ASCAT User Guide

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Document Change Record

Issue / Revision	*Date*	*DCN No.*	*Changed Pages / Paragraphs*
v1	08/09/2004		First issue of the document.
v2	31/08/2007		Update to reflect start of Metop/ASCAT
v2A	16/11/2007		Section 3: Configuration history tables updated and enhanced.
v2B	18/12/2007		Section 3: Configuration history table 3.2 updated for new PPF version.
v2C	18/04/2008		Section 3 Section 6.3.2 Configuration history tables updated.
v2D	07/11/2008		Section 3: General Configuration history tables updated and Level 2 tables added. Also several minor text and hyperlink amendments.
v3A	10/12/2008		Sec 3: Configuration history tables updated. Sec 1,2,4,6 and Appendix 12: Introduction of EARS ASCAT and ASCAT L2 soil moisture products. (NB: Document restructured - App. F & G renamed as Sec. 10 & 11, and common appendices removed
v3B	11/12/2008		Section 6.5: Updates to details of WMO BUFR formats.
v4	29/05/2009		Section 3: Configuration history tables updated with new entries for Tables 3-2 & 3-5. Section 5: EPSView description replaced by text on available generic tools. (Also minor associated updates to Sec. 2 & 6.)
v4A	30/11/2009		Full document: Sec. 3: Configuration history tables updated. Sec. 4: Description of dynamic NTBs processing concept. Fig 4-3 (Functional overview) split into two 'before' and 'after' figures. Update of validation section. Sec. 1, 2, 3, 4, 6: Introduction of the ASCAT reprocessed data set Phase 1. Sec. 8: Introduction of validation results. Sec. 12: New tables for new or updated SOMO records. Other minor text, reference and hyperlink corrections.
v4B	11/11/2011		Section 3, Section 4, Section 6 Main update: addition of the ASCAT multi-parameter

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			product. Configuration history tables updated. Various text edits (including Table 4-1) to bring up to date. Table 6-1: Additions for multi-parameter product, OSI SAF FTP service, NetCDF format. Sec. 6.5: Updates to descriptions of products available in WMO BUFR format. New Sec. 6.6 “The NetCDF format”. Other minor textual and hyperlink updates.
v4C	11/08/2011		Section 2: Configuration history tables updated (Tables 3-2, 3-3, 3-5, 3-6).
v5	16/07/2015	ECP 304 ECP 659	Level 1 V8.1, V9.3 processors (format change) Level 2 V3.1, V5.0 processors (format change) Addition of ASCAT-B Signature list reflecting new EUMETSAT organisation Revision of figures, reference documents Removal of references to HDF5 – format not supported anymore
V5A	06/10/2016	ECP 640	Updated processor version (on-the-fly generation of normalisation factors) and simplification of the ASCAT Product suite.
V5B	06/01/2017		Corrections to template, update tables and figures tables.
V5C	18/06/2018		Update to include ASCAT-C
V6	01/11/2022	ECP 1043	• Signature list update • Level-1 format update for PPF v11 release – inclusion of the Land Contribution Ratio • Corrected Fig 4-1, updated URLs linked in the text • Major clean-up, removed duplication of the PFS

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1 INTRODUCTION

This user guide is intended for users of EPS (EUMETSAT Polar System) ASCAT data products. It provides information about the products available, how to access them, how to extract and interpret the data, and it also aims to help the user in choosing a product for a particular application.

A full list of EPS products generated at EUMETSAT is given in Appendix A. These products will be addressed in this guide:

- ASCAT Level 0 (instrument packets)
- ASCAT Level 1b (normalised radar backscatter)

Note that the ASCAT Level 2 global wind products are generated and distributed by the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF), as part of the EPS distributed Applications Ground Segment [RD 22]. References to the OSI SAF user help information will be made when appropriate and the product format and contents will not be discussed here. Additionally, the ASCAT Level 2 wind product operational quality control is performed by the EUMETSAT Numerical Weather Prediction Satellite Application Facility (NWP SAF). The NWP SAF also makes available to users an ASCAT wind processing software package.

The ASCAT Level 2 regional short-timeliness wind product is generated and disseminated within the EUMETSAT Advanced Retransmission Service (EARS), with processing software equivalent to that used for the global chain, but within a system implementation optimised to provide fast products on a regional scale. Refer to our website www.eumetsat.int for more details on the EARS service.

The ASCAT Level 2 Soil Moisture products are generated in the EPS Core Ground Segment. The products have been developed by the Department of Geodesy and Geoinformation of the Vienna University of Technology and the data service is provided in partnership with the SAF on support to Operational Hydrology and Water Management (H-SAF).

Apart from the near-real-time products listed above, reprocessed Level 1b and Level 2 soil moisture data for ASCAT on Metop-A has been released and it is referred to in the product configuration section.

For further questions not addressed in this guide, on these or other EPS products, see the EUMETSAT Polar System pages on our website www.eumetsat.int, or to contact directly the EUMETSAT User Services Helpdesk. These pages should be the main interface for information on access to all EPS products.

2 REFERENCE DOCUMENTS

The following documents have been used to compile the information in this guide. Some of them are referenced within the text, others are provided here for further reading.

2.1 EUMETSAT technical documents

Ref	Title	Document ID
RD 1	EPS Generic Product Format Specification	EPS.GGS.SPE.96167
RD 2	ASCAT Level 1 Product Format Specification	EUM/RSP/SPE/13/702073
RD 3	Estimation of ASCAT Normalised Radar Cross Section: ATBD	EUM.TSS.SPE.14.762689
RD 4	ASCAT Calibration and Validation Plan	EUM.EPS.SYS.PLN.01.011
RD 5	ASCAT Verification, Validation and Validation Plan	EUM.MET.TEN.11.0187
RD 6	ASCAT Calibration 2010	EUM.MET.TEN.11.0198
RD 7	ASCAT Measurement Data Interface Specification	MO.TN.DOR.SC.0015
RD 8	ASCAT Calibration 2012	EUM.MET.TEN.12.0254
RD 9	ASCAT-B Level 1 Calibration and Validation report	EUM.OPS.DOC.12.3436
RD 10	EPS Product file naming for EUMETCast	EUM/OPS-EPS-TEN/07/0012
RD 11	ASCAT L2 Soil Moisture Product Format Specification	EUM/OPS-EPS/SPE/07/0343
RD 12	Metop-A ASCAT Commissioning Quality Report	EUM.MET.REP.08.0525
RD 13	ASCAT Level 1 Reprocessing Phase 1 – dataset description	EUM.OPS.DOC.09.2481
RD 14	ASCAT Level 2 Soil Moisture reprocessing Phase 1 – dataset description	EUM.OPS.DOC.09.2569
RD 15	ASCAT Reprocessing Phase 1 – validation report	EUM.OPS.REP.09.3033
RD 16	Metop Space to Ground Interface Specification	MO-IF-MMT-SY0001
RD 17	Metop-A ASCAT L1 Data Record Release 2 (CF-003): User Guide	EUM/OPS-EPS/USR/14/739701
RD 18	Metop-A ASCAT L1 Data Record Release 2 (CF-003): Validation Report	EUM.TSS.REP.14.753112
RD 19	ASCAT-B Calibration report	EUM.RSP.TEN.13.701051
RD 20	ASCAT-B Level 2 soil moisture validation report	EUM.OPS.DOC.12.3849
RD 21	ASCAT-C Level 1 Commissioning Report	EUM/RSP/REP/18/1035367

See www.eumetsat.int for more information on the project.

2.2 SAF documents

Ref	Title	Document ID
RD 22	OSI SAF ASCAT Product User Manual	SAF/OSI/KNMI/TEC/MA/134
RD 23	CMOD5.n - the CMOD5 GMF for neutral winds	SAF/OSI/CDOP/KNMI/TEC/TN/165
RD 24	Algorithm Theoretical Basis Document for the OSI SAF wind products	SAF/OSI/CDOP2/KNMI/SCI/MA/197
RD 25	Calibration and Validation of ASCAT Winds	SAF/OSI/CDOP/KNMI/TEC/TN/163
RD 26	ASCAT-B NWP Ocean Calibration and Validation	SAF/OSI/CDOP2/KNMI/TEC/RP/199
RD 27	Product User Manual for H25/SM-OBS-4, METOP ASCAT Soil Moisture Time Series	SAF/HSAF/CDOP2/PUM-25/0.7
RD 28	Effects on Level 2 Soil Moisture using Level 1b sigma- re-sampled with a circular top-hat window and exploration of the Level 1b full-resolution sigma0 product	EUM/RSP/REP/14/786259
RD 29	ASCAT land correction, version 1.0	SAF/OSI/CDOP3/KNMI/TEC/TN/384

See https://www.nwpsaf.eu for more information on the NWP SAF project. See https://osi-saf.eumetsat.int for more information on the OSI SAF project and www.knmi.nl/scatterometer for more information on the SAF wind products, http://hsaf.meteoam.it/ for more information on the H-SAF project and https://www.geo.tuwien.ac.at/mrs/ for more information ASCAT soil moisture products.

2.3 Papers, reports and other technical documentation

Ref	Title	Authors
RD 30	The Advanced Scatterometer (ASCAT) on the meteorological operational (MetOp) platform: A follow on for European wind scatterometers	J. Figa-Saldaña, J.J.W. Wilson, E. Attema, R. Gelsthorpe, M.R. Drinkwater and A. Stoffelen *Can.J.Remote Sensing*, Vol.28, No.3, pp.404-412, 2002
RD 31	ASCAT-MetOp’s Advanced Scatterometer	Gelsthorpe, R.V., Schied, E., Wilson, J.J.W. *ESA Bulletin* No. 102, 2000 (http://www.esa.int/esapub/bulletin/bullet102/Gelsthorpe102.pdf)
RD 32	Scatterometry	A. Stoffelen, PhD Thesis, 1998
RD 33	CMOD5 - An improved geophysical model function for ERS C-Band scatterometry	H. Hersbach, 2003
RD 34	Manual on the Global Telecommunication System	WMO - No. 386
RD 35	World Meteorological Organization Manual on Codes	WMO - No. 306

RD 36	ASCAT Soil Moisture Product Handbook	*ASCAT Soil Moisture Report Series* No. 15, Institute of Photogrammetry and Remote Sensing, Vienna University of Technology, Austria, 2008.
RD 37	The ASCAT Soil Moisture Product: A Review of its Specifications, Validation Results, and Emerging Applications	Wagner, W, et al. METEOROL Z. 2013; 22(1): 5-33
RD 38	ERS-ASCAT backscatter and soil moisture inter-comparison – First results	*ASCAT Soil Moisture Report Series* No. 6, Institute of Photogrammetry and Remote Sensing, Vienna University of Technology, Austria, 2008.
RD 39	Analysis of ASCAT Ocean Backscatter Measurement Noise	Anderson, C. et al., IEEE T. Geoscience and Remote Sensing, 50(7): 2449-2457 (2012)
RD 40	Radiometric Calibration of the Advanced Wind Scatterometer Radar ASCAT carried on board the Metop-A satellite	Wilson, J.J.W. et al., IEEE T. Geoscience and Remote Sensing, 48(8): 3236-3255 (2010)
RD 41	Validation of backscatter measurements from advanced Scatterometer on Metop-A	Anderson et al., J. Atm. Oceanic Technology, 29, 77-88, (2012)
RD 42	**Adapting the SIR algorithm to ASCAT.**	**Lindsey, R.D., Long, D.G., *Geoscience and Remote Sensing Symposium (IGARSS), 2010 IEEE International*, pp3402-3405 (2010)**
RD 43	On the quality of high-resolution scatterometer winds	Vogelzang, J., A. Stoffelen, A. Verhoef and J. Figa-Saldana, *J. Geophys. Res.*, 116, C10033. (2011).
RD 44	Land-Contamination Compensation for QuikSCAT Near-Coastal Wind Retrieval	Owen M.P., Long, D.G., IEEE T. on Geoscience and Remote Sensing, vol. 47, issue 3, pp. 839-850 (2009)
RD 45	The CMOD7 Geophysical Model Function for ASCAT and ERS Wind Retrievals	Stoffelen, A., J. Verspeek, J. Vogelzang and A. Verhoef, IEEE Journal of Selected Topics in Applied Earth O, 2017, 10, 5, 2123-2134, doi:10.1109/JSTARS.2017.2681806

3 ASCAT PRODUCTS CONFIGURATION HISTORY

The PPF and auxiliary file versions installed in the operational Ground Segment are the versions with the most recent time stamp listed in the tables below.

3.1 Near real-time Products

3.1.1 ASCAT L1b

On 9 September 2009, an important change in the operational L1 processing chain was implemented. This consisted of the activation of an orbit-based generation (and utilisation) of the file ASCA_NTB_xx_, which was previously a static file. After this change, the file **ASCA_NTB_xx_** became dynamic. Because of this, its configuration control will not be covered in the tables below. Instead, the static input for its generation has been introduced, the **ASCA_XCL file**, which contains the latest transponder-based instrument calibration and was used to generate the latest static ASCA_NTB and ASCA_INS files listed above.

