

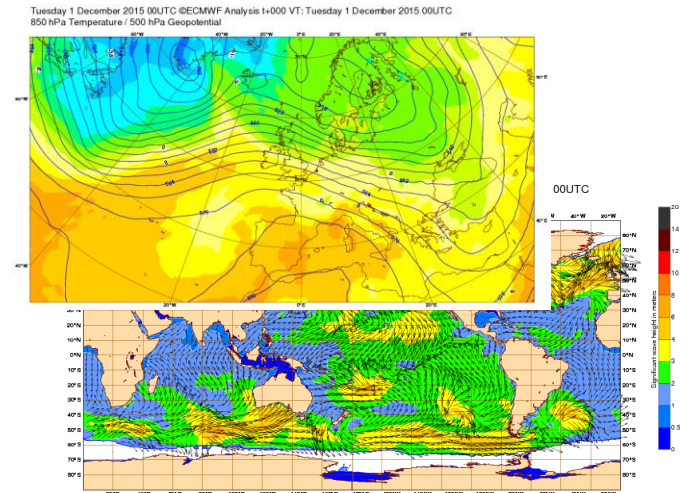
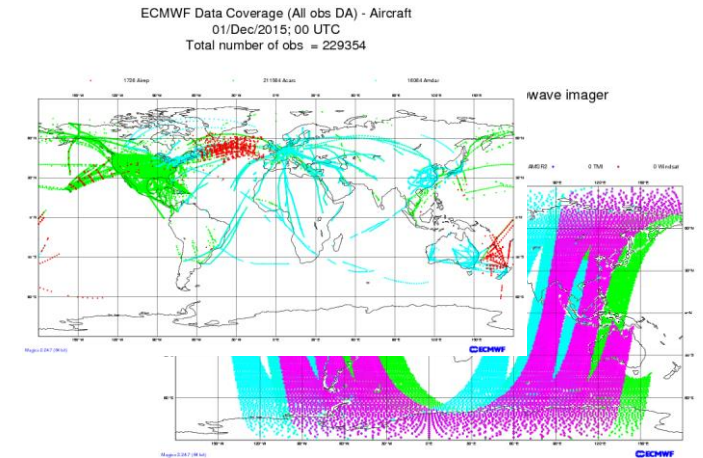
BUFR format in a nutshell

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WMO Binary Codes

- **BUFR** (Binary Universal Form for the Representation of meteorological data) is
 - a flexible binary format
 - mainly used to encode **in situ and satellite observations**
 - can also represent forecast data.
- **GRIB** (General Regularly-distributed Information in Binary form) is
 - designed to encode data produced by **numerical weather prediction** models.
 - can also represent observations, but on a regularly distributed coverage

