EUMETSAT OSI SAF
OCEAN AND SEA ICE

CWDP Test Plan and Test Report

CFOSAT Wind Data Processor

Version 1.0
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1. Introduction

This document describes the test plan and test report for the CFOSAT software package. It is set up according to the guidelines of the NWP SAF, see the NWP SAF Development Procedures for Software Deliverables [5]. Parts of the development of CFOSAT include genscat developments and the tests of genscat modules are also included in this document. A large part of the code in genscat is used by PenWP and other NWP SAF wind processors. For CFOSAT here, all module tests have been repeated.

1.1 Aims and scope

The CFOSAT Wind Data Processor (CWDP) is a software package written mainly in Fortran 90. The parts and libraries for handling HDF5, NetCDF, and BUFR format data have been partly written in C. It is intended to be a generic wind processor for Ku-band rotating fan-beam scatterometer data. It is capable of handling data from future instruments such as WindRAD with certain adaptations.

CWDP derives surface winds based on rotating fan beam radar backscatter data. It supports the ambiguity removal with the Two-dimensional Variational Ambiguity Removal (2DVAR) and the Multiple Solution Scheme (MSS). The input of CWDP is the Normalized Radar Cross Section (NRCS $\sigma°$) and their geometries (azimuth, incidence angle, and polarization, etc.). They are in BUFR format. The output of CWDP are the retrieved wind vectors representing the surface winds in the ground swath of the scatterometer. The output can be provided in two formats: BUFR and NetCDF.

CWDP is able to process data with 25 km or 50 km swath grid spacing depending on the input data resolution. In the conversion from L1B to L2A, the convertor aggregates L1B data into 25 km or 50 km grid spacing BUFR data as L2A input file to CWDP. After wind processing BUFR data can be transferred into NetCDF format.

Numerical Weather Prediction (NWP) model winds are also needed for CWDP as a first guess for the Ambiguity Removal step (AR), those need to be provided in GRIB file format.

1.2 Development of CWDP

CWDP is developed within EUMETSAT Ocean and Sea Ice (OSI) and NWP Satellite Application Facilities (SAFs). Originally the wind software packages were NWP SAF products but from the beginning of the CDOP3 SAF phase, they are OSI SAF products. The packages are still distributed through the NWP SAF web site. CWDP will run on Unix or Linux platforms. It is also possible to run on a Windows machine if a Linux environment like the Windows Installer for Ubuntu (Wubi) is installed. Details of the CWDP package and its system requirements can be found in [1] and [2].

1.3 Testing CWDP, traceability matrix

This section describes the Test Plan of the CWDP deliverable. Tests have been carried out in all stages of the development of CWDP. The inversion module is not tested here because it has been tested for the QuikSCAT Data Processor (QDP) development. Compilation is done on the Linux platform with a Fortran 90 compiler.

The following section 2 contains a number of module tests. Those modules are tested with associated programs under the folders where the modules are. The output of the test programs is the standard output on a terminal screen or/and some output files saved in the corresponding folders. Section 3 describes the integration test of CWDP. A folder with test data is available for CWDP and the retrieved wind field of the test data is shown. Section 4 gives validation tests. CWDP wind retrieval result is compared with ECMWF model winds. Section 5 describes the portability tests and section 6 describes the user documentation test.

The table below is the traceability matrix. It shows the requirements in the Product Specification (PS) [1], User Manual (UM) [2], and Top Level Design (TL) [6], how they are tested and where in this report these tests are described.

Table 1 Traceability matrix.

Require-ment		**Section of PS or UM**	**Testing method**	**Test plan reference (section)**	**Passed?**
CWDP-001	CWDP generates output in the same WVC spacing as the input data (L2A HDF5)	PS2.1, PS2.2, PS2.3 PS3.1	Process L1B file in cwdp/execs folder and inspect output	3.1	Passed
CWDP-002	CWDP aggregates	PS2.1	Process L2A HDF5	3.1	Passed

Require-ment		Section of PS or UM	Testing method	Test plan reference (section)	Passed?
	L2A HDF5 data into views and process into BUFR and NetCDF files	PS2.2 PS3.3	data in cwdp/execs folder and subsequently reprocess BUFR and NetCDF output		
CWDP-003	CWDP generates sea surface winds	UM2.1 UM2.2	Process L2A BUFR data in cwdp/execs folder and inspect output	3.1	Passed
CWDP-004	L2A backscatter slices are averaged into a regular WVC swath grid.	PS2.1	Process a few orbits of data, check WVC swath grid, and compare output winds to ECMWF background winds.	3.1, 4	Passed
CWDP-005	CWDP can process one orbit within 5 minutes wall clock time.	PS2.3, UM2.2, TL1.1	Process L1B file into L2B file and check total processing time.	3.1	Passed
CWDP-006	CWDP will compile and run on Linux platforms and with different Fortran compilers	PS2.3, UM2.2	Compile and run PenWP on different platforms	5	Passed
CWDP-007	Wind accuracy better than 2 m/s in wind component std. dev. with a bias of less than 0.5 m/s in wind speed	TL1.1	Process at least one day of data and compare output winds to ECMWF background.	3.2, 4	Passed

1.4 Test folders

The Test folder of the CWDP software package is located in subdirectory `cwdp/test_data` and `cwdp/execs`. These subdirectories contain a number of input files for CWDP that are discussed in more detail in section 3. The scripts for executing these tests are located in directory `cwdp/execs`. It is recommended to use these scripts (or a modified version) also for normal CWDP operation, as the environment variables needed by CWDP are set in these scripts.

1.5 Conventions

Names of physical quantities (e.g., wind speed components *u* and *v*), modules (e.g. *BufrMod*), subroutines and identifiers are printed italic.

Names of directories and subdirectories (e.g. `cwdp/src`), files (e.g. `cwdp.F90`), and commands (e.g. `cwdp -f input`) are printed in Courier. Software systems in general are addressed using the normal font (e.g. CWDP, genscat).

Hyperlinks are printed in blue and underlined (e.g. https://scatterometer.knmi.nl/).

2. Module tests

Tests for individual modules within CWDP are presented in this section. The tests are listed alphabetically by the module names in Table 2. Table 2 shows the name of tested modules, location and the name of the associated test programs.

Module tests have been included in CWDP if the following conditions were satisfied:

1. The test does not need additional software.
2. The output of the test program is able to judge the quality of the outcome of the test by itself.

Most of the tests are the same as in PenWP and the new tests for CFOSAT are `NetCDFMod` and `bufr_data_extraction_module`.

`NetCDFMod` and `bufr_data_extraction_module` are described in section 2.1 and 2.2. The other tests can be seen in [3].

Table 2 list of tested modules [3].

(`NetCDFMod` and `bufr_data_extraction_module` are added in the end of the list).

Module name	Location	Test program
BFGSMod	`genscat/support/BFGS`	*Test_BFGS*
BufrMod	`genscat/support/bufr`	*test_modules*
convert	`genscat/support/convert`	*test_convert*
CostFunction	`genscat/ambrem/twodvar`	*Test_SOS*
StrucFunc	`genscat/ambrem/twodvar`	*Test_SOS*
DateTimeMod	`genscat/support/datetime`	*TestDateTimeMod*
ErrorHandler	`genscat/support/ErrorHandler`	*TestErrorHandler*
gribio_module	`genscat/support/grib`	*test_read_GRIB1, test_read_GRIB2, test_read_GRIB3*
HDF5Mod	`genscat/support/hdf5`	*TestHDF5*
LunManager	`genscat/support/file`	*TestLunManager*
numerics	`genscat/support/num`	*test_numerics*
SingletonFFT	`genscat/support/singletonfft`	*TestSingleton*
SortMod	`genscat/support/sort`	*SortModTest*
NetCDFMod	`genscat/support/netcdf`	*TestNetCDF*
bufr_data_extraction_module	`genscat/tools/bufr_l2_reader`	*test_bufr_data_extraction_module*

2.1 Module NetCDF

Directory `genscat/support/netcdf` contains the program `TestNetCDF` for testing `NetCDFMod`. The test program creates a small NetCDF test file called '`testfile.nc`' using the interface routines and the UCAR/UNIDATA software package. Part of the file contents is shown in Table 3 and the contents can be checked with command line utility `ncdump`.

