WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

JOINT WMO/IOC TECHNICAL COMMISSION FOR OCEANOGRAPHY AND MARINE METEOROLOGY (JCOMM)
EXPERT TEAM ON MARINE CLIMATOLOGY

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SECOND SESSION

ITEM 3.3

GENEVA, SWITZERLAND, 26 TO 27 MARCH 2007

Original: ENGLISH

DATA QUALITY AND EXCHANGE

Review of the status of marine and oceanographic BUFR templates

(Submitted by the Secretariats)

Summary and purpose of document

This document summarizes the issues regarding the GTS table driven coding requirements for ship-based and other marine and oceanographic observations. This document is similar to one that will be presented to the upcoming Fourth Session of the SOT (SOT-IV, Geneva, Switzerland, 16-21 April 2007).

ACTION PROPOSED

The Expert Team on Marine Climatology is invited to:

(a) Review the current situation regarding ocean related BUFR templates;

(b) Formulates a proposal to address the requirements for FM13 to BUFR conversion;

(c) Discuss possibilities for a continuing ETMC role in the implementation of table driven formats, including the important potential role of automated validation of data integrity;

(d) Review existing climate related templates (B/C32, B/C35);

(e) Make specific suggestions and recommendations to the upcoming SOT-IV for its consideration regarding concerns of ship-based observations, as necessary and/or appropriate.

Appendices: A. Terms of References of the SOT Task Team on Coding
B. Terms of References of the JCOMM DMPA Task Team on Table Driven Codes
C. PMO-III Recommendations on Migration from Ship to BUFR
D. Code Migration Schedule
E. List of proposed fields for inclusion in a new BUFR template for VOS data
F. BUFR template for synoptic reports from sea stations suitable for VOS observation data (B/C10 – Reporting SHIP data in TDCF)
G. BUFR Template for VOS data
H. BUFR Template for ASAP data (B/C25 – Reporting TEMP, TEMP SHIP and TEMP

MOBIL data in TDCF)

I. BUFR template for XBT/XCTD report (sequence 3 15 004)
J. BUFR Template for TRACKOB data (Approved by CBS Ext. 6)
K. B/C32 – Reporting CLIMAT SHIP data in TDCF
L. B/C35 – Reporting CLIMAT TEMP and CLIMAT TEMP SHIP and data in TDCF
M. Additional comparisons of NCEP BUFR with FM 13 GTS messages (2006 data)

DISCUSSION

1. Ship Observations Team (SOT) requirements

1.1 VOS

1.1.1 The Third Session of the SOT (SOT-III, Brest, France, 7-12 March 2005) discussed the GODAE High Resolution SST Pilot Project (GHRSST) requirements for the GTS distribution of SST data, and decided to establish a Task Team on Coding to be chaired by Dr Craig Donlon, to address this issue. The Members and Terms of Reference (ToR) of the Task Team are provided in Appendix A to this document.

1.1.2 The Task Team had then been working via email and submitted a proposal to the CBS Expert Team on Data Representation and Codes (ET-DRC) for its meeting in Montreal, Canada, 8-12 May 2006. The Task Team proposed additions for the SST temperature type/method of measurement, as well as the depth of measurement below the sea surface. As the VOS SHIP template was still being considered for other requirements (PMO-III recommendations, META-T), it was not proposed to substantially change the template at the time of the ET-DRC meeting. Only the following modifications related to: (i.) B/C10, "Regulations for reporting SHIP data in TDCF", and (ii.) to the BUFR template for synoptic reports from sea stations suitable for VOS observation data have been proposed as pre-operational (see Appendix F):

- New entries in code table 0 02 038 "Method of water temperature and/or salinity measurement" to deal with additional methods such as infrared radiometer, in line thermosalinograph, and towed body";
- New descriptor 0 07 063 "Depth below sea water surface" (High resolution) to provide for higher resolution of depth (scale=2, i.e. 1cm);
- Change sequence 3 02 056 for adding descriptor 0 07 063 for indicating water temperature depth. So the sequence 3 02 056 (comprised of 0 02 038 "Method of sea surface temperature measurement" and 0 22 043 "Sea/water temperature") in the templates was replaced by the new one.

1.1.3 It must be noted that there are now three different templates (existing or proposals) for VOS data:

- B/C10, "Regulations for Reporting SHIP data in TDCF" (see Appendix F). This is basically a translation of FM-13 SHIP data into BUFR;
- BUFR Template for VOS data (see Appendix G). This is the result of past discussions between the ET-DRC, the SOT, and various experts regarding the requirement for the GTS distribution of VOS data. Specific requirements such as the need to report sensor height have been added;
- PMO-III list of required fields for the VOS and VOSClim (see Appendix C). See below for details regarding this issue.

1.1.4 The SOT might consider how many templates will eventually be needed, bearing in mind that this number should be kept to a minimum. One or two templates/list(s) might be merged or integrated in a new template that would supersede them.

1.2 SOOPIP

1.2.1 The existing BUFR template for the XBT and XCTD data is listed in Appendix I to this document. The SOT-III agreed that this template met most of the current requirements for GTS distribution of such data. The SEAS, USA is now evaluating development costs for starting GTS distribution of XBT data in BUFR using the existing template. The SOT Technical Coordinator and SEAS will report on progress at upcoming SOT-IV. The SOT will be invited to make further suggestions and/or recommendations in that regard as necessary and/or appropriate.

1.2.2 Regarding ADCP data, the SOT-III invited Member States presently making ADCP measurements and having the capability and willingness of transmitting the data in real-time on the GTS to work with the SOT in order to study feasibility of using BUFR. The Meeting therefore asked such Members States to designate appropriate contact points to work with the SOOP Coordinator in order to work on potential impact of developing BUFR encoding/distribution capabilities and to work out a proposed BUFR template for ADCP data. Once a template was agreed upon, the Meeting invited the SOOP Coordinator to submit proposed template to the ET-DRC. This will have to be coordinated with the META-T Pilot Project in liaison with the newly established JCOMM/DMCG Table Driven Codes Group.

1.3 ASAP

1.3.1 The SOT-III noted that high-resolution ASAP sounding data were required for new modeling. The Meeting also noted that such high-resolution data could be collected using BUFR codes, be archived in relevant national archives and be made available on their websites after each cruise. The Meeting suggested that the E-ASAP store high-resolution data, if appropriate and possible.

1.3.2 The E-ASAP recently explained that BUFR capabilities still needed to be developed. Data telecommunication costs associated with the distribution of higher-resolution data remains an issue.

1.3.3 The SOT will be invited to discuss whether there will be a need to revise existing ASAP template (see Appendix H).

1.4 GOSUD

1.4.1 The SOT-III noted that the GOSUD was developing a BUFR template to move beyond limitations imposed by the present character code form TRACKOB in order to consider new requirements such as for pCO_2 and those expressed by the SAMOS. The GOSUD will be invited to report on progress.

1.4.2 The ET-DRC, at its meeting in Muscat, Oman, from 5 to 8 December 2005, approved for validation the TRACKOB template and sequence that had been proposed by the Japan Meteorological Agency (JMA). The descriptors are listed in the Appendix J to this document. After the meeting, a validation test for these table D descriptors has been carried out by the European Centre for Medium-range Weather Forecast (ECMWF) and JMA with sample BUFR data produced by the JMA. The result of the test shows no problem(s) was/were found in those descriptors.

1.5 GTSPP

1.5.1 The SOT-III agreed that the addition of the GTSPP unique tag in BUFR tables and templates will be required, and asked the SOT Technical Coordinator to further pursue this issue. To date, this has not been completed. It is proposed that the SOT Task Team on Codes and the META-T addressed the issue in liaison with the newly established JCOMM/DMPA Table Driven Codes Group.

1.6 SeaKeepers

It has been proposed to use the BUFR Master Table 10[1] (MT10) as a Pilot Project for the real-time distribution of ship data produced by SeaKeepers, while taking GHRSST-PP requirements into account. The DMCG-II suggested that the new DMCG Table Driven Codes Group be responsible for regularly reviewing and updating BUFR Master Table 10 for oceanographic data.

2. Third International PMO workshop recommendations

2.1 The third International Workshop of Port Meteorological Officers (PMO-III, Hamburg, Germany,

1 MT10 is a distinct set of BUFR tables for oceanographic data (MT0 contains the usual meteorological tables) that had been defined a few years ago and is now being reviewed to comply with the rules proposed by the CBS ET/DRC for establishing and maintaining separate Master Tables.

23-24 March 2006), discussed migration to table driven code forms for VOS and VOSClim observations. The Workshop made recommendations and established a small group to review the data and metadata elements that would be required in a VOS (including VOSClim) BUFR template, and to develop a draft template to be submitted for endorsement by the SOT-IV (see Appendix C).

2.2 The Group eventually agreed on a draft "template" (i.e., list of required field) which is provided in further detail in Appendix E to this document.

3. Expert Team on Marine Climatology

3.1 For reference, the First Session of the Expert Team on Marine Climatology, (ETMC-I, Gdynia, Poland, from 7 to 10 July 2004), made a limited review of marine BUFR data (http://icoads.noaa.gov/etmc/etmc1/doc3.2.pdf), based on comparisons of BUFR data from NOAA's National Centers for Environmental Prediction (NCEP) with originally reported ship (FM-13) and buoy (FM-18) data. The following items are selected general findings from that review:

- Among the (limited) set of elements compared, data problems or omissions still existed in the NCEP's version of BUFR. Generally, however, the problems appeared to be confined to secondary elements such as clouds and waves, or special codes mixed with data that otherwise were translated properly to BUFR (e.g., the code 99 for variable wind direction in FM 13, which at least at that time was not represented in the BUFR ship template);

- In addition to data improperly or incompletely converted, fields could be completely absent in the BUFR that were present in the original GTS data. The comparisons were limited in scope, concentrating on the most widely used and often reported elements. Not all FM-13 and FM-18 elements were checked for their presence and accuracy as represented in BUFR;

- Retention by the NCEP of the original GTS message strings was felt to be critical, and was recommended for consideration for inclusion in the BUFR template, because it permits effective, automated verifications of the translations made into BUFR by the NMCs from the original data;

- For example, differences were known to exist between the BUFR data produced by the NCEP, the United Kingdom Met Office, and the US Navy (FNMOC). Amongst these NMCs, it appeared that only the NCEP attached (or otherwise archived) the original message strings;

- Even if the BUFR template was able to prescribe a complete set of field-by-field mappings of the FM 13 and FM 18 into BUFR (which it does not appear to have achieved yet), differences likely would arise between versions of BUFR produced at different NMCs due to differences (or inadvertent errors), in the event that the handling of a given field is not 100% specified (as for instance in the case of variable wind direction).

