ALADIN Project Stay report – version 0.0 (March 2018)

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Topics

1 Introduction

This document reports the activities done during a short stay at CHMI on the implementation of the WMO BUFR templates for SHIP, DRIFTING and MOORED BUOY observations records on a local version of the BATOR source code. This work followed a previous work done in 2016 and 2017 to back-phase a local code source of BATOR in accordance to the latest WMO SYNOP, TEMP and AMDAR BUFR templates, which was described in [1 & 2].

As shown by the WMO web server OSCAR[1] nowadays, SHIP and BUOY observations network provide a worldwide record of low atmospheric conditions over sea. Although sparse, SHIP and BUOY are two types of observations which can add value to analysis when used on data assimilation systems, since they are the only two types of in-situ measurements over areas where usually only satellite observations are available. Studies like the one presented by Météo-France [3] on the global model ARPEGE, where pressure and wind measurements are used for upper-air analysis and surface temperature for surface analysis, have revisited the relative impact of these type of observations. For instance, it has been reported by UK MetOffice [4] that, though their relative impact on surface pressure/wind forecasts was expected to be higher (on the global model), surface pressure observations from drifting buoys contribute substantially to total forecast skill. More recently Met.no [6] has shown, by performing OSSE with a convection-permitting model, that over the Artic buoys can play an important role in adjusting the analyses and can also have considerable influence on the forecast.

The above mentioned studies bring the attention to this type of WWW observations. At the same time, since WMO is promoting an upgrade on the GTS dissemination procedures which involve a change of the observations transmission code forms - namely, the use of Table Driven Code Forms (TDCF) like BUFR data, instead of the Traditional Alphanumeric Codes (TAC) – it is timely to promote the upgrade of the BATOR source code. In the short term it is expected to stop the transmission of observations under TAC format worldwide and the local pre-processing systems have to suffer upgrades to deal with the most recently published WMO BUFR templates.

1.1 Particularities of surface-sea observations

SHIP and BUOY are WMO surface-sea observations (see Table A[2]). Table 1 shows the correspondence between the observation types used by different GDPFS centers, when referencing surface-sea observations, such as SHIP and BUOY.

Table 1 – Correspondence on the classification of surface-sea observation types by WMO, ECMWF and Météo-France.

Observation type	**WMO BUFR categories**	**ECMWF categories (MARS retrieval)**	**ODB categories**
SHIP(*)	DATA CATEGORY = 1 DATA SUB-CATEGORY = 0 LOCAL DATA SUB-CATEGORY = 0	RDB Type = 1 RDB subtype = 11, ...	obstype@hdr = 1 codetype@hdr = 21(**) or 24(***)
DRIFTING BUOY	DATA CATEGORY = 1 DATA SUB-CATEGORY = 25 LOCAL DATA SUB-CATEGORY = 25	RDB Type = 1 RDB subtype = 181	obstype@hdr = 4 codetype@hdr = 165
MOORED BUOY	DATA CATEGORY = 1 DATA SUB-CATEGORY = 0 LOCAL DATA SUB-CATEGORY = 25	RDB Type = 1 RDB subtype = 182	obstype@hdr = 4 codetype@hdr = 165

1 https://oscar.wmo.int/surface//index.html#/

2 http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/WMO306_vI2_BUFR_TableA_en.pdf

Note:
(*) For SYNOP, the same WMO BUFR parameters can take the values:

```
  DATA CATEGORY                    0
  DATA SUB-CATEGORY                0
  LOCAL DATA SUB-CATEGORY          1
```

(**) Automatic
(***) Manual

Table 2 shows the parameters association done by BATOR; an example of a BUFR message template is provided in Appendices I, II and III for each of the observation types: SHIP, DRIFTING BUOY and MOORED BUOY.

Table 2 – Correspondence between BUFR and ODB parameters, provided by back-phased BATOR.

Ship	**BUFR table B meaning**	**ODB Physical parameter**	**ODB parameter (varno)**
010004	Pressure	Pressure	39 (for instance and) vertco_reference_1
010051	Pressure reduced to mean sea level	0. or NULL Pressure reduced to mean sea level	3 or 4 (and) vertco_reference_1
012101	Temperature/air temperature(*)	2m Temperature	39
012103	Dewpoint temperature	2m Relative Humidity	58
013003	Relative humidity	(2m) Specific humidity	7
022043	Sea/water temperature	Surface Temperature	11
011001 (and) 011002	Wind direction Wind speed	10m zonal wind component 10m meridional wind component	41
Remaining SYNOP param.	… … …	… … …	… … …
Drifting Buoy	**BUFR Table B meaning**	**ODB Physical parameter**	**ODB parameter**
010004 010051 (option for sea)	Pressure Pressure reduced to mean sea level	Geopotential=0. Mean Sea Level Pressure (**)	1 vertco_reference_1
022043	Sea/water temperature	Surface Temperature	11
012101	Temperature/air temperature(*)	2m Temperature	39
011001 (and) 011002	Wind direction(***) Wind Speed	Not found.	Not found.
Moored Buoy	**BUFR Table B meaning**	**ODB Physical parameter**	**ODB parameter**
010004 010051 (option for sea)	Pressure Pressure reduced to mean sea level	Geopotential=0. Mean Sea Level Pressure (**)	1 vertco_reference_1
022049	Sea-surface temperature	Surface Temperature	11
012101	Temperature/air temperature(*)	2m Temperature	39
012103	Dewpoint temperature(*)	2m Dew Point	40
011001 (and) 011002	Wind direction Wind speed	10m zonal wind component 10m meridional wind component	41 42

Note:
(*) On the DRIFTING BUOY, this variable is related to the previous descriptor, which is “007033 Height of sensor above water surface” which has “value=0” or “value=MISSING” most of the time.
(**) In this case Surface Pressure is equal to Mean Sea Level Pressure.
(***) For DRIFTING BUOY observations, the wind parameters were always missing in Toulouse data set.

2 Acquisition & decoding

The first goal of this work was to identify the typical surface-sea records available worldwide and eventually relevant for ALADIN LAMs. To proceed with this task, data available from GTS/CHMI, ARPEGE/Météo-France, GTS/IPMA and OPLACE were examined. The date chosen for this exercise was 18 March 2018 (except for GTS/IPMA data). After examination, the Tables on the next sections summarize the main characteristics of the different bulletins, messages and templates available for BUOY and SHIP records.

