

Definition of Basic Polar Data Product

OPERA project 1d3: working document WD_02_03

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1 Introduction

During the OPERA project an additional deliverable for working group 1 has been identified. This deliverable concerns with the definition of the mandatory BUFR descriptors and data layout for a basic polar data product. This project is carried out by working group 1 and it has been added to project 1d: “To agree on the production of a standard set of data for international exchange”.

When a weather radar collects polar scan data, the antenna rotates clockwise at a fixed elevation. The radar processor receives data as a function of range and azimuth which are averaged into rays of data. These rays consists of a number of range bins with a given size in azimuth and range. A basic polar data product contains the rays collected during a rotation of the antenna along the vertical axis. The angle of the antenna with respect to the horizontal plane, i.e, elevation, is fixed during the rotation. The spatial extent of a polar data product is defined by the range-bin size, the azimuthal resolution, the number of range bins per ray, and the number of rays. A Doppler weather radar can simultaneously observe several distinct quantities, like reflectivity factor, mean radial velocity, and spectral width. A basic polar data product may contain data from several elevations and/or quantities.

In this document only the minimum required information to unambiguously store and retrieve basic polar data is described. Information relevant to judgment of the data quality, for instance, has not been defined. It is noted, however, that most of the product quality descriptors defined in working document WD_05_03 (OPERA project 1c3) are applicable to basic polar data products.

The OPERA manual of the FM94-BUFR Encoding and Decoding Software (version 1.2, draft 3) contains a mechanism for storing several (CAPPI) images into a single BUFR message. It is suggested that this mechanism can also be used to support the encoding of basis polar data from multiple elevations and/or multiple quantities.

2 Definition of data layout and mandatory descriptors

Basic polar data have to be stored in “B-scope” polar datablocks as a rectangular image, where the rows represent the rays for all azimuths and each row consists of all range bins at a certain azimuth. The number of pixels per rows reflects the number of range bins and the number of pixels per column reflects the number of azimuthal steps. The range-bins are ordered from the nearest to farthest from the radar antenna. In addition it is defined that the rays are always sequenced clockwise, i.e., from north to east. When rays are absent, the corresponding rows have to be set to “missing data” value, i.e, all bits to 1.

2.1 Mandatory general information

In this section the mandatory BUFR descriptors for general information about the basic polar data product are defined. These BUFR descriptors for WMO station number, date, and time have already been defined by WMO.

F	X	Y	Element name	Unit	Scale	Reference	Width
0	01	001	WMO block number	Numeric	0	0	7
0	01	002	WMO station number	Numeric	0	0	10
0	04	001	Time of observation (year)	Year	0	0	12
0	04	002	Time of observation (month)	Month	0	0	4
0	04	003	Time of observation (day)	Day	0	0	6
0	04	004	Time of observation (hour)	Hour	0	0	5
0	04	005	Time of observation (minute)	Minute	0	0	6

2.2 Mandatory geographical information

In this section mandatory BUFR descriptors for the geographical information about the basic polar data product are defined. They constitute the geographical position of the radar, the height of the antenna feed, and information about the coordinate grid type.

F	X	Y	Element name	Unit	Scale	Reference	Width
0	05	002	Latitude of station	Degree	2	-9000	15
0	06	002	Longitude of station	Degree	2	-18000	16
0	07	001	Height of station	Meter	0	-400	15
0	29	002	Coordinate grid type ⁽¹⁾	Table	0	0	3

(1) To be set equal to 1 for basic polar data.

2.3 Mandatory scan data information

The basic polar data product is stored as an 8-bits per pixel rectangular image (polar datablock). The number of pixels per row is equal to the number of range bins per ray, and the number of pixels per column is equal to the number of azimuth steps, i.e., number of rays. Bit value 255 represents missing data. Each bit value has to be converted to the value of the represented quantity, which is either the reflectivity factor (dBZ), the mean radial velocity (V), or the spectral width (W). For the reflectivity factor, BUFR descriptors for the offset and the increment have already been defined. Corresponding BUFR descriptors for the mean radial velocity and the spectral width have still to be defined.

