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The EUMETSAT
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OSI SAF
Ocean and Sea Ice

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Ocean and Sea Ice SAF

SeaWinds wind Climate Data Record Product User Manual
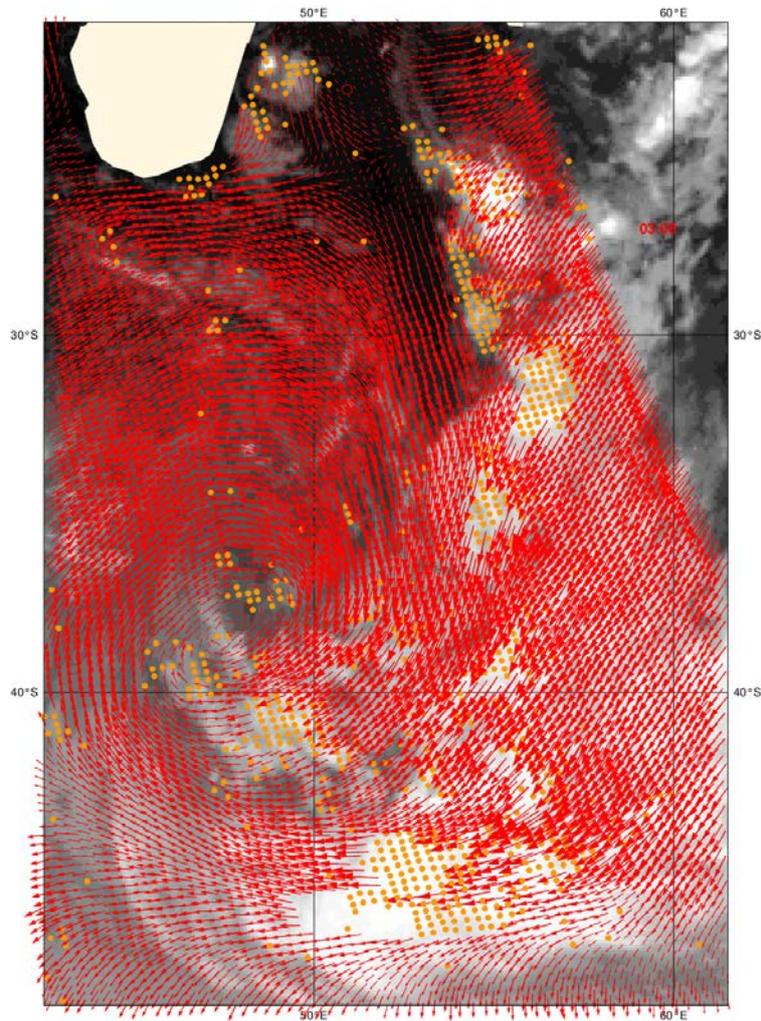
25 and 50 km wind products (OSI-151)

Version 1.3, March 2015

DOCUMENT SIGNATURE TABLE

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DOCUMENTATION CHANGE RECORD

Issue / Revision	Date	Change	Description
Version 1.0	Nov 2014		First version
Version 1.1	Nov 2014	Minor	Version for DRR
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Version 1.3	Mar 2015	Minor	Updated results after new reprocessing

KNMI, De Bilt, the Netherlands
Reference: SAF/OSI/CDOP2/KNMI/TEC/MA/220

Cover illustration: QuikSCAT wind field retrieved in the Indian Ocean at 25 km WVC spacing on 8 January 2008, approximately 3:00 UTC, overlaid on a Meteosat infrared satellite image. The orange dots are rejected WVCs; the locations where heavy precipitation is likely to occur (bright patches in the infrared cloud pattern) clearly correspond to locations where a large fraction of the winds are rejected.

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 SeaWinds 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 complete QuikSCAT SeaWinds level 2a data record, spanning the period of 19 July 1999 to 22 November 2009 was obtained from the Physical Oceanography Distributed Active Archive Center (PO.DAAC) at the NASA Jet Propulsion Laboratory (http://podaac.jpl.nasa.gov/). The data have been processed using the SeaWinds Data Processor (SDP) software version 2.2, as available in the Numerical Weather Prediction (NWP) SAF [4]. The OSI SAF Climate Data Records (CDRs) can be obtained from the EUMETSAT Data Centre.

There are three main justifications for reprocessing the SeaWinds data record. Firstly, the archived OSI SAF near-real time products do not span the complete 10 years of SeaWinds operations. Secondly, the wind retrievals were improved in the sense that calibration was applied to reduce wind speed biases w.r.t. buoys and that the 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 SeaWinds Wind CDRs on 25 km and 50 km grid spacing, OSI-151. Section 2 presents a brief description of the SeaWinds 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 [5].