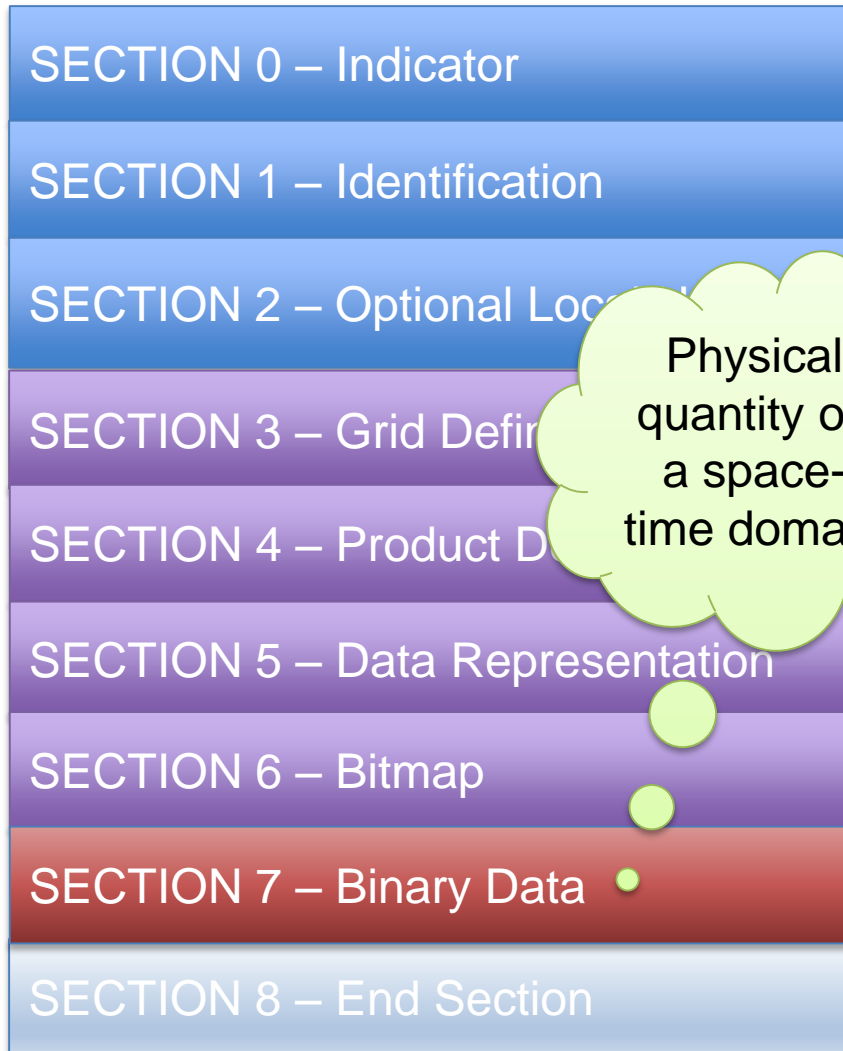


WMO Binary Codes



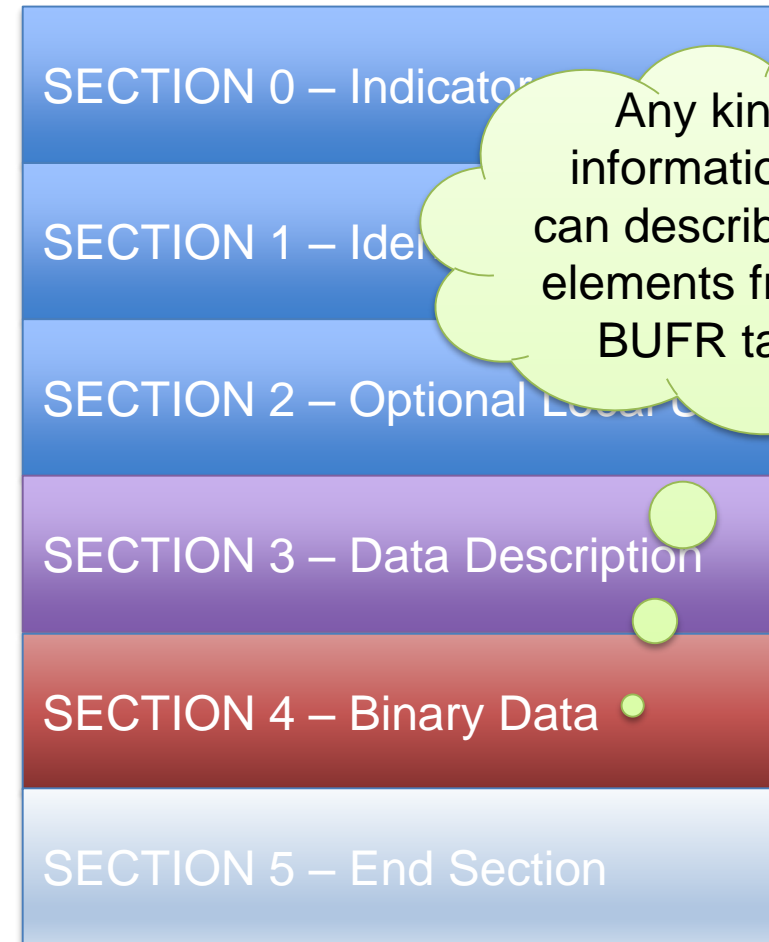
- Fully describes GRIB and BUFR coding standards
- Anyone reading the manual can implement a decoder/encoder
- It is the only authoritative source for the WMO binary codes GRIB and BUFR
- It is publicly accessible on the WMO web site <http://www.wmo.int/pages/prog/www/WMOCodes.html>
- There are some freely available decoders/encoders
- There isn't any reference decoder/encoder
- A **revision of the full manual** is published **every three years**
- A **new version of the tables** which are part of the manual is released externally **twice a year**.
- Latest version of the tables is accessible in several formats from the WMO web site http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vl2/LatestVERSION/LatestVERSION.html
- WMO Inter-Program Expert Team on Data Representation Maintenance and Monitoring is maintaining the manual

