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CWDP L2A processor Specification and User Manual

CFOSAT Wind Data Processor

Version 1.0
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1. Introduction

CFOSAT (China-France Oceanography SATellite) was launched on 29th Oct 2018 and carries a Rotating Fan-beam SCATterometer (RFSCAT, referred to as SCAT from now on), which scans the earth in a circular mode with a swath width of more than 1000 km. It has one Ku-band fan-beam using alternating HH and VV polarization in turns. This document describes details on the specifications of the Level-2A (L2A) processor.

SCAT is one of the two payloads of CFOSAT. It measures the electromagnetic backscatter (sigma0) over the oceans, which can be used to compute the wind vectors. A Ku-band (13.256GHz) rotating fan-beam antenna is onboard. This rotating fan-beam concept combines the advantages of fixed fan-beam and rotating pencil-beam designs. The fan-beam rotates when the satellite flies over the earth such that its footprint sweeps a donut-shape on the earth surface. The footprint is also called as pulse and each pulse contains many slices (Figure 1 [1]). It is able to cover a large swath of more than 1000 km width and gives multiple views with various geometry at one WVC (Wind Vector Cell).

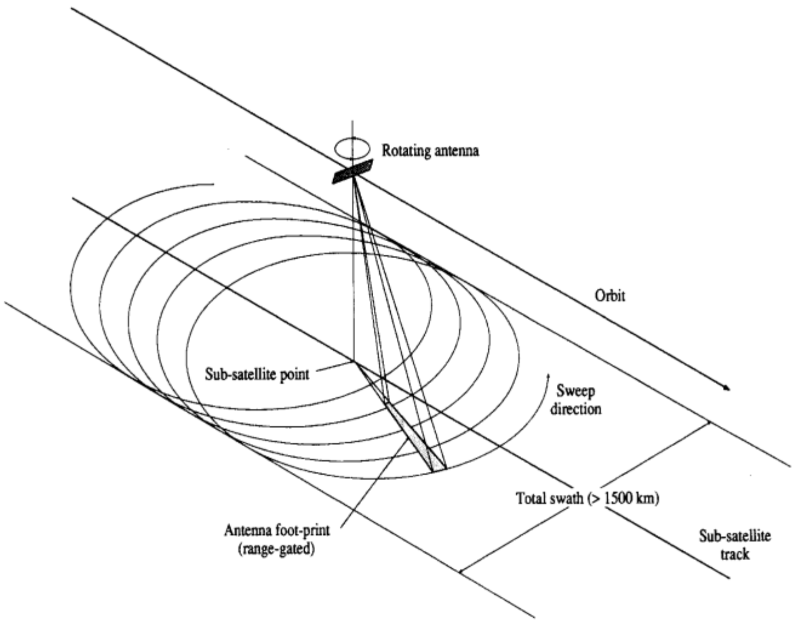

Figure 1 Illustration of RFSCAT swath and footprint.

This document describes CWDP software packages:

- A L2A processor uses L1B files to generate L2A files in HDF5 format. The L1B files are the real SCAT data.
- A HDF5 to BUFR converter converts the L2A HDF5 data into BUFR format files which can be used for wind retrieval by the CWDP (CFOSAT Wind Data Processor).

2. L2A product specifications

2.1 Input specifications

The input to the 'cfosat_l1b_l2a' processor is L1B data. For L1B data specifications see [2].

2.2 Output specifications (HDF5, BUFR and NetCDF)

The L2A output can be generated in three formats: HDF5, BUFR and NetCDF. BUFR and NetCDF are the standardized output format. Initially HDF5 is generated by the 'cfosat_l1b_l2a' processor and subsequently the HDF5 format can be converted into BUFR format by the 'cfosat_hdf2bufr' processor. Finally, BUFR format can be converted into NetCDF by 'Bufr2Nc' in genscat/tools/ bufr2nc_cfosat_L2A.

HDF5 format: This format of data is organized in rows. All the slice level information in L1B data is co-located onto the swath rows with WVC index. 'cfosat_l1b_l2a' is used to transform L1B to L2A HDF5 at 25 or 50 km WVCs. It is an internal product of the L2A processor. Table 1 gives the parameter list of the HDF5 file.