When retrieving GTS BUFR bulletins, one should pay attention to the follwoing general information:

i) WMO/GTS BUFR bulletins designation[3] take the form

T1T2A1A2ii CCCC

where,

T1 = I (Observational data binary coded - BUFR)
T2A1 = SS (Surface Sea/Synoptic observations from marine stations) or OB (Oceanographic/Buoy observations)
A2 = Geographical designators A1A2 for use in abbreviated headings T1T2A1A2 ii CCCC YYGGgg for bulletins containing ships' weather reports and oceanographic data including reports from automatic marine stations:

Designator	Geographical Area
A	Area between 30°N - 60°S, 035°W - 070° E
B	Area between 90°N - 05°N, 070°E - 180°E
C	Area between 05°N - 60°S, 120°W - 035°W
D	Area between 90°N - 05°N, 180°W - 035°W
E	Area between 05°N - 60°S, 070°E - 120°W
F	Area between 90°N - 30°N, 035°W - 070°E
J	Area between 60°S
X	More than one area

Note:
1. In opposition to what happens on surface and upper-air observations (reported in [2], for instance), for sea/water observations the geographical areas covered on a bulletin have now a different designation. For instance, for Portugal, the former type of observations (SYNOP, TEMP and AMDAR) should come on a bulletin with geographical designator equal to A, D, N or X, while on the latest (SHIP and BUOY) the geographical area of interest should be covered by bulletins with with A2 designator equal to D or X.

ii) Identification of WMO BUFR originating centers

Although incomplete,Table 3 shows the different designators of different BUFR originating

3 http://www.wmo.int/pages/prog/www/ois/Operational_Information/Publications/WMO_386/AHLsymbols/TableDefinitions.html

centers[4][5].

Table 3 – Example of identification of WMO BUFR originating centers.

Stream/ Abreviation	**Identification**	**Centre/country**
LPMG	212	Lisboa/Portugal
BIRK		Reykyavik Airport/Iceland
EGRR	74, 75	UK Meteorological Office Exeter/England
EIDB		Dublin/Ireland
ESWI		Norkoping/Sweden
EDZW	78	Offenbach/Germany
ENMI		Oslo/Norway
LGAT		Athainai/Greece
LFPW	85	France

2.1 SHIP observations

As said before (see Table 1), SHIP data is considered as Data Category equal to “1” (surface data – sea). This identification is particularly important when separating SHIP from SYNOP BUFR records. For the examination of the WMO/GTS BUFR bulletins the tool **bufr_decode_all** was used providing an expanded format of BUFR records.

2.1.1 GTS/CHMI data set

The first data set examined was from GTS/CHMI. Totally it was possible to find 1158 in one day (20180318) from 7 emission/originating centers (Table 4), with the following distribution: 27 from EIDB; 536 from ESWI; 1 from LPMG; 166 from ENMI; 349 from EGRR; 52 from EDZW; and 28 from BIRK. A typical name of a bulletin is ISSD04_ENMI_181100_xxx.

Table 4 – SHIP bulletins prefix according to the geographical origin available from GTS/CHMI on 20180318.

GTS bulletin	**Dissemination centers**
ISSA	BIRK, EGRR, EIDB, ESWI, LPMG
ISSB	EGRR, ESWI
ISSC	EGRR, ESWI
ISSD	EGRR, ESWI, ENMI
ISSE	EGRR, ESWI
ISSF	ESWI
ISSG	ESWI
ISSH	ESWI
ISSI	EGRR, ESWI
ISSJ	EGRR, ESWI
ISSK	EGRR, ESWI
ISSL	EGRR, ESWI
ISSX	EDZW

By originating center it was possible to find the SHIP BUFR templates summarized in Table 5.

4 http://www.wmo.int/pages/prog/www/ois/Operational_Information/VolumeC1/notused/CCCC_en.html
5 http://apps.ecmwf.int/codes/grib/format/mars/centre/

Table 5 – BUFR SHIP records characterization, according to the originating center.

Disseminating center	Bulletin name	Number of subsets	Unexpanded (sequence) descriptors	Notes
EDZW	ISSX01_EDZW_ddhh00_xxx	1	308009	3 different bulletins. No amends, no corrections, no retards. Hourly bulletins.
	ISSX22_EDZW_ddhh00_xxx	1	308009	
	ISSX81_EDZW_ddhh00_xxx	1	308009	
BIRK	ISSA01_BIRK_ddhh00_xxx	1	301093 302001 302054 008002 302055 302057 302060	3 different bulletins. No amends, no corrections, no retards. Hourly; 3-hour and 6-hour bulletins.
	ISSA11_BIRK_ddhh00_xxx	8	301093 302001 302054 008002 302055 302057 302060	
	ISSA21_BIRK_ddhh00_xxx	9	301093 302001 302054 008002 302055 302057 302060	
EGRR	ISSA01_EGRR_ddhh00_xxx	28	308009	25 different bulletins. No amends, no corrections, no retards. Hourly bulletins, among others.
	ISSA11_EGRR_ddhh00_xxx	28	308009	
	ISSA16_EGRR_ddhh00_xxx	30	308009	
	ISSB11_EGRR_ddhh00_xxx	1	308009	
	ISSB16_EGRR_ddhh00_xxx	1	308009	
	ISSC01_EGRR_ddhh00_xxx	8	308009	
	ISSC11_EGRR_ddhh00_xxx	2	308009	
	ISSC16_EGRR_ddhh00_xxx	1	308009	
	ISSD01_EGRR_ddhh00_xxx	29	308009	
	ISSD11_EGRR_ddhh00_xxx	29	308009	
	ISSD16_EGRR_ddhh00_xxx	29	308009	
	ISSE16_EGRR_ddhh00_xxx	3	308009	
	ISSJ16_EGRR_ddhh00_xxx	1	308009	
	ISSI01_EGRR_ddhh00_xxx	5	308009	
	ISSI16_EGRR_ddhh00_xxx	5	308009	
	ISSK01_EGRR_ddhh00_xxx	1	308009	
	ISSK11_EGRR_ddhh00_xxx	1	308009	
	ISSK16_EGRR_ddhh00_xxx	1	308009	
	ISSL01_EGRR_ddhh00_xxx	1	308009	
	ISSL11_EGRR_ddhh00_xxx	1	308009	
	ISSL16_EGRR_ddhh00_xxx	1	308009	
EIDB	ISSA01_EIDB_ddhhh00_xxx	1	308009	3 different bulletins. No amends, no corrections, no retards. Hourly bulletins, among others.
	ISSA21_EIDB_ddhhh00_xxx	1	308009	
	ISSA22_EIDB_ddhhh00_xxx	1	308009	
ESWI	ISSA01_ESWI_ddhh00_xxx			12 different bulletins. No amends; corrections and retards (up to RRJ)
	ISSB01_ESWI_ddhh00_xxx			

	ISSC01_ESWI_ddhh00_xxx			found. Hourly bulletins, among others. Most of original bulletins were empty; just the retards had some info.
	ISSD01_ESWI_ddhh00_xxx	2	308009	
	ISSE01_ESWI_ddhh00_xxx			
	ISSF01_ESWI_ddhh00_xxx			
	ISSG01_ESWI_ddhh00_xxx			
	ISSH01_ESWI_ddhh00_xxx			
	ISSI01_ESWI_ddhh00_xxx	2	308009	
	ISSJ01_ESWI_ddhh00_xxx			
	ISSK01_ESWI_ddhh00_xxx			
	ISSL01_ESWI_ddhh00_xxx			
LPMG	ISSA01_LPMG_ddhh00_xxx	1	308009	1 bulletin found. No amends, no corrections, no retards. Daily bulletin (at 18:00).
ENMI	ISSD01_ENMI_ddhh00_xxx	2	308009 004025 011042	4 bulletins found. No amends; corrections and retards found. Hourly bulletins.
	ISSD02_ENMI_ddhh00_xxx	25	308009 004025 011042	
	ISSD03_ENMI_ddhh00_xxx	1	001001 001002 308009 004025 011042	
	ISSD04_ENMI_ddhh00_xxx	1	001001 001002 308009 004025 011042	

Note:
1. It has to be checked if within corrections we have duplications; it was not been the case for retards.