GRIB structure



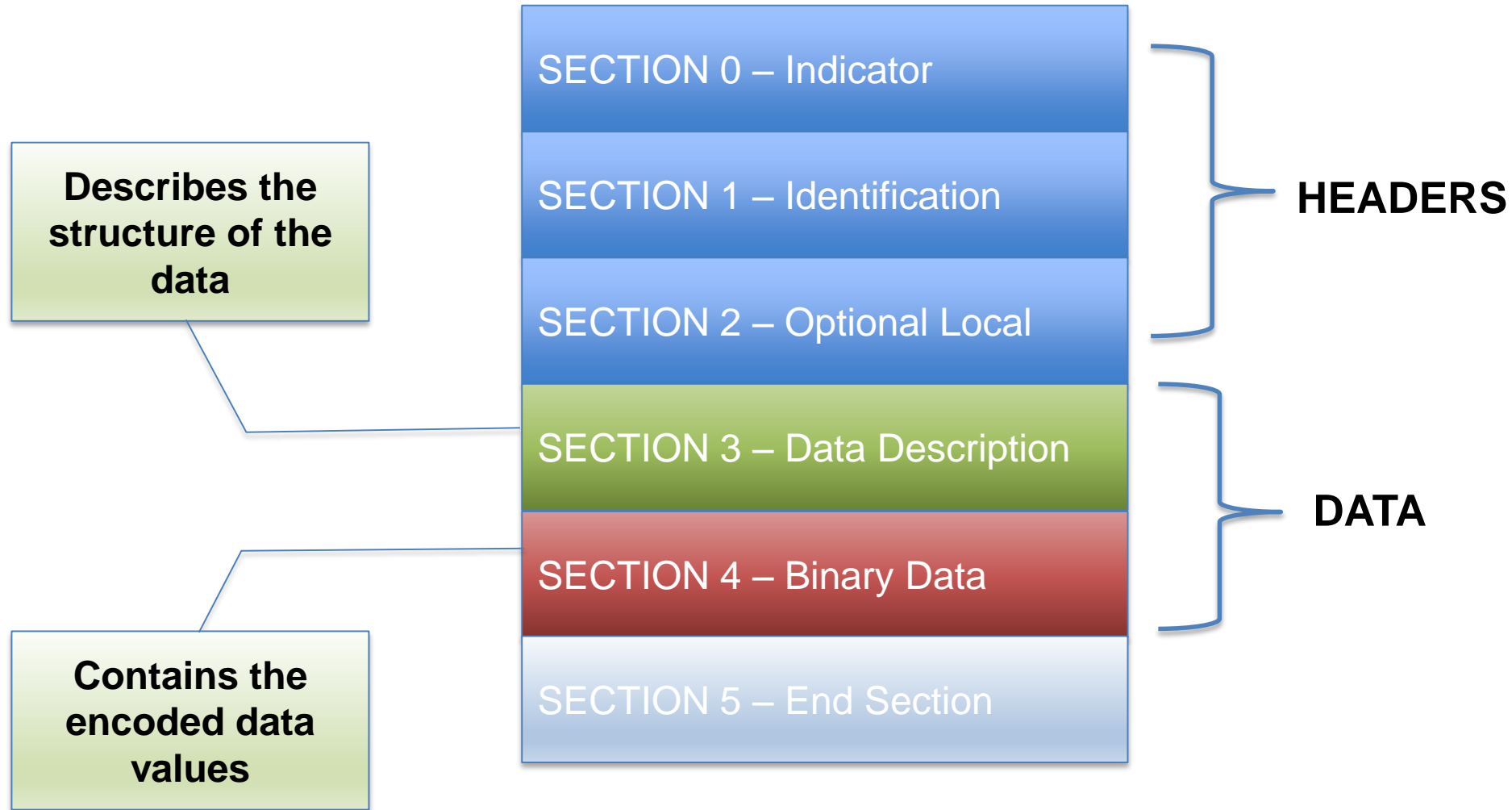
Physical quantity on a space-time domain

