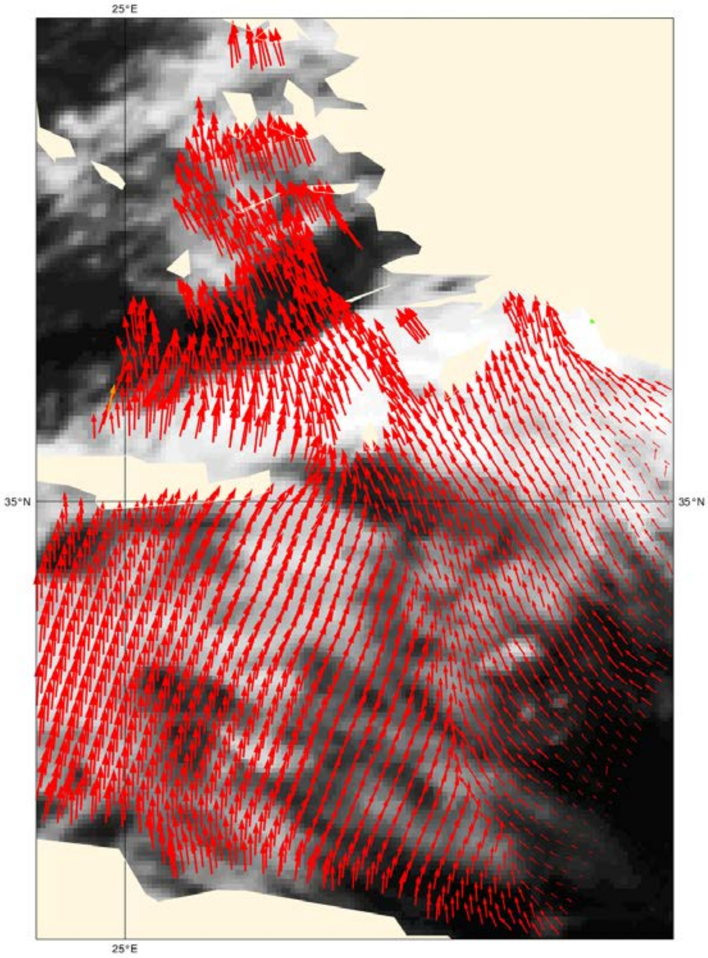
Ocean and Sea Ice SAF

ASCAT L2 winds Data Record Product User Manual



25 km and 12.5 km coastal level 2 wind products (OSI-150-a and OSI-150-b)

DOI: 10.15770/EUM_SAF_OSI_0006, 10.15770/EUM_SAF_OSI_0007

Version 1.2, July 2016

DOCUMENT SIGNATURE TABLE

	Name	**Date**	**Signature**
Prepared by:	O&SI SAF Project Team	Jul 2016	
Approved by:	O&SI SAF Project Manager	Jul 2016	

DOCUMENTATION CHANGE RECORD

Issue / Revision	**Date**	**Change**	**Description**
Version 1.0	Nov 2015		First version
Version 1.1	Jan 2016	Minor	Changes according to comments from DRR
Version 1.2	Jul 2016	Minor	Version for release

KNMI, De Bilt, the Netherlands
Reference: SAF/OSI/CDOP2/KNMI/TEC/MA/238

Cover illustration: ASCAT-A wind field retrieved in the eastern Mediterranean at 12.5 km WVC spacing (coastal wind product) on 29 November 2012, approximately 8:00 UTC, overlaid on a Meteosat infrared satellite image. A frontal zone is visible in the lower right part of the wind field which is reflected in the cloud pattern.

Contents

1. Introduction

1.1. Overview

The EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF) produces a range of air-sea interface products, namely: wind, sea ice characteristics, Sea Surface Temperatures (SST) and radiative fluxes, Surface Solar Irradiance (SSI) and Downward Long wave Irradiance (DLI). The Product Requirements Document [1] provides an overview of the committed products and their characteristics in the current OSI SAF project phase, The Service Specification Document [2] provides specifications and detailed information on the services committed towards the users by the OSI SAF in a given stage of the project.

KNMI is involved in the OSI SAF as the centre where the level 1 to level 2 scatterometer wind processing is carried out. This document is the Product User Manual to the Metop-A ASCAT wind climate data record. More general information on the OSI SAF project is available on the OSI SAF web site: http://www.osi-saf.org/. The user is strongly encouraged to register on this web site in order to receive the service messages and the latest information about the OSI SAF products. More information about this product can also be found on http://www.knmi.nl/scatterometer/.

The scatterometer is an instrument that provides information on the wind field near the ocean surface, and scatterometry is the knowledge of extracting this information from the instrument's output. Space-based scatterometry has become of great benefit to meteorology and climate in the past years. This is extensively described in the Algorithm Theoretical Baseline Document, see [3].

KNMI has a long experience in scatterometer processing and is developing generic software for this purpose. Processing systems have been developed for the ERS, NSCAT, SeaWinds, ASCAT, Oceansat-2 and RapidScat scatterometers. Scatterometer processing software is developed in the EUMETSAT Numerical Weather Prediction Satellite Application Facility (NWP SAF), whereas wind processing is performed operationally in the Ocean and Sea Ice SAF (OSI SAF).

The Metop-A level 1b reprocessed data record, spanning the period of 1 January 2007 to 31 March 2014 [4] was obtained from the EUMETSAT Data Centre. The data have been processed using the ASCAT Wind Data Processor (AWDP) software version 2.4, as available in the NWP SAF [5]. The OSI SAF Climate Data Records (CDRs) can be obtained from the EUMETSAT Data Centre.

There are three main justifications for reprocessing the Metop-A data record. Firstly, EUMETSAT has reprocessed the ASCAT data record up to March 2014 using uniform calibration settings and one single processing software version. Since March 2014, the same processing version is used in near real time so that in this respect the historic and near real time level 1b data form a seamless data record. Secondly, the OSI SAF wind retrievals have been improved in the past years and the data record processing was done using the latest knowledge on wind processing. Thirdly, the ambiguity removal and product monitoring are done now using the ECMWF re-analysis (ERA) Interim winds rather than the ECMWF operational winds. The ERA-Interim winds are much more uniform over time than the operational winds.