Table 3 Output of program *TestNetCDF*.

```
netcdf testfile {
dimensions:
        observation = 4 ;
variables:
        short dum_short(observation) ;
                dum_short:_FillValue = -32767s ;
                dum_short:missing_value = -32767s ;
                dum_short:valid_min = -10s ;
                dum_short:valid_max = 9890s ;
                dum_short:standard_name = "dum_short_var" ;
                dum_short:long_name = "dummy short variable" ;
                dum_short:units = "1" ;
                dum_short:scale_factor = 0.01 ;
                dum_short:add_offset = 0.1 ;
        int dum_int(observation) ;
                dum_int:_FillValue = -2147483647 ;
                dum_int:missing_value = -2147483647 ;
                dum_int:valid_min = 0 ;
                dum_int:valid_max = 999 ;
                dum_int:standard_name = "dum_int_var" ;
                dum_int:long_name = "dummy integer variable" ;
                dum_int:units = "1" ;
        float dum_float(observation) ;
                dum_float:_FillValue = -999999.9f ;
                dum_float:missing_value = -999999.9f ;
                dum_float:valid_min = 0.f ;
                dum_float:valid_max = 999.f ;
                dum_float:long_name = "dummy float variable" ;
                dum_float:units = "1" ;
        double dum_double(observation) ;
                dum_double:_FillValue = -999999.9 ;
                dum_double:missing_value = -999999.9 ;
                dum_double:valid_min = 0. ;
                dum_double:valid_max = 999. ;
                dum_double:long_name = "dummy double variable" ;
                dum_double:units = "1" ;

// global attributes:
                :title = "Dummy NetCDF test file" ;
data:

 dum_short = 0, 1, 2, _ ;

 dum_int = 0, 2, 4, _ ;

 dum_float = 0, 3.3, 6.6, _ ;

 dum_double = 0, 4.8, 9.6, _ ;
}
```

2.2 Module bufr_data_extraction_module

Directory `genscat/tools/bufr_l2_reader` contains the program `test_bufr_data_extraction_module` for testing the `bufr_data_extraction_module`. The test program extracts information from a BUFR file named `rapid_20141128_004759_iss____01018_o_250_ovw_l2.bufr`. Part of the file contents is shown in Table 4.

Table 4 Output of program *test_bufr_data_extraction_module.*

```
Data in SeaWinds format
 results for message:            3  and subset:           38
 get_mspd(tbd) =    8.97999954
 incident angles:    47.8699989       1.69999998E+38   47.8400002       54.4000015      [deg]
 azimuth angles:    352.190002       1.69999998E+38   2.42999268       34.5000000      [deg]
 sigma0 values:   -26.0000000       1.69999998E+38  -25.9200001      -20.2700005      [dB]
 polarisation:            0           0           0           1  [0=HH, 1=VV]
 results for message:            4  and subset:           37
 get_mspd(tbd) =    8.60000038
 incident angles:    47.8899994       1.69999998E+38   47.8499985       54.4399986      [deg]
 azimuth angles:    347.130005       1.69999998E+38   14.6000061       37.8200073      [deg]
 sigma0 values:   -24.9699993       1.69999998E+38  -25.2500000      -20.5300007      [dB]
 polarisation:            0           0           0           1  [0=HH, 1=VV]
 results for message:            4  and subset:           38
 get_mspd(tbd) =    8.44999981
 incident angles:    47.8699989       1.69999998E+38   47.8400002       54.4000015      [deg]
 azimuth angles:    350.339996       1.69999998E+38   1.11999512       33.7000122      [deg]
 sigma0 values:   -25.4899998       1.69999998E+38  -25.6000004      -21.0200005      [dB]
 polarisation:            0           0           0           1  [0=HH, 1=VV]
 results for message:            5  and subset:           37
 get_mspd(tbd) =    8.06999969
 incident angles:    47.8899994       1.69999998E+38   47.8499985       54.4599991      [deg]
 azimuth angles:    345.859985       1.69999998E+38   14.8900146       38.6699829      [deg]
sigma0 values:   -24.7099991       1.69999998E+38  -24.6000004      -19.8899994      [dB]
```

3. CWDP integration test

3.1 Integration test for one orbit data

Directory `cwdp/execs/` contains the necessary executable files for the integration test. The executable files are `cfosat_l1b_l2a`, `cfosat_hdf2bufr`, and `cwdp`. The user can test the proper functioning of CWDP (L1B to L2A and L2A to L2B) by reading in L1B data with `cfosat_l1b_l2a` (the location of ECWMF wind model data is defined in `cwdp_l1b_l2a_retrieval_deliver`).

1. Set environment variable (they are included in the bash file `cwdp_l1b_l2a_retrieval_deliver`):

```
export BUFR_TABLES=../../genscat/support/bufr/bufr_tables/
export GRIB_DEFINITION_PATH=../../genscat/support/grib/definitions
export LUT_FILENAME_KU_HH=../data/little_endian/nscat4ds_250_73_51_hh.dat
export LUT_FILENAME_KU_VV=../data/little_endian/nscat4ds_250_73_51_vv.dat
export LUTSDIR=../data/
export NWPDIR=(defined by user)
```

2. Run a bash file `cwdp_l1b_l2a_retrieval_deliver` located in `cwdp/execs` with one orbit L1B data (`CFO_OPER_SCA_L1B_OR_C_20181219T000418_20181219T014321_00771_01.nc`).

   Use following command lines in the bash file starting with:

```
./cfosat_l1b_l2a *
./cfosat_hdf2bufr*
./cwdp *
```

`cfosat_l1b_l2a` aggregates L1B data to L2A data `L2A_25km_cfosat_20181219T000418_20181219T014321_00771_01.h5`

`cfosat_hdf2bufr` converts HDF5 format to BUFR format `L2A_25km_cfosat_20181219T000418_20181219T014321_00771_01.bufr`.

`cwdp` takes the BUFR file and ECMWF wind data to retrieve the wind field L2B data in CFOSAT BUFR format and quality monitoring text file:

`rfsca_20181219_000453_cfosat_00770_o_250_ovw_l2.bufr`

`rfsca_20181219_000453_cfosat_00770_o_250_ovw_l2.bufr.mon`

Note that the L2A file name convention is the same as L1B data, while the L2B file name convention is a bit different. `000453` is the actual scan starting time and not the orbit starting time, `00770` is equal to orbit number minus one.

3. Output format standardization:

   L2A BUFR format and L2B BUFR format are converted into NetCDF by entering the following commands in the terminal.

```
genscat/tools/bufr2nc_cfosat_L2A/Bufr2Nc <bufr file name> <nc file name>
genscat/tools/bufr2nc_cfosat_L2B/Bufr2Nc <bufr file name> <nc file name>
```

Figure 1 shows the global coverage of the one orbit CWDP test run on 25 km WVC. The color indicates the value of the wind speed. Figure 2 shows the detailed wind vector plots located at the marked area in Figure 1, with 25 km WVC spacing. In Figure 2, the purple wind arrows indicate that the Variational Quality Control flag is set, i.e. the Wind Vector Cell is spatially inconsistent. The orange wind vector means that the KNMI Quality Control flag (MLE flag) is set. The red wind vector means both the KNMI QC flag and Var QC flag are set.

