

#### SMOS\_NRT\_BUFR\_ECMWF - v3.1

25 May 2021

### **SMOS NRT BUFR specification**

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- 3- INDRA
- 4- European Space Agency (ESA)

#### **Change Record:**

	DATE	CHANGE STATUS		
1.0	14/03/2008	Document prepared by ECMWF		
1.1	26/03/2008	Incorporates comments from M. Zapáta Gonzales		
		and file naming convention. Includes a section on BUFR encoding		
1.2	04/04/2008	File naming convention updated according to INDRA's request to		
		include sensing stop time in the file name.		
1.3	29/05/2008	Clarifications from DEIMOS (Andrés Canales) concerning the file		
		naming convention.		
1.4	07/08/2008	Correction of scale and data width of Faraday and Azimuth angles		
		(comment by Andres Canales and Antonio Gutiérrez).		
1.5	09/09/2008	Update of the TEC element name according to WMO document		
		updated by Milan Dragosavac. Spelling correction on the		
		"Radiometric accuracy name".		
1.6	27/10/2008	WMO update on references 001024, 007011, 025144, 002098 which		
		become 001124, 007012, 025174, 002099 respectively.		
1.7	07/11/2008	Modification of the overall quality corresponding parameters. The overall		
		quality refers to the Product_Confidence of the SO-TN-IDR- 005		
		document of the Main Product Header (instead of to the 'Overall_quality'		
		of the SO-ID-DMS-GS-002 document as it was indicated in version 1.6).		
1.8	10/11/2008	Clarification of the relation between the TB fields (012080, 012081) and		
		the polarisation information code table (R. Crapolicchio).		
		Calibration degradation and multiple degradation included in the		
1.0	10/02/2000	overall quality code table (reserved codes 5 and 6).		
1.9	18/03/2009	Compression setting and WMO version table clarified		
2.0	06/02/2012	Upgrades in the information flag table, in particular in the RFI Flag		
3.0	02/04/2015	Update the flags information to processor V620 in agreement with the		
		NK1 Product Specification document (SO-ID-DMS-GS-0002 v4.1)		
3.1	25/05/2021	Update the RFI flags information into Flag Table for processor baseline		
		V724 in agreement with the NRT Product Specification document (SO-		
		ID-DMS-GS-0002 v4.2). Few minor text editing		

This document provides the BUFR specification for the Level 1c SMOS NRT products. It was prepared by ECMWF with input from Deimos and ESA.

The SMOS NRT BUFR specification is based on both:

- WMO data representation and codes,
- SMOS NRT product format specification provided by DEIMOS in the document SO-ID-DMS-GS-0002 v4.1.

The SMOS BUFR specification has been validated by WMO at the end of October 2008.

The following table indicates the BUFR message content. Each BUFR message contains the data describing one snapshot and data for each of its pixels. One BUFR file may contain several BUFR messages.

For each field both the DEIMOS and WMO references are indicated. In WMO Common Tables driven codes contain a sequence of data descriptors, which is like a set of "pointers" towards elements in predefined and internationally agreed tables (stored in the official WMO Manual on Codes). By definition these descriptors are six digits reference numbers as defined in the WMO Common Codes Tables. The list of new Table entries and corresponding codes will proposed to WMO meeting of the Expert Team on Data Representation and Codes (ET/DRC).

In BUFR most meteorological or oceanographic parameters are represented in Standard International (SI) units such as meters or degrees Kelvin. However, the data may also be Numeric (e.g. a WMO block number), or character. Furthermore, the units may also refer to a code or flag table following the WMO Manual On Codes. The scale factor is the exponent of the power of 10 by which the value of the element has to be multiplied prior to encoding. The reference value is a number to be subtracted from the data after multiplication by the scale factor (if any) but before encoding in order to produce a nonnegative value in all cases. It corresponds to the minimum possible value of the field after scaling. The data width is a count of how many bits the largest possible value of an individual data item occupies, after multiplication with the scale factor and subtraction of the reference value.

