ALADIN Project Stay report – version 0.2 (January 2017)

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Topic title: Upgrade of the source code BATOR to WMO AMDAR template 311010 v7

1 Introduction

This document reports the activities done during a short stay at CHMI on the implementation of the WMO BUFR AMDAR template 311010 on a local version of the BATOR CY38t1 source code. The main steps of the validation process are also described. This work followed a previous work done in 2016 to upgrade the local code source to the latest SYNOP and TEMP WMO BUFR templates, which is described in [1].

The upgrade of the BATOR source code in this moment is important since WMO is promoting an upgrade on the GTS dissemination procedures which involves a change of the observations transmission code forms, namely, the use of Table Driven Code Forms (TDCF) like BUFR, instead of the Traditional Alphanumeric Codes (TAC). In the short term it is expected to stop the transmission of observations under TAC format and the local pre-processing systems have to suffer upgrades to deal with the direct ingestion of the BUFR format and moreover with the most recently WMO published templates.

The Aircraft Meteorological Data Relay (AMDAR) observation was established by WMO in 2003 [2] and a few regional centers are already disseminating this type of observation on the atmospheric conditions along their aircraft trajectories, after collecting from the corresponding flying companies. Over Central Europe there is already a good coverage of this type of meteorological observations as is illustrated in Figure 1 and several studies have already shown that the assimilation of this type of observation has a good impact on convective-scale forecasts [3].

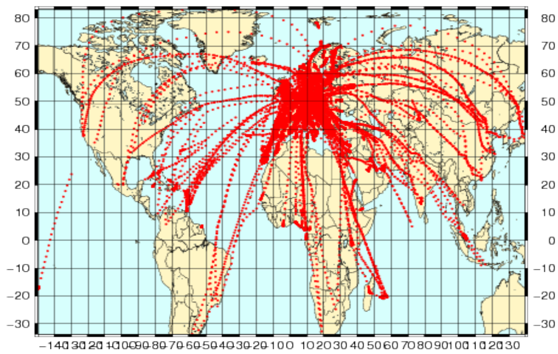

Figure 1 – AMDAR observations during one day (2017.01.08) from the UK Met Office.

In opposition to the work which was done in 2016 concerning the observation types SYNOP and TEMP, for which it was possible to rely on pioneering work previously done by Météo-France, for the AMDAR it was now necessary to implement locally the new templates. In fact, according to [4] for the AMDAR data Météo-France still uses a local template – 311192 – which is provided by their local observation pre-processing. In order to make it simple the work started with the most recently WMO published template 311010 v7, which is already in use for the E-AMDAR bulletins issued by UK Met Office (see Figure 1).

The document structure is as follows: in section 2 it is done a preliminary analysis of the WMO BUFR AMDAR data which arrives by GTS to CHMI; in section 3 the implementation of the WMO AMDAR template in BATOR is described; in section 4 the validation process of the changed source code is described and in section 5 some conclusions and foreseen activities are registered.

2 Analysis of the AMDAR data arriving by GTS to the local NMS

To understand the distribution and diversity of AMDAR templates worldwide the daily information which arrives by the Global Telecommunication System (GTS) to CHMI was examined (note that a different set of bulletins may be received at each national meteorological service). Bulletins IUA[A, B, C, D, E, F, G, H, I, K, L, S and X] were identified according with the geographical area, following the distribution present on Table 1. The corresponding AMDAR data dissemination centers have been identified, as set in Table 2.

Table 1 – Geographical area designator A1 and geographical area designator A2 [5].

A1	Geographical Area Designator
A	0° - 90°W northern hemisphere
B	90°W - 180° northern hemisphere
C	180° - 90°E northern hemisphere
D	90°E - 0° northern hemisphere
E	0° - 90°W tropical belt
F	90°W - 180° tropical belt
G	180° - 90°E tropical belt
H	90°E - 0° tropical belt
I	0° - 90°W southern hemisphere
J	90°W - 180° southern hemisphere
K	180° - 90°E southern hemisphere
L	90°E - 0° southern hemisphere
N	Northern hemisphere
S	Southern hemisphere
T	45°W - 180° northern hemisphere
X	Global Area (area not definable)

Table 2 – Actual AMDAR data dissemination centers according to the geographical.