On 4 April 2016, another important change was implemented in the processor: the generation of the normalisation factors (the contents of the ASCA_NTB_xx file) *on the fly* during Level 1 processing. In this scenario, the ASCA_NTB_xx auxiliary file as such is no longer part of the near real-time processing.

The update on 22 November 2022 includes a new scientific parameter – the Land Contribution Ratio (LCR) into the product, and re-organises the product flags.

Table 3-1: ASCAT L1b product format version history

Date introduced on operational G/S	Product format version		PFS version	PGS version	Comments
	Major number	Minor number			
19/10/2006	10	0	6.8	6.6	
03/04/2007	11	0	7.0 / v8B	6.6	Addition of an SPHR, removal of several VIADRs and addition of several VEADRs. No change in any MDR records.
29/05/2013	12	0	v9	7.0/v7B	Change to all L1 formats and several algorithm revisions
22/11/2022	13	1	v12	8	Changes to all L1 formats: revision of the product flagging and introduction of LCR

Table 3-2: ASCAT L1b PPF software version history

PPF software version	Date introduced on operational G/S	Comments
4.2.12	11/04/2007	
5.2.1	10/10/2007	Improved geolocation.
5.3.1	12/12/2007	Correct implementation of DEFAULT values for missing fields. Correction of Kp range and setting of F_KP flag.
5.6.0	03/04/2008	Implementation of three-transponders absolute σ_0 calibration, as well as a product format change.
6.2.0	23/10/2008	Implementation of several corrections to L1a and L1b flags.
6.3.0	02/12/2008	Implementation of final results of external calibration campaign with 3 transponders (solving the mid left antenna gain pattern oscillation).
6.4.2	09/12/2008	Introduction of protection against out of range values for all fields.
6.5.0	08/04/2009	Modification of data gap handling and migration to AIX 6 OS.
7.2.0	09/07/2009	Modification for allowing dynamic Normalisation Table Baseline (NTB) generation.
7.3.0	07-09/09/2009	Tuning related to dynamic NTB configuration and activation of dynamic NTB generation.
7.3.0	10/09/2009	Processing with dynamic NTB files.

PPF software version	*Date introduced on operational G/S*	*Comments*
7.4.3	18/08/2011	Implementation of the 2010 transponder calibration and a revised Kp algorithm.
8.1.0	20/03/2012	Revised implementation of the SFE corrections and activation of the HKTM telemetry handling
9.0.2	29/05/13	Product format change (v12.0), specifically significant for L1B SZF products; quality flag revision and new strategy for the along-track generation of lines of nodes.
9.2.0	12/03/2014	Update of Level 1 processor to reflect the configuration of the ASCAT-A CDR generation
9.3.0	20/05/2014	Minor fix related to line of nodes generation and auxiliary file format handling
10.1.0	10/04/2016	On-the-fly generation of normalisation factors, suppression of ASCA_NTB_xx file in the NRT processing system. Porting of the code to Linux.
10.3.0	13/09/2017	Minor bug fix for the Linux version.
10.3.1	22/08/2019	Fixes anomaly on the CFI library / orbit propagation (ASCAT-A end of life).
10.3.2	06/04/2022	Update of ASCAT for the AIX version and compiler suite update.
11.3.5	22/11/2022	Updates to the build system and the messaging. L1 format changes due to updates of the flagging. Introduction of the LCR (Land Contamination Ratio) parameter.

3.1.1.1 Generic ASCAT L1b PPF auxiliary parameter files

Table 3-3: XTC auxiliary parameter file version history

Auxiliary file version	*Auxiliary files filename – XTC*	*Date introduced on operational G/S*	*Comments*
1.1	ASCA_XTC_xx_xxx_20061017000000Z_xxxxxxxxxxxxxxZ_20061218000101Z_xxxx_xxxxxxxxxx	30/01/2007	
1.2	ASCA_XTC_xx_xxx_20070621000000Z_xxxxxxxxxxxxxxZ_20070621000102Z_xxxx_TURxxxxMTC	10/10/2007	

Auxiliary file version	Auxiliary files filename – XTC	Date introduced on operational G/S	Comments
1.4	ASCA_XTC_xx_xxx_20080326000000Z_xxxxxxxxxxxxxxZ_20080225000104Z_xxxx_TURxxxxMTC	03/04/2008	
1.8	ASCA_XTC_xx_xxx_20110817000000Z_xxxxxxxxxxxxxxZ_20100909000108Z_xxxx_TURxxxxMTC	18/08/2011	Corrected transponder internal delays after transponder maintenance
1.9	ASCA_XTC_xx_xxx_20111109000000Z_xxxxxxxxxxxxxxZ_20111102000109Z_xxxx_TURxxxxTCE.4061652	20/10/2011	Updated T2 configuration after maintenance in Autumn 2011

Table 3-4: LSM auxiliary parameter file version history

Auxiliary file version	Auxiliary files filename – LSM	Date introduced on operational G/S	Comments
1.0	xxxx_LSM_xx_xxx_20060717000000Z_xxxxxxxxxxxxxxZ_20060713000100Z_xxxx_xxxxxxxxxx	31/01/2007	
2.0	xxxx_LSM_xx_xxx_20220621000000Z_xxxxxxxxxxxxxxZ_20180101000000Z_xxxx_xxxxxxxxxx	22/11/2022	Format change for LCR calculation.

3.1.1.2 ASCAT L1b PPF auxiliary parameter files for M02 (ASCAT-A)

Table 3-5: ASCAT-A L1b PPF auxiliary parameter file version history for M02

Auxiliary file version	*Auxiliary files filename – PRC*	*Date introduced on operational G/S*	*Comments*
1.6	ASCA_PRC_xx_M02_20070220000000Z_xxxxxxxxxxxxxxZ_20070219000106Z_xxxx_FM2xxxxxx	26/04/2007	
2.5	ASCA_PRC_xx_M02_20070716000000Z_xxxxxxxxxxxxxxZ_20070813000205Z_xxxx_FM2xxxxMTC	10/10/2007	
3.2	ASCA_PRC_xx_M02_20080326000000Z_xxxxxxxxxxxxxxZ_20080304000302Z_xxxx_FM2xxxxTCE	03/04/2008	
3.3	ASCA_PRC_xx_M02_20080716000000Z_xxxxxxxxxxxxxxZ_20081022000303Z_xxxx_FM2xxxxTCE	23/10/2008	F_ORBIT threshold for radial distance w.r.t. reference orbit set to 500 m.
3.4	ASCA_PRC_xx_M02_20081202000000Z_xxxxxxxxxxxxxxZ_20081029000304Z_xxxx_FM2xxxxTCE	02/12/2008	NTB State vector updated to better reference orbit.
4.0	ASCA_PRC_xx_M02_20090424000000Z_ xxxxxxxxxxxxxxZ_20090423000400Z_xxxx_FM2xxxxTCE	09/07/2009	Preparation for dynamic NTB generation.
5.0	ASCA_PRC_xx_M02_20090907000000Z_ xxxxxxxxxxxxxxZ_20090731000500Z_xxxx_FM2xxxxTCE	07/09/2009	Configuration tuning for NTB generation, including an increase of time samples for NTB generation from 201 to 221, necessary for the EARS operational Metop Level0 service activation.
5.2	ASCA_PRC_xx_M02_20110817000000Z_ xxxxxxxxxxxxxxZ_20100419000502Z_xxxx_FM2xxxxTCE	18/08/2011	Correction of Hamming window width function for the SZR product.
7.2	ASCA_PRC_xx_M02_20120320000000Z_xxxxxxxxxxxxxxZ_20120227000702Z_xxxx_FM2xxxxTCE	20/03/2012	Correction of the configuration of the Solar Array Flagging algorithm, HKTM trending thresholds and new Level 0 data gap handling
8.0	ASCA_PRC_xx_M02_20140520000000Z_xxxxxxxxxxxxxxZ_20140415000800Z_xxxx_FM2xxxxTCE	20/05/2014	Removal of NTG triggering parameters
Auxiliary file version	*Auxiliary files filename – NTB*	*Date introduced on operational G/S*	*Comments*

1.5	ASCA_NTB_xx_M02_20070202000000Z_xxxxxxxxxxxxxxZ_20070201000105Z_xxxx_FM2xxxxMPC	12/02/2007	
1.9	ASCA_NTB_xx_M02_20070716000000Z_xxxxxxxxxxxxxxZ_20070817000109Z_xxxx_FM2xxxxMTC	10/10/2007	July 2007 one-transponder calibration.
1.10	ASCA_NTB_xx_M02_20080326000000Z_xxxxxxxxxxxxxxZ_20080225000110Z_xxxx_FM2xxxxMTC	03/04/2008	March 2008 three-transponder calibration.
1.11	ASCA_NTB_xx_M02_20081202000000Z_xxxxxxxxxxxxxxZ_20081029000111Z_xxxx_FM2xxxxTCE	02/12/2008	Refined March 2008 three transponder calibration (solving the mid left antenna gain pattern oscillation) and better reference orbit used.
2.0	ASCA_NTB_xx_M02_20090424000000Z_xxxxxxxxxxxxxxZ_20090430000200Z_xxxx_FM2xxxxTCE	09/07/2009	New format and fast algorithm.
n/a	ASCA_NTB_xx_M02_<*>_xxxxxxxxxxxxxxZ_<*>_CGS1_xxxxxxxxxx	10/09/2009	Dynamic NTBs with 221 entries.
Auxiliary file version	***Auxiliary files filename – INS***	***Date introduced on operational G/S***	***Comments***
1.3	ASCA_INS_xx_M02_20070127000000Z_xxxxxxxxxxxxxxZ_20070126000103Z_xxxx_FM2xxxxMPC	30/01/2007	
1.4	ASCA_INS_xx_M02_20061221000000Z_xxxxxxxxxxxxxxZ_20070727000104Z_xxxx_FM2xxxxMTC	10/10/2007	Antenna pointing as per July 2007 one-transponder calibration.
2.2	ASCA_INS_xx_M02_20080326000000Z_xxxxxxxxxxxxxxZ_20080225000202Z_xxxx_FM2xxxxMTC	03/04/2008	Antenna pointing as per March 2008 one-transponder calibration.
2.4	ASCA_INS_xx_M02_20081202000000Z_xxxxxxxxxxxxxxZ_20081029000204Z_xxxx_FM2xxxxTCE	02/12/2008	Refined antenna pointing and correction of typo in receiver characterisation.
2.6	ASCA_INS_xx_M02_20110817000000Z_xxxxxxxxxxxxxxZ_20100909000206Z_xxxx_FM2xxxxTCE	18/08/2011	Antenna pointing as per 2010 transponder calibration, and corrected calibration timeline.
2.7	ASCA_INS_xx_M02_20140312000000Z_xxxxxxxxxxxxxxZ_20131129000207Z_xxxx_FM1xxxxTCE	12/03/2014	Antenna pointing as used in ASCAT-A CDR generation
Auxiliary file version	***Auxiliary files filename – XCL***	***Date introduced on operational G/S***	***Comments***

2.1	ASCA_XCL_xx_M02_20090907000000Z__xxxxxxxxxxxxxxZ_20090423000101Z_xxxx_ FM2xxxxTCE	09/09/2009	Input to dynamic NTB generation – compatible with ASCA_INS_ v2.4 and all ASCA_NTB_ files from v1.11 inclusive.
2.2	ASCA_XCL_xx_M02_20110817000000Z_xxxxxxxxxxxxxxZ_20100908000202Z_xxxx_FM2xxxxTCE	17/08/2011	Antenna patterns as per 2010 transponder calibration.
2.3	ASCA_XCL_xx_M02_20140312000000Z_xxxxxxxxxxxxxxZ_20130325000203Z_xxxx_FM1xxxxTCE	12/03/2014	Antenna patterns as used in ASCAT-A CDR generation

3.1.1.3 ASCAT L1b PPF auxiliary parameter files for M01 (ASCAT-B)

Table 3-6: ASCAT-B L1b PPF auxiliary parameter file version history for M01

Auxiliary file version	*Auxiliary files filename – PRC*	*Date introduced on operational G/S*	*Comments*
1.2	ASCA_PRC_xx_M01_20121022000000Z_xxxxxxxxxxxxxxZ_20121001000102Z_xxxx_FM1xxxxTCE	22/10/2012	Internal calibration locked
1.3	ASCA_PRC_xx_M01_20130625000000Z_xxxxxxxxxxxxxxZ_20130325000103Z_xxxx_FM1xxxxTCE	25/06/2013	Correction of the configuration of the Solar Array Flagging algorithm
8.0	ASCA_PRC_xx_M01_20140520000000Z_xxxxxxxxxxxxxxZ_20140415000800Z_xxxx_FM2xxxxTCE	20/05/2014	Removal of NTG triggering parameters
Auxiliary file version	*Auxiliary files filename – INS*	*Date introduced on operational G/S*	*Comments*
1.0	ASCA_INS_xx_M01_20120816000000Z_xxxxxxxxxxxxxxZ_20120814000100Z_xxxx_FM1xxxxTCE	22/10/2012	Preliminary external calibration
1.1	ASCA_INS_xx_M01_20130625000000Z_xxxxxxxxxxxxxxxZ_201303250000101Z_xxxx_FM1xxxxTCE	25/06/2013	Transponder-based external calibration 2013
Auxiliary file version	*Auxiliary files filename – XCL*	*Date introduced on operational G/S*	*Comments*
1.2	ASCA_XCL_xx_M01_20121022000000Z_xxxxxxxxxxxxxxZ_20121016000102Z_xxxx_FM1xxxxTCE	22/10/2012	Preliminary external calibration