Line	Deimos Table SO-ID-	WMO Table	Element name	BUFR			
	DMS-GS-002	Reference					
		(descriptor)			_	1	
		FXY		Unit	Scale	Ref. value	Data
							width
1	Fixed value = 046	001007	Satellite identifier	Code table	0	0	10
2	Fixed value = 176	002019	Instrument type	Code table	0	0	11
3	Table 12 field #3	001144	Snapshot identifier	Numeric	0	0	31
4	Table 13/14 field #2	001124	Grid point identifier	Numeric	0	0	24
5	Table 13/14 field #7	030010	Number of grid points	Numeric	0	0	13
6	Table 13/14 field #2	004001	Year	Year	0	0	12
7	Table 13/14 field #2	004002	Month	Month	0	0	4
8	Table 13/14 field #2	004003	Day	Day	0	0	6
9	Table 13/14 field #2	004004	Hour	Hour	0	0	5
10	Table 13/14 field#2	004005	Minute	Minute	0	0	6
11	Table 13/14 field #2	004006	Second	Second	0	0	6
12	Table 13/14 field #3	005001	Latitude	Degrees	5	-9000000	25
13	Table 13/14 field #4	006001	Longitude	Degrees	5	-18000000	26
14	Table 13/14 field #5	007012	Grid point altitude	М	2	-50000	20
15	Table 12 field #17	015012	Total electron count per	1/M**2	-16	0	6
			square meter				
16	Table 12 field #23	012165	Direct sun brightness	K	0	0	23
			temperature				
17	Table 12 field #24	012166	Snapshot accuracy	K	1	-4000	13
18	Table 12 field #25	012167	Radiometric accuracy	K	1	0	9
			(pure polarisation)				
19	Table 12 field# 25	012168	Radiometric accuracy	K	1	0	9
			(cross polarisation)				
20	Table 13/14 field #16	027010	Footprint axis 1	М	-1	0	14
21	Table 13/14 field #17	028010	Footprint axis 2	М	-1	0	14
22	Table 13/14 field #8	002099	Polarisation	Code table	0	0	3
23	Table 13/14 field #6	013048	Water fraction	%	1	0	10
24	Table 13/14 field #11	025081	Incidence angle	Degree	3	0	17
25	Table 13/14 field #12	025082	Azimuth angle	Degree	3	0	19
26	Table 13/14 field #13	025083	Faraday rotational angle	Degree	3	0	19
27	Table 13/14 field #14	025084	Geometric rotational	Degree	5	0	26
			angle	C			
28	Table 13/14 field #9a	012080	Brightness temperature	K	2	-10000	16
			real part				
29	Table 13/14 field #9b	012081	Brightness temperature	K	2	-10000	16
	-		imaginary part			-	
30	Table 13/14 field #10	012082	Pixel radiometric	K	2	0	12
			accuracy				
31	Table 13/14 field #8	025174	SMOS information flag	Flag table	0	0	14
32	Table 4-1, field #23 (Doc.	033028	Snapshot Overall Ouality	Code table	0	0	3
-	SO-TN-IDR-GS-0005)		1 (		-		-
				1	1		1

Table: SMOS BUFR message content

The overall unexpanded date WMO descriptor is 301011. Its expanded descriptors are defined in WMO Common Code Table and used here: 004001 (year), 004002 (month), 004003 (day). The unexpanded time of observation's descriptor is 301012. It encompasses the expanded descriptors used here: 004004 (Hour) and 004005 (Minutes). The unexpanded latitude-longitude descriptor is 301021 (high accuracy). The expanded descriptors 005001 (latitude) and 005001 (longitude) are used respectively.

#### WMO entries

For the purpose of SMOS data encoding, the following entries have been proposed by M. Dragosavac to WMO Common Codes Tables (WMO Table B). These entries have been validated by the WMO:

1	001007	SATELLITE IDENTIFIER	CODE TABLE 1007
2	002019	SATELLITE INSTRUMENT TYPE	CODE TABLE 2019
3	001144	SNAPSHOT IDENTIFIER (VAL)	NUMERIC
4	001124	GRID POINT IDENTIFIER (VAL)	NUMERIC
5	030010	NUMBER OF GRID POINTS (VAL)	NUMERIC
14	007012	GRID POINT ALTITUDE (VAL)	М
15	015012	TOTAL ELECTRON COUNT (VAL)	1/M**2
16	012165	DIRECT SUN BRIGHTNESS TEMPERATURE (VAL)	Κ
17	012166	SNAPSHOT ACCURACY (VAL)	Κ
18	012167	RADIOMETRIC ACCURACY (PURE POLARISATION) (VAL)	Κ
19	012168	RADIOMETRIC ACCURACY (CROSS POLARISATION) (VAL)	K
20	027010	FOOTPRINT AXIS 1 (VAL)	М
21	028010	FOOTPRINT AXIS 2 (VAL)	М
22	002099	POLARISATION (VAL)	CODE TABLE
23	013048	WATER FRACTION	%
24	025081	INCIDENCE ANGLE (VAL)	DEGREE
25	025082	AZIMUTH ANGLE (VAL)	DEGREE
26	025083	FARADAY ROTATIONAL ANGLE (VAL)	DEGREE
27	025084	GEOMETRIC ROTATIONAL ANGLE (VAL)	DEGREE
28	012080	BRIGHTNESS TEMPERATURE REAL PART (VAL)	Κ
29	012081	BRIGHTNESS TEMPERATURE IMAGINARY PART (VAL)	K
30	012082	PIXEL RADIOMETRIC ACCURACY (VAL)	Κ
31	025174	SMOS INFORMATION FLAG (VAL)	FLAG TABLE
32	033028	SNAPSHOT OVERALL QUALITY	CODE TABLE

This provides the structure of the BUFR message. Within this structure, some of the provided codes might be updated by the WMO ET/DRC.

