenna characterisation in the operational processor was updated in summer 2011 in order to align the backscatter calibration of the six beams again. This had as the effect of a sudden change of the calibration of the operational products, as can be seen in Figure 2. By comparing the results of EC-2012 with respect to the other two previous campaigns, it was confirmed that this change in the mid-left beam was a permanent one. The cause of the change in the mid-left beam antenna could not be determined because the chance was very small and there were a wide range of possible causes.

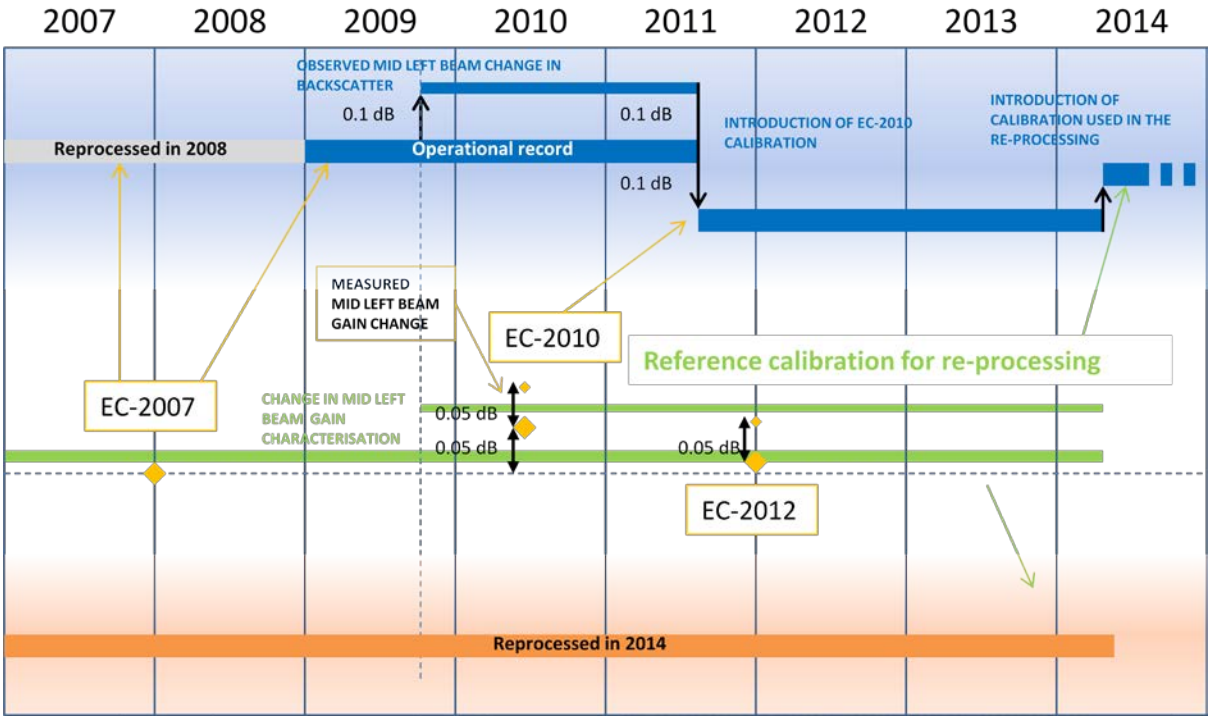

Figure 2. ASCAT-A transponder External Calibrations (EC) and continuity of the operational and re-processed data records

One of the main reasons for re-processing the ASCAT-A data was to provide a long-term consistently-processed record, using our best knowledge of the instrument calibration model through its life time, thus avoiding the sudden changes brought in by operational updates. What we know from the transponder campaigns is that the ASCAT-A instrument has been very stable so far, except for the sudden change in the Mid-Left Beam, but we have a precise date for this event (11 September) that is based on the rainforest and ocean monitoring tools. This knowledge was then applied to create an instrument calibration model represented by the green line in Figure 2. With respect to the small variations in the calibration for all beams measured by the three transponder campaigns, it was considered appropriate to assign the same uncertainty to the estimations of each of the campaigns, and to take an average gain from the three measurements (thick green line), i.e., a stable instrument characterisation for all beams until September 2009, where a characterisation change was introduced for the Mid-Left beam (thin green line), of amplitude as measured by EC-2010 (0.05 dB in gain). This approach was endorsed by the EUMETSAT Science Advisory Group.