Table 1 L2A HDF5 data content

No. of rows = maximum number of rows in one orbit

No. of slices = maximum number of slices in one row

No. of WVCs = maximum number of WVCs in one row

PARAMETER	DESCRIPTION	UNIT	TYPE	DIM1	DIM2
Azimuth_angle	The azimuth angle of a slice in a row.	Deg	Float32	No. of rows	No. of slices
Cell_index	The cell (WVC column) index of a slice in a row.	-	Int32	No. of rows	No. of slices
Incidence_angle	The incidence angle of a slice in a row.	Deg	Float32	No. of rows	No. of slices
KpA	The kp coefficient A of a slice in a row.	-	Float32	No. of rows	No. of slices

KpB	The kp coefficient B of a slice in a row.	-	Float32	No. of rows	No. of slices
KpC	The kp coefficient C of a slice in a row.	-	Float32	No. of rows	No. of slices
Latitude_footprint	The latitude of the center of a slice in a row.	Deg	Float32	No. of rows	No. of slices
Longitude_footprint	The longitude of the center of a slice in a row.	Deg	Float32	No. of rows	No. of slices
Num_sigma0_per_cell	Number of slices (sigma0) in one WVC	-	Int32	No. of rows	No. of WVCs
Num_sigma0_per_row	Number of slices (sigma0) in one row	-	Int32	No. of rows	
Pol	The polarization type (VV=1, HH=0) of a slice in a row	-	Int32	No. of rows	No. of slices
Row_index	The row index of a row	-	Int32	No. of rows	
SNR	The SNR. of a slice in a row.	-	Float32	No. of rows	No. of slices
Sigma0	The sigma0 of a slice in a row.	-	Float32	No. of rows	No. of slices
Sigma0_quality_flag	The sigma0 quality flag of a slice in a row.	-	Int32	No. of rows	No. of slices
WVC_row_time	The time when satellite pass by a row.	-	Character	No. of rows	No. of slices
v_label	The number of views in one WVC.	-	Int32	No. of rows	No. of slices

BUFR format: This format of data is organized in WVCs, which is the generic format input for the wind processor. A conversion program 'cfosat_hdf2bufr' is used to convert L2A HDF5 to L2A BUFR. It aggregates information from the individual slice measurements, such as sigma0 etc., into views for each WVC. The data size for L1B in NetCDF format is about 900 MB per orbit, after conversion to L2A NetCDF format with cfosat_l1b_l2a the data size has increased to about 1.5 GB per orbit. The cfosat_hdf2bufr conversion to L2A BUFR format reduces the data size to about 15 MB per orbit. The parameter list of the BUFR file is described in Appendix A.

NetCDF format: The parameters in the NetCDF output files are the same as in the BUFR format. It is converted from BUFR by 'Bufr2Nc' under genscat/tools/bufr2nc_cfosat_L2A/.

Table 2 L2A NetCDF data content

NUMROWS = maximum number of rows in one orbit

NUMCELLS = maximum number of WVCs in one row

NUMVIEWS = maximum number of views in one WVC

PARAMETER	**DESCRIPTION**	**UNIT**	**TYPE**	**DIM1**	**DIM2**	**DIM3**
row time	Observing time (Julian date in second of each row), seconds since 1990-01-01 00:00:00.	Sec	Integer	NUMROWS	NUMCELLS	-
lat	The latitude of the center of a WVC in a row (In degree north, range -90° to 90°).	Deg	Float32	NUMROWS	NUMCELLS	-
lon	The longitude of the center of a WVC in a row (In degree east, range -180° to 180°).	Deg	Float32	NUMROWS	NUMCELLS	-
wvc_sigma0	sigma0 of WVC for each view	dB	Float32	NUMROWS	NUMCELLS	NUMVIEWS
wvc_azimuth	azimuth of WVC for each view (with respect to the North pole)	Deg	Float32	NUMROWS	NUMCELLS	NUMVIEWS
wvc_incidence	incidence of WVC for each view	Deg	Float32	NUMROWS	NUMCELLS	NUMVIEWS
wvc_pol	polarization of WVC for each view, 0-HH, 1-VV	-	Integer	NUMROWS	NUMCELLS	NUMVIEWS
wvc_kpa*	kp alpha	-	Float32	NUMROWS	NUMCELLS	NUMVIEWS
wvc_kpb*	kp beta	-	Float32	NUMROWS	NUMCELLS	NUMVIEWS
wvc_kpc*	kp gamma	dB	Float32	NUMROWS	NUMCELLS	NUMVIEWS
wvc_quality_flag	WVC quality	-	Integer	NUMROWS	NUMCELLS	-

* wvc_kpa, wvc_kpb, wvc_kpc have been changed in order to fit into the standard wind inversion procedure later in CWDP.