This user manual outlines user information for the OSI SAF ASCAT Wind CDRs on 25 km and 12.5 km grid spacing, OSI-150-a and OSI-150-b, respectively. Section 2 presents a brief description of the ASCAT instrument, and section 3 gives an overview of the data processing configuration. Section 4 provides details on how to access the products. Detailed information on the file content and format is given in section 5. The product quality is elaborated in the validation report to this CDR [6].

1.2. Disclaimer

The OSI SAF is much interested in receiving your feedback, would appreciate your acknowledgment in using and publishing about the data, and like to receive a copy of any publication about the application of the data. Your feedback helps us in maintaining the resources for the OSI SAF wind services.

1.3. Useful links

KNMI scatterometer web site: http://www.knmi.nl/scatterometer/

Information on OSI SAF activities at KNMI: http://www.knmi.nl/scatterometer/osisaf/

OSI SAF wind product documentation on http://www.osi-saf.org/

NWP SAF website: http://nwpsaf.eu/

EUMETSAT Data Centre:
http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETSATDataCentre/index.html

1.4. Limitations and remaining issues

ASCAT wind speed probability density functions show a small WVC dependency, which may be cured by a higher-order calibration with probably marginal beneficial impact on the verification. This is being incorporated as a minor update.

2. The ASCAT scatterometer

The Advanced SCATterometer (ASCAT) is one of the instruments carried on-board the Meteorological Operational (Metop) polar satellites launched by the European Space Agency (ESA) and operated by the EUropean organisation for the exploitation of METeorological SATellites (EUMETSAT). Metop-A, the first in a series of three satellites, was launched on 19 October 2006, Metop-B was launched on 17 September 2012. Metop-C is planned to be launched in 2018. Metop is in a sun-synchronous orbit with an inclination of 98.7° and a repeat cycle of 29 days/412 orbits (14.21 orbits per day). The local sun time at ascending node is 21:30.

ASCAT is a real aperture radar using vertically polarised antennas. 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.

Two sets of three antennas are used to generate radar beams looking 45 degrees forward, sideways, and 45 degrees backwards with respect to the satellite's flight direction, on both sides of the satellite ground track. These beams illuminate approximately 550 km-wide swaths (separated by about 700 km) as the satellite moves along its orbit, and each provide measurements of radar backscatter from the sea surface on a 25 km or 12.5 km grid, i.e. each swath is divided into 21 or 41 so-called Wind Vector Cells (WVCs). This brings the effective swath width to 525 km (21x25) or 512.5 km (41x12.5) for the 25 km and 12.5 km products, respectively. For each WVC, we obtain three independent backscatter measurements using the three different viewing directions and separated by a short time delay. As the backscatter depends on the sea surface roughness as a function of the wind speed and direction at the ocean surface, it is possible to calculate the surface wind speed and direction by using these 'triplets' within a mathematical model.

The instrument operates at a frequency of 5.255 GHz (C-band), which makes it rather insensitive to rain.

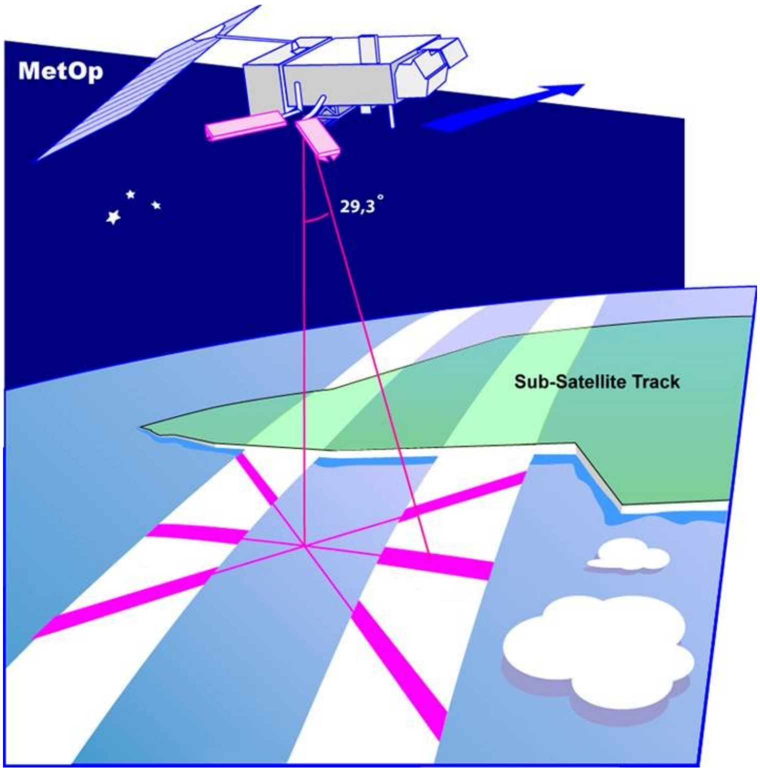


Figure 1: ASCAT wind scatterometer geometry (source: EUMETSAT web site).

3. Processing scheme

Figure 2 shows the system architecture to generate the wind data sets. The processing environment consists of a set of software components to collocate scatterometer data with ECMWF model data, to generate the wind data and to convert the output BUFR data into level 2 (swath) NetCDF data and level 3 (gridded to a regular lat/lon grid) NetCDF data. General information about the scatterometer wind processing algorithms can be found in the Algorithm Theoretical Basis Document (ATBD) [3].

