BUFR with ecCodes

Enrico Fucile

Enrico.Fucile@ecmwf.int

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What is ecCodes?

ecCodes = GRIB-API (GRIB decoder) + **BUFR decoder** + GTS headers decoder

+ METAR decoder + ???? decoder

WMO Binary Codes

Manual on Codes
International Codes
VOLUME I.2

PART B – Binary Codes
PART C – Common Features to Binary and Alphanumeric Codes

2011 edition
Updated in 2014

World
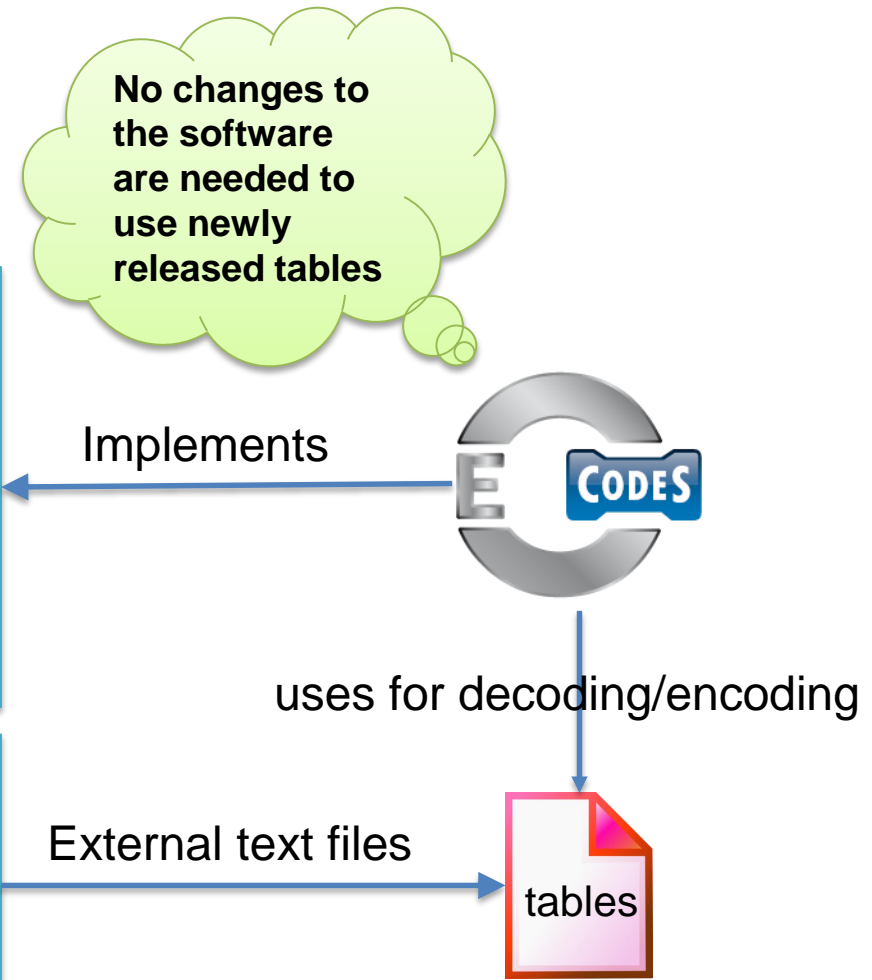Meteorological
Organization

WMO-No. 306
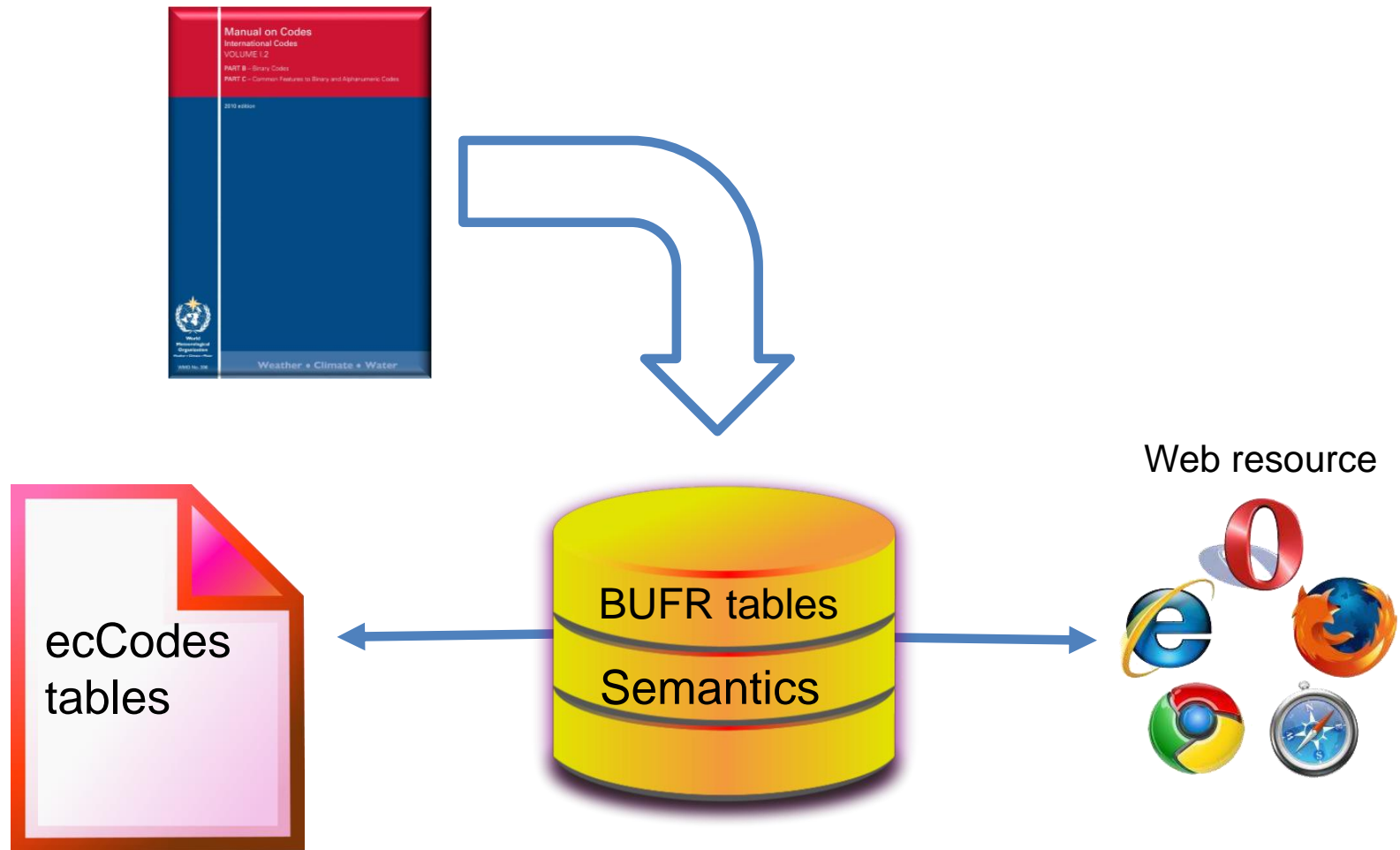
Weather • Climate • Water
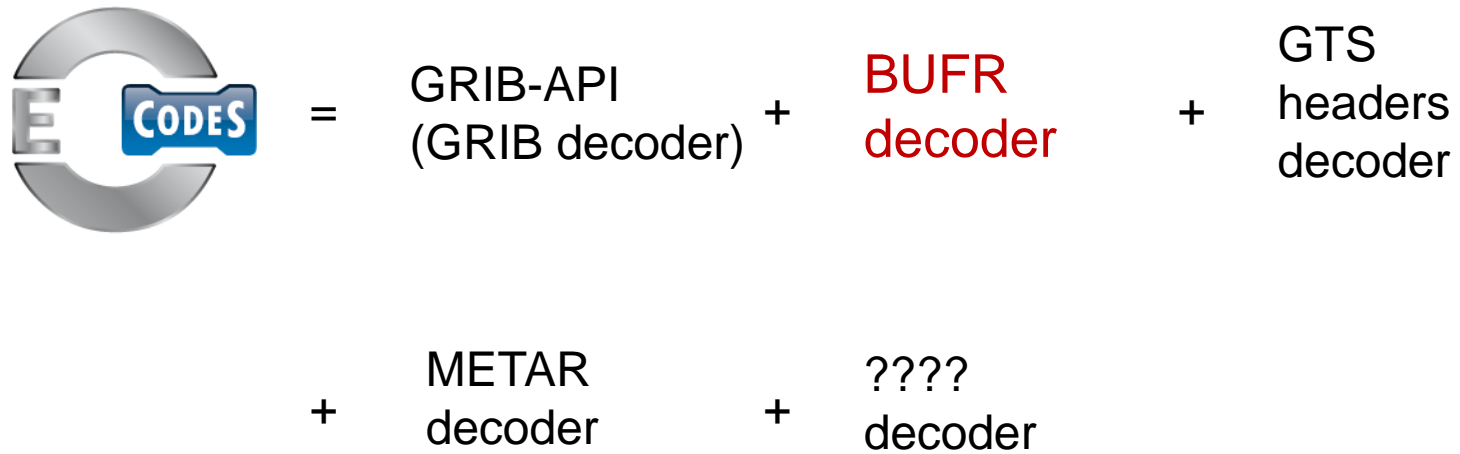
Regulations. Setting the rules for encoding/decoding by using external tables.