* wvc_kpa = kpa + 1

* wvc_kpb = kpb × sigma0 / SNR

* wvc_kpc = kpc × $sigma0^2$ / SNR^2

2.3 System requirements

Table 3 gives the platforms and compilers for which the L2A processor has been tested. It is designed for Unix (Linux) based computer platform with a Fortran compiler and a C compiler. To install the CWDP package, approximately 1G of disk space is needed. The output needs about 1.5 GB disk space for a HDF5 file and 15 MB for a BUFR file to store one orbit data. A minimum of 16 GB RAM and a minimum CPU speed of 3.5 GHz are recommended.

Most scatterometer wind processors for ASCAT, OSCAT, and HSCAT instruments are used in the OSI SAF near real time wind processing at KNMI where one orbit input file should be processed and dissemination within typically 10 minutes. To allow some margin we request the complete CFOSAT processing (L1B NetCDF -> L2A HDF5, L2A HDF5 -> L2A BUFR, L2A BUFR -> L2B BUFR) to be done within 5 minutes. This is subdivided in

- 90 seconds for L1B NetCDF -> L2A HDF5 (cfosat_l1b_l2a)
- 30 seconds for L2A HDF5 -> L2A BUFR (cfosat_hdf2bufr)
- 180 seconds for L2A BUFR -> L2B BUFR (cwdp)

Table 3 Platforms and compilers on which the L2A processor has been tested.

Platform	**Fortran compiler**	**C compiler**
Fedora workstation Linux	GNU gfortran 10.2.1	GNU gcc 10.2.1
Fedora workstation Linux	Portland 11.10-0	GNU gcc 10.2.1
Virtual server Red Hat Enterprise Linux	GNU gfortran 4.8.5	GNU gcc 4.8.5

Normally the compilation can be done as well with other compiler versions but the listed versions have been tested recently.

3. Details of functionality and module test results

3.1 L2A HDF5

The L2A processor workflow (Figure 2) contains two main parts. The first step is grouping slices into the proper WVCs, output is HDF5 format, and the second step is to convert HDF5 to BUFR format.

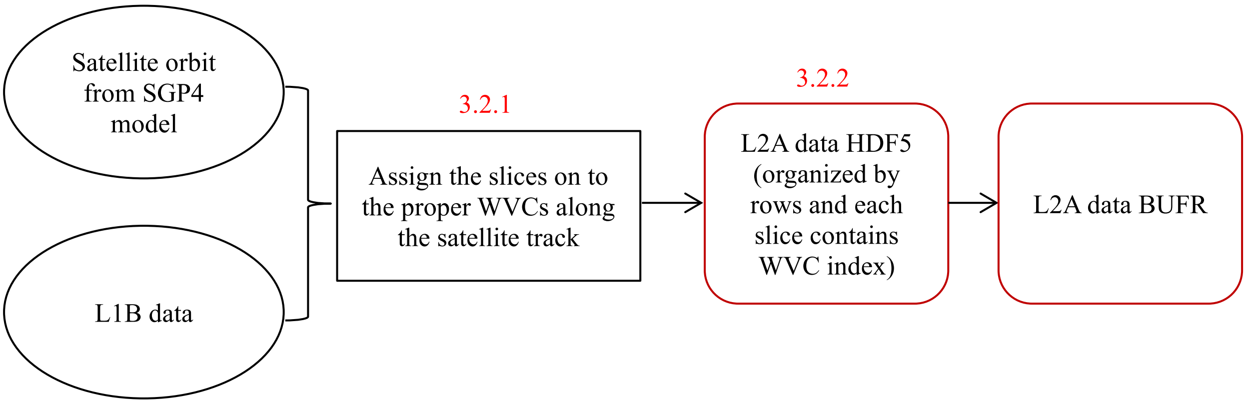

Figure 2 L2A processor workflow.

'cfosat_l1b_l2a' reads in L1B data and assigns slices along with their information onto proper WVCs. Time oriented L1B data are converted to WVC oriented data (Figure 3). Measurements are grouped explicitly by row and the sigma0 counts within one row are attached with a cross-track WVC index. This allows a more compact data storage in the L2A product. At the time when the pulse emits, routine 'compute_orbit_elements' computes the satellite orbit elements using the state vectors at that time point and then routine 'sws_ijbin' assigns the sub-track coordinate indices (i.e., along track row number and across track cell number) by utilizing orbit elements. Details of the WVC assignment algorithm can be found in the report [10].