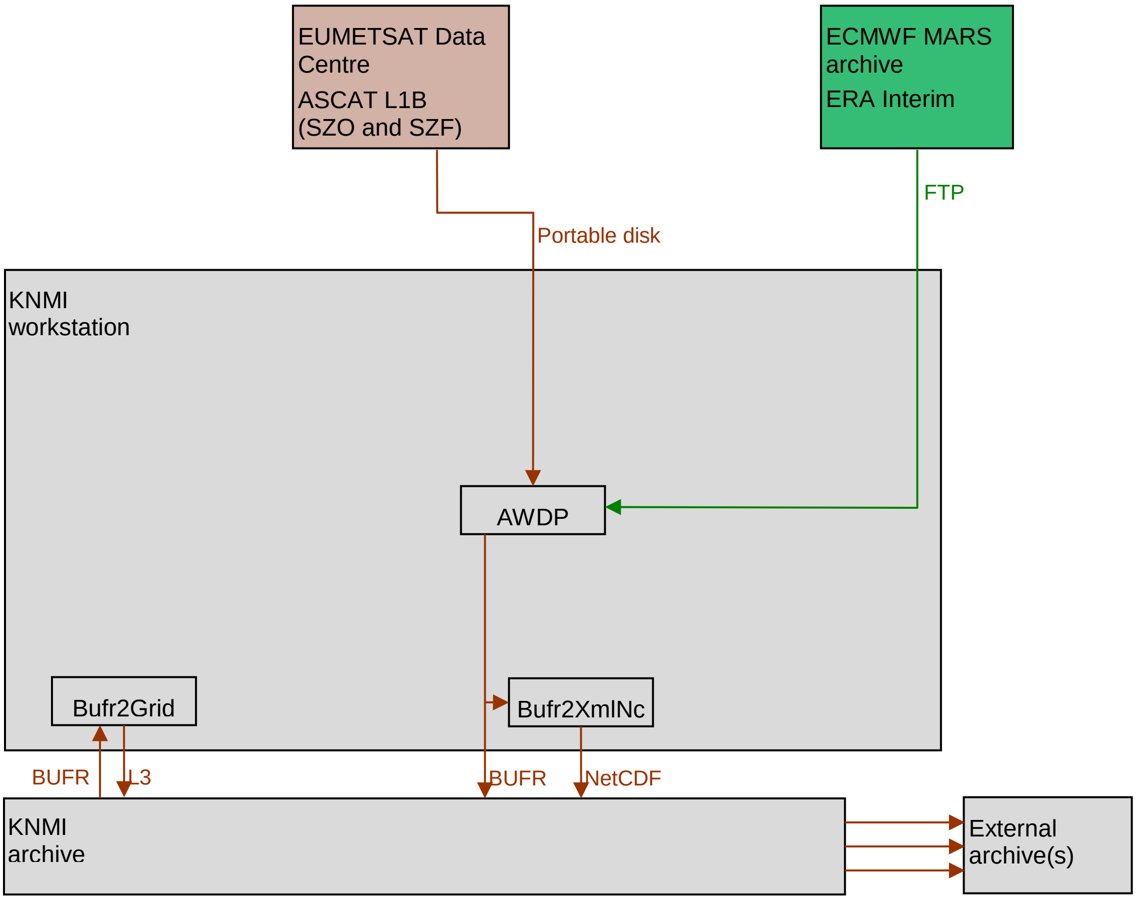


Figure 2: System architecture of reprocessing chain

The following components are shown in Figure 2.

- AWDP is the wind processing software for ASCAT data. It is publicly available in the NWP SAF, see [5].
- Bufr2XmlNc is a program to convert BUFR scatterometer data into level 2 NetCDF data. It is currently used in the near-real time OSI SAF processing.
- Bufr2Grid is a program to convert BUFR scatterometer data into level 3 NetCDF data. Two daily files are produced containing the ascending and descending parts of the orbits, respectively. It is currently used in the near-real time data processing for the Copernicus Marine Environment Service.

3.1. Backscatter averaging

In this step, which is performed only for the 12.5 km coastal product, the full resolution ASCAT level 1 product is used to re-compute backscatter values (σ^0s) in the Wind Vector Cells. The full resolution backscatter data are averaged using a spatial box filter rather than the Hamming window filter that is used in the spatial averaging of the σ^0s of the nominal level 1 products. All full resolution σ^0s within 15 km from the Wind Vector Cell centre are used in the averaging [7]. Also the time difference between the Wind Vector Cell time and the full resolution data acquisition time is considered to prevent mixing up of data from different orbits which may be close to the same location. Moreover, in Wind Vector Cells close to the coast, only those full resolution σ^0s are used that are entirely over sea. As the position of the averaged σ^0 is an averaged value of the positions of the full resolution σ^0s, the coastal Wind Vector Cell is slightly displaced away from the coast. On the other hand, it is possible to compute winds as close as ~15 km from the coast, while in a 12.5 km Hamming filtered product, Wind Vector Cells closer than ~35 km from the coast are flagged because of land contamination. See [7] for more information on the coastal product.

3.2. Backscatter calibration

The backscatter values in the Level 1b products are calibrated by adding a WVC and beam dependent bias in dB to the incoming σ^0s. The calibration table was obtained by fitting the actual measurements to the theoretical GMF function. More details are provided in [8]. Note that the calibrated backscatter values are only available within the wind processing software; the σ^0 data in the wind product are identical to those in the input product.

3.3. NWP collocation

NWP forecast wind data are necessary in the ambiguity removal step of the processing. The scatterometer winds have been collocated with ERA-Interim wind data from ECMWF [9]. Stress equivalent (U10S) winds have been computed from the real ERA-Interim forecast 10m winds, sea surface temperature, air temperature, Charnock parameter and specific humidity, using a stand-alone implementation of the ECMWF model surface layer physics [10]. The equivalent neutral winds have been converted to stress equivalent winds (U10S) by multiplying by a correction factor of $\sqrt{(\rho/\langle\rho\rangle)}$, where ρ is the air density and $\langle\rho\rangle$ is the average air density (1.225 kg/m^3).

