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ITEM: 5.2

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REVIEW OF THE BUFR (AND OTHER) TEMPLATES FOR SURFACE MARINE DATA

(Submitted by the WMO Secretariat)

SUMMARY AND PURPOSE OF DOCUMENT

The document provides information on the current status of the migration to table driven codes, and the review of BUFR templates for surface marine data.

ACTION PROPOSED

The Meeting is invited to note the information contained in this document when considering its recommendations.

Appendix:

A. Current status of BUFR templates for marine data
B. Preliminary Report on the Preservation of Voluntary Observing Ship (VOS) Data as Reported at Three Levels
C. Excerpt of SOT-6 final report regarding preservability of marine data
D. Marine sequences proposed by JCOMM (draft)

DISCUSSION

-A- DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

BUFR Templates

5.2.1 The Team recalled that WMO Commission for Basic Systems (CBS) migration to table driven codes for marine data shall be in principle be completed by the end of 2012. The Team recognized that progress with regard to the development and updating of the required BUFR[1] templates for marine meteorological and oceanographic data has been limited since the third ETMC Session (ETMC-3, Melbourne, Australia, 8-12 February 2010). The ETMC recommendations agreed at ETMC-3 remain valid (see ETMC-3 doc 4, and ETMC-3 final report for details, which relevant section is reproduced in Annex I of Appendix B). The current status of the BUFR templates for marine meteorological and oceanographic data is provided in Appendix A.

5.2.2. The Team noted that plans are underway for sharing tools for BUFR encoding/decoding software within the oceanographic community, and example of BUFR reports have been produced for training purposes. It was also noted that JCOMM-4 requested the DMPA to keep the "Cookbook for submitting ocean data in real-time and delayed mode" under review, and continue to maintain the BUFR templates for ocean data under review so that they continue to take end-user requirements into account. Highlighting the importance of BUFR, JCOMM-4 further requested the DMPA to finalize the BUFR Master Table 10 (Oceanographic Data).

5.2.3 The Team noted that JCOMM has engaged a process for the rationalization of BUFR sequences for marine data in order to provide some standardization and consistency for the reporting of specific ocean variables and their metadata between the different types of ocean observation platforms reporting in BUFR format (e.g. same sequence for data + metadata for SST observations from VOS, moorings, drifters, tide gauges …). Details are provided in Appendix D.

5.2.4 See also agenda item 5.4 (and corresponding ETMC-4 preparatory document) relating to the provision of encrypted ship's call sign (ship masking) within the BUFR template for VOS data.

Preservability of marine data

5.2.5 Regarding the issue of preservability of the real-time data, the Team recalled that it had established a small *ad hoc* group at ETMC-3 to address each of the following levels:

1. Observing practices and the recording of the observations on-board the ship.
2. Transmission of the observations in real-time from ship to shore. While it is not proposed to standardize the format(s) used for the transmission of VOS data from ship to shore, the Team felt that it would be useful to provide guidance regarding the elements that should be transmitted, on a variable-by-variable basis.
3. Transmission of the observations in real-time onto the GTS in BUFR format.

5.2.6 The Team noted that the *ad hoc* group had produced a report (Appendix B) that was then submitted to the sixth Session of the Ship Observations Team (SOT-6, Hobart, 11-15 April 2011). The outcome of the SOT-6 discussions in this regard are reflected in Appendix C. The Team noted that E-SURFMAR has developed a data format for the transmission of VOS data from ship to shore that is taking into account the marine climatology requirements formulated by the ETMC. The format, which is referred as dataformat#100, is available from the E-SURFMAR website[2].

1: FM-94 BUFR : Binary Universal Form for the Representation of Meteorological Data (used for distribution of time critical data onto the Global Telecommunication System – GTS.

2: http://esurfmar.meteo.fr/doc/o/vos/E-SURFMAR_VOS_formats_v014.pdf (see section 4 for dataformat#100)

5.2.7 The Team thanked the *ad hoc* group for its work, and noting outstanding issues, agreed to re-activate it, and to refresh its membership. The Team selected the following people to be part of the refreshed *ad hoc* group:

- [to be decided by the Team]

5.2.8 The Team requested the *ad hoc* group to address the SOT-6 decisions, and to make further proposals to the SOT-7 (Victoria, Canada, April 2013), especially regarding practices to be included in the *Guide to Marine Meteorological Services* (WMO 2001a) (i.e. for the part describing the VOS Scheme) and in the *Manual on Codes* (WMO 1995, 2001c) (***action; ad hoc group; end 2012***).

Appendices: 4

APPENDIX A

CURRENT STATUS OF BUFR TEMPLATES FOR MARINE DATA

	Current template(s)	*Status*	*Plans*
Drifting buoy data	Template for buoy data including directional and non-directional wave data	Validation	Template is currently the same for drifting, moored, and wave buoys. The plan is to produce a specific simplified template for drifting buoys
Moored buoy data	Template for buoy data including directional and non-directional wave data	Validation	Template is currently the same for drifting, moored, and wave buoys. The plan is to produce a specific simplified template for moored buoys
Wave buoy data	Template for buoy data including directional and non-directional wave data	Validation	Template is currently the same for drifting, moored, and wave buoys. The plan is to produce a specific simplified template for wave buoys
	Templates for the wave observations from different platforms suitable for WAVEOB data	Validation	Template should undergo validation
VOS data	B/C10 - Regulations for reporting SHIP data in TDCF	Operational (TM308009)	No specific plan for this template
	Synoptic reports from sea stations suitable for SHIP observation data from VOS stations	Validation	Template should be revised to allow for the encryption of the ship's call sign.
XBT data	New BUFR template for XBT Temperature Profile data, version 10.2	Validation, updated in May 2012	Template should undergo validation
Argo data	Sub-surface profiling floats	Operational (TM315003)	No specific plan for this template
TRACKOB data	TRACKOB data	Operational (TM308010)	No specific plan for this template
Sea-level data	BUFR/CREX templates for tsunameter data and dart buoy system messages	Validation (TM306027)	No specific plan for this template
	BUFR/CREX templates for reporting time series of tide data	Validation	Template should undergo validation

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APPENDIX B

PRELIMINARY REPORT ON THE PRESERVATION OF VOLUNTARY OBSERVING SHIP (VOS) DATA AS REPORTED AT THREE LEVELS

(9 March 2011)

Report submitted by the ETMC ad hoc group: Frits Koek (lead, Netherlands), Gudrun Rosenhagen (Germany), Shawn Smith (USA), Elizabeth Kent (UK), Nicola Scott (UK), and Scott Woodruff (USA)

1. Introduction

Many merchant (and some Research Vessels and other) ships are members of the WMO Voluntary Observing Ship (VOS) Scheme. VOS meteorological data are circulated in real-time over the Global Telecommunication System (GTS) data, and/or collected in delayed-mode (DM) under the WMO Marine Climatological Summaries Scheme (MCSS)—from paper/electronic logbooks—using the International Maritime Meteorological Tape (IMMT) format.

VOS data presently are circulated over the GTS using the SHIP code (FM 13; WMO 2010a)—one of the code forms known as Traditional Alphanumeric Codes (TACs), which have been used for telecommunicated data for decades (others relevant to JCOMM include FM 18 BUOY, FM 63 BATHY, and FM 64 TESAC). However, under the new WMO Information System (WIS) the requirement has been expressed to transition all time-critical observational GTS traffic (and possibly some other data exchanges) to use Table-Driven Code (TDC) forms (WMO 2010b). In the VOS context the Binary Universal Form for the Representation of meteorological data (BUFR) (FM 94; WMO 2010b) appears likely to be the only appropriate TDC format, but it is optimized for contemporary and operational data requirements, and the need to handle all possible forms of meteorological data leads to a high degree of complexity.

The "owner" of the current FM 13 code is WMO and effectively its Commission for Basic Systems (CBS). WMO/CBS planned for FM 13 to be abandoned as soon as possible, with BUFR intended to serve as its complete replacement by 2012. This impending transition to TDC forms and particularly BUFR was the reason that no essentially changes have been allowed to FM 13 (as well as presumably other TACs) for over 20 years.[1] Therefore the FM 13 code has ended up being increasingly inadequate for reporting the evolving data and information that are observed from the VOS. Within the official constraints of FM 13, several methods were discussed nationally to attempt to carry additional required data configurations/elements (e.g. the extra VOSClim parameters), but those efforts were ultimately unsuccessful.

During the Third Session of the JCOMM Expert Team on Marine Climatology (ETMC-III; Melbourne, Australia, 8-12 February 2010; JCOMM 2010a), a small *ad hoc* group was formed. The purpose of this group is to make proposals to the JCOMM Ship Observations Team (SOT) regarding practices to be included (as applicable) in the *Guide to* and *Manual on Marine Meteorological Services* (WMO 1990, 2001) and in the *Manual on Codes* (WMO 2010a, b). The relevant section of the session's Final Report (JCOMM 2010) on this subject (particularly its paragraph 4.2) is reproduced in Annex I.

1 e.g. WMO (1990): "6.4.33 The Commission [CBS] reaffirmed its decision that changes to character codes should be introduced only when it was absolutely necessary." Also from NOAA/NWS (2010): "Codes are changed occasionally to meet operational needs – the last major change was in January 1982. Some minor changes were made in November, 1994."

The activities of this *ad hoc* group also interrelate partially with those of the JCOMM cross-cutting Task Team on Table Driven Codes (TT-TDC; http://www.jcomm.info/tdc), which was established to help manage the development and evolution of the use of TDCs within JCOMM, and to coordinate their implementation with WMO/CBS and its applicable Expert Teams. Additional potentially interrelated developments in recent years have included JCOMM's Water Temperature metadata (META-T) Pilot Project,[1] and the JCOMM Pilot Project for the WMO Integrated Global Observing System (WIGOS) (JCOMM 2011).

At the ETMC-III meeting it was recognized that, with respect to the preservation of the real-time data, there are three different levels of observations (see Fig. 1):

A. Observing practices and the recording of the observations on-board the ship.

B. Transmission of the observations in real-time from ship to shore. While it was not proposed to standardize the format(s) used for the transmission of VOS data from ship to shore, ETMC felt that it would be useful to provide guidance regarding the elements that should be transmitted, on a variable-by-variable basis.

C. Transmission of the observations in real-time onto the GTS in BUFR format.

The data and metadata that are collected from the VOS fleet can be divided into real-time (or synoptic) and delayed-mode (or climatological) information. Another more abstract way to classify the information is between the actual meteorological/oceanographic data, versus associated (platform and instrumental) metadata. Finally a more specific way of looking at the information is through data and metadata formats presently utilized by WMO, for which purpose we will survey only the FM 13 SHIP code, IMMT (WMO 2010c), and the WMO Pub. 47 (WMO 1955–) metadata format.