3.2 Comparisons of the NCEP BUFR with FM 13 GTS messages

By means of comparisons of the ICOADS data (i.e., FM 13 data translated from the NCEP BUFR) with United Kingdom Met Office GTS data, Mr Dave Berry, National Oceanography Centre, Southampton, United Kingdom, recently discovered what appear to be some new problems in the NCEP BUFR data (i.e., iced bulb temperatures positive, and a small bias in some wind speeds translated from knots).

The NOAA Earth System Research Laboratory (ESRL), and the NOAA National Centers for Environmental Prediction (NCEP) have since looked more closely at those issues here, and drafted (with Mr Berry) the brief note reproduced in Appendix M. The apparent inability of the BUFR to retain originally reported FM 13 wind direction codes for "variable" and "calm" is also reiterated and detailed in the note.

3.3 In addition to a possible participation of the ETMC in the development and continuing review of the VOS (and possibly other marine and oceanographic template(s)), the ETMC might be willing to investigate further development of the following templates:

- B/C35 – Reporting CLIMAT TEMP and CLIMAT TEMP SHIP and data in TDCF (see Appendix L); and
- B/C32 –Reporting CLIMAT SHIP data in TDCF (see Appendix K).

4. Water Temperature Metadata Pilot Project (META-T)

4.1 The META-T Pilot Project is currently defining the instrumental metadata required for the GTS distribution in real-time as far as water temperature and SST measurements are concerned. The exercise is considering a number of requirements, including: (i.) SST analysis and GODAE High-Resolution SST Pilot Project (GHRSST), (ii.) data assimilation and ocean field analysis, (iii.) ocean modelling, (iv.) ocean modelling validation, (v.) climate forecasting, (vi.) seasonal to decadal climate variability, (vii.) numerical weather prediction, (viii.) satellite calibration, (ix.) satellite validation, (x.) operational activities (e.g., weather forecasters, disaster response), (xi.) quality assurance activities serving above applications, and (xii.) diagnostics for platform operators.

4.2 Metadata from ship-based observing systems (among other marine and oceanographic data) fall within the remit of this project, including those under the VOS, VOSClim, and SOOP.

4.3 Progress will be reported at the upcoming SOT-IV Session by the META-T Pilot Project. The META-T requirements will have to be considered and merged into existing ship-based observations BUFR templates or into the new ones being defined.

5. Recommendations from the Data Management Coordination Group (DMCG)

5.1 At its Second Session, the Data Management Coordination Group (DMCG-II, Geneva, Switzerland, from 10 to 12 October 2006), the DMCG noted that Groups and Panels under the JCOMM are increasingly requiring additions or changes to the WMO Code Tables, and, in particular, to the BUFR and CREX Tables, and to the BUFR templates. Some of the requirements relate to more than one Panel (e.g., META-T, Tsunami monitoring, GHRSST and ADCP). Additionally, the provision of the same variable or metadata from different types of platforms or instruments requires introducing some level of consistency between the different BUFR templates proposed (e.g., Consistency between templates Expendable Bathythermograph (XBT) / Expandable Conductivity, Temperature and Depth profiling system (XCTD) and Argo templates, consistency between the VOS and TRACKOB (Report of marine surface observation along a ship's track, FM 62–VIII Ext. TRACKOB), consistency between all ship templates with regards to metadata and consistency between all templates providing SST and/or Temperature profile data as far as metadata are concerned (META-T). In other cases, one Panel might have to deal with different coding requirements. For example, the JCOMM Ship Observations Team (SOT) was considering a large number of coding requirements, and has established a Task Team on coding to deal with GHRSST-PP requirements, as well as an *ad-hoc* SOT Task Team on BUFR for the VOS and the VOSClim, which was established by the PMO-III. The SOT is currently interacting with the META-T Pilot Project considering metadata encoding requirements. The DMCG noted that the SOT intended to further review all these requirements and proposals at its next meeting in April 2007.

5.2 A summary of JCOMM table driven coding requirements are listed in the table below:

Requirement	Panels	Code	Status
Real-time distribution of Tsunami monitoring stations and buoys	GLOSS, DBCP	CREX	Considered by ET-DRC, May 2006 Requirements still

			unclear
GODAE High-Resolution SST Pilot Project and requirements for SST type/method of measurement and depth	GHRSST-PP, SOT	BUFR	Considered by the ET-DRC, May 2006
VOSClim requirements (quality information flags as well as metadata)	SOT	BUFR	Under study by the SOT
VOS data	SOT	BUFR	Considered at the PMO-3-INT, list has been proposed
ASAP data	SOT	BUFR	Existing template
XBT and XCTD data	SOT	BUFR	To be defined
ADCP data	SOT, DBCP	BUFR	To be defined
GOSUD (TSG data distributed in TRACKOB)	GOSUD SOT	BUFR	To be defined
SeaKeepers ship data	SOT	BUFR, MT10	To be defined
META-T requirements for real-time distribution of metadata along with the observation (i.e., category 1 metadata)	META-T, DBCP, SOT, etc.	BUFR	To be defined
Buoy directional and non directional wave data	DBCP	BUFR	Considered by ET-DRC, December 2005, needs validation
GTSPP and water temperature profile data, including Argo profiling float data	GTSPP Argo DMT	BUFR	Considered by the ET-DRC, December 2005, validated
NWP and requirements for upper air profiles	SOT (ASAPP)	BUFR	To be clarified
Marine Climatology	ETMC	BUFR	To be considered by the ETMC-II

5.3 All the above-mentioned requirements need to be relayed to the Commission for Basic Systems (CBS) Expert Team on Data Representation and Codes (ET-DRC) for adoption (see the Codes migration schedule as adopted at CBS Ext. 06 in Appendix D). Each Panel is presently submitting its requirements separately. Considering the diversity of the requirements, the number of groups involved, and cross-cutting issues, the DMCG-II agreed that it would be more efficient if there was a group within the JCOMM DMPA responsible for collecting all JCOMM-related coding requirements, for compiling them in a consolidated JCOMM proposal and for submitting them to the CBS Expert Team. A representative from the group could also attend the CBS ET-DRC Meeting on behalf of the JCOMM. Therefore, the DMCG-II established a Table Driven Codes Group. Its Terms of References and Membership is provided in Appendix B.

5.4 A strategic plan for the JCOMM Data Management is nearing completion. Draft recommendations related to the migration to table driven codes include the following:

Recommendation 4.2a: DMPA lead the development of the detailed plan to change the GTS data reporting from TACs to TDCs.

Recommendation 4.2b: The DMPA, in association with the appropriate WMO committee or bodies should evaluate MT10 for its relevance to present needs.

Recommendation 4.2c: Enhanced interaction between the JCOMM and CBS or other appropriate WMO committees is needed to expand the scope of TDCs to more fully incorporate the JCOMM considerations, including software reliability, human readability, and the archival and exchange of historical and delayed-mode data in its originally reported form.

Recommendation 4.3.3b: JCOMM to work with partners to encourage the continuing evolution of exchange formats to more robust forms, while at the same time assuring that sufficient flexibility and agility can be preserved for the archival of the JCOMM's delayed-mode data and metadata.

6. The way forward for ship-based observations

6.1 The JCOMM Ship Observations Team (SOT) is currently working on this issue and is presently considering a large number of requirements. At this time, it is not yet in a position to make a comprehensive proposal at this meeting due to the following issues:

(i) Working groups such as the SOT Task Team on Coding (of SST), the *ad-hoc* SOT Task Team on BUFR for VOS/VOSClim (established at the Third International Port Meteorological Officers Conference (PMO-III, Hamburg, Germany, 23-24 March 2006), and the recently established water temperature metadata (META-T) Pilot Project, need to provide the SOT with their conclusions or recommendations before the SOT-IV; and

(ii) Approval from the SOT-IV meeting in early 2007 will be required before any formal proposal(s) can be made to the ET-DRC to be held in Darmstadt, Germany, from 23 to 27 April 2007.

6.2 Proposals for new SHIP (VOS and VOSClim), XBT/XCTD, and TRACKOB templates are being defined and will eventually be proposed. The SOT is invited to consider how the ASAP and ADCP templates need to be addressed. The SOT will be invited to review the requirements expressed by the ETMC-II. The following requirements are being considered:

- Requirements for the GODAE High-Resolution SST Pilot Project (GHRSST);
- VOSClim requirements (metadata and quality information flags);
- META-T Pilot Project (metadata of category 1 required for real-time exchange);
- XBT/XCTD requirements;
- GTSPP, SOOPIP, TIP, and Argo requirements: Consistency between templates XBT/XCTD and Argo templates (both providing sub-surface temperature profiles);
- GOSUD requirements: Consistency between VOS and TRACKOB;
- Consistency between all ship templates as far as metadata;
- Requirements for high resolution upper air soundings (ASAP);
- Requirements for ocean current profiles (ADCP);
- Requirements for marine climatology (ETMC-II recommendations);
- Requirements for SeaKeepers

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Appendices: 12

APPENDIX A

Terms of References of the SOT Task Team on Coding

Tasks:

1. Develop a draft new code table for BUFR which accommodates new types of SST measurements.

2. Submit the draft proposal to a relevant body of the CBS.

3. Investigate possible future inclusion of bio-chemical data in BUFR through various interactions with other ship-based observation communities.

4. Report to the SOT-IV.

Members:

Mr Craig Donlon (TT Chairperson, United Kingdom)
Mr Graeme Ball (Australia)
Mr Etienne Charpentier (JCOMMOPS)
Mr Robert Keeley (Canada)
Mr Loïc Petit de la Villéon (France)

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APPENDIX B

TERMS OF REFERENCE (TOR) OF THE JCOMM DMPA TASK TEAM ON TABLE DRIVEN CODE FORMS

Objectives:

(i) Collect and compile requirements from the JCOMM Panels and Expert Teams and submit them to the CBS Expert Team on Data Representation and Codes (ET-DRC) (one Member of the Group to attend the ET-DRC Meetings);
(ii) Make BUFR Master Table 10 (MT10) compliant with the WMO Rules;
(iii) Define a mechanism for updating and maintaining the MT10 on behalf of the JCOMM in compliance with rules defined by the CBS ET-DRC. Coastal variables and bio-chemical data will have to be included;
(iv) Look at templates and suggest how to standardize content.

Current Membership:

Mr Robert Keeley (TT Chairperson), (a metadata expert designated by the NMDIS), Mr Etienne Charpentier (WMO Secretariat), Ms Hester Viola (Technical Coordinator of the SOT), an expert designated by Mr David Thomas, an IODE expert designated by Dr Leslie Rickards, Mr Scott Woodruff (Chairperson of the ETMC), and an E2EDM expert designated by Mr Nick Mikhailov.

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APPENDIX C

PMO-III RECOMMENDATIONS ON MIGRATION FROM SHIP TO BUFR

1) Frits Koek and Sarah North undertook to review the required data and metadata elements that would be required in a VOS (including VOSClim) BUFR template. The resultant list would then be submitted to a new informal ad hoc SOT task team on VOS migration to BUFR (Frits Koek, Sarah North, Pierre Blouch, Graeme Ball, Julie Fletcher, Etienne Charpentier) by 1 June 2006. Comments submitted by the team by 1 July 2006.