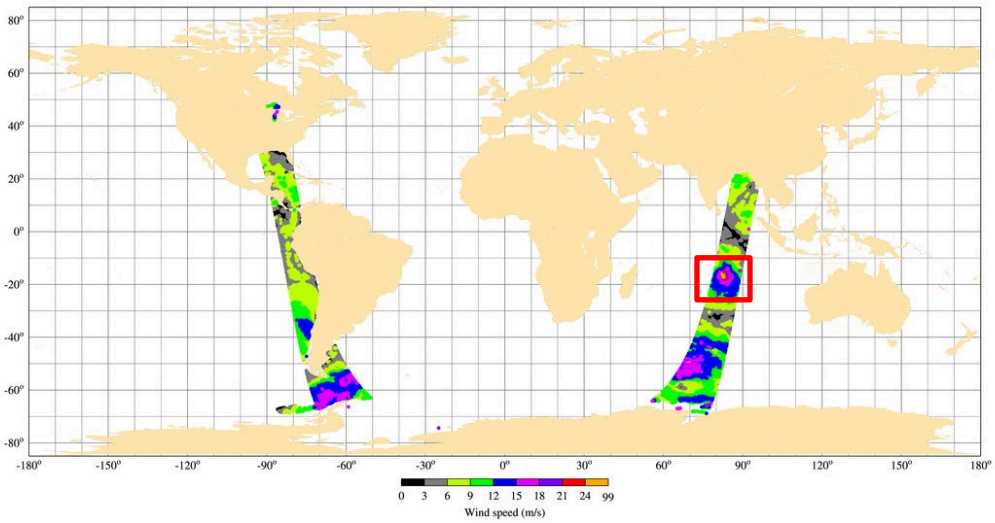

Figure 1 Global coverage of the CFOSAT test run, one orbit (`CFO_OPER_SCA_L1B_OR_C_20181219T000418_20181219T014321_00771_01.nc`), wind speed result of 25 km product.

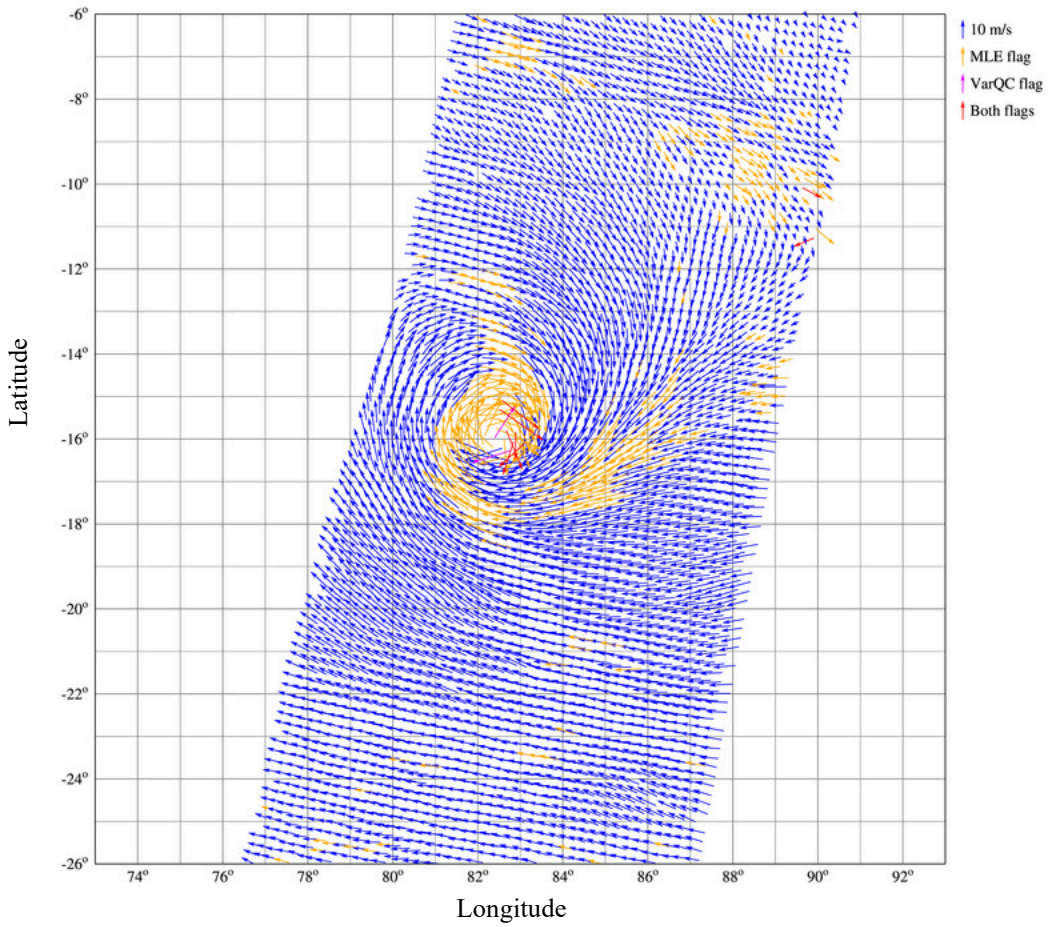

Figure 2 Detail plot of CFOSAT test run, orbit `CFO_OPER_SCA_L1B_OR_C_20181219T000418_20181219T014321_00771_01`), 25 km product.

The wind vector cells in Figure 2 are clearly on a regular swath grid which indicates that the backscatter slice averaging works well. We can simply approximate the WVC spacing from Figure 2. There are 42 wind vectors across track visible spanning a longitude range of 9.5°. So the WVC spacing is 9.5/42=0.226°. The earth circumference at the plot area latitude (15° south) is approximately 40,000×cos(-15°)=38,637 km. This leads to a WVC spacing of 0.226/360×38,639=24.3 km, close to the nominal 25 km grid spacing.

The processing times (wall clock time) for the different steps on a Fedora Linux workstation with Intel Xeon 3.6 GHz CPUs are:

- 66 seconds for L1B NetCDF -> L2A HDF5 (cfosat_l1b_l2a) – should be less than 90 sec.
- 8 seconds for L2A HDF5 -> L2A BUFR (cfosat_hdf2bufr) – should be less than 30 sec.
- 48 seconds for L2A BUFR -> L2B BUFR (cwdp) – should be less than 180 sec.

3.2 Integration test for one day's data (17 orbits)

The number of orbits of the day (2019-12-19) used for the integration test is 17. The commands for generating and processing these 17 orbits are integrated into one bash file `cwdp/execs/cwdp_l1b_l2a_retrieval_deliver`. Users need to define the locations of the ECMWF grib data and L1B data for the day 2019-12-19 by themselves in `cwdp_l1b_l2a_retrieval_deliver`.

Figure 2 shows the global coverage of the 17 orbits CWDP test run on 25 km WVC. The color indicates the value of the wind speed. Table 5 is the decoded CFOSAT BUFR format of one WVC. Note that in the BUFR content, many parameters are called as 'SeaWinds' due to the heritage from the BUFR template which was originally designed for SeaWinds.

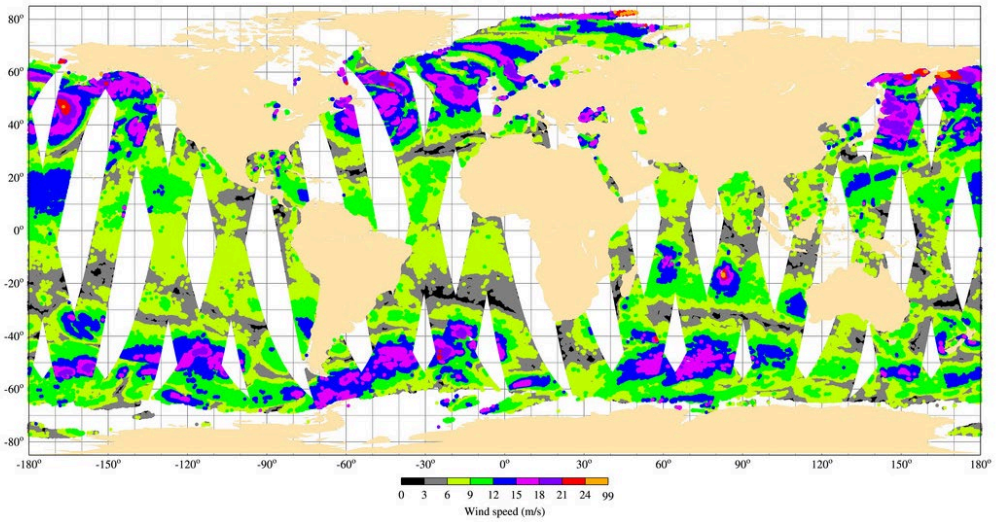

Figure 3 Global coverage of the CFOSAT test run, 17 orbit from day 2019-12-19, wind speed result of 25 km product.