1 META-T (from http://marinemetadata.org/community/teams/metat) is aimed "…at providing an international standardization framework for collecting SST and water temperature profile instrumental metadata from a number of marine observational systems, including drifting and moored buoys, observing ships, sea level stations, sub-surface profiling floats, ocean reference stations, and ODAS [Ocean Data Acquisition Systems]…"

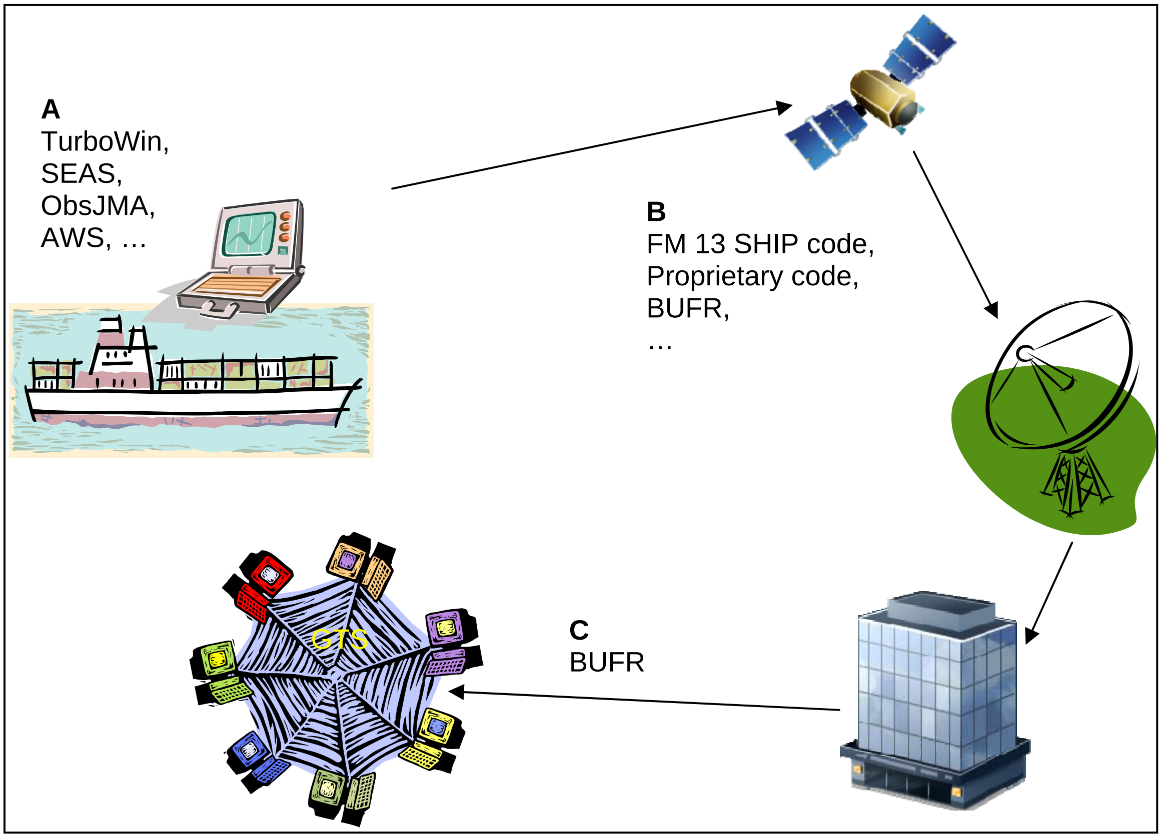

Figure 1. Three levels/phases of the real-time observation: (A) the assembly, (B) ship to shore and (C) onto the GTS.

Annex II provides a summary of these anticipated data and metadata requirements on a field-by-field basis, versus their synoptic/climatological classifications and format availability. Comparison results of NOAA National Centers for Environmental Prediction (NCEP) BUFR data with FM 13 GTS messages (2006 data) are presented in Annex III, illustrating some of the challenging technical issues that will complicate the planned transition to BUFR. Finally, Annex IV provides a technical discussion of features of the BUFR formats used by NCEP and the UK Met Office, including report-length comparisons of BUFR and TAC forms, and also of selected delayed-mode formats (e.g. IMMT).

The remainder of this report's main text is divided into three sections (A, B and C) corresponding to these three levels, and reporting on the limited progress thus far by the ad hoc group.

2. Level A: Observing practices and the shipboard recording of observations

In Annex II, as discussed above, a partial inventory is given of the data and metadata that are needed from VOS, and which information is (should be) available on board. In that table an indication is given in which "class" the information can be found. If no existing class can be assigned, the element is new and should be taken into account in a new observation class/form.

The *Manual on Codes* appears to have preserved a large body of important guidance developed gradually over many years regarding shipboard observing practices, specifically through its Regulations governing FM 13 (and other code forms). Some of the Regulations are dated and not clearly applicable for the future, but others probably remain important, e.g. (WMO 2010a):

> **12.1.6** The actual time of observation shall be the time at which the barometer is read. […]
>
> **12.2.1.3.1** When the horizontal visibility is not the same in different directions, the shortest distance shall be given for VV.

Moreover, the Regulations need to be permanently preserved by WMO for historical marine climatology purposes and studies of past observing practices, but it is not clear that WMO's current publications policy will ensure preservation. Following up on an ETMC-III action, efforts have been initiated to locate, and hopefully in due course image to facilitate widespread public availability, all available past editions (and supplements) of the *Manual on Codes*.[1]

Frequently at least in the past, "supplements" and "amendments" to the *Manual on Codes*, and other WMO publications (e.g. WMO 1990, 2001), were issued in paper form instructing that worldwide libraries and other archives holding those publications make changes manually (e.g. removing old pages and inserting new pages, and in some cases via small pen and ink corrections), thus introducing the possibility that some such changes might not be made properly or in timely fashion at all such recipient institutions. While WMO's original motivation for this updating approach is understandable (e.g. reduced printing costs), from the historical standpoint of seeking to reconstruct the published documentation available at any given time in the past, it can introduce a variety of questions and complications.

Additional WMO published guidance relating to VOS observing practices that is important to keep in archived memory is the *Guide to the Applications of Marine Climatology*. This publication consists of a dynamic part (more recently: WMO 2005) and a static part (WMO 1994). As is the case for the *Manual on Codes*, this publication also contains valuable information that needs to be permanently preserved for historical marine climatology purposes.

Apart from these general WMO publications, there are also a variety of national practices. Nowadays probably most of them are documented in national marine observing manuals (e.g. NOAA/NWS, 2010), etc., but preservation of this type of information has not been centralized and/or regulated (Woodruff 2007).

> **Proposed action:** Continue to advocate for improved "best practices" and archival policies by WMO in terms of (a) publication maintenance (e.g. updating through the use of supplements), and (b) historical publication preservation.
>
> **Proposed action:** Endorse continuing efforts by NOAA's Climate Database Modernization Program (CDMP) and related international initiatives, e.g. RECovery of Logbooks And International Marine data (RECLAIM; Wilkinson et al. 2010) and Atmospheric Circulation Reconstructions over the Earth (ACRE), to rescue and make publicly available historical national and international documentation related to VOS observing practices.

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1 Evidently, editions of the *Manual on Codes* extend back to approximately 1971, however rescue work has thus far only located editions back to 1974 (current progress on this task: https://spreadsheets0.google.com/ccc?hl=en_GB&key=tBht7OdUdju0bV8K0qUEl_w&hl=en_GB - gid=0).

The introduction and increasing prevalence of electronic logbooks (e-logbooks) over the last 10-15 years has also led to new issues of preserving their documentation, and potentially also the underlying software and format information (e.g. SEAS uses a proprietary binary format to shore). The three main internationally recognized e-logbooks (TurboWin, SEAS, and OBSJMA) have each been issued in several editions (e.g. Turbo2, Turbo1, TurboWin, TurboWeb).

> **Proposed action:** Emphasize the importance for marine climatology of safeguarding old (expired) e-logbook documentation, formats, and software, including through the efforts of the Task Team on Instrument Standards (SOT TT-IS).

3. Level B: Transmission of observations in real-time from ship to shore

While it was not proposed to standardize the format(s) used for the transmission of VOS data from ship to shore, ETMC felt that it would be useful to provide guidance regarding the elements that should be transmitted, on a variable-by-variable basis.

With respect to the transmission costs, sending BUFR messages from the ship to the shore doesn't seem to be favorable. This would increase the communication costs drastically, and the probable requirement to develop separate (e.g. national/customized) BUFR encoder/decoders, would greatly aggravate the potential for inadvertent software differences and errors (e.g. Annex III). Since these costs are generally borne by only a reduced number of countries, this seems unacceptable.

A different method – developed by E-SURFMAR – seems to be that the message (either in official FM 13 or other proprietary formats) is compressed on board the ship, then sent to one of the pre-assigned shore stations. These institutes de-compress the messages, encode them into BUFR and subsequently transmit the BUFR message over the GTS.

> **Proposed action:** Liaise with E-SURFMAR's VOS Technical Advisory Group (VOS-TAG) and try to tune the different views and methods. It is important to limit the number of formats to a manageable set that is properly documented at a central location, which we suggest consideration of whether JCOMMOPS might be the appropriate location.
>
> **Proposed action:** Consider whether an informal continuing utilization of an FM 13-like code (i.e. essentially assuming "ownership" of the code after WMO/CBS officially discontinues it, and thus including the potential for future expansions and modifications) might be a useful component of the proposed solutions.
>
> **Proposed action:** No additional specific guidance has been developed yet under Level B, but we feel this is a very important continuing follow-up area for SOT.

4. Level C: Real-time GTS transmission of observations in BUFR format

The TT-TDC recently began consideration of the latest proposed new *BUFR Template for VOS data* (TT-TDC, 2010a), which in turn relies on a *Marine Template Common Sequence List* (TT-TDC, 2010b). These documents (and others similarly for other templates such to replace the FM 18 BUOY code) were led largely through the efforts of Bob Keeley (Canada, retired). This development effort has also been guided in part by this recommendation from the JCOMM Data Management Strategy draft (JCOMM 2007):

> "Recommendation 4.2c: Enhanced interaction between JCOMM and CBS or other appropriate WMO committees is needed to expand the scope of TDCs to

> more fully incorporate JCOMM considerations, including software reliability, human readability, and the archival and exchange of historical and delayed-mode data in its originally reported form."

While an earlier template for VOS data also exists, it is closer to a simple translation of FM 13 fields to BUFR descriptors. The template described in TT-TDC (2010a, b) goes further in repackaging the measurements that appear in FM 13 into more consistent packages, in adding important metadata elements that should accompany the data, and in showing the relationship between the data transmitted in BUFR to the international formats used in the delayed-mode data processing, i.e. the IMMT format used in the MCSS and in the International Maritime Meteorological Archive (IMMA) format (ICOADS 2010) used for the larger ICOADS historical archive (http://icoads.noaa.gov/; Woodruff et al. 2010).

Two critical "legacy" background elements of the new template were to establish within TT-TDC (2010a): Annex 2: *Mapping of the contents of the SHIP (FM 13–XIV) code to the BUFR template* and Annex 3: *Regulations associated with the SHIP (FM 13–XIV) code*. The latter is intended to ensure that no existing information, or regulatory guidance that still may be relevant on coding or observational practices (as discussed in sec. 2), is left out without good reason. Also WMO's plans for retention of legacy documentation (e.g. in the *Manual on Codes*) following the eventual termination of FM 13 are unknown (related to other WMO publications/maintenance issues as also discussed in sec. 2).