2) WMO will liaise with CBS ET/DRC and ET/MTDCF and advise that the SOT is working on revisiting the list of elements for inclusion in the VOS BUFR template for ship data and is seeking ET/DRC help.

3) The SOT and ET/DRC will liaise to develop a draft BUFR template suitable for VOS and VOSClim which will be submitted for endorsement by SOT-IV.

The meeting considered possible implementation scenarios as follows:

(i) Phase 1, target 2007: Member countries to work on software that converts SHIP to BUFR (1 to 1 conversion) and implement it on a case by case basis.
(ii) Phase 2, target 2006 to SOT-IV: analyze requirements and consider possible solutions (e.g. (proprietary format + metadata) to BUFR, or ("SOT" format + metadata) to BUFR. "SOT" format is a format inspired on FM-13 SHIP format and should be regarded as proprietary; it is not intended for direct GTS distribution but as a practical way of using existing software slightly modified to achieve BUFR distribution of the data on the GTS.
(iii) Phase 3, target 2008: Implementation of proposed recommendations.
(iv) Phase 4, target 2012: Operational system in place.

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APPENDIX D
CODE MIGRATION SCHEDULE

Category →	**Cat.1: common**	**Cat.2: satellite observations**	**Cat.3: aviation[1]**	**Cat. 4: maritime**	**Cat. 5[2]: miscellaneous**	**Cat. 6[2]: almost obsolete**
Lists of → Traditional code forms	SYNOP SYNOP MOBIL PILOT PILOT MOBIL TEMP TEMP MOBIL TEMP DROP CLIMAT CLIMAT TEMP	SAREP SATEM SARAD SATOB	METAR SPECI TAF AMDAR ROFOR	BUOY TRACKOB BATHY TESAC WAVEOB SHIP CLIMAT SHIP PILOT SHIP TEMP SHIP CLIMAT TEMP SHIP	RADOB IAC IAC FLEET GRID*(to GRIB)* RADOF	CODAR ICEAN GRAF NACLI etc. SFAZI SFLOC SFAZU RADREP ROCOB ROCOB SHIP ARFOR WINTEM MAFOR HYDRA HYFOR
Schedule ↓						
Start experimental Exchange[3]	**Nov. 2002** for some data (AWS SYNOP, TEMP USA)	Current at some Centres	**2006** **2002** at some Centres for AMDAR	**2005** **2003** for Argos data (BUOY, sub-surface floats, XBT/XCTD)	**2004**	Not applicable
Start operational exchange[3]	**Nov. 2005**	Current at some Centres	**2008** **2003** for AMDAR	**2007** **2003** for Argos data (BUOY, sub-surface floats, XBT/XCTD)	**2006**	Not applicable
Migration complete	**Nov. 2010**	**Nov. 2006**	**2016** **2005** for AMDAR	**2012** **2008** for Argos data (BUOY, sub-surface floats, XBT/XCTD)	**2008**	Not applicable

Notes:

(1) Aviation Codes require ICAO coordination and approval, except for AMDAR

(2) For category 5 consider that codes need to be reviewed in order to decide whether or not they should be migrated to BUFR/CREX. Codes in category 6 are not to be migrated.

(3) All dates above are meant as "not later than". However, Members and Organizations are encouraged to start experimental exchange, and, if all relevant conditions (see below) are satisfied, to start operational exchange as soon as possible.

- Start of experimental exchange: data will be made available in BUFR (CREX) but not operationally, i.e. in addition to the current alphanumeric codes, which are still operational.

- Start of operational exchange: data will be made available in BUFR (CREX) whereby some (but not all) Members rely on them operationally. Still the current alphanumeric codes will be distributed (parallel distribution).

- Migration complete: at this date the BUFR (CREX) exchange becomes the standard WMO practice. Parallel distribution is terminated. For archiving purposes and at places where BUFR (CREX) exchange still causes problems the alphanumeric codes may be used on a local basis only.

Relevant conditions to be satisfied before experimental exchange may start:

- Corresponding BUFR/CREX-tables and templates are available;
- Training of concerned testing parties has been completed;
- Required software of testing parties (encoding, decoding, viewing) is implemented;

Relevant conditions to be satisfied before operational exchange may start:

- Corresponding BUFR/CREX-tables and templates are fully validated;
- Training of all concerned parties has been completed;
- All required software (encoding, decoding, viewing) is operational.

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APPENDIX E

LIST OF PROPOSED FIELDS FOR INCLUSION IN A NEW BUFR TEMPLATE FOR VOS DATA

	Element	Code	WMO code table	Units	Scale	Remarks
1	Identifier for a ship report (BBXX)	MiMiMjMj	2582			
2	Ships call sign	D....D				
3	WMO Regional Association	A_1	0161			
4	Subdivision of the WMO Regional Association	b_w	0161			
5	Type and Serial number of bouy or platform	$n_b n_b n_b$			0	
6	Day of the month	YY		Day	0	
7	Time of observation to the nearest hour UTC	GG		Hour	0	
8	Time of observation to the nearest minutes UTC	gg		Minute	0	
9	Wind speed indicator	i_w	1855			
10	Latitude in degrees and tenths	$L_a L_a L_a$		Degree	1	
11	Longitude in degrees and tenths, hundreds included	$L_o L_o L_o L_o$		Degree	1	
12	Precipitation data indicator	i_R	1819			
13	Type of station and present and past weather indicator	i_x	1860			
14	Height above sea of the base of the lowest cloud seen	H	1600			
15	Horizontal visibility at surface	VV	4377			
16	Total amount of cloud	N	2700			
17	True direction from which the surface wind is blowing	dd	0877	Degrees true	-1	
18	Surface Wind speed	Ff		from iw	0	
19	Wind speed, when speed >= 99	00fff		from iw	0	
20	Sign of air temperature	S_n	3845			
21	Air temperature	TTT		C	1	
22	Sign of dew point temperature	S_n	3845			
23	Dew point temperature	$T_d T_d T_d$		C	1	

24	Relative humidity of the air, in per cent, the first figure being zero except for UUU = 100 per cent	UUU		%	0
25	Sea level pressure	PPPP		Pa	1
26	Characteristic of the pressure tendency during the three hours preceding the time of the observation	A	0200		
27	Amount of pressure tendency at station level during the three hours preceding the time of observation	ppp		Pa	1
28	Amount of precipitation which has fallen during the period preceding the time of observation, as indicated by t_R	RRR	3590		
29	Duration of period of reference for amount of precipitation, ending at the time of the report	t_R	4019		
30	Present weather	ww	4677		
31	Past weather (primary type)	W_1	4561		
32	Past weather (secondary type)	W_2	4561		
33	Present weather reported from an automatic weather station	$w_a w_a$	4680		
34	Past weather reported from an automatic weather station (primary type)	W_{a1}	4531		
35	Past weather reported from an automatic weather station (secondary type)	W_{a2}	4531		
36	Amount of all the C_L cloud present or, if no C_L cloud is present, the amount of all the C_M cloud present	N_h	2700		
37	Clouds of types Stratocumulus, Stratus, Cumulus and Cumulonimbus	C_L	0513		
38	Clouds of types Altocumulus, Altostratus, and Nimbostratus	C_M	0515		
39	Clouds of types Cirrus, Cirrocumulus, and Cirrostratus	C_H	0509		
40	Ships course (true) made good during the three hours preceding the time of the observation	D_s	0700		
41	Ships average speed made good during the three hours preceding the time of the observation	V_s	4451		
42	Sign and type of sea temperature	S_s	3850		
43	Sea surface temperature	$T_w T_w T_w$		C	1
44	Period of waves, obtained by instrumental methods	$P_{wa} P_{wa}$		s	0
45	Height of waves, obtained by instrumental methods	$H_{wa} H_{wa}$		m	log(2)
46	Period of the wind waves	$P_w P_w$		s	0

47	Height of the wind waves	H_wH_w		m	log(2)
48	Direction (true) from which the predominant/first swell waves are coming	$d_{w1}d_{w1}$	0877	degrees true	-1
49	Direction (true) from which the secondary swell waves are coming	$d_{w2}d_{w2}$	0877	degrees true	-1
50	Period of predominant swell waves	$P_{w1}P_{w1}$		s	0
51	Height of predominant swell waves	$H_{w1}H_{w1}$		m	log(2)
52	Period of the secondary swell waves	$P_{w2}P_{w2}$		s	0
53	Height of secondary swell waves	$H_{w2}H_{w2}$		m	log(2)
54	Ice accretion on ships	I_s	1751		
55	Thickness of ice accretion on ships in centimeters	E_sE_s		m	2
56	Rate of ice accretion on ships	R_s	3551		
57	Icing plain language				
58	Height of waves, obtained by instrumental methods	$H_{wa}H_{wa}H_{wa}$		m	1
59	Indicator for the sign and type of measurement of sea surface temperature	S_w	3855		
60	Wet-bulb temperature	$T_bT_bT_b$		C	1
61	Concentration or arrangement of sea ice	c_i	0639		
62	Stage of development	S_i	3739		
63	Ice of land origin	b_i	0439		
64	Bearing of principal ice edge	D_i	0739		
65	Present ice situation and trend of conditions over preceding three hours	z_i	5239		
66	Sea ice plain language				
67	Sign of maximum air temperature	s_n	3845		
68	Maximum air temperature	$T_xT_xT_x$		C	1
69	Sign of minimum air temperature	s_n	3845		
70	Minimum air temperature	$T_nT_nT_n$		C	1
71	Amount of individual cloud layer or mass whose genus is indicated by C	Ns	2700		
72	Genus of cloud	C	0500		
73	Height of base of cloud layer or mass whose genus is indicated by C	h_sh_s	1677		

74	Supplementary information	$S_pS_ps_ps_p$	3778			
75	Total amount of precipitation during the 24-hour period ending at the time of observation, in tenths of a millimetre	$R_{24}R_{24}R_{24}R_{24}$		m	4	
76	Highest gust during the 10-minute period immediately preceding the observation	FmFm		m/s	0	This may be reported under the 9 group -SpSpspsp (see table 3778 910ff)
77	Highest gust during the period covered by W_1W_2	FxFx		m/s	0	This may be reported under the 9 group -SpSpspsp (see table 3778 911ff)

Additional elements for VOSClim

78	Ship's heading; the direction to which the bow of the ship is pointing referenced to Ture North	HDG		degrees true	0
79	Ship's ground course; the direction that the vessel actually moves over the fixed globe referenced to True North	COG		degrees true	0
80	Ship's ground speed; the speed of the vessel over the fixed earth	SOG		knots	0
81	Maximum height of the deck cargo above the Summer load line	SLL		m	0
82	Sign of hh	s_L			
83	Departure of reference level (Summer load line) from actual sea level. Positive when Summer load line is above sea level and negative if below the water line	hh			
84	Relative wind direction in degrees off the bow	RWD		degrees	0
85	Relative wind speed reported in units indicated by iw	RWS		from iw	0