Notes. Specifying and clarifying special cases.

Tables. External tables to be used by the decoder/encoder software.

No changes to the software are needed to use newly released tables

Implements

E CODES

uses for decoding/encoding

External text files

tables

Vocabulary of key names from BUFR tables

ecCodes tables

BUFR tables

Semantics

Web resource

BUFR structure

Describes the structure of the data

Contains the encoded data values

SECTION 0 – Indicator

SECTION 1 – Identification

SECTION 2 – Optional Local

SECTION 3 – Data Description

SECTION 4 – Binary Data

SECTION 5 – End Section

HEADERS

DATA

Headers keys always available

Decoded only after setting unpack=1
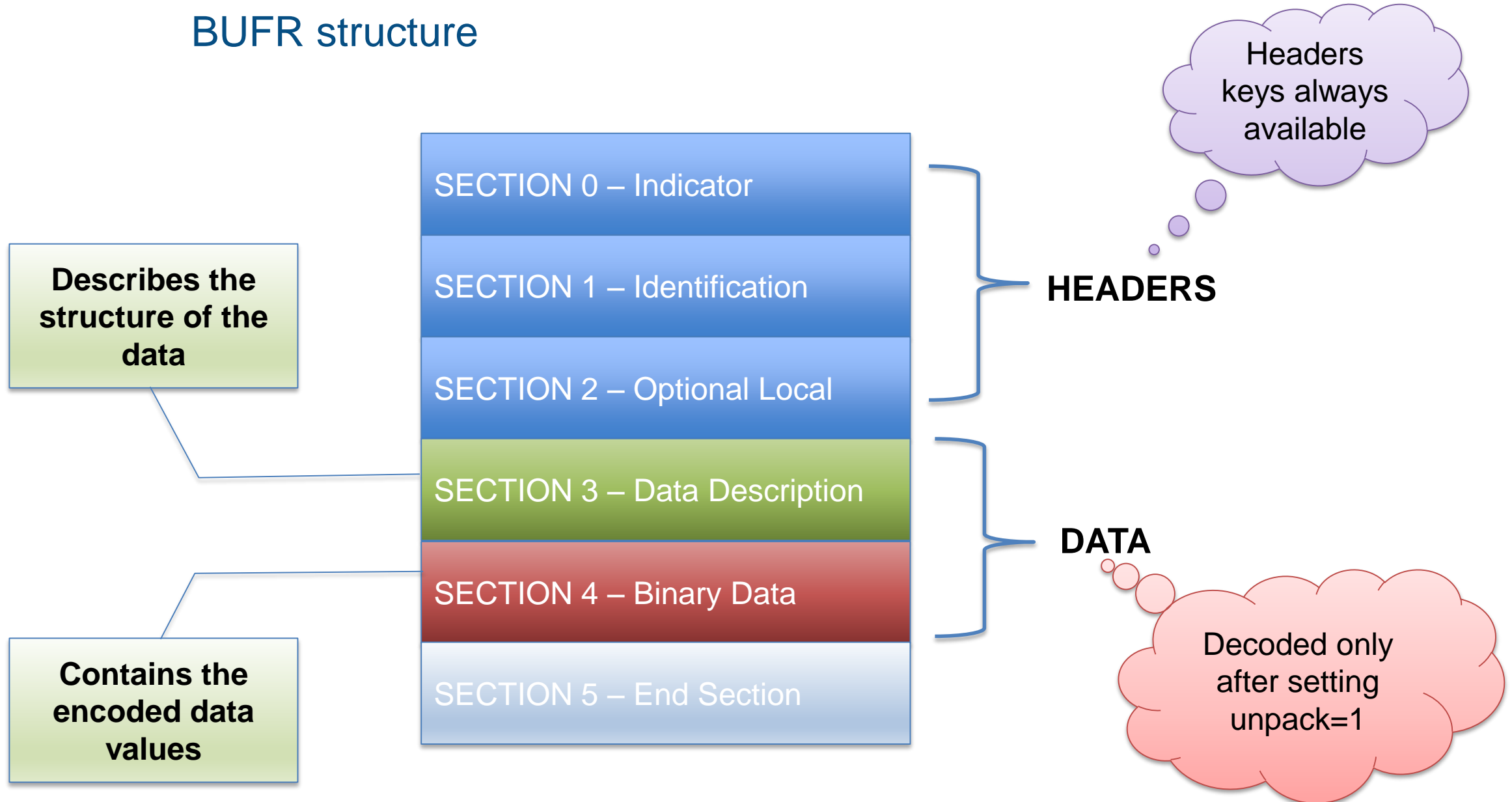
BUFR data