The correction factor follows from the fact that the surface roughness as measured by the scatterometer is more closely correlated with surface stress τ than with the actual wind speed at 10 m. The surface stress τ is proportional to the air density and to the square of the equivalent neutral 10 m wind. In order to make the NWP winds equivalent to the scatterometer winds, we need to apply a correction, i.e. multiply by the square root of the normalised density.

The air density is computed from the NWP model mean sea level pressure (*msl*), specific humidity (*q*) and air temperature (*T*) as $\rho = msl / (287.04 \times (1 + 0.6078 \times q) \times T)$ [11].

Wind forecasts are available twice a day (00 and 12 GMT analysis time) with forecast time steps of +3h, +6h, …, +18h. The model wind vector component data have been quadratically interpolated with respect to time and linearly interpolated with respect to location and put into the level 2 information part of each WVC.

3.4. Quality control and monitoring

In each WVC, the σ^0 data is checked for quality and completeness and the inversion residual [3] is checked. Degraded WVCs with excessive wind variability [12] are flagged; see section 5.2 for more details.

An information file is made for each product. The content of the file is identical for each product and results from a compilation of all the global information concerning this product. From these files, various graphs have been produced to visually display the confidence levels of the products and their evolution with time. Any deviations from nominal behaviour would be immediately visible as steps in these graphs. An example of such a graph is shown in Figure 3. It shows that the average MLE values are quite constant over time showing only some seasonal fluctuations. Data quality is also available to the users within the products; see section 5 for a description of quality flags. More information on the data quality and stability over time can be found in the validation report [6].

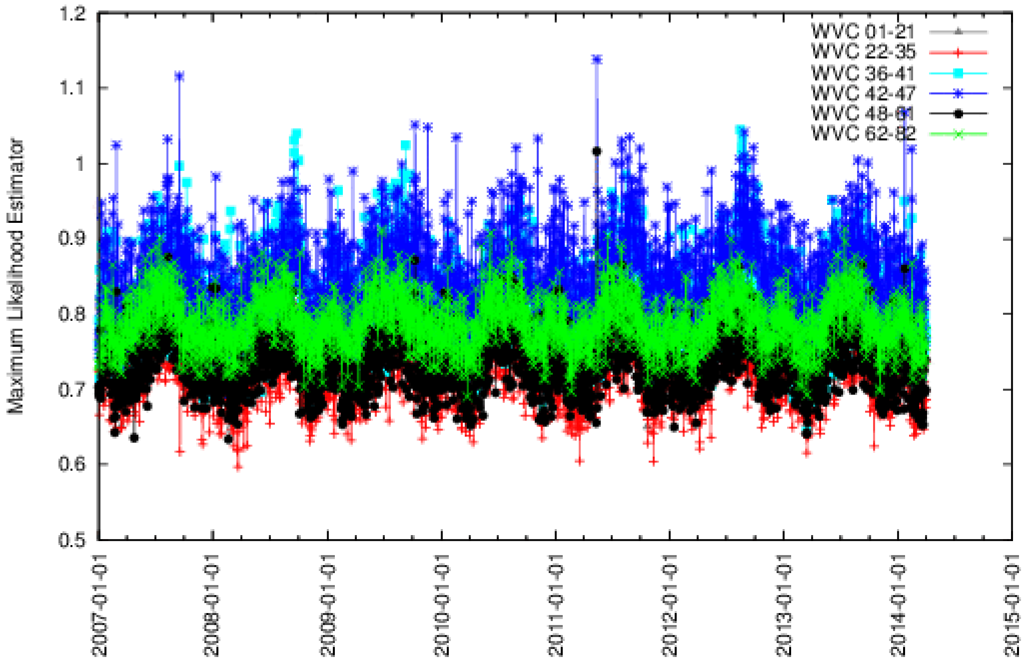


Figure 3: Daily average MLE values (1st rank wind solution) per group of WVCs (left outer swath, left mid swath, left inner swath, right inner swath, right mid swath and right outer swath) of 12.5 km wind products over the entire reprocessing period.

4. Helpdesk and data availability

For a swift response management procedure, user requests on the OSI SAF data products should be issued at the Ocean and Sea Ice SAF website (http://www.osi-saf.org/). You can also send an email to scat@knmi.nl.

A BUFR reader which is able to convert BUFR data into ASCII or NetCDF format is available at www.knmi.nl/scatterometer/bufr_reader/.

Unique Digital Object Identifiers (DOIs) are attached to the 25 km and 12.5 km data records. A landing page containing the latest product availability information and documentation is connected to each DOI:

http://dx.doi.org/10.15770/EUM_SAF_OSI_0006 for the reprocessed ASCAT L2 25 km winds

http://dx.doi.org/10.15770/EUM_SAF_OSI_0007 for the reprocessed ASCAT L2 12.5 km winds

The products are available (after registration) from the EUMETSAT Data Centre, http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETSATDataCentre/index.html. The data sizes for the entire data set and per orbit file are listed in the table below. There are 14.21 Metop orbits per day, the repeat cycle is 29 days (412 orbits).

Product	**Size of one orbit file**	**Size of 7+ years data record**
25 km BUFR	3 MB	115 GB
25 km NetCDF (g-zipped)	860 kB	32 GB
12.5 km BUFR	12 MB	450 GB
12.5 km NetCDF (g-zipped)	3.2 MB	120 GB

Note that the Metop-A ASCAT winds are still being produced in near real time. Archived data can be obtained from the EUMETSAT Data Centre (see link above) and from the NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC) archive, see http://podaac.jpl.nasa.gov/datasetlist?ids=Sensor&values=ASCAT&search=.

5. Data description

5.1. Wind product characteristics

Physical definition

Horizontal stress equivalent wind vector at 10 m height, obtained using the CMOD7 GMF, see [13].

Units and range

Wind speed is measured in m/s. The wind speed range is from 0-50 m/s, but wind speeds over 25 m/s are generally less reliable [3]. In the BUFR products, the wind direction is in *meteorological* (World Meteorological Organisation, WMO) convention relative to North: 0 degrees corresponds to a wind flowing to the *South* with a clockwise increment. In the NetCDF products, the wind direction is in *oceanographic* convention: 0 degrees corresponds to a wind flowing to the *North* with a clockwise increment.

