WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

OPAG ON INFORMATION SYSTEMS AND SERVICES

MEETING OF THE EXPERT TEAM ON DATA REPRESENTATION AND CODES

FINAL REPORT

ARUSHA, 17-21 FEBRUARY 2003

EXECUTIVE SUMMARY

The Meeting of the Expert Team on Data Representation and Codes (ET/DR&C) was held, at the kind invitation of the United Republic of Tanzania, in Arusha, from 17 to 21 February 2003.

The Team reviewed the status of validation tests for the new FM 92 GRIB Edition 2 encoding/decoding. Further validation tests and experimental exchanges were recommended for some templates: PDT 4.10 and 4.14, GDT 3.1000/1100/1200 and PDT 4.1000/1001/1002/1100/1101. The Team proposed, for experimental testing, the addition of two new compression schemes based on JPEG 2000 and PNG. Clarifications of regulations for scaling, use of local Tables and local Templates, and for spatial differencing were developed. The guide for GRIB Edition 2 was finalized.

Several Centres reported on experimental and operational exchanges of fields in GRIB2. Japan Meteorological Agency (JMA) had a separate GRIB2 encoder for specific generated products and a decoder for limited products. Provision of three and six month ensemble forecast products in GRIB2 should start next autumn for national and international users; new products in field form would be considered in GRIB Edition 2. NCEP has both a Fortran 90 and C version of an encoder/decoder. An experimental project (called National Digital Forecast Database) managed by NWS/TDL made use of GRIB2. ECMWF should start migration to GRIB2 and provide EPS probabilities on the GTS in 2003. A decoder will be available to decode these products. EUMETSAT is generating Cloud mask products in GRIB2. Satellite images will also be available in GRIB2. A decoder for this type of data is available to users upon request. It is still to be included in the PUMA work-station.

The Team agreed to define a new Common Code Table C-12 for recording Sub-Centre entries linked to originating Centres. The Team agreed that recording of Sub-Centres in the WMO Manual should be a recommended practice, and recommended also the allocation of entries in Table C-11 for all non-listed NMCs, RSMCs, RTH, etc.

The Team discussed, finalized and recommended additions of descriptors to BUFR Tables. Descriptors with pre-operational status were recommended for oceanographic data and for new satellite data, including ENVISAT and AIRS satellites. A proposal to encode in BUFR all SIGMET data (to be validated), including description in 3-D of meteorological features, was finalized. The Team also recognized the possible usefulness of a separate Master Table for satellite data to help managing the continuously increasing number of related descriptors. A proposal will be coordinated by EUMETSAT for the next meeting of the ET/DR&C.

The recommended BUFR templates for transmission of traditional observations were revisited by the Team. For PILOT and TEMP data, it was agreed to indicate by a note that the first time corresponds to the nominal time of observation, and to indicate that the first latitude and longitude are those of the launching site. Time increment in seconds and increments of high accuracy latitude and longitude will be reported at each level. These additions will satisfy requirements of high resolution modeling. In the BUFR/ CREX template for SYNOP and SYNOP MOBIL data, it was agreed to qualify the descriptor 0 20 014 as “height of top of the clouds above mean sea level” and to express the significant cloud layers using delayed replication.

The Team considered the impact that a change to a new edition in November 2005 might have on the migration process. The Team agreed to debate on this issue during the coming year to reach a final decision at its next meeting.

The Team noted that new experimental or operational exchange of new BUFR data was taking place. Experimental transmission of Buoy, BATHY and TESAC data by Service Argos in BUFR should start during 2003. JMA is planning to disseminate SHIP data in BUFR, and is already disseminating wind profiler data in BUFR. Météo-France will soon disseminate JASON 1 satellite data in BUFR. Within the EUMETNET PWS-GTS project, CHMI (Czech Republic), KNMI (Netherlands) and SHMI (Slovakia) are disseminating AWS observations in BUFR. DWD (Germany) will start in July 2003. As part of its EARS (EUMETSAT ATOVS Retransmission Service) project, EUMETSAT encodes in BUFR the level 1c ATOVS data.

In order to correct a weakness in the text of some regulations, the Team agreed to clearly specify, in code forms FM 71, FM 72, FM 73, FM 75, FM 76, FM 81, FM 82 and FM 83 that, when several reports

are included in a bulletin then each report inside the bulletin does not need to have the code name and MMJJJ indicated.

The Team proposed a potential list of keynote lecturers and defined a programme for a workshop on use of XML in meteorology.

To facilitate the implementation of new descriptors in Code Tables, the Team recommended that the Secretariat create a MS-Word merged file of all Table B and Table D entries, with an indicator attached to each entry: version number, or pre-operational or for validation. Another file in ASCII format for direct computer program processing will be created with the help of a data processing centre.

The Team agreed that samples of BUFR and CREX Templates will be placed in an Attachment to the Manual, and should include links to the general reporting practices. Appropriate common sequences may be generated as required. The Team recommended this activity to be performed under the responsibility of the WMO Secretariat. A consultant might be hired for a few weeks to finalize the task. The new Annex on reporting practices and the Templates, once finalized, will have to be reviewed by appropriate Teams of CBS.

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REPORT OF THE MEETING OF THE EXPERT TEAM ON DATA REPRESENTATION AND CODES
(Arusha, 17-21 February 2003)

1. ORGANIZATION OF THE MEETING

1.1 OPENING OF THE MEETING

1.1.1 At the kind invitation of the United Republic of Tanzania, the Meeting of the Expert Team on Data Representation and Codes (ET/DR&C) took place at Mount Meru Hotel in Arusha from 17 to 21 February 2003 (the participants' list can be found in the Annex to this paragraph). The Meeting was opened on Monday 17 February at 9.30 a.m. by Mr Mohamed Matitu, Manager of International Relations in Tanzania Meteorological Agency (TMA). Mr Matitu welcomed the Experts and recalled the importance of the work of the Team. He stressed that it was the first time this Expert Team meets in a developing country. It was an hopeful sign for the WMO strategy to share the advanced knowledge and technology with developing countries, especially the African countries. Mr Matitu wished to all Experts a good stay in Tanzania.

1.1.2 The representative of the WMO Secretariat thanked Tanzania for hosting the meeting. He thanked Tanzania Meteorological Agency for providing excellent hospitality and facilities and having work hard for the organisation and logistic of the meeting. He thanked especially the local organisers from TMA, Mr Matitu and Mr Scylla Sillayo (member of the Expert Team) and all the other staff involved, for their good work. The Team had several challenging tasks on the agenda, in particular: further refine GRIB 2 Tables and Templates, finalize the GRIB 2 Guide, consider the need for a new edition of BUFR and plan a workshop on XML, in additions to the usual examination of the set of requests for additions to the Codes Tables.

1.1.3 Mr Jean Clochard, Chairman of the Team, after having thanked Tanzania, welcomed the participants. He then led the Team with diplomacy and efficiency.

1.2 APPROVAL OF THE AGENDA

The Team agreed to the content of the agenda as proposed (see Table of Contents in front).

2. GRIB 2 CODE FORM

2.1 STATUS AND COORDINATION OF FINAL VALIDATION TESTS FOR GRIB 2 ENCODING/DECODING

2.1.1 Templates referred in the Code Manual as "not validated" were revisited. In 2001 and 2002, several new templates were defined at ET/DR&C level, and some also were fixed. What follows is a result of a recent survey which included answers received from NCEP, ECMWF, JMA and UKMO.

2.1.1.1 EPS related templates

- Product Definition Templates 4.9, 4.11, 4.12 and 4.13 were cross-validated between NCEP, ECMWF and JMA.
- PDT 4.10 and 4.14: no validation work was performed.
- PDT 4.3 and 4.4 were fixed in 2002 (addition of missing information describing properties of the cluster) but it is not certain that existing encoding/decoding packages have been adjusted accordingly, except at USA/NDFD.

2.1.1.2 Templates for support of non-horizontal grids

These templates were designed in 2001 to handle cross sections, time sections and Hovmöller-type

diagrams. Up to now, only NCEP (USA) has implemented these templates.

2.1.2 Proposal

The Team recommended as an editorial change to remove the preliminary note in the Manual attached to Template 4.9 since this Template is now validated. The Team urged Centres to validate PDT 4.10 and 4.14 in order to get more results/work on these templates. The Team reminded concerned Centres that PDT 4.3 and 4.4 have changed.

2.2 VALIDATION OF SPECIAL TEMPLATES FOR THE TRANSMISSION IN GRIB 2 OF CROSS-SECTIONS AND HOVMÖLLER TYPE DIAGRAMS

The Team asked that at least a second Centre implement GDT 3.1000/1100/1200 and PDT 4.1000/1001/1002/1100/1101 to enable cross-validation, and look for assessment from users who have an interest in these templates.

2.3 ADDITION OF NEW COMPRESSION SCHEMES

2.3.1 GRIB2 was designed to be extensible and is now capable of storing satellite and radar data, which are inherently images and thus may benefit from being encoded into a standard graphic format. In addition, numerical model data can also be effectively encoded with an image-encoding algorithm since, after the model gridpoint data is scaled to retain the desired precision and the minimum value is subtracted out, the resulting grid can be thought of and processed as a grayscale image.

2.3.2 Throughout the past many years, much research and development has been conducted regarding image compression and standardization of graphic formats, so it seems as though it should be possible to take advantage of these results for incorporation as new compression techniques within GRIB2. Two prominent standards are supported by the International Organization for Standardization (ISO) and the NCEP (USA) proposed to the Team methodologies by which they might be incorporated for use in GRIB2. These two standards are JPEG 2000 (http://www.jpeg.org/JPEG2000.html) and PNG (http://www.libpng.org/pub/png), and they were chosen not only because of their inclusion in ISO/IEC international standards, but also because of their demonstrated effectiveness on sample data as well as their intent to be license and royalty free. This last point is currently the subject of some further investigation, as obviously it will be necessary to adhere to any requirements that may be imposed by ISO or other scientific bodies in exchange for being allowed to make use of their work in the creation of new templates for GRIB2. The current understanding is that such requirements would likely be limited to the inclusion of footnotes and/or certain disclaimers within any such GRIB2 templates.

2.3.3 NCEP indicated that several simulations had already been run comparing the JPEG 2000 (with lossless compression) and PNG compression algorithms against the current GRIB2 packing methods. The tests were run on various output fields from the NCEP 12km ETA model, and the results showed an impressive savings of storage space when using the two new methods, albeit at the expense of additional system processing time that was, in most cases, quite significant.

2.3.4 The following two standards were considered by the Team.

2.3.4.1 JPEG 2000

The JPEG 2000 image coding system uses wavelet transforms and subsequent arithmetic coding to encode an image. The compressed image is stored in the code stream syntax described in Part 1 of the standard (ISO/IEC 15444-1:2000). The JPEG 2000 standard contains both lossless and lossy compression algorithms allowing users the option of specifying an increased compression rate in exchange for some noise in the data.

2.3.4.2 Portable Network Graphics (PNG)

The PNG encoding algorithm applies one of several invertible filters to each scanline of an image, and then subsequent compression is obtained using the zlib (http://www.gzip.org/zlib/zlib.html) deflate

algorithm. The PNG specification is currently under consideration by ISO/IEC JTC 1/SC24. PNG image compression is lossless.

2.3.5 The team agreed that the two templates listed in Annex to this paragraph be used for validation and experimental testing.

2.4 OTHER ADDITIONS OR MODIFICATIONS TO GRIB EDITION 2

2.4.1 New regulation related to scaling

2.4.1.1 Within GRIB edition 2, some entities in sections 3 (Grid Description Section) and 4 (Product Description Section) are documented in a scaled way. A typical example may be given by the value associated to a vertical level. This was defined to avoid use of decimal shifted units; and also to avoid floating-point descriptors, which may lead to ambiguities. The description of these entities is a pair of descriptors: a scaled factor (on a single octet), and a scaled value (on four octets); however, it is not indicated in the Manual how to use it precisely. There is still an ambiguity on the sign convention for this factor.

2.4.1.2 The Team therefore agreed to add a new general regulation (considered as editorial change since it only adds a clarification) as listed in Annex to this paragraph.

2.4.2 Albers equal-area projection in GRIB2

In GRIB edition 2 Manual, the Code Table 3.1 (Grid Definition Template Number) exhibits for code entry 30 (Lambert conformal) a note stating that it is “also called Albers equal-area”. As mentioned by a user from USA (from the geographical community) the note referred to was clearly erroneous. Lambert conformal projection preserves angles, whilst Albers’s preserves areas; such properties may not be reached at the same time, except for very simple transformations. The confusion came from the fact that these projections share the same descriptors list. The Team then agreed to:

- remove the wrong note for entry 30 in Code Table 3.1
- add a new entry 31 in Code Table 3.1, called “Albers equal-area”
- Introduce a new template 3.31
- submit these changes as listed in Annex to this paragraph for pre-operational implementation.

2.4.3 Need for a Note on use of Local Tables or Templates in GRIB Edition 2.

Following a request from Japan, the Team agreed to add a Note clarifying the use of Local Tables or Templates in GRIB Edition 2 (see Annex to this paragraph).

2.4.4 Addition of note to DRT 5.2 and 5.3

The Team agreed that to avoid misunderstanding such as raised in the GRIB2 guide for spatial differencing, a note should be added to these templates (see Annex to this paragraph).

2.5 REPORT ON EXPERIMENTAL AND OPERATIONAL EXCHANGES OF FIELDS IN GRIB2

NCEP has both a Fortran 90 and C version of an encoder/decoder. An experimental project (called National Digital Forecast Database) managed by NWS/TDL makes use of GRIB2, with a participation from NCEP.

ECMWF should start migration to GRIB2 and provide EPS probabilities on the GTS in 2003. A decoder will be available to decode these products.

JMA has separate encoder for specific generated products and decoder for limited products, and an extra package will be developed for domestic use of products of very short range forecast on precipitation. Provision of 3 and 6 months ensemble forecast products should start next autumn for national and international users. New products in field form would be considered in GRIB edition 2.

EUMETSAT is generating Cloud mask products in GRIB2. Satellite images will also be available in GRIB 2. A decoder for this type of data is available to user at request. It is still to be included in the PUMA work-station.

3. BUFR AND CREX

3.1 ADDITIONS FOR SATELLITE DATA

3.1.1 ENVISAT data

In March 2002, ENVISAT satellite was successfully launched by ESA. ENVISAT is now completing its commissioning phase. The satellite carries a number of instruments among which ASAR, MERIS, AATSR, RA-2, GOMOS, MIPAS and SCIAMACHY are of meteorological interest. ECMWF developed software to extract ENVISAT PDS data and create BUFR data containing subset information available in the original data set. At the same time some evaluation of SCIAMACHY, MIPAS, GOMOS and ASAR data has been done at ECMWF. The Team agreed to the corresponding additions in BUFR Tables as listed in Annex to this paragraph and urged centres concerned to finalize validation of these entries, in order to declare them pre-operational since the data are already available for exchange.

3.1.2 Other Satellite data

3.1.2.1 Additional entries for AIRS satellite data in BUFR

During the past couple of years, much work has been done to represent and exchange AIRS satellite data in BUFR. In order to assist in this effort, a Table B descriptor was proposed last year as “ALLOCATED ENTRIES (AWAITING VALIDATION)”. Since then, and using the sequences described below (although not the actual Table D numbers), successful data exchange had taken place between centers in the U.S.A., Canada, and Europe (among others), and the usefulness of the below descriptors has been demonstrated. Therefore, the Team now requested that the descriptors as listed in Annex to this paragraph be approved for “PRE-OPERATIONAL” status.