1.2. Disclaimer

All intellectual property rights of the OSI SAF products belong to EUMETSAT. The use of these products is granted to every interested user, free of charge. If you wish to use these products, EUMETSAT's copyright credit must be shown by displaying the words "copyright (year) EUMETSAT" on each of the products used.

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

We plan to attach a Digital Object Identifier (DOI) and associated landing page to these data sets. Due to delays in the signature of the DOI contract, a DOI could not yet be established for these CDRs.

2. The SeaWinds scatterometer

The SeaWinds scatterometer is carried on-board the QuikSCAT polar satellite. It was launched on 19 June 1999 into a sun-synchronous orbit with an inclination of 98.6° and a repeat cycle of 4 days (14.25 orbits per day). The local sun time at ascending node is 6:00 AM. The QuikSCAT mission was a 'quick recovery' mission from the National Aeronautics and Space Administration (NASA) to fill the gap created by the loss of data from NSCAT, when the ADEOS-1 satellite lost power in June 1997. The QuikSCAT nominal mission ended on 23 November 2009 due to problems with the SeaWinds instrument antenna spinning mechanism. A similar version of the instrument (SeaWinds-2) flew on the Japanese ADEOS-2 satellite, launched in December 2002, which was regrettably lost in October 2003. For detailed information on the instrument and data we refer to [6] and [7]. A brief description is given below.

The SeaWinds instrument is a conically scanning pencil-beam scatterometer. It uses a 1-meter dish antenna rotating at 18 rpm with two "spot" beams of about 25 km x 55 km size on the ground, a horizontal polarisation beam (HH) and a vertical polarisation beam (VV) at incidence angles of 46º and 54º, respectively, that sweep the surface in a circular pattern as depicted in Figure 1. Note that the egg-shaped beam footprints are divided into slices by applying a modulated chirp signal. Due to the conical scanning, a WVC is generally viewed when looking forward (fore) and a second time when looking aft. As such, up to four measurement classes (called "beam" here) emerge: HH fore, HH aft, VV fore, and VV aft, in each wind vector cell (WVC). The 1800 km-wide swath covers 90% of the ocean surface in 24 hours and represents a substantial improvement compared to side-looking scatterometers like ERS, NSCAT and ASCAT.
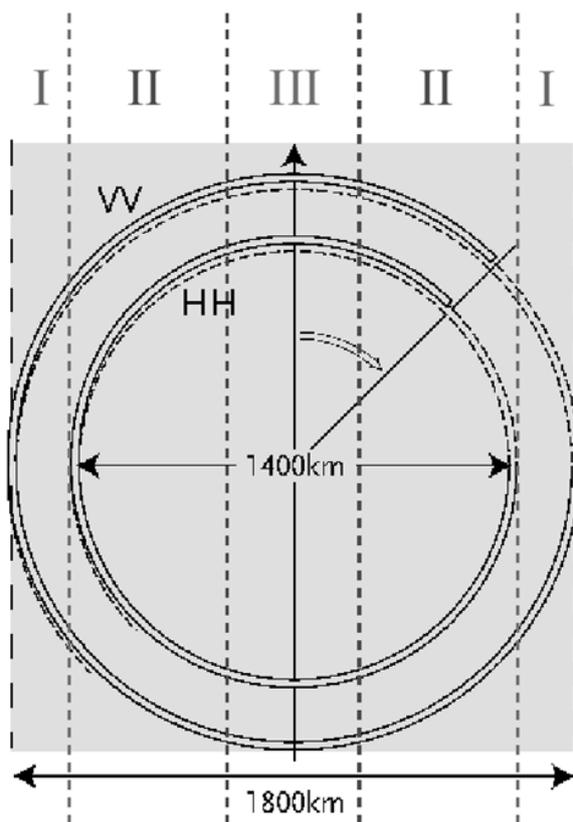
Figure 1: Earth surface coverage of the scans of the horizontal (HH) and vertical polarisation (VV) pencil-beams of SeaWinds. As the satellite propagates towards the top of the page the swath (in grey) is illuminated, and three areas are discriminated:
I: Outer swath: only viewed once by the VV beam in the forward direction, and once in the aft direction (2 views);
II: Sweet (inner) swath: Viewed both by the VV and HH beam, both in fore and aft direction (4 views);
III: Nadir (inner) swath: As II, but the azimuth view direction is close to the satellite propagation direction, or just opposite to it.