1.3	ASCA_XCL_xx_M01_20130625000000Z_xxxxxxxxxxxxxxZ_20130325000103Z_xxxx_FM1xxxxTCE	25/06/2013	Transponder-based external calibration 2013

3.1.1.4 ASCAT L1b PPF auxiliary parameter files for M03 (ASCAT-C)

Table 3-7: ASCAT-B L1b PPF auxiliary parameter file version history for M03

Auxiliary file version	*Auxiliary files filename – PRC*	*Date introduced on operational G/S*	*Comments*
	ASCA_PRC_xx_M03_20181206160000Z_xxxxxxxxxxxxxxZ_20181206160000Z_xxxx_FM2xxxxTCE	13/12/2018	Internal calibration locked
Auxiliary file version	*Auxiliary files filename – INS*	*Date introduced on operational G/S*	*Comments*
	ASCA_INS_xx_M03_20181115170000Z_xxxxxxxxxxxxxxZ_20181115170000Z_xxxx_xxxxxxxxxx	13/12/2018	Updated gain patterns, 1st cross-calibration with ASCAT A/B
	ASCA_INS_xx_M03_20190213000000Z_xxxxxxxxxxxxxxZ_20190213000000Z_xxxx_xxxxxxxxxx	26/02/2019	Updated pointing based on transponder data, refined cross-calibration with ASCAT A/B
Auxiliary file version	*Auxiliary files filename – XCL*	*Date introduced on operational G/S*	*Comments*
	ASCA_XCL_xx_M03_20180516000000Z_xxxxxxxxxxxxxxZ_20180516000000Z_xxxx_xxxxxxxxxx	13/12/2018	Preliminary calibration
	ASCA_XCL_xx_M03_20190207000000Z_xxxxxxxxxxxxxxZ_20190207000000Z_xxxx_FM3xxxxTCE	26/02/2019	Updated pointing based on transponder data, refined cross-calibration with ASCAT A/B

3.1.2 ASCAT L2 Soil Moisture Index

Table 3-8: ASCAT L2 Soil Moisture Index product format version history

Date introduced on operational G/S	*Product format version*		*PFS version*	*PGS version*	*Comments*
	Major number	*Minor number*			
15/05/2008	10	0	v2	n/a	Start of trial dissemination.
10/12/2009	11	0	v3A	n/a	Inclusion of L1 values
20/07/2014	12	0	v4A	n/a	Update of L1 section

Table 3-9: ASCAT L2 Soil Moisture Index software version history

PPF software version	*Date introduced on operational G/S*	*Comments*
1.0.2	15/05/2008	Start of trial dissemination.
1.1.0	23/07/2008	
1.1.2	23/10/2008	Soil moisture parameter database update.
1.2.1	10/12/2008	Allow more values of Soil Moisture to be generated.
1.3.1	04/05/2009	Correction of left swath biases.
2.0.0	10/12/2009	Format change.
3.1.0	18/08/2011	ASCAT-based soil moisture parameter database.
5.0.0	20/07/2015	Update of parameter database, format change
5.1.0	22/11/2022	Include support for L1B format change

Table 3-10: ASCAT-A L2 Soil Moisture Index auxiliary parameter file version history for M02

Auxiliary file version	*Auxiliary files filename*	*Date introduced on operational G/S*	*Comments*
1.0	ASCA_SMC_xx_M02_20080327000000Z_xxxxxxxxxxxxxxZ_20080515000100Z_xxxx_xxxxxxxxx	15/05/2008	Start of trial dissemination.
1.2	ASCA_SMC_xx_M02_20081202000000Z_xxxxxxxxxxxxxxZ_20081117000102Z_xxxx_FM2xxxTCE	02/12/2008	Synchronisation with new ASCAT L1b calibration.
3.2	ASCA_SMC_xx_M02_20110817000000Z_xxxxxxxxxxxxxxZ_20100615000301Z_xxxx_FM2xxxTCE	18/08/2011	New (ASCAT-A based) parameter database and synchronisation with new ASCAT L1b calibration.
3.4	ASCA_SMC_xx_M02_20140312000000Z_xxxxxxxxxxxxxxZ_20140211000304Z_xxxx_FM2xxxxTC	12/03/2014	Synchronisation with new ASCAT L1b calibration.
3.1	ASCA_SMC_xx_M02_20150720000000Z_xxxxxxxxxxxxxxZ_20150504000301Z _xxxx_FM2xxxxTC	20/07/2015	New (ASCAT-A based) parameter database

Table 3-11: ASCAT-A L2 Soil Moisture Index auxiliary parameter file version history for M01.

Auxiliary file version	*Auxiliary files filename*	*Date introduced on operational G/S*	*Comments*
1.0	ASCA_SMC_xx_M01_20120814000000Z_xxxxxxxxxxxxxxZ_20120814000100Z_xxxx_ FM1xxxTCE	14/08/2012	Start of trial dissemination.
1.2	ASCA_SMC_xx_M01_20130625000000Z_xxxxxxxxxxxxxxZ_20130620000102Z_xxxx_FM2xxxTCE	25/06/2013	Synchronisation with new ASCAT L1b calibration.
1.4	ASCA_SMC_xx_M01_20150720000000Z _xxxxxxxxxxxxxxZ_20150512060104Z _xxxx_FM2xxxTC	20/07/2015	New (ASCAT-A based) parameter database

3.1.3 ASCAT L2 Ocean Surface Wind Products

For details on both the global and regional wind products, please refer to the OSI SAF Scatterometer webpage.

3.2 Reprocessed data sets

In the following tables the configuration of the available reprocessed data sets is described.

There have been two re-processing campaigns for ASCAT data on M02:

- In 2009, including both Level 1 (ASCL1R1) and Level 2 soil moisture (ASCL2SMR1) products
- In 2014, including only Level 1 products (CF-003)

3.2.1 ASCL1R1

Table 3-12: ASCAT L1b reprocessed data sets configuration history

Release name	*Release date*	*Reprocessing period*	*Reprocessing version*	*L1 processor version*	*Static auxiliary file configuration*	
ASCL1R1	10/11/2009	01/01/2007 – 31/12/2008	1.0	6.4.2	ASCA_INS	2.4
					ASCA_PRC	3.4
					ASCA_NTB	1.11
				7.3.0	ASCA_INS	2.4
					ASCA_PRC	5.0
					ASCA_NTB	2.0

See [RD 14] for further details. The document is available on the EUMETSAT Technical Documents web page. See *Satellites/Technical Documents*.

3.2.2 ASCL2SMR1

Table 3-13: ASCAT L2 Soil Moisture Index reprocessed data sets configuration history

Release name	***Release date***	***Reprocessing period***	***Reprocessing version***	***L2 soil moisture processor version***	***Static auxiliary file configuration***	
ASCL2SMR1	10/11/2009	01/01/2007 – 31/12/2008	1.0	1.3.1	ASCA_SMC	1.2
					Parameter database	1.0

See [RD 15] for further details. The document is available on the EUMETSAT Technical Documents web page. See *Satellites/Technical Documents*. Any subsequent reprocessing campaigns of the L2 soil moisture products are documented on the H SAF website.

3.2.3 ASCAT Level 1 CF-003

Table 3-14: ASCAT L1b reprocessed data sets configuration history

Release name	***Release date***	***Reprocessing period***	***Reprocessing version***	***L1 processor version***	***Static auxiliary file configuration***	
CF-003	07/10/2014	01/01/2007 – 31/03/2014	2.0	9,1	ASCA_INS	27
					ASCA_PRC	7.2
					ASCA_XCL (*)	2.4 before 11/09/2009 12:00
						2.3 after 11/09/2009 12:00

(*) This change was introduced to account for an instrument calibration change. See [RD28] for further details.

4 ASCAT PRODUCTS OVERVIEW

4.1 Inheritance from ERS scatterometers and key features of the ASCAT mission

The design of ASCAT is based on the robust and well-understood concept of the ERS scatterometers. Among the common features are:

- fan-beam geometry with antennas oriented at 45°, 90° and 135° with respect to the satellite track
- VV polarisation
- Radar frequency: C-band
- Swath gridded into nodes, one triplet of averaged backscatter measurements per node
- Generation of an operational product at 50 km resolution on a nodal grid of 25 km

The experience acquired with nearly one decade of operations of ERS scatterometers and the use of their data have also identified areas where improvement was possible, in order to allow operational use of the data, as well as for emerging scatterometer applications to develop. This experience has been taken into consideration by introducing a number of new key features, which are listed below and further discussed in detail in the following paragraphs:

- Continuous data acquisition and product generation without sharing operation time in orbit with other instruments, which has increased the data coverage
- Increased spatial coverage via the use of a double swath
- Higher incidence angle range towards an area which offers a higher wind direction sensitivity in the geophysical model and therefore better performance of the wind retrieval algorithm
- Additional generation of a research product at a higher resolution of approximately 30 km on a 12.5 km nodal grid
- Improved instrument design, resulting in higher stability and reliability
- Improved on-board processing concept, allowing for a lower raw data rate

4.2 The ASCAT instrument

4.2.1 Technical description

ASCAT is a real-aperture radar operating at 5.255 GHz (C-band) and using vertically polarised antennas for transmission and reception. It transmits a long pulse with Linear Frequency Modulation (‘chirp’). Ground echoes are received by the instrument and, after de-chirping, the backscattered signal is spectrally analysed and detected. In the power spectrum, frequency can be mapped into slant range provided the chirp rate and the Doppler frequency are known. The above processing is in effect a pulse compression, which provides range resolution.

The contribution of the thermal noise to the radar measurement is observed within each pulse-repetition interval by monitoring the output of the receiver during a period of time when all the pulse echoes have decayed. Noise measurements are sent to the ground with echo measurements, to enable measurement noise subtraction to be performed during ground processing.

Considerable data rate reduction is achieved by pre-processing the noise and echo measurements on board. The on-board processing consists of a power spectrum estimation followed by a spatial low-pass filtering. Different averaging takes place for echo and noise measurements, reducing the raw data rate by a factor of approximately 25. On-board processing carries as a result a degree of spatial correlation between different and within received echoes, which is taken into account later on by the Level 1b processing.

4.2.2 Instrument modes

The ASCAT instrument may operate in three different modes: Measurement, Calibration and Test. Additionally, in Measurement mode the instrument occasionally generates special source packets for Gain Compression Monitoring.

The nominal instrument mode, and the only one that generates science data for the users, is *Measurement* mode.

During external calibration campaigns, the instrument is operated in *Calibration* mode when it passes over the ground transponders. Additionally, the instrument is operated in Calibration mode over the ground transponders for one ascending pass and one descending pass every orbit cycle (29 days). Operating the instrument in Calibration mode implies an interruption of the Measurement mode for that pass of approximately 6 minutes. Taking into account the measurement geometry (fore and aft viewing), the completeness of the data for a location in the swath may be affected by this 6-minute measurement interruption during up to 5000 km for far swath locations.

In addition, the instrument Gain Compression needs to be monitored periodically. This is a special variant of measurement mode, called *Gain Compression Monitoring* mode, and monitors the relationship between the transmitted power and the RFU drive level setting. These measurements are not used to retrieve science data. The acquisition of Gain Compression Monitoring data interrupts the nominal Measurement mode for approximately 5 minutes. The instrument needs to monitor the Gain Compression once per orbit cycle over land.

4.2.3 Instrument calibration

The Internal Calibration loop is part of the nominal operation. Within every pulse repetition interval, a calibration phase and a noise estimation phase are included. The calibration signal and the noise data are used to correct for the instrument internal effects during the ground processing. This mechanism allows the combined variation of the transmitter power and the receiver gain to be monitored and accounts for internal instrument drifts during the mission lifetime. At the beginning of the mission, the internal calibration level is established, and its monitoring later on is done with respect to this reference value.

The objective of the *External Calibration* is to ensure that the normalised radar backscatter value measured from a target is correct (absolute calibration) for all incidence angles (relative calibration). In order to achieve this, the absolute gain of each antenna and the pointing need to be established in flight, and this is done with the help of ground transponders.