Additional requirements for the VOS

86	Height of the barometer above the Summer load line (fixed)	m
87	Height of the anemometer (if fitted) above the Summer load line (fixed)	m
88	Height of the temperature sensor/screen above the Summer load line (fixed)	m
89	Depth of the sea temperature sensor below the Summer load line (fixed)	m
90	Depth of the keel below the Summer load line (fixed)	m
91	Average draught at the time of the observation (variable)	m

Note use 90 + 91 (all known values) instead of 82 + 83 to derive heights and depths

APPENDIX F

BUFR TEMPLATE FOR SYNOPTIC REPORTS FROM SEA STATIONS SUITABLE FOR VOS OBSERVATION DATA

B/C10 – Reporting SHIP data in TDCF

(details at: http://www.wmo.int/web/www/WMOCodes/MigrationTDCF/MANUALTEMPLATES.html)

TM 308009 - BUFR template for synoptic reports from sea stations suitable for SHIP data

3 08 009		**Sequence for representation of synoptic reports from a sea station suitable for SHIP data**
	3 01 093	Ship identification, movement, date/time, horizontal and vertical coordinates
	3 02 001	Pressure data
	3 02 054	SHIP "instantaneous" data
	0 08 002	Vertical significance
	3 02 055	Icing and ice
	3 02 057	SHIP marine data
	3 02 060	SHIP "period" data

This BUFR template for synoptic reports from sea stations further expands as follows:

3 01 093			**Ship identification, movement, date/time, horizontal and vertical coordinates**	Unit, scale
	3 01 036	0 01 011	Ship or mobile land station identifier **D….D**	CCITT IA5, 0
		0 01 012	Direction of motion of moving observing platform(3)	Degree true, 0
		0 01 013	Speed of motion of moving observing platform(4)	m s^{-1}, 0
		0 02 001	Type of station ($\mathbf{i_x}$)	Code table, 0
		0 04 001	Year	Year, 0
		0 04 002	Month	Month, 0
		0 04 003	Day **YY**	Day, 0
		0 04 004	Hour **GG**	Hour, 0
		0 04 005	Minute **gg**	Minute, 0
		0 05 002	Latitude (coarse accuracy) $\mathbf{L_aL_aL_a}$	Degree, 2
		0 06 002	Longitude (coarse accuracy) $\mathbf{L_oL_oL_oL_o}$	Degree, 2
	0 07 030		Height of station platform above mean sea level	m, 1
	0 07 031		Height of barometer above mean sea level	m, 1
			Pressure data	
3 02 001	0 10 004		Pressure $\mathbf{P_0P_0P_0P_0}$	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
3 02 054			**SHIP "instantaneous" data**	
			Temperature and humidity data	
	3 02 052	0 07 032	Height of sensor above marine deck platform	m, 2

			(for temperature and humidity measurement)	
		0 07 033	Height of sensor above water surface (for temperature and humidity measurement)	m, 1
		0 12 101	Temperature/dry-bulb temperature (sc.2) **s_nTTT**	K, 2
		0 02 039	Method of wet-bulb temperature measurement	Code table, 0
		0 12 102	Wet-bulb temperature (scale 2) **$s_wT_bT_bT_b$**	K, 2
		0 12 103	Dew-point temperature (scale 2) **$s_nT_dT_dT_d$**	K, 2
		0 13 003	Relative humidity	%, 0

			Visibility data	
	3 02 053	***0 07 032***	Height of sensor above marine deck platform (for visibility measurement)	m, 2
		0 07 033	Height of sensor above water surface (for visibility measurement)	m, 1
		0 20 001	Horizontal visibility **VV**	m, –1
	0 07 033		Height of sensor above water surface (set to missing to cancel the previous value)	m, 1
			Precipitation past 24 hours	
	3 02 034	0 07 032	Height of sensor above marine deck platform (for precipitation measurement)	m, 2
		0 13 023	Total precipitation past 24 hours **$R_{24}R_{24}R_{24}R_{24}$**	kg m^{-2}, 1
	0 07 032		Height of sensor above marine deck platform (set to missing to cancel the previous value)	m, 2
			Cloud data	
	3 02 004	0 20 010	Cloud cover (total) **N**	%, 0
		0 08 002	Vertical significance	Code table, 0
		0 20 011	Cloud amount (of low or middle clouds) **N_h**	Code table, 0
		0 20 013	Height of base of cloud **h**	m, –1
		0 20 012	Cloud type (low clouds) **C_L**	Code table, 0
		0 20 012	Cloud type (middle clouds) **C_M**	Code table, 0
		0 20 012	Cloud type (high clouds) **C_H**	Code table, 0
	1 01 000		Delayed replication of 1 descriptor	
	0 31 001		Delayed descriptor replication factor	Numeric, 0
	3 02 005	0 08 002	Vertical significance	Code table, 0
		0 20 011	Cloud amount **N_s**	Code table, 0
		0 20 012	Cloud type **C**	Code table, 0
		0 20 013	Height of base of cloud **h_sh_s**	m, -1
0 08 002			Vertical significance (set to missing to cancel the previous value)	Code table, 0
			Icing and ice	
3 02 055	0 20 031		Ice deposit (thickness) **E_sE_s**	m, 2
	0 20 032		Rate of ice accretion **R_s**	Code table, 0
	0 20 033		Cause of ice accretion **I_s**	Flag table, 0
	0 20 034		Sea ice concentration **c_i**	Code table, 0
	0 20 035		Amount and type of ice **b_i**	Code table, 0
	0 20 036		Ice situation **z_i**	Code table, 0
	0 20 037		Ice development **S_i**	Code table, 0
	0 20 038		Bearing of ice edge **D_i**	Degree true, 0
3 02 057			**SHIP marine data**	
	3 02 056		Sea surface temperature, method of	

			measurement, and depth below sea surface	
		0 02 038	Method of sea/water temperature measurement	Code table, 0
		0 07 063	Depth below sea/water surface (for sea surface temperature measurement)	m, 2
		0 22 043	Sea/water temperature **$s_sT_wT_wT_w$**	K, 2
		0 07 063	Depth below sea/water surface (set to missing to cancel the previous value)	m, 2
			Waves	
	3 02 021	0 22 001	Direction of waves	Degree true
		0 22 011	Period of waves **$P_{wa}P_{wa}$**	s, 0
		0 22 021	Height of waves **$H_{wa}H_{wa}$**	m, 1
	3 02 024	0 22 002	Direction of wind waves	Degree true, 0
		0 22 012	Period of wind waves **P_wP_w**	s, 0
		0 22 022	Height of wind waves **H_wH_w**	m, 1
		1 01 002	Replicate 1 descriptor 2 times	
		3 02 023	Swell waves (2 systems of swell) **$d_{w1}d_{w1}$, $P_{w1}P_{w1}$, $H_{w1}H_{w1}$ $d_{w2}d_{w2}$, $P_{w2}P_{w2}$,**	
3 02 060			**SHIP"period" data**	
			Present and past weather	
	3 02 038	0 20 003	Present weather **ww**	Code table, 0
		0 04 024	Time period in hours	Hour, 0
		0 20 004	Past weather (1) **W_1**	Code table, 0
		0 20 005	Past weather (2)	Code table, 0
			Precipitation measurement	
	3 02 040	0 07 032	Height of sensor above marine deck platform (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**	kg m^{-2}, 1
			Extreme temperature data	
	3 02 058	0 07 032	Height of sensor above marine deck platform (for temperature measurement)	m, 2
		0 07 033	Height of sensor above water surface (for temperature measurement)	m, 1
		0 04 024	Time period or displacement	Hour, 0
		0 04 024	Time period or displacement (see Notes 1 and 2)	Hour, 0
		0 12 111	Maximum temperature (scale 2) at height and over period specified **$s_nT_xT_xT_x$**	K, 2
		0 04 024	Time period or displacement	Hour, 0
		0 04 024	Time period or displacement (see Note 2)	Hour, 0
		0 12 112	Minimum temperature (scale 2) at height and over period specified **$s_nT_nT_nT_n$**	K, 2
			Wind data	
	3 02 059	0 07 032	Height of sensor above marine deck platform (for wind measurement)	m, 2
		0 07 033	Height of sensor above water surface (for wind measurement)	m, 1
		0 02 002	Type of instrumentation for wind measurement	Flag table, 0

			$\mathbf{i_w}$	
		0 08 021	Time significance (= 2 (time averaged))	Code table, 0
		0 04 025	Time period (= - 10 minutes, or number of minutes after a significant change of wind)	Minute, 0
		0 11 001	Wind direction **dd**	Degree true, 0
		0 11 002	Wind speed **ff**	m s^{-1}, 1
		0 08 021	Time significance (= missing value)	Code table, 0
		1 03 002	Replicate next 3 descriptors 2 times	
		0 04 025	Time period in minutes	Minute, 0
		0 11 043	Maximum wind gust direction	Degree true, 0
		0 11 041	Maximum wind gust speed 910$\mathbf{f_m f_m}$, 911$\mathbf{f_x f_x}$	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.

2) Within RA-III, the maximum day-time temperature and the minimum night-time temperature is reported (i.e., the ending time of the period may not be 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.

3) 0 01 012: Means course made good (average course over the ground) during the three hours preceding the time of observation.

4) 0 01 013: Means speed made good (average speed over the ground) during the three hours preceding the time of observation.

5) If “plain language” text is reported within Section 2, this information can be conveyed in BUFR via the use of an appropriate 205YYY field as an extra descriptor following the above basic template.

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APPENDIX G

BUFR TEMPLATE FOR VOS DATA

This template is a modified version of the SHIP observation template. Delayed replications have been used extensively to reduce the volume of an individual message, which is a crucial aspect for transmission from VOS stations. It is proposed to represent this template by a single descriptor **3 08 008** from **Category 8 – Surface report sequences (sea).**

Sequence descriptor numbers written in blue in this template, have not yet been included in BUFR table D (release November 2005).