GTS bulletin	Dissemination centers
IUAA	VHHH, EGRR, CWAO
IUAB	VHHH, EGRR
IUAC	VHHH, RJTD, RKSL, EGRR
IUAD	VHHH, EGRR
IUAE	EGRR
IUAF	EGRR
IUAG	VHHH, RKSL, EGRR
IUAH	VHHH, EGRR
IUAI	EGRR
IUAK	PANC
IUAL	EGRR
IUAS	NZKL
IUAX	VHHH, KARP

Since this work is focused on data to be used in Pan-European limited area models, the analysis has progressed only over the IUAA bulletins. In this way, a small sample of bulletins coming from the VHHH (China), EGRR (UK) and CWAO (Canada) were examined leading to the identification of the diversity of AMDAR templates which is present in Table 3.

Table 3 – Basic characteristics of bulletins arriving to CHMI from world AMDAR dissemination centers.

Bulletin	WMO center	BUFR data category (Table A)	BUFR data sub-categry	Sequence AMDAR template	Typical number of subsets
IUAA01_CWAO_08hhmm_xxx	53	4	255	311001	n
IUA[A,B]01_EGRR_08hhmm_xxx	74	4	255	311010	n
IUA[A,B]0[1,4]_VHHH_08hhmm_xxx	110	4	4	311006	n
IUAC01_VHHH_08hhmm_xxx	110	4	4	311006	1
IUAC04_VHHH_08hhmm_xxx	110	4	255	311006	n
IUAC03_VHHH_08hhmm_xxx	110	4	4	311006	n
IUAC02_VHHH_08hhmm_xxx	110	4	4	311007	n
IUAA02_VHHH_08hhmm_xxx	110	4	4	311007	n

The examination of these bulletins was done by using the following two tools: DecodBufr and a local version of decode_bufr_all (ECMWF) both with the BUFR tables from Météo-France.

It is important to note for further developments that no correction messages were found for this geographical area (0º-90º W northern hemisphere) and on this day. Moreover, it was important to note that many retards (bulletins with the 3 last digits of its identification as RR[A to E, at least]) of AMDAR template 311010 were found, however, it was never found duplicated messages between the originals and the retards.

The next step onto this analysis was to examine the diversity of AMDAR BUFR templates by expanding section 3 of BUFR messages. In particular these templates were compared with the one in use by Météo-France, for which BATOR was maintained up to now.

We arrived then to the conclusion that in order to be able to ingest information from the IUAA bulletins which arrive to CHMI the following BUFR templates, at least, have to be handled by BATOR facility: 311001, 311006, 31107 and 311010. Note that the Atlantic Area bulletin IUAA from LPMG dissemination center which is available from Portugal with BUFR AMDAR template 311005 does not arrive to CHMI yet.

In order to make this exercise simpler and due to the fact that most of the information which covers Europe comes from the EGRR dissemination center - see coverage of data from various centers on Figure 2 - the next steps of this work were based only on WMO BUFR template 311010. In fact, at the date of writing this report, this is the only dissemination center from which AMDAR data arrives with the template 311010 and it is the only center which is received and processed in Hungary for the purpose of the common observation processing system of LACE (OPLACE). Appendix I reproduces the expansion of this AMDAR template, as published in [6].