Input satellite data

The ASCAT level 1b data at 25 km swath grid (SZO) was used to generate the 25 km wind product and the ASCAT level 1b data at full sensor resolution (SZF) was used to generate the 12.5 km coastal wind product. Both were obtained from the EUMETSAT Data Centre. The generation of ASCAT level 1b data by EUMETSAT is described in their technical documentation [14]. The data record covers the period from January 2007 to March 2014, see section 10 for an overview of missing data.

Geographical definition

The Metop satellite flies in a near-polar sun synchronous orbit at 98 degrees inclination at approximately 800 km orbit height. The two satellite swaths are located to the left and to the right of the satellite ground track. The swath width is either 21 25 km size WVCs, corresponding to 525 km or 41 12.5 km size WVCs, corresponding to 512.5 km. The data are organised in rows of 42 or 82 WVCs, respectively. Products are organised in files containing one orbit, starting at the South Pole. Note that the Metop orbit counter is increased at each ascending overpass over the equator, but we have chosen to split the data files in a region without wind information, i.e., the South Pole. This prevents unnecessary discontinuities in the wind field due to edge effects in the ambiguity removal.

Output product

The input products have been processed into a BUFR output product including a unique wind solution (chosen), its corresponding ambiguous wind solutions and quality information (distance to cone, quality flag). See section 8 for an overview of the used descriptors in the BUFR data format. The products are also available in NetCDF format; see section 9 for more details.

Expected accuracy

The expected accuracy is defined as the expected bias and standard deviation of the primary calculations. The accuracy is validated against in situ wind measurements from buoys, and against NWP data. Even better, the errors of all NWP model winds, in situ data, and scatterometer winds are computed in a triple collocation exercise [15]. The performance is pretty constant over the globe and depends mainly on the sub footprint wind variability. The performance of the products issued by the OSI SAF is characterised by a wind component standard deviation smaller than 2 m/s and a bias of less than 0.5 m/s in wind speed. More validation information is available in [6], showing that the actual products are much more accurate. As compared to ECMWF model winds, the wind component standard deviations are approximately 1.6 to 1.7 m/s for 25 km products and 1.7 to 1.9 m/s for 12.5 km products, with a wind speed bias of less than 0.2 m/s. As compared to buoy winds, the wind component standard deviations are approximately 1.6 m/s with a wind speed bias of less than 0.3 m/s.

5.2. File formats

Wind products are in BUFR Edition 4 or in NetCDF format. A complete description of BUFR can be found in WMO publication No 306, Manual on Codes.

The file name convention for the level 2 BUFR product is

ascat_YYYYMMDD_HHMMSS_SAT_ORBIT_SRV_T_SMPL_CONT.l2_bufr or

OR1ASW025_YYYYMMDD_HHMMSS_ORBIT_M02.bufr (25 km data from the EUM Data Centre)

OR1ASWC12_YYYYMMDD_HHMMSS_ORBIT_M02.bufr (12.5 km data from the EUM Data Centre)

- YYYYMMDD denotes the acquisition date (year, month and day) of the first data in the file
- HHMMSS denotes the acquisition time (hour, minute and second) of the first data in the file
- SAT denotes the satellite name, ‘metopa’ for this data record
- ORBIT is the orbit number of the first data in the file (00000-99999)
- SRV is the service (‘eps’ for global OSI SAF)
- T is the processing type (‘o’ for operational)
- SMPL is the WVC sampling (cell spacing): it contains ‘250’ for the 25 km product and ‘coa’ for the 12.5 km coastal product
- CONT refers to the product contents: always ‘ovw’ for a product containing Ocean Vector Winds

File name examples are

ascat_20081231_000826_metopa_11412_eps_o_250_ovw.l2_bufr or

OR1ASW025_20081231_000826_11412_M02.bufr (from EUM Data Centre)

The wind product is stored in the BUFR format as proposed for ASCAT and described in the WMO Manual on Codes, a list of descriptors (fields) contained in each WVC is provided in section 8.

The BUFR data contain three main sections: level 1 information (fields 1-62), level 2 Soil Moisture information (fields 63-82) and level 2 wind information (fields 83 and up). The level 1 information is simply copied into the level 2 data, except for the coastal product, where the backscatter data are calculated based on the data in the ASCAT full resolution level 1b product [7]. The reprocessed wind products do not contain Soil Moisture information.

The NetCDF data have almost the same file name convention as the BUFR data, only the part ‘l2_bufr’ is replaced by ‘.l2.nc’, for example:

ascat_20081231_000826_metopa_11412_eps_o_250_ovw.l2.nc or

OR1ASW025_20081231_000826_11412_M02.nc (from EUM Data Centre)

Contrary to the BUFR products, the NetCDF data do not contain backscatter information but only the level 2 wind (selected wind solution only) and sea ice information. They are intended to be an easy to handle wind-only product, see section 9.

Field 84 (‘Generating Application’) contains the value 91 which means that first guess model winds are used for ambiguity removal. The interpolated model winds are in the fields 85-86.

The Wind Vector Cell Quality Flag (field 89, table 021155) has the following definitions:

Description	**BUFR bit**	**Fortran bit**
Reserved	1	23
Not enough good sigma-0 available for wind retrieval	2	22
Poor azimuth diversity among sigma-0 for wind retrieval	3	21
Any beam noise content above threshold	4	20
Product monitoring not used	5	19
Product monitoring flag	6	18
KNMI quality control data rejection	7	17
Variational quality control data rejection	8	16
Some portion of wind vector cell is over land	9	15
Some portion of wind vector cell is over ice	10	14
Wind inversion not successful for wind vector cell	11	13
Reported wind speed is greater than 30 m/s	12	12
Reported wind speed is less than or equal to 3 m/s	13	11
Not used	14	10
Not used	15	9

Description	BUFR bit	Fortran bit
No meteorological background used	16	8
Data are redundant	17	7
Distance to GMF too large	18	6
Reserved	19-23	5-1
Missing value	All 24 set	All 24 set

In Fortran, if the Wind Vector Cell Quality Flag is stored in an integer **I** then use **BTEST(I,NDW-NB)** to test BUFR bit **NB**, where **NDW**=24 is the width in bits of the data element in BUFR. The **BTEST** function is equivalent to **(I/2^NF) modulo 2** where **NF** is the Fortran bit number.