On the other hand, the wind retrieval from SeaWinds data is not trivial. In contrast with the side-looking scatterometers, the number of measurements and the beam azimuth angles vary with the sub-satellite cross-track location. The wind retrieval skill will therefore depend on the position in the swath. A detailed discussion is provided in [3]. Here we only summarise some issues specific to SeaWinds.

In the outer swath (where only VV beam data are available), the individual backscatter measurements (slices or eggs) contributing to the VV fore or aft beam in a specific WVC are re-distributed to form four more or less independent backscatter observations. Slices or eggs are accumulated and averaged based on their azimuth angles. The outer swath winds have slightly reduced quality but they are still very well usable. These winds are flagged in the product and can be filtered out easily if requested, see section 5.2.

The SeaWinds scatterometer operates at a Ku-band radar wavelength (13.5 GHz). The atmosphere is not transparent at these wavelengths and in particular rain is detrimental for wind computation. In fact, moderate and heavy rain cause bogus wind retrievals of 15-20 m/s wind speed which need to be eliminated by a quality control step. Wind-rain discrimination is easiest to manage in the sweet swath, but still performs acceptably in nadir and outer swath.

Due to the availability of VV and HH polarisation measurements, discrimination of water and ice surfaces is generally well possible [8]. The SeaWinds Bayesian ice screening algorithm as implemented in SDP was used when creating the CDRs.

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 do data conversions, 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].
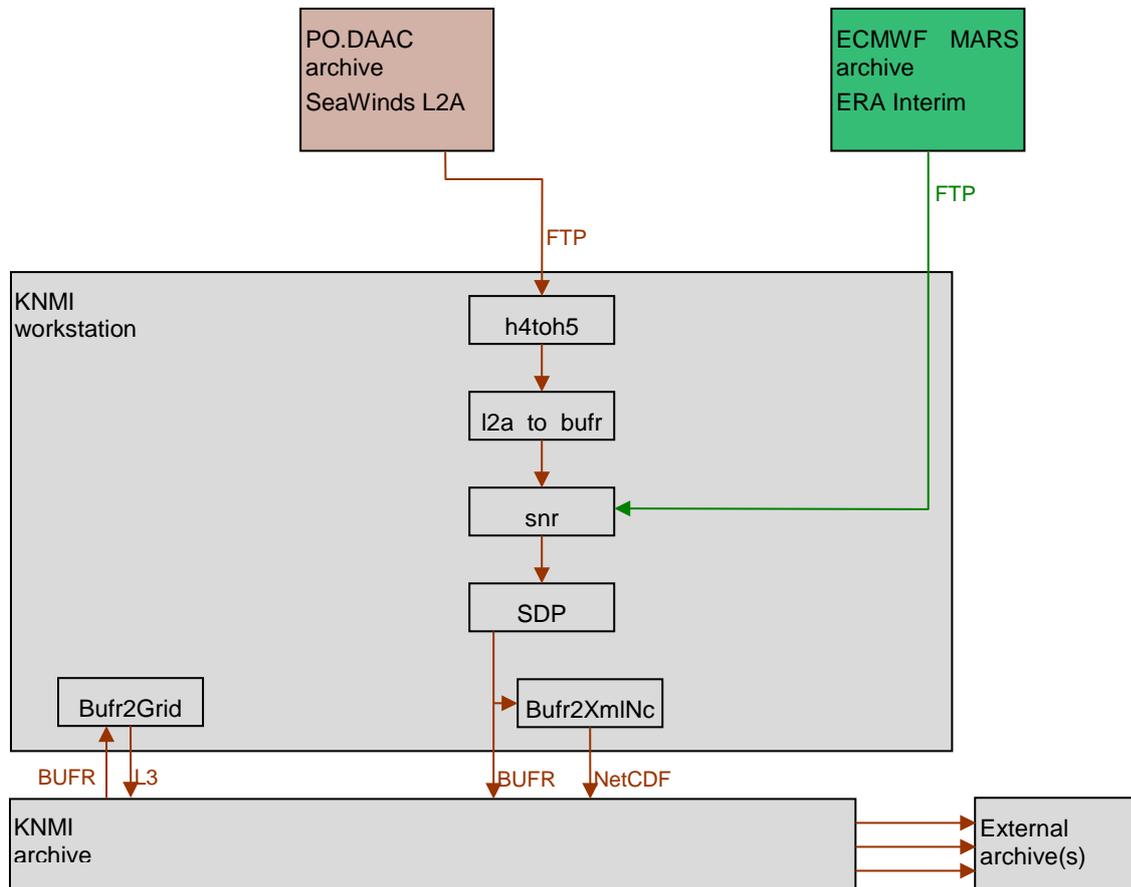
Figure 2: System architecture of reprocessing chain

The following components are shown in Figure 2.