3.1.2.2 Other additional entries for satellite data in BUFR

The Team agreed to a request by NCEP USA for new BUFR table entries for use with certain types of satellite data. Some entries (see Annex to this paragraph) are ready for “PRE-OPERATIONAL” status, while others are requested only as “ALLOCATED ENTRIES (AWAITING VALIDATION)”.

3.2 UPDATED PROPOSAL FOR ENCODING SIGMETS IN BUFR

3.2.1 Following an original joint proposal presented by the representatives from Australia and ICAO for the encoding of volcanic ash SIGMET messages in BUFR, the U.S. National Weather Service's Aviation Weather Center proceeded to expand the proposal to include a methodology for the encoding of all types of SIGMET messages, including those for tropical cyclones, turbulence, icing, etc. However, one major issue still remained to be decided, and that was the issue of whether to allow for the ability to define volumes of any shape as a SIGMET target region, versus only being able to define volume regions which, when viewed from above, have sides that are always perpendicular to the ground between two 0-07-010 flight levels (i.e. base and top). In other words, it might be useful to be able to use the code figure "3" within 0-08-007 and thereby define a sequence of points describing 3-D volume. The current ICAO Annex 3 regulations do not allow for such odd-shaped objects; however, the US Aviation Weather Center has the intention to soon make such a proposal to ICAO, so it is useful to allow for this possibility now rather than to create some new descriptors and sequences that may soon become obsolete.

3.2.2 The proposal of the Team (see Annex to this paragraph) was simpler but retained the ability to define volumes of any reasonable shape as a SIGMET target region. This approach allowed for the specification of volumes defined by a sequence of horizontal sections on flight levels. The Team felt that the overall proposal was ready to be validated, and requested members of the ET/DR&C, and also the UK Met Office as a WAFS center, to assist the US Aviation Weather Center personnel in this task through the generation and exchange of various test messages encoded according to the specifications of this proposal.

3.3 NEW ORIGINATING CENTRES AND SUB-CENTRES

Following a request from USA to add a list of Sub-Centres to US NWS, NCEP, the Team agreed to define a new Common Code Table C-12 for recording Sub-Centres entries linked to originating centres (see Annex to this paragraph). This table being just a new way of presenting information will be considered as additional entries and can be included in the next supplement to the Manual (pre-operational). However, the Team raised the question of mandatory reporting and recording of Sub-Centres in the WMO Manual. The Team agreed that it should be a recommended practice and agreed to add a note to Table C-12 saying that Sub-centres should be recorded in the Manual on Codes and that entries should be given to the WMO secretariat. The Meeting recommended also the allocation of entries in Table C-11 for all non-listed NMCs, RSMCs, RTH, etc.. according to English alphabetical order.

3.4 OTHER ADDITIONS TO BUFR/CREX

3.4.1 Additions for oceanographic data

The Team approved a set of new BUFR descriptors requested by the Data Buoy Cooperation Panel (DBCP) for buoy data in BUFR and by the Ship Of Opportunity Programme (SOOP) to transmit XBT data. The proposed additions to code tables would need validation, except the new entries for Common Code tables which can be seen as pre-operational. The additions can be found in Annex to this paragraph.

3.4.2 BUFR regulations: Points which require clarification

Six proposals to amend some notes and regulations were submitted by Chris Long from UKMO. These additions were examined by the Team who approved the first one as listed in Annex to this paragraph. This change should be considered as editorial since it simply adds clarification to the existing regulation. However, for the five other amendments the Team considered they deserved further studies in relation to the current practices.

3.4.3 Identification of ship's movement in the BUFR template for SHIP data

The Team considered a proposal from Eva Cervena following a request from the Royal Netherlands Meteorological Institute (KNMI) to qualify or rename the descriptors for Direction of motion of moving observing platform and for Speed of motion of moving observing platform. KNMI intends to produce messages not only in the SHIP code, but also in BUFR. It was noted that in the SHIP code:

Ships' movement in the SHIP code is expressed by $\mathbf{D_s v_s}$, where

$\mathbf{D_s}$ = True direction of resultant displacement of the ship during the three hours preceding the time of observation,
$\mathbf{v_s}$ = Ship's average speed made good during the three hours preceding the time of observation.

In the BUFR template for SHIP data, however, $\mathbf{D_s}$ and $\mathbf{v_s}$ are represented by descriptors 0 01 012 and 0 01 013, respectively:

0 01 012	Direction of motion of moving observing platform	Degree true
0 01 013	Speed of motion of moving observing platform	m s^{-1}

The current element names of both 0 01 012 and 0 01 013 suggest "instantaneous" character of the element, which might cause misunderstanding when encoding ship data. The Team agreed to keep the existing names in Table B, but add an appropriate note in the SHIP BUFR template and a note in Table B indicating the parameter may have different meanings (see Annex to this paragraph). These additions will be considered as editorial.

3.4.4 BUFR Templates for PILOT and TEMP data with identification of radiosonde drift

The BUFR templates for PILOT and TEMP data were revisited by the Team at the request of Eva Cervena. It was agreed to Indicate by a note that the first time is the nominal time of observation. It was also agreed to indicate that the first latitude and longitude were those of launching site. Then time increment in seconds and increments of high accuracy latitude and longitude will be reported at each level. These additions will satisfy requirements of high resolution modeling (see Annex to this paragraph)

3.4.5 BUFR/CREX template for SYNOP and SYNOP MOBIL data

The BUFR/CREX template for SYNOP and SYNOP MOBIL data were revisited by the Team at the request of Eva Cervena. It was agreed to qualify the descriptor 0 20 014 as “height of top of the clouds above mean sea level”, add two entries to Code Table 0 08 002 and to express the significant cloud layers using delayed replication (see Annex to this paragraph).

3.5 ADDITIONS RELATED TO A NEW EDITION OF BUFR

3.5.1 Representation of probabilities and other forecast values

The Team considered that the requirements expressed in the previous Meeting of the Expert Team in 2002 in Prague for representation of probabilities and other forecast values were still valid and remained part of a set of additions necessary in a new edition of BUFR.

3.5.2 New operators

The Team considered that the requirements expressed in the previous Meeting of the Expert Team in 2002 in Prague for new operators were still valid and remained part of a set of additions necessary in a new edition of BUFR.

3.5.3 Data category and sub-category definitions

The Team agreed to satisfy the requirement for official definition of data sub-category in BUFR. However, it was agreed that existing local sub-categories should remain available since they were used by many data processing centers. It was recommended that in the frame of new edition changes, a new two-octet field be defined to contain the official international sub-category. The new table could be structured in a manner similar to the Common Table C-12 for sub-centres. The Team wished that the Secretariat, assisted by member(s) of the Team, define an exhaustive list of known data sub-categories for submission to the Meeting next year.

3.5.4 Full date in BUFR

Following the problems encountered during the Y2K transition, the Team agreed to modify the system of reporting dates in BUFR, using the opportunity of the new edition. The proposed format for the new BUFR Edition 4 is to follow the system adopted for GRIB Edition 2 (as listed in Annex to this paragraph). The Team recommended however that a significance for the date recorded in Section 1 was a possibility (similar to what is done in GRIB Edition 2), whose real necessity and content should be studied before finalising the proposals for BUFR next edition.

3.5.5 Other addition with a new edition

The Team agreed to change the regulation which make mandatory the padding of even number of octets, to a padding to a full octet (see Annex to this paragraph). The Team also recognized the possible usefulness of a separate Master Table for satellite data to help managing the continually increasing number of related descriptors. A proposal will be coordinated by EUMETSAT for the next meeting of the ET/DR&C.

3.6 IMPLICATIONS OF A NEW EDITION OF BUFR

The Team considered the impact that a change to a new edition in November 2005, might have on the migration process. The Team considered that few changes would be required in a BUFR decoder or encoder, and that it ought not delay migration, especially if the software houses were performing well, being confident that the updating of decoders for BUFR data should not slow or hamper the migration process.. However, the decoder will have to be re-installed and that could be a difficulty for the remote countries. The alternative could be to postpone this new edition 4 to 2007, or to implement it in part with only the new operators which could affect only the specific data types using these features. The Team agreed to debate on this issue during the coming year to reach a final decision at its next Meeting.

3.7 IMPLEMENTATION OF EXPERIMENTAL EXCHANGES OF OBSERVATIONS IN BUFR (OR CREX)

3.7.1 The Meeting was pleased to note that experimental transmission of Buoy data by Service Argos in BUFR should start during 2003. A test period was expected to last for a couple of months or more depending upon results from the tests. Meteorological centres interested to participate in the tests are invited to contact the Technical Coordinator of the DBCP, Mr. Etienne Charpentier (charpentier@jcommops.org). After the test period, operational distribution of buoy data in BUFR will start for those buoys reporting via Argos and which data are processed at the US Argos Global Processing Centre of Largo, USA (KARS), and at the French Argos Global Processing Centre of Toulouse, France (LFPW). Parallel distribution of buoy data in BUOY code will continue for an

undefined period from these centres.

3.7.2 A limited number of ships are transmitting their XBT data via Argos (less than 20 ships). As Service Argos is developing BUFR encoding capability for buoy data, such capability might be used for GTS distribution of XBT data from those ships as well. In that case, as for the buoy data, and for an undefined period, data should be distributed in both BUFR and BATHY code forms.

3.7.3 Most of the profiling floats are presently reporting via Argos. As Service Argos is developing BUFR encoding capability for buoy data, such capability might be used for GTS distribution of profiling float data as well (as early as mid-2003). In that case, as for the buoy data, and for an undefined period, data should be distributed in both BUFR and TESAC code forms. Before a coordinated approach can be proposed, decision to go to BUFR will be made by individual float operators.

3.7.4 Japan Meteorological Agency is planning to disseminate SHIP data in BUFR, and it is already disseminating wind profiler data in BUFR.

3.7.5 Météo-France will soon disseminate JASON 1 satellite data in BUFR.

3.7.6 Within the EUMETNET PWS-GTS project, CHMI (Czech Republic), KNMI (Netherlands) and SHMI (Slovakia) are disseminating AWS observations in BUFR. DWD (Germany) will start in July 2003.

3.7.7 As part of its EARS (EUMETSAT ATOVS Retransmission Service) project, EUMETSAT operates a network of local receiving stations across the North Atlantic region for data from the NOAA spacecraft. The data are processed at these stations and the level 1c ATOVS data are then encoded in BUFR at EUMETSAT's headquarters prior to insertion onto the GTS at RTH Offenbach. The timeliness of these data (less than 30 minutes from satellite over pass to RTH Offenbach) makes them very valuable for NWP centres operating with a short cut-off time. More details of EARS are available from the web site, http://www.eumetsat.de.

4. MODIFICATIONS TO TRADITIONAL ALPHANUMERIC CODES

4.1 MODIFICATIONS TO AERONAUTICAL CODES

CBS Ext. (02) approved only Amendment 72 to Annex 3, because Amendment 73 was still subject to examination by ICAO Member States. The ICAO representative had indicated that a document will be submitted at the next Meeting of the Team.

4.2 HARMONIZATION OF REGULATION FOR REPORT HEADER

A weakness in the text of some regulations had been noted by Dr John Hodkinson from UKMO. In the regulations for FM 75 CLIMAT, one can read in:

75.1 "The code name CLIMAT TEMP or CLIMAT TEMP SHIP and the group MMJJ shall appear as a prefix to individual reports."

and in:

75.2 "... Individual reports in the bulletin shall contain neither the code names nor the code group MMJJ."

The Team agreed that these regulations need clarification. It is understood that when a report is standing alone, then reg. 75.1 applies. When several reports are in a bulletin, then each report inside the bulletin does not need to have the code name and MMJJJ indicated. The same problem can be

found in other code forms: FM 71, FM 72, FM 73, FM 76, FM 81, FM 82 and FM 83. It was probably an old formulation, which had been kept through the ages, and it was not well expressed. The Team recommended to modify all the regulations xx.1, saying: "…prefix to an individual report." and the regulations xx.2 saying: "In this case, individual reports in the bulletin shall contain neither ...." and apply that to all the code forms concerned. It should be considered as an editorial correction.

5. FINALISING GUIDE TO GRIB EDITION 2

The Team agreed to small additions in the Guide to GRIB Edition 2 to finalize the excellent work performed by Dr Cliff Dey. (see Annex to this paragraph)

6. WORKSHOP ON USE OF XML AND DEFINITION OF METEOROLOGICAL OBJECTS IN XML

6.1 DEFINITION OF METEOROLOGICAL OBJECTS IN XML

The Team examined a proposal submitted by a Sub-group of EGOWS (European Group on Operational Worskstation Systems) on Meteorological Objects. The Team agreed that there should be a tight coupling with BUFR. It recognized that BUFR Tables would have to be updated to include these objects. The Meeting agreed to introduce progressively these objects into BUFR Tables when requirements are expressed and clearly defined. The Meeting found that the list of meteorological objects needed further revision.

6.2 ORGANISATION OF AN XML WORKSHOP

6.2.1 XML (eXtensible Markup Language) is becoming increasingly important in the exchange of data and it is desirable for WMO to develop standards for the use of XML in meteorology. The Expert Team on Data Representation and Codes did not believe that it had the necessary expertise to develop these standards and suggests that a workshop be held to start the process of developing meteorological XML standards. Participants in the workshop should be either XML specialists or meteorological experts with experience in XML. Organisations who have experience in representing or exchanging meteorological data in XML should be encouraged to send representatives.

6.2.2 Some organisations believed to have relevant XML expertise include:

- The Russian Federal service for Hydrometeorology and Environment monitoring, who have very extensive XML experience.
- The US Navy, with Observational Markup Format (OMF) and other XML initiatives, some in conjunction with other branches of the US armed services
- The WMO Expert Team on Integrated Data Management (ET/IDM)
- The European working Group on Operational Workstation Systems (EGOWS)
- The Canadian Marine Environmental Data Service (MEDS)
- The UK MetOffice
- The Meteorological Systems (formerly Regional Computing) section of the Australian Bureau of Meteorology, who have developed several XML based data formats

Active participation should also be sought from any other organisations that have relevant expertise or experience.

6.2.3 An agenda for such a workshop could include:

1. Review the current usage of XML in meteorology.
2. Examine existing XML standards and decide if they are suitable for use in meteorology or can be adapted to be suitable.

3. Suggest standards for the representation and exchange of meteorological data in XML, preferably in a language independent form.
4. Suggest standards for the use of XML technology to permit the automated translation of meteorological data from a language independent standard (as defined by agenda item 2) to an end user's language. Values from code and flag tables, unit names, element names and other information would be translated to the user's preferred language while retaining the XML structure of the data.