Table 5 Wind Vector Cell in CFOSAT BUFR format

1	SATELLITE IDENTIFIER	0.802000000000000E+003	CODE TABLE 1007
2	DIRECTION OF MOTION OF MOVING OB	0.348000000000000E+003	DEGREE TRUE
3	SATELLITE SENSOR INDICATOR	MISSING	CODE TABLE 2048
4	WIND SCATTEROMETER GEOPHYSICAL M	0.900000000000000E+001	CODE TABLE 21119
5	SOFTWARE IDENTIFICATION (SEE NOT	0.901000000000000E+003	NUMERIC
6	CROSS TRACK RESOLUTION	0.250000000000000E+005	M
7	ALONG TRACK RESOLUTION	0.250000000000000E+005	M
8	ORBIT NUMBER	0.465000000000000E+004	NUMERIC
9	YEAR	0.201900000000000E+004	YEAR

```
 10 MONTH                                0.90000000000000E+001 MONTH
 11 DAY                                  0.10000000000000E+001 DAY
 12 HOUR                                 0.10000000000000E+001 HOUR
 13 MINUTE                               0.22000000000000E+002 MINUTE
 14 SECOND                               0.35000000000000E+002 SECOND
 15 LATITUDE (COARSE ACCURACY)          -0.33100000000000E+002 DEGREE
 16 LONGITUDE (COARSE ACCURACY)         -0.87730000000000E+002 DEGREE
 17 TIME DIFFERENCE QUALIFIER            0.50000000000000E+001 CODE TABLE 8025
 18 SECOND                               0.10890000000000E+004 SECOND
 19 ALONG TRACK ROW NUMBER               0.25500000000000E+003 NUMERIC
 20 CROSS-TRACK CELL NUMBER              0.23000000000000E+002 NUMERIC
 21 SEAWINDS WIND VECTOR CELL QUALIT     0.00000000000000E+000 FLAG TABLE 21109
 22 MODEL WIND DIRECTION AT 10M          0.52770000000000E+002 DEGREE TRUE
 23 MODEL WIND SPEED AT 10M              0.66900000000000E+001 M/S
 24 NUMBER OF VECTOR AMBIGUITIES         0.40000000000000E+001 NUMERIC
 25 INDEX OF SELECTED WIND VECTOR        0.20000000000000E+001 NUMERIC
 26 TOTAL NUMBER OF SIGMA-0 MEASUREM     0.10000000000000E+002 NUMERIC
 27 PROBABILITY OF RAIN                                MISSING NUMERIC
 28 SEAWINDS NOF* RAIN INDEX             0.10100000000000E+003 NUMERIC
 29 INTENSITY OF PRECIPITATION                         MISSING KG/(M**2)S
 30 ATTENUATION CORRECTION OF SIGMA-                   MISSING dB
 31 WIND SPEED AT 10 M                   0.53400000000000E+001 M/S
 32 FORMAL UNCERTAINTY IN WIND SPEED                   MISSING M/S
 33 WIND DIRECTION AT 10 M               0.31750000000000E+003 DEGREE TRUE
 34 FORMAL UNCERTAINTY IN WIND DIREC     0.30000000000000E+000 DEGREE TRUE
 35 LIKELIHOOD COMPUTED FOR SOLUTION     0.26600000000000E+000 NUMERIC
 36 WIND SPEED AT 10 M                   0.56300000000000E+001 M/S
 37 FORMAL UNCERTAINTY IN WIND SPEED                   MISSING M/S
 38 WIND DIRECTION AT 10 M               0.32500000000000E+002 DEGREE TRUE
 39 FORMAL UNCERTAINTY IN WIND DIREC     0.32000000000000E+000 DEGREE TRUE
 40 LIKELIHOOD COMPUTED FOR SOLUTION     0.26200000000000E+000 NUMERIC
 41 WIND SPEED AT 10 M                   0.51900000000000E+001 M/S
 42 FORMAL UNCERTAINTY IN WIND SPEED                   MISSING M/S
 43 WIND DIRECTION AT 10 M               0.35250000000000E+003 DEGREE TRUE
 44 FORMAL UNCERTAINTY IN WIND DIREC     0.34000000000000E+000 DEGREE TRUE
 45 LIKELIHOOD COMPUTED FOR SOLUTION     0.25700000000000E+000 NUMERIC
 46 WIND SPEED AT 10 M                   0.66500000000000E+001 M/S
 47 FORMAL UNCERTAINTY IN WIND SPEED                   MISSING M/S
 48 WIND DIRECTION AT 10 M               0.23500000000000E+003 DEGREE TRUE
 49 FORMAL UNCERTAINTY IN WIND DIREC     0.59000000000000E+000 DEGREE TRUE
 50 LIKELIHOOD COMPUTED FOR SOLUTION     0.21500000000000E+000 NUMERIC
 51 ANTENNA POLARISATION                               MISSING CODE TABLE 2104
 52 TOTAL NUMBER (WITH RESPECT TO AC                   MISSING NUMERIC
 53 BRIGHTNESS TEMPERATURE                             MISSING K
 54 STANDARD DEVIATION BRIGHTNESS TE                   MISSING K
```

```
55 ANTENNA POLARISATION                              MISSING CODE TABLE 2104
56 TOTAL NUMBER (WITH RESPECT TO AC                  MISSING NUMERIC
57 BRIGHTNESS TEMPERATURE                            MISSING K
58 STANDARD DEVIATION BRIGHTNESS TE                  MISSING K
59 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.10000000000000E+001 NUMERIC
60 LATITUDE (COARSE ACCURACY)        -0.33140000000000E+002 DEGREE
61 LONGITUDE (COARSE ACCURACY)       -0.88030000000000E+002 DEGREE
62 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
63 RADAR LOOK ANGLE                   0.34908000000000E+003 DEGREE
64 RADAR INCIDENCE ANGLE              0.48560000000000E+002 DEGREE
65 ANTENNA POLARISATION               0.00000000000000E+000 CODE TABLE 2104
66 SEAWINDS NORMALIZED RADAR CROSS   -0.28550000000000E+002 dB
67 KP VARIANCE COEFFICIENT (ALPHA)    0.10020000000000E+001 NUMERIC
68 KP VARIANCE COEFFICIENT (BETA)     0.53530000000000E-004 NUMERIC
69 KP VARIANCE COEFFICENT (GAMMA)    -0.60498000000000E+002 dB
70 SEAWINDS SIGMA-0 QUALITY           0.00000000000000E+000 FLAG TABLE 21115
71 SEAWINDS SIGMA-0 MODE              0.00000000000000E+000 FLAG TABLE 21116
72 SEAWINDS LAND/ICE SURFACE TYPE     0.00000000000000E+000 FLAG TABLE 8018
73 SIGMA-0 VARIANCE QUALITY CONTROL                  MISSING NUMERIC
74 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.20000000000000E+001 NUMERIC
75 LATITUDE (COARSE ACCURACY)        -0.33110000000000E+002 DEGREE
76 LONGITUDE (COARSE ACCURACY)       -0.87970000000000E+002 DEGREE
77 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
78 RADAR LOOK ANGLE                   0.35010000000000E+003 DEGREE
79 RADAR INCIDENCE ANGLE              0.40550000000000E+002 DEGREE
80 ANTENNA POLARISATION               0.00000000000000E+000 CODE TABLE 2104
81 SEAWINDS NORMALIZED RADAR CROSS   -0.24680000000000E+002 dB
82 KP VARIANCE COEFFICIENT (ALPHA)    0.10010000000000E+001 NUMERIC