2.1.2 ARPEGE/Météo-France data set

The second data set examined was from GTS/Météo-France, but after being pre-processed (the reference). In ARPEGE, at the BUFR input level, there is no distinction between SYNOP and SHIP, so the same file is used for both type of messages. Data from the file 2018031812_bufr.synop was, therefore, examined. It was possible to see that each BUFR message/record contains only one data subset and therefore there are no duplications of information, which means that amends, corrections and retards have been filtered and sorted already, before this BUFR file was assembled.

Basic characteristics of BUFR records contained in 2018031812_bufr.synop are shown on the Table 6.

Table 6 – BUFR SHIP records characterisation on ARPEGE input for 12UTC network on 18 March 2018

Parameter	**Value**
Number of messages	34019
Number of observations	34019
Number of ships	1120 (166 from ODB codetype=21; 998 with ODB codetype=24)
Number of synops	32899
Originating centers	4, 12, 26, 28, 30, 34, 36, 40, 73, 74, 78, 80, 82, 85, 86, 87, 88, 89, 91, 94, 96, 99, 110, 113, 128, 136, 212, 213, 214, 215, 217, 220,

	221, 224, 226, 227, 230, 231, 233, 234, 238, 242, 244, 245, ...
Data category	0[6], 1
Data sub-category	0, 1, 2, 6, 7, 50
BUFR edition number	3, 4
BUFR master table	0
Version number of master table	13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 26, 27
BUFR template	308009

The examination of this file drive us to the conclusion that no extra unexpanded sequence descriptors are present besides those already identified in Table 5 (see results from run_bator_ship_tls, for instance).

2.1.3 GTS/IPMA data set

Data from GTS/IPMA was used as a cross-confirming method on the conclusions already taken with the previous data set. In this case, the BUFR SHIP records corresponded to a random sample (instead of total) taken during the 48-hour period from 13 to 14 March 2018.

The number of emission centers was now increased in comparison to that found in GTS/CHMI. In particular, it was possible to find bulletins from the following originating centers: BIRK, EGRR, EIDB, ESWI, LFPW, PANC, VHHH, KWBC, RJTD, ENMI, NZKL, RKSL, in a total of 12 emission centers (against 7 arriving to GTS/CHMI), with the following distribution: 6 from BIRK; 76 from EGRR; 6 from EIDB; 88 from ESWI; 174 from LFPW; 67 from PANC; 7 from VHHH; 70 from KWBC; 10 from RJTD; 34 from ENMI; 6 from NZKL and 2 from RKSL.

Totally, 569 bulletins were examined. A typical name is ISSA01EGRR141200. Table A.1 of Appendix IV gives more details on the BUFR SHIP records found. In fact, just confirmed the actual usage of the 4 different templates worldwide (Table 12), reducing the effort to read them in BATOR.

2.2 BUOY (drifting & moored) observations

According to WMO BUFR Table A, BUOY observations are considered as (see Table 1):

Data Category : code figure 1 (surface data – sea)
Data sub-Category : code figure 25

Moreover, it is possible to distinguish two different BUFR templates, in accordance with the type of buoy, as summarized in Table 7.

Table 7 – Actual BUOY observations types.

Name of BUOY observation	**BUFR Type of buoy**	**BUFR template (sequence) descriptor**
DRITFING BUOY	10	315009
MOORED BUOY	25	315008

Note:
1. See info on the templates at
http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/TemplateExamples.html#Attachment

6 Code figure 0 (surface data – land) from BUFR Table A.

2.2.1 GTS/ CHMI data set

2.2.1.1 Drifting & moored BUOY

Totally it was possible to find 699 bulletins in one day (20180318) from 4 emission (originating centers) in accordance with Table 8. A typical name of a bulletin is IOBA01_LPMG_180000_xxx.

Table 8 – BUFR BUOY bulletins prefix according to the geographical origin, available from GTS/CHMI on 20180318.

GTS bulletin	Dissemination centers
IOBA	LPMG, EIDB, LFPW
IOBD	LGAT, LFPW
IOBE	LFPW
IOBF	LFPW
IOBG	LFPW
IOBH	LFPW
IOBI	LFPW
IOBJ	LFPW
IOBK	LFPW
IOBL	LFPW

And, by originating centre, it was possible to find the BUFR record templates summarized in Table 9.

Table 9 – Actual BUFR BUOY records characterization, according to the originating center.

Disseminating center	Bulletin name	Number of subsets	Unexpanded descriptors	Notes
LPMG	IOBA01_LPMG_ddhh00_xxx	4	315008	1 bulletins found. No amends, no corrections, no retards. Hourly bulletins (from 0 to 6)
EIDB	IOBA21_EIDB_ddhh00_xxx	4	315008	1 bulletins found.. No amends, no corrections, no retards. Hourly bulletins.
LGAT	IOBD01_LGAT_ddhh00_xxx	3	315008	1 bulletins found. No amends, no corrections, no retards. 3-hour bulletins.
LFPW	IOBA01_LFPW_ddhh00_xxx	81	315009	11 bulletins found. No amends or corrections. Retards found.
	IOBA03_LFPW_ddhh00_xxx	19	315008	
	IOBD01_LFPW_ddhh00_xxx	9	315009	
	IOBD03_LFPW_ddhh00_xxx	13	315008	
	IOBE01_LFPW_ddhh00_xxx	57	315008	
	IOBF01_LFPW_ddhh00_xxx	1	315009	
	IOBG01_LFPW_ddhh00_xxx	1	315009	
	IOBH01_LFPW_ddhh00_xxx	11	315009	
	IOBI01_LFPW_ddhh00_xxx	9	315009	
	IOBJ01_LFPW_ddhh00_xxx	7	315009	
	IOBL01_LFPW_ddhh00_xxx	21	315009	

Note:

1. In opposition to SHIP data, BUOY records did not revealed duplications due to

corrections, amends or retards (just like the E-AMDARs, thought this information should be confirmed).

2.2.2 ARPEGE/ Météo-France data set

In ARPEGE, BUOY BUFR data input appears in two separated files, one for drifting buoys and another for moored buoys. In this way, in this section, data is treated distinctly.

2.2.2.1 Drifting BUOY

The DRIFTING BUOY records contained in ARPEGE input file 2018031812_bufr.drift for the 12UTC network on 18 March 2018 have been examined and their characterization is summarizes in Table 10.