In addition information about the antenna elevation, the range-bin size, the azimuthal resolution, and the offsets in range and azimuth directions has to be provided. 4 New BUFR descriptors are needed here. The first descriptor is the “range-bin size” which gives the linear size of the polar elements. The range-bin size should not be confused with the range-gate

length which refers to the sampling frequency of the received signal. The second descriptor is the “azimuthal resolution” which in combination with the number of pixels per column describes the azimuthal extent of the polar datablock. The other descriptors are the “range-bin offset” and “azimuth offset” of the first polar kernel, i.e, pixel (0,0) in the rectangular image. When the first range bin starts at the radar, the range-bin offset is defined to be 0 m. When the first ray is towards north, the azimuth offset is defined to be 0 deg.

The OPERA manual of the FM94-BUFR Encoding and Decoding Software (version 1.2, draft 3) contains a mechanism for storing several (CAPPI) images into a single BUFR message. This mechanism can also be used to support the encoding of basis polar data from multiple elevations and/or multiple quantities. For this, it must be possible to repeat the descriptor with the 8-bits polar datablock. The polar datablocks and the attached BUFR descriptors are grouped per quantity using a delayed replication of the descriptors. The replication factor refers to the number of elevations in the basic polar data product.

F	X	Y	Element name	Unit	Scale	Reference	Width
1	10	000	Delayed replication of 10 descriptors				
0	31	001	Replication factor (Num. elevations)				
0	02	135	Antenna elevation	Degree	2	-9000	15
0	30	021	Number of pixels per row	Numeric	0	0	12
0	30	022	Number of pixels per column	Numeric	0	0	12
0	xx	yyy	Range-bin size	Meter	0	0	14
0	xx	yyy	Azimuthal resolution	Degree	1	0	8
0	xx	yyy	Range-bin offset	Meter	-1	0	14
0	xx	yyy	Azimuth offset	Degree	1	0	12
0	21	yyy	Quantity offset (α)	unit	scale	ref	width
0	21	yyy	Quantity increment (β)	unit	scale	ref	width
3	21	yyy	8-bits polar datablock				

Naturally the quantity offset and increment are dependent on the type of basic polar data. This type can be reflectivity factor, mean radial velocity, or spectral width. For the last two quantities new BUFR descriptors have to be defined. Instead of using this delayed replication, the 10 descriptors can also be physically repeated in the input file with the descriptors. The current structure of the BUFR conversion software is such that the descriptor for the 8-bits datablock cannot be repeated using the delayed replication mechanism. The first implementation of the polar data products in BUFR will be using the physical repetition of the 10 descriptors.

F	X	Y	Element name	Unit	Scale	Reference	Width
0	21	198	Quantity offset (α)	dBZ	1	-640	11
0	21	199	Quantity increment (β)	dBZ	1	0	7
0	21	yyy	V-value offset (α)	m/s	2	-16384	15
0	21	yyy	V-value increment (β)	m/s	2	0	8
0	21	yyy	W-value offset (α)	m/s	2	0	14
0	21	yyy	W-value increment (β)	m/s	2	0	8

2.4 Summary of conventions

In this section a listing of the conventions used for the basic polar data product will be given.

- Basic polar data are stored in “polar datablocks” containing data of a single elevation and of a single quantity.
- The polar data are stored ray-by-ray to obtain a rectangular datablock, where the rows represent the rays. The number of pixels per row represent the number of range-bins per ray, and the number of pixels per column represents the number of rays.
- The range-bins are ordered from the nearest to the farthest from the radar.
- The rays are always sequenced clockwise, i.e., from north to east.
- Basic polar data from multiple elevations and/or quantities are stored by repetition of the polar datablocks.
- The polar datablocks and the attached BUFR descriptors are grouped per quantity using (a delayed) replication of the descriptors. The replication factor refers to the number of elevations.

3 Conclusion

It is possible to encode a basic polar data product containing data from multiple elevations and/or from multiple quantities. A new mechanism for encoding several (CAPPI) images into a single BUFR message is employed for this. In this document only mandatory BUFR descriptors are defined which are needed for an unambiguous storage and retrieval of basic polar data. Additional BUFR descriptors for product quality description are defined in another OPERA working document (WD_05_02). Most BUFR descriptors have already been defined by WMO or OPERA, but 10 descriptors have to be defined.