83 KP VARIANCE COEFFICIENT (BETA)     0.57320000000000E-004 NUMERIC
84 KP VARIANCE COEFFICENT (GAMMA)    -0.58669000000000E+002 dB
85 SEAWINDS SIGMA-0 QUALITY           0.00000000000000E+000 FLAG TABLE 21115
86 SEAWINDS SIGMA-0 MODE              0.00000000000000E+000 FLAG TABLE 21116
87 SEAWINDS LAND/ICE SURFACE TYPE     0.00000000000000E+000 FLAG TABLE 8018
88 SIGMA-0 VARIANCE QUALITY CONTROL                  MISSING NUMERIC
89 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.30000000000000E+001 NUMERIC
90 LATITUDE (COARSE ACCURACY)        -0.33120000000000E+002 DEGREE
91 LONGITUDE (COARSE ACCURACY)       -0.87900000000000E+002 DEGREE
92 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
93 RADAR LOOK ANGLE                   0.35223000000000E+003 DEGREE
94 RADAR INCIDENCE ANGLE              0.30210000000000E+002 DEGREE
95 ANTENNA POLARISATION               0.00000000000000E+000 CODE TABLE 2104
96 SEAWINDS NORMALIZED RADAR CROSS   -0.15570000000000E+002 dB
97 KP VARIANCE COEFFICIENT (ALPHA)    0.10010000000000E+001 NUMERIC
98 KP VARIANCE COEFFICIENT (BETA)     0.12985000000000E-003 NUMERIC
99 KP VARIANCE COEFFICENT (GAMMA)    -0.48800000000000E+002 dB
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100 SEAWINDS SIGMA-0 QUALITY           0.00000000000000E+000 FLAG TABLE 21115
101 SEAWINDS SIGMA-0 MODE              0.00000000000000E+000 FLAG TABLE 21116
102 SEAWINDS LAND/ICE SURFACE TYPE     0.00000000000000E+000 FLAG TABLE 8018
103 SIGMA-0 VARIANCE QUALITY CONTROL                MISSING NUMERIC
104 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.40000000000000E+001 NUMERIC
105 LATITUDE (COARSE ACCURACY)        -0.33090000000000E+002 DEGREE
106 LONGITUDE (COARSE ACCURACY)       -0.87570000000000E+002 DEGREE
107 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
108 RADAR LOOK ANGLE                   0.15686000000000E+003 DEGREE
109 RADAR INCIDENCE ANGLE              0.30490000000000E+002 DEGREE
110 ANTENNA POLARISATION               0.00000000000000E+000 CODE TABLE 2104
111 SEAWINDS NORMALIZED RADAR CROSS   -0.17090000000000E+002 dB
112 KP VARIANCE COEFFICIENT (ALPHA)    0.10010000000000E+001 NUMERIC
113 KP VARIANCE COEFFICIENT (BETA)     0.13511000000000E-003 NUMERIC
114 KP VARIANCE COEFFICENT (GAMMA)    -0.48584000000000E+002 dB
115 SEAWINDS SIGMA-0 QUALITY           0.00000000000000E+000 FLAG TABLE 21115
116 SEAWINDS SIGMA-0 MODE              0.00000000000000E+000 FLAG TABLE 21116
117 SEAWINDS LAND/ICE SURFACE TYPE     0.00000000000000E+000 FLAG TABLE 8018
118 SIGMA-0 VARIANCE QUALITY CONTROL                MISSING NUMERIC
119 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.50000000000000E+001 NUMERIC
120 LATITUDE (COARSE ACCURACY)        -0.33070000000000E+002 DEGREE
121 LONGITUDE (COARSE ACCURACY)       -0.87510000000000E+002 DEGREE
122 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
123 RADAR LOOK ANGLE                   0.15927000000000E+003 DEGREE
124 RADAR INCIDENCE ANGLE              0.40680000000000E+002 DEGREE
125 ANTENNA POLARISATION               0.00000000000000E+000 CODE TABLE 2104
126 SEAWINDS NORMALIZED RADAR CROSS   -0.29650000000000E+002 dB
127 KP VARIANCE COEFFICIENT (ALPHA)    0.10010000000000E+001 NUMERIC
128 KP VARIANCE COEFFICIENT (BETA)     0.56180000000000E-004 NUMERIC
129 KP VARIANCE COEFFICENT (GAMMA)    -0.58308000000000E+002 dB
130 SEAWINDS SIGMA-0 QUALITY           0.00000000000000E+000 FLAG TABLE 21115
131 SEAWINDS SIGMA-0 MODE              0.00000000000000E+000 FLAG TABLE 21116
132 SEAWINDS LAND/ICE SURFACE TYPE     0.00000000000000E+000 FLAG TABLE 8018
133 SIGMA-0 VARIANCE QUALITY CONTROL                MISSING NUMERIC
134 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.60000000000000E+001 NUMERIC
135 LATITUDE (COARSE ACCURACY)        -0.33060000000000E+002 DEGREE
136 LONGITUDE (COARSE ACCURACY)       -0.87410000000000E+002 DEGREE
137 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
138 RADAR LOOK ANGLE                   0.16012000000000E+003 DEGREE
139 RADAR INCIDENCE ANGLE              0.48930000000000E+002 DEGREE
140 ANTENNA POLARISATION               0.00000000000000E+000 CODE TABLE 2104
141 SEAWINDS NORMALIZED RADAR CROSS   -0.33990000000000E+002 dB
142 KP VARIANCE COEFFICIENT (ALPHA)    0.10020000000000E+001 NUMERIC
143 KP VARIANCE COEFFICIENT (BETA)     0.61120000000000E-004 NUMERIC
144 KP VARIANCE COEFFICENT (GAMMA)    -0.59347000000000E+002 dB
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145 SEAWINDS SIGMA-0 QUALITY           0.81920000000000E+004 FLAG TABLE 21115
146 SEAWINDS SIGMA-0 MODE              0.00000000000000E+000 FLAG TABLE 21116
147 SEAWINDS LAND/ICE SURFACE TYPE     0.00000000000000E+000 FLAG TABLE 8018
148 SIGMA-0 VARIANCE QUALITY CONTROL                MISSING NUMERIC
149 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.70000000000000E+001 NUMERIC
150 LATITUDE (COARSE ACCURACY)        -0.33130000000000E+002 DEGREE
151 LONGITUDE (COARSE ACCURACY)       -0.88010000000000E+002 DEGREE
152 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
153 RADAR LOOK ANGLE                   0.34941000000000E+003 DEGREE
154 RADAR INCIDENCE ANGLE              0.44790000000000E+002 DEGREE
155 ANTENNA POLARISATION               0.10000000000000E+001 CODE TABLE 2104
156 SEAWINDS NORMALIZED RADAR CROSS   -0.22290000000000E+002 dB
157 KP VARIANCE COEFFICIENT (ALPHA)    0.10010000000000E+001 NUMERIC
158 KP VARIANCE COEFFICIENT (BETA)     0.32350000000000E-004 NUMERIC
159 KP VARIANCE COEFFICENT (GAMMA)    -0.64460000000000E+002 dB
160 SEAWINDS SIGMA-0 QUALITY           0.00000000000000E+000 FLAG TABLE 21115
161 SEAWINDS SIGMA-0 MODE              0.00000000000000E+000 FLAG TABLE 21116