The result of this model is a data record processed with a stable characterisation, since the only change is introduced to compensate for a measured instrument calibration change. This data record is marked in Orange in Figure 2. Additionally, the instrument calibration model used, the green lines in Figure 2, was also introduced into the operational processor—in Figure 2, you see this in the raised performance and gap in the blue line in 2014. This allows for the operational products to continue the re-processed data record without interruption.

5.2.3 Instrument Parameter Files

The processor requires information about the characteristics and configuration of the ASCAT instrument. There have been no instrument configuration changes between 2007 and 2013 and all the ASCAT-A instrument components are still functioning in prime redundancy.

The only section of the parameter files that has been changed relates to the antenna depointing angles derived from the transponder calibrations. For the reprocessing, a set of constant depointing angles for each beam has been used for the entire mission. These are an average from the values obtained from the different transponder campaigns. The depointing angles for the mid-left beam are also constant for the whole mission, because the small change in September 2009 was determined to be in the antenna gain rather than in the antenna pointing.

5.2.4 Processing Parameter Files

The processor takes its processing parameters from a processing parameter file. This is constant for all the reprocessed data and is the same as that used in the operational processor.

5.3 ASCAT Processor

The ASCAT processor performs the following tasks:

- calculation of normalisation factors,
- production of Level 1A data,
- production of Level 1B data (SZO, SZR and SZF),
- processing of calibration mode data into antenna gain values,
- monitoring of gain compression mode data.

The processor has undergone continual improvements to deal with a variety of issues (e.g. improving the geolocation accuracy, changes to product formats and improving the flagging of data).

Version 9.1.3 of the ASCAT processor was used for the reprocessing. This version was also introduced in the EPS operational Core Ground Segment (CGS) on 12 March 2014 for the operational production of near-real-time products. These products are routinely monitored, regularly validated and have been used operationally for NWP and soil moisture retrieval with no significant problems being found. More details on the configuration history and further changes of the ASCAT operational processor after this date can be found in [RD4]. With respect to the usage of the re-processed data record, there are a few known minor issues with the ASCAT-A data which are not handled by version 9.1.3 in an optimum manner. These are discussed in section 6.4, together with other issues and limitations of the data set.

6 DATA SET CHARACTERISTICS, VALIDATION AND LIMITATIONS

This section describes the characteristics of the data record, the validation of the data record and any known issues and limitations.

6.1 Spatial and Temporal Characteristics

The data record is global, covers the latitude from 90° S to 90° N and is continuous over the period 1 January 2007 to 31 March 2014.

In terms of spatio-temporal coverage, METOP-A flies on a repeat orbit track of approximately 29 days duration. Each orbit repeat cycle consists of 415 orbits.

The METOP satellites have a polar, sun-synchronous orbit and provide daily coverage of ASCAT SZO backscatter triplets in the left-hand and right-hand swaths, as illustrated in Figure 3. The coverage near the equator is approximately 3000 backscatter triplets per degree of latitude per day, and rises to approximately 7000 triplets per degree of latitude per day at high latitudes. Note that the left-hand swath covers the Antarctic region more completely than the right-hand swath—the opposite is true for the Arctic region. In this example, the effect of calibration operations over Turkey is evident in the total daily data coverage, it is seen as a small reduction in measurement triplets around the latitude from 20° to 50°.