BUFR structure



Any kind of information you can describe using elements from the BUFR tables

BUFR structure



BUFR headers

SECTION 0 – Indicator	BUFR Total length of BUFR message BUFR edition number
SECTION 1 – Identification	Length of section BUFR master table Identification of originating/generating centre Identification of originating/generating sub-centre Data category International data sub-category Local data sub-category Version number of master tables Version number of local tables Year Month Day Hour Minute Second
SECTION 2 – Optional Local	Whatever the originating centre needs for internal purposes (processing, archiving)

BUFR data

recipe

SECTION 3

```
301051 004006 007002 010004  
012001 011001 011002 011031  
011032 011033 020041
```

- Contains a list of six digit descriptors in the form **F-X-Y** → **0-04-006**
- Descriptors starting with **F=0** are elements listed in **Table B**
F=1 denote replication of descriptors
F=2 are operators acting on descriptors
F=3 are sequences of descriptors listed in **Table D**

SECTION 4

```
01001010111010100101010101010  
10100010001010101010001010100  
10100101010010010100101001010  
10101010101111000010101001001
```

ingredients

- Contains the encoded values as a bit stream which can be decoded**
- Implementing the decoding regulations and notes
 - Using the Tables

BUFR Table B (descriptors starting with 0)

Class 12 – BUFR/CREX Temperature

encoding parameters

meaning

Elements descriptors

TABLE REFERENCE F X Y	ELEMENT NAME	BUFR				CREX		
		UNIT	SCALE	REFERENCE VALUE	DATA WIDTH (Bits)	UNIT	SCALE	DATA WIDTH (Characters)
0 12 001	Temperature/air temperature	K	1	0	12	°C	1	3
0 12 002	Wet-bulb temperature	K	1	0	12	°C	1	3
0 12 003	Dewpoint temperature	K	1	0	12	°C	1	3
0 12 004	Air temperature at 2 m	K	1	0	12	°C	1	3
0 12 005	Wet-bulb temperature at 2 m	K	1	0	12	°C	1	3
0 12 006	Dewpoint temperature at 2 m	K	1	0	12	°C	1	3
0 12 007	Virtual temperature	K	1	0	12	°C	1	3
0 12 011	Maximum temperature, at height and over period specified	K	1	0	12	°C	1	3
0 12 012	Minimum temperature, at height and over period specified	K	1	0	12	°C	1	3
0 12 013	Ground minimum temperature, past 12 hours	K	1	0	12	°C	1	3
0 12 014	Maximum temperature at 2 m, past 12 hours	K	1	0	12	°C	1	3
0 12 015	Minimum temperature at 2 m, past 12 hours	K	1	0	12	°C	1	3
0 12 016	Maximum temperature at 2 m, past 24 hours	K	1	0	12	°C	1	3
0 12 017	Minimum temperature at 2 m, past 24 hours	K	1	0	12	°C	1	3
0 12 021	Maximum temperature at 2 m	K	2	0	16	°C	2	4
0 12 022	Minimum temperature at 2 m	K	2	0	16	°C	2	4
0 12 023	Temperature	°C	0	-99	8	°C	0	2
0 12 024	Dewpoint temperature	°C	0	-99	8	°C	0	2
0 12 030	Soil temperature	K	1	0	12	°C	1	3
0 12 049	Temperature change over specified period	K	0	-30	6	°C	0	2
0 12 051	Standard deviation temperature	K	1	0	10	°C	1	3
0 12 052	Highest daily mean temperature	K	1	0	12	°C	1	3