162 SEAWINDS LAND/ICE SURFACE TYPE     0.00000000000000E+000 FLAG TABLE 8018
163 SIGMA-0 VARIANCE QUALITY CONTROL                MISSING NUMERIC
164 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.80000000000000E+001 NUMERIC
165 LATITUDE (COARSE ACCURACY)        -0.33130000000000E+002 DEGREE
166 LONGITUDE (COARSE ACCURACY)       -0.87930000000000E+002 DEGREE
167 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
168 RADAR LOOK ANGLE                   0.35104000000000E+003 DEGREE
169 RADAR INCIDENCE ANGLE              0.35480000000000E+002 DEGREE
170 ANTENNA POLARISATION               0.10000000000000E+001 CODE TABLE 2104
171 SEAWINDS NORMALIZED RADAR CROSS   -0.17650000000000E+002 dB
172 KP VARIANCE COEFFICIENT (ALPHA)    0.10010000000000E+001 NUMERIC
173 KP VARIANCE COEFFICIENT (BETA)     0.24480000000000E-004 NUMERIC
174 KP VARIANCE COEFFICENT (GAMMA)    -0.63788000000000E+002 dB
175 SEAWINDS SIGMA-0 QUALITY           0.00000000000000E+000 FLAG TABLE 21115
176 SEAWINDS SIGMA-0 MODE              0.00000000000000E+000 FLAG TABLE 21116
177 SEAWINDS LAND/ICE SURFACE TYPE     0.00000000000000E+000 FLAG TABLE 8018
178 SIGMA-0 VARIANCE QUALITY CONTROL                MISSING NUMERIC
179 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.90000000000000E+001 NUMERIC
180 LATITUDE (COARSE ACCURACY)        -0.33090000000000E+002 DEGREE
181 LONGITUDE (COARSE ACCURACY)       -0.87540000000000E+002 DEGREE
182 ATTENUATION CORRECTION ON SIGMA-   0.18000000000000E+000 dB
183 RADAR LOOK ANGLE                   0.15839000000000E+003 DEGREE
184 RADAR INCIDENCE ANGLE              0.35950000000000E+002 DEGREE
185 ANTENNA POLARISATION               0.10000000000000E+001 CODE TABLE 2104
186 SEAWINDS NORMALIZED RADAR CROSS   -0.19170000000000E+002 dB
187 KP VARIANCE COEFFICIENT (ALPHA)    0.10010000000000E+001 NUMERIC
188 KP VARIANCE COEFFICIENT (BETA)     0.29790000000000E-004 NUMERIC
189 KP VARIANCE COEFFICENT (GAMMA)    -0.62924000000000E+002 dB
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190	SEAWINDS SIGMA-0 QUALITY	0.00000000000000E+000	FLAG TABLE	21115
191	SEAWINDS SIGMA-0 MODE	0.00000000000000E+000	FLAG TABLE	21116
192	SEAWINDS LAND/ICE SURFACE TYPE	0.00000000000000E+000	FLAG TABLE	8018
193	SIGMA-0 VARIANCE QUALITY CONTROL	MISSING	NUMERIC	
194	NUMBER OF INNER-BEAM SIGMA-0 (FO	0.10000000000000E+002	NUMERIC	
195	LATITUDE (COARSE ACCURACY)	-0.33080000000000E+002	DEGREE	
196	LONGITUDE (COARSE ACCURACY)	-0.87440000000000E+002	DEGREE	
197	ATTENUATION CORRECTION ON SIGMA-	0.18000000000000E+000	dB	
198	RADAR LOOK ANGLE	0.15958000000000E+003	DEGREE	
199	RADAR INCIDENCE ANGLE	0.45190000000000E+002	DEGREE	
200	ANTENNA POLARISATION	0.10000000000000E+001	CODE TABLE	2104
201	SEAWINDS NORMALIZED RADAR CROSS	-0.23480000000000E+002	dB	
202	KP VARIANCE COEFFICIENT (ALPHA)	0.10010000000000E+001	NUMERIC	
203	KP VARIANCE COEFFICIENT (BETA)	0.29330000000000E-004	NUMERIC	
204	KP VARIANCE COEFFICENT (GAMMA)	-0.64970000000000E+002	dB	
205	SEAWINDS SIGMA-0 QUALITY	0.00000000000000E+000	FLAG TABLE	21115
206	SEAWINDS SIGMA-0 MODE	0.00000000000000E+000	FLAG TABLE	21116
207	SEAWINDS LAND/ICE SURFACE TYPE	0.00000000000000E+000	FLAG TABLE	8018
208	SIGMA-0 VARIANCE QUALITY CONTROL	MISSING	NUMERIC	
209	NUMBER OF INNER-BEAM SIGMA-0 (FO	0.00000000000000E+000	NUMERIC	
210	LATITUDE (COARSE ACCURACY)	MISSING	DEGREE	
211	LONGITUDE (COARSE ACCURACY)	MISSING	DEGREE	
212	ATTENUATION CORRECTION ON SIGMA-	MISSING	dB	
213	RADAR LOOK ANGLE	MISSING	DEGREE	
214	RADAR INCIDENCE ANGLE	MISSING	DEGREE	
215	ANTENNA POLARISATION	MISSING	CODE TABLE	2104
216	SEAWINDS NORMALIZED RADAR CROSS	MISSING	dB	
217	KP VARIANCE COEFFICIENT (ALPHA)	MISSING	NUMERIC	
218	KP VARIANCE COEFFICIENT (BETA)	MISSING	NUMERIC	
219	KP VARIANCE COEFFICENT (GAMMA)	MISSING	dB	
220	SEAWINDS SIGMA-0 QUALITY	MISSING	FLAG TABLE	21115
221	SEAWINDS SIGMA-0 MODE	MISSING	FLAG TABLE	21116
222	SEAWINDS LAND/ICE SURFACE TYPE	MISSING	FLAG TABLE	8018
223	SIGMA-0 VARIANCE QUALITY CONTROL	MISSING	NUMERIC	
224	NUMBER OF INNER-BEAM SIGMA-0 (FO	0.00000000000000E+000	NUMERIC	
225	LATITUDE (COARSE ACCURACY)	MISSING	DEGREE	
226	LONGITUDE (COARSE ACCURACY)	MISSING	DEGREE	
227	ATTENUATION CORRECTION ON SIGMA-	MISSING	dB	
228	RADAR LOOK ANGLE	MISSING	DEGREE	
229	RADAR INCIDENCE ANGLE	MISSING	DEGREE	
230	ANTENNA POLARISATION	MISSING	CODE TABLE	2104
231	SEAWINDS NORMALIZED RADAR CROSS	MISSING	dB	
232	KP VARIANCE COEFFICIENT (ALPHA)	MISSING	NUMERIC	
233	KP VARIANCE COEFFICIENT (BETA)	MISSING	NUMERIC	
234	KP VARIANCE COEFFICENT (GAMMA)	MISSING	dB	

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235 SEAWINDS SIGMA-0 QUALITY                          MISSING FLAG TABLE 21115
236 SEAWINDS SIGMA-0 MODE                             MISSING FLAG TABLE 21116
237 SEAWINDS LAND/ICE SURFACE TYPE                    MISSING FLAG TABLE 8018
238 SIGMA-0 VARIANCE QUALITY CONTROL                  MISSING NUMERIC
239 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.00000000000000E+000 NUMERIC
240 LATITUDE (COARSE ACCURACY)                        MISSING DEGREE
241 LONGITUDE (COARSE ACCURACY)                       MISSING DEGREE
242 ATTENUATION CORRECTION ON SIGMA-                  MISSING dB
243 RADAR LOOK ANGLE                                  MISSING DEGREE
244 RADAR INCIDENCE ANGLE                             MISSING DEGREE
245 ANTENNA POLARISATION                              MISSING CODE TABLE 2104
246 SEAWINDS NORMALIZED RADAR CROSS                   MISSING dB
247 KP VARIANCE COEFFICIENT (ALPHA)                   MISSING NUMERIC
248 KP VARIANCE COEFFICIENT (BETA)                    MISSING NUMERIC
249 KP VARIANCE COEFFICENT (GAMMA)                    MISSING dB