Another critical requirement in the proposed new BUFR template(s) is the attachment of the original FM 13 message, or in the future potentially other replacement proprietary formats, specifically using this proposed BUFR construct (from TT-TDC, 2010a):

> 2 05 YYY Plain language – used to send original SHIP message

Retention by NOAA/NCEP of the original GTS reports (i.e. attached to the translated BUFR data) in this fashion has proven to be of critical importance for data continuity, because it permitted us to make detailed comparisons (e.g. Annex III), and also allows the possibility of future correction of data errors or omissions, which sometimes can remain undetected for long periods. Annex IV discusses the technical and storage cost issues associated with this NCEP practice in more detail, and also provides technical comparison information with the UK Met Office BUFR VOSClim BUFR format.

If WMO permits this input data retention feature to be incorporated (or at least encouraged at a national level) in the VOS BUFR template, this would guard against inadvertent translation errors or data omissions, and allow for their correction, possibly long after the data are transmitted. This reduces pressure on the need for complete and fully successful advance validation of the BUFR template, which otherwise assumes more importance. A related complication however is that advance validation sufficient to "prove" that the VOS BUFR template is correct and complete (see Annex III), is very unlikely to be affordable from a resource standpoint – and current CBS validation rules appear too weak to meet the more stringent requirements of marine climatology (in contrast probably e.g. to some NWP requirements).

An add-on "JCOMM field abbreviation" is proposed as an important further component of the template, but which falls outside the ordinary documentation used for BUFR in the Manual on Codes (WMO 2010b). As also discussed in JCOMM (2007) and ICOADS (2010), FM 13 and other TACs have had at least one simple, but important, advantage over BUFR in that there is a commonly understood protocol for naming variables. ICOADS (2010) elaborates further on these and other BUFR issues:

> "In BUFR, for example, table references "0 11 001" and "0 11 002" specify wind speed and direction. In FM 13 in contrast, these elements are abbreviated by symbolic letters "dd" and "ff" (dd was in use since at least 1913 in the International Synoptic Code; NCDC 1960). As noted above, the existing symbolic letters can provide an important communication mechanism among producers and users of the data. A similar user-friendly mechanism, and linkage with the historical synoptic codes, does not yet appear to exist in TDCF. Moreover, the complexity of TDCF appears to require large computer programs for data encoding and decoding in full generality. The need to rewrite complex software at multiple sites to interface with local requirements (e.g. countries digitizing data) raises software reliability questions and could potentially lead to data continuity problems."

Furthermore, the proposed JCOMM abbreviations will be useful to provide a specific mapping from BUFR into the IMMT and IMMA formats.

Following is some additional background information about the template adapted from TDC (2010a):

> A feature of this template is that it takes some of the information about measurement practices that is imbedded in the many regulations attached to FM 13 and incorporates the information into explicit BUFR fields. This is done for two reasons. One, it reminds the people making the measurements of what the regulations say, and two, it attaches this information, particularly that which is important for correct interpretation of the measurements reported, to the measurements themselves. We feel this is an important attribute and is worth the extra bits needed even though the information can be repetitive across BUFR messages.
>
> Another feature of this new template is that it has grouped measurement values and information about those measurements into discrete packages. Whereas in FM 13 for some variables such as water temperature, information is spread out over a number of symbolic letters and can appear in different sections, we have grouped these all together into a single information package. The reason for this is because we want observing information about the variable to be clearly associated with the variable, but also it gives a sub-template (Table D descriptor) that can be used in other BUFR templates where that same variable is measured and reported. This provides a consistency in reporting that is not now present.
>
> The existing FM 13 code form allows for a section for regional exchange (section 3) and for national use (section 5). In BUFR such practices are handled by using local BUFR descriptors that are numbered from 192 to 255 in the yyy component of the Class B descriptor (F-xx-yyy). It allows individual nations or partners to define whatever variables they wish and to use these in regional exchange without impacting international BUFR exchanges and decoders. In spite of this, certain of the fields in section 3 do have BUFR descriptors that can be used to report them. In this case, the template does include the facility to report the information. Where BUFR descriptors do not exist, the reporting of such information is left to the use of local use descriptors as described above.

FM 13 also allows for free text components to be used when describing icing or ice information. BUFR is designed primarily for binary encoding of information, but it does have the facility to include free text. A scan of FM 13 messages over the last few years shows that there is still use of this free text component but it is not obvious that it is being used as originally intended. Nevertheless, this template provides the facility for free text transmissions.

Converting VOS observations from FM 13 code figures to BUFR descriptors in some cases means a conversion of units, or the use of different code tables. This conversion process risks losing information (as illustrated in Annex III). Further issues that need to be addressed are the proposal (from ETMC) to develop WMO "certified" BUFR encoders/decoders. To be able in the future to understand what happened in the past, it is important to keep track of all changes and versions, including the documentation.

Proposed action: SOT should strongly recommend the adoption of features of the new VOS BUFR template that support recommendations from JCOMM (2007) including for BUFR to "more fully incorporate JCOMM considerations, including software reliability, human readability, and the archival and exchange of historical and delayed-mode data in its originally reported form."

While the recent creation of TT-TDC has advantageously established a single point of interaction for JCOMM with CBS (and its relevant expert teams), already many attempts by quasi-independent JCOMM-related bodies have been made to come up with several solutions to the complex challenges in the transition of SHIP FM 13 to BUFR format, including issues related to the preservation of the original observations (e.g. by TT-TDC), and addressing extended metadata requirements (e.g. by META-T). Sometimes it is not even clear what the status of these efforts across JCOMM is, let alone whether anyone has a complete understanding of the whole picture. Meanwhile more working, task, and advisory groups (e.g. JCOMM Pilot Project for WIGOS) seem to join this playfield, making the situation even more complex.

Proposed action: Seek to better connect all JCOMM-related groups that currently work on this problem and try to reach a consensus, as well as designating clear leadership (e.g. possibly to TT-TDC). Expanded use of modern electronic collaboration systems (e.g. Google Docs, ThinkFree, etc.) could potentially be very useful and speed up the results.

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ANNEX I of Appendix C

Excerpt from JCOMM (2010c) (ETMC-III Final Report)

4.2 Review of the BUFR (and other) templates for VOS and other surface marine data

4.2.1 The Team discussed BUFR encoding requirements and template development status for ship data and other marine data, including the work by the DMPA Task Team on Table Driven Codes (TT-TDC) and the former SOT Task Team on Coding. This discussion was connected with the related issues of (a) standards for data transmission from ship to shore, and (b) Automatic Identification System (AIS) binary weather messages, and the desirability of convergence as practical with those separate requirements.

4.2.2 Much discussion took place since the last ETMC meeting with regard to the development of a new BUFR template for VOS data that would take a wide spectrum of requirements into account, including those expressed by the ETMC and the need to transmit metadata in real-time as proposed by the META-T Pilot Project. The Team reviewed the proposal from TT-TDC, and recommended the following elements and features for inclusion the new template:

- Essential VOSClim elements (e.g. for bias adjustment);
- A flag to indicate whether cloud data were originally recorded in Oktas or percentage before encoding in BUFR reports;
- It must be possible to derive heights of sensors above deck and above water (e.g. gives an indication of how clear the sensor is of the deck and potentially other obstructions as this information cannot always be derived from WMO-No. 47 records).
- Provision for reporting both the wind at anemometer height and at 10m (including method of height adjustment if any);
- Wind measurement system and possibly associated quality information;
- Time of last GPS fix if different from report time.

4.2.3 The Team agreed that the TT-TDC was a good mechanism for addressing the coding issues in terms of marine climatology requirements, and for interacting with the CBS in this regard.

4.2.4 The Team stressed that the recording and distribution of the original data was essential to meet the requirements for marine climatology. For example, the Team agreed that the NCEP practice of attaching the original FM13 (and other original message formats including FM18) data to BUFR reports was extremely valuable and that the practice should be more widely encouraged. It invited the SOT to address the issue of making the original data available in FM13 or other format as appropriate (e.g. IMMT plus some IMMA elements) through attachment to BUFR reports in the view to make specific recommendations to Members in this regard.

4.2.5 The Team also recognized that the issue of preservability of the real-time data could be addressed at three different levels and clear guidance should be proposed for each of those steps:

1. Observing practices and the recording of the observations on-board the ship.

2. Transmission of the observations in real-time from ship to shore. While it is not proposed to standardize the format(s) used for the transmission of VOS data from ship to shore, the Team felt that it would be useful to provide guidance regarding the elements that should be transmitted, on a variable-by-variable basis.
3. Transmission of the observations in real-time onto the GTS in BUFR format.

4.2.6 The Team formed a small group comprised of Frits Koek (lead, Netherlands), Gudrun Rosenhagen (Germany), Shawn Smith (USA), Elizabeth Kent (UK), Nicola Scott (UK), and Scott Woodruff (USA) to address each of those levels, and make proposals to the SOT regarding practices to be included in the *Guide to Marine Meteorological Services* (WMO 2001a) (i.e. for the part describing the VOS Scheme) and in the *Manual on Codes* (WMO 1995, 2001c) (***action; ad hoc group; Apr 2011***).

ANNEX II of Appendix C

Element-by-Element Comparison of Requirements for Climate versus Synoptic Applications, and their Availability in Selected WMO Formats

An outline is given in the following table of presently available and anticipated new required VOS data and metadata elements, classified according to whether they are typically needed ("X") in delayed-mode (climate) or real-time (synoptic), and their availability ("X") in three different available WMO data/metadata formats. [Notes: in future, consideration will be give to the utility of enhancing this table with another column for the International Maritime Meteorological Archive (IMMA) format as utilized for ICOADS. Also this table is similar in some respects to an earlier format/requirements exercise for the "META-T" project (META-T 2007), which also however covered the IMMA format. In addition, the Global Collecting Centres (GCCs), in response to an ETMC-III action, collected an inventory (15 April 2010) of potential additional future marine data format requirements, which are not reflected in this table; e.g. maximum ship operating speed, salinity, radiation (short and long wave), and current data and instrument metadata, and height of barometer above sea level.]