Transponders are active devices that, after receiving a pulse from ASCAT, send a delayed pulse back. Each transponder has a known and stable radar cross section as well as a known and stable response delay, and its position on the Earth's surface is accurately known too. ASCAT receives and detects the transponder pulses from within its swath. By comparing the measured transponder echo level and its associated localisation data with the expected data for each transponder, three antenna depointing angles and antenna gain correction values are estimated. This allows a reference calibrated system to be established, against which the system performance can be evaluated and monitored.

The three transponders used for the ASCAT absolute calibration are situated in Turkey. Their relative positions have been carefully chosen to allow a continuous and sufficiently dense sampling of the antenna gains for all elevation angles. For the Metop orbit, over a period of one month, this allows transponder measurements to be obtained for each antenna beam over the full range of incidence angles with cuts at approximately 10 - 20 km intervals in ground range.
The external calibration with three transponders has been carried out several times. For each ASCAT, the first external calibration campaign takes place during the Commissioning Phase.

4.3 Measurement principle, geometry and coverage

Like the ERS scatterometers, the ASCAT system geometry is based on the use of fan-beam antennas. It covers two 550-km swaths which are separated from the satellite ground track by about 336 km for the minimum orbit height. The ASCAT incidence angle ranges from 25° to 65° (Figure 4-1). For each swath, three antennas illuminate the sea surface at three different azimuth angles, measuring the backscattered signal.
At such incidence angles and over ocean, the main backscattering mechanism is considered to be Bragg resonance, which describes the interaction of the radar signal with short sea surface waves having a wavelength of a few centimetres. The wind speed and direction near the ocean surface with respect to the antenna viewing angles are determined by using an empirical Geophysical Model Function (GMF), which relates these parameters to the observed normalised radar cross section (NRCS, also known as σ_0) [RD].

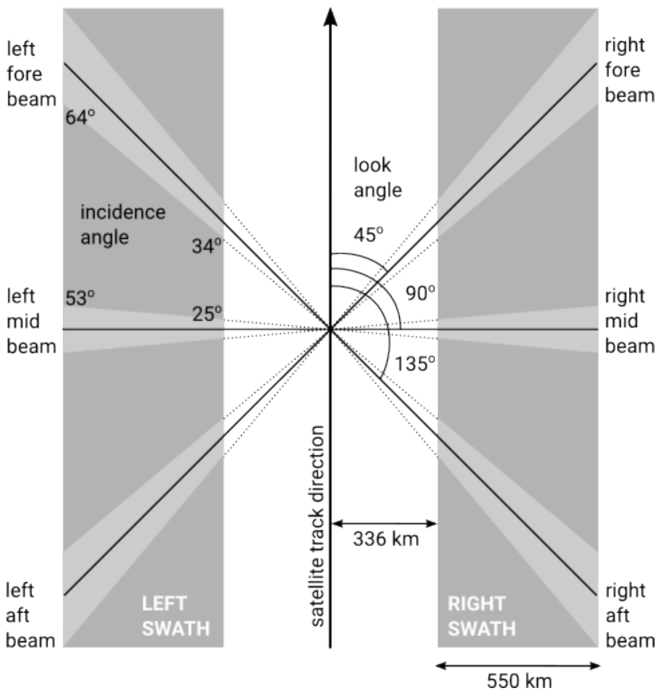

Figure 4-1: ASCAT swath geometry for a Metop minimum orbit height (822 km)

For the Metop operational orbit (see Appendix B), a coverage map can be seen in Figure 4-3 for a full day of Metop-A and B ASCAT data.

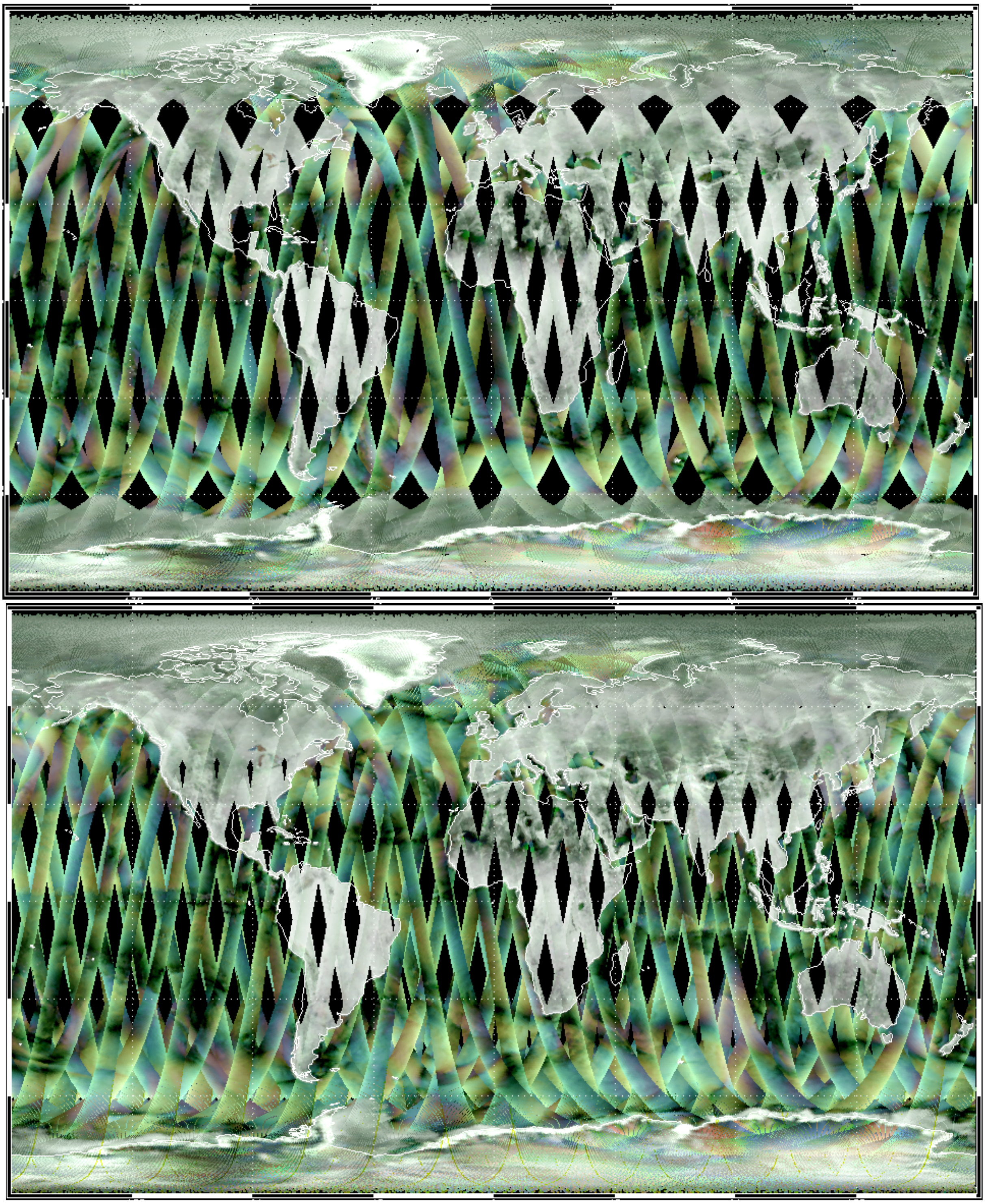

Figure 4-2: Example of ASCAT swath coverage for 1 day, from top to bottom: Global coverage of ASCAT-A; global coverage of ASCAT-A and ASCAT-B. The values mapped are an RGB composition of the NRCS data from the FORE (Red), MID (Green) and AFT (Blue) beams.

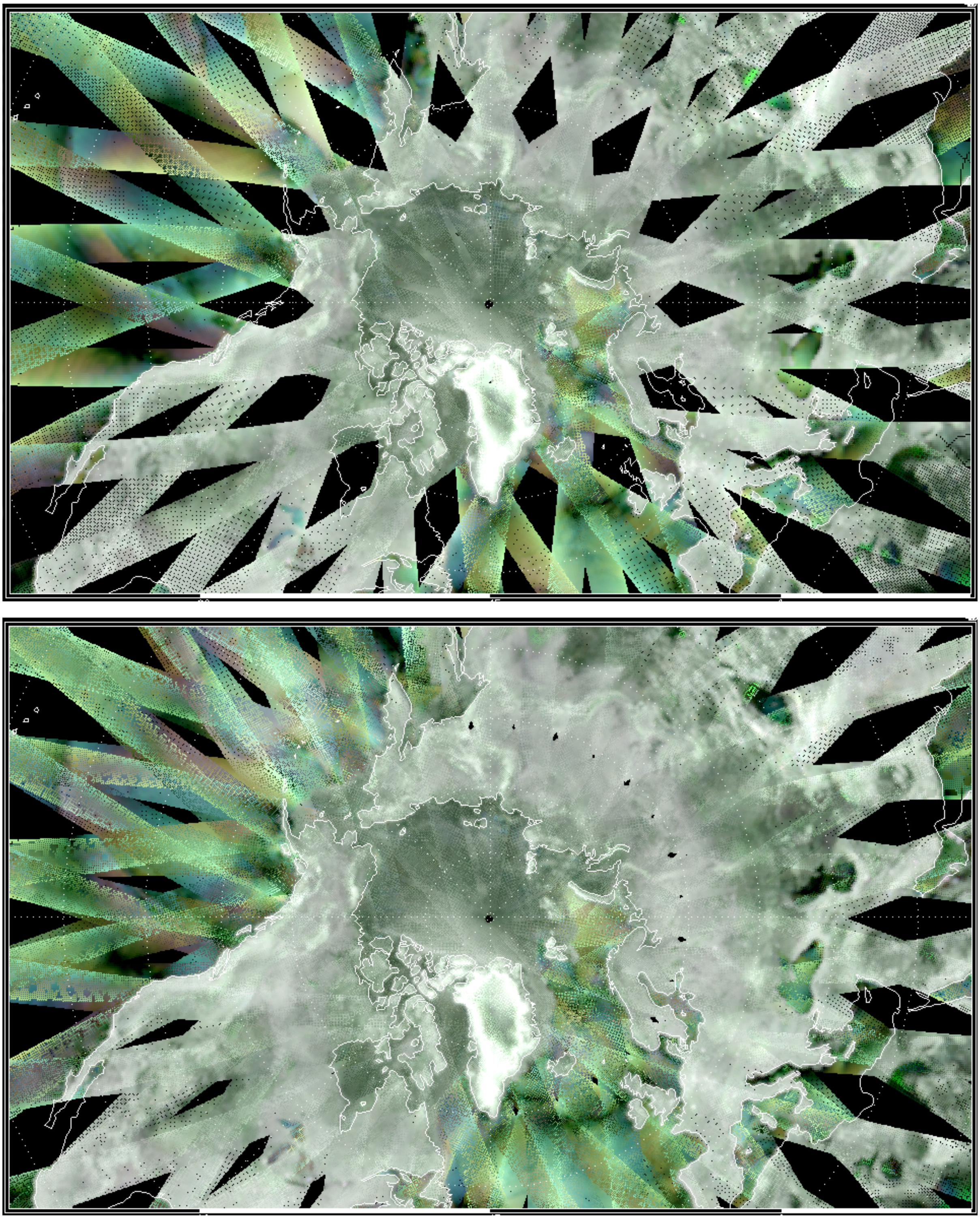

Figure 4-3: Example of ASCAT swath coverage for 1 day, from top to bottom: Coverage over high latitudes of ASCAT-A; Coverage over high latitudes of ASCAT-A and ASCAT–B. The values mapped are an RGB composition of the NRCS data from the FORE (Red), MID (Green) and AFT (Blue) beams.

4.4 Overview of the ground processing and calibration

4.4.1 The Level 1 ground processing

The Level 1 ground processing chain is illustrated in Figure 4-4. The goal of Level 1 ground processing for ASCAT is the generation of the radiometrically-calibrated Level 1b NRCS (σ_0) values.
The functionality of the ASCAT main processing chain is highlighted in blue in Figure 4-4. This chain is data driven and is applied to every science source packet to generate Level 1b products. The operational processor also includes an external calibration processing chain, highlighted in red, which is driven by the acquisition of calibration source packets and the need for generating in-flight instrument characterisation functions after an external calibration measurement acquisition campaign. In-flight instrument characterisation parameters are generated and validated off-line and highlighted in green. After they are satisfactorily assessed, the instrument in-flight characterisation parameters are uploaded to the main processing chain.