250 SEAWINDS SIGMA-0 QUALITY                          MISSING FLAG TABLE 21115
251 SEAWINDS SIGMA-0 MODE                             MISSING FLAG TABLE 21116
252 SEAWINDS LAND/ICE SURFACE TYPE                    MISSING FLAG TABLE 8018
253 SIGMA-0 VARIANCE QUALITY CONTROL                  MISSING NUMERIC
254 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.00000000000000E+000 NUMERIC
255 LATITUDE (COARSE ACCURACY)                        MISSING DEGREE
256 LONGITUDE (COARSE ACCURACY)                       MISSING DEGREE
257 ATTENUATION CORRECTION ON SIGMA-                  MISSING dB
258 RADAR LOOK ANGLE                                  MISSING DEGREE
259 RADAR INCIDENCE ANGLE                             MISSING DEGREE
260 ANTENNA POLARISATION                              MISSING CODE TABLE 2104
261 SEAWINDS NORMALIZED RADAR CROSS                   MISSING dB
262 KP VARIANCE COEFFICIENT (ALPHA)                   MISSING NUMERIC
263 KP VARIANCE COEFFICIENT (BETA)                    MISSING NUMERIC
264 KP VARIANCE COEFFICENT (GAMMA)                    MISSING dB
265 SEAWINDS SIGMA-0 QUALITY                          MISSING FLAG TABLE 21115
266 SEAWINDS SIGMA-0 MODE                             MISSING FLAG TABLE 21116
267 SEAWINDS LAND/ICE SURFACE TYPE                    MISSING FLAG TABLE 8018
268 SIGMA-0 VARIANCE QUALITY CONTROL                  MISSING NUMERIC
269 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.00000000000000E+000 NUMERIC
270 LATITUDE (COARSE ACCURACY)                        MISSING DEGREE
271 LONGITUDE (COARSE ACCURACY)                       MISSING DEGREE
272 ATTENUATION CORRECTION ON SIGMA-                  MISSING dB
273 RADAR LOOK ANGLE                                  MISSING DEGREE
274 RADAR INCIDENCE ANGLE                             MISSING DEGREE
275 ANTENNA POLARISATION                              MISSING CODE TABLE 2104
276 SEAWINDS NORMALIZED RADAR CROSS                   MISSING dB
277 KP VARIANCE COEFFICIENT (ALPHA)                   MISSING NUMERIC
278 KP VARIANCE COEFFICIENT (BETA)                    MISSING NUMERIC
279 KP VARIANCE COEFFICENT (GAMMA)                    MISSING dB
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280 SEAWINDS SIGMA-0 QUALITY                          MISSING FLAG TABLE 21115
281 SEAWINDS SIGMA-0 MODE                             MISSING FLAG TABLE 21116
282 SEAWINDS LAND/ICE SURFACE TYPE                    MISSING FLAG TABLE 8018
283 SIGMA-0 VARIANCE QUALITY CONTROL                  MISSING NUMERIC
284 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.00000000000000E+000 NUMERIC
285 LATITUDE (COARSE ACCURACY)                        MISSING DEGREE
286 LONGITUDE (COARSE ACCURACY)                       MISSING DEGREE
287 ATTENUATION CORRECTION ON SIGMA-                  MISSING dB
288 RADAR LOOK ANGLE                                  MISSING DEGREE
289 RADAR INCIDENCE ANGLE                             MISSING DEGREE
290 ANTENNA POLARISATION                              MISSING CODE TABLE 2104
291 SEAWINDS NORMALIZED RADAR CROSS                   MISSING dB
292 KP VARIANCE COEFFICIENT (ALPHA)                   MISSING NUMERIC
293 KP VARIANCE COEFFICIENT (BETA)                    MISSING NUMERIC
294 KP VARIANCE COEFFICENT (GAMMA)                    MISSING dB
295 SEAWINDS SIGMA-0 QUALITY                          MISSING FLAG TABLE 21115
296 SEAWINDS SIGMA-0 MODE                             MISSING FLAG TABLE 21116
297 SEAWINDS LAND/ICE SURFACE TYPE                    MISSING FLAG TABLE 8018
298 SIGMA-0 VARIANCE QUALITY CONTROL                  MISSING NUMERIC
299 NUMBER OF INNER-BEAM SIGMA-0 (FO   0.00000000000000E+000 NUMERIC
300 LATITUDE (COARSE ACCURACY)                        MISSING DEGREE
301 LONGITUDE (COARSE ACCURACY)                       MISSING DEGREE
302 ATTENUATION CORRECTION ON SIGMA-                  MISSING dB
303 RADAR LOOK ANGLE                                  MISSING DEGREE
304 RADAR INCIDENCE ANGLE                             MISSING DEGREE
305 ANTENNA POLARISATION                              MISSING CODE TABLE 2104
306 SEAWINDS NORMALIZED RADAR CROSS                   MISSING dB
307 KP VARIANCE COEFFICIENT (ALPHA)                   MISSING NUMERIC
308 KP VARIANCE COEFFICIENT (BETA)                    MISSING NUMERIC
309 KP VARIANCE COEFFICENT (GAMMA)                    MISSING dB
310 SEAWINDS SIGMA-0 QUALITY                          MISSING FLAG TABLE 21115
311 SEAWINDS SIGMA-0 MODE                             MISSING FLAG TABLE 21116
312 SEAWINDS LAND/ICE SURFACE TYPE                    MISSING FLAG TABLE 8018
313 SIGMA-0 VARIANCE QUALITY CONTROL                  MISSING NUMERIC
314 NUMBER OF INNER-BEAM SIGMA-0 (FO                  0.00000000000000E+000 NUMERIC
315 LATITUDE (COARSE ACCURACY)                        MISSING DEGREE
316 LONGITUDE (COARSE ACCURACY)                       MISSING DEGREE
317 ATTENUATION CORRECTION ON SIGMA-                  MISSING dB
318 RADAR LOOK ANGLE                                  MISSING DEGREE
319 RADAR INCIDENCE ANGLE                             MISSING DEGREE
320 ANTENNA POLARISATION                              MISSING CODE TABLE 2104
321 SEAWINDS NORMALIZED RADAR CROSS                   MISSING dB
322 KP VARIANCE COEFFICIENT (ALPHA)                   MISSING NUMERIC
323 KP VARIANCE COEFFICIENT (BETA)                    MISSING NUMERIC
324 KP VARIANCE COEFFICENT (GAMMA)                    MISSING dB
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325	SEAWINDS SIGMA-0 QUALITY	MISSING FLAG TABLE 21115
326	SEAWINDS SIGMA-0 MODE	MISSING FLAG TABLE 21116
327	SEAWINDS LAND/ICE SURFACE TYPE	MISSING FLAG TABLE 8018
328	SIGMA-0 VARIANCE QUALITY CONTROL	MISSING NUMERIC