	Needed		Available		
Element	**Climate (delayed mode)**	**Synop (real-time)**	**FM 13**	**IMMT**	**Pub.47**
General					
Ship's name	X				X
Call sign	X			X	X
IMO number	X			X	X
Country of registration	X				X
Vessel type	X				X
Length overall of the ship	X				X
Moulded breadth	X				X
Freeboard	X				X
Draught	X				X
Max height of deck cargo above Summer load line	X			X	X
Departure of reference level (max summer load line) above water	X			X	
General route information	X				X
Source of observation	X			X	
Observation platform type	X			X	X
General observing practice	X				X
Routine observing frequency	X				X
Satellite system for transmitting reports	X				X
Name and version of electronic logbook software	X				X
Baseline check of AWS	X				X
Recruiting country	X			X	X
FM code version	X			X	
IMMT version	X			X	
Pub. 47 version	X				X
AWS indicator	X			X	

	Needed		Available		
Element	**Climate (delayed mode)**	**Synop (real-time)**	**FM 13**	**IMMT**	**Pub.47**
Make and model of AWS	X				X
Name and version of AWS processing software	X				X
Name and version of the AWS data entry/display software	X				X
General observational information					
Year	X			X	
Month	X			X	
Day	X	X	X	X	
Time	X	X	X	X	
Latitude	X	X	X	X	
Longitude	X	X	X	X	
Ship’s present heading	X			X	
Ship’s present ground course	X			X	
Ship’s present ground speed	X			X	
Ship's ground course in past three hours	X	X	X	X	
Ship's ground speed in past three hours	X	X	X	X	
QC indicator for ships’ position	X			X	
QC indicator for ships’ course	X			X	
QC indicator for ships’ speed	X			X	
Wind					
True wind direction	X	X	X	X	
Sample frequency of measured wind speed	X				
Method (instantaneous/average/median) of determining Wind speed	X				
True wind speed 10m	X	X	X	X	
True wind speed at anemometer height	X				
Sample frequency of measured wind direction	X				
Method (instantaneous/average/median) of determining wind direction	X				
Relative wind direction	X			X	
Relative wind speed	X			X	
Indicator for wind speed	X			X	
Method of reduction of wind speed	X				
Wind observing practice	X				X
Visual wind observing height	X				X
Primary anemometer height	X				X
Make and model of primary anemometer	X				X
Location of primary anemometer	X				X
Distance of primary (fixed) anemometer from the bow	X				X
Distance of primary (fixed) anemometer from centre line	X				X
Height of primary (fixed) anemometer above max summer load line	X				X
Height of primary (fixed) anemometer above deck on which it is installed	X				X
Most recent calibration date of primary anemometer	X				X
Make and model of secondary anemometer	X				X

Element	Needed: Climate (delayed mode)	Needed: Synop (real-time)	Available: FM 13	Available: IMMT	Available: Pub.47
Location of secondary anemometer	X				X
Distance of secondary (fixed) anemometer from the bow	X				X
Distance of secondary (fixed) anemometer from centre line	X				X
Height of secondary (fixed) anemometer above max summer load line	X				X
Height of secondary (fixed) anemometer above deck on which it is installed	X				X
Most recent calibration date of secondary anemometer	X				X
QC indicator for wind direction	X			X	
QC indicator for wind speed	X			X	
Sea level pressure					
Air pressure at sea level	X	X	X	X	
Air pressure precision	X				
Air pressure at instrument level	X				
Sample frequency	X				
Method (instantaneous/average/median) of determining SLP	X				
Pressure tendency	X	X	X	X	
Character of pressure tendency	X	X	X	X	
Method of correcting SLP observation to sea level	X				
Primary barometer type	X				X
Make and model of primary barometer	X				X
Height of primary barometer above max summer load line	X				X
Location of primary barometer	X				X
Pressure units of primary barometer	X				X
Most recent calibration date of primary barometer	X				X
Secondary barometer type	X				X
Make and model of secondary barometer	X				X
Height of secondary barometer above max summer load line	X				X
Location of secondary barometer	X				X
Most recent calibration date of secondary barometer	X				X
Primary method of determining pressure tendency	X				X
Primary barograph type	X				X
Make and model of primary barograph	X				
Height of primary barograph above max summer load line	X				
Location of primary barograph	X				
Pressure units of primary barograph	X				
Most recent calibration date of primary barograph	X				
Secondary method of determining pressure tendency	X				X
Secondary barograph type	X				X
Make and model of secondary barograph	X				
Height of secondary barograph above max summer load line	X				
Location of secondary barograph	X				

	Needed		Available		
Element	**Climate (delayed mode)**	**Synop (real-time)**	**FM 13**	**IMMT**	**Pub.47**
Most recent calibration date of secondary barograph	X				
QC indicator for sea level pressure	X			X	
Air temperature (dry bulb)					
Air temperature dry bulb (Tdry) reading	X	X	X	X	
Precision of dry bulb temperature	X	X	X	X	
Sample frequency of dry bulb reading	X				
Method (instantaneous/average/median) of determining dry bulb temperature	X				
Reported air temperature units	X	X	X	X	
Dry bulb thermometer type No. 1	X				X
Make and model of dry bulb thermometer No. 1	X				X
Exposure of dry bulb thermometer No. 1	X				X
Location of dry bulb thermometer No. 1	X				X
Height of dry bulb thermometer No. 1 above max summer load line	X				X
Dry bulb thermometer type No. 2	X				X
Make and model of dry bulb thermometer No. 2	X				X
Exposure of dry bulb thermometer No. 2	X				X
Location of dry bulb thermometer No. 2	X				X
Height of dry bulb thermometer No. 2 above max summer load line	X				X
QC indicator for dry bulb temperature	X			X	
Air temperature (wet bulb)					
Wet bulb temperature (Twet) reading	X	X	X	X	
Precision of wet bulb temperature	X				
Sample frequency of wet bulb reading	X				
Method (instantaneous/average/median) of determining wet bulb temperature	X				
Method of determining wet bulb temperature	X			X	
Reported wet bulb temperature units	X	X	X	X	
Iced instrument	X			X	
Wet bulb thermometer type No. 1	X				X
Make and model of wet bulb thermometer No. 1	X				X
Exposure of wet bulb thermometer No. 1	X				X
Location of wet bulb thermometer No. 1	X				X
Height of wet bulb thermometer No. 1 above max summer load line	X				X
Wet bulb thermometer type No. 2	X				X
Make and model of wet bulb thermometer No. 2	X				X
Exposure of wet bulb thermometer No. 2	X				X
Location of wet bulb thermometer No. 2	X				X
Height of wet bulb thermometer No. 2 above max summer load line	X				X
QC indicator for wet bulb temperature	X			X	
Dew-point temperature					
Dew-point temperature (Tdew) reading	X	X	X	X	

	Needed		Available		
Element	**Climate (delayed mode)**	**Synop (real-time)**	**FM 13**	**IMMT**	**Pub.47**
Precision of dew-point	X				
Sample frequency of dew-point reading	X				
Method (instantaneous/average/median) of determining dew-point temperature	X				
Method of determining dew-point	X			X	
Dew-point temperature units	X	X	X	X	
Iced instrument	X	X	X	X	
Dew-point instrument type No. 1	X				
Make and model of dew-point instrument No. 1	X				
Exposure of dew-point instrument No. 1	X				
Location of dew-point instrument No. 1	X				
Height of dew-point instrument No. 1 above max summer load line	X				
Dew-point instrument type No. 2	X				
Make and model of dew-point instrument No. 2	X				
Exposure of dew-point instrument No. 2	X				
Location of dew-point instrument No. 2	X				
Height of dew-point instrument No. 2 above max summer load line	X				
QC indicator for dew-point temperature	X			X	
Relative humidity					
Reported relative humidity	X	X	X	X*	
Method of determining relative humidity	X			X	
Precision of reported relative humidity	X			X	
Sample frequency of relative humidity	X				
Method (instantaneous/average/median) of determining relative humidity	X				
Hygrometer type No. 1	X				X
Make and model of hygrometer No. 1	X				X
Exposure of hygrometer No. 1	X				X
Location of hygrometer No. 1	X				X
Height of hygrometer No. 1 above max summer load line	X				X
Hygrometer type No. 2	X				X
Make and model of hygrometer No. 2	X				X
Exposure of hygrometer No. 2	X				X
Location of hygrometer No. 2	X				X
Height of hygrometer No. 2 above max summer load line	X				X
QC indicator for humidity	X				
Sea surface temperature					
Sea surface temperature reading	X	X	X	X	
Precision of SST reading	X	X	X	X	
Sample frequency of SST measurement	X				
Method (instantaneous/average/median) of determining	X				

* Humidity in IMMT may be derived from a combination of Tdry, Twet and/or Tdew

	Needed		Available		
Element	**Climate (delayed mode)**	**Synop (real-time)**	**FM 13**	**IMMT**	**Pub.47**
SST					
Units of SST reading	X	X	X	X	
Method of determining SST with instrument No. 1	X			X	X
Make and model of SST instrument No. 1	X				
Location where measurement took place with SST instrument No. 1	X				
Depth of SST instrument No. 1 below the max summer load line	X				X
Depth of SST instrument No. 1 below sea surface	X				
Method of determining SST with instrument No. 2	X				X
Make and model of SST instrument No. 2	X				
Location where measurement took place with SST instrument No. 2	X				
Depth of SST instrument No. 2 below the max summer load line	X				X
Depth of SST instrument No. 2 below sea surface	X				
QC indicator for SST	X			X	
Waves					
Wave measurement instrumentation/method	X				
Make and model of wave instrument	X				
Direction of wind waves	X				
Wind wave period indicator	X				
Period of wind waves	X	X	X	X	
Height of wind waves	X	X	X	X	
Visual wind wave observing height	X				X
Swell period indicator	X				
Direction of predominant swell waves	X	X	X	X	
Period of predominant swell waves	X	X	X	X	
Height of predominant swell waves	X	X	X	X	
Direction of secondary swell waves	X	X	X	X	
Period of secondary swell waves	X	X	X	X	
Height of secondary swell waves	X	X	X	X	
(Non)-directional spectral wave information	?				
QC indicator for wind wave period	X			X	
QC indicator for wind wave height	X			X	
QC indicator for swell direction	X			X	
QC indicator for swell period	X			X	
QC indicator for swell height	X			X	
General weather					
Present weather	X	X	X	X	
Other present weather phenomena	X				
Intensity of other present weather phenomena	X				
Time period or displacement	X				
Past weather (1)	X	X	X	X	
Other past weather phenomena	X				

Element	Needed: Climate (delayed mode)	Needed: Synop (real-time)	Available: FM 13	Available: IMMT	Available: Pub.47
Intensity of other past weather phenomena	X				
Past weather (2)	X	X	X	X	
Horizontal visibility					
Visibility measurement system	X		X*	X*	
Make and model of visibility instrument	X				
Height of sensor above deck	X				
Height of sensor above water surface	X				
Horizontal visibility	X	X	X	X	
Obscuration	X				
Character of obscuration	X				
Phenomena occurrence	X				
QC indicator for horizontal visibility	X			X	
Clouds					
Cloud height indicator	X		X*	X*	
Height of cloud base	X	X	X	X	
Total cloud cover	X	X	X	X	
Amount of lowest clouds	X	X	X	X	
Genus of lowest clouds	X	X	X	X	
Genus of middle clouds	X	X	X	X	
Genus of highest clouds	X	X	X	X	
QC indicator for cloud height	X			X	
QC indicator for clouds	X			X	
Ice/icing					
Ice deposit (thickness)	X	X	X	X	
Rate of ice accretion	X	X	X	X	
Cause of ice accretion	X	X	X	X	
Sea ice concentration	X	X	X	X	
Ice of land origin	X	X	X	X	
Amount and type of sea ice	X				
Sea ice situation	X				
Sea ice development	X		X	X	
Bearing of sea ice edge	X	X	X	X	
Precipitation					
Method of observing amount of precipitation	X				
Model and version of instrument	X				
Amount of precipitation	X	X	X	X	
Duration of recording the observed precipitation	X	X	X	X	
QC indicator for precipitation observation	X		X	X	

* In FM13 and IMMT the indicators for visibility and cloud height are combined

ANNEX III of Appendix C

Additional Comparisons of NCEP BUFR with FM 13 GTS Messages (2006 Data)

(DRAFT 14 March 2007; a version of Appendix M in: http://icoads.noaa.gov/etmc/etmc2/etmc2-docs/ETMC2-Doc-3.3-Ship-BUFR.pdf)

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1. Introduction

The First Session of the Expert Team on Marine Climatology (JCOMM 2004) made a limited review of marine BUFR data (see webpage: http://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 UK Met Office GTS reports, with matching ICOADS reports converted from NCEP BUFR.