3 08 008 = 3 01 093 + 3 02 062 + 3 02 063

3 01 093			**Ship identification, movement, type, date/time, horizontal and vertical coordinates**	Unit, scale
	3 01 036	0 01 011	Ship or mobile land station identifier **D….D**	CCITT IA5, 0
		0 01 012	Direction of motion of moving observing platform(3)	Degree true, 0
		0 01 013	Speed of motion of moving observing platform(4)	m s^{-1}, 0
		0 02 001	Type of station **(i_x)**	Code table, 0
		0 04 001	Year	Year, 0
		0 04 002	Month	Month, 0
		0 04 003	Day **YY**	Day, 0
		0 04 004	Hour **GG**	Hour, 0
		0 04 005	Minute **gg**	Minute, 0
		0 05 002	Latitude (coarse accuracy) **$L_aL_aL_a$**	Degree, 2
		0 06 002	Longitude (coarse accuracy) **$L_oL_oL_oL_o$**	Degree, 2
	0 07 030		Height of station platform above mean sea level	m, 1
	0 07 031		Height of barometer above mean sea level	m, 1
3 02 062			**SHIP "instantaneous" data from VOS**	
			Pressure data	
	3 02 001	0 10 004	Pressure **$P_0P_0P_0P_0$**	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
			Temperature and humidity data	
	3 02 052	0 07 032	Height of sensor above marine deck platform (for temperature measurement)	m, 2
		0 07 033	Height of sensor above water surface (for temperature measurement)	m, 1
		0 12 101	Temperature/dry-bulb temperature(sc.2) **s_nTTT**	K, 2
		0 02 039	Method of wet-bulb temperature measurement	Code table, 0
		0 12 102	Wet-bulb temperature (scale 2) **$s_wT_bT_bT_b$**	K, 2
		0 12 103	Dew-point temperature (scale 2) **$s_nT_dT_dT_d$**	K, 2
		0 13 003	Relative humidity	%, 0
			Visibility data	
	3 02 053	***0 07 032***	Height of sensor above marine deck platform (for visibility measurement)	m, 2
		0 07 033	Height of sensor above water surface (for visibility measurement)	m, 1
		0 20 001	Horizontal visibility **VV**	m, –1
	0 07 033		Height of sensor above water surface (set to missing to cancel the previous value)	m, 1

			Precipitation past 24 hours	
	1 01 000		Delayed replication of 1 descriptor	
	0 31 000		Short delayed descriptor replication factor	Numeric, 0
	3 02 034	0 07 032	Height of sensor above marine deck platform (for precipitation measurement)	m, 2
		0 13 023	Total precipitation past 24 hours **$R_{24}R_{24}R_{24}R_{24}$**	kg m^{-2}, 1
	0 07 032		Height of sensor above marine deck platform (set to missing to cancel the previous value)	m, 2
			Cloud data	
	1 01 000		Delayed replication of 1 descriptor	
	0 31 000		Short delayed descriptor replication factor	Numeric, 0
	3 02 004	0 20 010	Cloud cover (total) **N**	%, 0
		0 08 002	Vertical significance	Code table, 0
		0 20 011	Cloud amount (of low or middle clouds) **N_h**	Code table, 0
		0 20 013	Height of base of cloud **h**	m, –1
		0 20 012	Cloud type (low clouds C_L) **C_L**	Code table, 0
		0 20 012	Cloud type (middle clouds C_M) **C_M**	Code table, 0
		0 20 012	Cloud type (high clouds C_H) **C_H**	Code table, 0
	1 01 000		Delayed replication of 1 descriptor	
	0 31 001		Delayed descriptor replication factor	Numeric, 0
	3 02 005	0 08 002	Vertical significance	Code table, 0
		0 20 011	Cloud amount (N_s) **N_s**	Code table, 0
		0 20 012	Cloud type (C) **C**	Code table, 0
		0 20 013	Height of base of cloud (h_sh_s) **h_sh_s**	m, -1
	0 08 002		Vertical significance (set to missing to cancel the previous value)	Code table, 0
			Icing and ice	
	1 01 000		Delayed replication of 1 descriptor	
	0 31 000		Short delayed descriptor replication factor	Numeric, 0
	3 02 055	0 20 031	Ice deposit (thickness) **E_sE_s**	m, 2
		0 20 032	Rate of ice accretion **R_s**	Code table, 0
		0 20 033	Cause of ice accretion **I_s**	Flag table, 0
		0 20 034	Sea ice concentration **c_i**	Code table, 0
		0 20 035	Amount and type of ice **b_i**	Code table, 0
		0 20 036	Ice situation **z_i**	Code table, 0
		0 20 037	Ice development **S_i**	Code table, 0
		0 20 038	Bearing of ice edge **D_i**	Degree true, 0
			Sea/water temperature	
	1 01 000		Delayed replication of 1 descriptor	
	0 31 000		Short delayed descriptor replication factor	Numeric, 0
	3 02 056	0 02 038	Method of sea surface temperature measurement	Code table, 0
		0 22 043	Sea/water temperature **$s_sT_wT_wT_w$**	K, 2
			Waves	
	1 01 000		Delayed replication of 1 descriptor	
	0 31 000		Short delayed descriptor replication factor	Numeric, 0
	3 02 021	0 22 001	Direction of waves	Degree true, 0
		0 22 011	Period of waves **$P_{wa}P_{wa}$**	s, 0
		0 22 021	Height of waves **$H_{wa}H_{wa}$**	m, 1
	1 01 000		Delayed replication of 1 descriptor	
	0 31 000		Short delayed descriptor replication factor	Numeric, 0
	3 02 024	0 22 002	Direction of wind waves	Degree true, 0
		0 22 012	Period of wind waves **P_wP_w**	s, 0
		0 22 022	Height of wind waves **H_wH_w**	m, 1
		1 01 002	Replicate 1 descriptor 2 times	

		3 02 023	Swell waves (2 systems of swell) **$d_{w1}d_{w1}$, $P_{w1}P_{w1}$, $H_{w1}H_{w1}$ $d_{w2}d_{w2}$, $P_{w2}P_{w2}$, $H_{w2}H_{w2}$**	
3 02 063			**SHIP"period" data from VOS**	
			Present and past weather	
	3 02 038	0 20 003	Present weather **ww**	Code table, 0
		0 04 024	Time period in hours	Hour, 0
		0 20 004	Past weather (1) **W_1**	Code table, 0
		0 20 005	Past weather (2)	Code table, 0
			Precipitation measurement	
	1 01 000		Delayed replication of 1 descriptor	
	0 31 000		Short delayed descriptor replication factor	Numeric, 0
	3 02 040	0 07 032	Height of sensor above marine deck platform (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**	kg m^{-2}, 1
			Extreme temperature data	
	1 01 000		Delayed replication of 1 descriptor	
	0 31 000		Short delayed descriptor replication factor	Numeric, 0
	3 02 058	0 07 032	Height of sensor above marine deck platform (for temperature measurement)	m, 2
		0 07 033	Height of sensor above water surface (for temperature measurement)	m, 1
		0 04 024	Time period or displacement	Hour, 0
		0 04 024	Time period or displacement (see Notes 1 and 2)	Hour, 0
		0 12 111	Maximum temperature (scale 2) at height and over period specified **$s_nT_xT_xT_x$**	K, 2
		0 04 024	Time period or displacement	Hour, 0
			Time period or displacement (see Note 2)	Hour, 0
		0 12 112	Minimum temperature (scale 2) at height and over period specified **$s_nT_nT_nT_n$**	K, 2
			Wind data	
	3 02 064	0 07 032	Height of sensor above marine deck platform (for wind measurement)	m, 2
		0 07 033	Height of sensor above water surface (for wind measurement)	m, 1
		0 02 002	Type of 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 minutes, or number of minutes after a significant change of wind)	Minute, 0
		0 11 001	Wind direction **dd**	Degree true, 0
		0 11 002	Wind speed **ff**	m s^{-1}, 1
		0 08 021	Time significance (= missing value)	Code table, 0
		1 03 000	Delayed replication of 3 descriptors	
		0 31 001	Delayed descriptor replication factor	Numeric, 0
		0 04 025	Time period in minutes	Minute, 0
		0 11 043	Maximum wind gust direction	Degree true, 0
		0 11 041	Maximum wind gust speed 910**f_mf_m**, 911**f_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.

2) Within RA-III, the maximum day-time temperature and the minimum night-time temperature is reported (i.e., the ending time of the period may not be 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.

3) 0 01 012: Means course made good (average course over the ground) during the three hours preceding the time of observation.

4) 0 01 013: Means speed made good (average speed over the ground) during the three hours preceding the time of observation.

5) If “plain language” text is reported within Section 2, this information can be conveyed in BUFR via the use of an appropriate 205YYY field as an extra descriptor following the above basic template.

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APPENDIX H

BUFR TEMPLATE FOR ASAP DATA

B/C25 – Reporting TEMP, TEMP SHIP and TEMP MOBIL data in TDCF

(details at http://www.wmo.int/web/www/WMOCodes/MigrationTDCF/MANUALTEMPLATES.html)

A BUFR (or CREX) message should be sent when level the 100 hPa is reached. In any case, a BUFR (or CREX) message shall be produced when the sounding is completed containing data from the entire sounding.

TM 309052 - BUFR template for P, T, U and wind vertical profiles suitable for TEMP, TEMP SHIP and TEMP MOBIL observation data

3 09 052		**Sequence for representation TEMP, TEMP SHIP and TEMP MOBIL observation type data**
	3 01 111	Identification of launch site and instrumentation
	3 01 113	Date/time of launch
	3 01 114	Horizontal and vertical coordinates of launch site
	3 02 049	Cloud information reported with vertical soundings
	0 22 043	Sea/water temperature (for ship stations)
	1 01 000	Delayed replication of 1 descriptor
	0 31 002	Extended delayed descriptor replication factor
	3 03 054	Temperature, dew-point and wind data at a pressure level
	1 01 000	Delayed replication of 1 descriptor
	0 31 001	Delayed descriptor replication factor
	3 03 051	Wind shear data at a pressure level

This BUFR template for P, T, U and wind profiles further expands as follows:

3 01 111		**Identification of launch site and instrumentation**	
	3 01 001	WMO block number	Numeric
		WMO station number	Numeric
	0 01 011	Ship or mobile land station identifier	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
3 01 113		**Date/time of launch**	
	0 08 021	Time significance (= 18 (launch time))	Code table
	3 01 011	Year	Year
		Month	Month
		Day	Day
	3 01 013	Hour	Hour
		Minute	Minute
		Second	Second
3 01 114		**Horizontal and vertical coordinates of launch site**	
	3 01 021	Latitude (high accuracy)	Degree, scale 5
		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

3 02 049		**Cloud information reported with vertical soundings**	
	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
	0 08 002	Vertical significance (= missing value)	Code table
0 22 043		Sea/water temperature (for ship stations)	K, scale 2
		Temperature, dew-point and wind data at pressure levels	
1 01 000		Delayed replication of 1 descriptor	
0 31 002		Extended delayed descriptor replication factor	Numeric
3 03 054		**Temperature, dew-point and wind data at a pressure level with radiosonde position**	
	0 04 086	Long time period or displacement (since launch time)	Second
	0 08 042	Extended vertical sounding significance	Flag table
	0 07 004	Pressure	Pa, scale –1
	0 10 009	Geopotential height	gpm
	0 05 015	Latitude displacement since launch site (high accuracy)	Degree, scale 5
	0 06 015	Longitude displacement 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	
1 01 000		Delayed replication of 1 descriptor	
0 31 001		Delayed descriptor replication factor	Numeric
3 03 051		**Wind shear data at a pressure level**	
	0 04 086	Long time period or displacement (since launch time)	Second
	0 08 042	Extended vertical sounding significance	Flag table
	0 07 004	Pressure	Pa, scale –1
	0 05 015	Latitude displacement since launch site (high accuracy)	Degree, scale 5
	0 06 015	Longitude displacement since launch site (high accuracy)	Degree, scale 5
	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) Time of launch 3 01 013 shall be reported with the highest possible accuracy available. If the launch time is not available with second accuracy, the entry for seconds shall be put to zero.
(2) Long time displacement 0 04 086 represents the time offset from the launch time 3 01 013 (in seconds).
(3) Latitude displacement 0 05 015 represents the latitude offset from the latitude of the launch site. Longitude displacement 0 06 015 represents the longitude offset from the longitude of the launch site.
(4) If additional information on sounding instrumentation is required, the sequence <3 09 052> may be supplemented by one or more additional parameters to allow data representation of this information (e.g., Radiosonde serial number (0 01 081)).