4. Validation test

Scatterometer wind results can be compared with in-situ buoy winds and NWP data. In the scope of this report, the CWDP wind solutions are compared to ECMWF model winds. The reason for not using buoy data for verification is that we need at least 2 to 3 months of data to gather enough statistics. This is normally done in Operational Readiness Reviews for OSI SAF wind products. ECMWF comparisons can be gathered with only one day of data and give a good indication of the quality of the retrieved winds, i.e., if the winds are within. OSI SAF requirements when comparing with ECMWF winds, they will also be within OSI SAF requirements when comparing with buoy winds.

The CWDP wind retrieval result is from one day: 19th Dec 2018 (17 orbits). ECMWF model wind is from the operational model: +3 to +21 hours forecasts from the 00 UTC and 12 UTC runs.

Figure 3 shows the collocation between CWDP wind results (2DVAR solution) and ECMWF model winds. Contoured histograms are shown for wind speed, wind direction and *u* and *v* wind components and after rejection of Quality Controlled (KNMI QC flagged) wind vectors. ECMWF winds are real 10m winds, whereas the scatterometer winds are equivalent neutral 10m winds, which are 0.2 m/s higher on average. The wind directions with wind speeds lower than 4m/s are not taken into account in the wind direction plots. The bin sizes for the histograms are 0.5 m/s for wind speed, *u* and *v*, and 2.5° for wind direction.

The average wind speed bias is very low (0.07 m/s) and the standard deviations of the wind components are both 1.26 m/s in *u* and *v* directions. These numbers can be compared to the accuracy requirements for all OSI SAF scatterometer wind products stated in the OSI SAF Product Requirements Document [4]: ‘Better than 2 m/s in wind component std. dev. with a bias of less than 0.5 m/s in wind speed on a monthly basis’. Hence the bias and wind component standard deviations for the CWDP winds are well within the general OSI SAF product requirements.

NOC (Numerical Ocean Calibration) as a function of incidence angle has been applied, and we expect the wind retrieval results can be improved by applying calibration as a function of both incidence angle and relative antenna angle (relative to the satellite moving direction).

This is subject to further investigation.

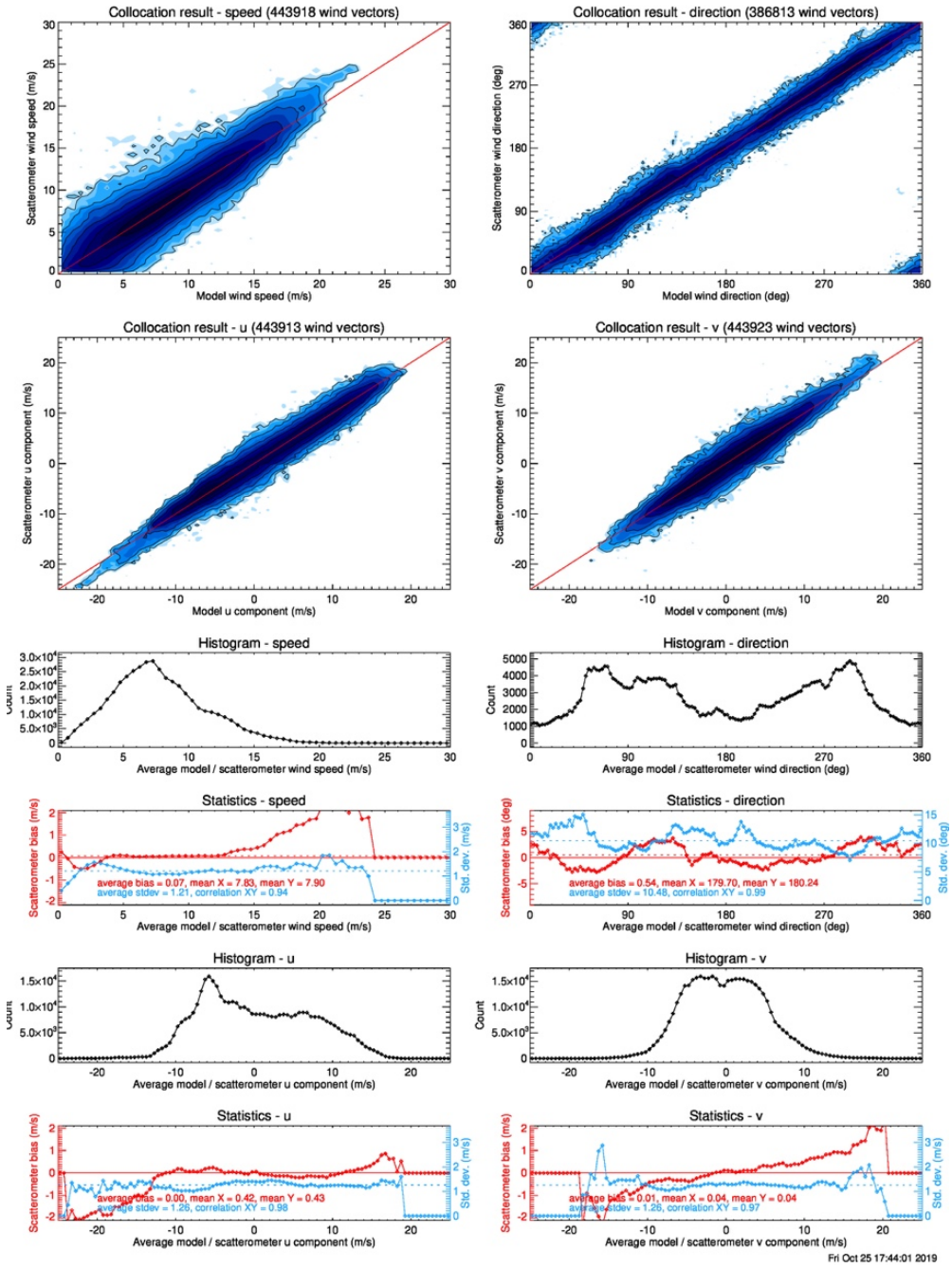

Figure 4 Collocation results of CWDP wind retrieval 2DVAR solution and ECMWF forecast winds: wind speed (top left), wind direction (top right), and u, v components (the 2st row), wind speed and wind direction pdf (the 3rd row), wind speed and direction statistics (the fourth row), u/v components pdf and statistics (the 5th and 6th row).

5. Portability test

The CWDP software package inherits its portability by using strict Fortran 90 code (with a few low-level routines for reading and writing binary in C). CWDP is delivered with a complete make system. The Make options include file of genscat takes care of the different settings needed under various platforms. This Make options file is also used for the PenWP pencil beam scatterometer wind processor and the ASCAT wind processor AWDP. The default platform for development is a Linux work station and it has been tested successfully. The gfortran (gcc) and pgf90 (Portland) Fortran compilers are both successfully tested on Linux workstations and virtual servers, see the table below which is copied from the User Manual and Reference Guide.

Table 6 Platform and compiler for CWDP.

Platform	**Fortran compiler**	**C compiler**
Fedora workstation Linux	GNU gfortran	GNU gcc
Fedora workstation Linux	Portland compiler	GNU gcc
Virtual server Red Hat Enterprise Linux	GNU gfortran	GNU gcc

6. User documentation test

The user documentation (readme files within the software package and the CWDP user documents [1], [2]) have been provided to beta testers for review. The beta tester's comments have been implemented in the user documentation. User feedback on the documentation will also be implemented in future versions of the documentation.

References

[1] Z. Li, A. Verhoef, and A. Stoffelen, “CWDP L2A processor Specification and User Manual,” SAF/OSI/CDOP3/KNMI/TEC/MA/319, 2021.

[2] Z. Li, A. Verhoef, and A. Stoffelen “CWDP User Manual and Reference Guide”, SAF/OSI/CDOP3/KNMI/TEC/MA/320, 2021.

[3] A. Verhoef, J. Vogelzang, J. Verspeek, and A. Stoffelen, “PenWP Test Plan and Test Report,” de Bilt, the Netherlands, 2015.

[4] "OSI SAF CDOP 3 Product Requirement Document", SAF/OSI/CDOP3/MF/MGT/PL/2-001, EUMETSAT OSI SAF, 2021

[5] NWP SAF Development Procedures for Software Deliverables, NWPSAF-MO-SW-002, EUMETSAT NWP SAF 2016

[6] Z. Li, A. Verhoef, and A. Stoffelen, "CWDP Top Level Design", SAF/OSI/CDOP3/KNMI/TEC/TN/321, 2021

Appendix A: Acronyms

2DVAR	2 Dimensional Variational ambiguity removal (2DVAR)
AR	Ambiguity Removal
BUFR	Binary Universal Form for the Representation of data
CFOSAT	China-France Oceanography SATellite
CWDP	CFOSAT Wind Data Processor
ECEF	Earth Centered Earth Fixed
ECI	Earth Centered Inertial
genscat	generic scatterometer software routines
GMF	Geophysical Model Function
GRIB	GRIdded Binary or General Regularly-distributed Information in Binary form
HDF5	Hierarchical Data Format version 5
L1B	Level 1-B
L2A	Level 2-A
L2B	Level 2-B
LUT	Look-up Table
MSS	Multiple Solution Scheme
NetCDF	Network Common Data Form
NRCS	Normalized Radar Cross Section
NWP	Numerical Weather Predictio
PenWP	Pencil beam Wind Processor
QDP	QuikSCAT Data Processor
UCAR	University Corporation for Atmospheric Research
UNIDATA	A member of the UCAR Community Program
WVC	Wind Vector Cell