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

Retention by 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 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 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 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			

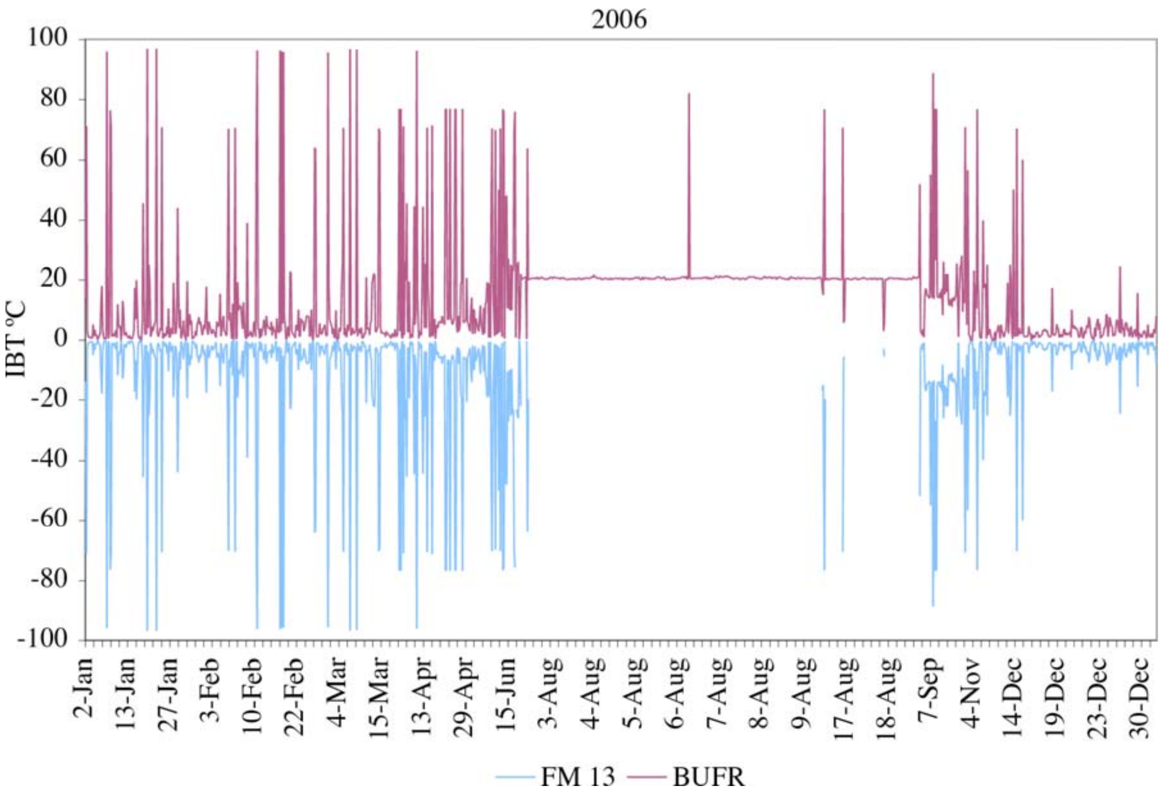

Figure 1. All NCEP BUFR iced bulb temperatures (IBT) in 2006, plotted against date (data points are connected by lines, so as to be clearly visible). The FM 13 values (translated by the ICOADS decoder from the 1st or only attached message) are shown in blue, and the BUFR values (translated by NCEP) in 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 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 latter features appear to derive from differences in the decoding as performed by 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 probably illustrates the approximate amount of wind speeds currently biased +0.1 m/s in ICOADS per year for 2000-2006.

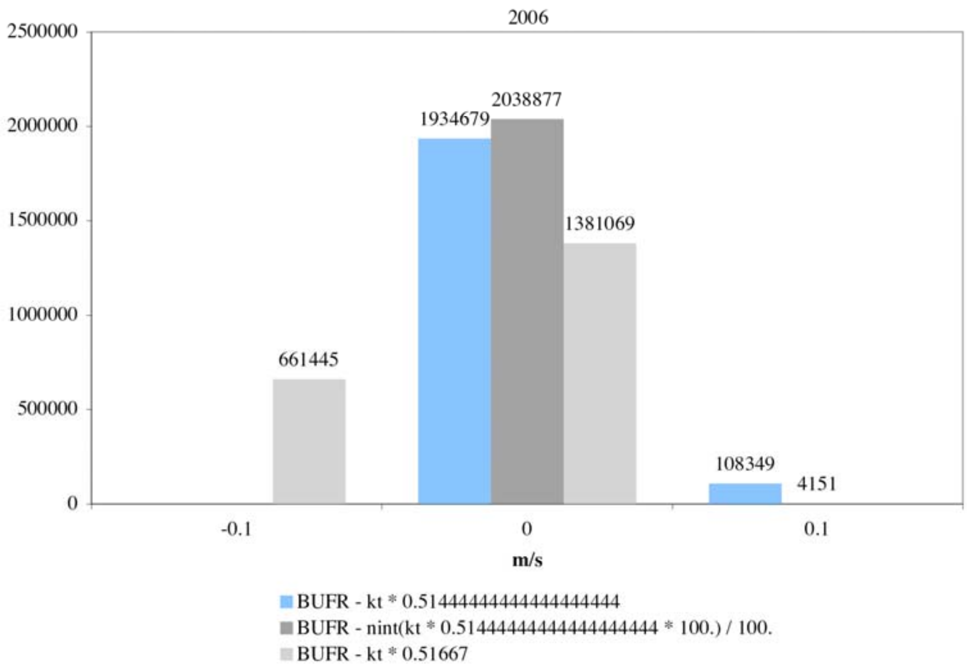

Figure 2. Results of converting all FM 13 wind speeds for 2006 from knots to ms^{-1} according to three different algorithms, and then subtracting the result from the corresponding NCEP BUFR value in ms^{-1}. The total number of extant wind speed reports in the FM 13 data is 3.7M, thus about 1.7M reports 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 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 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

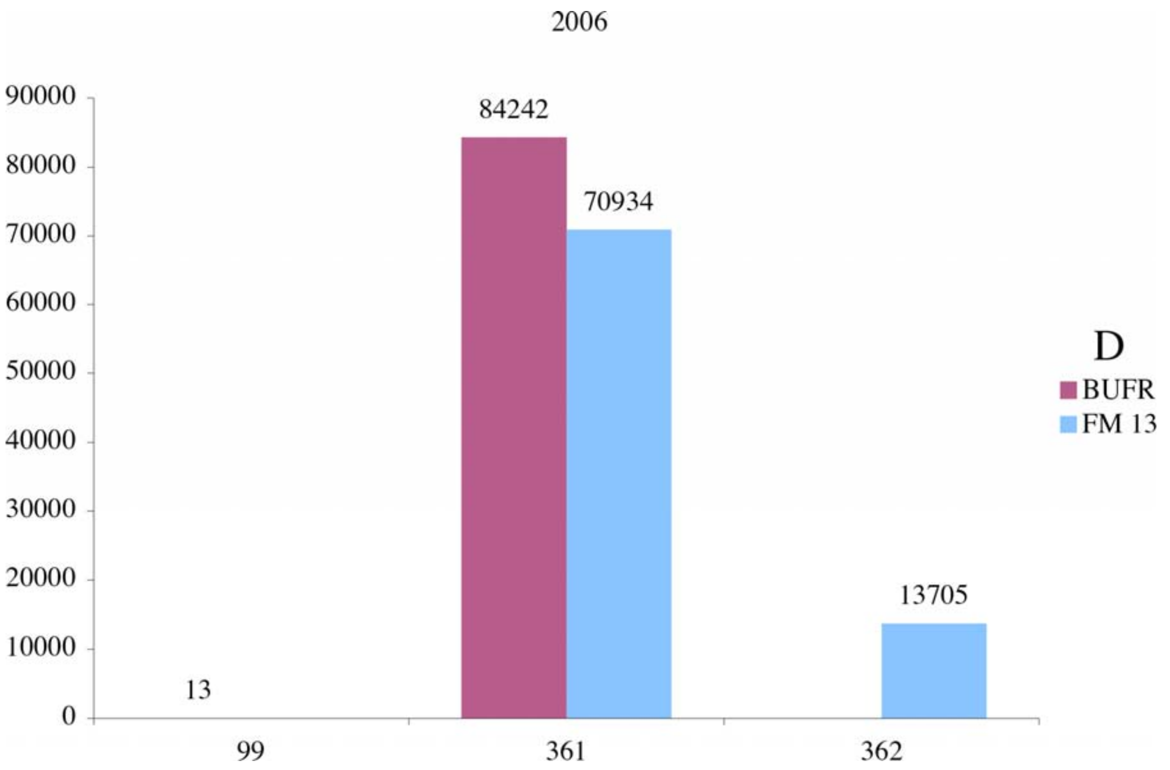

Figure 3. NCEP BUFR (red bars) and FM 13 (blue bars; ICOADS decoding of the first or only attached message) "calm" and "variable" wind directions, as translated into IMMA field D (see Table 3). The numbers do not match up precisely (13705 + 70934 = 84639), but it appears most of the variable wind directions 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.).

ANNEX IV of Appendix C

Report-length comparisons of BUFR and TAC forms; also of selected delayed-mode formats (revised Draft)

(S. Woodruff and S. Lubker, NOAA Earth System Research Laboratory)

This comparison information was assembled to help inform discussions of the feasibility and storage (and other) costs of possibly retaining "original" data forms within the proposed new BUFR VOS template (and similarly within additional marine BUFR templates of direct interest to JCOMM). Presently the relevant original data forms consist of the Traditional Alphanumeric Code (TAC) forms, and primarily those for SHIP (FM 13) and BUOY (FM 18) data. Table 1 compares, for two example days (or months) in 2009, the average report lengths of BUFR data from the NOAA National Centers for Environmental Prediction (NCEP), with "VOSClim" BUFR data from the UK Met Office. Table 1 also compares the average report lengths of original TAC data and selected delayed-mode formats, specifically the International Maritime Meteorological Tape (IMMT) and Archive (IMMA) formats (ICOADS 2010).

Table 1. Comparisons of the average report sizes of BUFR, TACs, and selected delayed-mode formats (IMMT and IMMA) for 15 January and 15 July 2009, except full months were used for (b) and (d), as noted. As discussed below the table, the BUFR report sizes include different amounts of overhead or other information, thus leading to the large size differences between NCEP and the UK Met Office VOSClim versions of BUFR. Since estimating the size of modern FM 13 messages was the initial question motivating these comparisons, our best estimate of that size (upper limit, including some GTS header overhead) is shaded in the table.

Format	*Data being stored*	*Avg. report size (8-bit bytes) [15] Jan 2009*	*Avg. report size (8-bit bytes) [15] Jul 2009*
(a) NCEP BUFR	Five types*	252	255
(b) UK Met Office BUFR†	VOSClim ships (FM 13)	113	101
*(c) Est. from IMMA: NCEP**:*			
FM 13	ship	116	117
FM 13 and FM 18	moored buoy	139	139
FM 18	drifting buoy	117	118
C-MAN	C-MAN	84	85
*(d) Est. from IMMA: NCDC†**:*			
FM 13	ship	114	114
FM 13 and FM 18	moored buoy	137	136
FM 18	drifting buoy	117	117
C-MAN	C-MAN	77	77
(e) IMMA (w/ orig. TAC string)††:			
IMMA w/ FM 13 report(s)	ship	370	371
IMMA w/ FM 13 or FM 18 report(s)	moored buoy	381	382
IMMA w/ FM 18 report(s)	drifting buoy	295	296
IMMA w/ C-MAN report(s)	C-MAN	338	339
(f) IMMT format			
IMMT-III	generally VOS	159 (fixed length)	
IMMT-IV	generally VOS	172 (fixed length; eff. 2011)	

* Surface marine ship (FM 13), moored and drifting buoy (FM 18), moored buoy (FM 13), Coastal-Marine Automated Network (C-MAN format, a variant of FM 13), and tide gauge data (CREX format).