APPENDIX I

BUFR TEMPLATE FOR XBT/XCTD REPORT (SEQUENCE 3 15 004)

Name	Descriptor	Order	Forced value	Forced missing	Name	Comment
XBT/XCTD	001003	1			WMO region	
XBT/XCTD	001020	2			WMO region sub-area	
XBT/XCTD	001005	3			Buoy/platform identifier	
XBT/XCTD	001011	4			Ship call sign	
XBT/XCTD	001019	5			Ship name	
XBT/XCTD	001080	6			Ship line number according to SOOP	
XBT/XCTD	005036	7			Ship transect number according to SOOP	
XBT/XCTD	001036	8			Agency in charge of operating the observing platform	
XBT/XCTD	301011	9			Date	
XBT/XCTD	301012	10			Time	
XBT/XCTD	301021	11			Latitude and longitude (high accuracy)	
XBT/XCTD	007030	12			Height of station above MSL	
XBT/XCTD	002040	13			Method of removing platform direction and speed from current	
XBT/XCTD	022067	14			Instrument type for water temperature profile measurement	
XBT/XCTD	022068	15			Water temperature profile recorder type	
XBT/XCTD	*008080*	*16*	*0*		*Qualifier for quality class*	*Value: 0=global water pressure profile*
XBT/XCTD	*033050*	*17*			*Global GTSPP quality class*	*For global water pressure profile as qualified above*
XBT/XCTD	*008080*	*18*	*1*		*Qualifier for quality class*	*Value: 1=global water temperature profile*
XBT/XCTD	*033050*	*19*			*Global GTSPP quality class*	*For global water temperature profile as qualified above*
XBT/XCTD	*008080*	*20*	*2*		*Qualifier for quality class*	*Value: 2=global water salinity profile*
XBT/XCTD	*033050*	*21*			*Global GTSPP quality class*	*For global water salinity profile as qualified above*
XBT/XCTD	*008080*	*22*	*3*		*Qualifier for quality class*	*Value: 3=global water conductivity profile*
XBT/XCTD	*033050*	*23*			*Global GTSPP quality class*	*For global water conductivity profile as qualified above*
XBT/XCTD	025100	24			XBT/XCTD fall rate equation coefficient a	
XBT/XCTD	025101	25			XBT/XCTD fall rate equation coefficient b	
XBT/XCTD	022063	26			Total depth of water	
XBT/XCTD	302021	27			Waves	
XBT/XCTD	306004	28			Sea temperature and salinity profile	*Sequence containing the profile itself*
XBT/XCTD	002030	29			Method of current measurement	
XBT/XCTD	306005	30			Time/duration of current measurement, depths/directions/speeds	
XBT/XCTD	007032	31			Height of thermometer above station platform	Here height of thermometer
XBT/XCTD	012101	32			Dry-bulb temperature (scale 2)	
XBT/XCTD	012103	33			Dew-point temperature (scale 2)	
XBT/XCTD	007032	34			Height of anemometer above station platform	Here height of anemometer
XBT/XCTD	011001	35			Wind direction	
XBT/XCTD	011002	36			Wind speed	

APPENDIX J

BUFR TEMPLATE FOR TRACKOB DATA
(Approved by CBS Ext. 6)

BUFR template

3 08 010	0 01 011	Ship or mobile land station identifier
	1 13 000	Delayed replication of 13 descriptors
	0 31 001	Delayed descriptor replication factor
	3 01 011	Date
	3 01 012	Time
	3 01 021	Latitude/Longitude (high accuracy)
	0 04 080	Averaging period for following value
	0 22 049	Sea surface temperature
	0 04 080	Averaging period for following value
	0 22 059	Sea surface salinity
	0 04 080	Averaging period for following value
	0 22 005	Direction of sea surface current
	0 02 042	Indicator for sea surface current speed
	0 22 032	Speed of sea surface current
	0 02 042	Indicator for sea surface current speed (cancel)
	0 04 080	Averaging period for following value (cancel)

CREX template

D 08 010	B 01 011	Ship or mobile land station identifier
	R 13 000	Delayed replication of 13 descriptors
	D 01 011	Date
	D 01 012	Time
	D 01 021	Latitude/Longitude (high accuracy)
	B 04 080	Averaging period for following value
	B 22 049	Sea surface temperature
	B 04 080	Averaging period for following value
	B 22 059	Sea surface salinity
	B 04 080	Averaging period for following value
	B 22 005	Direction of sea surface current
	B 02 042	Indicator for sea surface current speed
	B 22 032	Speed of sea surface current
	B 02 042	Indicator for sea surface current speed (cancel)
	B 04 080	Averaging period for following value (cancel)

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APPENDIX K

B/C32 – REPORTING CLIMAT SHIP DATA IN TDCF

(details at: http://www.wmo.int/web/www/WMOCodes/MigrationTDCF/MANUALTEMPLATES.html)

TM 308013 - BUFR template for reports of monthly values from an ocean weather station suitable for CLIMAT SHIP data

3 08 013		**Sequence for representation of monthly values suitable for CLIMAT SHIP data**
	3 08 011	Monthly values from an ocean weather station
	3 08 012	Monthly normals for an ocean weather station

Monthly values from an ocean weather station (data of CLIMAT SHIP Section 1) Sequence BUFR descriptor **<3 08 011>** expands as shown in the leftmost column below.			
		Station identification, date/time, horizontal and vertical coordinates	Unit, scale
0 01 011		Ship's call sign	CCITT IA5, 0
0 02 001		Type of station	Code table, 0
3 01 011	0 04 001	Year[(1)]	Year, 0
	0 04 002	Month[(1)]	Month, 0
	0 04 003	Day (= 1) [(1)]	Day, 0
3 01 012	0 04 004	Hour (= 0) [(1)]	Hour, 0
	0 04 005	Minute (= 0) [(1)]	Minute, 0
3 01 023	0 05 002	Latitude (coarse accuracy) **$L_aL_aL_a$**	Degree, 2
	0 06 002	Longitude (coarse accuracy) **$L_oL_oL_oL_o$**	Degree, 2
0 07 030		Height of station platform above mean sea level	m, 1
0 07 031		Height of barometer above mean sea level	m, 1
		Monthly mean values of pressure, temperature, vapour pressure and sea/water temperature	
0 04 074		Short time displacement (= UTC - LST) [(1)]	Hour, 0
0 04 023		Time period (= number of days in the month)	Day, 0
0 08 023		First order statistics (= 4; mean value)	Code table, 0
0 10 051		Pressure reduced to msl **PPPP**	Pa, –1
0 07 032		Height of sensor above marine deck platform (for temperature measurement) [(3)]	m, 2
0 07 033		Height of sensor above water surface (for temperature measurement) [(3)]	m, 1
0 12 101		Temperature/dry-bulb temperature **s_nTTT**	K, 2
0 13 004		Vapour pressure **eee**	Pa, -1
0 07 032		Height of sensor above marine deck platform (set to missing to cancel the previous value)	m, 2
0 07 033		Height of sensor above water surface (set to missing to cancel the previous value)	m, 1
3 02 056		Sea surface temperature, method of measurement,	

		and depth below sea surface	
	0 02 038	Method of sea/water temperature measurement(3)	Code table, 0
	0 07 063	Depth below sea/water surface (for sea surface temperature measurement) (3)	m, 2
	0 22 043	Sea/water temperature $\overline{\mathbf{s_n T_w T_w T_w}}$	K, 2
	0 07 063	Depth below sea/water surface (set to missing to cancel the previous value)	m, 2
0 08 023		First order statistics (set to missing to cancel the previous value)	Code table, 0
		Monthly precipitation data	
0 04 003		Day (= 1) (2)	Day, 0
0 04 004		Hour (= 6) (2)	Hour, 0
0 04 023		Time period (= number of days in the month) (2)	Day, 0
0 07 032		Height of sensor above marine deck platform(3)	m, 2
0 13 060		Total accumulated precipitation $\mathbf{R_1R_1R_1R_1}$	kg m^{-2}, 1
0 13 051		Frequency group; precipitation $\mathbf{R_d}$	Code table, 0
0 04 053		Number of days with precipitation equal to or more than 1 mm $\mathbf{n_r n_r}$	Numeric, 0
0 07 032		Height of sensor above marine deck platform (set to missing to cancel the previous value)	m, 2
Monthly normals for an ocean weather station (data of CLIMAT SHIP Section 2) Sequence BUFR descriptor **<3 08 012>** expands as shown in the leftmost column below.			
		Normals of pressure, temperature, vapour pressure and sea/water temperature	Unit, scale
0 04 001		Year (of beginning of the reference period)	Year, 0
0 04 001		Year (of ending of the reference period)	Year, 0
0 04 002		Month	Month, 0
0 04 003		Day (= 1) (1)	Day, 0
0 04 004		Hour (= 0) (1)	Hour, 0
0 04 074		Short time displacement (= UTC - LST) (1)	Hour, 0
0 04 022		Time period (= 1)	Month, 0
0 08 023		First order statistics (= 4; mean value)	Code table, 0
0 10 051		$\overline{}$ Pressure reduced to msl **PPPP**	Pa, –1
0 07 032		Height of sensor above marine deck platform (for temperature measurement) (3)	m, 2
0 07 033		Height of sensor above water surface (for temperature measurement) (3)	m, 1
0 12 101		$\overline{}$ Temperature/dry-bulb temperature $\mathbf{s_n TTT}$	K, 2
0 13 004		$\overline{}$ Vapour pressure **eee**	Pa, -1
0 07 032		Height of sensor above marine deck platform (set to missing to cancel the previous value	m, 2
0 07 033		Height of sensor above water surface (set to missing to cancel the previous value)	m, 1
3 02 056		Sea surface temperature, method of measurement, and depth below sea surface	
	0 02 038	Method of sea/water temperature measurement(3)	Code table, 0

	0 07 063	Depth below sea/water surface (for sea surface temperature measurement) (3)	m, 2
	0 22 043	Sea/water temperature $\overline{s_n T_w T_w T_w}$	K, 2
	0 07 063	Depth below sea/water surface (set to missing to cancel the previous value)	m, 2
0 08 023		First order statistics (set to missing to cancel the previous value)	Code table, 0
		Normals of precipitation	
0 04 001		Year (of beginning of the reference period)	Year, 0
0 04 001		Year (of ending of the reference period)	Year, 0
0 04 002		Month	Month, 0
0 04 003		Day (= 1) (2)	Day, 0
0 04 004		Hour (= 6) (2)	Hour, 0
0 04 022		Time period (= 1)	Month, 0
0 07 032		Height of sensor above marine deck platform (for precipitation measurement) (3)	m, 2
0 08 023		First order statistics (= 4; mean value)	Code table, 0
0 13 060		Total accumulated precipitation $R_1R_1R_1R_1$	kg m^{-2}, 1
0 04 053		Number of days with precipitation equal to or more than 1 mm $n_r n_r$	Numeric, 0
0 08 023		First order statistics (set to missing to cancel the previous value)	Code table, 0

Notes:

(1) The time identification refers to the beginning of the one-month period. Except for precipitation measurements, the one-month period is recommended to correspond to the local standard time (LST) month [7].