BUFR Table B (descriptors starting with 0)

Element descriptors corresponding to the following classes in Table B shall remain in effect until superseded by redefinition:

X (class)

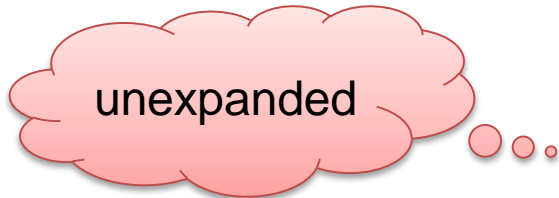
- 01 Identification**
- 02 Instrumentation**
- 03 Reserved**
- 04 Location (time)**
- 05 Location (horizontal – 1)**
- 06 Location (horizontal – 2)**
- 07 Location (vertical)**
- 08 Significance qualifiers**
- 09 Reserved**

BUFR replication (descriptors starting with 1)

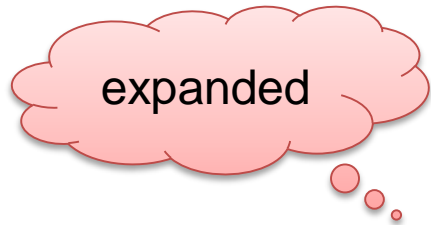
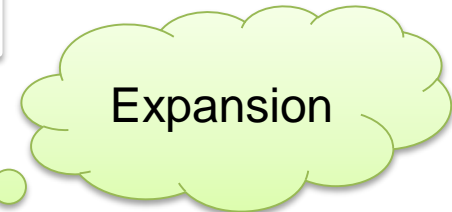
```
103002 004006 007002 010004  
012001 011001 011002 011031  
011032 011033 020041
```



```
004006 007002 010004 004006 007002 010004  
012001 011001 011002 011031 011032 011033  
020041
```



```
106002 008002 104003 005002 006002 010002 012001
```

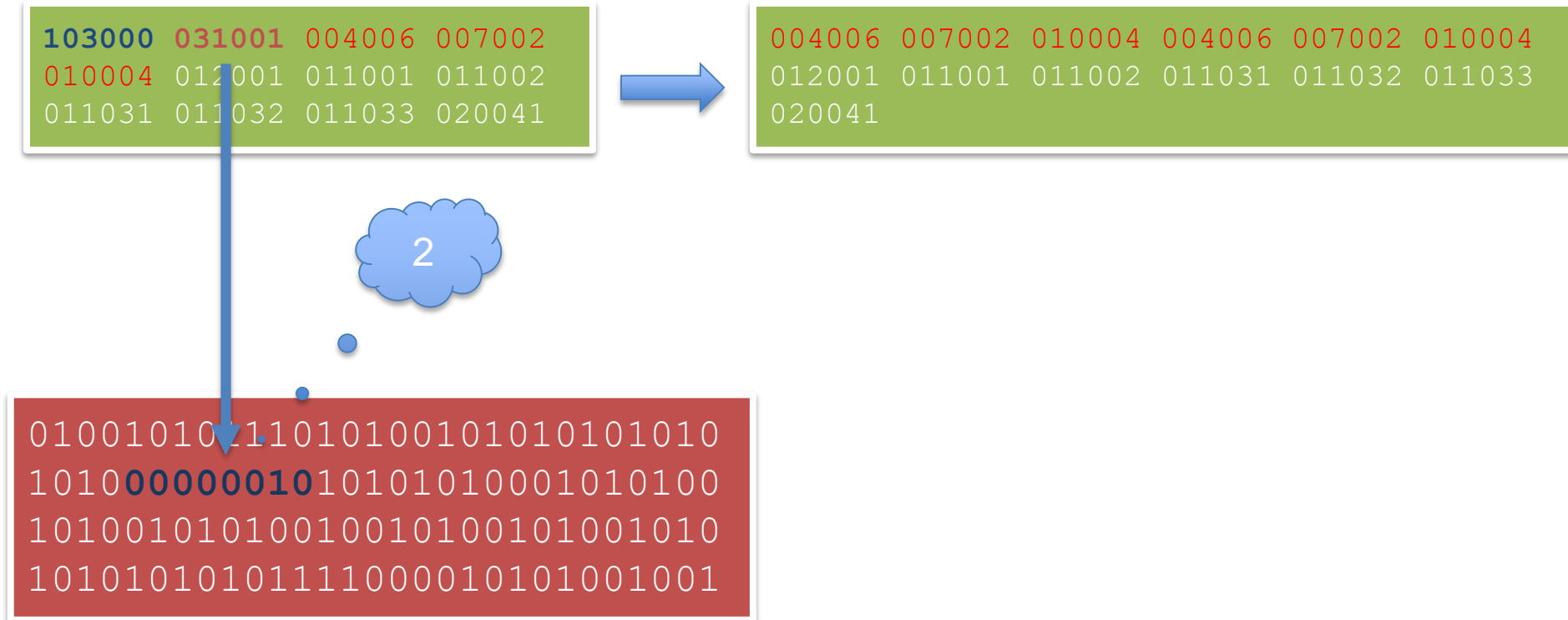


```
008002 104003 005002 006002 010002 012001  
008002 104003 005002 006002 010002 012001
```