If the ‘product monitoring not used’ bit, Fortran bit 19, is set to zero, the product is monitored. If the product is monitored and the ‘product monitoring flag’ bit, Fortran bit 18, is set to zero, the product is valid; otherwise it is rejected by the product monitoring [3]. This is based on a statistical check of the number of WVC QC rejections, the wind speed bias with respect to the NWP background, and the wind vector RMS difference with respect to the NWP background. The product monitoring bits have the same value for all WVCs in one BUFR output file. Since all problematic data due to instrument issues already have been removed from the input data set, product monitoring rejection does not occur in these wind data records.

If the KNMI QC flag, Fortran bit 17, is set in a WVC this means that the backscatter information is of poor usability for various reasons, such as a too large inversion residual, or a too high noise value in the input product. WVCs in which the KNMI QC flag is set, are not used in the calculation of the analysis field in the ambiguity removal step. However, after the ambiguity removal the wind solution closest to the analysis field is chosen (if wind solutions are present in the WVC). This means that such a WVC may contain a selected wind solution, but it is suspect.

The land presence flag, Fortran bit 15, is set if a land fraction (see section 3.3) larger than zero is calculated for the WVC. As long as the land fraction is below the limit value, a reliable wind solution may however still be present so there is normally no reason to reject WVCs with the land flag set.

The Bayesian ice screening algorithm as implemented in AWDP [16] was used when creating the CDRs. The ice presence flag, Fortran bit 14, is set if the Bayesian sea ice screening algorithm calculates ice for the WVC [3]. Note that the products contain wind solutions also over sea ice regions. These bogus winds are flagged both by the KNMI quality control flag and by the ice flag. Hence it is important to reject any winds with the KNMI quality control flag set when ingesting the products. Note that WVCs that are rejected due to a large inversion residual (e.g., in case of excessive local wind variability), only have the KNMI quality control flag set. On the other hand, WVCs that are rejected due to sea ice, have both the KNMI quality control flag and the ice flag set.

If the variational QC flag, Fortran bit 16, is set, the wind vector in the WVC is rejected during ambiguity removal due to spatial inconsistency. A wind solution is present, but it may be suspect.

It is recommended not to use WVCs with the KNMI quality control flag or the variational quality control flag set. See [3] for more information on product reliability.

The ‘likelihood computed for solution’ (descriptor 021104) actually contains the $\log_{10}$ of the calculated likelihood for the wind solution. This is done since otherwise values close to zero will be rounded to zero in the BUFR encoding. In order to recalculate the probability, the user should compute 10 to the power <value from BUFR>.

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7. Abbreviations and acronyms

2DVAR	Two-dimensional Variational Ambiguity Removal
ATBD	Algorithm Theoretical Basis Document
AR	Ambiguity Removal
ASCAT	Advanced Scatterometer
AWDP	ASCAT Wind Data Processor
BUFR	Binary Universal Format Representation
CDR	Climate Data Record
DLI	Downward Long wave Irradiance
ECMWF	European Centre for Medium-Range Weather Forecasts
ERA	ECMWF re-analysis
ERS	European Remote-Sensing Satellite
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GMF	Geophysical Model Function
KNMI	Royal Netherlands Meteorological Institute
Metop	Meteorological operational satellite
MLE	Maximum Likelihood Estimator
NASA	National Aeronautics and Space Administration (USA)
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration (USA)
NSCAT	NASA Scatterometer
NWP	Numerical Weather Prediction
OSI SAF	Ocean and Sea Ice SAF
QC	Quality Control
QuikSCAT	US Quick Scatterometer mission carrying the SeaWinds scatterometer
SAF	Satellite Application Facility
SSI	Surface Solar Irradiance
SST	Sea Surface Temperature
u	West-to-east (zonal) wind component
v	South-to-north (meridional) wind component
WMO	World Meteorological Organisation
WVC	Wind Vector Cell

8. Appendix A: BUFR data descriptors

Number	Descriptor	Parameter	Unit
1	001033	Identification Of Originating/Generating Centre	Code Table
2	001034	Identification Of Originating/Generating Sub-Centre	Code Table
3	025060	Software Identification	Numeric
4	001007	Satellite Identifier	Code Table
5	002019	Satellite Instruments	Code Table
6	001012	Direction Of Motion Of Moving Observing Platform	Degree True
7	004001	Year	Year
8	004002	Month	Month
9	004003	Day	Day
10	004004	Hour	Hour
11	004005	Minute	Minute
12	004006	Second	Second
13	005001	Latitude (High Accuracy)	Degree
14	006001	Longitude (High Accuracy)	Degree
15	005033	Pixel Size On Horizontal-1	m
16	005040	Orbit Number	Numeric
17	006034	Cross Track Cell Number	Numeric
18	010095	Height Of Atmosphere Used	m
19	021157	Loss Per Unit Length Of Atmosphere Used	dB/m
20	021150	Beam Collocation	Flag Table
21	008085	Beam Identifier	Code Table
22	002111	Radar Incidence Angle	Degree
23	002134	Antenna Beam Azimuth	Degree
24	021062	Backscatter	dB
25	021063	Radiometric Resolution (Noise Value)	%
26	021158	ASCAT Kp Estimate Quality	Code Table
27	021159	ASCAT Sigma-0 Usability	Code Table
28	021160	ASCAT Use Of Synthetic Data	Numeric
29	021161	ASCAT Synthetic Data Quality	Numeric
30	021162	ASCAT Satellite Orbit And Attitude Quality	Numeric
31	021163	ASCAT Solar Array Reflection Contamination	Numeric
32	021164	ASCAT Telemetry Presence And Quality	Numeric
33	021165	ASCAT Extrapolated Reference Function	Numeric
34	021166	ASCAT Land Fraction	Numeric
35	008085	Beam Identifier	Code Table
36	002111	Radar Incidence Angle	Degree
37	002134	Antenna Beam Azimuth	Degree
38	021062	Backscatter	dB
39	021063	Radiometric Resolution (Noise Value)	%
40	021158	ASCAT Kp Estimate Quality	Code Table
41	021159	ASCAT Sigma-0 Usability	Code Table
42	021160	ASCAT Use Of Synthetic Data	Numeric
43	021161	ASCAT Synthetic Data Quality	Numeric
44	021162	ASCAT Satellite Orbit And Attitude Quality	Numeric
45	021163	ASCAT Solar Array Reflection Contamination	Numeric
46	021164	ASCAT Telemetry Presence And Quality	Numeric
47	021165	ASCAT Extrapolated Reference Function	Numeric
48	021166	ASCAT Land Fraction	Numeric
49	008085	Beam Identifier	Code Table
50	002111	Radar Incidence Angle	Degree
51	002134	Antenna Beam Azimuth	Degree