#### **Code Tables**

Concerning the polarisation information (line 22) a W M O code table is used (002098 Polarisation). It is defined in agreement with the polarisation flag of the SMOS NRT product format specification of the Deimos document SO-ID-DMS-GS-0002 (v4.2), section 6.2.3.

In the BUFR format its meaning is defined as: Code

Meaning

0	HH polarisation
1	VV polarisation
2	HV polarisation real valued component
3	HV polarisation imaginary valued component
4-6	Reserved
7	Missing value

The two TB numbers (lines 28 and 29) are the 3rd and 4th Stokes parameter for the HV polarisation (code 2) and the 3rd and 4th Stokes parameter for the VH polarization (code 3). In case of pure polarization HH (code 0) and VV (code 1) only the line 28 is filled.

Concerning the overall quality (line32) a code table has been included to WMO code (Code table 22028, Snapshot overall quality). It is defined in agreement with the Product\_Confidence of the SMOS NRT product format specification (document SO-TN-IDR-GS-0005):

1	Nominal
2	Degraded by SW error: any error reported by the algorithms
3	Degraded by instrument error
4	Degraded by corrupted/missing ADF
5-6	Reserved
7	Missing value

The reserved value 5 indicates data degraded by calibration errors. In case of multiple degradation causes, the following codes are used:

- 2 indicates any combination of multiple errors including SW error,
- 3 indicates any combination of multiple errors including instrument error and not including SW error,
- 6 indicates degraded by corrupted/missing ADF and degraded by calibration errors.

## Flag Table

For the SMOS information flag (line 31), a f WMO Code flag table is used (code 025144). In agreement with the SMOS NRT product specification (SO-ID-DMS-GS-0002, v4.2, section 6.2.3) it is defined as:

Bit number Meaning Pixel is affected by RFI effects as identified in the AUX RFILST or it has 1 exceeded the Brightness Temperature thresholds 2 Pixel is located in the hexagonal alias directions centred on a Sun alias (if Sun is not removed, measurement may be degraded in these directions) 3 Pixel is close to the border delimiting the Extended Alias free zone or to the unit circle replicas borders. 4 Measurement is affected by the tails of a point source RFI as identified in the AUX RFI list (tail width is dependent on the RFI expected Brightness Temperature, from each snapshot measurements, corresponding to 0.16 of the radius of the RFI circle flagged) 5 Pixel is inside the exclusive zone of Alias free. 6 Pixel is located in a zone where a Moon alias was reconstructed 7 Pixel is located in a zone where Sun reflection has been detected 8 Pixel is located in a zone where a Sun alias was reconstructed 9 Measurement is affected by RFI effects as identified in the AUX RFI list whose contribution generates a contamination in Brightness Temperature above 30K in the corresponding polarization. 10 Scene has not been combined with an adjacent scene in opposite polarisation during image reconstruction Direct Moon correction has been performed during image reconstruction of 11 this pixel 12 Reflected Sun correction has been performed during image reconstruction of this pixel 13 Direct Sun correction has been performed during image reconstruction of this pixel Missing value All 14

# WMO Identifiers

• For the satellite identifier, the following new sub category has been added to the WMO Common Code Table C-13:

Data categoryInternational sub-category12 Surface data (satellite)007SMOS data

- WMO Common Code Table C-5 contains the SMOS satellite identifier (code figure 046)
- WMO Common Code Table C-8 contains the MIRAS instrument identifier (code figure 176)

#### An example of expanded sequence

The sequence for SMOS data in a BUFR message is: DATA DESCRIPTORS (UNEXPANDED)