(2) In case of precipitation measurements, the one-month period begins at 06 UTC on the first day of the month and ends at 06 UTC on the first day of the following month [5].

(3) If the heights/depth of sensors or method of sea/water temperature measurement were changed during the period specified, the value shall be that which existed for the greater part of the period.

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APPENDIX L

B/C35 – REPORTING CLIMAT TEMP AND CLIMAT TEMP SHIP AND DATA IN TDCF

(details at: http://www.wmo.int/web/www/WMOCodes/MigrationTDCF/MANUALTEMPLATES.html)

A BUFR (or CREX) message shall contain reports for one specific month only.

TM 309054 - BUFR template for reports of monthly aerological means suitable for CLIMAT TEMP and CLIMAT TEMP SHIP data

3 09 054		**Sequence for representation CLIMAT TEMP and CLIMAT TEMP SHIP data**

Sequence BUFR descriptor <3 09 054> expands as it is shown in the leftmost column below:

		Identification of launch site	Unit, scale
3 01 001	0 01 001	WMO block number	Numeric, 0
	0 01 002	WMO station number	Numeric, 0
0 01 011		Ship's call sign	CCITT IA5, 0
		Date/time(1)	
3 01 011	0 04 001	Year(1)	Year, 0
	0 04 002	Month(1)	Month, 0
	0 04 003	Day (= 1) (1)	Day, 0
3 01 012	0 04 004	Hour (= 0) (1)	Hour, 0
	0 04 005	Minute (= 0) (1)	Minute, 0
		Horizontal and vertical coordinates	
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 mean sea level	m, 1
0 07 031		Height of barometer above mean sea level	m, 1
0 07 007		Height release of sonde above mean sea level	m, 0
		Monthly mean data	
0 04 023		Time period (= number of days in the month)	Day, 0
0 04 059		Times of observations used to compute the reported mean values	Flag table, 0
1 15 000		Delayed replication of 15 descriptors	
0 31 001		Delayed descriptor replication factor	Numeric, 0
0 08 001		Vertical sounding significance	Flag table, 0
0 08 023		First order statistics (= 4; mean value)	Code table, 0
0 07 004		Pressure	Pa, –1
0 10 009		Geopotential height	gpm, 0
0 12 101		Temperature/dry-bulb temperature	K, 2
0 12 103		Dew-point temperature	K, 2
0 08 023		First order statistics (= 32; vector mean)	Code table, 0
0 11 001		Wind direction	Degree true, 0
0 11 002		Wind speed	m s^{-1}, 1
0 08 023		First order statistics (= 63; missing value)	Code table, 0
0 11 019		Steadiness of wind	%, 0
0 08 050		Qualifier for number of missing values in calculation of statistic (= 2; temperature)	Code table, 0
0 08 020		Total number of missing entities (days)	Numeric, 0
0 08 050		Qualifier for number of missing values in calculation of statistic (= 9; wind)	Code table, 0

0 08 020		Total number of missing entities (days)	Numeric, 0

Note:

(1) The time identification refers to the beginning of the one-month period.

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APPENDIX M

ADDITIONAL COMPARISONS OF NCEP BUFR WITH FM 13 GTS MESSAGES (2006 DATA)

(DRAFT 14 March 2007)

(Submitted by Mr Scott Woodruff[1], Mr David Berry[2], Mr Sandy Lubker[1])
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(2) National Oceanography Centre, Southampton, UK

1. Introduction

The First Session of the Expert Team on Marine Climatology (ETMC-I, JCOMM 2004) made a limited review of marine BUFR data (see webpage: icoads.noaa.gov/etmc/etmc1/doc3.2.pdf), based on comparisons of BUFR data from the NOAA National Centers for Environmental Prediction (NCEP), with originally reported Global Telecommunication System (GTS) SHIP (FM 13) and BUOY (FM 18) data (WMO 1995). More recently, some additional problems in the NCEP BUFR data came to light by comparing the UK Met Office GTS reports, with matching ICOADS reports converted from the NCEP BUFR.

Sections 2-3 provide further information regarding these new problems, which were again more fully evaluated through comparisons of the original FM 13 reports, with the NCEP BUFR data for 2006. Section 4 reviews a previously known problem, which was first identified in BUFR evaluation work completed in 1997 (icoads.noaa.gov/real-time.html), and reiterated as part of the comparisons for JCOMM (2004).

Retention by the NCEP of the original GTS reports (i.e., attached to the translated BUFR data) was critical because it permitted us to make these comparisons, and also allows the possibility of future correction of these and other data problems. In addition, in the BUFR files presently used for ICOADS, NCEP performs a "dup-merge" processing that blends near duplicates and fragmentary receipts to improve BUFR data quality and completeness (see this webpage for additional information: icoads.noaa.gov/rt.html). As another consequence of the dup-merge processing, around March 2002, the NCEP began attaching from one up to several FM 13 reports to each BUFR report, depending on whether more than one original message was blended together.

In this case, for simplicity, it should be noted that our interpretation of the original FM 13 data used only the first (usually most recent) GTS message, since the messages were generally attached by the NCEP in reverse order of receipt time (e.g., assuming the more recent transmission was corrected).

2. Iced bulb temperature (IBT) sign error

In FM 13, wet bulb temperature (WBT) is associated with an indicator s_W (code 3855) for the sign and type of wet bulb temperature reports (Table 1). Note that the code does not explicitly specify that the iced bulb WBT (i.e., IBT) settings 2 and 7 should be negative. Apparently, the Met Office (correctly) sets IBT to negative, whereas the NCEP (incorrectly) sets the IBT to positive.

Table 1. FM 13 s_W (code 3855) mapped to BUFR code 0 02 039. The "map" column shows the transformation of the six FM 13 values to the four BUFR values. For ICOADS, the BUFR "MWBT" values are transformed into a somewhat different set of codes in IMMA field WBTI.

FM 13	*code 3855: s_W*	*map*	*BUFR*	*0 02 039 ("MWBT" by NCEP)*	*WBTI*
0	Positive or zero measured WBT	0	0	Measured WBT	0
1	Negative measured WBT	0	1	Iced bulb measured WBT	2
2	Iced bulb measured WBT	1	2	Computed WBT	1
5	Positive or zero computed WBT	2	3	Iced bulb computed WBT	3
6	Negative computed WBT	2			
7	Iced bulb computed WBT	3			

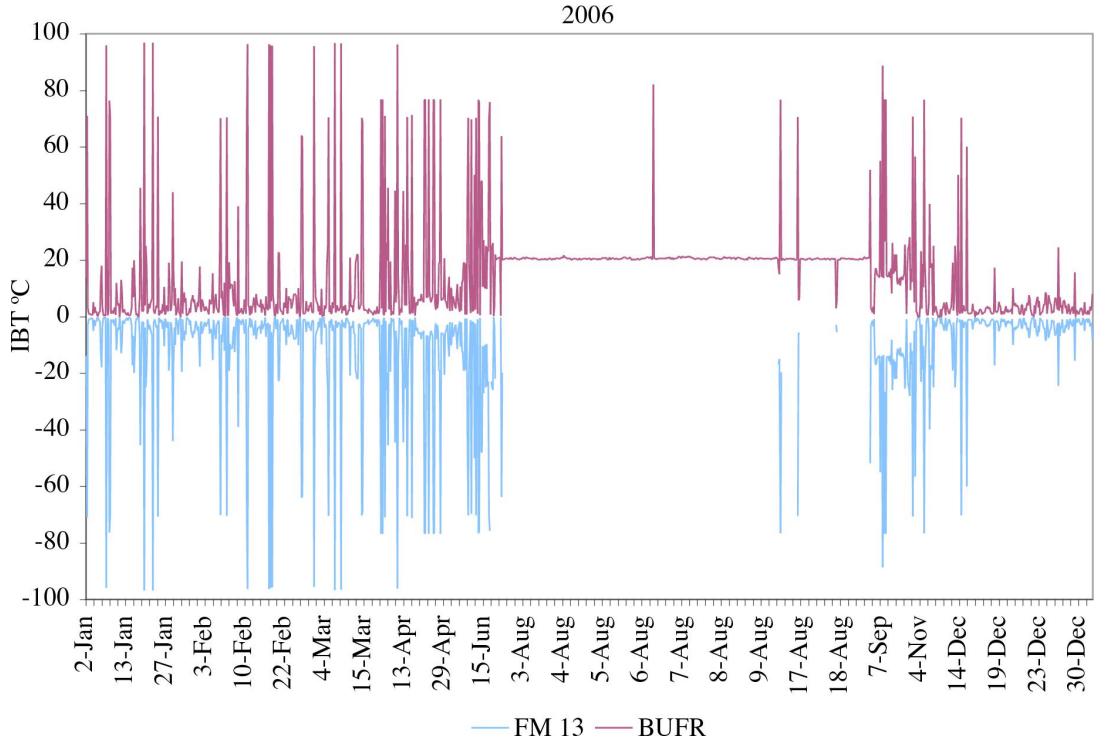

Figure 1. All NCEP BUFR iced bulb temperatures (IBT) in 2006, plotted against date (data points are connected by lines, so as to be clearly visible). The FM 13 values (translated by the ICOADS decoder from the 1st or only attached message) are shown in blue, and the BUFR values (translated by the NCEP) are indicated in red.

Table 2. Lists of call signs or buoy numbers associated with: (a.) extreme (≥ |50|°C) IBT values, and (b.) the "flat" ~20°C pattern for July-August are shown in Figure 1. In each case a representative FM 13 report or set of two such reports is also listed, with the example ID highlighted in turquoise; and the FM 13 group highlighted in yellow: (a.) containing IBT=|96.5|°C, or (b.) apparently containing IBT=|20.5|°C (since only NCEP decoded that value).