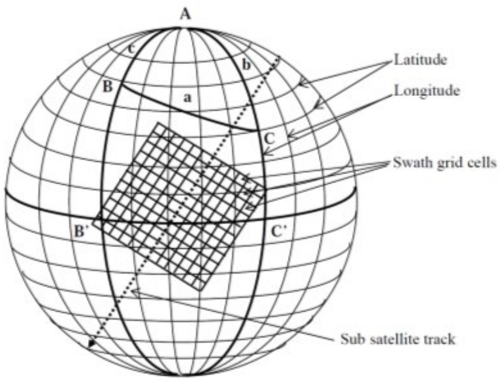

Figure 3 Satellite sub-track grid.

Module test result:

Figure 4 shows that slices are assigned on rows correctly. In the example row (Figure 5), different color represents different WVCs and it shows the allocation of the slices are correct.

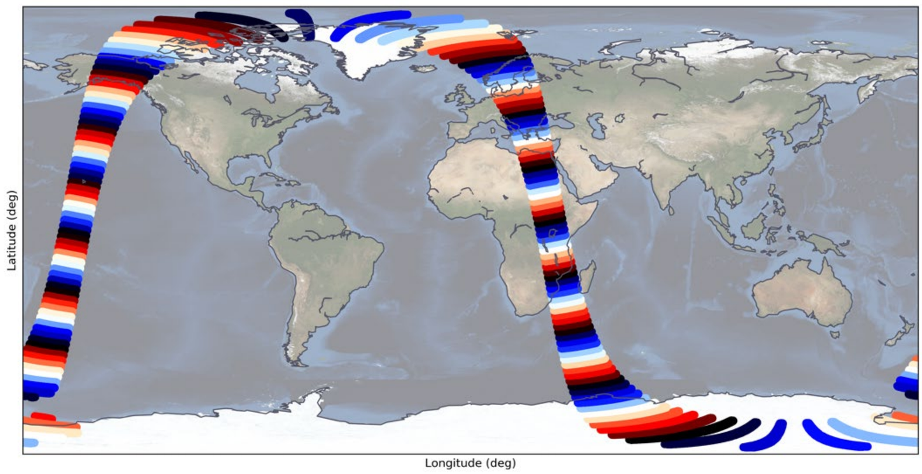

Figure 4 Illustration of the slices organized by rows (10 rows interval, the orbit is 20190827T163206_20190827T180158_04584_01).

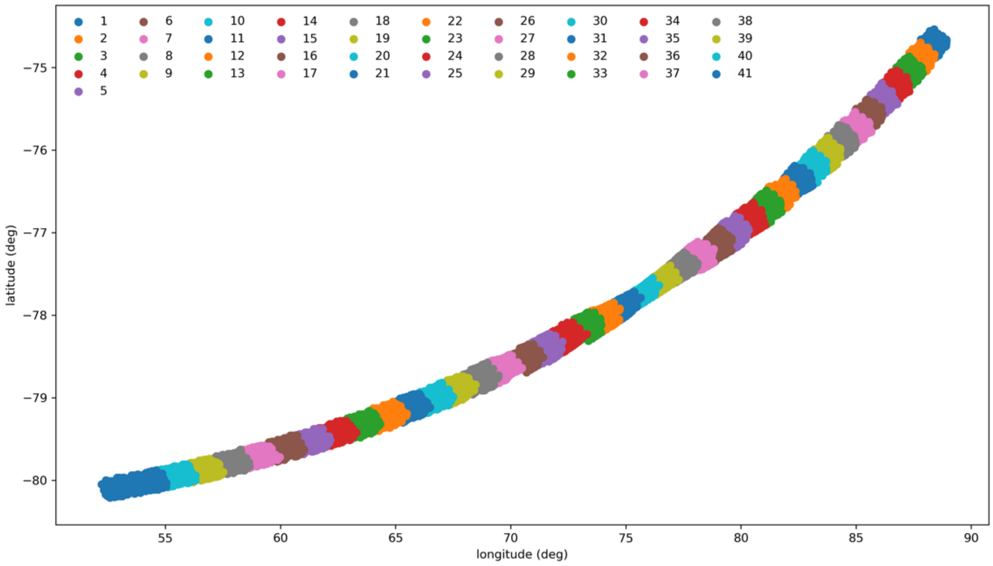

Figure 5 Slices WVC distribution of row number 100 from orbit 20190827T163206_20190827T180158_04584_01 (color indicates different WVCs).