Table 10 - Actual BUFR DRIFTING BUOY records characterization on ARPEGE input for 12UTC network on 18 March 2018.

Characterization parameter	**Value**
Number of message	29
Number of observations	29
Originating centers	53, 62, 85, 161
Data category	1, 31[7]
Data sub-category	25, 5[6]
BUFR edition number	4
BUFR master table	0
Version number of master table	22, 23, 27
BUFR template	315009

Note:
1. In opposition to what is disseminated directly by GTS, for ARPEGE/Météo-France each BUFR message contains only one single DRIFTING BUOY observation, which is to say, that each BUFR message/record contains one single subset.

2.2.2.2 Moored BUOY

Moored buoys contained in ARPEGE input file 2018031812_bufr.moored for 12UTC network on 18 March 2018 have been examined and their characterization is summarized in Table 11.

Table 11 – BUFR MOORED BUOY records characterization, on ARPEGE input for 12UTC network on 18 March 2018.

Characterization parameter	**Value**
Number of message	46
Number of observations	46
Originating centers	85, 214, 233
Data category	1
Data sub-category	0 *, 25
BUFR edition number	4
BUFR master table	0
Version number of master table	22, 23, 24
BUFR Template	315008

7 Oceanographic data According to BUFR Table A.

Note:
1. In opposition to what is disseminated directly by GTS, for ARPEGE/Météo-France each BUFR message contains one single BUOY observation, which is to say, that each BUFR message/record contains one single subset observation's BUFR files.

3.1 Back-phasing implementation

3.1.1 BUFR SHIP observations processing

In the previous sections it was possible to identify the 4 distinct SHIP BUFR templates as registered in Table 12.

Table 12 – WMO SHIP templates found (GTS/CHMI data set).

A. 308009 B. 308009 004025 011042 C. 001001 001002 308009 004025 011042 D. 302001 302054 008002 302055 302057 302060

To allow the processing of the SHIP BUFR templates shown in Table 12 by the local BATOR version at CY38T1, the following steps have been done:

i) BATOR code source and input files (in Odb/pandor/modules) from CY43T2_bf05 have been compared to the corresponding CY38T1.

Since BUFR SHIP is read as Synop_2 on BATOR, nothing was done on the local source code, since there no differences were identified at this level.

ii) Compatibility of the BUFR SHIP templates,

At this level changes have to be identified. Templates for SHIP data existed in ARPEGE param.cfg, however, there was one missing. Therefore, the new unexpanded template (equivalent to 308009, but in a semi-expanded way – template D from Table 12) was created and introduced in the local param.cfg. The summary of changes is given in Table 13.

Table 13 – Changes introduced in the local BATOR code source, compatible with BUFR SHIP.

Source	**ARPEGE available templates:**	**Newly created:**
Param.cfg	# 36 (A), # 37 (B), # 38 (C)	# 39 (D)

Note:
1. Since this work was done at CHMI, the sources are under /home/mma236/scr/namelist use of server kazi.chmi.cz.

3.1.2 BUFR BUOY observations processing

In the local BATOR at CY38T1 there were no tracks of the processing of BUFR BUOY records. Therefore the local BATOR source code was compared to a more recent cycle - CY43T2_bf05, and the relevant changes were back-phased and tested on the local code. Table 14 summarizes the findings.

Table 14 - Changes introduced in the local BATOR code source, compatible with BUFR DRIFTING and MOORED BUOY records..

Source	Local	New local
bator_init_mod.F90	CASE ('buoyomm')	CASE ('buoyomm','moored')
	- - -	CASE ('drift') knbw = 4 kilsup = 0
bator_decodbufr_mod.F90	- - -	Subroutine/Function | DriftBuoy (*)
	- - -	Subroutine/Function | moored (*) (*) Note that TabSlots was back-phased to the CY38T1 form, so that the subroutine arguments became, for instance for Moored buoys: SUBROUTINE Moored(kobs,kw,kel,kfic,tconfig,iterr) instead of SUBROUTINE Moored(kobs,kw,kel,kfic,tconfig,TabSlots,iterr) and the following declaration was deleted TYPE(TDate),DIMENSION(:),INTENT(IN) :: TabSlots

Subroutine/Function | DriftBuoy		t_date(1:5) = values(j*kel+inddate:j*kel+inddate+4)
		IF (ANY(t_date(1:5) == rabsi) .OR. &
		& .NOT.(VerifDate(INT(t_date(1:6))))) THEN
		iterr(3) = iterr(3) + 1
		CYCLE
		ENDIF
		
		instead of
		
		! t_date(1:5) = values(j*kel+inddate:j*kel+inddate+4)
		! IF (.NOT.(VerifDate(INT(t_date(1:6)),TabSlots))) THEN
		! iterr(3) = iterr(3) + 1
		! CYCLE
		! ENDIF
		
		zwagon(kw,1) = 1
		! zwagon(kw,1) = Varno%z
		
		zwagon(kw,1) = 11
		! zwagon(kw,1) = Varno%ts
		
		zwagon(kw,1) = 39
		! zwagon(kw,1) = Varno%t2m
		
		zwagon(kw,1) = 41
		! zwagon(kw,1) = Varno%u10m

Subroutine/Function | moored		t_date(1:5) = values(j*kel+inddate:j*kel+inddate+4)
		IF (ANY(t_date(1:5) == rabsi) .OR. &
		& .NOT.(VerifDate(INT(t_date(1:6))))) THEN
		iterr(3) = iterr(3) + 1
		CYCLE
		ENDIF
		
		! t_date(1:5) = values(j*kel+inddate:j*kel+inddate+4)
		! IF (.NOT.(VerifDate(INT(t_date(1:6)),TabSlots))) THEN
		! iterr(3) = iterr(3) + 1

		! CYCLE
		! ENDIF
		
		  zwagon(kw,1) = 1
		! zwagon(kw,1) = Varno%z
		
		  zwagon(kw,1) = 11
		! zwagon(kw,1) = Varno%ts
		
		  zwagon(kw,1) = 39
		! zwagon(kw,1) = Varno%t2m
		
		  zwagon(kw,1) = 40
		! zwagon(kw,1) = Varno%td2m
		
		  zwagon(kw,1) = 41
		! zwagon(kw,1) = Varno%u10m

Param.cfg		# 33, # 34 & # 35 were introduced

3.2 Validation

An experiment setup just to run BATOR and create the ODB files was used to process different data sets of BUFR records. In order to get more flexibility due to eventual limitations on the data sets, the following changes have been done in BATOR environment settings:

i) In order to allow the ingestion on a 24 interval:

```
dat=`$smsdate ${YYYYMMDD}${NT} -12`; echo ${dat}0000 > ficdate
dat=`$smsdate ${dat} +24` ; echo ${dat}0000 >> ficdate
```

ii) to prevent the filtering by geographical area

```
export BATOR_LAMFLAG=0
```

iii) as a remark one should note also that refdata file should appear as:

'synop BUFR synop 20180318 12'

Note:
1. Investigation should proceed in order to understand why the BUFR messages temperature comes as ‘Temperature’ and on ODB it comes as T2m

3.2.1 SHIP observations

3.2.1.1 Decoding/ODB contents checking

The following data set files from GTS/CHMI were then processed, so that the different BUFR SHIP templates could be tested:

ISSD01_ENMI_181100_xxx
ISSA01_BIRK_181200_xxx
ISSA01_EGRR_181200_xxx

and from ARPEGE/Météo-France, where just the template 308009 is used, the file

2018031812_bufr.synop was processed. The ODB data base contents was then been checked in terms of the number of messages read. For instance, for the latest data set it was possible to obtain the information:

Total number of messages taken care: 1120
Number of accepted messages: 998
Number of rejected messages: 122

Which was in agreement with the expected (see Section 2.1.2).