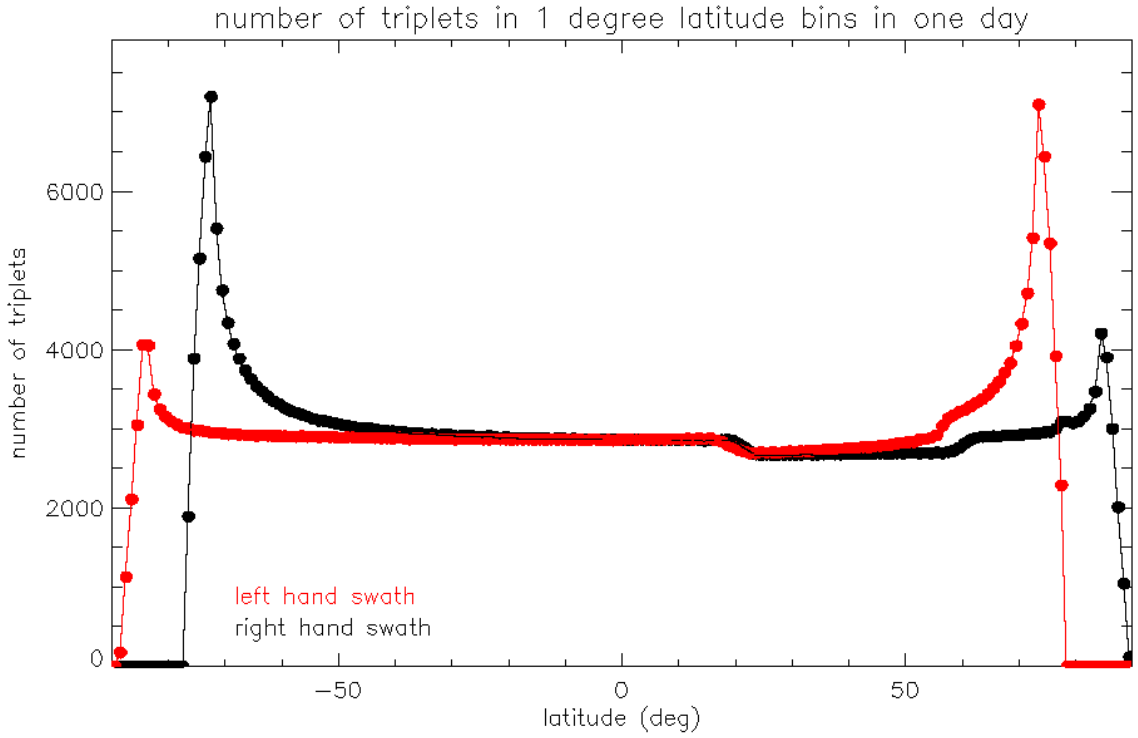

Figure 3. Coverage of ASCAT SZO backscatter triplets in the left and right hand swaths during one day which includes a transponder calibration operation.

6.2 Data Gaps

ASCAT is operated normally during in-plane satellite manoeuvres. Initially, the instrument was switched off during out-of-plane manoeuvres; however, this is not done now. Other reasons for gaps are due to spacecraft anomalies like PayLoad Switch-Off Line (PLSOL) or instrument Equipment Switch-Off Line (EQSOL). A PLSOL is a METOP payload switch-off event, while EQSOLs are an ASCAT instrument switch-off event. Additionally, a few file gaps are due to the unavailability of Level 0 in the EUMETSAT Data Centre. These periods of ASCAT data unavailability are listed in Appendix A.

Other smaller gaps may be present in the ASCAT files. One such gap lasts up to a few seconds and is due to ground station problems or anomalies in the on-board data recorder. These gaps typically occur at the edge of data dumps as shown in Figure 3 or in data acquired at the McMurdo receiving station during descending passes from June 2011. A second type of small gap is caused by calibration mode operations of the instrument over the ground transponders in Turkey, or due to gain compression monitoring checks. In both of these gaps, the nominal measurement mode is interrupted for 5–6 minutes. Gain compression monitoring normally occurs monthly over Africa or Asia.

Instrument calibration operations are carried out routinely four times a month, but are more frequent during extensive calibration or transponder testing campaigns. During these campaigns, the instrument switches into calibration mode while over transponders in Turkey. This can last for a period of several weeks. Table 10 identifies these calibration campaigns, to highlight periods during which data over this area has reduced quantity.

Date start	*Date end*	*Remarks*
2007-11-09	2008-02-16	ASCAT-A first calibration
2008-03-07	2008-04-04	ASCAT-A transponder cross calibration
2010-03-15	2010-07-05	ASCAT-A second calibration
2011-10-20	2012-01-14	ASCAT-A third calibration
2012-04-25	2012-05-13	ASCAT-A transponder maintenance

Table 10: Periods in which ASCAT was often in calibration mode.

6.3 Validation Summary

The data record has been scientifically and technically validated by EUMETSAT; this includes Level 1A, SZF, SZR, and SZO. Full details are given in [RD6]. The validation involved the following criteria:

- Basic checks of the data set, ensuring all the products are present and readable and that the metadata available is complete and consistent with the re-processing system configuration;
- Basic monitoring of the geophysical information in the products (background noise, internal calibration, incidence angles, azimuth angles, backscatter) to ensure that they are within the ranges expected;
- Analysis of non-nominal or degraded measurements and the effectiveness of internal product flags in identifying them;

- Inspection of the Level 1B data over Amazon rainforest, open ocean, and Antarctic sea ice, done to validate a consistent calibration of the beams over all incidence angles, to validate the inter-beam calibration and validate its stability over time;
- Assessment of K_p over all natural targets.

The data has been found to be consistent and of very high quality over the seven-year period. The assessment over the different targets results in a very uniform picture, which makes the analysis very robust.