recipe

SECTION 3

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

SECTION 4

```
01001010111010100101010101010
1010001000101010101010001010100
10100101010010010100101001010
10101010101111000010101001001
```
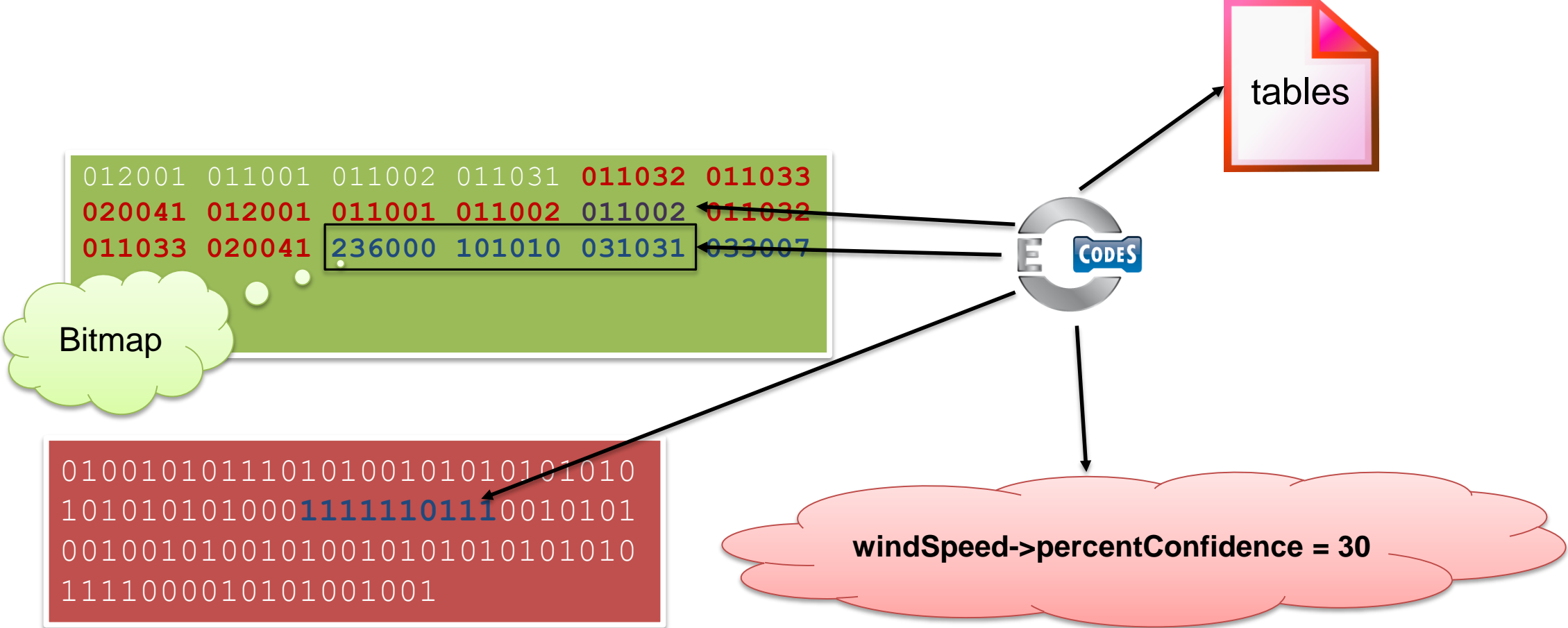
ingredients