** These report sizes all included the 4-character $M_iM_iM_jM_j$ construct, plus a further 15 characters of GTS header overhead (counting a 1-space delimiter). Compared with the NCDC GTS counts, the NCEP report sizes are slightly inflated because in some cases multiple TAC strings were included in BUFR and retained in IMMA (discussed further in the text).

† All 31 days of the indicated month were included for these counts.

†† Based on storage of the NCEP data in IMMA format. The variable-length IMMA format (ICOADS 2010) has a fixed "core" (108 characters) with the most commonly reported variables, plus a series of "attachments" (such that empty attachments are omitted) containing additional data or metadata. The source TAC (or other original) report(s) are stored in the last of those attachments.

The average report sizes listed in Table 1 for BUFR contain different amounts of overhead or other information, in addition to the data volume required to store in BUFR the reported TAC data alone (or likely in all cases a subset of all possible reported TAC data configurations; see Figure 1). Some of this overhead appears to be intrinsic to BUFR, in that a BUFR "message" typically contains multiple individual marine reports, BUFR "sections," etc.

Additionally however the overhead amounts differ depending on choices made by the originating centers to store different amounts of reported data or ancillary information (e.g. GTS header information that is separate from the basic TAC reports, and QC flags), and also to a limited degree in terms of some technical implementation issues (i.e. control words that are part of the NCEP data).

For example, the Met Office BUFR data are provided in a specialized "VOSClim" format, which contains only a small subset of the total possible reported ship data fields together with some model background information (as discussed in further detail below), so just in those respects the size comparison with NCEP BUFR is not comparing like-with-like.

Decoders are available both from NCEP and the Met Office, but for a variety of reasons including the technical implementation issues, it currently seems unlikely that the decoder from one center would work to read data from the other center, without significant modifications. Following are more detailed comments regarding the NCEP and UK Met Office BUFR formats:

NOAA/NCEP BUFR
In contrast to the approach adopted by the Met Office, NCEP (2010) embeds the utilized BUFR table information within each BUFR file (effective 24 January 2011, more than one such table could be included in a given file, thus accommodating possible BUFR table changes within e.g. a temporal file). This approach would appear advantageous from the standpoint of preserving the table information together with the data, e.g. in the event of changes through time in the published BUFR codes. NCEP stores about a dozen fields derived from the GTS bulletin header (e.g. corrected report indicator and date and time of receipt) as well as a few QC flags set by NCEP (see Woodruff 2006).

Also as illustrated in Woodruff (2006), and documented in NCEP (2009), NCEP already retains original data by dividing the input TAC report string(s) into a sequence of 64-bit (i.e. eight bytes of CCITT IA5 or ASCII) called the "raw report string" (abbreviated as RRSTG by NCEP; code 058008). However, this raw string does not include the $M_iM_iM_jM_j$ construct that marks the beginning of each TAC report (e.g. BBXX or ZZYY). The number of RRSTG fields (replications) in the sequence is specified by another descriptor "raw report" (RAWRPT; 363002). Not counting the RRSTG fields (or other replication indicators), the Woodruff (2006) example message contains around 68 fields, thus confirming that a more complete set of data is being preserved by NCEP, in comparison to the Met Office VOSClim format.

The NCEP data used for these comparisons were a form of BUFR data used recently for ICOADS, which have been subjected to a "dup-merge" processing at NCEP in which exact duplicates were removed and partial duplicates blended to create more complete BUFR reports. Also some QC flags were set by NCEP and retained in the BUFR data. In this form of NCEP BUFR data, all constituent (i.e. one or more) TAC reports (plus bulletin header information) were included (generally attached in reverse order of receipt time; see ICOADS 2009 for additional information). All such constituent TAC reports were also attached when the NCEP data were translated to IMMA format for ICOADS, thus the TAC size estimates in Table 1 (part c) include this extra overhead (but the impact appears to be relatively small, when compared with the more accurate part d estimates).

NCEP uses a Fortran unformatted read in their BUFR library, thus the data have some further overhead in the form of (4-byte) control words (possibly utilized at the “message” level of BUFR and introducing an overhead of approximately 2% in data volume), which turned out to be big-endian. It was therefore necessary to write a filter to byte swap just the control words. While the compiler we used[6] had a byte-swap option, that worked on the control words, but then the data were corrupted.

UK Met Office BUFR

The VOSClim[7] BUFR format has 52 elements per report, including two GTS header fields (collecting center and bulletin ID) and 17 fields of co-located Met Office model comparison data (see Table C3 in ICOADS 2010). As noted above, this is a reduced amount of information in comparison to that stored in the NCEP data. Multiple (but varying numbers of) reports are known to be stored within each BUFR message within this VOSClim format.

According to documentation received from the Met Office in 2001 with their decoder, the BUFR tables are stored externally to the BUFR data and linked to the software (in contrast to NCEP). However, a revised decoder was also recently received from the Met Office[8], and may include additional/revised documentation about the Met Office BUFR format.

References

ICOADS, 2009: Release 2.1 Real-time (ICOADS.RT) Archive Overview (1997-2002) [Updated: Jul 27, 2009 13:41:18 MDT: http://icoads.noaa.gov/rt.html].

ICOADS, 2010: Archival of Data Other than in IMMT Format: The International Maritime Meteorological Archive (IMMA) Format. [http://icoads.noaa.gov/e-doc/imma/R2.5-imma.pdf].

NCEP, 2010: BUFRLIB Software User Guide [Page last modified: Tuesday, 01-Jun-2010 15:26:41 GMT: http://www.nco.ncep.noaa.gov/sib/decoders/BUFRLIB/].

WMO, 2009: Manual on Codes, International Codes, Volume I.1 (Annex II to WMO Technical Regulations) Part A – Alphanumeric Codes WMO-No. 306, 2009 edition.

Woodruff, S., 2006: BUFR Template Replacement for the FM13 (SHIP) Code: Preliminary Comments and Questions [http://icoads.noaa.gov/etmc/sdw-bufr-notes.pdf].

6 GNU/Linux, with f77 compiler (/opt/sun/sunstudio12/bin/f77).

7 The Table 1 comparisons were performed using Met Office BUFR data only from VOSClim-classified ships. However, a larger set of historical ship and buoy BUFR data in the VOSClim format is slated to become publicly available in the future.

8 Both the 2001 and 2010 decoders required a License Agreement.

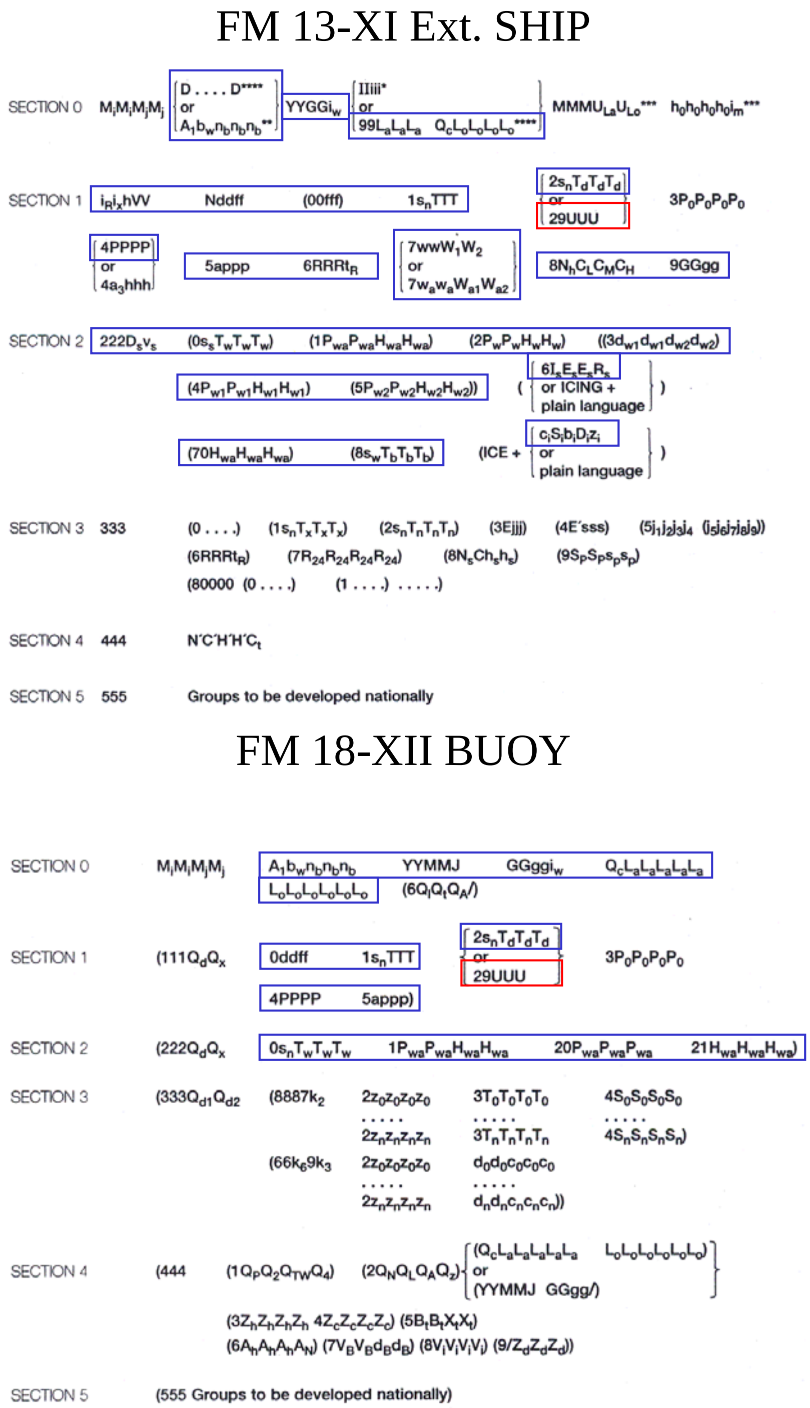

Figure 1. Sections and individual data elements (from WMO 2009) that could be reported in recent versions of FM 13 (top) and FM 18 (bottom). Blue boxes enclose elements previously converted into IMMA format for ICOADS, and red boxes enclose an element (i.e. relative humidity) added more recently to ICOADS as part of its Release 2.3 (completed in 2006). Thus elements that are not enclosed are not converted into IMMA regular fields (but are preserved, if reported, in the IMMA "supplemental" attachment, dedicated to the original data). We have not made a similar assessment of the extent of translation of all possible FM 18/13 elements into the NCEP or Met Office VOSClim BUFR formats, but believe that neither BUFR is complete.