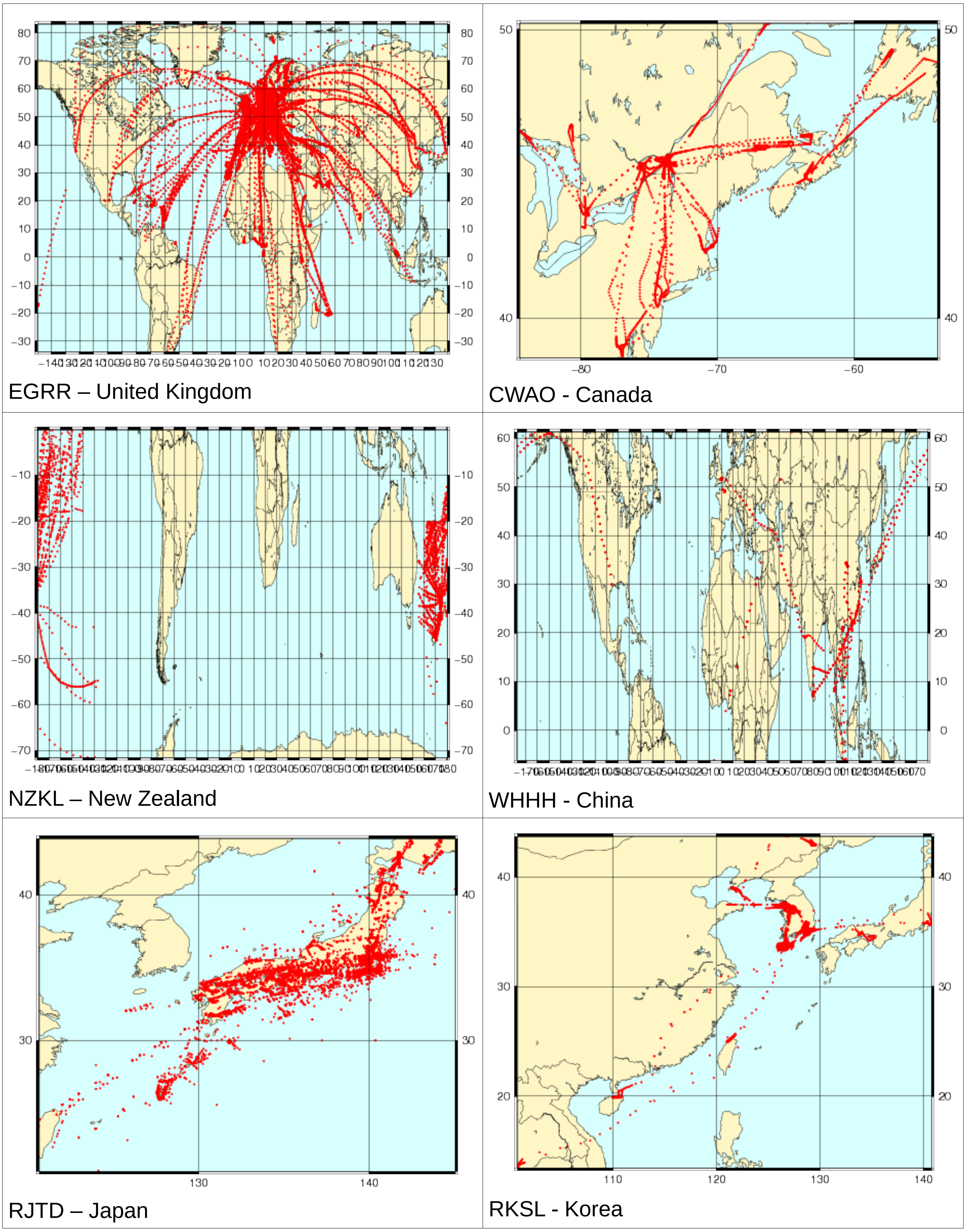

Figure 2 – Coverage of AMDAR observations available at CHMI during one day (2017.01.08) from various dissemination centers.

3 Implementation of the WMO BUFR AMDAR template 311010

In the ALADIN community, the retrieval of the meteorological data values present on a BUFR record is done by the BATOR application. This is achieved through an a priori identification of the position of the required parameters (see Table 4) on each template. This identification is done through its externalized file param.cfg. On each BUFR template identified in param.cfg the position of the observation expanded value contained in a BUFR record is associated to the corresponding BUFR element descriptor and the routine which does the retrieval of the data value is bator_decodbufr_mod.F90.

The first step in this task was to identify the different AMDAR templates which are in the local version of param.cfg. It was possible to identify 5 different templates where the sequence descriptor 311192 was always present.

The next step was to identify the BUFR message elements for which there is in fact a retrieval. The subroutine of bator_decodbufr_mod.F90 which does this task for the time being is amdar. Table 4 summarizes the actual descriptor elements (one for each BUFR meteorological value or for each metadata value) present on the template 311192 as well as the corresponding elements on the WMO AMDAR template 311010.

Table 4 – Correspondence between the element descriptors used to identify the expanded BUFR message parameters in the actual AMDAR templates 311192 and 311010.