4.4.1.1 The Level 1b main processing chain

The ASCAT power echoes corresponding to both Measurement mode and Calibration mode are subject to front-end processing, namely internal calibration (Power-Gain product correction) and noise corrections (receive filter shape correction and noise power subtraction). Corrected measurement power echoes are then normalised into 256 σ_0 values along every antenna beam projection on the ground and localised on the surface of the Earth.
The power-to-σ_0 normalisation factors are the coefficients needed within Level 1b processing to convert instrument raw data into σ_0. Their calculation is based on estimating the power scattered from a distributed target with constant $\sigma_0 = 1$ for different discrimination frequencies (e.g. along beam range positions). In order to do this, the System Response Function (SRF) of individual power samples along the beam needs to be estimated from knowledge of the measurement geometry and the range compression process. The normalisation factors and SRFs are estimated by applying the corresponding two-way radar equation while accounting for on-board echo processing corresponding to the ASCAT Measurement mode. In order to account for viewing geometry, the normalisation factors and SRF are currently generated in advance for every actual Metop orbit, using an orbit state vector prediction a few hours before actual sensing time.
Spatial averaging (smoothing) in the along- and across-track directions is further applied per beam over all available σ_0 values, with the objective of obtaining a set of three σ_0 values (one from each beam) for each grid node of each swath at the desired radiometric resolution (also called Kp). This implies a re-sampling of the NRCS values from their original geolocation to a swath grid generated during the processing.

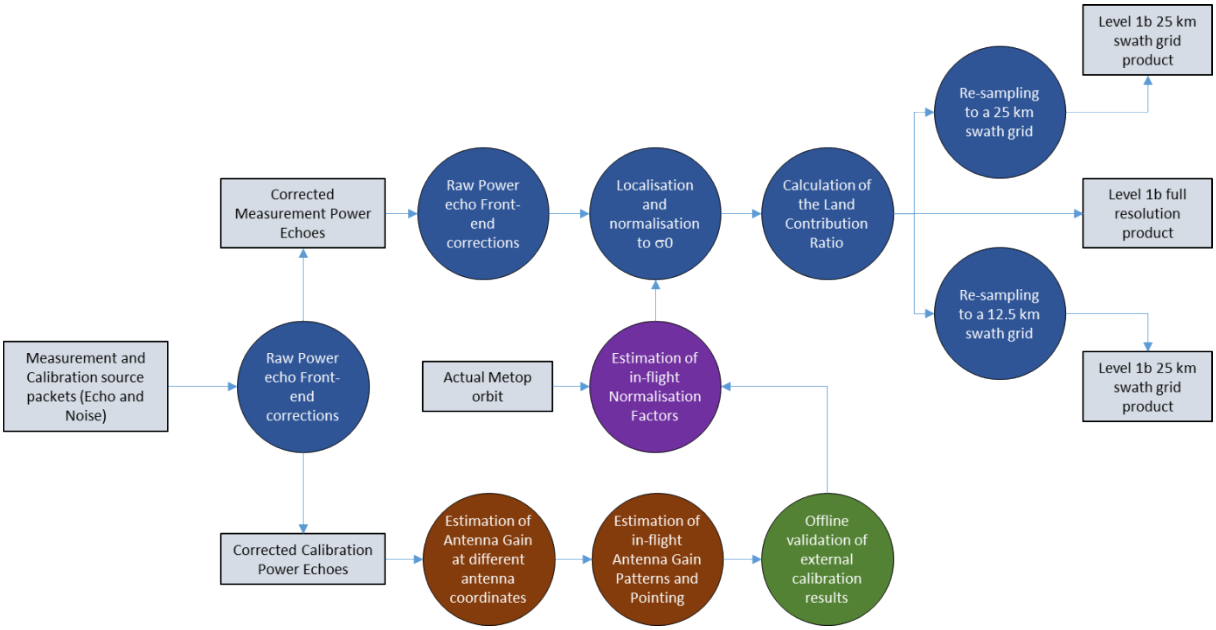

Figure 4-4: Functional overview of the ASCAT Level 1 ground processing chain.

4.4.1.2 Re-sampling, spatial resolution and spatial correlation

The need to deliver re-sampled σ_0 is two-fold. On one hand, most applications need NRCS values from three beams collocated into one location on the Earth surface. On the other hand, re-sampling through spatial averaging allows reducing the signal standard noise (Kp), also necessary for most applications. The weighting function used to carry out the spatial filtering is currently a two-dimensional Hamming window centred at every swath grid node position, which is based on a cosine function and designed to peak in the centre of the samples and taper to zero at the ends (see Figure 4-5 for its geometry). Its width determines in effect the spatial resolution of the σ_0 averaged values, which is defined in the principal cut in each of the along- and across-track directions, as the distance around the centre of the spatial filter when it reaches 50% of the peak value. The averaged σ_0 values at two different horizontal scales and spatial grids are generated this way, leading to two smoothed σ_0 products: with approximately 50 km and 30 km horizontal resolution on grids of 25 km and 12.5 km, respectively. Associated with the spatial filtering, the Kp of the averaged measurement is estimated as the standard noise within the averaging area defined by the Hamming window. In that step, the measurement correlation due to the previous on-board along-track and across-track average is additionally taken into account. Note that for the higher resolution product, a trade-off was necessary between spatial resolution and radiometric accuracy, by applying a Hamming window with variable width across the swath for the different beams. The resulting spatial resolution ranges from 25 km in the near swath to 34 km in the far swath.

The choice of Hamming window and grid spacing for the re-sampling was done according to Nyquist theory, in order to generate a NRCS product with reduced Kp that could moreover be further re-sampled without aliasing into other grids for further processing. This is relevant for the current soil moisture and sea ice retrieval techniques, where the reference algorithms are based on geographic pixels and not on individual NRCS triplet observations. However, the necessarily big size of the Hamming window used (about twice the achieved resolution) poses limitations at surface type boundaries (ocean/land/sea ice), and also hampers the efficiency of enhancing resolution techniques, because it effectively acts as a low pass filter of the measured surface σ_0 spatial variability [RD 45].

A different NRCS re-sampling technique has been explored in the past years as a pre-processing step in the Level 2 winds generation, in order to obtain winds closer to the coast. This is based on carrying out the re-sampling step with a circular top-hat filter, instead of the two-dimensional Hamming window (see figure 4-5 for its geometry). Several reports and publications generated in the context of both the OSI and NWP SAF work have come to demonstrate through spectral analysis and comparisons with buoy winds that the winds generated from NRCS values re-sampled with a circular top-hat filter window of 15 km diameter are equivalent in open ocean with the Hamming-window based values, when both are generated on a 12.5 km product grid [RD55]. The advantage of the smaller size of the circular top-hat window product is that allows estimation of re-sampled land-free NRCS values closer to the coast.

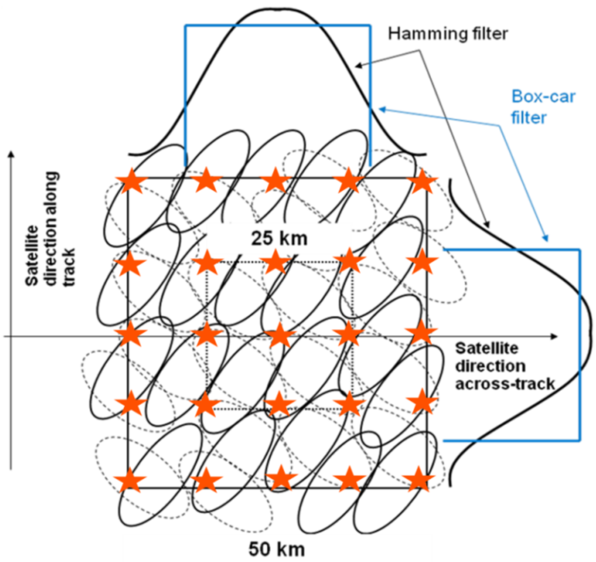

Figure 4-5: Ground geometry of the across-track component of the spatial smoothing for σ0 values corresponding to two across-track adjacent nodes

Since 29 May 2013 EUMETSAT has provided a new ASCAT full resolution Level 1 product, which includes the original NRCS values prior to re-sampling (i.e. different beams not-collocated but with individual geolocation for each value). This product is now available in NRT and includes a reference swath spacing grid of 6.25 × 6.25 km for customized re-sampling by the user. The OSI SAF is exploiting this product in the operational generation of the ASCAT Level 2 coastal winds, as well as exploring its potential in the generation of higher resolution wind products (at 5.7 km spacing). The H-SAF has also started to assess the use of this product for potential resolution enhancement over land particularly in areas with small lakes and wetlands, as well as from other land cover types such as stony soil rock outcrops and urban areas [RD37].
The resolution of the different ASCAT products prior to res-sampling is defined by the size of the target area scattering power back to the instrument, or SRF. The shape and size of the SRF of the individual samples of NRCS along the antenna footprint is a consequence of range compression in the along beam direction and limited by the diffraction effect due to the finite size of the antenna in the across beam direction (See Figure 4-6).

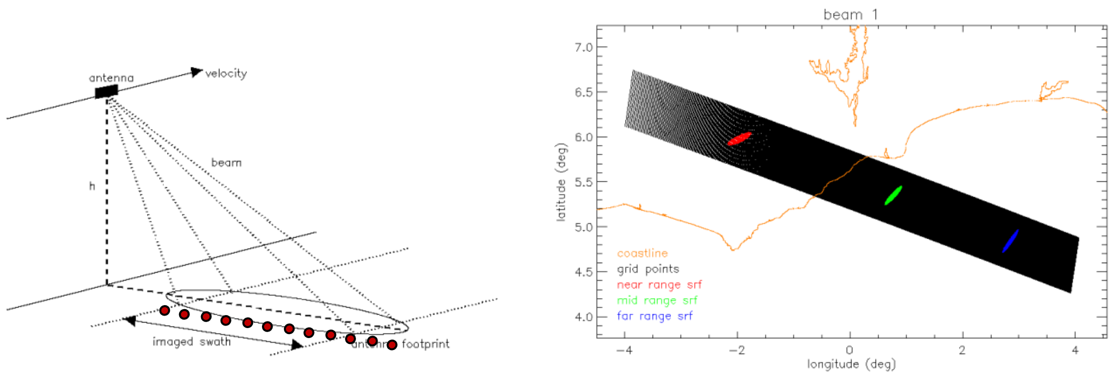

Figure 4-6: Ground geometry of the across-track component of the spatial smoothing for σ_0 values corresponding to two across-track adjacent nodes

For the re-sampled product, the Cumulative SRF (CSRF) is composed of the fundamental instrument SRFs of the measurements used in the re-sampling. During the re-sampling, all original NRCS with an associated latitude/longitude location within the specified window size are considered for each swath location. Consequently, the CSRF of the re-sampled products will be different after the use of different re-sampling windows (two-dimensional Hamming or circular top-hat).

4.4.1.3 Surface type

It is important for the Level 2 product generation to be able to identify the surface type, since different surface scattering mechanisms apply e.g. over ocean, land, snow and sea ice. It is however difficult to do this without relying on ancillary data in addition to NRCS measurements and hence surface type is generally assessed as part of the Level 2 processing. However, a land/ocean flag is included in all Level 1b products, based on an available coastline database.
For the NRCS on original instrument geometry, two different values are available:

- A binary flag (land/ocean) based on the latitude/longitude location assigned to the measurement
- A fractional land flag (LCR) based on the percentage of land within each measurement SRF.

For the re-sampled NRCS product, the land flag expresses the percentage of original NRCS values over land (according to the binary flag) used in the re-sampling and is calculated using the same weighting as in the spatial averaging. The LCR is resampled using the same weighting as in the spatial averaging of the NRCS.

4.4.1.4 Level 1b nominal and degraded operation modes

The different instrument modes generate data intended for different types of processing. These are all considered nominal and can be of three types;

- The main nominal processing mode is driven by continuous availability to the processor of measurement data and corresponds to the generation of ASCAT Level 1b products within the main processor chain. These are the products intended for users;
- Another nominal processing mode is driven by the availability to the processor of a sequence of Gain Compression Monitoring data, to the end of generating instrument performance assessment data, which are not intended for users but are used internally in the EPS CGS;
- Finally, the third processing mode considered nominal is the generation of calibration products within the external calibration processing chain, driven by the availability to the processor of a

sequence or a number of sequences of calibration data. Calibration products are not intended for users either.

Non-nominal operation modes are not defined as such for the ASCAT processor, but both the main Level 1b and the external calibration processing chains can generate products of non-nominal quality, referred to as degraded products. The ASCAT processor has the capability of flagging any degradation of the products in near real-time, by introducing the necessary flags and qualifiers within the products themselves. Those flags and qualifiers are addressed in detail in the sections of this document describing the ASCAT Level 1b product contents, but here the main product degradation scenarios are outlined:

- non-nominal antenna pointing, due to spacecraft orbit manoeuvres or orbit/attitude anomalies;
- instrument performance anomalies, assessed by examining instrument telemetry data and the estimated noise and internal calibration corrections;
- measurements of the left fore antenna affected by reflections from the solar array panel;
- start or end of a measurement mode sequence, due to non-availability of enough echo or noise data to compute the necessary internal calibration and noise correction functions;
- unavailability of good quality calibration data.