APPENDIX C

EXCERPT OF SOT-6 FINAL REPORT REGARDING PRESERVABILITY OF MARINE CLIMATE DATA

9.2.4.4 Regarding Observing practices and the shipboard recording of observations:

i. The Team agreed to continue to advocate for improved "best practices" and archival policies by WMO in terms of (a) publication maintenance (e.g. updating through the use of supplements), and (b) historical publication preservation.

ii. The Team endorsed continuing efforts by NOAA's Climate Database Modernization Program (CDMP) and related international initiatives, e.g. RECovery of Logbooks And International Marine data (RECLAIM; Wilkinson et al. 2010) and Atmospheric Circulation Reconstructions over the Earth (ACRE), to rescue and make publicly available historical national and international documentation related to VOS observing practices.

iii. The Team emphasized the importance for marine climatology of safeguarding old (expired) e-logbook documentation, formats, and software, including through the efforts of the Task Team on Instrument Standards (***action; TT-IS & ETMC; SOT-VII***).

9.2.4.5 Regarding the transmission of observations in real-time from ship to shore:

i. The Team agreed to liaise with the E-SURFMAR's VOS Technical Advisory Group (VOS-TAG) and try to tune the different views and methods (***action; TT-IS; SOT-VII***). It is important to limit the number of formats to a manageable set that is properly documented at a central location, preferably JCOMMOPS.

ii. The Team agreed that it would be acceptable to continue an informal utilization of an FM 13-like code (i.e. essentially assuming "ownership" of the code after WMO/CBS officially discontinues it, and thus including the potential for future expansions and modifications) as a useful component of the proposed solutions.

iii. The Team requested the Task Team on Instrument Standards to liaise with the ETMC ad hoc group in the view to make further recommendations to the Team at its Seventh Session (***action; TT-IS; SOT-VII***)

9.2.4.6 Regarding Real-time GTS transmission of observations in BUFR format:

i. The Team strongly recommend the adoption of features of the new VOS BUFR template that support recommendations from the JCOMM Data Management Strategy including for BUFR to "more fully incorporate JCOMM considerations, including software reliability, human readability, and the archival and exchange of historical and delayed-mode data in its originally reported form." The Team requested the DMPA Task Team on Table Driven Codes to address these issues (***action; DMPA TT-TDC; SOT-VII***).

ii. The Team agreed that it should seek to better connect all JCOMM-related groups that currently work on this problem and try to reach a consensus, as well as designating clear leadership (e.g. possibly to TT-TDC). Expanded use of modern electronic collaboration systems (e.g. Google Docs, ThinkFree, etc.) could potentially be very useful and speed up the results.

APPENDIX D

BUFR MARINE SEQUENCES PROPOSED BY JCOMM
(draft)

Last update: 19 November 2010

Marine template common sequence list

This document contains a list of all of the sequences that are needed to report oceanographic and meteorological information from marine platforms. They are ordered by sequence number.

The list of proposed new sequences is as follows:
3-01-200: Ship information
3-01-201: Float information (used for platforms that profile or drift subsurface for part of the time)
3-01-202: Location information
3-01-203: Date and time information
3-01-204: Buoy / platform information (used for surface drifting or fixed / moored platforms)
3-02-200: Air pressure data
3-02-201: Air temperature and humidity data
3-02-202: Cloud data
3-02-203: Horizontal visibility data
3-02-204: Wind data
3-02-205: Wave property data
3-02-206: Weather data
3-02-207: Precipitation data
3-02-208: Ice data
3-02-209: Non-directional spectral wave data (by frequency)
3-02-210: Directional spectral wave data (by frequency)
3-02-211: Partial directional spectral wave data (by frequency)
3-02-212: Solar Radiation data
3-02-213: Non-directional spectral wave data (by wavenumber)
3-02-214: Directional spectral wave data (by wavenumber)
3-02-215: Partial directional spectral wave data (by wavenumber)
3-06-200: Surface water temperature data (high precision)
3-06-201: Water temperature profile data
3-06-202: Surface salinity data (high precision)
3-06-203: Salinity profile data
3-06-204: Surface water current data
3-06-205: Water current profile data

Marine template common sequences

3-01-200: Ship information

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	01	079	Unique identifier for this message	Numeric	0	0	33	UID	(1)
0	01	078	IMO ship identifier	CCITT IA5	0	0	80		(2)
3	01	003	Ship's call sign plus motion 0-01-011 identifier 0-01-012 direction 0-01-013 speed	CCITT IA5 Degree true m s^{-1}	 0 0 0	 0 0 0	 72 9 10		(3)
0	01	044	Ship's ground course: the direction the vessel actually moves over the fixed earth and referenced to true north.	m s^{-1}	0	0	10		(4)

0	07	071	Maximum height of deck cargo above summer maximum load line	m	0	0	6		(5)
0	07	072	Departure of summer maximum load line from actual sea level	m	0	-32	6		(6)

Notes:

1. This is an identifier that can be used to track the data throughout its lifetime. Some countries are using a 32 bit CRC calculation to generate a unique identifier. If using the CRC algorithm, input to the algorithm should be the entire data stream beginning with the IMO ship identifier.
2. This is the IMO unique identifier for a ship. It consists of the 3 characters "IMO" followed by the 7 digit Lloyds registry number.
3. This field expands to:
   0-01-011: Ship or mobile land station identifier. Note this is where a masked call sign would be recorded.
   0-01-012: Direction of motion of moving observing platform (note 4)
   0-01-013: Speed of motion of moving observing platform (note 5)
   Note that 3-01-003 is filled only if the platform is a ship. If another type of platform, fill descriptor 0-02-045, or if a data buoy, use 0-02-149.
4. This field is required for meeting additional requirements for VOSClim (newly introduced descriptor)
5. Allows for a maximum height of 64 m. (newly introduced descriptor)
6. When the load line is above sea level, record this as positive. This field is required for meeting additional requirements for VOSClim. (newly introduced descriptor)

3-01-201: Float information (used for platforms that profile or drift subsurface for part of the time)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	01	079	Unique identifier for this message	Numeric	0	0	33	UID	(1)
0	01	087	WMO marine observing platform extended identifier	Numeric	0	0	23		
0	01	085	Observing platform manufacturer's model	CCITT IA5	0	0	160		
0	01	086	Observing platform manufacturer's serial number	CCITT IA5	0	0	256		
0	02	036	Buoy type	Code table	0	0	2		
0	02	148	Data collection and/or location system	Code table	0	0	5		
0	02	149	Type of data buoy	Code table	0	0	6		
0	22	055	Float cycle number	Numeric	0	0	10		
0	22	056	Direction of profile	Code table	0	0	2		

Notes:

1. This is an identifier that can be used to track the data throughout its lifetime. Some countries are using a 32 bit CRC calculation to generate a unique identifier. If using the CRC algorithm, input to the algorithm should be the entire data stream beginning with the IMO ship identifier.

3-01-202: Location information

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
3	01	021	Latitude and longitude 0-05-001 (Lat; high accuracy) 0-06-001 (Lon; high accuracy)	 Degree Degree	 5 5	 -9000000 -18000000	 25 26		(1)
0	08	080	Qualifier for quality class	Code table	0	0	6		(2)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	063	Total water depth	m	0	0	14		
1	05	000	Replication of 5 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		(3)
0	33	023	Quality of buoy location	Code table	0	0	2		
0	33	027	Location quality class (range of radius of 66 % confidence)	Code table	0	0	3		
0	02	148	Data collection and/or location system	Code table	0	0	5		
0	27	004	Alternate latitude (high accuracy)	Degree	5	-9000000	25		(4)
0	28	004	Alternate longitude (high accuracy)	Degree	5	-18000000	26		(4)
1	04	000	Replication of 4 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		(5)
0	08	021	Time significance	Code table	0	0	5		(6)
3	01	011	Date (of position) 0-04-001 (year) 0-04-002 (month) 0-04-003 (day)	 Year Month Day	 0 0 0	 0 0 0	 12 4 6		
3	01	012	Time (of position) 004004 (Hour) 004005 (Minutes)	 Hour Minute	 0 0	 0 0	 5 6		
0	08	021	Time significance	Code table	0	0	5		(7)

Notes:

1. These fields report the location of the platform
2. Set to qualifier = 20 to indicate the quality flag applies to position
3. For buoy reports and if the Argos location system is used, the information in the next descriptors (down to 0-28-004) may be available. If so, the value of this descriptor is set = 1, otherwise it is set to 0. If =0 the data from these descriptors are not present in the data section.
4. If the Argos system is used to determine position (or some other system that produces alternative locations) provide the alternative position here.
5. If the time of observation matches the time of when the position was determined, the value of this is set to 0 and none of the following fields need appear in the BUFR message. This is often the case for fixed or moored platforms.
6. If the time of position differs from the time of observation of the data, set this indicator =”26” and use the next date fields to record the time when the position was determined
7. Set this value = “31” (missing) to cancel the previous value.

3-01-203: Date and time information

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
3	01	011	Date (of observation) 0-04-001 (year) 0-04-002 (month) 0-04-003 (day)	 Year Month Day	 0 0 0	 0 0 0	 12 4 6		
3	01	012	Time (of observation) 004004 (Hour) 004005 (Minutes)	 Hour Minute	 0 0	 0 0	 5 6		
0	08	080	Qualifier for quality class	Code table	0	0	6		(1)
0	04	024	Time period or displacement	Hour	0	-2048	12		(2)
0	33	050	GTSPP quality class	Code table	0	0	4		

Notes:

1. Add a new meaning in this code table. Set 21 = date and time.
2. This field indicates the time period over which the direction and speed of motion of the ship has been determined.

3-01-204: Buoy / platform information (used for surface drifting or fixed / moored platforms)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	01	079	Unique identifier for this message	Numeric	0	0	33		(1)
0	01	087	WMO Marine observing platform extended identifier	Numeric	0	0	23		
2	08	016	Change width of CCITT IA5 field to 16						
0	01	051	Platform transmitter ID number	CCITT IA5	0	0	96		
2	08	000	Reset width						
0	01	010	Stationary buoy platform identifier; e.g. C-MAN buoys	CCITT IA5	0	0	64		
0	01	007	Satellite identifier	Code table	0	0	10		
0	01	001	WMO block number	Numeric	0	0	7		
0	01	002	WMO station number	Numeric	0	0	19		
0	33	022	Quality of buoy satellite transmission	Code table	0	0	2		
0	02	045	Indicator for type of platform	Code table	0	0	4		(2)
0	02	149	Type of data buoy	Code table	0	0	6		
0	01	012	Direction of motion of moving observing platform	Degree true	0	0	9		(3)
0	01	014	Platform drift speed (high precision)	m/s	2	0	10		(3)
0	02	040	Method of removing velocity and motion of platform	Code table	0	0	4		(3)
1	02	003	Replication 2						

			descriptors 3 times						
0	08	081	Type of equipment	Code table	0	0	6		(4)
0	25	026	Battery voltage	V	1	0	9		
0	08	081	Type of equipment	Code table	0	0	6		(5)
1	07	000	Replication of 7 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		(6)
0	02	034	Drogue type	Code table	0	0	5		(3)
0	22	060	Lagrangian drifter drogue status	Code table	0	0	3		(3)
0	07	070	Drogue depth	m	0	0	10		(3)
0	02	190	Lagrangian drifter submergence (% time submerged)	%	0	0	7		(3)
0	25	086	Depth correction indicator (for sub-surface measurements along cable)	Code table	0	0	2		(3)
0	02	035	Cable length	m	0	0	9		(3)
0	02	168	Hydrostatic pressure of lower end of cable (thermistor string)	Pa	-3	0	16		(3)
0	33	021	Quality of following value	Code table	0	0	2		
0	25	028	Operator or manufacturer defined parameter (#1)	Numeric	1	-16384	15		
0	33	021	Quality of following value	Code table	0	0	2		
0	25	028	Operator or manufacturer defined parameter (#2)	Numeric	1	-16384	15		
0	33	021	Quality of following value	Code table	0	0	2		
0	25	028	Operator or manufacturer defined parameter (#3)	Numeric	1	-16384	15		

Notes:

1. This is an identifer that can be used to track the data throughout its lifetime. Some countries are using a 32 bit CRC calculation to generate a unique identifier. If using the CRC algorithm, input to the algorithm should be the entire data stream beginning with the IMO ship identifier.
2. We need a new entry in 0-02-045: Indicator for type of platform

Code Figure	Meaning
0	Sea station
1	Automatic data buoy
2	Aircraft
3	Satellite
4	Ship or drilling platform
5-14	Reserved
15	Missing value

3. Code this as missing for a fixed or moored platform.
4. Record battery voltages for the observing platform (value=3), the transmitter (value=1) and the receiver (value=2)

5. Set to missing to cancel the previous value
6. Set this value to 1 if there is information about a drogue, otherwise set to missing.