Parameter name	Element descriptor in 311192	Position on the BUFR expanded values	Element descriptor in 311010	Position on the BUFR expanded values
Aircraft flight number	001006	1	001008	1
Aircraft navigational system	002061	2	002064	35
Year	004001	3	004001	9
Latitude (high accuracy)	005001	8	005001	21
Longitude (high accuracy)	006001	9	006001	23
Phase of aircraft flight	008004	10	008009	29
Height or altitude	007002	11	007010	25
Temperature/dry-bulb temperature	012192	12	012101	47
Wind direction	011001	13	011001	39
Wind speed	011002	14	011002	41
Dew-point temperature	012194	22	012103	56

To create the elements sequence from the 311010 template that should be introduced in param.cfg the tool Guessparamcfg, from the H version of the ALADIN-HIRLAM shared system [7] has been locally installed using Météo-France bufr library version 383 from auxlibs_installer.2.3. Note that decoding is critically dependent both on BUFR library and corresponding tables. BUFR decoders and BATOR were linked with Météo-France bufr library version 383 and tables from beaufix:/opt/softs/libraries/emos/tables/bufr/000383/ were used.

The final step was to change/re-create the subroutine amdar from the local source code bator_decodbufr_mod.F90 based on CY38T1 (or preferably from the back-phased version from CY40T1 of the source code to the amdar data like the one which is in beaufix, under the directory /home/gmap/mrpe/monteiro/public/bator/amdar/back/bator_decodbufr_mod.F90) in order to make it compatible with the new template 311010. This has lead us to a new form of this subroutine where the new descriptors were hardcoded and some changes had to be done on the date retrieval (due to the presence of new offsets between these parameters) and also to account with new parameters for pressure and relative humidity (optional for the time being).

This work was done at the platform yaga from CHMI. Therefore, the new bator_decodbufr_mod.F90 can be found at:

```
/worklocal/mma236/build_bator_op6bufr_amdar/Odb/pandor/module
```

and the used param.cfg file in

```
/work/mma236/CY38T1/bator_op6bufr_amdar/nam38/bator
```

The next step on this work consisted on the validation of the recently changed source code.

4 Validation of the BATOR source code to the new 311010 AMDAR BUFR template

In order to validate the recently changed BATOR source code to the 311010 AMDAR BUFR template, two files containing the same AMDAR information were created and used for comparison.

Those data files, can be found at the directory:

```
/home/mma/mma236/work/amdar/data_OPLACE
```

under sub-paths

```
obsoul/OBSOUL_20170108
```

and

```
bufr/bufr_2_amdar_xxxx_20170108
```

They came from the OPLACE pre-processing chain. The first one contains information under the (ASCII) format OBSOUL, which was created from BUFR messages via a decoding to the local database and then processed by OBSOUL program. The second file contains all original BUFR messages.

These two files have been ingested by BATOR application deriving into two separated ODB data bases which were then examined through the tool ODBSQL.

The corresponding ODB databases can be found at the directory:

```
/work/mma236/CY38T1/bator_op6bufr_amdar/data/OUTPUT
```

under the sub-paths:

```
conv/ECMA_conv
```

and

```
amdar/ECMA_amdar
```

respectively.

One proposed technique to examine the two local databases relies on creating output files from the same ODBSQL command line. For example:

```
odbsql -q 'select statid,date,time,lat,lon,vertco_reference_2,varno,obsvalue,obstype,codetype
           from hdr,body where (obsvalue < 1000) sort by statid,time' -k > out.obstype
```

The difference on the output files can be then identified. It is important to notice that the validation of the source code is iterative, since many times it lead us to new code changes, in order to converge to a final solution, the one were the two above mentioned ODB data bases are equal. This working methodology was in fact used to validate the new source code. Moreover, the direct comparison of the original OBSOUL file and the expanded version of the original BUFR file was added to this process whenever needed.

In the final code solution, however there were still two differences identified on the two ODBs (both related to the ASCII reference created by OULAN program):

i) OULAN version implemented in Hungary supress observations when the flight level is equal to zero, while bator_decodbufr_mod.F90 is not filtering this situation;
ii) OULAN does not treat properly undefined observations with value -9999, which leads to unrealistic winds in ODB.

Along this validation, a couple of tests more were done whose conclusions may help on the upgrade of the local pre-processing systems. They are here registered:

a) bator_decodbufr_mod.F90 is able to properly handle BUFR compressed (several subsets on the same message) or uncompressed messages;

5 Ongoing work and conclusions

During this stay a solution to the implementation (and validation) of the WMO AMDAR BUFR template 311010 in the local version of the BATOR CY38t1 data assimilation tool was achieved. Moreover, a methodology to implement further templates was tracked. On this process a new tool to create the param.cfg file was successfully tested, in particular, the tool Guessparamcfg.F90 from the HIRLAM community.