7. MANUAL ON CODES

7.1 IMPLEMENTATION OF THE PROCEDURES FOR MODIFICATIONS TO CODE TABLES

7.1.1 The Team took note of the difficulty with the present system of Code Tables updating and maintenance. In the WMO Web server are:

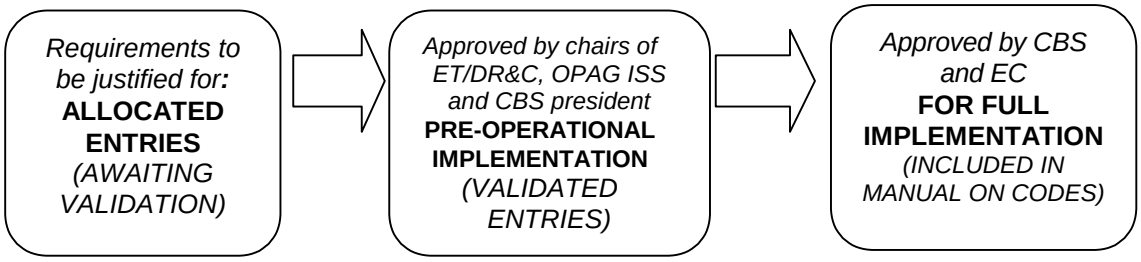
- The operational Tables (extract from the Manual on Codes)
- The Tables of pre-operational entries, notes and regulations
- The Table entries, notes and regulations awaiting validation.

All this information is kept in Word 97 files. The last two files contain the information sorted by application requests and not by table entry number. It is difficult to find if an entry has been already attributed or not with the present system. It is also difficult to convert these files into information that a computer program (decoder/encoder) can process. In order to overcome those difficulties, the Team recommended that the Secretariat create a Word merged file of all Table B and Table D entries, with an indicator attached to each entry: version number, or pre-operational or for validation. Another file in ASCII format for direct computer program processing will be made, based on the word file, perhaps with the help of a data processing centre. Such an ASCII file would help updating tables in BUFR packages. Both new files will be kept in the WMO server.

7.1.2 In order to facilitate the processing of requests for allocation of new table entries by the Secretariat, the Team agreed to recommend a standard format for definition of new descriptors as defined in Annex to this paragraph.

7.1.3 The Team recommended also that entries to all Common Code Tables be approved by the chairman of ET/DR&C and chairman of OPAG/ISS just by email to speed up their implementation.

IMPLEMENTATION PROCEDURES FOR ADDITIONS OF DESCRIPTORS IN BUFR/CREX TABLES A, B AND D, AND NEW GRIB TEMPLATES AND CODE TABLES -- TABLES ARE LISTED IN WMO WEB SERVER



7.2 PROPOSED MANUAL ON REPORTING PRACTICES

7.2.1. It is a fact that the Manual on Codes, Volume I.1, contains more regulations related to reporting practices than formatting rules. The Volume I.2, on the contrary defines formatting procedures, and practically no reporting regulations. The Volume I.1 links reporting practices to the alphanumeric coding format. The migration to BUFR/CREX will push producers and users (human decoders) of BUFR/CREX codes to consider Volume I.2, rather than Volume I.1. It is necessary to re-write the regulations on reporting practices, disconnecting them from the traditional alphanumeric format, and making them "universal", to fit, for instance, various national Automatic Weather Station templates which would be used to report the so-called "surface synoptic observations" in BUFR. It would make the migration to TDCF easier for the programmers of automatic platform software, for the meteorologists and the observers.

7.2.2 The Team noted that reporting requirements as well as observing practices were currently included along with the data representation formats for the traditional code forms. CBS agreed these requirements and practices should be separated from the data representation and recommends placing them in an Annex to Volume 1.2.

7.2.3. The Team agreed on that the BUFR and CREX Templates will be placed in an Attachment to Volume I.2 of the Manual, and should include links to the general reporting practices. Appropriate common Sequences may be generated as required. The question of unit and precision of reported parameters will be implicitly included in the Templates. The Team recommended this activity to be performed under the responsibility of the WMO Secretariat. A consultant might be hired for a few weeks to finalize the task. The new Annex on reporting practices and the Templates, once finalized, will have to be reviewed by appropriate Teams of CBS.

8. ACTIONS PLAN

8.1 NEXT MEETING:
It was suggested to have the next meeting in a place situated in RA II or RA V to be able organize a follow-up training event in the same manner as it was done in Arusha.

8.2 TASKS:
- ECMWF and NCEP with possible help of NWS/MDL to validate PDTs 4.10 and 4.14 (2.1.2)
- Some Centres to validate GDTs 3.1000/1100/1200 and PDTs 4.1000/1001/1100/1101, and check users feed-back (2.2).
- Some Centres to validate and experimentally test JPEG DRT 5.40000 and DT 7.40000 and PNG DRT 5.40010 and DT 7.40010 (2.3.5).
- Centres to validate ENVISAT templates (3.1.1)
- NCEP and Australian Weather Bureau to validate SIGMET in BUFR
- Centres to validate oceanographic additions (3.4.1)
- Secretariat, assisted by member(s) of the Team, to define an exhaustive list of known data sub-categories (3.5.3)
- Members to study necessity of date significance for a new edition of BUFR (3.5.4)

- Proposal for a new Satellite Master Table by Simon Elliott (EUMETSAT) (3.5.5)
- Team to debate on content of new edition and its impact on migration (3.6)
- Members test buoy data from service ARGOS in BUFR (3.7.1)
- Document by ICAO at next meeting on Amendment 73 (4.1)
- Organisation of XML Workshop by Secretariat (6.2)
- Secretariat to create merged Word file with all new descriptor entries and a file for computer processing with the help of a data processing centre (7.1.1)
- Finalize reporting practices and common sequences - Secretariat and consultant (7.2.3)
- Validation of BUFR templates for traditional observations including TEMP, PILOT, SYNOP, CLIMAT and updating METAR and SPECI Templates.

9. CLOSURE OF THE MEETING

The Meeting was closed by the Chairman of the ET/DR&C at 14.00 on Friday 21 February 2003.

ANNEX TO PARAGRAPH 1.1.1

ET/DR&C, Arusha, 17-21 February 2003

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ANNEX TO 2.3.5

JPEG 2000

The following Templates and Code tables are proposed for use with the JPEG 2000 image encoding. Note that a local table value of 40000 is used in the following examples.

Data Representation Template 5.40000: Grid point data - JPEG 2000 Code Stream Format
Octet Number(s) Contents 12-15 Reference value (R) (IEEE 32-bit floating-point value) 16-17 Binary scale factor (E) 18-19 Decimal scale factor (D) 20 Number of bits required to hold the resulting scaled and referenced data values. (i.e. The depth of the grayscale image.) (see Note 2) 21 Type of original field values (see Code Table 5.1) 22 Type of Compression used. (see Code Table 5.40000) 23 Target compression ratio, M:1 (with respect to the bit-depth specified in octet 20), when octet 22 indicates Lossy Compression. Otherwise, set to missing. (see Note 3)
Notes: (1) The intent of this template is to scale the grid point data to obtain desired precision, if appropriate, and then subtract out reference value from the scaled field as is done using Data Representation Template 5.0. After this, the resulting grid point field can be treated as a grayscale image and is then encoded into the JPEG 2000 code stream format. To unpack the data field, the JPEG 2000 code stream is decoded back into an image, and the original field is obtained from the image data as described in regulation 92.9.4, Note (4). (2) The JPEG 2000 standard specifies that the bit-depth must be in the range of 1 to 38 bits. (3) The compression ratio M:1 (e.g. 20:1) specifies that the encoded stream should be less than (1/M)*depth*number_of_data points bits, where depth is specified in octet 20 and number_of_data points is specified in octets 6-9 of the Data Representation Section. (4) The order of the data points should remain as specified in the scanning mode flags (Flag Table 3.4) set in the appropriate Grid Definition Template, even though the JPEG 2000 standard specifies

that an image is stored starting at the top left corner. Assuming that the encoding software is expecting the image data in raster order (left to right across rows for each row), users should set the image width to Ni (or Nx) and the height to Nj (or Ny) if bit 3 of the scanning mode flag equals 0 (adjacent points in i (x) order), when encoding the "image". If bit 3 of the scanning mode flags equals 1 (adjacent points in j (y) order), it may be advantageous to set the image width to Nj (or Ny) and the height to Ni (or Nx).

(5) When the data points are not available on a rectangular grid, such as a would occur if some data points are bit-mapped out or if section 3 describes a quasi-regular grid, the data field can be treated as a one dimensional image where the height is set to 1 and the width is set to the total number of data points specified in octets 6-9.

Data Template 7.40000: Grid point data - JPEG 2000 Code Stream Format
Octet Number(s) Contents 6-nn JPEG 2000 Code Stream as described in Part1 of the JPEG 2000 standard. (ISO/IEC 15444-1:2000)
Note: For simplicity, image data should be packed specifying a single component (i.e. grayscale image) instead of a multi-component color image.

Code Table 5.40000: Type of Compression
Code Figure Meaning 0 Lossless 1 Lossy 2-254 Reserved 255 Missing

Portable Network Graphics (PNG)

The following Templates are proposed for use with PNG image encoding. Note that a local table value of 40010 is used in the following examples.

Data Representation Template 5.40010: Grid point data - Portable Network Graphics (PNG) Format
Octet Number(s) Contents 12-15 Reference value (R) (IEEE 32-bit floating-point value) 16-17 Binary scale factor (E) 18-19 Decimal scale factor (D) 20 Number of bits required to hold the resulting scaled and referenced data values. (i.e. The depth of the image.) (see Note 2) 21 Type of original field values (see Code Table 5.1)

Notes:

(1) The intent of this template is to scale the grid point data to obtain desired precision, if appropriate, and then subtract out reference value from the scaled field as is done using Data Representation Template 5.0. After this, the resulting grid point field can be treated as an image and is then encoded into PNG format. To unpack the data field, the PNG stream is decoded back into an image, and the original field is obtained from the image data as described in regulation 92.9.4, Note (4).

(2) PNG does not support all bit-depths in an image, so it is necessary to define which depths can be used and how they are to be treated. For grayscale images, PNG supports depths of 1, 2, 4, 8 or 16 bits. RGB color images can have depths of 8 or 16 bits with an optional alpha sample. Valid values for octet 20 can be:

1, 2, 4, 8, or 16 - treat as grayscale image

24 - treat as RGB color image (each component having 8 bit depth)
32 - treat as RGB w/ alpha sample color image (each component having 8 bit depth)

(3) The order of the data points should remain as specified in the scanning mode flags (Flag Table 3.4) set in the appropriate Grid Definition Template, even though the PNG standard specifies that an image is stored starting at the top left corner and scans across each row from left to right starting with the top row. Users should set the image width to Ni (or Nx) and the height to Nj (or Ny) if bit 3 of the scanning mode flag equals 0 (adjacent points in i (x) order), when encoding the "image". If bit 3 of the scanning mode flags equals 1 (adjacent points in j (y) order), it may be advantageous to set the image width to Nj (or Ny) and the height to Ni (or Nx).

(4) When the data points are not available on a rectangular grid, such as a would occur if some data points are bit-mapped out or if section 3 describes a quasi-regular grid, the data field can be treated as a one dimensional image where the height is set to 1 and the width is set to the total number of data points specified in octets 6-9.

Data Template 7.40010: Grid point data - Portable Network Graphics (PNG) Format
Octet Number(s) Contents 6-nn PNG encoded image

Note:

If octet 20 of Data Representation Template 5.40010 specifies the data is packed into either 1, 2, 4, 8, or 16 bits, then encode the "image" as a grayscale image. If octet 20 specifies 24 bits, encode the "image" as an RGB color image with 8 bit depth for each color component, and finally if octet 20 is 32, encode the "image" as a RGB color image with an alpha sample using an 8 bit depth for each of the four components.

ANNEX TO 2.4.1.2

New regulation for scaling

92.1.12 Items in sections 3 and 4 which consist of a scale factor F and a scaled value V are related to the original value L as follows:

$L * 10^F = V$

ANNEX TO 2.4.2

- remove the bracket: (also called “Albers equal-area”) for entry 30 in Code Table 3.1

- add a new entry 31 in Code Table 3.1:
  31 Albers equal area
  32-39 Reserved

- Introduce a new template 3.31:

Grid Definition Template 3.31: Albers equal area

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Nx - number of points along the X-axis
35-38	Ny - number of points along the Y-axis
39-42	La1 - latitude of first grid point
43-46	Lo1 - longitude of first grid point
47	Resolution and component flags (see Flag Table 3.3)
48-51	LaD - Latitude where Dx and Dy are specified
52-55	LoV - Longitude of meridian parallel to Y-axis along which latitude increases as the Y-coordinate increases
56-59	Dx - X-direction grid length (see Note 1)
60-63	Dy - Y-direction grid length (see Note 1)
64	Projection centre flag (see Flag Table 3.5)
65	Scanning mode (see Flag Table 3.4)
66-69	Latin 1 - first latitude from the pole at which the secant cone cuts the sphere
70-73	Latin 2 - second latitude from the pole at which the secant cone cuts the sphere
74-77	Latitude of the southern pole of projection
78-81	Longitude of the southern pole of projection

Notes:
(1) Grid lengths are in units of 10^{-3} m, at the latitude specified by LaD.
(2) If Latin 1 = Latin 2, then the projection is on a tangent cone.
(3) The resolution flags (bits 3-4 of Flag Table 3.3) are not applicable
(4) LoV is the longitude value of the meridian which is parallel to the Y-axis (or columns of the grid) along which latitude increases as the Y-coordinate increases (the orientation longitude may or may not appear on a particular grid).

ANNEX TO 2.4.3

CLARIFICATION OF USE OF TABLE VERSION NUMBERS

Specification of octet contents, Section 1 (Page I.2 - Grib Reg – 6):

Change Octet 10 from

GRIB Master tables version number (see Code table 1.1)

to

GRIB Master tables version number (see Code table 1.1 and Note 1)

And:

Change Octet 11 from

GRIB Local tables version number (see Code table 1.2)

to

GRIB local tables version number used to augment master table (see Code table 1.2 and Note 2)

Add two notes to the end of the section 1 contents:

(1) If octet 10 contains 255 then only local tables are in use, the local table version number (Octet 11) must not be zero nor missing, and local tables may include entries from the entire range of the tables.
(2) If Octet 11 is zero, Octet 10 must contain a valid master tables version number and only those parts of the tables not reserved for local use may be used.

Code tables used in section 1:

Code table 1.0 – GRIB master tables version number

Change:

255 Local table used

to

255 Master tables not used. Local table entries and local templates may use the entire range of the table, not just those sections marked “Reserved for local use”.

Code table 1.1 – GRIB local table version number

Change:

0 Local tables not used

to

0 Local tables not used. Only table entries and templates from the current master table are valid.

ANNEX TO 2.4.4

SUGGESTED ADDITIONAL NOTE TO THE MANUAL ON CODES FOR DRT 5.2 and 5.3

To avoid misunderstanding such as raised in the GRIB2 guide for spatial differencing, the following note should be added for these templates:

DRT 5.2:

(15) See Data Template 7.2 and associated notes for complementary information.

DRT 5.3:

(3) See Data Template 7.3 and associated notes for complementary information.

ANNEX TO 3.1.1

ADDITIONS FOR ENVISAT DATA

a) AATSR - **A**dvanced **A**long **T**rack **S**canning **R**adiometer is the advanced version of the ATSR system operated on ERS1 and ERS2. The main objective of the AATSR is precise measurement of sea surface temperature (SST).