3.2 L2A BUFR

In the conversion from HDF5 to BUFR, slice sigma0, instrument coefficients (A B C), and SNR with the same view number and WVC number are aggregated. The slices in one WVC are first classified into views. The view definition is that all the pulses in one circle of the rotation are counted as one view, and the next successive circle is the next view and so on. The sigma0s in the same view are aggregated (1).

$$\sigma^\circ = \frac{\sum_s A_s^{-1} \sigma^\circ{}_s}{\sum_s A_s^{-1}} \qquad (1)$$

where σ° is the WVC view backscatter, $\sigma^\circ{}_s$ is the slice backscatter and A_s is the slice instrument noise coefficient A. The weight A_s^{-1} are proportional to the estimated transmitted power contained in a slice (3.1.3) and thus the above weighting relates to a summation over backscattered power.

Instrument noise coefficients A, B, C for a WVC view are computed from the slice A_S,B_S,C_S with (2).

$$\mathrm{A} = \left(\sum_s A_s^{-1}\right)^{-1}$$
$$\mathrm{B} = \left(\sum_s B_s^{-1}\right)^{-1} \qquad (2)$$

$$C = (\sum_s C_s^{-1})^{-1}$$

SNR. of a WVC is obtained from the slice received power (3).

$$\mathrm{SNR} = \mathrm{B} \cdot \frac{P}{2} \quad (3)$$

$$P = \sum_s P_s \quad (4)$$

$$\text{where } P_s = 2 \cdot \frac{SNR_s}{B_s}$$

Now the instrument noise $K_p^2 = A + \frac{B}{SNR} + \frac{C}{SNR^2}$ is obtained for each WVC view.

Module test result:

Data is saved as BUFR format using an adapted BUFR definition table from SeaWinds (Figure 6).

```
 1 SATELLITE IDENTIFIER              0.42100000000000E+003 CODE TABLE 1007
 2 DIRECTION OF MOTION OF MOVING OB  0.27400000000000E+003 DEGREE TRUE
 3 SATELLITE SENSOR INDICATOR                      MISSING CODE TABLE 2048
 4 WIND SCATTEROMETER GEOPHYSICAL M                MISSING CODE TABLE 21119
 5 SOFTWARE IDENTIFICATION (SEE NOT  0.20170000000000E+004 NUMERIC
 6 CROSS TRACK RESOLUTION            0.25000000000000E+005 M
 7 ALONG TRACK RESOLUTION            0.25000000000000E+005 M
 8 ORBIT NUMBER                      0.11816000000000E+005 NUMERIC
 9 YEAR                              0.20110000000000E+004 YEAR
10 MONTH                             0.12000000000000E+002 MONTH
11 DAY                               0.17000000000000E+002 DAY
12 HOUR                              0.10000000000000E+001 HOUR
13 MINUTE                            0.15000000000000E+002 MINUTE
14 SECOND                            0.50000000000000E+001 SECOND
15 LATITUDE (COARSE ACCURACY)       -0.83190000000000E+002 DEGREE
16 LONGITUDE (COARSE ACCURACY)       0.65960000000000E+002 DEGREE
17 TIME DIFFERENCE QUALIFIER                       MISSING CODE TABLE 8025
18 SECOND                                          MISSING SECOND
19 ALONG TRACK ROW NUMBER                          MISSING NUMERIC
20 CROSS-TRACK CELL NUMBER           0.32000000000000E+002 NUMERIC
21 SEAWINDS WIND VECTOR CELL QUALIT  0.20000000000000E+001 FLAG TABLE 21109
22 MODEL WIND DIRECTION AT 10M                      MISSING DEGREE TRUE
23 MODEL WIND SPEED AT 10M                          MISSING M/S
24 NUMBER OF VECTOR AMBIGUITIES      0.00000000000000E+000 NUMERIC
25 INDEX OF SELECTED WIND VECTOR                   MISSING NUMERIC
26 TOTAL NUMBER OF SIGMA-0 MEASUREM  0.14000000000000E+002 NUMERIC
27 PROBABILITY OF RAIN                             MISSING NUMERIC
28 SEAWINDS NOF* RAIN INDEX          0.10000000000000E+002 NUMERIC
29 INTENSITY OF PRECIPITATION                      MISSING KG/(M**2)S
30 ATTENUATION CORRECTION OF SIGMA-                MISSING dB
31 WIND SPEED AT 10 M                              MISSING M/S
32 FORMAL UNCERTAINTY IN WIND SPEED                MISSING M/S
33 WIND DIRECTION AT 10 M                          MISSING DEGREE TRUE
34 FORMAL UNCERTAINTY IN WIND DIREC                MISSING DEGREE TRUE
35 LIKELIHOOD COMPUTED FOR SOLUTION                MISSING NUMERIC
36 WIND SPEED AT 10 M                              MISSING M/S
37 FORMAL UNCERTAINTY IN WIND SPEED                MISSING M/S
38 WIND DIRECTION AT 10 M                          MISSING DEGREE TRUE
39 FORMAL UNCERTAINTY IN WIND DIREC                MISSING DEGREE TRUE
40 LIKELIHOOD COMPUTED FOR SOLUTION                MISSING NUMERIC
41 WIND SPEED AT 10 M                              MISSING M/S
42 FORMAL UNCERTAINTY IN WIND SPEED                MISSING M/S
43 WIND DIRECTION AT 10 M                          MISSING DEGREE TRUE
44 FORMAL UNCERTAINTY IN WIND DIREC                MISSING DEGREE TRUE
45 LIKELIHOOD COMPUTED FOR SOLUTION                MISSING NUMERIC
46 WIND SPEED AT 10 M                              MISSING M/S
47 FORMAL UNCERTAINTY IN WIND SPEED                MISSING M/S
48 WIND DIRECTION AT 10 M                          MISSING DEGREE TRUE
49 FORMAL UNCERTAINTY IN WIND DIREC                MISSING DEGREE TRUE
50 LIKELIHOOD COMPUTED FOR SOLUTION                MISSING NUMERIC
51 ANTENNA POLARISATION              0.00000000000000E+000 CODE TABLE 2104
52 TOTAL NUMBER (WITH RESPECT TO AC  0.00000000000000E+000 NUMERIC
53 BRIGHTNESS TEMPERATURE            0.00000000000000E+000 K
54 STANDARD DEVIATION BRIGHTNESS TE  0.00000000000000E+000 K
55 ANTENNA POLARISATION              0.10000000000000E+001 CODE TABLE 2104
56 TOTAL NUMBER (WITH RESPECT TO AC  0.00000000000000E+000 NUMERIC
57 BRIGHTNESS TEMPERATURE            0.00000000000000E+000 K
58 STANDARD DEVIATION BRIGHTNESS TE  0.00000000000000E+000 K
59 NUMBER OF INNER-BEAM SIGMA-0 (FO  0.10000000000000E+001 NUMERIC
```

Figure 6 BUFR file sample.

4. Installing L2A processor

4.1 Installation

To install L2A processor, the following steps must be taken:

1. Copy the `CWDP` package to the directory where L2A processor will be applied.

2. The installation of BUFR/GRIB library (ecCodes) and HDF5 library can be checked in [11] and they are already in `CWDP`, extra installation is not needed.

3. Go to the directory of `CWDP` and run `Makefile`. It will compile all the necessary codes and link executable files to `execs` directory.

4. Test run: for testing you will need NetCDF format CFOSAT level 1b data files. The script `cwdp_l1b_l2a_retrieval_deliver` in the directory `cwdp/execs` provides an example how to test the L2A processor. This script will execute the L2A processor. (Note that the inversion command line `../src/cwdp` is also in the bash file, it can be commented out for test L2A processor). Note: please redefine the directory of the data and environment variables by yourself in the test run file.

5. Convert L2A BUFR to NetCDF:

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

There are several environment variables to be set in Table 4 and they are set at the beginning of the bash file `cwdp_l1b_l2a_retrieval_deliver`.