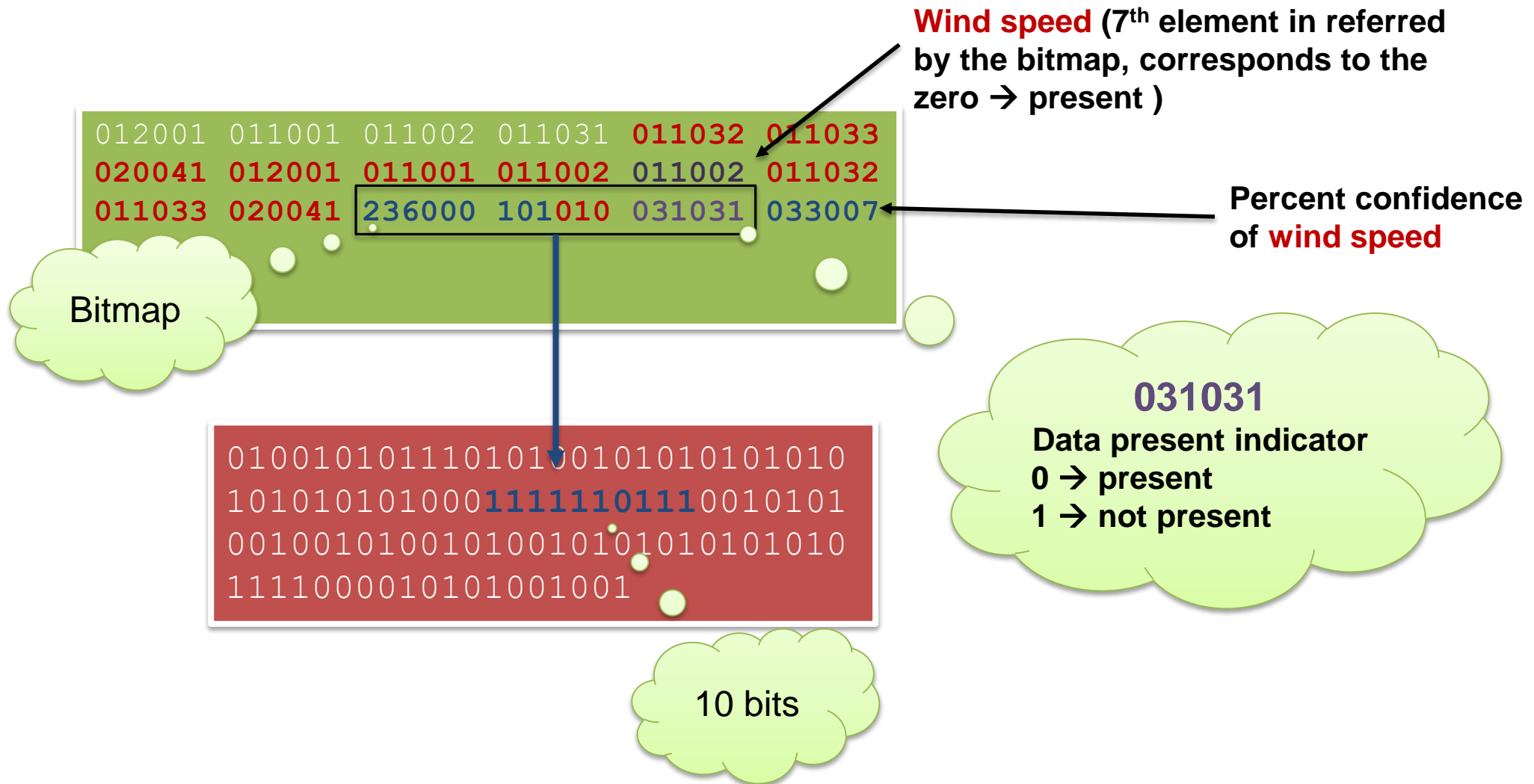


```
008002 005002 006002 010002 012001 005002 006002 010002 012001 005002 006002 010002 012001  
008002 005002 006002 010002 012001 005002 006002 010002 012001 005002 006002 010002 012001
```