(a:)	*IBT Extreme Values (≥ 50°C)*
Frequency (in parentheses) and call signs associated with the extremes in Fig. 1:	(1) 9HCH7, (1) A8CI9, (1) A8CJ2, (1) C6FN5, (1) C6NO5, (1) C6UB2, (1) D5XH, (1) ELQQ4, (1) ELYT5, (1) HZRX, (1) KAFO, (1) KNBD, (1) MCDW2, (1) OUZW2, (1) OXKO2, (1) VNVF, (1) WCBP, (1) WCX8883, (1) WCY8453, (1) WDA7827, (1) WDB9986, (1) WDC6907, (1) WFLG, (1) WGXO, (1) WPGK, (1) WSDX, (1) WXAE, (1) ZCAQ8, (2) V7HX4, (2) WCY2920, (3) DQVG, (4) WADZ, (5) SHIP, (6) S6ES, (6) WN4201
Example FM 13 report (*Horizon Spirit*; USA):	WFLG 11063 99310 71408 41598 50215 10480 2//// 41199 5/272 734// 8//69 22219 0//// 2//// 3//// 4//// 5//// 6//// 82965 ICE ///92
(b:)	*"Flat" ~20°C Segment*
Frequency (in parentheses), and call signs or buoy numbers associated with the flat segment in Fig. 1:	(1) 44022, (1) 44039, (1) 46054, (1) C6NO5, (1) SHIP, (1) WCY2920, (1) WN4201, (2) 45004, (4) KNBD, (4) NEPP, (6) 44040, (12) 45007, (14) 44005, (14) 44033, (18) 44037, (18) 46075, (19) 44031, (19) 44035, (19) 46029, (19) 46071, (20) 44029, (20) 44034, (21) 42039, (21) 46069, (22) 46076, (23) 44030, (23) 44032, (23) 44038, (25) 44024, (48) 41009, (48) 41010
Example FM 13 reports; two were attached by NCEP to the BUFR report in this case (NDBC buoy 28.95°N, 78.48°W):	41010 03131 99290 70785 46/// /2305 10285 20253 40192 91320 22200 00289 10901 20301 300// 40901 70006 33391 20555 51104 82205 41010 03131 99290 70785 46/// /2305 10285 20253 40192 91320 22200 00289 10901 20301 300// 40901 70006 333 91205 555 11048 22051

Distinct from the sign problem, Figure 1 indicates additional questionable features in the IBT data. These include unrealistic extremes, and, from approximately July through August, generally a static BUFR value of ~20°C, associated with what appears from Figure 1 to be missing IBT in FM 13. However, these later features appear to derive from differences in the decoding as performed by the NCEP (resulting in the static values, mostly associated with moored buoy reports), versus our independent ICOADS decoding of the FM 13 messages (which found very few IBT data during this period). Table 2 lists call signs and buoy numbers associated with some of these suspicious features, plus representative FM 13 patterns.

3. Bias (0.1 ms^{-1}) in wind speeds converted from knots to ms^{-1}

It was originally speculated that the NCEP conversion might have employed an inaccurate factor (0.51667; light grey in Figure 2). However, Figure 2 illustrates that the problem is likely instead the result of an intermediate rounding to hundredths (perhaps during dup-merge processing), and then to tenths, since that algorithm provides the best match with BUFR (dark grey). The blue bar to the right in Figure 2 most probably illustrates the approximate amount of wind speeds currently biased +0.1 m/s in ICOADS per year for 2000-2006.

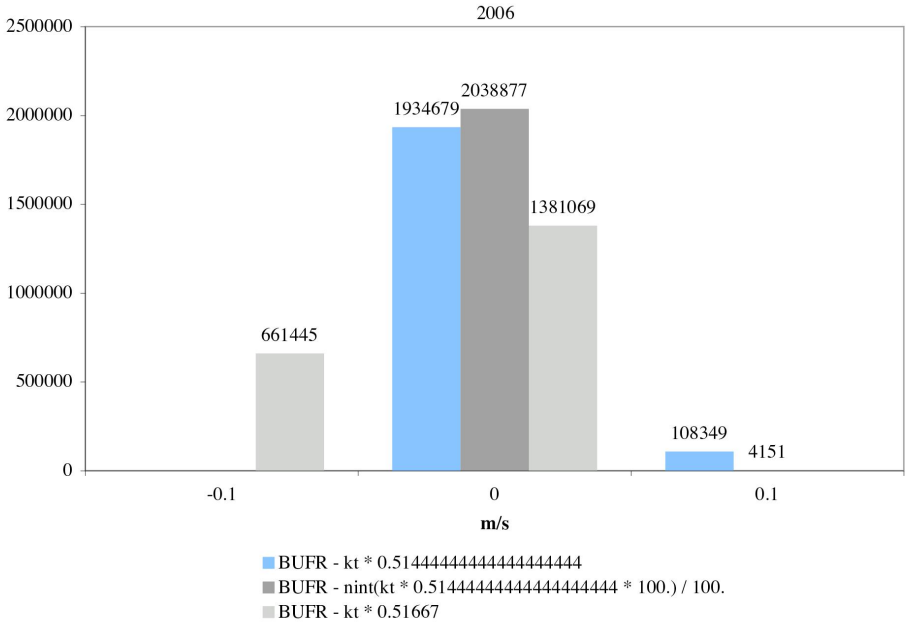

Figure 2. Results of converting all FM 13 wind speeds for 2006 from knots to ms^{-1} according to three different algorithms, and then subtracting the result from the corresponding NCEP BUFR value in ms^{-1}. The total number of extant wind speed reports in the FM 13 data is 3.7M, thus about 1.7M reports are not shown above - those reports were originally in ms^{-1}, and thus did not undergo any conversion. There are also very small numbers of cases (not shown) with differences >0.1 ms^{-1}, presumably arising from dup-merge processing (e.g., an FM 13 message other than the first attached message was used to create the BUFR wind speed field).

4. Wind direction variable (dd=99) erroneously mapped to calm direction

Special codes for calm (00) and variable (99) wind direction exist in FM 13 (Table 3). In the NCEP BUFR (a problem that has been recognized since 1997), most of the "variable" wind directions appear to have been mapped to 0° (Figure 3). Moreover, the current BUFR template for wind direction also does not appear to preserve the other non-degrees code in FM 13 for "calm."

Table 3. FM 13 dd (code 0877) to BUFR code 0 11 001 (whole degrees true, with no distinction for "calm" or "variable"). Thus, as currently documented (WMO 1995), the BUFR code appears to be redundant at 0°=360°, which is not a characteristic of the originally reported FM 13 data. The "map" column shows the apparent transformation of the FM 13 values to the BUFR values (similarly for the omitted dd values 03-35). In the IMMA, wind direction is also stored in whole degrees in field D, except with special codes 361 for "calm," and 362 for "variable."

FM 13	*code 0877: dd*	*Map*	*BUFR 0 11 001 ("WDIR" by NCEP)*	*D*
00	Calm	× 10	0° (presumably, or calm)	361
01	5°-14°	× 10	10°	10°
02	15°-24°	× 10	20°	20°
…	…	…	…	…
36	355°-4°	× 10	360°	360°
99	Variable, or all directions	(unknown)	(undefined)	362

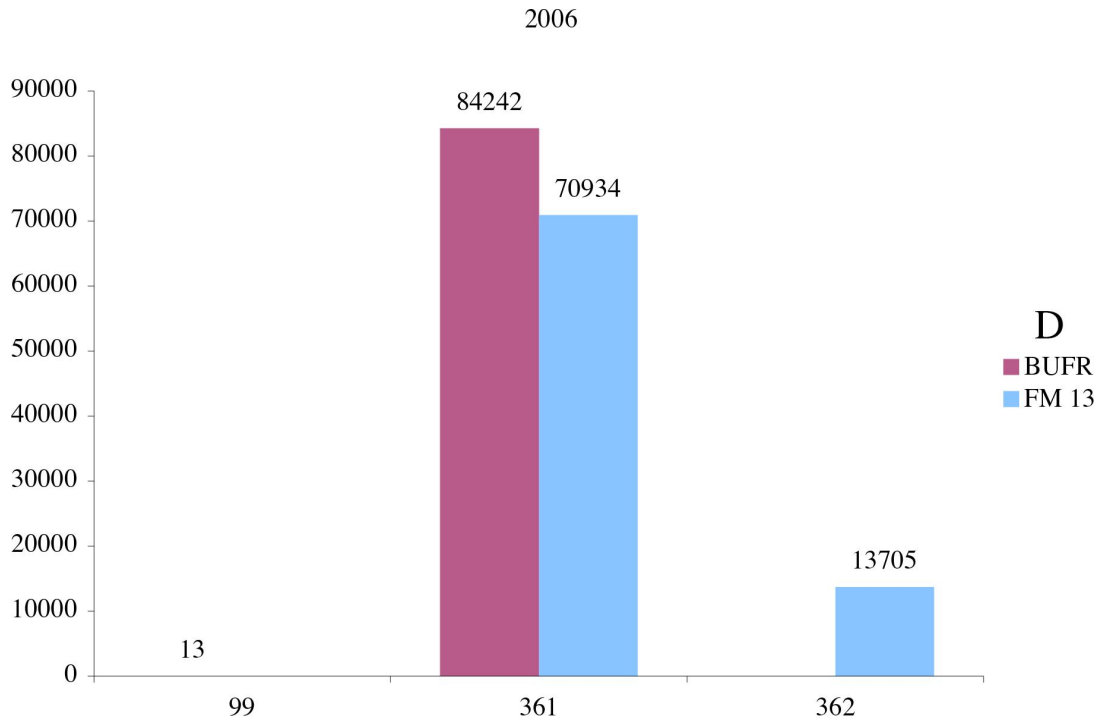

Figure 3. The NCEP BUFR (red bars) and FM 13 (blue bars; ICOADS decoding of the first or only attached message) "calm" and "variable" wind directions, as translated into the IMMA field D (see Table 3). The numbers do not match up precisely (13705 + 70934 = 84639), but it appears most of the variable wind directions were mapped to 0° in BUFR. Also, 13 anomalous values of 99° appeared in BUFR, and were interpreted as such (almost certainly erroneously) in the ICOADS translation to D (in FM 13, code 99 indicates "variable").

References:

JCOMM, 2004: *Expert Team on Marine Climatology, First Session, Gdynia, Poland, 7-10 July 2004, Final Report*. JCOMM Meeting Report No. 32.

WMO, 1995: *Manual on Codes.* WMO–No.306, Geneva, Switzerland (Vol. I.1: 1995 Ed. including Suppl. through No. 3 (VIII.2001); Vol. I.2: 2001 Ed.).

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