Proposal for standard WMO BUFR Table B entries:

025061	SOFTWARE IDENTIFICATION AND VERSION NUMBER	CCITTIA5	0	0	96
001096	STATION ACQUISITION	CCITTIA5	0	0	160
002174	MEAN ACROSS TRACK PIXEL NUMBER	NUMERIC	0	0	9
012180	AVERAGED 12 MICRON BT FOR ALL CLEAR PIXELS AT NADIR	K	2	0	16
012181	AVERAGED 11 MICRON BT FOR ALL CLEAR PIXELS AT NADIR	K	2	0	16
012182	AVERAGED 3.7 MICRON BT FOR ALL CLEAR PIXELS AT NADIR	K	2	0	16
012183	AVERAGED 12 MICRON BT FOR ALL CLEAR PIXELS, FORWARD VIEW	K	2	0	16
012184	AVERAGED 11 MICRON BT FOR ALL CLEAR PIXELS, FORWARD VIEW	K	2	0	16
012185	AVERAGED 3.7 MICRON BT FOR ALL CLEAR PIXELS, FORWARD VIEW	K	2	0	16
012186	MEAN NADIR SEA SURFACE TEMPERATURE	K	2	0	16
012187	MEAN DUAL VIEW SEA SURFACE TEMPERATURE	K	2	0	16
021086	NUMBER OF PIXELS IN NADIR ONLY, AVERAGE	NUMERIC	0	0	9
021087	NUMBER OF PIXELS IN DUAL VIEW, AVERAGE	NUMERIC	0	0	9
033043	AST CONFIDENCE	FLAG TABLE	0	0	8

033043 FLAG TABLE AST CONFIDENCE

Bit No.	Meaning
1	SEA MDS. NADIR ONLY SST RETRIEVAL USED 3.7 MICRON CHANNEL. LAND MDS RESERVED
2	SEA MDS. DUAL VIEW SST RETRIEVAL USED 3.7 MICRON CHANNEL. LAND MDS RESERVED
3	NADIR VIEW CONTAINS DAY TIME DATA
4	FORWARD VIEW CONTAINS DAY TIME DATA
5-7	RESERVED
All	MISSING VALUE

Common Code Table C-5:

001007 - satellite identifier
Add 60 for ENVISAT

Proposal for standard WMO BUFR Table D entries:

```
 ---------------------------------------------

 312045    - AATSR sea surface temperatures

 312045    001007 Satellite identifier
           002019 Satellite instruments
           001096 Station acquisition
           025061 Software identification and version number
           005040 Orbit number
           301011 Date
           301013 Time
           301021 Lat/long
           007002 Height or altitude
           012180 Average 12 micron BT for all clear pixels at nadir
           012181 Average 11 micron BT for all clear pixels at nadir
           012182 Average 3.7 micron BT for all clear pixels at nadir
           012183 Average 12 micron BT for all clear pixels, forward
                  view
           012184 Average 11 micron BT for all clear pixels, forward
                  view
           012185 Average 3.7 micron BT for all clear pixels, forward
                  view
           002174 Mean across track pixel number
           021086 Number of pixels in nadir only, average
           012186 Mean nadir sea surface temperature
           021087 Number of pixels in dual view, average
           012187 Mean dual view sea surface temperature
           033043 ATS confidence
```

b) SCIAMACHY- The Scanning Imaging Absorbtion Spectrometer for Atmospheric Cartography. The instrument provides spectra measured from light transmitted, back scattered or reflected by trace gases in the atmosphere.

Use standard entry 310020

c) MIPAS - The Michelson Interferometer for Passive Atmospheric Sounding. The instrument measures atmospheric radiation emitted by trace gases in the infrared spectral range 4.14 to 14.6 micro meters.

BUFR Table B reserved entry:

```
013098 INTEGRATED WATER VAPOUR KG/M**2       8      0    30
       DENSITY
```

BUFR table D reserved entry:

```
310030     310022 Satellite id, product type
           301011 Date
           301013 Time
           301021 Lat/long
           304034 Lat/long, solar elevation, number of layers
           310029 Layer, ozone, height, temperature and water vapour


310029     110000
           031001 Delayed replication
           201138 Change data width
```

```
           202130 Change scale
           007004 Pressure
           007004 Pressure
           202000 Cancel operator
           201000 Cancel operator
           015020 Integrated ozone density
           010002 Height
           012101 Temperature
           013098 Integrated water vapour density
```

d) GOMOS - The Global Ozone Monitoring by Occulation of Stars Gomos measures tangential atmospheric ultraviolet, visual and infrared light.

The BUFR template is the same as for **MIPAS** data

e) MERIS - The Medium Resolution Imaging Spectrometer: The instrument produces multi-spectral images obtained in a downward viewing push broom imaging manner. The 15 bands acquire radiance in the visible and near infra-red bands.

BUFR table B reserved entries:

```
010080 VIEWING ZENITH ANGLE       DEGREE        2        -9000  15
027080 VIEWING AZIMUTH ANGLE      DEGREE TRUE   2            0  16
013093 CLOUD OPTICAL THICKNESS    NUMERIC       0            0   8
013095 TOTAL COLUMN WATER VAPOUR  KG/M**2       4            0  19
```

BUFR table D reserved entries:

```
312050     001007 Satellite identifier
           002019 Instrument type
           001096 Station acquisition
           025061 Software identification
           005040 Orbit number
           301011 Date
           301013 Time
           301021 Lat/long
           007025 Solar zenith angle
           005022 Solar azimuth
           010080 Viewing zenith angle
           027080 Viewing azimuth angle
           008003 Vertical significance
           007004 Pressure
           013093 Cloud optical thickness
           008003 Vertical significance
           201131 Change data width
           202129 Change scale
           007004 Pressure
           007004 Pressure
           202000 Cancel operator
           201000 Cancel operator
           013095 Total column water vapour
```

f) ASAR - The Advanced Synthetic Aperture Radar is a high resolution imaging radar.

```
Ocean cross spectra -   ( WVS )

312051     001007 Satellite identifier
           002019 Satellite instrument type
           001096 Station acquisition
           025061 Software identification
           005040 Orbit number
           008075 Ascending/descending orbit qualifier
           301011 Date
           301013 Time
           301021 Lat/long
           001012 Direction of motion of moving observing platform
           201131 Change data width
           001013 Speed of motion of moving observing platform
           201000 Cancel operator
           010032 Satellite distance to Earth centre
           010033 Altitude (platform to ellipsoid)
           010034 Earth radius
           007002 Height
           008012 Land/sea qualifier
           025110 Image processing summary
           025111 Number of input data gaps
           025102 Number of missing lines excluding data gaps
           002104 Antenna polarisation
           025103 Number of directional bins
           025104 Number of wave-length bins
           025105 First directional bin
           025106 Directional bin step
           025107 First wave-length bin
           025108 Last wave-length bin
           002111 Radar incidence angle
           002121 Mean frequency
           002026 Cross track resolution
           002027 Along track resolution
           021130 Spectrum total energy
           021131 Spectrum maximum energy
           021132 Direction of spectrum max on higher resolution grid
           021133 Wavelength of spectrum max on higher resolution grid
           021064 Clutter noise estimate
           025014 Azimuth clutter cut-off
           021134 Range resolution of cross covariance spectrum
           107018 Replicate next 7 descriptors 18 times
           005030 Direction (spectral)
           105024 Replicate 5 descriptors 24 time
           201130 Change data width
           006030 Wave number (spectral)
           201000 Cancel operator
           021135 Real part of cross spectra
           021136 Imaginary part of cross spectra
           033044 ASAR quality
```

New Table B descriptors

```
010032 SATELLITE DISTANCE TO EARTH       M          1           0  27
       CENTRE
010033 ALTITUDE (PLATFORM TO ELLIPSOID)  M          1           0  27
010034 EARTH RADIUS                      M          1           0  27
025110 IMAGE PROCESSING SUMMARY          FLAG TABLE 0           0  10
025111 NUMBER OF INPUT DATA GAPS         NUMERIC    0           0   8
025102 NUMBER OF MISSING LINES EXCLUDING NUME       0           0   8
       DATA GAPS
025103 NUMBER OF DIRECTIONAL BINS        NUMERIC    0           0   8
025104 NUMBER OF WAVE-LENGHT BINS        NUMERIC    0           0   8
025105 FIRST DIRECTIONAL BIN             DEGREES    3           0  19
```

025106	DIRECTIONAL BIN STEP	DEGREES	3	0	19
025107	FIRST WAVE-LENGHT BIN	M	3	0	29
025108	LAST WAVE-LENGHT BIN	M	3	0	29
021130	SPECTRUM TOTAL ENERGY	NUMERIC	6	0	28
021131	SPECTRUM MAX ENERGY	NUMERIC	6	0	28
021132	DIRECTION OF SPECTRUM MAX ON HIGHER RESOLUTION GRID	DEGREES	3	0	19
021133	WAVE-LENGHT OF SPECTRUM MAX ON HIGHER RESOLUTION GRID	M	3	0	29
021134	RANGE RESOLUTION OF CRESS COVARIANCE SPECTRUM	RAD/M	3	0	19
021135	REAL PART OF CROSS SPECTRA POLAR GRID NUMBER OF BINS	NUMERIC	3	-524288	20
021136	IMAGINARY PART OF CROSS SPECTRA POLAR GRID NUMBER OF BINS	NUMERIC	3	-524288	20
033044	ASAR QUALITY INFORMATION	FLAG TABLE	0	0	15

Flag table 025100 IMAGE PROCESSING SUMMARY

bit number	Meaning
1	Raw data analysis used for raw data correction. Correction done using default parameters
2	Raw data analysis used for raw data correction. Correction done using raw data analysis results
3	Antenna elevation pattern correction applied
4	Nominal chirp replica used
5	Reconstructed chirp used
6	Slant range to ground range Conversion applied
7-9	Reserved
All 10	Missing value

Flag table 033044 ASAR QUALITY INFORMATION

bit number	Meaning
1	Input data mean outside nominal range flag
2	Input data standard deviation outside nominal range flag
3	Number of input data gaps > threshold value
4	Percentage of missing lines > threshold value
5	Doppler centroid uncertain. Confidence measure < specific value
6	Doppler ambiguity estimate uncertain. Confidence measure < specific value
7	Output data mean outside nominal range flag
8	Output data standard deviation outside nominal range flag
9	Chirp reconstruction failed or is of low quality flag
10	Data set missing
11	Invalid downlink parameters
12	Azimuth cut-off iteration count. The azimuth cut- off fit did not converge within minimum number of iterations
13	Azimuth cut-off fit did not converge within a minimum number of iterations
14	Phase information confidence measure. The imaginary spectral peak is less than a minimum threshold, or the zero lag shift is greater than a minimum threshold
All 15	Missing value

OCEAN WAVE SPECTRA

Table D sequence

312053	001007 Satellite identifier
	002019 Satellite instrument type
	001096 Station acquisition
	025061 Software identification and version number
	005040 Orbit number
	008075 Ascending/descending orbit qualifier
	301011 Date
	301013 Time
	301021 Lat/long
	001012 Direction of motion of moving observing platform
	201131 Change data width
	001013 Speed of motion of moving observing platform
	201000 Cancel operator
	010032 Satellite distance to Earth centre
	010033 Altitude (platform to ellipsoid)
	010034 Earth radius
	007002 Height or altitude
	008012 Land/sea qualifier
	025110 Image processing summary
	025111 Number of input data gaps
	025102 Number of missing lines excluding data gaps
	002104 Antenna polarisation
	025103 Number of directional bins
	025104 Number of wave-length bins
	025105 First directional bin
	025106 Directional bin step
	025107 First wave-length bin
	025108 Last wave-length bin
	011001 Wind direction
	011002 Wind speed
	022160 Normalized inverse wave age
	025138 Average signal to noise ratio
	201130 Change data width
	202129 Change scale
	022021 Height of waves
	202000 Cancel operator
	201000 Cancel operator
	033048 Confidence measure for SAR inversion
	033049 Confidence measure for wind retrieval
	002026 Cross track resolution
	002027 Along track resolution
	021130 Spectrum total energy
	021131 Spectrum max energy
	021132 Direction of spectrum max
	021133 Wave-length of spectrum max
	025014 Azimuth clutter cut-off
	106036 Replicate 6 descriptors 36 times
	005030 Direction (spectral)
	104024 Replicate 4 descriptors 24 time
	201130 Change data width
	006030 Wave number (spectral)
	201000 Cancel operator
	022161 Wave spectra
	033044 ASAR quality

Table B descriptors

```
 022160 NORMALIZED INVERSE WAVE AGE  NUMERIC       6            0  21
 025138 AVERAGE SIGNAL TO NOISE      NUMERIC       0        -2048  12
        RATIO
 033048 CONFIDENCE MEASURE OF SAR    CODE TABLE    0            0   2
        INVERSION
 033049 CONFIDENCE MEASURE OF WIND   CODE TABLE    0            0   2
        RETRIEVAL
 022161 WAVE SPECTRA                 M**4          4            0  27
```

Code table 033048 CONFIDENCE MEASURE OF SAR INVERSION

code figure	Meaning
0	inversion successful
1	inversion not successful
2	reserved
3	Missing

Code table 033049 CONFIDENCE MEASURE OF WIND RETRIEVAL

code figure	Meaning
0	external wind direction used during inversion
1	External wind direction not used during inversion
2	reserved
3	Missing

g) RA2 - Radar Altimeter-2

```
    ----------------------
```

```
312052    001007 Satellite identifier
          002019 Satellite instrument type
          001096 Station acquisition
          025061 Software identification
          005040 Orbit number
          025120 Ra2 L2 processing flag
          025121 Ra2 L2 processing quality
          025124 MWR L2 processing flag
          025125 MWR L2 processing quality
          025122 Hardware configuration for RF
          025123 Hardware configuration for HPA
          301011 Date
          301013 Time
          301021 Lat/long
          007002 Height or altitude
          002115 Instrument operations
          033047 Measurement confidence data
          010081 Altitude of COG above reference ellipsoid
          010082 Instantaneous altitude rate
          010083 Off nadir angle of the satellite from platform data
          010084 Off nadir angle of the satellite from waveform data
          002116 Percentage of 320 MHz band processed
          002117 Percentage of 80 MHz band processed
          002118 Percentage of 20 MHz band processed
          002156 Percentage of valid Ku ocean retracker measurements
          002157 Percentage of valid S  ocean retracker measurements
          014055 Solar activity index
          022150 Number of 18 Hz valid points for Ku band
          022151 Ku band ocean range
          022152 STD of 18Hz Ku band ocean range
```

022153 Number of 18 Hz valid points for S band
022154 S band ocean range
022155 STD of 18 Hz S band ocean range
022156 Ku band significant wave height
022157 STD of 18 Hz Ku band significant wave height
022158 S band significant wave height
022159 STD 18 Hz S band significant wave height
021137 Ku band corrected ocean backscatter coefficient
021138 STD Ku band corrected ocean backscatter coefficient
021139 Ku band net instrumental correction for AGC
021140 S band corrected ocean backscatter coefficient
021141 STD S band corrected ocean backscatter coefficient
021142 S band net instrumental correction for AGC
010085 Mean sea surface height
010086 Geoid height
010087 Ocean depth/land elevation
010088 Total geocentric ocean tide height solution 1
010089 Total geocentric ocean tide height solution 2
010090 Long period tide height
010091 Tidal loading height
010092 Solid earth tide height
010093 Geocentric pole tide height
011002 wind speed
025126 Model dry tropospheric correction
025127 Inverted barometer correction
025128 Model wet tropospheric correction
025129 MWR derived wet tropospheric correction
025130 Ra2 ionospheric correction on Ku band
025131 Ionospheric correction from Doris on Ku band
025132 Ionospheric correction from model on Ku band
025133 Sea state bias correction on Ku band
025134 Ra2 ionospheric correction on S band
025135 Ionospheric correction from Doris on S band
025136 Ionospheric correction from model on S band
025137 Sea state bias correction on S band
013096 MWR water vapour content
013097 MWR liquid water content
011085 u component of model wind vector
011086 v component of model wind vector
012188 Interpolated 23.8 GHz brightness temp from MWR
012189 Interpolated 36.5 GHz brightness temp from MWR
002158 RA- 2 instrument
002159 MWR instrument
033052 S band ocean retracking quality
033053 Ku band ocean retracking quality
021143 Ku band rain attenuation
021144 Altimeter rain flag