Number	Descriptor	Parameter	Unit
52	021062	Backscatter	dB
53	021063	Radiometric Resolution (Noise Value)	%
54	021158	ASCAT Kp Estimate Quality	Code Table
55	021159	ASCAT Sigma-0 Usability	Code Table
56	021160	ASCAT Use Of Synthetic Data	Numeric
57	021161	ASCAT Synthetic Data Quality	Numeric
58	021162	ASCAT Satellite Orbit And Attitude Quality	Numeric
59	021163	ASCAT Solar Array Reflection Contamination	Numeric
60	021164	ASCAT Telemetry Presence And Quality	Numeric
61	021165	ASCAT Extrapolated Reference Function	Numeric
62	021166	ASCAT Land Fraction	Numeric
63	025060	Software Identification	Numeric
64	025062	Database Identification	Numeric
65	040001	Surface Soil Moisture (Ms)	%
66	040002	Estimated Error In Surface Soil Moisture	%
67	021062	Backscatter	dB
68	021151	Estimated Error In Sigma0 At 40 Deg Incidence Angle	dB
69	021152	Slope At 40 Deg Incidence Angle	dB/Degree
70	021153	Estimated Error In Slope At 40 Deg Incidence Angle	dB/Degree
71	021154	Soil Moisture Sensitivity	dB
72	021062	Backscatter	dB
73	021088	Wet Backscatter	dB
74	040003	Mean Surface Soil Moisture	Numeric
75	040004	Rain Fall Detection	Numeric
76	040005	Soil Moisture Correction Flag	Flag Table
77	040006	Soil Moisture Processing Flag	Flag Table
78	040007	Soil Moisture Quality	%
79	020065	Snow Cover	%
80	040008	Frozen Land Surface Fraction	%
81	040009	Inundation And Wetland Fraction	%
82	040010	Topographic Complexity	%
83	025060	Software Identification	Numeric
84	001032	Generating Application	Code Table
85	011082	Model Wind Speed At 10 m	m/s
86	011081	Model Wind Direction At 10 m	Degree True
87	020095	Ice Probability	Numeric
88	020096	Ice Age (A-Parameter)	dB
89	021155	Wind Vector Cell Quality	Flag Table
90	021101	Number Of Vector Ambiguities	Numeric
91	021102	Index Of Selected Wind Vector	Numeric
92	031001	Delayed Descriptor Replication Factor	Numeric
93	011012	Wind Speed At 10 m	m/s
94	011011	Wind Direction At 10 m	Degree True
95	021156	Backscatter Distance	Numeric
96	021104	Likelihood Computed For Solution	Numeric
97	011012	Wind Speed At 10 m	m/s
98	011011	Wind Direction At 10 m	Degree True
99	021156	Backscatter Distance	Numeric
100	021104	Likelihood Computed For Solution	Numeric

Note that descriptor numbers 93-96 can be repeated 1 to 144 times, depending on the value of the Delayed Descriptor Replication Factor (descriptor number 92)

9. Appendix B: NetCDF data format

The wind products are also available in the NetCDF format, with the following characteristics:

- The data format meets the NetCDF Climate and Forecast Metadata Convention version 1.4 (http://cfconventions.org/).
- The data contain, contrary to the BUFR data, only level 2 wind and sea ice information, no sigma0 nor soil moisture information. The aim was to create a compact and easy to handle product for oceanographic and climatological users.
- The data contain only the selected wind solutions, no ambiguity information.
- The wind directions are in oceanographic rather than meteorological convention (see section 5.1)
- The format is identical for ASCAT, SeaWinds and any other scatterometer data.
- The data has file sizes somewhat smaller than those of the corresponding BUFR data (e.g., one orbit file of 25 km wind data is 3 MB in BUFR and 2.2 MB in NetCDF). When compressed with gzip, the size of one file in NetCDF reduces to 0.9 MB.

The file name convention for the gzipped NetCDF product is

ascat_YYYYMMDD_HHMMSS_SAT_ORBIT_SRV_T_SMPL_VERS_CONT.l2.nc.gz or

OR1ASW025_YYYYMMDD_HHMMSS_ORBIT_M02.nc.gz (from EUM Data Centre) where the meaning of the fields is identical to those in the BUFR file names (see section 5.2). The VERS part of the file name denotes the AWDP software version (2400 for this data record). A file name example is: ascat_20081231_000826_metopa_11412_eps_o_250_2400_ovw.l2.nc.gz.