An important step was done by verifying the values of meteorological parameters inside ODB against those present on the corresponding decoded input file. This was done for each parameter of Table 2 and randomly on the sequence of BUFR messages, using the ARPEGE input file as reference.

3.2.1.2 Geographical coverage

Figures 1 and 2 show a typical coverage by SHIP on a 6-hour time-window, as treated by Météo-France.

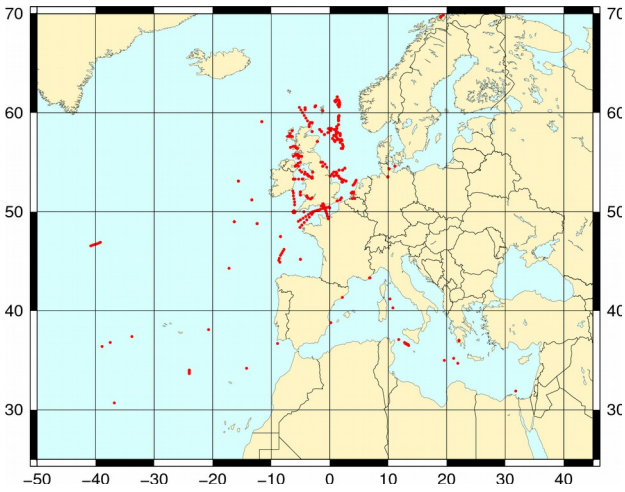

Figure 1 – WMO SHIP records contained in ARPEGE 2018031812_bufr.synop (6 hour time-window) over the north-European region.

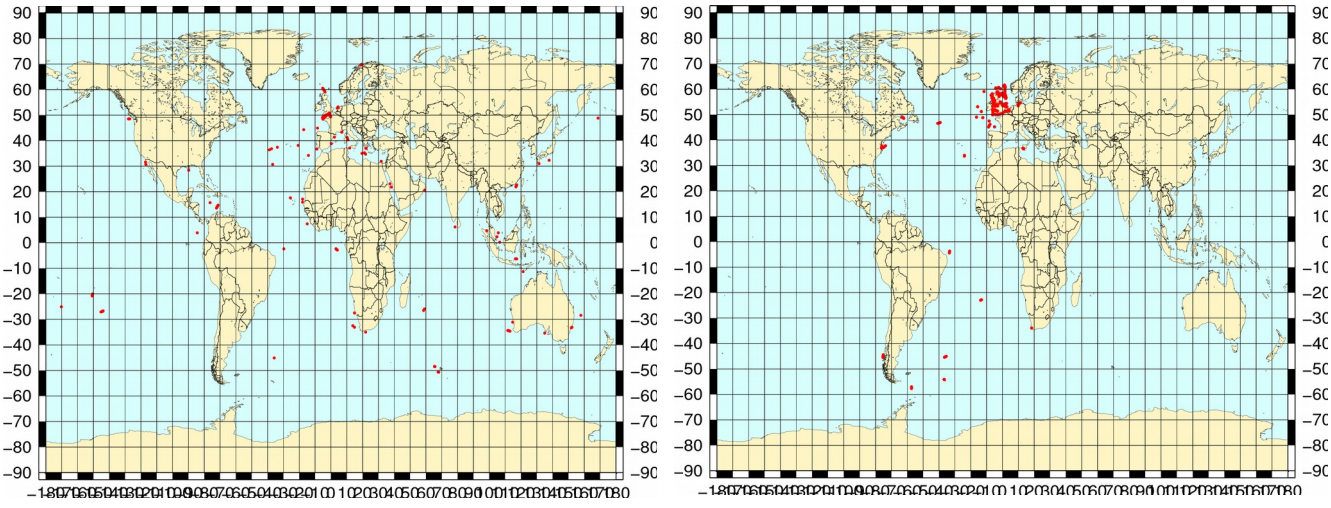

Figure 2 – WMO SHIP records contained in ARPEGE 2018031812_bufr.synop (6 hour time-window) with different ODB codetypes: 21 (left) and 24 (right).

3.2.1.3 Cross-checking of GTS/CHMI and ARPEGE/Météo-France data sets

For this exercise, the GTS/CHMI bulletins valid for one single date were all assembled in to a single bufr file and processed by BATOR. From the delivered ODB, data from 12UTC was then selected (see Figure 3). The geographical distribution was then compared with the corresponding 12UTC figure coming from GTS/Météo-France data set (see Figure 3).

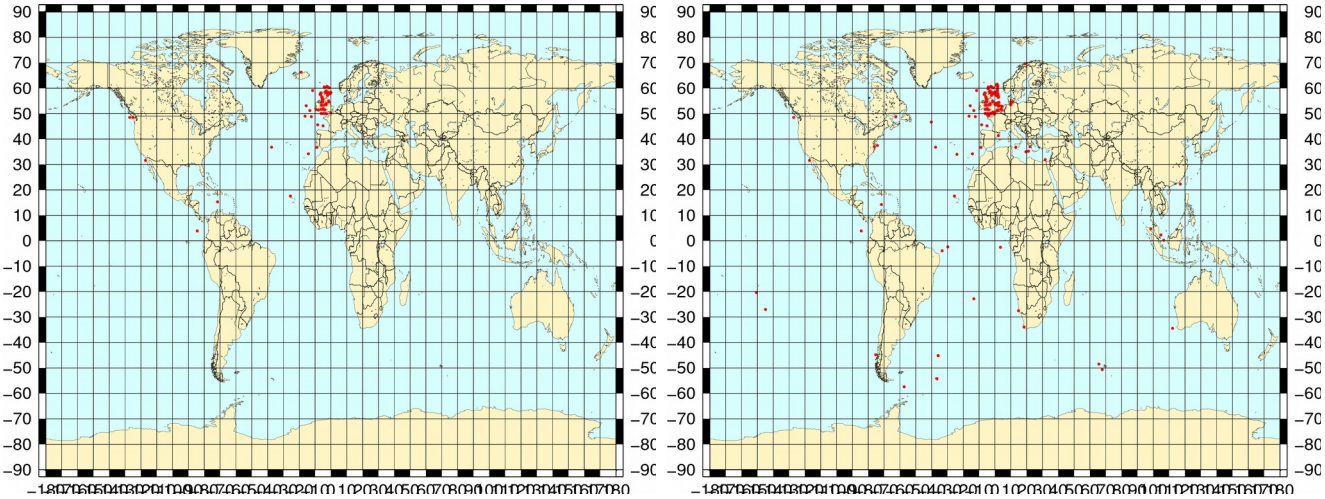

Figure 3 – WMO SHIP records received in GTS/CHMI (left) and GTS/Météo France (right) on 20180318 valid at 12UTC.