The reliability of the quality flags to identify non-nominal or degraded measurement scenarios was assessed and shown to be satisfactory. The aggregated quality flag F_USABLE has proven to be particularly reliable. Only one minor issue relating to the spatial averaging in the neighbourhood of data gaps was noted. This issue is discussed in the next section.

The data record has also undergone preliminary inspection and testing by teams at ECMWF, the OSI SAF (KNMI) and the H-SAF (TU Wien). None have reported any significant issues or limitations

6.4 Issues and Limitations

Although the monitoring and validation described in [RD6] has shown the reprocessed data is of consistently high quality over the entire campaign period, these issues must be mentioned:

Reduced data quantities over Turkey
Data quantities near Turkey are slightly reduced due to the regular occurrence of calibration activities over transponders there. This has little or no impact on open ocean or sea ice applications, but this reduction may affect soil moisture applications or other studies involving the eastern Mediterranean.

Radio frequency interference
Signals from ground-based equipment can create anomalously large measurements of background noise. This can impact data in two ways: First, when the anomalous noise is used to correct the echo signal, it will introduce an error. Analysis suggests that this will affect only 2 or 3 measurements per month and will only be statistically significant — greater than 0.1 dB — when the backscatter is low, less than –16 dB. Second, the anomalous noise may lead to an incorrect estimate of the filter shape. Analysis suggests that this may introduce an error of 0.6 dB or less in the calibrated backscatter. This problem has only occurred 16 times, with each occurrence only affecting approximately 10 minutes of data. This is unlikely to affect any user applications.

Azimuth angle differences between side-beams and mid-beams
Usually, the azimuth angle differences between measurements from the side and mid beams are close to 45°. However near the poles where the azimuth angle is changing rapidly, small gaps in the ASCAT data can result in azimuth angle differences reaching values as low as 35° or as high as 55°. This does not affect data quality, but data users should be aware of the issue, especially if their application assumes a fixed value for azimuth angle differences.

Selection of grid lines for SZO and SZR products

During validation, an issue with the selection of grid lines for the SZO and SZR products from the reference grid provided in the SZF products was identified. Although the grid spacing in every SZO/SZR product is correct, the position of all the grid lines in the product may occasionally be offset along-track from the intended reference grid lines. This can result in gaps in the SZO/SZR grid line spacing at the boundaries between successive files. The discontinuities found are at these boundaries:

- SZO is either 6.25, 12.5, 18.75 or 31.25 km instead of a constant 25 km,
- SZR is either 6.25 or 18.75 km, instead of a constant 12.5 km.

While, this does not affect data quality, users should be aware of this issue if they are merging data from different products or using data from high latitudes in the Northern Hemisphere which assume or require continuous sampling. For those types of applications, the user needs also to account for the fact that many other small gaps are present in the global data set and that full reliance on a continuously-sampled data set, by line of nodes or across the swath, as for spectral analysis, is not advisable. We recommend provisions in the user end applications software for dealing with small gaps.

Number of values used in resampling

Occasionally, the number of samples in the spatial averaging can be reduced due to small gaps in the ASCAT data. The summary data usability flag in the SZO and SZR data does *no*t take this into account. As spatial averages calculated from a small number of samples can have poor quality, the user is advised to use only data where the summary data quality flag is set to 0 or 1 and the number of samples is greater than 200 for SZO data or 30 for SZR data. The number of samples is always shown in the NUMVAL field in Level 1B spatially-averaged products.

7 DATA ORDERING

Access to the data record is granted to all users without charge and without conditions of use. To access data, you need to be registered with the EUMETSAT Data Centre. When registered, you can place orders for the data you need. The EUMETSAT Data Centre is the only place that accepts orders for the data record.

7.1 Register with the Data Centre

Do this to register with the EUMETSAT Data Centre:

1. Register in the EUMETSAT EO-Portal https://eoportal.eumetsat.int/ by clicking on the New User – Create New Account tab;
2. After finalisation of the registration process, an e-mail is sent to the e-mail address entered in the registration. Click the confirmation link in the e-mail to activate your account;
3. Login and subscribe to the Data Centre Service by going to the Service Subscription Tab and selecting Data Centre Service. Follow instructions issued from the web page to add needed information;

7.2 Order data

The data can also be ordered via the Product Navigator :

1. Go to the Product Navigator tool in the EUMETSAT web page: http://www.eumetsat.int. The Product navigator includes a search function and a detailed help if needed to find the required data record.
2. Follow the detailed information provided in [RD7]

Further information on data ordering and delivery can be found under *Data/Data Delivery* at www.eumetsat.int.