height = 134

height->units = "m"

height->code = 7002
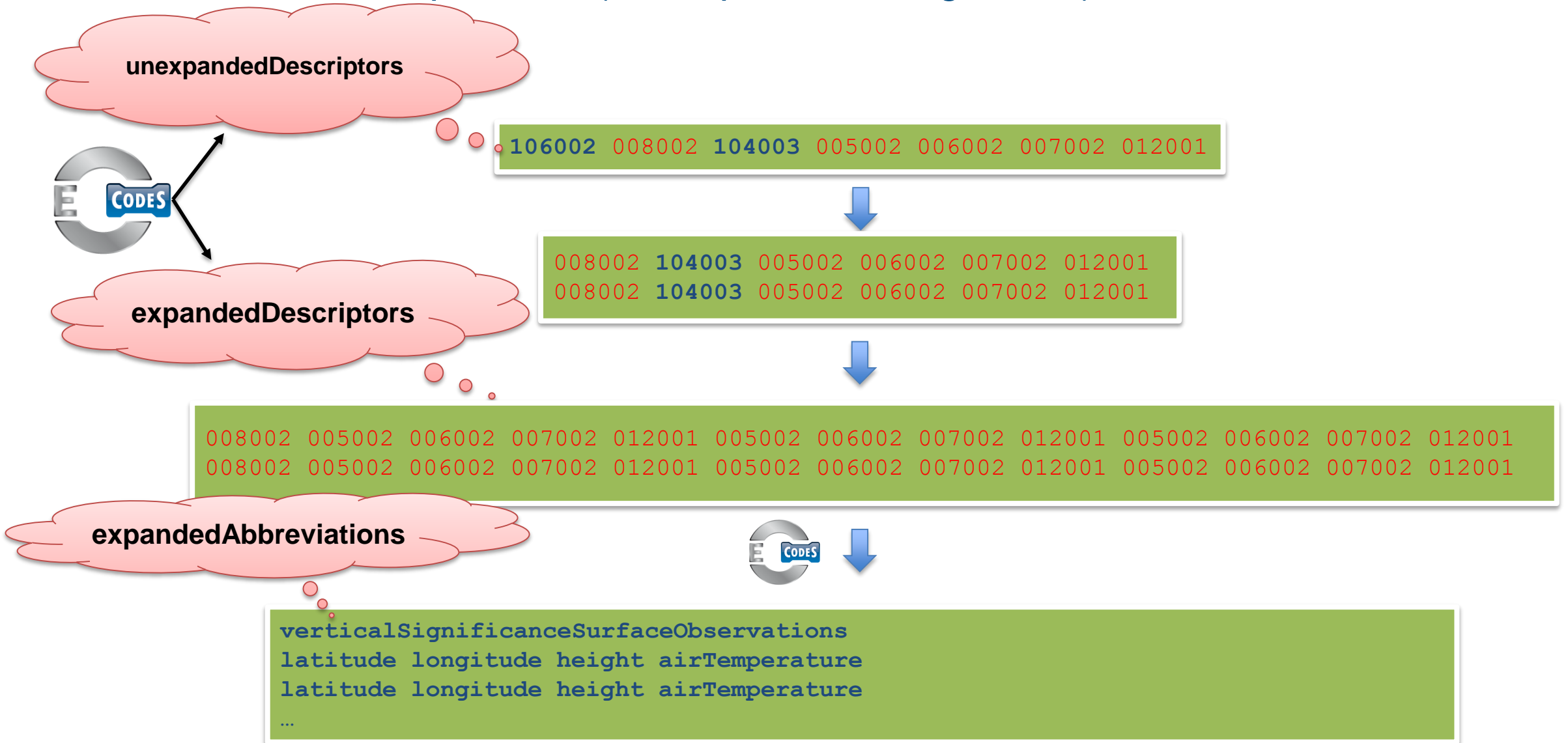height->width = 16
height->scale = -1
height->reference=-40