Table 4 Environment variables

Name	Value
`$LUT_FILENAME_KU_HH`	`cwdp/data/little_endian/nscat4ds_250_73_51_hh.dat`
`$LUT_FILENAME_KU_VV`	`cwdp/data/little_endian/nscat4ds_250_73_51_vv.dat`
`$GRIB_DEFINITION_PATH`	`genscat/support/eccodes/definitions`
`$LUTSDIR`	`cwdp/data/`

A new BUFR table D entry (3 12 034) is added for CFOSAT, it is delivered together with the software. CWDP uses the NSCAT-4DS Geophysical Model Function [12] by default, this is set by the variables `$LUT_FILENAME_KU_HH` and `$LUT_FILENAME_KU_VV`.

4.2 Directories and files

All the codes for the L2A processor are stored in `cwdp/`. There are two subdirectories: `cwdp` and `genscat`, each of them contains a number of files and subdirectories. Table 5 shows the contents of the `cwdp` directory and the contents of genscat can be seen in [11]. After compilation, the subdirectories with the source code will also contain the object codes of the various modules and routines.

Table 5 Contents of directory `cwdp`

Name	Contents
`data`	Look-up tables necessary in the processing
`l1b_l2a`	L2A processor to generate L2A data, HDF5 format
`hdf2bufr`	Tool to convert L2A HDF5 to BUFR
`src`	Source code for CWDP and supporting routines
`execs`	Link to cwdp executables, shell script for running L2A processor.

5. Command line options

‘<   >’ indicates obligatory input.
All the commands can be executed with a bash file ‘cwdp_l1b_l2a_retrieval_deliver’ under `execs/`.

5.1 cfosat_l1b_l2a

cfosat_l1b_l2a: process L1B data to L2A HDF5 data.

cfosat_l1b_l2a -l1b <input file L1B NetCDF> -s <wvc size>

-l1b <input file L1B NetCDF> *Read in L1B data in NetCDF4 format*

-s <wvc size> *Define WVC size: 25 or 50 (km).*

6.5 cfosat_hdf2bufr

cfosat_hdf2bufr: convert L2A HDF5 to BUFR format.

cfosat_hdf2bufr -f <input file L2A hdf> -o <output bufr file>

-f <input file L2A hdf> *Read in L2A HDF5 data.*

-o <output bufr file> *Define output file name.*

References

[1] C. C. Lin, B. Rommen, J. J. W. Wilson, F. Impagnatiello, and P. S. Park, “An analysis of a rotating, range-gated, fanbeam spaceborne scatterometer concept,” *IEEE Trans. Geosci. Remote Sens.*, vol. 35, no. 5, pp. 2114–2121, 2000.

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[9] K. Donald, “Converting earth-centered, earth-fixed coordinates to geodetic coordinates,” *IEEE Trans. Aerosp. Electron. Syst.*, vol. 32, no. 1, pp. 473–476, 1996.

[10] R. S. Dunbar, S. V. Hsiao, Y. Kim, K. S. Pak, B. H. Weiss, and A. Zhang, “Science Algorithm Specification,” *Jet Propuls.*, 2001.

[11] A. Verhoef, J. Vogelzang, J. Verspeek, and A. Stoffelen, “PenWP User Manual and Reference Guide,” de Bilt, the Netherlands, 2017.

[12] See https://scatterometer.knmi.nl/nscat_gmf/ and references thereon

Appendix A: BUFR data descriptors

This appendix contains lists of descriptors for the BUFR format in tables A.1. The format is derived from the SeaWinds format, but it has extra space for more views per WVC. The title CFOSAT is substituted by SeaWinds to keep the table consistence. Line number 59 to 73 are repeated 18 times for the maximum 18 views in one WVC.

Table A.1 List of data descriptors for the NOAA BUFR format.

CFOSAT BUFR format			
Number	**Descriptor**	**Parameter**	**Unit**
1	001007	Satellite Identifier	Code Table
2	001012	Direction Of Motion Of Moving Observing Platform	Degree True
3	002048	Satellite Sensor indicator	Code Table
4	021119	Wind Scatterometer Geophysical Model Function	Code Table
5	025060	Software Identification	Numeric
6	002026	Cross Track Resolution	m
7	002027	Along Track Resolution	m
8	005040	Orbit Number	Numeric
9	004001	Year	Year
10	004002	Month	Month
11	004003	Day	Day
12	004004	Hour	Hour
13	004005	Minute	Minute
14	004006	Second	Second
15	005002	Latitude (Coarse Accuracy)	Degree
16	006002	Longitude (Coarse Accuracy)	Degree
17	008025	Time Difference Qualifier	Code Table
18	004006	Time to Edge	Second
19	005034	Along Track Row Number	Numeric
20	006034	Cross Track Cell Number	Numeric
21	021109	SeaWinds Wind Vector Cell Quality	Flag Table
22	011081	Model Wind Direction At 10 m	Degree True
23	011082	Model Wind Speed At 10 m	m/s
24	021101	Number Of Vector Ambiguities	Numeric
25	021102	Index Of Selected Wind Vector	Numeric
26	021103	Total Number of Sigma-0 Measurements	Numeric
27	021120	Probability of Rain	Numeric
28	021121	SeaWinds NOF* Rain Index	Numeric
29	013055	Intensity of Precipitation	kg/m^2s