Detailed information on the EUMETSAT data policy can be found in [RD8]

If you have more questions or support issues, please contact the User Service Helpdesk directly via e-mail:

ops@eumetsat.int

8 SUMMARY OF DATA GAPS

The SZO products are not completely continuous. There can be gaps between the end of one product and the start of the next. The reprocessed data set has these gap instance totals [RD6].

- 31 gaps less than 50 minutes,
- 31 gaps greater that 50 minutes but less than 150 minutes,
- 19 gaps greater than 150 minutes.

The gaps greater than 150 minutes are identified in the list below.

Start time	*End time*	*Elapsed time (hours)*	*Cause*
2007-01-01 09:35	2007-01-01 17:57	8.4	
2007-02-22 16:53	2007-02-23 17:53	25.0	Instrument anomaly
2007-02-27 08:14	2007-03-01 10:48	50.6	Instrument anomaly
2007-04-20 08:38	2007-04-25 13:05	124.4	Payload anomaly
2007-09-17 05:11	2007-09-19 17:57	60.8	Payload anomaly
2007-10-11 20:23	2007-10-12 01:30	5.1	Level 0 anomaly
2007-10-15 00:23	2007-10-15 03:51	3.5	Level 0 anomaly
2008-01-16 13:32	2008-01-18 09:24	43.9	Payload anomaly
2008-03-19 21:50	2008-03-21 14:22	40.5	Instrument anomaly
2008-04-08 07:47	2008-04-09 04:30	20.7	OOP manoeuvre
2008-10-23 09:35	2008-10-23 15:49	6.2	OOP manoeuvre
2010-02-18 09:50	2010-02-18 15:24	5.6	Instrument anomaly
2010-03-19 23:29	2010-03-20 06:24	6.9	Payload anomaly
2011-01-03 03:27	2011-01-04 09:43	30.3	Instrument anomaly
2011-01-04 09:41	2011-01-04 14:39	5.0	Level 0 anomaly
2011-05-14 10:50	2011-05-16 10:48	48.0	Instrument anomaly
2011-10-22 21:53	2011-10-23 14:35	16.7	Payload anomaly
2012-10-25 12:11	2012-10-25 20:33	8.4	Level 0 anomaly
2013-11-12 11:44	2013-11-12 16:48	5.1	Level 0 anomaly

9 METOP-A MANOEUVRES

The METOP-A manoeuvres dates that took place during the period covered by the reprocessed data set are listed below. Manoeuvres are either in plane (IP) or out of plane (OOP).

Date	*Type*
2007-04-19 14:05:00	IP
2007-04-19 14:55:00	IP
2007-07-12 14:48:00	IP
2008-01-31 14:38:00	IP
2008-04-08 12:36:00	OOP
2008-04-09 03:36:00	OOP
2008-04-24 1 4:46:00	IP
2008-04-24 15:36:00	IP
2008-10-23 14:30:00	OOP
2008-10-30 14:11:00	IP
2008-10-30 15:00:00	IP
2009-01-22 14:11:00	IP
2009-06-18 15:20:00	IP
2009-09-17 14:17:00	OOP
2009-12-10 15:31:00	IP
2010-06-10 13:31:00	IP
2010-10-05 12:11:00	OOP
2010-10-06 03:12:00	OOP
2011-03-31 13:19:00	IP
2011-05-01 03:27:00	IP
2011-06-09 13:12:00	IP
2011-09-28 12:04:00	OOP
2011-09-28 23:41:00	OOP
2011-12-14 14:08:00	IP
2012-03-02 12:59:00	IP
2012-04-14 18:14:00	IP
2012-07-18 13:05:00	IP
2012-11-21 12:57:00	IP
2013-03-20 12:51:00	OOP
2013-03-21 00:30:00	OOP
2013-04-16 12:34:00	IP
2013-06-26 13:40:00	IP
2013-09-04 13:36:00	IP
2013-12-04 12:38:00	IP
2014-02-05 13:29:00	IP
2014-03-26 13:15:00	OOP

Table 11: METOP-A manoeuvre dates

The summary usability flag F-USABLE should have a value of two during satellite manoeuvres. Inspection of the flag shows that this does not occur for these in-plane manoeuvres:

Date	*Time*
2011-05-01	03:27:59
2012-04-14	18:14:57

The flag also performs erratically during these out-of-plane manoeuvres:

Date	*Time*
2010-10-06	03:12:18
2011-09-28	23:41:49
2013-03-21	00:30:28

This issue is discussed in the validation report [RD6] and is caused by a combination of factors leading to an incorrect setting of the flag.

These instances have not been removed from the data set, but users are advised not to use data taken from the times indicated here.