It was possible to see that, thought most of data points was located in the same places in both data samples, there were more ships found in Méte-France data settings, meaning that some bulletins were missing in GTS/CHMI data set.

3.2.2 DRIFTING and MOORED BUOY observations

For this type of record, both the decoding/ODB contents and geographical coverage inspection were done. Figure 4 shows the geographical distribution from the ARPEGE/Météo-France data sets as an example.

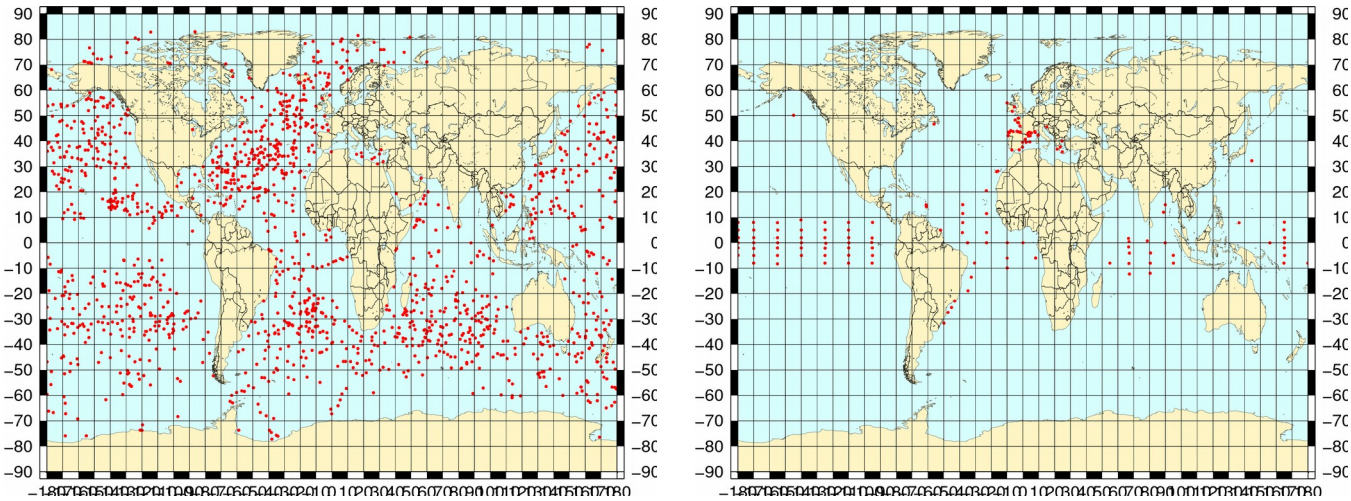

Figure 4 – WMO DRIFTING BUOY records contained in GTS/Météo France on 20180318 valid at 12 UTC bufr.drift (left) and bufr.moored (left) within 6 hour time-window.

4 Ongoing work and conclusions

The work done during this stay provides a methodology to back-phase BATOR in order to allow the processing of WMO BUFR SHIP and BUOY observations records. It was found that SHIP records are read as Synop_2 in BATOR and for this type of message there was only need to implement one of the 4 distinct BUFR sequences used worldwide. In opposition, it was need to back-phase fully the code to process DRIFTING and MOORED BUOY records, from CY43T2_bf05. On-going work should allow to take conclusions what concerns CY40, most probably in IPMA's platforms.

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Bibliography

[1] Monteiro, M. (2016), Validation of a back-phased version of the source code BATOR (SYNOP and TEMP), ALADIN Project Stay report, 11-15 January 2016, RC-LACE, CHMI, Czech Republic.

[2] Monteiro, M. (2017), Upgrade of the source code BATOR to 311010 WMO AMDAR template, ALADIN Project Stay report, 9-20 January 2017, RC-LACE, CHMI, Czech Republic.

[3] MAHFOUF, J,-F. (2012) ,On the use of BUOY observations in the Numerical Weather Prediction data assimilation systems at Météo-France, at https://www.wmo.int/pages/prog/www/OSY/Meetings/Wshop-Impact-NWP-5/dbcp/documents/DBCP-SLP1_Météo-France-SLP_Mahouf.pdf.

[4] Eyre, J. (2012), Impact of drafting buoy observations on NWP at the Met Office, at https://www.wmo.int/pages/prog/www/OSY/Meetings/Wshop-Impact-NWP-5/dbcp/documents/DBCP-SLP1_UK-Metoffice_Eyre.pdf.

[5] Randriamampianina, R., (2016), Observing system experiments and observing system simulation experiments using mesoscale model in Arctic, at https://www.wmo.int/pages/prog/www/WIGOS-WIS/reports/6NWP_Shanghai2016/Session-3/3.10.pdf.