As part of the product validation activities, an assessment of the impact on the product accuracy of the above scenarios is carried out during the commissioning phase and thereafter monitored during operations. Guidelines on the usage of degraded products are provided in the product validation section in this document.

4.4.1.5 The external calibration processing chain

Before launch, the instrument is delivered with a set of characterisation parameters in the form of several LUTs, estimated on-ground and characterising the expected instrument performance. Among them are the antenna absolute gain patterns and their electrical boresight pointing, which determine the values of the normalisation factors used later for the generation of σ_0 values during the Level 1b processing. Antenna absolute gain patterns and their electrical boresight pointing are expected to depend on in-flight conditions, and they have to be estimated subsequently in flight. Once these parameters have been characterised in flight, a corresponding in-flight set of normalisation factors can be generated (i.e., key data). The normalisation factors are the conversion coefficients needed within Level 1b processing to convert instrument raw data (in Power units) into σ_0 and are estimated based on the in-flight knowledge of the instrument and the measurement geometry.

As illustrated in Figure 4-4, antenna gain measurements in the antenna coordinate system are obtained from every transponder calibration measurement and a set of antenna gain patterns and pointings are derived, which need to be examined off-line and their quality evaluated, before they can be uploaded to the operational processor.

A two-dimensional reconstruction of the antenna gain patterns and the estimation of three depointing angles is the method applied in the external calibration processing, based on fitting absolute gain values estimated at different angular positions (antenna azimuth and elevation) by using ground transponders.

4.4.2 The Level 2 ground processing

4.4.2.1 Ocean winds processing

Level 2 ocean winds processing takes the radiometrically-calibrated NRCS product to derive winds near the ocean surface (at a nominal height of 10 m). ASCAT Level 2 ocean wind global and regional products are respectively produced and distributed by the EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF) and the EARS Project. In both cases the core activities are carried out by KNMI (Royal Netherlands Meteorological Institute).

Near-surface ocean wind vectors are derived from ASCAT Level 1b data, by using a Geophysical Model Function (GMF), which relates σ_0 values to wind speed and direction. The wind retrieval is an inversion problem at each node where, given a set of three σ_0 values and the GMF, the wind vector is computed that has the highest probability of representing the true wind. An inversion problem presented in these probabilistic terms is usually equivalent to the minimisation of a cost function. Usually, two wind vectors are obtained as the most likely solutions, with directions separated by 180°. The measurement noise and the harmonic nature of the GMF result in this wind direction ambiguity as two equal-probability minima occurring in the cost function. The GMF currently used to retrieve ASCAT winds is CMOD7. See also [RD 2344].

A wind direction ambiguity removal step is further applied, based on variational meteorological analysis and relying on prior numerical weather prediction (NWP) model information. In 2D-VAR a cost function is minimised. The cost function is formulated in terms of wind increments and penalises deviations from both a background wind field and the ambiguous scatterometer wind solutions obtained from scatterometer wind retrieval. Finally, sea ice screening is applied, based on the scatterometer data itself and on sea ice history information.

More information on the ASCAT wind retrieval can be found on the OSI SAF scatterometer webpage.

4.4.2.2 Soil moisture processing

Level 2 soil moisture processing takes the radiometrically calibrated backscatter product to derive soil moisture over land surfaces. ASCAT Level 2 Soil Moisture Index products are produced and distributed by EUMETSAT using a processor developed and prototyped for EUMETSAT by the Department of Geodesy and Geoinformation of the Vienna University of Technology and later on integrated in the EUMETSAT operational ground segment. The products are part of the portfolio maintained by the SAF on support of Hydrology and water managements (H-SAF), who also offers user support on their utilisation.

The method for retrieving soil moisture from scatterometer data is a change detection method. Instantaneous backscatter measurements are extrapolated to a reference incidence angle (taken at 40°) and compared to dry and wet backscatter references. By knowing the typical yearly vegetation cycle and how it influences the backscatter-incidence angle relationship for each location on the Earth, the vegetation effects can be removed, revealing the soil moisture variations. Soil moisture is considered to have a linear relationship to backscatter. The historically lowest and highest values of observed soil moisture are then assigned to the 0% (dry) and 100% (wet) references respectively and a value for the relative (surface) soil moisture for each particular ASCAT measurement can be estimated in near real time. The backscatter references are derived a-priori from analysis of multi-annual ASCAT NRCS time series.

More information on the ASCAT soil moisture retrieval can be found on the H SAF webpages.

4.5 ASCAT product characteristics and use

This summarises the main characteristics of the operational near real time ASCAT products available to users. All products contain quality control and other information about the retrieval and their use, which are important to know when you choose the product needed for your application.

The ASCAT Level 0 product is not considered in this section, but available to expert users and data and software services providers, interested in the instrument raw measurements and their further processing. Its contents and format is discussed in Section 6 (the section dedicated to ASCAT product formats and dissemination).

Parameter content	EO portal collection reference	Sampling characteristics and resolution			EUMETCast	GTS	FTP (SAF)	EUM Archive	Other archive
		Spatial representation (sampling)	Approx. spatial resolution	Spatial averaging window	3-min along track product length for Global products, other for EARS data			Dump or orbits	
σ0 full-resolution	ASCSZF1B	Original sampling 192 samples along each of 6 beams (no beam collocation)	10km x 25 km	-	Native / HDF5	-	-	Native / HDF5	-
σ0 triplets	ASCSZO1B	swath grid 25 km, 42 nodes	50 km	Hamming	-			Native / netCDF / BUFR	-
	ASCSZR1B	swath grid 12.5 km, 82 nodes	25 - 30 km						
σ0 triplets +soil moisture	SOMO25	swath grid 25 km, 42 nodes	50 km	Hamming	BUFR		-	Native / netCDF	-
	SOMO12	swath grid 12.5 km, 82 nodes	25 - 30 km						
σ0 triplets +wind	OSI-104 and EARS-ASCAT	swath grid 12.5 km, 82 nodes	25 - 30 km	Top-hat	BUFR (EARS and global coverage consolidated in one service)			BUFR	KNMI
wind	OSI-104	swath grid 12.5 km, 82 nodes	25 - 30 km	Top-hat	-		netCDF	netCDF	KNMI, PODAAC
soil moisture time series	-	Lat/lon grid 12.5 km	25 - 30 km	Hamming	-			-	TU-Wien (netCDF)

Table 4-1: Summary of the main characteristics of ASCAT NRT products

4.5.1 The ASCAT Level 1b re-sampled products

4.5.1.1 General characteristics

The main geophysical parameter contained is the re-sampled normalised backscatter radar cross section values, known as σ_0 triplets. Each triplet contains three σ_0 values corresponding to each instrument beam for the corresponding swaths, and localised on the surface of the Earth to a set of nodes on a horizontal surface grid. This grid is generated with a node distance of 25 km for the 50-km resolution product and 12.5 km for the higher resolution product. The σ_0 values are calculated through spatially averaging the original ones. Other important information provided for each triplet is incidence angle, azimuth angle, Kp value (associated with each re-sampled σ_0) and geographical position of the node.
Important to understand is that, due to the processing on-board and to the characteristics of the spatial averaging, the data from adjacent nodes are correlated. As explained in Section 4.4, the size of the spatial resolution window is about twice the re-sampling distance, and thus the σ_0 value corresponding to a node contains information from individual σ_0 values corresponding to several adjacent nodes along and across track.
Note: Due to the antenna geometry, σ_0 triplets may be partially filled at the start or end of a Measurement mode sequence. Those empty σ_0 values are replaced by a default value.

4.5.1.2 Accuracy

The accuracy of the σ_0 triplets is summarised by the following parameters.

Parameter	Measure
radiometric accuracy and inter-beam radiometric stability, also called calibration accuracy	around 0.1 dB
radiometric resolution over ocean (*Kp)*	around 2 % to 3 % for the product re-sampled at 25 km and around 4 % to 5 % for that at 12.5 km.
localisation accuracy	within 4 km

4.5.1.3 Quality information in the products

Level 1b data contain a number of flags that indicate the quality of the σ_0 and Kp values. The summary flags that take an integer value are as follows:

Name	Description	Codes
F_USABLE	summary flag for σ_0	0 = good 1 = usable 2 = bad
F_KP	Kp quality flag	0 = good 1 = bad

For each triplet, there are a number of product flags which are inherited from the full-resolution product.

F_USABLE is an advisory flag on the overall quality of the product. Its value is nominally set to 0 (= GOOD) if:

- the value of all the specific flags described above is 0 and
- the instrument calibration is considered good (set via configuration).

F_USABLE can also have a value of 1 (= USABLE), triggered by:

- non-zero values of any of the flags with "minor" severity (see Table 4-2)
- cases of inaccurate instrument calibration (set by us via configuration),

F_USABLE is set to a value of 2 (= BAD) if it is neither GOOD nor USABLE. Typically, this is:

- non-zero values of any of the flags with "major" severity (see Table 4-2)

Due to the antenna geometry, the triplets generated at the beginning and end of a measurement mode sequence are incomplete, when the corresponding node locations are only viewed by one or two antennas. There is no flag for incomplete triplets; the missing values are set to the default field value.

The Level 1b data products contains the land contamination ratio (LCR). This parameter contains floating point values ranging from 0 (no contribution from land) to 1 (full contribution from land). It estimates the signal contribution of the land surface from the spatial response function of the individual footprints. In case of resampled data, the LCR has been spatially averaged following the same approach taken for the σ_0 triplets.

For the flags listed above referring to a 'fraction of data' affected by some anomaly, the flag is calculated by applying the same Hamming window used for the spatial averaging to the corresponding individual flags associated with the individual σ_0 values averaged for that node. The flags are therefore not a *fraction* in the strict sense, but rather a weighted average of flags associated with individual σ_0 values.

4.5.2 The ASCAT Level 1b full resolution product

4.5.2.1 General characteristics

The main geophysical parameter contained in the product is the NRCS–192 values along each antenna beam– localised on the surface of the Earth. The measurements from the three different beams in each swath are not collocated, but have each their own independent geolocation. This corresponds to an intermediate product generated just before the swath node generation and re-sampling in the main processing chain, hence called a 'full resolution' product. The data are thus organised per position along each beam, and not per node in a swath. Other important information provided for each σ_0 value is incidence angle, azimuth angle and geographical position of the sample.

The 192 samples are a selection of the original 256 retrieved by the Level 1 processing for each beam and correspond to the nominal ASCAT performance swath, i.e., the area of coverage where the instrument performance is expected by design to be nominal.

The resolution of these σ_0 values is defined across-beam by the diffraction effect due to the finite size of the antenna. The antenna pattern averages about 20 km across-beam on ground, and the sampling rate corresponds to 1.2 antenna measurements per second pear each antenna, about 6 km on ground. Along-beam the resolution of the individual σ_0 values is determined by the range discrimination provided by the azimuth pulse compression. This resolution is variable along the beam but is of the order of 10 km. The sampling of individual σ_0 values along-beam is of approximately two km for mid beams and three km for side beams. As a result, the full resolution σ_0 values along every antenna beam represent footprints of about 10 × 20 km of various shapes and orientations, depending on the Doppler pattern over the surface. Due to the on-board processing, the individual σ_0 values carry a certain amount of measurement correlation. For a deeper understanding of this correlation, see more details about the on-board processing in [**Error! Reference source not found.**].

4.5.2.2 Accuracy

The accuracy of the σ_0 individual values is summarised by the following parameters.