- SDP is the wind processing software for SeaWinds data. It is publicly available in the NWP SAF, see [4].

- h4toh5 is a tool available from the HDF Group which converts the SeaWinds level 2a data from HDF4 into HDF5 format.

- l2a_to_bufr is a tool which was built to convert SeaWinds level 2a data from HDF5 into BUFR format. SDP cannot handle HDF5 data, only BUFR.

- snr (SeaWinds NWP Replacer) is a program to collocate ECMWF model winds with scatterometer data. This functionality is not available in SDP. snr was used in the operational near-real time OSI SAF wind processing until the end of the QuikSCAT mission in 2009.

- 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 MyOcean.

3.1. Backscatter egg averaging

The level 2a backscatter data from JPL are organised in eggs, each σ^0 is based on the sum of the echo energies measured among the eight centre high resolution slices in a single scatterometer pulse. The eggs are beam-wise accumulated to a WVC level by program l2a_to_bufr before wind inversion is done. The egg weights are proportional to the estimated transmitted power contained in an egg, i.e., inversely proportional to the Kp value. The Sigma0 Quality Flag present in the level 2a data is evaluated and egg data with one of the following flags set are skipped:

- Bit 0: Measurement not usable
- Bit 1: Signal to Noise Ratio level low
- Bit 3: Data outside acceptable range
- Bit 4: Pulse quality unacceptable
- Bit 5: Location algorithm does not converge
- Bit 6: Frequency shift beyond range
- Bit 7: Temperature outside range
- Bit 8: No applicable attitude records
- Bit 9: Ephemeris data unacceptable

3.2. Backscatter calibration

No absolute instrumental instrument calibration exists for Ku-band pencil-beam scatterometers. Ku-band pencil-beam backscatter distributions should however be matched to achieve wind intercalibration of all space-borne scatterometer instruments. We thus developed methods that calibrate the winds of each scatterometer effectively to the mean winds at collocated moored buoys. No signs of azimuth (or WVC) dependent instrument biases have been found for QuikSCAT. Also the beam incidence angles are constant and hence we have chosen to apply backscatter corrections that are only dependent on the beam polarisation. The goal of applying backscatter corrections was to remove any wind speed biases between scatterometer winds and buoy winds over the year 2008. The year 2008 was chosen as reference year since in 2008 both SeaWinds and ASCAT data were available and cross calibration can easily be done. With this in mind, the calibration corrections have been obtained such that we get calibration coefficients close to 1.0 from the triple collocation analysis over 2008 [5]. The ratio between HH and VV corrections was obtained such that we get uniform wind speed biases against ERA-Interim winds over the swath both in the regions with HH and VV backscatter data as well as in the regions with VV-only backscatter data (outer swath). In this simple way, within a few iterations the two calibration coefficients could be obtained:

- For HH, 0.25 dB has been added in the 25 km products and 0.18 dB in the 50 km products
- For VV, 0.22 dB has been added in the 25 km products and 0.15 dB in the 50 km products

The constant (WVC independent) σ^0 correction used, yields an average wind speed bias of -0.16 m/s against the buoy winds over the year 2008 for the 25 km product and -0.13 m/s for the 50 km product. The wind speed biases against ERA-Interim winds are 0.0 m/s over the year 2008 both for the 25 km and the 50 km products [5]. Note that the calibrated backscatter values are only available within the wind processing software; the σ^0 data in the BUFR wind product are uncorrected values.

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]. Equivalent neutral (U10N) 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]. 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 are flagged; see section 5.2 for more details.

An information file is made for each product. The content of the file is identical whatever the 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. Data quality is also available to the users within the products; see section 5 for a description of quality flags.

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 is available at www.knmi.nl/scatterometer/bufr_reader/.

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 14.25 QuikSCAT orbits per day, the repeat cycle is 4 days (57 orbits).

Product	Size of one orbit file	Size of 10 years data record
25 km BUFR	11 MB	600 GB
25 km NetCDF (g-zipped)	1.1 MB	60 GB
50 km BUFR	1.8 MB	100GB
50 km NetCDF (g-zipped)	0.3 MB	17 GB

5. Data description

5.1. Wind product characteristics

Physical definition

Horizontal equivalent neutral wind vector at 10 m height, obtained using the NSCAT-4 GMF, see [3].

