Practical Aspects Related to Meteorological Data Encode in FM94 BUFR
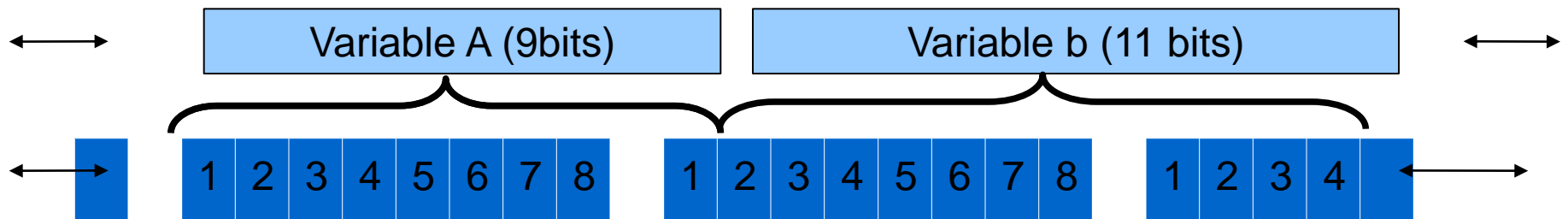
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The codification process is complex. Here we just present the basic idea

1) Each variable in section 4 may have different sizes.

2) The size (in bits) and other necessary parameters to encode all possible variable are defined in the BUFR table B..

3) For each descriptor in section 3, a search must be performed in BUFR table B to obtain the corresponding value of size, scale factor and reference value

4) The value of each variable is written in section4 (not in bytes, but in bits). If a variable does not fill a specific byte completely, the remaining bits of this byte will be used to encode the next variable. (see figure)

Variable A (9bits)	Variable b (11 bits)

1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8		1	2	3	4

BUFR – Binary Universal Form for representation of Meteorological Data is a WMO code that will replace the traditional Alfa-numeric codes such as SYNOP, SHIP, etc for data transfers through the Global Telecommunication System (GTS)
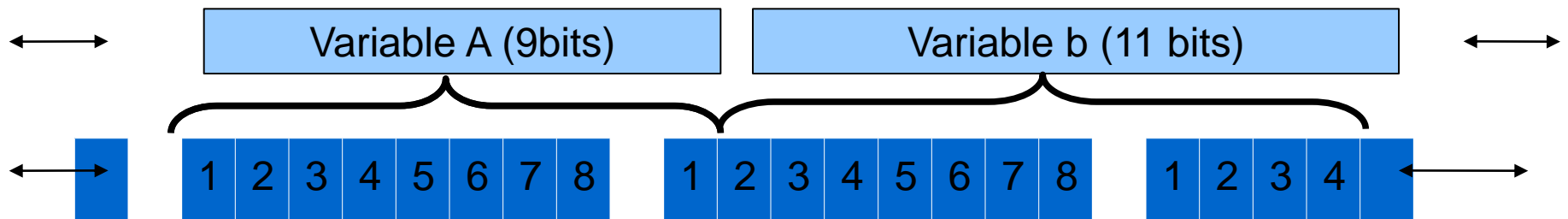
Code Migration Schedule

Category →	Cat.1: common	Cat.2: satellite observations	Cat.3: aviation[1]	Cat. 4: maritime	Cat. 5[2]: miscellaneous	Cat. 6[2]: almost obsolete
Lists of → Traditional code forms Schedule ↓	SYNOP SYNOP MOBIL PILOT PILOT MOBIL TEMP TEMP MOBIL TEMP DROP CLIMAT CLIMAT TEMP	SAREP SATEM SARAD SATOB	METAR SPECI TAF AMDAR ROFOR	BUOY TRACKOB BATHY TESAC WAVEOB SHIP CLIMAT SHIP PILOT SHIP TEMP SHIP CLIMAT TEMP SHIP	RADOB IAC IAC FLEET GRID(to GRIB) MAFOR HYDRA HYFOR RADOF	CODAR ICEAN GRAF NACLI etc. SFAZI SFLOC SFAZU RADREP ROCOB ROCOB SHIP ARFOR WINTEM
Start experimental Exchange[3]	Nov. 2002 for some data (AWS SYNOP, TEMP USA)	Current at some Centres	2006 2002 at some Centres for AMDAR	2005 2003 for Argos data (BUOY, sub-surface floats, XBT/XCTD)	2004	Not applicable
Start operational exchange[3]	Nov. 2005	Current at some Centres	2008 2003 for AMDAR	2007 2003 for Argos data (BUOY, sub-surface floats, XBT/XCTD)	2006	Not applicable
Migration complete	Nov. 2010	Nov. 2006	2015 2005 for AMDAR	2012 2008 for Argos data (BUOY, sub-surface floats, XBT/XCTD)	2008	Not applicable