Appendix I: WMO BUFR SHIP template 308009

```
DATA CATEGORY                          1
DATA SUB-CATEGORY                      0
LOCAL DATA SUB-CATEGORY                0

       DATA DESCRIPTORS (UNEXPANDED)

   1  308009


       DATA DESCRIPTORS (EXPANDED)

    1  001011  Ship or mobile land station identifier
    2  001012  Direction of motion of moving observing platform
    3  001013  Speed of motion of moving observing platform
    4  002001  Type of station
    5  004001  Year
    6  004002  Month
    7  004003  Day
    8  004004  Hour
    9  004005  Minute
   10  005002  Latitude (coarse accuracy)
   11  006002  Longitude (coarse accuracy)
   12  007030  Height of station ground above mean sea level
   13  007031  Height of barometer above mean sea level
   14  010004  Pressure
   15  010051  Pressure reduced to mean sea level
   16  010061  3-hour pressure change
   17  010063  Characteristic of pressure tendency
   18  007032  Height of sensor above local ground (or deck of marine platform
   19  007033  Height of sensor above water surface
   20  012101  Temperature/air temperature
   21  002039  Method of wet-bulb temperature measurement
   22  012102  Wet-bulb temperature
   23  012103  Dewpoint temperature
   24  013003  Relative humidity
   25  007032  Height of sensor above local ground (or deck of marine platform
   26  007033  Height of sensor above water surface
   27  020001  Horizontal visibility
   28  007033  Height of sensor above water surface
   29  007032  Height of sensor above local ground (or deck of marine platform
   30  013023  Total precipitation past 24 hours
   31  007032  Height of sensor above local ground (or deck of marine platform
   32  020010  Cloud cover (total)
   33  008002  Vertical significance (surface observations)
   34  020011  Cloud amount
   35  020013  Height of base of cloud
   36  020012  Cloud type
   37  020012  Cloud type
   38  020012  Cloud type
   39  031001  Delayed descriptor replication factor
   40  008002  Vertical significance (surface observations)
   41  020011  Cloud amount
   42  020012  Cloud type
   43  020013  Height of base of cloud
   44  008002  Vertical significance (surface observations)
   45  020031  Ice deposit (thickness)
   46  020032  Rate of ice accretion (estimated)
   47  020033  Cause of ice accretion
   48  020034  Sea ice concentration
   49  020035  Amount and type of ice
   50  020036  Ice situation
   51  020037  Ice development
   52  020038  Bearing of ice edge
   53  002038  Method of water temperature and/or salinity measurement
   54  007063  Depth below sea/water surface (cm)
   55  022043  Sea/water temperature
   56  007063  Depth below sea/water surface (cm)
   57  022001  Direction of waves
   58  022011  Period of waves
```

```
59  022021  Height of waves
60  022002  Direction of wind waves
61  022012  Period of wind waves
62  022022  Height of wind waves
63  022003  Direction of swell waves
64  022013  Period of swell waves
65  022023  Height of swell waves
66  022003  Direction of swell waves
67  022013  Period of swell waves
68  022023  Height of swell waves
69  020003  Present weather
70  004024  Time period or displacement
71  020004  Past weather (1)
72  020005  Past weather (2)
73  007032  Height of sensor above local ground (or deck of marine platform
74  004024  Time period or displacement
75  013011  Total precipitation/total water equivalent
76  004024  Time period or displacement
77  013011  Total precipitation/total water equivalent
78  007032  Height of sensor above local ground (or deck of marine platform
79  007033  Height of sensor above water surface
80  004024  Time period or displacement
81  004024  Time period or displacement
82  012111  Maximum temperature, at height and over period specified
83  004024  Time period or displacement
84  004024  Time period or displacement
85  012112  Minimum temperature, at height and over period specified
86  007032  Height of sensor above local ground (or deck of marine platform
87  007033  Height of sensor above water surface
88  002002  Type of instrumentation for wind measurement
89  008021  Time significance
90  004025  Time period or displacement
91  011001  Wind direction
92  011002  Wind speed
93  008021  Time significance
94  004025  Time period or displacement
95  011043  Maximum wind gust direction
96  011041  Maximum wind gust speed
97  004025  Time period or displacement
98  011043  Maximum wind gust direction
99  011041  Maximum wind gust speed
```

Appendix II: WMO BUFR DRFTING BUOY template 315009

```
DATA CATEGORY                          1
DATA SUB-CATEGORY                     25
LOCAL DATA SUB-CATEGORY               25

       DATA DESCRIPTORS (UNEXPANDED)

   1  315009


       DATA DESCRIPTORS (EXPANDED)

    1  001087  WMO marine observing platform extended identifier
    2  001019  Long station or site name
    3  002149  Type of data buoy
    4  008021  Time significance
    5  004001  Year
    6  004002  Month
    7  004003  Day
    8  004004  Hour
    9  004005  Minute
   10  005001  Latitude (high accuracy)
   11  006001  Longitude (high accuracy)
   12  001051  Platform transmitter ID number
   13  002148  Data collection and/or location system
   14  001012  Direction of motion of moving observing platform
   15  001014  Platform drift speed (high precision)
   16  033022  Quality of buoy satellite transmission
   17  033023  Quality of buoy location
   18  033027  Location quality class (range of radius of 66 % confidence)
   19  025026  Battery voltage (large range)
   20  002034  Drogue type
   21  022060  Lagrangian drifter drogue status
   22  007070  Drogue depth
   23  002190  Lagrangian drifter submergence (% time submerged)
   24  008021  Time significance
   25  004001  Year
   26  004002  Month
   27  004003  Day
   28  004004  Hour
   29  004005  Minute
   30  002005  Precision of temperature observation
   31  022043  Sea/water temperature
   32  002033  Method of salinity/depth measurement
   33  022059  Sea-surface salinity
   34  008029  Surface type
   35  013115  Ice thickness
   36  031000  Short delayed descriptor replication factor
   37  002005  Precision of temperature observation
   38  002032  Indicator for digitization
   39  002033  Method of salinity/depth measurement
   40  031001  Delayed descriptor replication factor
   41  007062  Depth below sea/water surface
   42  022043  Sea/water temperature
   43  022062  Salinity
   44  002005  Precision of temperature observation
   45  010004  Pressure
   46  010051  Pressure reduced to mean sea level
   47  031000  Short delayed descriptor replication factor
   48  031000  Short delayed descriptor replication factor
   49  002169  Anemometer type
   50  007033  Height of sensor above water surface
   51  008021  Time significance
   52  004025  Time period or displacement
   53  011001  Wind direction
   54  011002  Wind speed
   55  031000  Short delayed descriptor replication factor
```

Appendix III: WMO BUFR MOORED BUOY template 315008

```
DATA CATEGORY                          1
DATA SUB-CATEGORY                      0
LOCAL DATA SUB-CATEGORY               25
       DATA DESCRIPTORS (UNEXPANDED)

   1  315008


       DATA DESCRIPTORS (EXPANDED)

    1  001087  WMO marine observing platform extended identifier
    2  001015  Station or site name
    3  002149  Type of data buoy
    4  004001  Year
    5  004002  Month
    6  004003  Day
    7  004004  Hour
    8  004005  Minute
    9  005001  Latitude (high accuracy)
   10  006001  Longitude (high accuracy)
   11  010004  Pressure
   12  010051  Pressure reduced to mean sea level
   13  007033  Height of sensor above water surface
   14  012101  Temperature/air temperature
   15  012103  Dewpoint temperature
   16  013003  Relative humidity
   17  007033  Height of sensor above water surface
   18  008021  Time significance
   19  004025  Time period or displacement
   20  011001  Wind direction
   21  011002  Wind speed
   22  008021  Time significance
   23  004025  Time period or displacement
   24  011041  Maximum wind gust speed
   25  004025  Time period or displacement
   26  007033  Height of sensor above water surface
   27  002005  Precision of temperature observation
   28  007063  Depth below sea/water surface (cm)
   29  022049  Sea-surface temperature
   30  031000  Short delayed descriptor replication factor
   31  020001  Horizontal visibility
   32  004024  Time period or displacement
   33  013011  Total precipitation/total water equivalent
   34  031000  Short delayed descriptor replication factor
   35  004025  Time period or displacement
   36  014002  Long-wave radiation, integrated over period specified
   37  014004  Short-wave radiation, integrated over period specified
   38  014016  Net radiation, integrated over period specified
   39  014028  Global solar radiation (high accuracy), integrated over period
   40  014029  Diffuse solar radiation (high accuracy), integrated over period
   41  014030  Direct solar radiation (high accuracy), integrated over period
   42  031000  Short delayed descriptor replication factor
   43  031000  Short delayed descriptor replication factor
   44  031000  Short delayed descriptor replication factor
   45  031000  Short delayed descriptor replication factor
   46  002005  Precision of temperature observation
   47  002032  Indicator for digitization
   48  002033  Method of salinity/depth measurement
   49  031001  Delayed descriptor replication factor
   50  007062  Depth below sea/water surface
   51  022043  Sea/water temperature
   52  022062  Salinity
   53  007062  Depth below sea/water surface
   54  022043  Sea/water temperature
   55  022062  Salinity
   56  007062  Depth below sea/water surface
   57  022043  Sea/water temperature
   58  022062  Salinity
   59  007062  Depth below sea/water surface
```

```
60  022043  Sea/water temperature
61  022062  Salinity
62  007062  Depth below sea/water surface
63  022043  Sea/water temperature
64  022062  Salinity
65  007062  Depth below sea/water surface
66  022043  Sea/water temperature
67  022062  Salinity
68  007062  Depth below sea/water surface
69  022043  Sea/water temperature
70  022062  Salinity
71  007062  Depth below sea/water surface
72  022043  Sea/water temperature
73  022062  Salinity
74  007062  Depth below sea/water surface
75  022043  Sea/water temperature
76  022062  Salinity
77  007062  Depth below sea/water surface
78  022043  Sea/water temperature
79  022062  Salinity
80  007062  Depth below sea/water surface
81  022043  Sea/water temperature
82  022062  Salinity
83  007062  Depth below sea/water surface
84  022043  Sea/water temperature
85  022062  Salinity
86  007062  Depth below sea/water surface
87  022043  Sea/water temperature
88  022062  Salinity
89  031000  Short delayed descriptor replication factor
```