tables

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BUFR bitmap and quality information

tables

```
012001 011001 011002 011031 011032 011033
020041 012001 011001 011002 011002 011032
011033 020041 236000 101010 031031 033007
```

Bitmap

```
0100101011101010010101010101010
1010101010001111110111 0010101
0010010100101001010101010101010
11110000101010010001001
```

windSpeed->percentConfidence = 30

BUFR replication (descriptors starting with 1)

unexpandedDescriptors

```
106002 008002 104003 005002 006002 007002 012001
```

expandedDescriptors

```
008002 104003 005002 006002 007002 012001
008002 104003 005002 006002 007002 012001
```

```
008002 005002 006002 007002 012001 005002 006002 007002 012001 005002 006002 007002 012001
008002 005002 006002 007002 012001 005002 006002 007002 012001 005002 006002 007002 012001
```

expandedAbbreviations

```
verticalSignificanceSurfaceObservations
latitude longitude height airTemperature
latitude longitude height airTemperature
…
```

BUFR uncompressed data and subsets

SECTION 3

- **numberOfSubsets**
- **observedData**
- **compressedData**

unexpandedDescriptors = {301051 004006 007002 010004 012001 011001 011002 011031 011032 011033 020041}

numberOfSubsets= 2
compressedData=0

SECTION 4

```
010010101110101001010101010101010001000101
010101000101010010100101010010010100101001
010101010101011110000101010010010100011010
010101000101010101001010101010010101011010
101010101010101010101010010101010101010101010101
010101010101010101010101010101010101010101
001010001010010011010101101010101010010101
010101010100010100101001
```

subsetNumber=1
…
airTemperature=301
…

subsetNumber=2
…
airTemperature=305.2
…

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BUFR compressed data and subsets

SECTION 3

- **numberOfSubsets**
- **observedData**
- **compressedData**

unexpandedDescriptors = {301051 004006
007002 010004 012001 011001 011002
011031 011032 011033 020041}