Table B descriptors

002119	RA - 2 INSTRUMENT OPERATIONS	CODE TABLE	0	0	3
002116	PERCENTAGE OF 320 MHZ BAND PROCESSED	%	0	0	7
002117	PERCENTAGE OF 80 MHZ BAND PROCESSED	%	0	0	7
002118	PERCENTAGE OF 20 MHZ BAND PROCESSED	%	0	0	7
002156	PERCENTAGE OF VALID KU OCEAN RETRACKER MEASUREMENTS	%	0	0	7
002157	PERCENTAGE OF VALID S OCEAN RETRACKER MEASUREMENTS	%	0	0	7
002158	RA - 2 INSTRUMENT	FLAG TABLE	0	0	9
002159	MWR INSTRUMENT	FLAG TABLE	0	0	8
010081	ALTITUDE OF COG ABOVE REFERENCE ELLIPSOID	M	3	0	31
010082	INSTANTANEOUS ALTITUDE RATE	M/S	3	-65536	17
010083	OFF NADIR ANGLE OF THE SATELLITE FROM PLATFORM DATA	DEGREE	2	-36000	17
010084	OFF NADIR ANGLE OF THE SATELLITE FROM WAVEFORM DATA	DEGREE	2	-36000	17
010085	MEAN SEA SURFACE HEIGHT	M	3	-131072	18
010086	GEOID HEIGHT	M	3	-131072	18
010087	OCEAN DEPTH/LAND ELEVATION	M	1	-131072	18
010088	TOTAL GEOCENTRIC OCEAN TIDE HEIGHT SOLUTION 1	M	3	-32768	16
010089	TOTAL GEOCENTRIC OCEAN TIDE HEIGHT SOLUTION 2	M	3	-32768	16
010090	LONG PERIOD TIDE HEIGHT	M	3	-32768	16
010091	TIDAL LOADING HEIGHT	M	3	-32768	16
010092	SOLID EARTH TIDE HEIGHT	M	3	-32768	16
010093	GEOCENTRIC POLE TIDE HEIGHT	M	3	-32768	16
011085	U COMPONENT OF THE MODEL WIND VECTOR	M/S	1	-4096	13
011086	V COMPONENT OF THE MODEL WIND VECTOR	M/S	1	-4096	13
012188	INTERPOLATED 23.8 GHZ BRIGHTNESS T FROM MWR	K	2	0	16
012189	INTERPOLATED 36.5 GHZ BRIGHTNESS T FROM MWR	K	2	0	16
013096	MWR WATER VAPOUR CONTENT	KG/M**2	2	0	14
013097	MWR LIQUID WATER CONTENT	KG/M**2	2	0	14
014055	SOLAR ACTIVITY INDEX	NUMERIC	0	-32768	14
021137	KU BAND CORRECTED OCEAN BACKSCATTER COEFFICIENT	DB	2	-32768	16
021138	STD KU BAND CORRECTED OCEAN BACKSCATTER COEFFICIENT	DB	2	-32768	16
021139	KU BAND NET INSTRUMENTAL CORRECTION FOR ACG	DB	2	-2048	12
021140	S BAND CORRECTED OCEAN BACKSCATTER COEFFICIENT	DB	2	-32768	16
021141	STD S BAND CORRECTED OCEAN BACKSCATTER COEFFICIENT	DB	2	-32768	16
021142	S BAND NET INSTRUMENTAL CORRECTION FOR ACG	DB	2	-1024	11
021143	KU BAND RAIN ATTENUATION	DB	2	-1073741824	31
021144	ALTIMETER RAIN FLAG	FLAG TABLE	0	0	2
022150	NUMBER OF 18 HZ VALID POINTS FOR KU BAND	NUMERIC	0	0	10
022151	KU BAND OCEAN RANGE	M	3	0	31
022152	STD OF 18 HZ KU BAND OCEAN RANGE	M	3	0	16
022153	NUMBER OF 18 HZ VALID POINTS FOR S BAND	NUMERIC	0	0	10
022154	S BAND OCEAN RANGE	M	3	0	31
022155	STD OF 18 HZ S BAND OCEAN RANGE	M	3	0	16
022156	KU BAND SIGNIFICANT WAVE HEIGHT	M	3	0	16
022157	STD 18 HZ KU BAND SIGNIFICANT WAVE HEIGHT	M	3	0	16
022158	S BAND SIGNIFICANT WAVE HEIGHT	M	3	0	16

022159	STD 18 HZ S BAND SIGNIFICANT WAVE HEIGHT	M	3	0	16
025120	RA2_L2_PROCESSING FLAG	CODE TABLE	0	0	2
025121	RA2_L2_PROCESSING QUALITY	%	0	0	7
025122	HARDWARE CONFIGURATION FOR RF	CODE TABLE	0	0	2
025123	HARDWARE CONFIGURATION FOR HPA	CODE TABLE	0	0	2
025124	MWR L2 PROCESSING FLAG	CODE TABLE	0	0	2
025125	MWR L2 PROCESSING QUALITY	%	0	0	7
025126	MODEL DRY TROPOSPHERIC CORRECTION	M	3	-32768	16
025127	INVERTED BAROMETER CORRECTION	M	3	-32768	16
025128	MODEL WET TROPOSPHERIC CORRECTION	M	3	-32768	16
025129	MWR DERIVED WET TROPOSPHERIC CORRECTION	M	3	-32768	16
025130	RA2 IONOSPHERIC CORRECTION ON KU BAND	M	3	-32768	16
025131	IONOSPHERIC CORRECTION FROM DORIS ON KU BAND	M	3	-32768	16
025132	IONOSPHERIC CORRECTION FROM MODEL ON KU BAND	M	3	-32768	16
025133	SEA STATE BIAS CORRECTION ON KU BAND	M	3	-32768	16
025134	RA2 IONOSPHERIC CORRECTION ON S BAND	M	3	-32768	16
025135	IONOSPHERIC CORRECTION FROM DORIS ON S BAND	M	3	-32768	16
025136	IONOSPHERIC CORRECTION FROM MODEL ON S BAND	M	3	-32768	16
025137	SEA STATE BIAS CORRECTION ON S BAND	M	3	-32768	16
033052	S BAND OCEAN RETRACKING QUALITY	FLAG TABLE	0	0	21
033053	KU BAND OCEAN RETRACKING QUALITY	FLAG TABLE	0	0	21
033047	MEASUREMENT CONFIDENCE DATA FLAG	TABLE	0	0	31

Code table 002180 INSTRUMENT OPERATIONS

Code figure	Meaning
0	Intermediate Frequency Calibration Mode (IF CAL)
1	Built-In Test Equipment Digital (BITE DGT)
2	Built-In test Equipment Radio Frequency (BITE RF)
3	Preset tracking (PSET TRK)
4	Preset LOOP OUT
5	ACQUISITION
6	TRACKING
7	MISSING VALUE

Flag table 002158 RA - 2 INSTRUMENT

bit number	Meaning
1	MISMATCH IN RED VEC HPA
2	MISMATCH IN RED VEC RFSS
3	PTR CALIBRATION BAND 320 MHz (Ku)
4	PTR CALIBRATION BAND 80 MHz (Ku)
5	PTR CALIBRATION BAND 20 MHz (Ku)
6	PTR CALIBRATION BAND 160 MHz (S)
7	Ku FLIGHT CALIBRATION PARAMETERS AVAILABLE
8	S FLIGHT CALIBRATION PARAMETERS AVAILABLE
All	Missing value

PTR - Pulse target response
HPA - High Power Amplifier
RFSS - Radio Frequency Sub-System
RED - Redundancy

Flag table 002159 MWR INSTRUMENT

bit number	Meaning
1	Temperature inconsistency
2	Data is missing
3	Redundancy channel
4	Power bus protection
5	Overvoltage/Overload protection
6	Reserved
7	Reserved
ALL	Missing

MWR - Microwave radiometer

Flag table 021144 Altimeter rain flag

bit number	Meaning
1	RAIN
all	Missing value

Code table 025120 RA2_l2_processing flag

code figure	Meaning
0	Percentage of DSRs free of processing errors during Level 2 processing is greater than the acceptable threshold
1	Percentage of DSRs free of processing errors during Level 2 processing is less than the acceptable threshold
2	Reserved
3	Missing value

DSR - Data set record

Code table 025122 Hardware configuration for RF

Code figure	Meaning
0	Hardware configuration for RF is A
1	Hardware configuration for RF is B
2	Reserved
3	Missing

RF - Radio frequency

Code table 025123 Hardware configuration for HPA

Code figure	Meaning
0	Hardware configuration for HPA is A
1	Hardware configuration for HPA is B
2	Reserved
3	Missing

Code table 025124 MWR l2 processing flag

Code figure	Meaning
0	Percentage of DSRs free of processing errors during Level 2 processing is greater than the acceptable threshold
1	Percentage of DSRs free of processing errors during Level 2 processing is less than the acceptable threshold
2	Reserved
3	Missing

DSR - Data Set Record
MWR - Microwave radiometer

Flag table 033053 Ku band ocean retracking quality

bit number	Meaning
1-20	First 20 least significant bits correspond to the 20 values (one per data block containing 0=valid measurement, 1=invalid) bit 1 applies to the 20th data block
All	Missing

Flag table 033052 S band ocean retracking quality

bit number	Meaning
1-20	First 20 least significant bits correspond to the 20 values (one per data block containing 0=valid measurement, 1=invalid) bit 1 applies to the 20th data block
All	Missing

Flag table 033047 Measurement confidence data

bit number	Meaning
1	Error detected and attempts to recover made
2	Anomaly in on-board data handling (OBDH) value detected
3	Anomaly in Ultra Stable Oscillator Processing (USOP) value detected
4	Errors detected by on-board computer
5	Automatic gain control (AGC) out of range
6	Rx delay fault. Rx distance out of range
7	Wave form samples fault identifier. Error
8	Reserved
9	Reserved
10	Reserved
11	Reserved
12	Brightness temperature (channel 1) out of range
13	Brightness temperature (channel 2) out of range
14	Reserved
15	Ku Ocean retracking error
16	S Ocean retracking error
17	Ku Ice 1 retracking error
18	S Ice 1 retracking error
19	Ku Ice 2 retracking error
20	S Ice 2 retracking error
21	Ku Sea Ice retracking error
22	Arithmetic fault error
23	Meteo data state. No map
24	Meteo data state. 1 map
25	Meteo data state 2 maps degraded
26	Meteo data state 2 maps nominal
27	Orbit propagator status for propagation mode, several errors
28	Orbit propagator status for propagation mode, warning detected
29	Orbit propagator status for initialisation mode, several errors
30	Orbit propagator status for initialisation mode, warning detected
All 31	Missing

ANNEX TO 3.1.2.1

DESCRIPTORS FOR AIRS SATELLITE DATA for “PREOPERATIONAL STATUS”

In BUFR Table B:

```
Log-10 of principal components normalized fit to data
0-25-052          Numeric     4     0     15
```

In BUFR Table D:

```
-------------------------------------------------------------
3-10-050    Satellite collocated 1C reports with 3 instruments
-------------------------------------------------------------
      3-10-051    Satellite position and instrument temperatures
      3-10-052    Satellite instrument type and position (AIRS)
      1-01-000    Delayed replication of 1 descriptor
      0-31-002    Extended delayed descriptor replication factor
      3-10-053    Satellite channels and brightness temperatures with expanded
                  channel set (AIRS)
      1-01-004    Replicate 1 descriptor 4 times
      3-10-054    Satellite visible channels and albedos with expanded channel
                  set
      0-20-010    Cloud cover (total)
      3-10-052    Satellite instrument type and position (AMSU-A)
      1-01-015    Replicate 1 descriptor 15 times
      3-10-053    Satellite channels and brightness temperatures with expanded
                  channel set (AMSU-A)
      3-10-052    Satellite instrument type and position (HSB)
      1-01-005    Replicate 1 descriptor 5 times
      3-10-053    Satellite channels and brightness temperatures with expanded
                  channel set (HSB)


-----------------------------------------------------
3-10-051    Satellite position and instrument temperatures
-----------------------------------------------------

      0-01-007    Satellite identifier
      0-05-040    Orbit number
      2-01-133    Change data width
      0-05-041    Scan line number
      2-01-000    Cancel change data width
      2-01-132    Change data width
      0-25-070    Major frame count
      2-01-000    Cancel change data width
      2-02-126    Change scale
      0-10-007    Height of station
      2-02-000    Cancel change scale
      0-07-025    Solar zenith angle
      0-05-022    Solar azimuth
      1-02-009    Replicate 2 descriptors 9 times
      0-02-151    Radiometer identifier
      0-12-064    Instrument temperature
```

3-10-052 Satellite instrument type and position

0-02-019	Satellite instruments
3-01-011	Year, month, day
3-01-012	Hour, minute
2-02-131	Change scale
2-01-138	Change data width
0-04-006	Second
2-01-000	Cancel change data width
2-02-000	Cancel change scale
3-01-021	Latitude and longitude (high accuracy)
0-07-024	Satellite zenith angle
0-05-021	Bearing or azimuth
0-05-043	Field of view number

3-10-053 Satellite channels and brightness temperatures with expanded channel set

---

2-01-134	Change data width
0-05-042	Channel number
2-01-000	Cancel change data width
0-25-076	Log-10 of temperature-radiance central wave number for ATOVS
0-33-032	Channel quality flags for ATOVS
0-12-163	Brightness temperature (scale 2)

3-10-054 Satellite visible channels and albedos with expanded channel set

---

2-01-134	Change data width
0-05-042	Channel number
2-01-000	Cancel change data width
0-25-076	Log-10 of temperature-radiance central wave number for ATOVS
0-33-032	Channel quality flags for ATOVS
2-01-131	Change data width
2-02-129	Change scale
1-02-002	Replicate 2 descriptors 2 times
0-08-023	First-order statistics
0-14-027	Albedo
0-08-023	First-order statistics
2-02-000	Cancel change scale
2-01-000	Cancel change data width

3-10-055 Satellite radiance/channel principle components

3-10-051	Satellite position and instrument temperatures
3-10-052	Satellite instrument type and position (AIRS)
1-02-020	Replicate 2 descriptors 20 times
0-25-076	Log-10 of temperature-radiance central wave number for ATOVS
0-25-052	Log-10 of principal components normalized fit to data
1-01-000	Delayed replication of 1 descriptor
0-31-002	Extended delayed descriptor replication factor
0-25-050	Principal components of satellite radiance

ANNEX TO 3.1.2.2

ADDITIONAL ENTRIES FOR SATELLITE DATA

For "PRE-OPERATIONAL" status:

(1) Within existing descriptor 0-02-163 "Height assignment method", add the following new table entry:

0	AUTO EDITOR

(2) Within existing descriptor 0-01-007 "Satellite identifier", add the following new table entries:

720	TOPEX
721	GFO (GEOSAT Follow On)

(3) New table entry (was previously listed under "ALLOCATED ENTRIES (AWAITING VALIDATION)", but has since been validated within processing of altimeter data):

Satellite cycle number				
0-05-044	Numeric	0	0	11
B-05-044	Numeric	0	4	

For "ALLOCATED ENTRIES (AWAITING VALIDATION)" status:

Satellite zenith angle				
0-07-026	Degrees	4	-900000	21
B-07-026	Degrees	4		7

ANNEX TO 3.2.2

FOR CODING SIGMET WITH VOLUME ADDITIONS (I.E. ENHANCED PROPOSAL)

Proposed Table B entries

Table Reference	Element name	BUFR				CREX		
F X Y		Unit	Scale	Ref. value	Data width	Unit	Scale	Data width
0 01 037	SIGMET sequence identifier	CCITT IA5	0	0	24	Character	0	3
0 01 065	ICAO region identifier	CCITT IA5	0	0	256	Character	0	32
0 08 019	Qualifier for following centre identifier	Code table	0	0	4	Code table	0	2
0 08 079	Change in status of following product	Code table	0	0	3	Code table	0	1
0 10 064	SIGMET cruising level	Code table	0	0	3	Code table	0	1
0 20 028	Expected change in intensity	Code table	0	0	3	Code table	0	1
0 27 035	Length of phenomenon	m	-3	0	13	m	-3	4
0 28 035	Width of phenomenon	m	-3	0	13	m	-3	4

Add the following new categories to Table A within BUFR and CREX:

13 Forecasts
14 Warnings

Add the following new code table values for the descriptors to Table B within BUFR:

0 08 011
21 Thunderstorm
22 Tropical Cyclone
23 Mountain Wave
24 Duststorm
25 Sandstorm

0 20 008
15 Obscured (OBSC)
16 Embedded (EMBD)

0 20 024
5 Severe

Code tables for proposed new Table B descriptors:

Code figure	**0 08 019** **Qualifier for following centre identifier**
0	Reserved
1	ATS (Air Traffic Service) unit serving FIR (Flight Information Region)
2	FIR (Flight Information Region)
3	UIR (Upper Information Region)
4	CTA (Control Area)
5	VAAC (Volcanic Ash Advisory Centre)
6	MWO (Meteorological Watch Office) issuing SIGMET
7-14	Reserved
15	Missing value

Code figure	**0 08 079** **Change in status of following product**
0	Cancelled
1-6	Reserved
7	Missing value

Code figure	**0 10 064** **SIGMET cruising level**
0	Subsonic
1	Transonic
2	Supersonic
3-6	Reserved
7	Missing value

Code figure	**0 20 028** **Expected change in intensity**
0	No change (NC)
1	Forecast to weaken (WKN)
2	Forecast to intensify (INTSF)
3-6	Reserved
7	Missing value

New Table D descriptors:

		(Description of a feature in 3-D or in 2-D, in the last case replication = 1)
3 01 027	1 01 000	Replicate one descriptor
	0 31 001	Replication count
	3 01 028	Description of horizontal section [1]
		(Horizontal section of a feature described as a polygon or a line or a point; in the last case replication = 1)
3 01 028	0 07 010	Flight Level
	1 02 000	Replicate two descriptors [2]
	0 31 001	Replication count
	0 05 002	Latitude (coarse accuracy)
	0 06 002	Longitude (coarse accuracy)
		(SIGMET header)
3 16 030	1 02 002	Replication of 2 descriptors two times (Define validity period)
	3 01 011	Year, Month, Day
	3 01 012	Hour, Minute
	0 01 037	SIGMET sequence identifier
	0 10 064	SIGMET cruising level
	0 08 019	Qualifier for location identifier, 1=ATS unit serving FIR
	0 01 062	Short ICAO location identifier
	1 02 000	Replicate two descriptors
	0 31 001	Replication count
	0 08 019	Qualifier for location identifier, 2=FIR, 3=UIR, 4=CTA
	0 01 065	ICAO region identifier
	0 08 019	Qualifier for location identifier, 6=MWO
	0 01 062	Short ICAO location identifier
	0 08 019	Qualifier for location identifier, Missing=Cancel
		(SIGMET, Obs or Fcst location and motion)
3 16 031	0 08 021	Time Significance, 16=Analysis, 4=Forecast
	3 01 011	Year, Month, Day
	3 01 012	Hour, Minute
	0 07 010	Flight level (base)
	0 07 010	Flight level (top)
	0 27 035	Length of phenomenon
	0 28 035	Width of phenomenon
	0 08 007	Dimensional significance, 1=point, 2=area, 3=volume
	3 01 027	Description of feature
	0 19 005	Direction of motion
	0 19 006	Speed of motion
	0 19 007	Radius of feature
	0 08 007	Dimensional significance, Missing=cancel
	0 20 028	Expected change in intensity
	0 08 021	Time significance, Missing=cancel
		(SIGMET, Fcst position)
3 16 032	0 08 021	Time Significance, 4=Forecast

1 3-D features should be described by a set of horizontal sections in successive ascending flight levels.
2 Polygon should be described by a sequence of contiguous points.

	3 01 011	Year, Month, Day
	3 01 012	Hour, Minute
	0 08 007	Dimensional significance, 1=point, 2=area
	1 01 000	Replicate one descriptor
	0 31 001	Replication count
	3 01 023	Latitude, longitude
	0 08 007	Dimensional significance, Missing=cancel
	0 08 021	Time significance, Missing=cancel
		(SIGMET, Outlook)
3 16 033	0 08 021	Time Significance, 4=Forecast
	3 01 011	Year, Month, Day
	3 01 012	Hour, Minute
	1 07 000	Replicate 7 descriptors
	0 31 001	Replication count
	0 07 010	Flight level (base)
	0 07 010	Flight level (top)
	0 08 007	Dimensional significance, 1=point, 2=area, 3=volume
	3 01 027	Description of feature
	0 08 007	Dimensional significance, Missing=cancel
	0 08 021	Time significance, Missing=cancel
		(Volcanic Ash SIGMET)
3 16 034	3 16 030	SIGMET Header
	0 08 011	Meteorological feature, 17=Volcano
	0 01 022	Name of feature
	0 08 007	Dimensional significance, 0=Point
	3 01 023	Location
	0 08 007	Dimensional significance, Missing=Cancel
	0 20 090	Special Clouds, 5=Clouds from volcanic eruptions
	3 16 031	SIGMET Obs or Fcst location and motion
	1 01 000	Delayed replication
	0 31 000	Short replication factor
	3 16 032	SIGMET Fcst position
	1 01 000	Delayed replication
	0 31 001	Delayed replication factor
	3 16 033	SIGMET Outlook
	0 08 011	Meteorological feature, Missing=Cancel
		(Thunderstorm SIGMET)
3 16 035	3 16 030	SIGMET Header
	0 08 011	Meteorological feature, 21=Thunderstorm
	0 20 023	Other weather phenomenon, bit 2=Squalls or all 18 bits = Missing
	0 20 021	Type of precipitation, bit 14=Hail or all 30 bits=Missing
	0 20 008	Cloud distribution 15=OBSC, 16=EMBD, 12=FRQ, 31=Missing
	3 16 031	SIGMET Obs or Fcst location and motion
	0 08 011	Meteorological feature, Missing=Cancel

		(Tropical Cyclone SIGMET)
3 16 036	3 16 030	SIGMET Header
	0 08 011	Meteorological feature, 22=Tropical Cyclone
	0 01 027	WMO storm name
	3 16 031	SIGMET Obs or Fcst location and motion
	1 01 000	Delayed replication
	0 31 000	Short replication factor
	3 16 032	SIGMET Fcst position
	1 01 000	Delayed replication
	0 31 001	Delayed replication factor
	3 16 033	SIGMET Outlook
	0 08 011	Meteorological feature, Missing=Cancel
		(Turbulence SIGMET)
3 16 037	3 16 030	SIGMET header
	0 08 011	Meteorological feature, 13=Turbulence
	0 11 031	Degree of turbulence, 10=Mod, 11=Severe
	3 16 031	SIGMET Obs or Fcst location and motion
	0 08 011	Meteorological feature, Missing=Cancel
		(Icing SIGMET)
3 16 038	3 16 030	SIGMET header
	0 08 011	Meteorological feature, 15=Airframe Icing
	0 20 041	Airframe icing, 7=Severe
	0 20 021	Type of precip, bit 3=Liquid freezing precip or all 30 bits = Missing
	3 16 031	SIGMET Obs or Fcst location and motion
	0 08 011	Meteorological feature, Missing=Cancel
		(Mountain Wave SIGMET)
3 16 039	3 16 030	SIGMET header
	0 08 011	Meteorological feature, 23=Mountain Wave
	0 20 024	Intensity of phenomena, 5=Severe
	3 16 031	SIGMET Obs or Fcst location and motion
	0 08 011	Meteorological feature, Missing=Cancel
		(Duststorm SIGMET)
3 16 040	3 16 030	SIGMET header
	0 08 011	Meteorological feature, 24=Duststorm
	0 20 024	Intensity of phenomena, 3=Heavy
	3 16 031	SIGMET Obs or Fcst location and motion
	0 08 011	Meteorological feature, Missing=Cancel
		(Sandstorm SIGMET)
3 16 041	3 16 030	SIGMET header
	0 08 011	Meteorological feature, 25=Sandstorm
	0 20 024	Intensity of phenomena, 3=Heavy
	3 16 031	SIGMET Obs or Fcst location and motion
	0 08 011	Meteorological feature, Missing=Cancel

		(Cancellation of SIGMET)
3 16 042	3 16 030	SIGMET header
	0 08 079	Change in status of following product, 0 = Cancelled
	1 02 002	Replication of 2 descriptors two times (Define validity period)
	3 01 011	Year, Month, Day of the SIGMET to be cancelled
	3 01 012	Hour, Minute of the SIGMET to be cancelled
	0 01 037	SIGMET sequence identifier of the SIGMET to be cancelled
	0 10 064	SIGMET cruising level of the SIGMET to be cancelled
	0 08 079	Change in status of following product, Missing = Cancel

ANNEX TO 3.3

Common Code Table C-12: Sub-Centres of Originating Centres *(entries in Tables C-1 and C-11)*

ORIGINATING CENTRES		SUB-CENTRES	
Code figure	**Name**	**Code figure**	**Name**
C-1 C-11		*Octet 5, Section 1 of BUFR* *Octet 26, Section 1 of GRIB*	
		0	No Sub-Centre
Region IV			
00007	US NWS, NCEP	1	NCEP Reanalysis Project
		2	NCEP Ensemble Products
		3	NCEP Central Operations
		4	Environmental Modeling Center
		5	Hydrometeorological Prediction Center
		6	Marine Prediction Center
		7	Climate Prediction Center
		8	Aviation Weather Center
		9	Storm Prediction Center
		10	Tropical Prediction Center
		11	NWS Techniques Development Laboratory
		12	NESDIS Office of Research and Applications
		13	Federal Aviation Administration
		14	NWS Meteorological Development Laboratory
00161	U.S. NOAA Office of Oceanic and Atmospheric Research	1	Great Lakes Environmental Research Laboratory
		2	Forecast Systems Laboratory
Region VI			
00074	UK M.O., Bracknell (RSMC)	1	Shanwick Oceanic Area Control Centre

ANNEX TO 3.4.1

ADDITIONS FOR OCEANOGRAPHIC DATA

1) Proposed new BUFR descriptors for buoy data

Tab		BUFR				CREX		
Ref	Name	Unit	Scale	Ref	Width	Unit	Scale	Width
008xxx	Artificial correction of sensor height to another value	Code	0	0	3	Code	0	1
022xxx	Lagrangian drifter drogue status	Code	0	0	3	Code	0	1
008yyy	Type of equipment	Code	0	0	6	Code	0	2
025yyy	Battery voltage	V	1	0	12	V	1	4
025uuu	Operator or manufacture defined parameter	Num	1	-16384	15	Num	1	5

Type of equipment
Code table 0 08 yyy

0	Sensor
1	Transmitter
2	Receiver
3	Observing platform
4-62	Reserved
63	Missing value

0 02 038 to be used instead of 0 22 yyy suggestion, will need renaming to include salinity reference, for example

0 02 038 element name

“Method of water temperature and/or salinity measurement”

0 08 xxx
Artificial correction of sensor height to another value

Code figure	Meaning
0	Height is not corrected
1	Height is artificially corrected to standard level using a formula
2	Reserved
3	Missing value

Note: Standard level is indicated by the descriptor of class 7, which immediately follows. Value of this class 7 descriptor is forced to missing in case height is not corrected. It is possible to indicate the real height of the sensor by preceding the descriptor by relevant class 7 descriptor.

0 22 yyy
Lagrangian drifter drogue status

Code figure	Meaning
0	Drogue is detached
1	Drogue is attached
2	Drogue status unknown
3	Missing value

Proposed new template for buoy data

Proposed modifications appear in **bold and red** below

001003 - WMO region
001020 - WMO region sub-area
001005 - Buoy/platform identifier
002001 - Type of station
002036 - Buoy type
002149 - Type of data buoy
301011 - Date
301012 - Time
008021 - Time significance (value = “26" (time of last known position))
301011 - Date
301012 - Time
008021 - Time significance (value = "missing")
301021 - Latitude and longitude (high accuracy)
027004 - Alternate latitude (high accuracy)
028004 - Alternate longitude (high accuracy)
007030 - Height of station above MSL
001051 - Platform Transmitter ID (CCITT IA5)
002148 - Data collection and/or Location system
001012 - Platform drift direction
001014 - Platform drift speed
002040 - Method of removing platform direction and speed from current
033022 - Quality of buoy satellite transmission
033023 - Quality of buoy location
033027 - Location quality class (range of radius of 66% confidence)
022063 - Total water depth
302021 - Waves
302022 - Wind waves
302023 - Swell waves
008yyy – Type of equipment (observing platform)
025yyy – Battery voltage
008yyy – Type of equipment (transmitter)
025yyy – Battery voltage
008yyy – Type of equipment (receiver)
025yyy – Battery voltage
008yyy – Type of equipment – Value Missing = cancel
002034 - Drogue type
022yyy – Lagrangian drifter drogue status
007070 - Drogue depth
002190 - Lagrangian drifter submergence
025086 - Depth correction indicator
002035 - Cable length
002168 - Hydrostatic pressure of lower end of cable
020031 - Ice deposit (thickness)
002038 - Method of water temperature and/or salinity measurement
306004 - Digitization, depth/salinity method, depths/salinities/temperatures
002030 - Method of current measurement
306005 - Time/duration of current measurement, depths/directions/speeds
007031 - Height of barometer above MSL
008yyy – Type of equipment (sensor)
012064 - Instrument temperature
302001 - Pressure and pressure change
008yyy – Type of equipment – Value Missing = cancel
007032 - Height of sensor above marine deck platform (for temp.&hum. measurement)
007033 - Height of sensor above water surface (for temp.&hum. measurement)
012101 - Dry-bulb temperature (scale 2)
012103 - Dew-point temperature (scale 2)

013003 - Relative humidity
007032 - Height of sensor above marine deck platform (for wind measurement)
007033 - Height of sensor above water surface (for wind measurement)
008xxx – Artificial correction of sensor height to another value
007033 - Height of sensor above water surface (here height of anemometer to which it is artificially corrected)
002169 - Anemometer type
002002 - Type of instrumentation for wind measurement
008021 - Time significance (value = “2" (time averaged))
004025 - Time period in minutes
011001 - Wind direction
011002 - Wind speed
008021 - Time significance (value = "missing”)
004025 - Time period in minutes
011043 - Maximum wind gust direction
011041 - Maximum wind gust speed
008xxx – Artificial correction of sensor height to another value (set to missing to reset previous value)
007033 - Height of sensor above water surface (set to missing to cancel previous value)
007032 - Height of sensor above marine deck platform (for precipitation measurement)
004024 - Time period in hours
013011 - Total precipitation
007032 - Height of sensor above marine deck platform (set to missing to cancel the previous value)
008021 - Time significance (value = “3" (accumulated))
004024 - Time period in hours
014021 - Global radiation, integrated over period specified
008021 - Time significance (value = "missing”)
025yyy – Operator or manufacturer defined parameter (#1)
025yyy – Operator or manufacturer defined parameter (#2)
025yyy – Operator or manufacturer defined parameter (#3)

2) Requirements by the Ship Of Opportunity Programme (SOOP)

Additions to BUFR tables required

Additions needed to Common code table C-3, Instrument type for water profile measurement with fall rate equation coefficients

Code figure for $I_xI_xI_x$	Code figure for BUFR (code table 0 22 067)	Instrument Make	Equation Coefficients	
			a	b
855	855	Profiling Float, NINJA, no conductivity sensor	Not applicable	
856	856	Profiling Float, NINJA, SBE conductivity sensor	Not applicable	
857	857	Profiling Float, NINJA, FSI conductivity sensor	Not applicable	
858	858	Profiling Float, NINJA, TSK conductivity sensor	Not applicable	
900	900	Sippican T-12 XBT	9.727	-0.0000473

Additions needed to Common code table C-4, Water temperature profile recorder types

Code figure for X_RX_R	Code for BUFR (Code table 0 22 068)	Recorder type
70	70	CSIRO Devil-1 XBT acquisition system
71	71	CSIRO Devil-2 XBT acquisition system

ANNEX TO 3.4.2

CLARIFICATION TO BUFR REGULATION

Note (1) to Class 04 should be modified from “shall be indicated…” to: "… may be indicated …".