Parameter	Measure
radiometric accuracy and inter-beam radiometric stability, also called calibration accuracy	around 0.1 dB
localisation accuracy	within 4 km

4.5.2.3 Quality information in the products

A number of quality flags are generated during the Level 1b processing, associated with every individual σ_0 sample along each antenna beam, and included in the Level 1b full resolution products. These contain equivalent information to those found in the averaged Level 1b product. The flags are contained in a bit field (with value = 1 when the flag is set), represented as a 32-bit integer value:

Table 4-2: Flagfield contents

Bit	Flag name	Category	Condition for setting flag value to 1
0	F_NOISE	Minor	If noise packets are interpolated during processing
1	F_PG	Minor	Degraded power gain product (PGP)
2	V_PG	Major	Invalid PGP
3	F_FILTER	Minor	Degraded filter shape
4	V_FILTER	Major	Invalid filter shape
5	F_PGP_OOL	Major	Estimated power gain product out of limits
6	F_NP_OOL	Major	Measured noise out of limits
7	F_PGP_DROP	Minor	Drop in PGP
8	F_ATTITUDE	Major	Non-nominal attitude
9	F_OMEGA	Major	Instrument parameter configuration mismatch
10	F_MAN	Major	Manoeuvre
11	F_OSV	Info	OSV file not available
12	F_E_TEL_PRES	Minor	Interpolated HKTM telemetry missing
13	F_ TEL_IR	Major	Some interpolated HKTM telemetry parameters out of prescribed thresholds
14	F_REF	Info	If F_PGP_OOL or F_ NP_OOL are 1
15	F_SA	Minor	Data may be corrupted by solar array reflections (affecting the FORE MID beam on descending passes only)
16	F_LAND	Info	Low-resolution land mask: set to 1 over land
17	F_GEO	Major	If geolocation algorithm failed
18	F_SIGN	Info	If σ_0 in linear units is negative and value in dB has been calculated from its unsigned value
19	F_COM_OP	Info	If instrument data taken during commissioning phase

20-31	Spare	n/a	n/a

Each flag belongs to a particular category which indicates the impact on data quality. Flags in the "minor" category indicate that the data is slightly degraded but still usable. Flags in the "major" category indicate that the data is severely degraded and should be discarded or used with caution. The ASCAT full resolution product does not contain an utilisation summary flag. A recommendation for the users is provided below instead, equivalent to the criteria followed to set up the F_USABLE (0=GOOD, 1=USABLE, 2=BAD) for the re-sampled products:

- If any of the major flags are set the data should not be used
- If any of the minor (but none of the major) flags are set, data should be used with caution
- If none of the minor, nor major flags are set the data is of good quality

The implementation of the solar array interference flag, F_SA is based solely on geometry considerations (relative angle between solar array panel and the ASCAT antennas) and no assessment has been done on the actual impact (if any) of the solar array reflections on the product quality (σ_0 and Kp). This flag has a warning level only (by triggering a value of F_USABLE = 1 instead of F_USABLE = 2), hence not actively affecting the current Level 2 processing.
The intention of the F_OA flag is to detect orbit or attitude anomalies that make the normalisation from echo power to σ_0 inaccurate or inappropriate– if the actual orbit or attitude deviates from the assumed ones in the generation of the normalisation factors. F_OA also takes into account the effect of manoeuvres. During Out-of-Plane (OOP) and In-Plane (IP) manoeuvres, the ASCAT instrument is left on and the processor running. In that situation, a manoeuvre flag is triggered, which contributes to F_OA.
The full resolution product also provides, as of format version 13.0, a field denominated LCR. It provides an estimation of the fraction of the signal originating from land within the Spatial Response Function associated to a given full resolution measurement. It assumes values between 0 And 1. The algorithm is based on the approach presented in [**Error! Reference source not found.**]. The ASCAT Level 2 ocean surface wind product. Here, only general information is given. For more details, please refer to the OSI SAF scatterometer webpage.

4.5.2.4 General characteristics

The ASCAT Level 2 ocean surface wind product is generated and distributed in near real-time. The main geophysical parameter is near surface (10 m height) ocean (neutral-equivalent) wind vectors. The operational Level 2 product is nominally generated by the OSI SAF based on the swath-based 50-km resolution Level 1b product received from EUMETSAT on a 25 km spacing grid. An additional ocean surface wind product with dedicated processing at the coast and based on averaging the NRCS full resolution data with a top-hat window is also available on a 12.5 km swath grid.
The products contain the two ambiguous wind vectors located at each node, as well as a flag indicating which one has been selected as corresponding to the correct wind direction by the ambiguity removal step. As an integral part of the product, the necessary geophysical parameters used for the retrieval from the Level 1b product are also included in the Level 2.
Additionally, the Level 2 product contains other auxiliary information used in the retrieval, such as collocated NWP ocean wind values used in the ambiguity removal step.

4.5.2.5 Accuracy

The expected accuracy of the ASCAT 50-km resolution ocean winds is 2 m/s RMS difference in wind vector components and 0.5 m/s wind speed bias with respect to a reference ‘true wind’.

4.5.2.6 Quality information in the products

With each ASCAT Level 2 wind vector, a value reflecting the likelihood of that retrieved wind solution is also given in the product, which accounts for the residual of the wind retrieval and a probability associated with that wind direction, as given by the wind direction ambiguity removal step.

4.5.3 The ASCAT Level 2 Soil Moisture product

Here, only general information is given. For more details, please refer to [RD], available at the TU-Wien ASCAT publications page.

4.5.3.1 General characteristics

The ASCAT Level 2 Soil Moisture product is generated and distributed in near real-time. The main geophysical parameter is relative land surface soil moisture, based on the swath-based grid. As an integral part of the product, the necessary geophysical parameters used for the retrieval from the Level 1b product are also included in the Level 2.

4.5.3.2 Accuracy

The expected average RMS error of the ASCAT soil moisture index is about 25%, which corresponds to about 0.03-0.07 m^3 water per m^3 soil, depending on soil type.

4.5.3.3 Quality information in the products

To help users in judge the quality of the soil moisture product, several quality and processing flags are delivered with the data. The quality flags comprise information about the intrinsic product quality, internal quality checks and specific processing details. The flags are derived directly from the incoming scatterometer data.
In addition to these quality flags, advisory flags are defined. The advisory flags will support the user in judging the reliability of the soil moisture product for a particular location on a particular day of the year and will allow the user to consider rejecting unreliable measurements. These indicators are based on average land cover characteristics, soil type and topography, which cannot be derived from the scatterometer data set, but need to rely on external data sets.

4.6 Summary of ASCAT product current and potential applications

A number of operational applications of scatterometer data have been developed in meteorology and climate monitoring, after the success of the recent scatterometer missions [RD41]. The main operational product from scatterometers remains the wind over the ocean surface, and the main operational application is the use of scatterometer winds in weather analysis and forecasting. Scatterometer winds are used routinely to track tropical and extra-tropical cyclones. The ASCAT soil moisture products have

been the first operational satellite soil moisture data set and also routinely exploited in the context of numerical land surface forecast models.
Another group of operational applications, based on the use of scatterometer σ_0 estimates, have been also developed, such as sea ice edge detection and monitoring, where maps of sea ice coverage based on scatterometer data are routinely produced. Besides the operational use of scatterometer data, there are a number of scatterometer applications at various levels of maturity, in the fields of oceanography as well as for monitoring sea ice, snow cover and hydrological modelling and forecasting.

4.6.1 Scatterometer ocean wind applications

4.6.1.1 Ocean winds assimilation in weather forecasting

The main application of scatterometer ocean winds is the assimilation in NWP models. Since the main limitation for this application is the problem of the wind direction ambiguity, the impact and the benefits of the assimilation of scatterometer winds in NWP models were clearly improved when variational data assimilation was developed. These schemes can ingest the two wind direction ambiguities and perform the ambiguity removal within the assimilation process, by weighting one wind direction or another according to the information provided by the background field and the other observations used in the assimilation. ERS and SeaWinds winds have been and are operationally assimilated in global models at ECMWF and the Met Office (UK). Also regional NWP models use scatterometer data following similar principles.

4.6.1.2 Nowcasting and forecasting of extreme events

Scatterometer ocean winds can be used also in Nowcasting and forecasting of extreme events. The added value of the scatterometer data in this particular application is two-fold. First, the scatterometer measurements are available in data-sparse oceanic regions where extreme weather events such as tropical cyclones are generated, and they are available in cloudy and rainy conditions. Secondly, scatterometer winds contain much sub-synoptic scale information that, though difficult to assimilate into NWP, is vital for Nowcasting applications. Moreover, the increased coverage and timeliness of ASCAT with respect to ERS winds facilitates the routine use of scatterometer winds by operational weather forecasters.

4.6.1.3 Winds forcing ocean and wave models

An important limitation in the interpretation of the results obtained by ocean models is considered to be the uncertainties in the surface wind fields, especially in tropical areas, where the ocean reacts strongly and quickly to the atmosphere's variability. Again in this case, conventional instrumentation data is generally sparse in these areas. The main parameter of interest in this case is ocean surface wind stress, related to the near-surface ocean winds.
The scatterometer winds play also an indirect role in operational ocean wave forecast models, as most of these models are coupled to or forced by an atmospheric model wind analysis that has assimilated scatterometer winds (e.g. ECMWF model).

4.6.2 Other scatterometer applications

4.6.2.1 Scatterometry over land surfaces

Radar backscatter from land corresponds to a mixture of surface and volume scattering associated with the radar penetration depth. The surface roughness, vegetation cover and terrain dielectric properties play an important role in determining what the dominant backscatter regime is. The response of the land surface to the radar with respect to incidence angle (slope) is different for both regimes. Hence examining not only the backscatter intensity but also the backscatter slope allows assessing surface type, vegetation cover and soil moisture content [RD 27].

4.6.2.2 Sea Ice monitoring: mapping and analysis

Sea ice detection based on scatterometer data is mainly based on two properties of the backscatter response from sea ice. First, sea ice surfaces have isotropic backscatter response, in contrast to the strong anisotropic response from the open water. Secondly, the dependency of the backscatter response with respect to incidence angle is generally smaller for sea ice than for the ocean. Based on these properties, and on available in situ validation sea ice data, models describing the scatterometer sea ice backscatter signatures have been developed, which point at one key sea ice characteristic driving the backscatter response: sea ice age.

Following these results, multi-sensor sea ice detection and classification algorithms relying on multivariate analysis with microwave (active and passive), infrared and visible data as input, have been developed, in which the sea ice information contained in the scatterometer measurements plays a key role.

5 DATA VIEWING AND READING

The products in netCDF formats can be read using standard libraries. For more information on netCDF, a good resource is the Unidata netCDF webpage. Software capable of reading the WMO formats is available from a variety of sources, including ECMWF. Additionally, the KNMI makes available specific ASCAT BUFR reader code, which can be adapted to read NRCS, wind and soil moisture information.

6 ASCAT PRODUCT FORMATS AND DISSEMINATION

ASCAT products are available through EUMETSAT and the Satellite Application Facilities through different mechanisms, depending on the latency of the data and the application timeliness requirements. All the mechanisms are described on the EUMETSAT data Delivery pages. The first step to gain access to any EUMETSAT product is a registration at the Earth Observation Portal. In the following paragraphs, a brief description of the difference dissemination mechanisms is provided, focusing down on ASCAT products and their formats.

6.1 EPS products available dissemination means

6.1.1 Satellite Direct Broadcast Service

Instrument and ancillary data acquired by the Metop satellites are broadcast and received by authorised users in real-time via High Resolution Picture Transmission (HRPT), which is transmission of data from all Metop instruments in full resolution. See also the EUMETSAT web page DATA/REGIONAL DATA SERVICE/EARS/EARS-ASCAT.
The data are received by local reception stations. It is the responsibility of the user to procure and install a local reception station. Specification documentation for a EUMETSAT-based HRPT Reference User Station is available for information on the EUMETSAT webpage. See the DATA/METOP SERVICES page. The output format of the EUMETSAT HRPT Reference User Station is Level 0 products in the EPS Native format. See [RD 7] and [RD 16]. The broadcast data are encrypted. To get authorisation to access the data, users need to register with the EUMETSAT User Services and will receive the data decryption information.

6.1.2 EUMETCast

Global EPS products at different levels are distributed in near real-time via EUMETSAT's Data Distribution System (EUMETCast). EUMETCast utilises the services of a satellite operator and telecommunications provider to distribute data files using Digital Video Broadcast (DVB) to a wide audience located within the geographical coverage zone which includes Europe, Africa and the American continent. EUMETCast is part of a wider network known as GEONETCast, with coverage also over Asia and Australia. Within the current EUMETCast configuration, the multicast system is based upon a client/server system with the server side implemented at the EUMETCast uplink site (Usingen, Germany) and the client side installed on the individual EUMETCast reception stations. The telecommunications suppliers provide the DVB multicast distribution mechanism. Data/product files are transferred via a dedicated communications line from EUMETSAT to the uplink facility. These files are encoded and transmitted to a geostationary communications satellite for broadcast to user receiving stations. Each receiving station decodes the signal and recreates the data/products according to a defined directory and file name structure. A single reception station can receive any combination of the provided services.
A typical EUMETCast reception station comprises a standard PC with DVB card inserted and a satellite off-set antenna fitted with a digital universal V/H LNB. In addition, users require the multicast client software, which can be obtained via the EUMETSAT User Services.

More detailed information on this service can be found in the EUMETSAT webpage EUMETCast Dissemination Scheme. ASCAT Level 1 and Level 2 products distributed on EUMETCast are formatted in EPS native format and the BUFR.

6.1.3 GTS/RMDCN

A subset of EPS products will be disseminated additionally in near real-time via the Global Telecommunication System (GTS). GTS is the World Meteorological Organization integrated network of point-to-point circuits, and multi-point circuits which interconnect meteorological telecommunication centres. Its purpose is to enable an efficient exchange of meteorological data and products in a timely and reliable way to meet the needs of World, Regional and National Meteorological Centres. The circuits of the GTS are composed of a combination of terrestrial and satellite telecommunication links. Meteorological Telecommunication Centres are responsible for receiving data and relaying them selectively on GTS circuits. The GTS is organised on a three-level basis as described below:

- The Main Telecommunication Network which links three world meteorological centres and 15 regional telecommunication hubs.
- The Regional Meteorological Telecommunication Networks which consists of an integrated network of circuits interconnecting meteorological centres in a region, which are complemented by radio broadcasts where necessary. In Europe, the GTS network is supported by the Regional Meteorological Data Communication Network (RMDCN).
- The National Meteorological Telecommunication Networks, which extend the GTS network down to national level.