1 312070

#### DATA DESCRIPTORS (EXPANDED)

ELEMENT NAME

UNIT

1	001007	SATELLITE IDENTIFIER	CODE TABLE 1007
2	002019	SATELLITE INSTRUMENT TYPE	CODE TABLE 2019
3	001144	SNAPSHOT IDENTIFIER (VAL)	NUMERIC
4	001124	GRID POINT IDENTIFIER (VAL)	NUMERIC
5	030010	NUMBER OF GRID POINTS (VAL)	NUMERIC
6	004001	YEAR	YEAR
7	004002	MONTH	MONTH
8	004003	DAY	DAY
9	004004	HOUR	HOUR
10	004005	MINUTE	MINUTE
11	004006	SECOND	SECOND
12	005001	LATITUDE (HIGH ACCURACY)	DEGREE
13	006001	LONGITUDE (HIGH ACCURACY)	DEGREE
14	007012	GRID POINT ALTITUDE (VAL)	М
15	015012	TOTAL ELECTRON COUNT (VAL)	1/M**2
16	012165	DIRECT SUN BRIGHTNESS TEMPERATURE (VAL)	Κ
17	012166	SNAPSHOT ACCURACY (VAL)	Κ
18	012167	RADIOMETRIC ACCURACY (PURE POLARISATION) (VAL)	Κ
19	012168	RADIOMETRIC ACCURACY (CROSS POLARISATION) (VAL)	Κ
20	027010	FOOTPRINT AXIS 1 (VAL)	М
21	028010	FOOTPRINT AXIS 2 (VAL)	М
22	002099	POLARISATION (VAL)	2099
23	013048	WATER FRACTION	%
24	025081	INCIDENCE ANGLE (VAL)	DEGREE
25	025082	AZIMUTH ANGLE (VAL)	DEGREE
26	025083	FARADAY ROTATIONAL ANGLE (VAL)	DEGREE
27	025084	GEOMETRIC ROTATIONAL ANGLE (VAL)	DEGREE
28	012080	BRIGHTNESS TEMPERATURE REAL PART (VAL)	Κ
29	012081	BRIGHTNESS TEMPERATURE IMAGINARY PART (VAL)	K
30	012082	PIXEL RADIOMETRIC ACCURACY (VAL)	K
31	025174	SMOS INFORMATION FLAG (VAL)	FLAG TABLE
32	033028	SNAPSHOT OVERALL QUALITY	22028

## Data size estimation

In average, one BUFR message will contain 4800 subsets which is equivalent to one snapshot with 4800 pixels. This averaged number can vary depending on the number of pixels considered in the snapshot. One file can contain one or more BUFR messages.

Averaged number of files per day:	28
Averaged size of each file:	400 MB
Total size per day:	11.5 GB

## File naming convention

For each snapshot, acquired data are provided in a separate BUFR message. Each file might contain several BUFR messages. In the case the acquisition covers more than one orbit, we request a maximum of one orbit per file. The file naming convention for the SMOS NRT level1c brightness temperature product is defined as follow:

 $\\ $Instrument_$SensingTime1_$SensingTime2_$Satellite_$orbit_$datatype_$GeneratingTime_$datalevel.bufr$ 

Where:

- \$Instrument is the name of the instrument in 5 characters. It is fixed to 'miras'
- \$SensingTime1 = \$YYYYMMDD\_\$HHMMSS is the first MIRAS integration time within the product
- \$SensingTime2 = \$YYYYMMDD\_\$HHMMSS is the last MIRAS integration time within the product
- \$YYYYMMDD is a 8 digits number to depict the year month day
- \$HHMMSS is a 6 digits number for hour minute second
- \$Satellite is the name of the satellite in 4 characters. It is fixed to: 'smos'
- \$orbit is the 5 digits orbit number
- \$datatype : is 1 character, either 'o' for operational, or 't' for test in case of delayed or degraded data
- \$GeneratingTime = \$YYYYMMDD\_\$HHMMSS is the time stamp of the BUFR generation date time
- \$datalevel : 3 characters fixed for level1c to '11c'

The character '\_' is the separator character. The extension '.bufr' indicates that the file is a bufr file. For SMOS NRT Level 1c products, this naming convention leads to: miras\_YYYYMMDD\_HHMMSS\_YYYYMMDD\_HHMMSS\_smos\_\$orbit\_o\_YYYYMMDD\_HHMMSS\_l1c.bufr

# **BUFR encoding**

BUFR messages can be encoded using the ECMWF BUFR software from ECMWF: <u>https://confluence.ecmwf.int/display/ECC/What+is+ecCodes</u>

A description of BUFR format is provided at: <u>https://confluence.ecmwf.int/display/ECC/Documentation</u>

BUFR tools are available at:

https://confluence.ecmwf.int/display/ECC/BUFR+tools

For more information, WMO documents provide detailed description of BUFR format, including information on BUFR compression: http://www.wmo.ch/pages/prog/www/WDM/Guides/BUFRCREXGuide-English.html

The BUFR files are using the WMO table version 14. Compression setting is: ksec3(4)=192 if more than 1 subset ksec3(4)=128 if 1 subset