Below are some meta data contained in the NetCDF data files:

```
dimensions:
        NUMROWS = 1622 ;
        NUMCELLS = 42 ;
variables:
        int time(NUMROWS, NUMCELLS) ;
                time:long_name = "time" ;
                time:units = "seconds since 1990-01-01 00:00:00" ;
        int lat(NUMROWS, NUMCELLS) ;
                lat:long_name = "latitude" ;
                lat:units = "degrees_north" ;
        int lon(NUMROWS, NUMCELLS) ;
                lon:long_name = "longitude" ;
                lon:units = "degrees_east" ;
        short wvc_index(NUMROWS, NUMCELLS) ;
                wvc_index:long_name = "cross track wind vector cell number" ;
                wvc_index:units = "1" ;
        short model_speed(NUMROWS, NUMCELLS) ;
                model_speed:long_name = "model wind speed at 10 m" ;
                model_speed:units = "m s-1" ;
        short model_dir(NUMROWS, NUMCELLS) ;
                model_dir:long_name = "model wind direction at 10 m" ;
                model_dir:units = "degree" ;
        short ice_prob(NUMROWS, NUMCELLS) ;
                ice_prob:long_name = "ice probability" ;
                ice_prob:units = "1" ;
        short ice_age(NUMROWS, NUMCELLS) ;
                ice_age:long_name = "ice age (a-parameter)" ;
                ice_age:units = "dB" ;
        int wvc_quality_flag(NUMROWS, NUMCELLS) ;
                wvc_quality_flag:long_name = "wind vector cell quality" ;
```

```
                wvc_quality_flag:flag_masks = 64, 128, 256, 512, 1024, 2048, 4096,
8192, 16384, 32768, 65536, 131072, 262144, 524288, 1048576, 2097152, 4194304 ;
                wvc_quality_flag:flag_meanings = "distance_to_gmf_too_large
data_are_redundant no_meteorological_background_used rain_detected
rain_flag_not_usable small_wind_less_than_or_equal_to_3_m_s
large_wind_greater_than_30_m_s wind_inversion_not_successful
some_portion_of_wvc_is_over_ice some_portion_of_wvc_is_over_land
variational_quality_control_fails knmi_quality_control_fails
product_monitoring_event_flag product_monitoring_not_used
any_beam_noise_content_above_threshold poor_azimuth_diversity
not_enough_good_sigma0_for_wind_retrieval" ;
        short wind_speed(NUMROWS, NUMCELLS) ;
                wind_speed:long_name = "wind speed at 10 m" ;
                wind_speed:units = "m s-1" ;
        short wind_dir(NUMROWS, NUMCELLS) ;
                wind_dir:long_name = "wind direction at 10 m" ;
                wind_dir:units = "degree" ;
        short bs_distance(NUMROWS, NUMCELLS) ;
                bs_distance:long_name = "backscatter distance" ;
                bs_distance:units = "1" ;

// global attributes:
                :title = "MetOp-A ASCAT Level 2 25.0 km Ocean Surface Wind Vector
Product" ;
                :title_short_name = "ASCATA-L2-25km" ;
                :Conventions = "CF-1.4" ;
                :institution = "EUMETSAT/OSI SAF/KNMI" ;
                :source = "MetOp-A ASCAT" ;
                :software_identification_level_1 = 901 ;
                :instrument_calibration_version = 0 ;
                :software_identification_wind = 2400 ;
                :pixel_size_on_horizontal = "25.0 km" ;
                :service_type = "eps" ;
                :processing_type = "O" ;
                :contents = "ovw" ;
                :granule_name =
"ascat_20081231_000826_metopa_11412_eps_o_250_2400_ovw.l2.nc" ;
                :processing_level = "L2" ;
                :orbit_number = 11412 ;
                :start_date = "2008-12-31" ;
                :start_time = "00:08:26" ;
                :stop_date = "2008-12-31" ;
                :stop_time = "01:49:45" ;
                :equator_crossing_longitude = " 339.708" ;
                :equator_crossing_date = "2008-12-30" ;
                :equator_crossing_time = "22:52:23" ;
                :rev_orbit_period = "6081.7" ;
                :orbit_inclination = "98.7" ;
                :history = "N/A" ;
                :references = "ASCAT Wind Product User Manual, http://www.osi-
saf.org/, http://www.knmi.nl/scatterometer/" ;
                :comment = "Orbit period and inclination are constant values. All
wind directions in oceanographic convention (0 deg. flowing North)" ;
                :creation_date = "2015-11-17" ;
                :creation_time = "09:57:40" ;
```

10. Appendix C: Data gaps and number of files

The ASCAT Data Record starts at orbit 1042 on 1st January 2007 and ends at orbit 38646 on 31st March 2014. The tables below show the gaps with a length of at least two orbits in the Data Record and the number of files (orbits) per year, respectively.

Start date	End date	Last orbit before gap	First orbit after gap	Number of missing orbits
1-Jan-2007	1-Jan-2007	1046	1052	5
22-Feb-2007	23-Feb-2007	1789	1805	15
27-Feb-2007	1-Mar-2007	1855	1886	30
20-Apr-2007	25-Apr-2007	2594	2668	73
17-Sep-2007	19-Sep-2007	4723	4760	36
11-Oct-2007	12-Oct-2007	5073	5077	3
14-Oct-2007	15-Oct-2007	5118	5121	2
16-Jan-2008	18-Jan-2008	6447	6474	26
19-Mar-2008	21-Mar-2008	7347	7372	24
8-Apr-2008	9-Apr-2008	7623	7636	12
23-Oct-2008	23-Oct-2008	10437	10441	3
18-Feb-2010	18-Feb-2010	17229	17303	3
19-Mar-2010	20-Mar-2010	17719	17724	4
3-Jan-2011	4-Jan-2011	21827	21849	21
14-May-2011	16-May-2011	23693	23722	28
22-Oct-2011	23-Oct-2011	25986	25997	10
25-Oct-2012	25-Oct-2012	31223	31229	5
12-Nov-2013	12-Nov-2013	36664	36668	3
26-Mar-2014	26-Mar-2014	38567	38571	3

Year	Number of files
2007	5028
2008	5136
2009	5185
2010	5178
2011	5127
2012	5196
2013	5181
2014	1276
Total	37307