ANNEX TO 3.4.3

FOR SHIP TEMPLATES

Add Note in Templates of SHIP to descriptor 0 01 012:

*Means course made good (average course over the ground) during the three hours preceding the time of observation

Add Note in Templates of SHIP to descriptor 0 01 013:

*****Means speed made good (average speed over the ground) during the three hours preceding the time of observation

Add a Note in Table B to descriptors 0 01 012 and 0 01 013 indicating the parameters may have different meanings and the corresponding value may be integrated on different periods.

ANNEX TO 3.4.4

BUFR TEMPLATES FOR VERTICAL SOUNDING DATA WITH DESCRIPTION OF RADIOSONDE POSITION DURING THE ASCENT

1 BUFR templates for PILOT, PILOT SHIP, PILOT MOBIL

a) with pressure as the vertical coordinate

		Identification and instrumentation	
3 01 001	0 01 001	WMO block number	Numeric
	0 01 002	WMO station number	Numeric
0 01 011		Ship or mobile land station identifier	CCITT IA5
0 02 011		Radiosonde type	Code table
0 02 014		Tracking technique/status of system used	Code table
0 02 003		Type of measuring equipment used	Code table
		Nominal date/time, horizontal and vertical coordinates of launch site	
3 01 011	0 04 001	Year	Year
	0 04 002	Month	Month
	0 04 003	Day	Day
3 01 012	0 04 004	Hour	Hour
	0 04 005	Minute	Minute
3 01 021	0 05 001	Latitude (high accuracy)	Degree, scale 5
	0 06 001	Longitude (high accuracy)	Degree, scale 5
0 07 030		Height of station ground above mean sea level	m, scale 1
0 07 031		Height of barometer above mean sea level	m, scale 1
0 07 007		Height of release of sonde above mean sea level	m
0 33 024		Station elevation quality mark (for mobile stations)	Code table
		Date/time of the launch	
0 08 021		Time significance (value = 18 (launch time))	Code table
3 01 011	0 04 001	Year	Year
	0 04 002	Month	Month
	0 04 003	Day	Day
3 01 012	0 04 004	Hour	Hour
	0 04 005	Minute	Minute
		Level data	
1 07 000		Delayed replication of 7 descriptors	
0 31 001		Delayed descriptor replication factor	Numeric
		Data from a single level	
0 04 016		Time increment in seconds (since launch time)	
0 08 001		Vertical sounding significance	Flag table
0 07 004		Pressure	Pa, scale –1
0 05 011		Latitude increment since launch site (high accuracy)	Degree, scale 5
0 06 011		Longitude increment since launch site (high accuracy)	Degree, scale 5
0 11 001		Wind direction	Degree true
0 11 002		Wind speed	m s^{-1}, scale 1
		Wind shear data	
0 08 001		Vertical sounding significance	Flag table
0 07 004		Pressure	Pa, scale –1
3 01 023	0 05 002	Latitude (coarse accuracy)	Degree, scale 2
	0 06 002	Longitude (coarse accuracy)	Degree, scale 2
0 11 061		Absolute wind shear in 1 km layer below	m s^{-1}, scale 1

0 11 062		Absolute wind shear in 1 km layer above	m s^{-1}, scale 1

b) with height as the vertical coordinate

		Identification and instrumentation	
3 01 001	0 01 001	WMO block number	Numeric
	0 01 002	WMO station number	Numeric
0 01 011		Ship or mobile land station identifier	CCITT IA5
0 02 011		Radiosonde type	Code table
0 02 014		Tracking technique/status of system used	Code table
0 02 003		Type of measuring equipment used	Code table
		Nominal date/time, horizontal and vertical coordinates of launch site	
3 01 011	0 04 001	Year	Year
	0 04 002	Month	Month
	0 04 003	Day	Day
3 01 012	0 04 004	Hour	Hour
	0 04 005	Minute	Minute
3 01 021	0 05 001	Latitude (high accuracy)	Degree, scale 5
	0 06 001	Longitude (high accuracy)	Degree, scale 5
0 07 030		Height of station ground above mean sea level	m, scale 1
0 07 007		Height of release of sonde above mean sea level	m
0 33 024		Station elevation quality mark (for mobile stations)	Code table
		Date/time of the launch	
0 08 021		Time significance (value = 18 (launch time))	Code table
3 01 011	0 04 001	Year	Year
	0 04 002	Month	Month
	0 04 003	Day	Day
3 01 012	0 04 004	Hour	Hour
	0 04 005	Minute	Minute
		Level data	
1 07 000		Delayed replication of 7 descriptors	
0 31 001		Delayed descriptor replication factor	Numeric
		Data from a single level	
0 04 016		Time increment in seconds (since launch time)	
0 08 001		Vertical sounding significance	Flag table
0 07 004		Pressure	Pa, scale –1
0 05 011		Latitude increment since launch site (high accuracy)	Degree, scale 5
0 06 011		Longitude increment since launch site (high accuracy)	Degree, scale 5
0 11 001		Wind direction	Degree true
0 11 002		Wind speed	m s^{-1}, scale 1
		Wind shear data	
0 08 001		Vertical sounding significance	Flag table
0 07 009		Geopotential height	gpm
3 01 023	0 05 002	Latitude (coarse accuracy)	Degree, scale 2
	0 06 002	Longitude (coarse accuracy)	Degree, scale 2
0 11 061		Absolute wind shear in 1 km layer below	m s^{-1}, scale 1
0 11 062		Absolute wind shear in 1 km layer above	m s^{-1}, scale 1

Notes: (1) If horizontal coordinates of the sonde are not available, latitude and longitude (coarse accuracy) of the location of launch shall be reported for 3 01 023.

2.2 BUFR templates for TEMP, TEMP DROP, TEMP SHIP, TEMP MOBIL

		Identification and instrumentation	
3 01 001	0 01 001	WMO block number	Numeric
	0 01 002	WMO station number	Numeric
0 01 011		Ship or mobile land station identifier	CCITT IA5
0 01 006		Aircraft identifier (for dropsondes)	CCITT IA5
0 02 011		Radiosonde type	Code table
0 02 013		Solar and infrared radiation correction	Code table
0 02 014		Tracking technique/status of system used	Code table
0 02 003		Type of measuring equipment used	Code table
		Nominal date/time, horizontal and vertical coordinates of launch site	
3 01 011	0 04 001	Year	Year
	0 04 002	Month	Month
	0 04 003	Day	Day
3 01 012	0 04 004	Hour	Hour
	0 04 005	Minute	Minute
3 01 021	0 05 001	Latitude (high accuracy)	Degree, scale 5
	0 06 001	Longitude (high accuracy)	Degree, scale 5
0 07 030		Height of station ground above mean sea level	m, scale 1
0 07 031		Height of barometer above mean sea level	m, scale 1
0 07 007		Height of release of sonde above mean sea level	m
0 33 024		Station elevation quality mark (for mobile stations)	Code table
		Sea water temperature	
0 22 043		Sea/water temperature (for ship stations)	K, scale 2
		Cloud data	
0 08 002		Vertical significance	Code table
0 20 011		Cloud amount (of low or middle clouds N_h)	Code table
0 20 013		Height of base of cloud (h)	m, scale –1
0 20 012		Cloud type (low clouds C_L)	Code table
0 20 012		Cloud type (middle clouds C_M)	Code table
0 20 012		Cloud type (high clouds C_H)	Code table
		Date/time of the launch	
0 08 021		Time significance (value = 18 (radiosonde launch time))	Code table
3 01 011	0 04 001	Year	Year
	0 04 002	Month	Month
	0 04 003	Day	Day
3 01 012	0 04 004	Hour	Hour
	0 04 005	Minute	Minute
		Level data	
1 10 000		Delayed replication of 10 descriptors	
0 31 001		Delayed descriptor replication factor	Numeric
		Data from a single level	
0 04 016		Time increment (since the launch time)	Seconds
0 08 001		Vertical sounding significance	Flag table
0 07 004		Pressure	Pa, scale –1
0 10 009		Geopotential height	gpm
0 05 011		Latitude increment since launch site (high accuracy)	Degree, scale 5
0 06 011		Longitude increment since launch site (high accuracy)	Degree, scale 5
0 12 101		Temperature/dry-bulb temperature (scale 2)	K, scale 2
0 12 103		Dew-point temperature (scale 2)	K, scale 2

0 11 001		Wind direction	Degree true
0 11 002		Wind speed	m s^{-1}, scale 1
		Wind shear data	
0 08 001		Vertical sounding significance	Flag table
0 07 004		Pressure	Pa, scale –1
3 01 023	0 05 002	Latitude (coarse accuracy)	Degree, scale 2
	0 06 002	Longitude (coarse accuracy)	Degree, scale 2
0 11 061		Absolute wind shear in 1 km layer below	m s^{-1}, scale 1
0 11 062		Absolute wind shear in 1 km layer above	m s^{-1}, scale 1

Notes: (1) If horizontal coordinates of the sonde are not available, latitude and longitude (high accuracy) of the location of launch shall be reported for 3 01 023.

ANNEX TO 3.4.5

ADDITION TO CODE TABLES

Vertical significance 0 08 002 Only adding two entries to 0 08 002

10 Cloud layer with base below and top above the station
11 Cloud layer with base and top below station level

To clarify the meaning o existing 0 08 002 entries

1 First non-Cb significant layer
2 Second non-Cb significant layer
3 Third non-Cb significant layer

Validation of BUFR template for SYNOP (and SYNOP MOBIL)

To modify the name of 0 20 014 to read (in Template):

Height of top of the clouds above mean sea level.

Example of BUR template expressing the significant cloud layers using delayed replication

BUFR template for SYNOP and SYNOP MOBIL data

		Surface station identification, time, horizontal and vertical coordinates	Unit, scale
3 01 001	0 01 001	WMO block number **II**	Numeric, 0
	0 01 002	WMO station number **iii**	Numeric, 0
0 01 015		Station or site name	CCITT IA5, 0
0 01 011		Mobile land station identifier **D.....D** = missing for fixed land stations	CCITT IA5, 0
0 01 003		WMO region number	Code table, 0
0 02 001		Type of station	Code table, 0
3 01 011	0 04 001	Year	Year, 0
	0 04 002	Month	Month, 0
	0 04 003	Day **YY**	Day, 0
3 01 012	0 04 004	Hour **GG**	Hour, 0
	0 04 005	Minute **gg**	Minute, 0
3 01 021	0 05 001	Latitude (high accuracy)	Degree, 5
	0 06 001	Longitude (high accuracy)	Degree, 5
0 07 030		Height of station ground above msl	m, 1
0 07 031		Height of barometer above msl	m, 1
0 33 024		Station elevation quality mark **i_m** = missing for fixed land stations	Code table, 0
		Pressure data	
3 02 001	0 10 004	Pressure **$P_oP_oP_oP_o$**	Pa, –1
	0 10 051	Pressure reduced to mean sea level **PPPP**	Pa, –1
	0 10 061	3-hour pressure change **ppp**	Pa, –1
	0 10 063	Characteristic of pressure tendency **a**	Code table, 0
0 07 004		Pressure (standard level) **a_3** = 925, 850, 700, ..hPa = missing for lowland stations	Pa, –1
0 10 009		Geopotential height of the standard level **hhh** = missing for lowland stations	gpm, 0
		Temperature and humidity data	
0 07 032		Height of sensor above local ground (for temperature measurement)	m, 2
0 12 101		Temperature/dry-bulb temperature (sc. 2) **s_nTTT**	K, 2
0 12 103		Dew-point temperature (sc. 2) **$s_nT_dT_dT_d$**	K, 2
0 13 003		Relative humidity	%, 0
		Visibility data	
0 07 032		Height of sensor above local ground (for visibility measurement)	m, 2
0 20 001		Horizontal visibility **VV**	m, –1
		Precipitation past 24 hours	
0 07 032		Height of sensor above local ground (for precipitation measurement)	m, 2
0 13 023		Total precipitation past 24 hours **RRRR** trace = - 0.1 **(gr. 7RRRR)**	kg m^{-2}, 1