Appendix IV:

Table A.1 – BUFR SHIP records characterization, according to the originating center, arriving to GTS/IPMA

Disseminating center	Bulletin name	Number of subsets	Unexpanded (sequence) descriptors	Notes
BIRK	ISSA01BIRKddhh00	1	301093 302001 302054 008002 302055 302057 302060	3 different bulletins. No amends, no corrections, no retards. Hourly; 3-hour and 6-hour bulletins.
	ISSA11BIRKddhh00	10	301093 302001 302054 008002 302055 302057 302060	
	ISSA21BIRKddhh00	9	301093 302001 302054 008002 302055 302057 302060	
EGRR	ISSA01EGRRddhh00	9	308009	25 different bulletins. No amends, no corrections, no retards. Hourly bulletins, among others.
	ISSA11EGRRddhh00	25	308009	
	ISSA16EGRRddhh00	8	308009	
	ISSB01EGRRddhh00			
	ISSB16EGRRddhh00			
	ISSC01EGRRddhh00			
	ISSC11EGRRddhh00			
	ISSC16EGRRddhh00			
	ISSD01EGRRddhh00			
	ISSD11EGRRddhh00			
	ISSD16EGRRddhh00			
	ISSE01EGRRddhh00			
	ISSE16EGRRddhh00			
	ISSF01EGRRddhh00			
	ISSG01EGRRddhh00			
	ISSG16EGRRddhh00			
	ISSI01EGRRddhh00			
	ISSI16EGRRddhh00			
	ISSJ01EGRRddhh00			
	ISSJ16EGRRddhh00			
	ISSK16EGRRddhh00			
	ISSL01EGRRddhh00			
	ISSL01EGRRddhh00			
	ISSL16EGRRddhh00			
EIDB	ISSA01EIDBddhhh00	1	308009	3 different bulletins. No amends, no corrections, no retards. Hourly bulletins, among others.
	ISSA22EIDBddhhh00	1	308009	
LFPW	ISSA01LFPW			

	ISSA02LFPW	2	308009	
	ISSA04LFPW	1	308009	
	ISSA05LFPW	11	308009	
	ISSB04LFPW			
	ISSC01LFPW			
	ISSC04LFPW			
	ISSD01LFPW			
	ISSD02LFPW			
	ISSD03LFPW			
	ISSD04LFPW			
	ISSD05LFPW			
	ISSE01LFPW			
	ISSE02LFPW			
	ISSE03LFPW			
	ISSE04LFPW			
	ISSE05LFPW			
	ISSF01LFPW			
	ISSF03LFPW			
	ISSF04LFPW			
	ISSG01LFPW			
	ISSG02LFPW			
	ISSG03LFPW			
	ISSG04LFPW			
	ISSG05LFPW			
	ISSH01LFPW			
	ISSH02LFPW			
	ISSH03LFPW			
	ISSH04LFPW			
	ISSI04LFPW			
	ISSJ01LFPW			
	ISSK03LFPW			
	ISSL02LFPW			
	ISSL03LFPW			
PANC	ISSA01PANC	1	308009	
	ISSB01PANC			
	ISSC01PANC			
	ISSD01PANC			
	ISSE01PANC			
	ISSH01PANC			
	ISSI01PANC			
	ISSK01PANC			
	ISSL01PANC			
	ISSN01PANC	5	308009	
	ISSS01PANC			
VHHH	ISSA01VHHH	1	308009	
	ISSB01VHHH			
	ISSC01VHHH			

	ISSX01VHHH	1	308009	
KWBC	ISSA90KWBC	1	308009	
	ISSB90KWBC			
	ISSC90KWBC			
	ISSD90KWBC			
	ISSG90KWBC			
	ISSH90KWBC			
	ISSK90KWBC			
	ISSL90KWBC			
	ISSN90KWBC	6	308009	
	ISSS90KWBC			
RJTD	ISSB02RJTD	1	301093 302001 302054 008002 302055 302057 302060	
	ISSC01RJTD	1	301093 302001 302054 008002 302055 302057 302060	
	ISSD02RJTD	1	301093 302001 302054 008002 302055 302057 302060	
ENMI	ISSD01ENMI	1	308009 004025 011042	4 bulletins found. No amends; corrections and retards found. Hourly bulletins.
	ISSD02ENMI	2	308009 004025 011042	
	ISSD03ENMI	1	001001 001002 308009 004025 011042	
	ISSD04ENMI	1	001001 001002 308009 004025 011042	
NZKL	ISSS01NZKL	2	301093 302001 302054 008002 302055 302057 302060	
	ISSS03NZKL	1	301093 302001 302054 008002 302055 302057 302060	
RKSL	ISSX01RKSL	8	308009	

	ISSX02RKSL	5	308009	
ESWI	ISSA01ESWIddhh00			12 different bulletins. No amends; corrections and retards (up to RRJ) found. Hourly bulletins, among others. Most of original bulletins were empty; just the retards had some info.
	ISSB01ESWIddhh00			
	ISSC01ESWIddhh00			
	ISSD01ESWIddhh00	25	308009	
	ISSE01ESWIddhh00			
	ISSF01ESWIddhh00			
	ISSG01ESWIddhh00			
	ISSH01ESWIddhh00			
	ISSI01ESWIddhh00			
	ISSJ01ESWIddhh00			
	ISSK01ESWIddhh00			
	ISSL01ESWIddhh00			