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 QuikSCAT level 2a input data [7] were obtained from PO.DAAC. These 'Surface Flagged Sigma0s and Attenuations in 25 km Swath Grid' data are so-called egg data, each σ^0 is based on the sum of the echo energies measured among the eight centre high resolution slices in a single scatterometer pulse. The product contains geo-located backscatter measurements on a satellite swath WVC grid of 25 km size.

Geographical definition

The QuikSCAT satellite flies in a near-polar sun synchronous orbit at 98 degrees inclination at approximately 800 km orbit height. Swath width is 76 25 km size WVCs or 38 50 km size WVCs. Products are organised in files containing one orbit, starting at the South Pole.

Output product

The input product in HDF5 is 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). 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 [14]. 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 [5], showing that the actual products are much more accurate.

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 OSI SAF wind product is stored in exactly the same BUFR format as described in the SeaWinds BUFR manual from NOAA [13], a list of descriptors (fields) contained in each WVC is provided in section 8. Data are organised in files containing approximately one orbit (100 minutes) of data.

The file name convention for the level 2 BUFR product is

seawi_YYYYMMDD_HHMMSS_qscat__ORBIT_T_SMPL_CONT_l2.bufr

- 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
- ORBIT is the orbit number of the first data in the file (00000-99999)
- T is the processing type (o for operational, t for test)
- SMPL is the WVC sampling (cell spacing): 250 for the 25 km and 500 for the 50 km product
- CONT refers to the product contents: always ovw for a product containing Ocean Vector Winds

An example of a file name is

seawi_20081231_094032_qscat__49654_o_250_ovw_l2.bufr.

In each node or wind vector cell (WVC) 118 data descriptors are defined. In addition some extra information/alterations have been put in place:

- In the BUFR header the value for "generating centre" is set to 99, representing KNMI.

- The products contain up to four ambiguous wind solutions, with an index to the selected wind solution. After the wind inversion step, we initially store the up to four solutions corresponding to the inversion residual (Maximum Likelihood Estimator, MLE) relative minima. However, subsequently the wind speed and wind direction of the after 2DVAR-selected MSS wind solution is put at the index of the selected wind solution. This index is set to the initial wind vector solution which is closest to the MSS wind vector selection obtained after 2DVAR. Thus, the former wind vector is not provided in the product, but rather the MSS selected wind vector. The 'Formal Uncertainty in Wind Direction' does not contain the uncertainty, but the normalised inversion residual (referred to as Rn in [15]).

- The Wind Vector Cell Quality Flag (table 021109) is redefined and now has the following definitions:

Description	BUFR bit	Fortran bit
Not enough good sigma-0 available for wind retrieval	1	15
Not used	2	14
VV polarised data in more than two beams	3	13
Product monitoring not used	4	12
Product monitoring flag	5	11
KNMI Quality Control (including rain) data rejection	6	10
Variational QC data rejection	7	9
Land presence	8	8
Ice presence	9	7
Not used	10	6
Reported wind speed is greater than 30 m/s	11	5
Reported wind speed is less than or equal to 3 m/s	12	4
Not used	13	3
Rain flag algorithm detects rain	14	2
Data from at least one of the four possible beam/view combinations are not available	15	1
Not used	16	0
Missing value	All 17 set	All 17 set

In Fortran, if the Wind Vector Cell Quality Flag is stored in an integer **I** then use **BTEST(I,NDW-NB-1)** to test BUFR bit **NB**, where **NDW**=17 is the width in bits of the data element in BUFR.

The flag indicating that more than two beams contain VV polarised data, BUFR bit 3, is active in the outer part of the swath (WVCs 1-8 and 69-76 at 25 km, WVCs 1-4 and 35-38 at 50 km). It indicates that outer beam data is used to obtain four independent σ^0 values, contrary to the middle part of the swath where two beams contain VV (outer beam) data and two beams contain HH (inner beam) data. In the outer parts of the swath, the VV backscatter data present in the level 2a product are distributed to two WVC beams based on their azimuth angle such that maximum azimuth dispersion is obtained. This generally results in slightly less optimal wind retrieval; users assimilating the data into NWP models may consider to reject WVCs for which this flag is set.

If the 'product monitoring not used' bit is set to zero, the product is monitored. If the product is monitored and the 'product monitoring flag' bit 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 PO.DAAC input data set, product monitoring rejection does not occur in the wind CDRs.