CFOSAT BUFR format			
Number	**Descriptor**	**Parameter**	**Unit**
30	021122	Attenuation Correction of Sigma-0 (from Tb)	dB
31	011012	Wind Speed At 10 m	m/s
32	011052	Formal Uncertainty in Wind Speed	m/s
33	011011	Wind Direction At 10 m	Degree True
34	011053	Formal Uncertainty in Wind Direction	Degree True
35	021104	Likelihood Computed For Solution	Numeric
36	011012	Wind Speed At 10 m	m/s
37	011052	Formal Uncertainty in Wind Speed	m/s
38	011011	Wind Direction At 10 m	Degree True
39	011053	Formal Uncertainty in Wind Direction	Degree True
40	021104	Likelihood Computed For Solution	Numeric
41	011012	Wind Speed At 10 m	m/s
42	011052	Formal Uncertainty in Wind Speed	m/s
43	011011	Wind Direction At 10 m	Degree True
44	011053	Formal Uncertainty in Wind Direction	Degree True
45	021104	Likelihood Computed For Solution	Numeric
46	011012	Wind Speed At 10 m	m/s
47	011052	Formal Uncertainty in Wind Speed	m/s
48	011011	Wind Direction At 10 m	Degree True
49	011053	Formal Uncertainty in Wind Direction	Degree True
50	021104	Likelihood Computed For Solution	Numeric
51	002104	Antenna Polarisation	Code Table
52	008022	Total Number (w.r.t. Accumulation or Average)	Numeric
53	012063	Brightness Temperature	K
54	012065	Standard Deviation Brightness Temperature	K
55	002104	Antenna Polarisation	Code Table
56	008022	Total Number (w.r.t. Accumulation or Average)	Numeric
57	012063	Brightness Temperature	K
58	012065	Standard Deviation Brightness Temperature	K
59	021110	Number of Inner-beam Sigma-0 (Forward of Satellite)	Numeric
60	005002	Latitude (Coarse Accuracy)	Degree
61	006002	Longitude (Coarse Accuracy)	Degree
62	021118	Attenuation Correction on Sigma-0	dB
63	002112	Radar Look Angle	Degree
64	002111	Radar Incidence Angle	Degree
65	002104	Antenna Polarisation	Code Table
66	021123	SeaWinds Normalised Radar Cross Section	dB
67	021106	Kp Variance Coefficient (Alpha)	Numeric
68	021107	Kp Variance Coefficient (Beta)	Numeric
69	021114	Kp Variance Coefficient (Gamma)	dB
70	021115	SeaWinds Sigma-0 Quality	Flag Table
71	021116	SeaWinds Sigma-0 Mode	Flag Table
72	008018	SeaWinds Land/Ice Surface Type	Flag Table
73	021117	Sigma-0 Variance Quality Control	Numeric

Appendix B: Acronyms

BUFR	Binary Universal Form for the Representation of data
CWDP	CFOSAT Wind Data Processor
CFOSAT	China-France Oceanography SATellite
ECEF	Earth Centered Earth Fixed
ECI	Earth Centered Inertial
ECMWF	European Centre for Medium-range Weather Forecasts
genscat	generic scatterometer software routines
GMF	Geophysical model function
HDF5	Hierarchical Data Format version 5
HH	Horizontal radar polarization
L1B	Level 1-B
L2A	Level 2-A
NetCDF	Network Common Data Form
NSOAS	National Ocean Satellite Application Center.
NWP	Numerical Weather Prediction
PRF	Pulse Repeat Frequency
RFSCAT	Rotating Fan-beam SCATterometer
SNR	Sigma to Noise Ratio
VV	Vertical radar polarization
WVC	Wind Vector Cell