BUFR is a TABLE-DRIVEN CODE FORM (TDCF), structured in 6 sections

section	Decription
Section 0	Indicator Section: Contains the prefix "BUFR" , that indicates the beginning of a BUFR message, and other internal specifications about the BUFR message
Section 1	Identification section – Contains information which identifies the kind of data encoded in BUFR. Example: BUFR data category, date and time of information and the originating data center.
Section 2	Optional section- This section may or may not be included in BUFR message. It can be used for any purpose by the originating data center
Section 3	Data description Section - This section contains the sequence of descriptor codes and other information which describes the structure of section 4. It represents the BUFR template used for encoding data in section 4.
Section 4	Data section – Contains meteorological data. The data in this section are encoded and compressed as described by section 3
Section 5	Indicate section – Contains the group "7777" that indicates the end of the BUFR message

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Variable A (9bits)	Variable b (11 bits)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 |

There are some encode/decode software available...

BUFR SOFTWARE	APPLICABILITY (OS)	AVAILABILITY
ECMWF(DECODING/ ENCODING)	UNIX, LINUX, Windows with GIGWIN emulator	INTERNET, FREE DOWNLOAD, DOCUMENTATION ON LINE
NCEP, USA(DECODING/ ENCODING)	UNIX, LINUX	INTERNET, FREE DOWNLOAD, DOCUMENTATION ON LINE
DWD(DECODING/ ENCODING)	UNIX, WINDOWS	AT REQUEST, AT COST (FROM 100 $ TO 2500$)
BUFR-World (DWD) (DECODING/ ENCODING/ GUI)	WINDOWS, UNIX, LINUX, SOLARIS, …	AT REQUEST, AT COST
UKMO(DECODING/ ENCODING)	UNIX	AT REQUEST FREE
BRAZIL (INPE)	WINDOWS/UNIX	FREE DOWNLOAD "MBUFRTOOLS" under "decoding/encoding" at http://downloads.cptec.inpe.br/publicacoes/distribuicao.jsp

Source: http://www.wmo.int/pages/prog/www/WMOCodes/MigrationInfoDocum.html

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Decoded BUFR EXAMPLE (ASCAT)

- :BUFR: # EDITION = 4
- 0 # MBUFR Error code
- :SEC1:
- 0 # BUFR MASTER TABLE
- 254 # ORIGINATING CENTER: EUMETSAT Operation Centre
- 0 # ORIGINATING SUBCENTER
- 0 # UPDATE SEQUENCE NUMBER
- 12 # DATA CATEGORY
- 255 # DATA SUBCATEGORY
- 190 # LOCAL DATA SUBCATEGORY
- 13 # BUFR MASTER TABLE VERSION NUMBER
- 0 # LOCAL TABLE VERSION NUMBER
- 2010 # YEAR
- 4 # MONTH
- 14 # DAY
- 10 # HOUR
- 0 # MINUTE
- :SEC3:
- 1890 # Num.subsets
- 1 # Num.descriptors
- 1 # Flag for Compressed data (1=compressed 0=uncompressed)
- 312061
- :SEC4:
- 202 # N. VARIABLES !!!
- :SUBSET 00001:
- 254.00000 #   1) 001033-IDENTIFICATION OF ORIGINATING/GENERATING CENTRE
- 0.00000 #   2) 001034-IDENTIFICATION OF ORIGINATING/GENERATING SUB-CENTR
- 200.00000 #   3) 025060-SOFTWARE IDENTIFICATION (SEE NOTE 2)
- 4.00000 #   4) 001007-SATELLITE IDENTIFIER
- 190.00000 #   5) 002019-SATELLITE INSTRUMENTS
- 196.00000 #   6) 001012-DIRECTION OF MOTION OF MOVING OBSERVING PLATFORM**
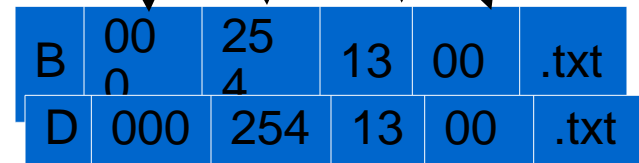- 2010.00000 #   7) 004001-YEAR