If the KNMI QC flag is set in a WVC, then the backscatter information is not useable for various geophysical reasons like rain, confused sea-state etc, resulting in a too large inversion residual. 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 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 ice presence flag 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 rain), 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 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.

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[14] Thesis *Scatterometry* by Ad Stoffelen, 1998 (*)

[15] Thesis *Wind Field Retrieval from Satellite radar systems* by Marcos Portabella, 2002 (*)

References marked with a (*) are available on http://www.knmi.nl/scatterometer/publications/.

7. Abbreviations and acronyms

2DVAR	Two-dimensional Variational Ambiguity Removal
ATBD	Algorithm Theoretical Basis Document
AR	Ambiguity Removal
ASCAT	Advanced Scatterometer
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
HDF	Hierarchical Data Format
HH	Horizontal polarisation of sending and receiving radar antennas
KNMI	Royal Netherlands Meteorological Institute
MLE	Maximum Likelihood Estimator
MSS	Multiple Solution Scheme
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
SDP	SeaWinds Data Processor
SeaWinds	Scatterometer on-board QuikSCAT platform (USA)
snr	SeaWinds NWP Replacer
SSI	Surface Solar Irradiance
SST	Sea Surface Temperature
u	West-to-east (zonal) wind component
v	South-to-north (meridional) wind component
VV	Vertical polarisation of sending and receiving radar antennas
WMO	World Meteorological Organisation
WVC	Wind Vector Cell

8. Appendix A: BUFR data descriptors

Number	Descriptor	Parameter	Unit
001	(01007)	Satellite Identifier	Code Table
002	(01012)	Direction of Flight	Degree True
003	(02048)	Satellite Instrument Identifier	Code Table
004	(21119)	Wind Scatterometer GMF	Code Table
005	(25060)	Software Identification	Numeric
006	(02026)	Cross Track Resolution	m
007	(02027)	Along Track Resolution	m
008	(05040)	Orbit Number	Numeric
009	(04001)	Year	Year
010	(04002)	Month	Month
011	(04003)	Day	Day
012	(04004)	Hour	Hour
013	(04005)	Minute	Minute
014	(04006)	Second	Second
015	(05002)	Latitude (Coarse Accuracy)	Degree
016	(06002)	Longitude (Coarse Accuracy)	Degree
017	(08025)	Time Difference Qualifier	Code Table
018	(04001)	Time to Edge	Second
019	(05034)	Along Track Row Number	Numeric
020	(06034)	Cross Track Cell Number	Numeric
021	(21109)	Seawinds Wind Vector Cell Quality Flag	Flag Table
022	(11081)	Model Wind Direction At 10 M	Degree True
023	(11082)	Model Wind Speed At 10 M	m/s
024	(21101)	Number of Vector Ambiguities	Numeric
025	(21102)	Index of Selected Wind Vector	Numeric
026	(21103)	Total Number of Sigma0 Measurements	Numeric
027	(21120)	Seawinds Probability of Rain	Numeric
028	(21121)	Seawinds NOF Rain Index	Numeric
029	(13055)	Intensity Of Precipitation	kg/m**2/sec
030	(21122)	Attenuation Correction On Sigma-0 (from Tb)	dB
031	(11012)	Wind Speed At 10 M	m/s
032	(11052)	Formal Uncertainty In Wind Speed	m/s
033	(11011)	Wind Direction At 10 M	Degree True
034	(11053)	Formal Uncertainty In Wind Direction	Degree True
035	(21104)	Likelihood Computed for Wind Solution	Numeric
036	(11012)	Wind Speed At 10 M	m/s
037	(11052)	Formal Uncertainty In Wind Speed	m/s
038	(11011)	Wind Direction At 10 M	Degree True
039	(11053)	Formal Uncertainty In Wind Direction	Degree True
040	(21104)	Likelihood Computed for Wind Solution	Numeric
041	(11012)	Wind Speed At 10 M	m/s
042	(11052)	Formal Uncertainty In Wind Speed	m/s
043	(11011)	Wind Direction At 10 M	Degree True
044	(11053)	Formal Uncertainty In Wind Direction	Degree True
045	(21104)	Likelihood Computed for Wind Solution	Numeric
046	(11012)	Wind Speed At 10 M	m/s
047	(11052)	Formal Uncertainty In Wind Speed	m/s
048	(11011)	Wind Direction At 10 M	Degree True
049	(11053)	Formal Uncertainty In Wind Direction	Degree True
050	(21104)	Likelihood Computed for Wind Solution	Numeric
051	(02104)	Antenna Polarisation	Code Table