The achieved implementation suggests that a deep change (eventually a new subroutine) should be done on the original source code bator_decodbufr_mod.F90 which requires coordination with Météo-France and in that sense an email has been sent.

From the comparison of the 311192 and 311010 templates some questions have been raised which require further attention: what concerns the usage of the pre-processing quality control flags, which are not present any longer in the BUFR messages and the role of the pressure and relative humidity parameter. Information on these two issues has also been requested to Météo-France.

Finally, from the comparison of the ODB data bases created from separate OBSOUL and BUFR data files corresponding to the same AMDAR observations, two inconsistencies have been found which seem to be related with the OULAN procedure used in OPLACE system and have to be checked: the processing of missing wind values and use of flight level 0.

Acknowledgments

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Bibliography

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[7] Eoin Whelan personal communication, Met Ireland. at https://hirlam.org/trac/browser/trunk/harmonie

Appendix I: 0311010 WMO BUFR AMDAR template

-- List of expanded data descriptors :

1 001008 Aircraft registration number or other identification
2 001023 Observation sequence number
3 001006 Aircraft flight number
4 001110 Aircraft tail number
5 001111 Origination airport
6 001112 Destination airport
7 031021 Associated field significance
8 999999 ASSOCIATED FIELD
9 004001 Year
10 999999 ASSOCIATED FIELD
11 004002 Month
12 999999 ASSOCIATED FIELD
13 004003 Day
14 999999 ASSOCIATED FIELD
15 004004 Hour
16 999999 ASSOCIATED FIELD
17 004005 Minute
18 999999 ASSOCIATED FIELD
19 004006 Second
20 999999 ASSOCIATED FIELD
21 005001 Latitude (high accuracy)
22 999999 ASSOCIATED FIELD
23 006001 Longitude (high accuracy)
24 999999 ASSOCIATED FIELD
25 007010 Flight level
26 999999 ASSOCIATED FIELD
27 010053 Global navigation satellite system altitude
28 999999 ASSOCIATED FIELD
29 008009 Detailed phase of flight
30 999999 ASSOCIATED FIELD
31 011001 Wind direction
32 999999 ASSOCIATED FIELD
33 011002 Wind speed
34 999999 ASSOCIATED FIELD
35 002064 Aircraft roll angle quality
36 999999 ASSOCIATED FIELD
37 011100 Aircraft true airspeed
38 999999 ASSOCIATED FIELD
39 011101 Aircraft ground speed u-component
40 999999 ASSOCIATED FIELD
41 011102 Aircraft ground speed v-component
42 999999 ASSOCIATED FIELD
43 011103 Aircraft ground speed w-component
44 999999 ASSOCIATED FIELD
45 011104 Aircraft true heading
46 999999 ASSOCIATED FIELD
47 012101 Temperature/air temperature
48 999999 ASSOCIATED FIELD
49 002170 Aircraft humidity sensors
50 999999 ASSOCIATED FIELD

51 013002 Mixing ratio
52 999999 ASSOCIATED FIELD
53 013003 Relative humidity
54 031000 Short delayed descriptor replication factor
55 999999 ASSOCIATED FIELD
56 012103 Dew-point temperature
57 999999 ASSOCIATED FIELD
58 033026 Moisture quality
59 031000 Short delayed descriptor replication factor
60 999999 ASSOCIATED FIELD
61 020042 Airframe icing present
62 031000 Short delayed descriptor replication factor
63 999999 ASSOCIATED FIELD
64 020043 Peak liquid water content
65 999999 ASSOCIATED FIELD
66 020044 Average liquid water content
67 999999 ASSOCIATED FIELD
68 020045 Supercooled large droplet (SLD) conditions
69 031000 Short delayed descriptor replication factor
70 999999 ASSOCIATED FIELD
71 033025 ACARS interpolated values indicator
72 031001 Delayed descriptor replication factor
73 031000 Short delayed descriptor replication factor
74 999999 ASSOCIATED FIELD
75 011037 Turbulence index
76 999999 ASSOCIATED FIELD
77 011077 Reporting interval or averaging time for eddy dissi
78 031000 Short delayed descriptor replication factor
79 999999 ASSOCIATED FIELD
80 011034 Vertical gust velocity
81 999999 ASSOCIATED FIELD
82 011035 Vertical gust acceleration
83 999999 ASSOCIATED FIELD
84 011036 Maximum derived equivalent vertical gust speed
85 031001 Delayed descriptor replication factor