More detailed information on this service can be found on the WMO website www.wmo.int.
Products distributed on the GTS are in official WMO formats, namely BUFR for the ASCAT Level 1 and Level 2 products.

6.1.4 EUMETSAT Data Centre

All EPS products and auxiliary data are normally archived and made available to users from the EUMETSAT Data Centre (formerly known as the UMARF or Archive Services) upon request.
Information of the Data Centre can be found on the Data Centre webpage. Access is through a web interface, the Online Ordering Application, through which the users are able to browse and order products, manage their user profile, retrieve products, documentation and software libraries, and get help. The Data Centre features include limited geographical and time sub-setting and image preview (only for AVHRR products). ASCAT products archived in the Data Centre can be accessed in a variety of formats, including EPS native format, netCDF BUFR.

6.2 ASCAT products dissemination

This section summarises the different dissemination means and formats for all ASCAT products available to users. For the description of product contents, please refer to Table 4-1.
Real-time broadcast of ASCAT raw data is not covered in this guide. The raw data streams mentioned in the table above indicate what is broadcast by the platform. Depending on the reception system used, different formats of this raw data stream are produced. This depends on the local reception station provider. For Metop HRPT stations, the Reference User Station has been developed to produce EPS Native Level 0 format products.
Although available through the EUMETSAT Data Centre, ASCAT Level 0 products are not considered an end-user product, hence they are not addressed in this guide. Currently, there is no user software package that can accept ASCAT L0 data and process it into Level 1 NRCS information.

Table 6-1: Summary of dissemination means and formats for ASCAT products

Format	Real-Time Direct Broadcast	Near-Real-Time dissemination on EUMETCast (timeliness)	Near-Real-Time dissemination on GTS (timeliness)	EUMETSAT Data Centre retrieval (timeliness)	OSI SAF FTP service (timeliness)	H- SAF FTP service (timeliness)
Metop raw data format	HRPT raw data stream and Metop Admin message	--	--	--	--	--
EPS native format	--	ASCSZ(F/O/R)1B (60 - 100 min)	--	Level 0, ASCSZ(F/O/R)1B, SOMO25/12 (8-9 h)	--	--
NetCDF	--	--	--	ASCSZ(O/R)1B, SOMO25/12, OAS025/012, OASW025/012, OSI-104 (8-9 h)	OAS025/012, OASW025/012, OSI-104 (70 - 110 min) EARS-ASCAT/25 (6-18 min)	Level 2 soil moisture time series (not an NRT product))
WMO (BUFR)	--	SOMO25/12, OAS025/012, OSI-104 (70 - 110 min) EARS-ASCAT/25 (6-18 min)	SOMO25/12, OAS025/012, OSI-104 (70 - 110 min) EARS-ASCAT/25 (6-18 min)	SOMO25/12, OAS025/012, OSI-104 (8-9 h)	OAS025/012, OSI-104 (70 - 110 min) EARS-ASCAT/25 (6-18 min)	--

Note: *Timeliness* refers to the elapsed time between sensing and dissemination.

6.2.1 Near-real-time dissemination

The ASCAT products disseminated to users in near real-time are as follows:

- ASCAT Level 1b products at full resolution, with a timeliness of 60 to 100 min from sensing;
- ASCAT Level 1b spatially averaged products, with a timeliness of 60 to 100 min from sensing (as part of the Level 2 files);
- ASCAT Level 2 products, with a timeliness of 70 to 110 min from sensing for global products and 6-18 min for regional products.

The dissemination granularity of the data is three minutes for both Level 1b and Level 2 global products, and between three minutes to 15 minutes for Level 2 regional products. For the ASCAT-A regional Level 2 regional service, the last 30 minutes of every global dump are also processed with a file granularity of 30 minutes.

6.2.2 Archive retrieval

The ASCAT products available from the EUMETSAT Data Centre are as follows:

- ASCAT Level 1b spatially averaged products at both resolutions
- ASCAT Level 1b full resolution product
- ASCAT Level 2 ocean winds and soil moisture global products

Reprocessed data corresponding to the above products are also available via the Data Centre.
All products are archived as full-dump products, but limited sub-setting capabilities are provided to the user in the retrieval step. The products are available for the users in the EUMETSAT Data Centre eight to nine hours after sensing. The static auxiliary data used in the generation of all products can also be found there.

6.3 ASCAT EPS native product formats

6.3.1 The EPS native formats

All products in EPS native format are structured and defined according to an EPS Generic Product Format. For more information, please refer to the format specifications provided in [RD 1] and [RD 2].

6.3.1.1 Granularity of the EPS products

The Full EPS product is produced by processing a dump of data. This is the product size used as archive in the EUMETSAT Data Centre. In addition, the Regional EPS product is a full product that has been passed through a geographical filter. This may happen, for example, during the retrieval of the product from the Data Centre.
Finally, a Product Dissemination Unit (PDU) is the near-real-time dissemination of the full product, and it is typically of three minutes. A PDU is often referred to as a product *granule*. The EPS Generic Product Format has been defined to apply to any length of sensing. This means that the same generic format described above applies to a three-minute duration granule, half an orbit or a full dump of data. The length in time of the product is contained in the MPHR.

6.3.1.2 Product naming convention

The file-naming convention for EPS products in EPS native format provides a product name that uniquely identifies any product and provides a summary of its contents. It follows the convention described in [**Error! Reference source not found.**].
For the ASCAT products, the resulting product file names are as follows in Table 6-2.

Product	Product Name
ASCAT Level 1b 25–km grid spacing	ASCA_SZO_1B_Mnn_< ...>
ASCAT Level 1b 12.5-km grid spacing	ASCA_SZR_1B_Mnn_< ...>
ASCAT Level 1b full resolution	ASCA_SZF_1B_Mnn_< ...>
ASCAT Level 2 Soil Moisture 25–km grid spacing	ASCA_SMO_02_Mnn_< ...>
ASCAT Level 2 Soil Moisture 12.5–km grid spacing	ASCA_SMR_02_Mnn_< ...>

Table 6-2: Generic ASCAT product names

The products retrieved from the EUMETSAT Data Centre have the same names as the original EPS-formatted ones, with the extension appended *.nat* for products in the native EPS format.

6.4 The WMO formats

The ASCAT products available in WMO (BUFR) format are summarised in Table 6-3.

Product	***Bulletin header***	***Originating station***	***Descriptor sequence***
ASCSZO1B	IESXii (ii from 01 to 10)	EUMP	3-12-061
ASCSZR1B	IESXii (ii from 11 to 99)		
SOMO25	IEOXii (ii from 01 to 10)		
SOMO12	IEOXii (ii from 11 to 99)		
ASCAT Level 2 multi-parameter products global: 25 km spacing grid	ISXXii (ii from 01 to 06)	EHDB	
ASCAT Level 2 wind products regional : 25 km spacing grid	ISXNii (ii from 01 to 06)		
ASCAT Level 2 wind products regional: 12.5 km spacing grid	ISXNii (ii from 11 to 16)		

Table 6-3: ASCAT products available in WMO (BUFR) format

Note: There is a single BUFR format to incorporate the ASCAT L1b spatially-averaged products and the L2 Soil Moisture and Near Surface Winds. If any of the product levels are not present, the corresponding fields are set to missing values. The full format description of these products is available in the WMO Manual on Codes [RD]. Further information on the ASCAT Level 2 products is available in [RD]. To distinguish between BUFR products from the global or the EARS processing chain, the descriptor Originating Sub-centre (001034) is set to 1 for the latter.

The names of the ASCAT Level 1b and Level 2 soil moisture BUFR products distributed on EUMETCast follow the WMO convention and are specified in [RD 10]. Here are some filename examples:

For: ASCSZR on METOP-B
W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPB+ASCAT_C_EUMP_20121113132701_00808_eps_o_125_l1.bin

For: ASCSZO on METOP-A
W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPA+ASCAT_C_EUMC_20110701090858_00101_eps_o_250_l1.bin

ASCSMR on METOP-A
W_XX-EUMETSAT-Darmstadt,SOUNDING+SATELLITE,METOPA+ASCAT_C_EUMC_20110701090858_00101_eps_o_125_ssm_l2.bin

In the case of ASCAT Level 2 wind and multi-parameter (soil moisture + wind) products, the following convention is followed:

for the global products	ascat_yyyymmdd_hhmmss_satellite_nnnnn_eps_o_iii_xxx.l2_bufr

for the regional products	ascat_yyyymmdd_hhmmss_satellite_nnnnn_ear_o_iii.l2_bufr

where:

yyyymmdd	stands for the UTC year, month, day of the data start sensing time
hhmmss	stands for the UTC hour, minute, second of the data start sensing time
satellite	‘metopa’, ‘metopb’
nnnnn	is the orbit number
iii_xxx	can take the value: • coa_ovw for OSI-104 • 125 for OAS012 • 250 for OAS025 • 125_{station}_ovw for EARS-ASCAT • 250_{station}_ovw for EARS-ASCAT25
station	can take the value of different HRPT stations, e.g. ‘sva’ (Svalbard), ‘mas’ (Maspalomas), ‘lan’ (Lannoin), etc or if missing, it refers to EARS data processed from the global dump (only for METOP-A).

6.5 The NetCDF format

Most of the Level 1b and Level 2 products are provided additionally in NetCDF format, the structure and contents of the files having been defined following the Climate and Forecast (CF) metadata conventions for the description of Earth sciences data.

In the case of the Level 1b and Level 2 soil moisture products, the filename formats are as per the BUFR products, but adding *.nc* at the end, instead of *.bin*.
In the case of the Level 2 wind products, the convention of the BUFR files is also followed, replacing the final *_bufr* string by *_nc* and the iii_xxx field by these values:

- 125_ovw for OASW012
- 250_ovw for OASW025

In the case of the Level 2 winds, a description of the NetCDF data is provided in [RD], available on the [OSI SAF scatterometer webpage.]()

7 ASCAT PRODUCT PROCESSING ALGORITHMS

See the **ASCAT NRCS Algorithm Technical Basis Description** for a detailed description of the ASCAT Level 1 processing algorithms.
For Level 2 soil moisture, see the **ASCAT Soil Moisture Product Handbook** [RD 27] that provides the most detailed algorithm description.
Finally, for Level 2 winds, see the **Algorithm Technical Basis for the OSI SAF Wind Products** [RD 24].

8 ASCAT PRODUCTS VALIDATION

The objective of the calibration and validation of Level 1 products is to ensure the following:

- the NRCS values and their localisation are calibrated and within the accuracy requirements
- the accompanying information (flags and qualifiers) faithfully address non-nominal quality scenarios
- the completeness of the data set is as expected, and all data gaps are addressed and explained

The accuracy requirements related to the following:

- absolute and inter-beam radiometric accuracy
- relative (with respect to incidence angle) radiometric accuracy
- radiometric resolution
- localisation

The NRCS is calibrated against ground transponders of known radiometric cross-section. The geographic location of these three is also precisely known, hence there is an opportunity of assessing the accuracy of the localisation of the NRCS against that reference. The calibrated radiometric accuracy is then validated over targets with well-modelled NRCS responses, such as the rainforest, the ocean, and stable sea ice areas.

In all cases, the general approach followed and adapted to the context of specific data sets can be summarised in two documents:

- The ASCAT Calibration and Validation Plan [**Error! Reference source not found.**]: Describes the pre-launch plans for calibration and validation of the products and reviews methods in the context of end-to-end (up to Level 2) validation.
- The ASCAT Verification, Calibration and Validation Plan [RD 5]: This was issued as a more specific step-by-step plan for the commissioning of ASCAT-B Level 1 products.

Several calibration exercises, associated with extended transponder measurement campaigns have taken place and their assessment documented:

- For ASCAT-A: in 2007, 2010 and 2012 ([RD 5], [RD 9])
- For ASCAT-B: in 2013 [**Error! Reference source not found.**]

The release of several ASCAT Level 1 product standards since initial launch has led to several major validation exercises, which have all been documented:

- Validation of ASCAT-A products after the commissioning of Metop-A [RD 15]
- Validation of ASCAT-A 2007-2008 re-processed products [RD 14]
- Validation of ASCAT-B products after the commissioning of Metop-B [RD20]
- Validation of ASCAT-A 2007-2014 re-processed products [RD 18]
- Validation of ASCAT-C products after the commissioning of Metop-C [RD 21]

For more details, please refer to the respective validation reports.

9 ASCAT PRODUCTS ROUTINE MONITORING

ASCAT Level 1 products are monitored daily and through a monthly time series of several parameters. The daily reports are available on the EUMETSAT website. See the Service Status page at http://www.eumetsat.int/website/home/Data/ServiceStatus/index.html.