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-

B	000	254	13	00	.txt
D	000	254	13	00	.txt

The BUFR TABLE B -> Variables, N. of bits, scale factor and reference values

The BUFR TABLE D -> BUFR templates: Sequence of BUFR TABLE B descriptors

Section 1 indicates the required BUFR TABLES

Commum problems associated with BUFRTABLES

    1 - The requested BUFRTABLE are not avaliable

    2 - The BUFRTABLES are avaliable, but contains table B descriptors those can be recognized by software application

Commum problems associated with BUFR TEMPLATES

    1 - Aplication don't recognize the BUFR TEPLATES

```
!---------------------------------------------------------------------------
!Links for equivalent BUFRTABLES
!The tables in this list are represented as AACCCVVLL where
!  AA = Master table
!  CCC = Generate Center code
!  VV  = Vertion of Master Table
!  LL  = Version of local table
!---------------------------------------------------------------------------
nrows=14,


!    AAACCCVVLL  -->  AAACCCVVLLL    ! Remarks

tab= "0000941201",   "0000461300",
     "0000740701",   "0000981301",
     "0000461100",   "0000461101",
     "0000461200",   "0000461201",
     "0000740201",   "0000460201",
     "0001600601",   "0000590303",
     "0000071201",   "0000070401",
     "0002550204",   "0000461300",
     "0002551305",   "0000461300",
     "0000531101",   "0000461101",
     "0000431300",   "0000461400",
     "0000780908",   "0000461400",
     "0002551300",   "0002551301",
     "0002551400",   "0002551301",
  /
```

How decoding the same variables even reding different bufr templates

```
&bufrvar
ncbt=31,
cbt ="004001",                                          !1 ) !Ano
    "004002",                                           ! 2) !mes
    "004003",                                           ! 3) dia
    "004004",                                           ! 4) hora
    "004005",                                           ! 5) minuto
    "005001,005002",                                    ! 6) Latitude baixa resolucao
    "006001,006002",                                    ! 7) Longitude baixa resolucao
    "007004",                                           ! 8) Pressao Atmosfeirica (coordenada vertical) em Pa
    "010004",                                           ! 9) Pressao Atmosferica
    "010009*9.8,010003,007002*9.8,007007*9.8", !10) Geopotencial (Joules/kg)
    "007006",                                           !11) Altura acima da estacao
    "007001,007030",                                    !12) Altitude da estacao
    "011001,011011",                                    !13) direcao do vento
    "011002,011012",                                    !14) velocidade do vento
    "011003",                                           !15) U-COMPONENT  M/S
    "011004",                                           !16) V-COMPONENT  M/S
    "011006",                                           !17) W-COMPONENT  M/S
    "010051*0.01",                                      !22) Pressao reduzida ao nivel medio do mar
    "002001",                                            !23) Tipo da Estacao...................typesta
    "012001,012101",                                    !24) Temperatura do ar (Kelvin)
    "012003,012103",                                     !25) Ponto de Orvalho (Kevin)
    "013002*1000",                                      !26) Razao de misitura  (g/Kg)
    "013003*1000",                                      !27) Umidade especifica (g/Kg)
    "8003",                                             !28) Vertical Significance
    "008001&96,008042/2048&96",                         !31) VERTICAL SOUNDING SIGNIFICANCE
    /
```

FM94 BUFR is a very flexble format to encode all kind of observed data.

Eventualy the data are correctly encoded, but is dificult to be decoded by other BUFR decode softwares...

If possible:

1 - Use only official BUFR tables

2 - Use only official BUFR templates

Thank you

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