numberOfSubsets= 2
compressedData=1

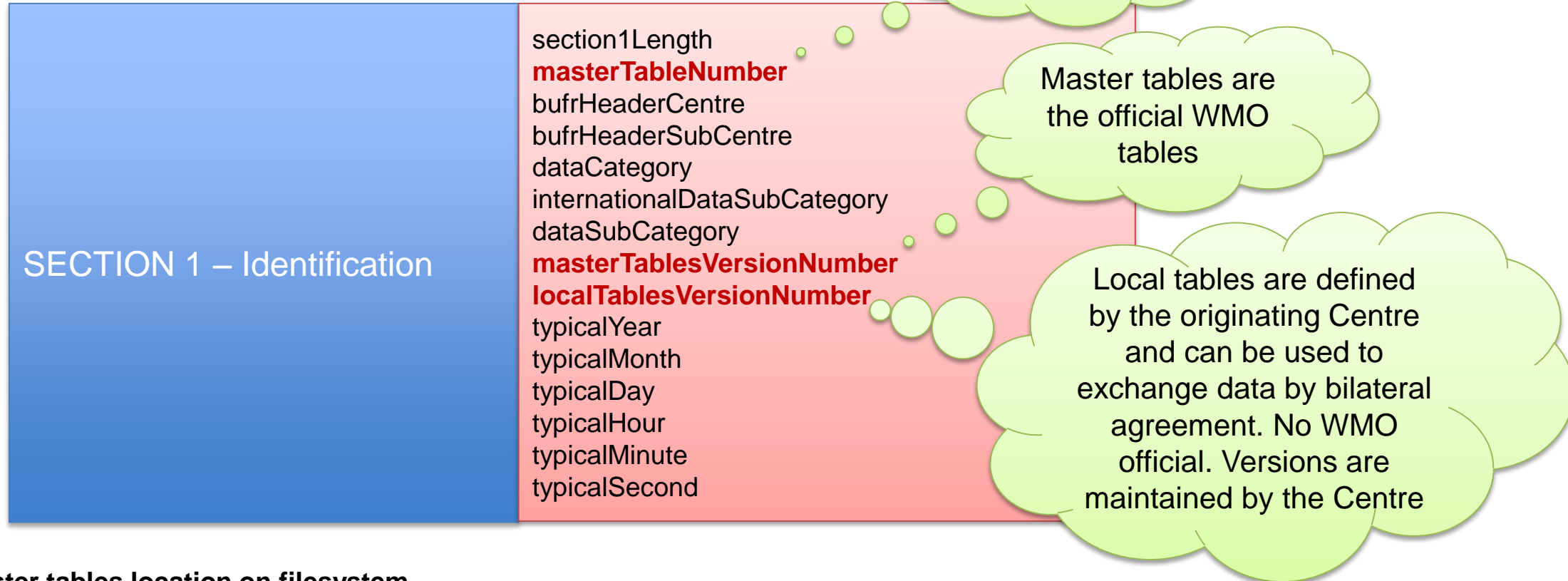Subset 1 and 2

…
airTemperature={301, 305.3}
…

SECTION 4

0100101011101010010101010101010101000100010 1
0101010001010100101001010100100101010 1001
010101010101011100001010100100101000011010
0101010001010101010010101010100101010 11010
10101010101010101010100101010101010101010101
01010101010101010101010101010101010101010101
00101000101001001101010110101010101010010101
01010101010001010010101001

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BUFR tables versions

SECTION 1 – Identification

section1Length
masterTableNumber
bufrHeaderCentre
bufrHeaderSubCentre
dataCategory
internationalDataSubCategory
dataSubCategory
masterTablesVersionNumber
localTablesVersionNumber
typicalYear
typicalMonth
typicalDay
typicalHour
typicalMinute
typicalSecond

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

WMO master tables location on filesystem
definitions/bufr/tables/[masterTableNumber]/wmo/[masterTablesVersionNumber]

Local tables location on filesystem
definitions/bufr/tables/[masterTableNumber]/local/[localTablesVersionNumber]/[bufrHeaderCentre:I]/[bufrHeaderSubCentre]

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Special BUFR Table B descriptors

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**

```
[
    {
      "key" : "latitude",
      "code" : "005002"
    },
    [
      {
        "key" : "longitude",
        "code" : "006002"
      },
      [
        {
          "key" : "height",
          "code" : "007002"
        },
        {
          "key" : "airTemperature",
          "code" : "12001"
        }
      ]
    ]
  ],
  [
    {
      "key" : "latitude",
      "code" : "005002"
    },
    …
  ]
```

JSON output from bufr_dump

```json
[  {"key" : "beamIdentifier",
     "value" : 1,
     "units" : "CODE TABLE" },
   [ {"key" : "radarIncidenceAngle",
      "value" : [...],
      "units" : "deg"},
    [ { "key" : "antennaBeamAzimuth",
       "value" : [...],
       "units" : "deg"},
      {"key" : "backscatter",
       "value" : [...],
       "units" : "dB"},
       ...
    ],
  [ {"key" : "beamIdentifier",
     "value" : 2,
     "units" : "CODE TABLE" },
      ...
```

Access by rank (python example)

```
x=codes_get(bufr,'#2#backscatter')


xu=codes_get(bufr,'#2#backscatter->units')
```

Access by condition (python example)

```
xc=codes_get(bufr,'/beamIdentifier=2/backscatter')
```

```
xc=codes_get(bufr,'/beamIdentifier=2/backscatter->units')
```

BUFR tools in ecCodes

Similar tools as for GRIB. Very few changes in behaviour.

- **bufr_dump** (different from GRIB as the output is JSON, different options)

- **bufr_filter**

- **bufr_compare (-b option not working for data keys, only headers)**

- **bufr_copy**

- **bufr_get**

- **bufr_set**

- **bufr_ls** (same as for GRIB, but less effective due to the complexity of the message)