0 07 032		Height of sensor above local ground (set to **missing** to cancel the previous value)	m, 2
		Cloud data	
3 02 004	0 20 010	Cloud cover (total) **N** If N = 9, /, then 0 20 010 = missing.	%, 0
	0 08 002	Vertical significance if only C_L are observed, 0 08 002 = 7 (low cloud), if only C_M are observed, 0 08 002 = 8 (middle cloud), if only C_H are observed, 0 08 002 = 9 (high cloud), if N = 9, then 0 08 002 = 5, if N = 0 or /, then 0 08 002 = missing; else 0 08 002 = 0	Code table, 0
	0 20 011	Cloud amount (of low or middle clouds) $\mathbf{N_h}$ If N = 0, then 0 20 011 = 0, if N = 9, then 0 20 011 = 9, if N = /, then 0 20 011 = missing.	Code table, 0
	0 20 013	Height of base of cloud **h** If N = 0 or /, then 0 20 013 = missing. If clouds with bases below and tops above station level are reported, 0 20 013 = missing or has a negative value.	m, –1
	0 20 012	Cloud type (low clouds) $\mathbf{C_L}$ 0 20 012 = C_L + 30, if N = 0, then 0 20 012 = 30, if N = 9 or /, then 0 20 012 = 62.	Code table, 0
	0 20 012	Cloud type (middle clouds) $\mathbf{C_M}$ 0 20 012 = C_M + 20, if N = 0, then 0 20 012 = 20, if N = 9 or / or C_M = /, then 0 20 012 = 61.	Code table, 0
	0 20 012	Cloud type (high clouds) $\mathbf{C_H}$ 0 20 012 = C_H + 10, if N = 0, then 0 20 012 = 10, if N = 9 or / or C_H = /, then 0 20 012 = 60.	Code table, 0
1 01 000		Delayed replication of 1 descriptor	
0 31 001		Delayed descriptor replication factor If sky clear (N = 0), then 0 31 001 = 0 (no significant cloud layer data)	Numeric, 0
3 02 005	0 08 002	Vertical significance In any Cb layer, 0 08 002 = 4 , else: in the first replication: if N = 9, then 0 08 002 = 5, if N = /, then 0 08 002 = missing, else 0 08 002 = 1; in the other replications 0 08 002 = 2, 3, 4**.**	Code table, 0
	0 20 011	Cloud amount $\mathbf{N_s}$ In the first replication: If N = /, then 0 20 011 = missing, else 0 20 011 = $\mathbf{N_s}$; in the other replications 0 20 011 = $\mathbf{N_s}$.	Code table, 0
	0 20 012	Cloud type **C** if N = 9, /, then 0 20 012 = missing, else 0 20 012 = **C**.	Code table, 0
	0 20 013	Height of base of cloud $\mathbf{h_s h_s}$ If clouds with bases below and tops above station level are reported, 0 20 013 = missing or has a negative value.	m, -1

		Clouds with bases below station level (SYNOP, Section 4)	
1 05 000		Delayed replication of 5 descriptors	
0 31 001		Delayed descriptor replication factor If no clouds with bases below station level are observed, then 0 31 001 = 0	Numeric, 0
0 08 002		Vertical significance = 10 or 11	Code table, 0
0 20 011		Cloud amount **N'**	Code table, 0
0 20 012		Cloud type **C'**	Code table, 0
0 20 014		Height of top of cloud above mean sea level **H'H'**	m, -1, 4
0 20 017		Cloud top description **C_t**	Code table, 0
		State of ground, snow depth, ground minimum temperature	
0 20 062		State of ground (with or without snow) **E or E'** If E = <0, ... , 9>, then 0 20 062 = E, if E' = <0, ... , 9>, then 0 20 062 = E' + 10, if state of ground is not reported, 0 20 062 = missing.	Code table, 0
0 13 013		Total snow depth **sss** no snow cover = 0 less than 0.005 m = - 0.01 (sss = 997) not continuous = - 0.02 (sss = 998) If snow depth not reported, 0 13 013 = missing.	m, 2
0 12 113		Ground minimum temperature, sc.2, past 12 hours **$s_nT_gT_g$**	K, 2
		Present and past weather	
0 20 003		Present weather **ww**	Code table, 0
0 04 024		Time period At 00, 06, 12, 18 UTC **= - 6.** At 03, 09,15, 21 UTC **= - 3.**	Hour, 0
0 20 004		Past weather (1) **W_1**	Code table, 0
0 20 005		Past weather (2) **W_2**	Code table, 0
		Evaporation measurement	
0 04 024		Time period in hours **= - 24**	Hour, 0
0 02 004		Type of instrument for evaporation or crop type for evapotranspiration **i_E**	Code table, 0
0 13 033		Evaporation /evapotranspiration **EEE**	kg m^{-2}, 1
		Sunshine data	
0 04 024		Time period in hours **= - 24**	Hour, 0
0 14 031		Total sunshine in minutes **SSS**	Minute, 0
		Radiation data	
0 04 025		Time period in minutes **= - 60**	Minute, 0
0 14 002		Long-wave radiation, integrated over period specified 553SS 4**FFFF** or 553SS 5**FFFF**	J m^{-2}, -3
0 14 004		Short-wave radiation, integrated over period specified 553SS 6**FFFF**	J m^{-2}, -3
0 14 016		Net radiation, integrated over period specified 553SS 0**FFFF** or 553SS 1**FFFF**	J m^{-2}, -4
0 14 028		Global solar radiation (high accuracy), integrated over period specified 553SS 2**FFFF**	J m^{-2}, -2
0 14 029		Diffuse solar radiation(high accuracy), integrated over period specified 553SS 3**FFFF**	J m^{-2}, -2
0 14 030		Direct solar radiation (high accuracy), integrated over period specified 55408 4**FFFF**	J m^{-2}, -2
		Precipitation measurement	

0 07 032		Height of sensor above local ground (for precipitation measurement)	m, 2
1 02 002		Replicate next 2 descriptors 2 times	
0 04 024		Time period in hours **t_R**	Hour, 0
0 13 011		Total precipitation / total water equivalent of snow **RRR** no precipitation = 0 trace = - 0.1	kg m^{-2}, 1
		Extreme temperature data	
0 07 032		Height of sensor above local ground (for temperature measurement)	m, 2
0 04 024		Time period in hours	Hour, 0
0 04 024		Time period in hours (see Note 1) (= 0, if the period ends at the time of observation)	Hour, 0
0 12 111		Maximum temperature at height and over period specified **$s_nT_xT_xT_x$**	K, 2
0 04 024		Time period in hours	Hour, 0
0 12 112		Minimum temperature at height and over period specified **$s_nT_nT_nT_n$**	K, 2
		Wind data	
0 07 032		Height of sensor above local ground (for wind measurement)	m, 2
0 02 002		Type for instrumentation for wind measurement **i_w**	Flag table, 0
0 08 021		Time significance **= 2** (time averaged)	Code table, 0
0 04 025		Time period **= - 10** (or number of minutes after a significant change of wind, if any)	Minute, 0
0 11 001		Wind direction **dd** If dd = 00 (calm) or dd = 99 (variable), 0 11 001 = 0.	Degree true, 0
0 11 002		Wind speed **ff**	m s^{-1}, 1
0 08 021		Time significance (set to **missing** to cancel the previous value)	Code table, 0
1 03 002		Replicate next 3 descriptors 2 times	
0 04 025		Time period	Minute, 0
0 11 043		Maximum wind gust direction	Degree true, 0
0 11 041		Maximum wind gust speed e.g. **f_mf_m** and **f_xf_x** (gr. 910f_mf_m and gr. 911f_xf_x)	m s^{-1}, 1

Notes:

1) Within RA-IV, the maximum temperature at 1200 UTC is reported for the previous calendar day (i.e. the ending time of the period is not equal to the nominal time of the report). To construct the required time range, descriptor 004024 has to be included two times. If the period ends at the nominal time of the report, value of the second 004024 shall be set to 0.

ANNEX TO 3.5.4

Proposed modified Section 1 for BUFR Edition 4 for full date inclusion:

13-14	Year (4 digits)	|
15	Month	|
16	Day	| Most typical for the BUFR message content
17	Hour	|
18	Minute	|
19	Second	|
20-	Reserved for local use by ADP centres	

ANNEX TO 3.5.5

Modify regulation 94.1.3 to say:

94.1.3 Each section included in the code form shall always contain an integer multiple of 8 bits (octet). This rule shall be applied by appending bits set to zero to the section where necessary.

ANNEX TO 5

MODIFICATIONS TO THE LAYER 3 OF THE GRIB2 GUIDE

Text to be replaced at page 74 (after formula giving the pressure at a given sigma level)

The hybrid coordinate system has been introduced in numerical models to have both sigma-type levels near the earth and pressure levels at the top of the atmosphere. The above formula is generalized as follows:

$$P_h = a_h \bullet P_{sfc} + b_h$$

Hybrid vertical coordinate values, when present, are encoded as the pair of numbers a_h and b_h in IEEE 32-bit floating point format. Each pair *…(remaining text unchanged)*

NOTE: also change "a • σ" *and* "b • P" *references in following expanded example (p. 75) to* (a_1, b_1) … (a_{10}, b_{10}).

Complex packing

*Note pages **80 and 85** within the Guide: text to be inserted as a substitute to Cliff remarks at these pages (**end of 3.3.1.1** and **end of 3.3.2.1**).*

As pointed out in the GRIB2 Manual, complex packing for grid-point is intended to reduce data section size as compared to simple packing. This is achieved at the expense of extra descriptors per group. In order to keep the volume of these descriptors as low as possible, group widths and lengths have their minimum value subtracted. As a complement, lengths may be scaled using the length increment feature.

This may be used in conjunction with splitting algorithm to determine groups of data. Efficient algorithms with a good quality/price ratio are based on the determination of groups starting from a basic length, say B, and possible extensions of either B or a shorter (incremental) length I. For example, B and I could be 15 and 3, respectively.

In such a case, all groups (but the last one) will have a minimum length of B and length increments multiple of I (assuming B is a multiple of I, which is easy to choose). So B would be stored in octets 38-41, I in octet 42, and the effective length of last groups (reference for group lengths not removed) in octets 43-46.

Finally, the number of bits N_L necessary to store the scaled group lengths (the Kn values in Note 14 of the Manual) will be stored in octet 47. Note that as soon as I is bigger than 1, N_L is reduced relative to using an increment of 1, leading to save space in Data Section.

The Kn values are stored in Data Section for all NG groups. The encoded value of Kn for n= NG is not relevant for decoding, and a zero value may be used.

Spatial differencing

Note page 84 of the Guide. All modifications to be done on this page:

Change start of first sentence of first paragraph as follows:

“For first order spatial differencing, a field of scaled values f (integers) is replaced by….”

In second paragraph, change 3rd sentence as follows:

“The overall minimum of the difference values will usually be negative therefore the Note (4) of Data Template 7.3 about the sign bit applies.”

ANNEX TO 7.1.2

In order to facilitate the processing of requests for allocation of new table entries by the Secretariat, the Team agreed to a standard format for definition of new descriptors when passing the information in document or email.

The format should be:

In Word table format as (possible in Attached file, ftp, etc..):

TABLE REFERENCE			TABLE ELEMENT NAME	BUFR				CREX		
F	X	Y		UNIT	SCALE	REF. VALUE	DATA WIDTH (Bits)	UNIT	SCALE	DATA WIDTH (Characters)
0	01	001	WMO block number	Numeric	0	0	7	Numeric	0	2
0	01	002	WMO station number	Numeric	0	0	10	Numeric	0	3

Or in ASCII as (column separated by space, but inside name with dash):

0 01 001 WMO-Block-number Numeric 0 0 7 Numeric 0 2

or as (column separated by commas, but inside name with space):

0,01,001,WMO Block number, Numeric,0,0,7,Numeric,0,2

ANNEX LIST OF ACRONYMS

ACARS	AirCraft Addressing and Reporting System
ADS	Astrophysics Data System (USA)
AFWA	Air Force Weather Agency
AIRS	Advanced Infra-Red Sounder
AMDAR	Aircraft Meteorological Data Relay
AMSU	Advanced Microwave Sounding Unit
ANSI	American National Standards Institute
API	Application Program Interface
AWIPS	Advanced Weather Interactive Processing System
AWS	Automatic Weather Station
ATSR	Along Tack Scanning Radiometer
BUFR	Binary Universal Form for data Representation
CBS	Commission for Basic Systems
CBS-Ext.(98)	Extraordinary session of CBS held in 1998
CCl	Commission for Climatology (WMO)
CIMO	Commission for Instruments and Methods of Observations
COST	European Co-Operation in the field of Scientific and Technical research
CREX	Character Representation form for data EXchange
DBCP	Drifting Buoy Cooperation Panel
DBMS	Data Base Management System
DCP	Data Collection Platform
DIF	Directory Interchange Format
DPFS	Data Processing and Forecasting Systems
DRT	Data Representation Template
DT	Data Template
DWD	Deutscher Wetter Dienst
EANPG	European Air Navigation Planning Group
EARS	EUMETSAT ATOVS Retransmission Service
EC	Executive Council of the WMO
ECMWF	European Centre for Medium-range Weather Forecast
EGOWS	European Group on Operational Worskstation Systems
EPS	Ensemble Prediction System
ESA	European Space Agency
ET	Expert Team
ET/EDF	Expert Team on Evolution of Data Formats
ET/DR&C	Expert Team on Data Representation and Codes
EUMETNET	European Meteorological Networks
EUMETSAT	EUropean organisation for the exploitation of METeorological SATellites
FNMOC	Fleet Numerical Meteorology and Oceanography Centre
FORTRAN	FORmula TRANslation
FTP	File Transfer Protocol
GDPS	Global Data Processing System
GDT	Grid Definition Template
GIF	Graphic Interchange Format
GIS	Geographic Information System
GOS	Global Observing System
GRIB 1	Processed data in the form of GRId-point values expressed in Binary form - GRIB Edition 1
GRIB 2	General Regularly distributed Information in Binary form - GRIB Edition 2
GTS	Global Telecommunications System
HTML	Hyper Text Markup Language
ICAO	International Civil Aviation Organisation
ICT	Implementation/Coordination Team (of CBS)
ICT/DRC	Implementation/Coordination Team on Data Representation and Codes
ID	Identifier
IEC	International Electrotechnical Commission
IEEE	Institution of Electrical and Electronics Engineers
IOC	International Oceanographic Commission
ISO	International Standards Organization
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JMA	Japan Meteorological Agency

JPEG	Joint Photographic Experts Group format
LINUX	*Not an acronym – name of an operating system*
MS/DOS	/Disk Operating System
MSG	METEOSAT Second Generation
MSS	Message Switching System
MTDCF	Migration to Table Driven Code Forms
MTN	Main Telecommunications Network (of the GTS)
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Centre (USA)
NCEP	National Centre for Environment Prediction (USA)
NESDIS	National Environmental Satellite Data and Information Service
NMC	National Meteorological Centre
NMHS	National Meteorological or Hydrological Service
NMS	National Meteorological Service
NWP	Numerical Weather Prediction
NWS	National Weather Service
OMF	weather Observation Markup Format
OPAG	Open Programme Area Group (of CBS)
OPAG-ISS	Open Programme Area Group on Information Systems and Services
PDT	Product Definition Template
PNG	Portable Network Graphic
RA	Regional Association (WMO)
RASS	Radio Acoustic Sounding System
RDBC	Regional Data Bank Centre
RSMC	Regional Specialised Meteorological Centre
RTH	Regional Telecommunication Hub
SGDR&C	Sub-Group on Data Representation and Codes (CBS)
SGML	Standard Generalized Markup Language
SI	System International
SOOP	Ship Of Opportunity Programme
SST	Sea Surface Temperature
TCP	Tropical Cyclone Programme
TCP/IP	Transport Control Protocol/Internet Protocol
TDL	Techniques Development Laboratory
TIFF	Tagged Image File Format
UKMO	United Kingdom Meteorological Office
UNIX	*Not an acronym – name of an operating system*
UTC	Universal Time Coordinate
VOS	Voluntary Observing Ship
WAFC	World Area Forecasting Centre (ICAO)
WAFS	World Area Forecasting System
WGDM	Working Group on Data Management (CBS)
WGS	Working Group on Standards
WMO	World Meteorological Organization
WWW	World Weather Watch
W3C	World Wide Web Consortium
XBT	eXpendable Bathy Thermograph
XCTD	eXpendable Conductivity Temperature Depth sensor
XML	eXtensible Markup Language