Number	Descriptor	Parameter	Unit
052	(08022)	Total Number w.r.t. accumulation or average	Numeric
053	(12063)	Brightness Temperature	K
054	(12065)	Standard Deviation Brightness Temperature	K
055	(02104)	Antenna Polarisation	Code Table
056	(08022)	Total Number w.r.t. accumulation or average	Numeric
057	(12063)	Brightness Temperature	K
058	(12065)	Standard Deviation Brightness Temperature	K
059	(21110)	Number of Inner-Beam Sigma0 (fwd of sat.)	Numeric
060	(05002)	Latitude (Coarse Accuracy)	Degree
061	(06002)	Longitude (Coarse Accuracy)	Degree
062	(21118)	Attenuation Correction On Sigma-0	dB
063	(02112)	Radar Look (Azimuth) Angle	Degree
064	(02111)	Radar Incidence Angle	Degree
065	(02104)	Antenna Polarisation	Code Table
066	(21105)	Normalized Radar Cross Section	dB
067	(21106)	Kp Variance Coefficient (Alpha)	Numeric
068	(21107)	Kp Variance Coefficient (Beta)	Numeric
069	(21114)	Kp Variance Coefficient (Gamma)	dB
070	(21115)	Seawinds Sigma-0 Quality Flag	Flag Table
071	(21116)	Seawinds Sigma-0 Mode Flag	Flag Table
072	(08018)	Seawinds Land/Ice Surface Flag	Flag Table
073	(21117)	Sigma-0 Variance Quality Control	Numeric
074	(21111)	Number of Outer-Beam Sigma0 (fwd of sat.)	Numeric
075	(05002)	Latitude (Coarse Accuracy)	Degree
076	(06002)	Longitude (Coarse Accuracy)	Degree
077	(21118)	Attenuation Correction On Sigma-0	dB
078	(02112)	Radar Look (Azimuth) Angle	Degree
079	(02111)	Radar Incidence Angle	Degree
080	(02104)	Antenna Polarisation	Code Table
081	(21105)	Normalized Radar Cross Section	dB
082	(21106)	Kp Variance Coefficient (Alpha)	Numeric
083	(21107)	Kp Variance Coefficient (Beta)	Numeric
084	(21114)	Kp Variance Coefficient (Gamma)	dB
085	(21115)	Seawinds Sigma-0 Quality Flag	Flag Table
086	(21116)	Seawinds Sigma-0 Mode Flag	Flag Table
087	(08018)	Seawinds Land/Ice Surface Flag	Flag Table
088	(21117)	Sigma-0 Variance Quality Control	Numeric
089	(21112)	Number of Inner-Beam Sigma0 (aft of sat.)	Numeric
090	(05002)	Latitude (Coarse Accuracy)	Degree
091	(06002)	Longitude (Coarse Accuracy)	Degree
092	(21118)	Attenuation Correction On Sigma-0	dB
093	(02112)	Radar Look (Azimuth) Angle	Degree
094	(02111)	Radar Incidence Angle	Degree
095	(02104)	Antenna Polarisation	Code Table
096	(21105)	Normalized Radar Cross Section	dB
097	(21106)	Kp Variance Coefficient (Alpha)	Numeric
098	(21107)	Kp Variance Coefficient (Beta)	Numeric
099	(21114)	Kp Variance Coefficient (Gamma)	dB
100	(21115)	Seawinds Sigma-0 Quality Flag	Flag Table
101	(21116)	Seawinds Sigma-0 Mode Flag	Flag Table
102	(08018)	Seawinds Land/Ice Surface Flag	Flag Table
103	(21117)	Sigma-0 Variance Quality Control	Numeric
104	(21113)	Number of Outer-Beam Sigma0 (aft of sat.)	Numeric
105	(05002)	Latitude (Coarse Accuracy)	Degree
106	(06002)	Longitude (Coarse Accuracy)	Degree