BUFR **delayed** replication (descriptors starting with 1)



BUFR bitmap and quality information



BUFR Table D (descriptors starting with 3)

TABLE REFERENCE	TABLE REFERENCES	ELEMENT NAME
F X Y		
3 09 052	3 01 111	(Sequence for representation of TEMP, TEMP SHIP and TEMP MOBIL observation type data)
	3 01 113	Identification of launch site and instrumentation for P, T, U and wind measurements
	3 01 114	Date/time of launch
	3 02 049	Horizontal and vertical coordinates of launch site
	0 22 043	Cloud information reported with vertical soundings
	1 01 000	Sea/water temperature
	0 31 002	Delayed replication of 1 descriptor
	3 03 054	Extended delayed descriptor replication factor
	1 01 000	Temperature, dewpoint and wind data at a pressure level with radiosonde position
	0 31 001	Delayed replication of 1 descriptor
	3 03 051	Delayed descriptor replication factor
		Wind shear data at a pressure level with radiosonde position

Sequence descriptor

Sequence description

In section 3 is equivalent to the list of descriptors

Names of the descriptors in the sequence

List of descriptors. It can contain sequence descriptors

BUFR **uncompressed** data and subsets

SECTION 3

- Number of data subsets
- Flag observed data/other data
- Flag compressed/uncompressed

```
301051 004006 007002 010004  
012001 011001 011002 011031  
011032 011033 020041
```

Number of subsets = 2

SECTION 4

```
010010101110101001010101010101010001000101  
010101000101010010100101010010010100101001  
010101010101011110000101010010010100011010  
010101000101010101001010101010010101011010  
1010101010101010101001010101010101010101  
0101010101010101010101010101010101010101  
001010001010010011010101101010101010010101  
010101010100010100101001
```

Subset 1

Subset 2

BUFR compressed data and subsets

SECTION 3

- Number of data subsets
- Flag observed data/other data
- Flag compressed/uncompressed

```
301051 004006 007002 010004  
012001 011001 011002 011031  
011032 011033 020041
```

Number of subsets = 2

SECTION 4

Subset 1 and 2

```
0100101011101010010101010101010001000101  
010101000101010010100101010010010100101001  
010101010101011110000101010010010100011010  
010101000101010101001010101001010101011010  
101010101010101010100101010101010101010101  
010101010101010101010101010101010101010101  
001010001010010011010101101010101010010101  
010101010100010100101001
```

BUFR tables versions

SECTION 1 – Identification

Length of section
BUFR master table
Identification of originating/generating
Identification of originating/generating
Data category
International data sub-category
Local data sub-category
Version number of master tables
Version number of local tables
Year
Month
Day
Hour
Minute
Second

0 -> meteorology
No other values
defined

Master tables are
the official WMO
tables

Local tables are defined
by the originating Centre
and can be used to
exchange data by bilateral
agreement. No WMO
official. Versions are
maintained by the Centre