Number	Descriptor	Parameter	Unit
107	(21118)	Attenuation Correction On Sigma-0	dB
108	(02112)	Radar Look (Azimuth) Angle	Degree
109	(02111)	Radar Incidence Angle	Degree
110	(02104)	Antenna Polarisation	Code Table
111	(21105)	Normalized Radar Cross Section	dB
112	(21106)	Kp Variance Coefficient (Alpha)	Numeric
113	(21107)	Kp Variance Coefficient (Beta)	Numeric
114	(21114)	Kp Variance Coefficient (Gamma)	dB
115	(21115)	Seawinds Sigma-0 Quality Flag	Flag Table
116	(21116)	Seawinds Sigma-0 Mode Flag	Flag Table
117	(08018)	Seawinds Land/Ice Surface Flag	Flag Table
118	(21117)	Sigma-0 Variance Quality Control	Numeric

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://cf-pcmdi.llnl.gov/).
- 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 SeaWinds, ASCAT 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 11 MB in BUFR and 4 MB in NetCDF). When compressed with gzip, the size of one file in NetCDF reduces to 1.1 MB.

The file name convention for the gzipped NetCDF product is

seawi_YYYYMMDD_HHMMSS_qscat__ORBIT_T_SMPL_VERS_CONT_l2.nc.gz 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 SDP software version (2202 for this data record). A file name example is: seawi_20080101_005132_qscat__44444_o_250_2202_ovw_l2.nc.gz.

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

```
dimensions:
        NUMROWS = 1624 ;
        NUMCELLS = 76 ;
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 = "QuikSCAT SeaWinds Level 2 25.0 km Ocean Surface Wind
Vector Product" ;
                :title_short_name = "SeaWinds-L2-25km" ;
                :Conventions = "CF-1.4" ;
                :institution = "EUMETSAT/OSI SAF/KNMI" ;
                :source = "QuikSCAT SeaWinds" ;
                :software_identification_level_1 = 2202 ;
                :instrument_calibration_version = 0 ;
                :software_identification_wind = 2202 ;
                :pixel_size_on_horizontal = "25.0 km" ;
                :service_type = "N/A" ;
                :processing_type = "O" ;
                :contents = "ovw" ;
                :granule_name =
"seawi_20080101_005132_qscat__44444_o_250_2202_ovw_l2.nc" ;
                :processing_level = "L2" ;
                :orbit_number = 44444 ;
                :start_date = "2008-01-01" ;
                :start_time = "00:51:32" ;
                :stop_date = "2008-01-01" ;
                :stop_time = "02:32:27" ;
                :equator_crossing_longitude = "  97.082" ;
                :equator_crossing_date = "2007-12-31" ;
                :equator_crossing_time = "23:35:45" ;
                :rev_orbit_period = "6059.1" ;
                :orbit_inclination = "98.6" ;
                :history = "N/A" ;
                :references = "SeaWinds Product 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 = "2014-10-27" ;
                :creation_time = "09:57:40" ;
```

10. Appendix C: Data gaps

The table below shows the gaps with a length of at least one orbit in the SeaWinds Data Record.

Start date	End date	Last orbit before gap	First orbit after gap	Number of missing orbits
17-Nov-1999	19-Nov-1999	2144	2172	27
1-Jan-2000	2-Jan-2000	2792	2811	18
20-Jan-2000	21-Jan-2000	3067	3071	3
18-Jul-2000	19-Jul-2000	5626	5637	10
28-Aug-2000	29-Aug-2000	6216	6219	2
16-Nov-2000	18-Nov-2000	7355	7386	30
11-May-2001	14-May-2001	9858	9908	49
7-Jul-2001	9-Jul-2001	10666	10695	28
17-Nov-2001	19-Nov-2001	12571	12600	28
19-Mar-2002	21-Mar-2002	14305	14330	24
4-Jul-2002	4-Jul-2002	15830	15837	6
19-Aug-2002	20-Aug-2002	16491	16505	13
18-Nov-2002	20-Nov-2002	17787	17808	20
19-May-2003	20-May-2003	20384	20390	5
11-Sep-2003	12-Sep-2003	22027	22030	2
17-Dec-2003	18-Dec-2003	23410	23424	13
6-Aug-2004	6-Aug-2004	26721	26730	8
17-Jun-2006	17-Jun-2006	36417	36427	9
15-Jul-2006	17-Jul-2006	36820	36856	35
11-Nov-2006	12-Nov-2006	38523	38528	4
3-Mar-2007	3-Mar-2007	40112	40116	3
7-Apr-2007	8-Apr-2007	40618	40622	3
6-Dec-2007	7-Dec-2007	44085	44097	11
24-Jun-2008	25-Jun-2008	46942	46963	20
25-Nov-2008	28-Nov-2008	49148	49191	42
6-Dec-2008	6-Dec-2008	49295	49303	7
3-Sep-2009	5-Sep-2009	53167	53197	29