3-02-200: Air pressure data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	191	Type of barometer	Code table					(1)
1	13	001	Replication of 13 descriptors 1 time						(2)
0	08	081	Type of equipment	Code table	0	0	6		(3)
0	12	064	Instrument temperature	K	1	0	12		
0	07	031	Height of barometer above mean sea level	m	1	-4000	17		
0	10	004	Pressure	Pa	-1	0	14		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	10	051	Pressure reduced to mean sea level	Pa	-1	0	14	SLP	
1	05	001	Replication of 5 descriptors 1 time						(4)
0	04	024	Time period or displacement	Hour	0	-2048	11		(5)
0	10	060	Pressure change	Pa	-1	-1024	10		
0	10	063	Characteristic of pressure tendency	Code table	0	0	4		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	04	024	Time period or displacement	Hour	0	-2048	11		(6)

Notes:

1. This is a new descriptor for type of barometer.

   0 02 191: Indicator for type of barometer

Code	Meaning
0	Marine Barograph
1	Marine Aneroid Barometer
2	Electronic Barometer / Barograph
3	Portable, Hand held instrument

2. This groups all of the properties of the following descriptors together.
3. Set this value="0" (sensor)
4. This groups the following 5 descriptors together for which conditions all apply.
5. Use this to record the time period over which the pressure change and tendency is recorded
6. Set this value="0"

3-02-201: Air temperature and humidity data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	192	Type of thermometer	Code table					(1)
0	07	032	Height of sensor above local ground (or deck of marine platform)	m	2	0	16		
0	07	033	Height of sensor above water surface	m	1	0	12		
1	14	001	Replication of 14 descriptors 1 time						(2)
0	12	101	Temperature/dry-bulb temperature	K	2	0	16	AT	
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	02	039	Method of wet-bulb temperature measurement	Code table	0	0	3	WBTI	
0	12	102	Wet-bulb temperature	K	2	0	16	WBT	
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	12	103	Dew-point temperature	K	2	0	16	DPT	
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	13	003	Relative humidity	%	0	0	7	RH	
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	04	001	Replication of 4 descriptors 1 time						(3)
0	04	024	Time period or displacement	Hour	0	-2048	12		
0	12	111	Maximum temperature, at height and over period specified	K	2	0	16		
0	04	024	Time period or displacement	Hour	0	-2048	12		
0	12	112	Minimum temperature, at height and over period specified	K	2	0	16		
0	04	024	Time period or displacement	Hour	0	-2048	11		(4)
0	07	032	Height of sensor above local ground (or deck of marine platform)	m	2	0	16		(5)

0	07	033	Height of sensor above water surface	m	1	0	12		(5)

Notes:

1. This is a new descriptor.

   0 02 192: Indicator for type of platform

   Code value Meaning
   - 0 Hygrometer Set (Dry and Wet Bulb)
   - 1 Electronic Thermometer
   - 2 Portable, Hand held instrument

2. This groups the properties of these 14 desciptors together
3. Groups the next 4 descriptors together for which the time period applies.
4. Set this value=”0”
5. Set to missing to cancel previous value.

3-02-202: Cloud data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	183	Cloud detection system	Code table	0	0	4		
0	20	010	Cloud cover (total)	%	0	0	7	N	(1,2)
0	20	109	Original units of cloud cover	Code table	0	0	1		(3)
0	08	002	Vertical significance (surface observations)	Code table	0	0	6		
0	20	011	Cloud amount	Code table	0	0	4		
0	20	012	Cloud type	Code table	0	0	6		
0	20	013	Height of base of cloud	m	-1	-40	11		
1	02	003	Delayed replication of 2 descriptors 3 times						(4)
0	08	002	Vertical significance (surface observations)	Code table	0	0	6		
0	20	012	Cloud type	Code table	0	0	6		

Notes:

1. A cloud cover (total) value 113 shall indicate “Sky obscured by fog and/or other meteorological phenomena.
2. If cloud cover is actually recorded in oktas, then converted to percent, it is important to know in order to preserve consistency with historical records. Conversion”

   1 okta = 12.5%
   2 oktas = 25%
   3 oktas = 37.5%
   4 oktas = 50%
   5 oktas = 62.5%
   6 oktas = 75%
   7 oktas = 87.5%
   8 oktas = 100%
3. New Code table: 0-20-109: Original units used to measure cloud cover

   Code Figure Meaning
   - 0 Original units of observation are percent
   - 1 Original units of cloud cover are oktas
4. This allows for reporting types of low, middle, and high clouds

3-02-203: Horizontal visibility data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	182	Visibility measurement system	Code table	0	0	4		(1)
0	07	032	Height of sensor above local ground (or deck of marine platform)	m	2	0	16		
0	07	033	Height of sensor above water surface	m	1	0	12		
0	20	001	Horizontal visibility	m	-1	0	13		
0	20	025	Obscuration	Flag table	0	0	21		(2)
0	20	026	Character of obscuration	Code table	0	0	4		
0	20	027	Phenomena occurrence	Flag table	0	0	9		

Notes:

1. This is a new descriptor

   0 02 182: Indicator for the visibility measurement system

Code Figure	Meaning
0	Visual Estimate
1	Electronic Sensor

2. This and the next 2 fields are to be used with automated weather systems and instead of reporting this information through present or past weather.

3-02-204: Wind data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	07	032	Height of sensor above local ground (or deck of marine platform)	m	2	0	16		
0	07	033	Height of sensor above water surface	m	1	0	12		
0	02	169	Anemometer type	Code table	0	0	4		
0	02	002	Type of instrumentation for wind measurement	Flag table	0	0	4		(1)
1	06	001	Replication of 6 descriptors, 1 time						(2)
0	08	021	Time significance	Code table	0	0	5		(3)
0	04	025	Time period or displacement	minute	0	-2048	12		(4)
0	11	001	Wind direction	Degree true	0	0	9	DD	
0	11	002	Wind speed	$m\ s^{-1}$	1	0	12	FF	
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	06	001	Replication of 6 descriptors, 1 time						(2)
0	08	021	Time significance	Code	0	0	5		(5)

				table					
0	04	025	Time period or displacement	minute	0	-2048	12		(6)
0	11	043	Maximum wind gust direction	Degree true	0	0	9		
0	11	041	Maximum wind gust speed	m s^{-1}	1	0	12		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	04	001	Replication of 4 descriptors, 1 time						(2)
0	11	099	Relative wind direction off the bow of a ship	Degree true	0	0	9		
0	11	100	Relative wind speed off the bow of a ship	m s^{-1}	1	0	12		(7)
0	08	080	Qualifier for quality class	Code table	0	0	6		(8)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	11	099	Method of adjustment of measured wind to 10m value	Code table	0	0	4		(9)
0	11	102	Wind direction adjusted to 10m	Degree true	0	0	9		
0	11	103	Wind speed adjusted to 10m	m s^{-1}	1	0	12		
0	04	025	Time period or displacement	minute	0	-2048	12		(10)
0	07	032	Height of sensor above local ground (or deck of marine platform)	m	2	0	16		(11)
0	07	033	Height of sensor above water surface	m	1	0	12		(11)

Notes:

1. This is a new descriptor.
   0 02 002: Indicator for type of platform
   Code Meaning
   0 Visual Estimate from Sea Surface
   1 Anemometer
   2 Effects of the wind on people or objects on the ship (apparent)
2. Use of this descriptor allows the grouping of the information that is relevant to the measured variable in the group. The time significance and time period values only apply within this group.
3. Set this value = 2 to indicate the following wind data represents a time average.
4. Provide the averaging period in minutes.
5. Set this value = 23 to indicate the following gust wind data was observed of a given period of time.
6. Indicate the time period over which the gust wind was observed.
7. Field required to meet additional VOSClim requirements (annotated as RWD in Hester’s table). Note that this allows for the same maximum and precision as true wind direction.
8. Field required to meet additional VOSClim requirements (annotated as RWS in Hester’s table). Note that this allows for the same maximum and precision as true wind speed.
9. This is a new code table that we must fill out. This can be adjusted.
   0-11-099 Method of adjustment of measured winds to 10m.
   Code Meaning
   0 Adjusted …
10. Set this value=”0”
11. Set to missing to cancel the previous value.

3-02-205: Wave property data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	046	Wave measurement instrumentation	Code table	0	0	4		(1)
0	22	001	Direction of waves	Degrees true	0	0	9		(2)
0	22	011	Period of waves	s	0	0	6		
0	22	021	Height of waves	m	1	0	10		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	03	002	Delayed replication of 3 descriptors 2 times						(3)
0	22	003	Direction of swell waves	Degrees true	0	0	9		
0	22	013	Period of swell waves	s	0	0	6		
0	22	023	Height of swell waves	m	1	0	10		
0	08	080	Qualifier for quality class	Code table	0	0	6		(3)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	002	Direction of wind waves	Degrees true	0	0	9		
0	22	012	Period of wind waves	s	0	0	6		
0	22	022	Height of wind waves	m	1	0	10		
0	08	080	Qualifier for quality class	Code table	0	0	6		(3)
0	33	050	GTSPP quality class	Code table	0	0	4		

Notes:

1. A new entry in code table 0 02 046 is required to indicate that wave properties are estimated from visual observations. The proposed entry is as follows:
   0-02-046: *Wave measurement instrumentation*
   Code Meaning
   0 Reserved for future use
   1 Heave sensor
   2 Slope sensor
   3 Visual
   4 Ship or satellite radar
   5-14 Reserved
   15 Missing value.
2. If the observer cannot distinguish sea from swell, they can use this, plus the next 2 descriptors to report wave conditions. If it is possible to distinguish wind wave properties from swell properties, other descriptors in this template should be used.
3. The three descriptors (003, 013, 023) are repeated twice, for 2 different swell wave components, the first reported being the dominant one, and the second being the secondary component.

3-02-206: Weather data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	20	003	Present weather	Code table	0	0	9	WW	(1)
0	20	023	Other weather phenomena	Flag table	0	0	18		
0	20	024	Intensity of phenomena	Code table	0	0	3		
0	04	024	Time period or displacement	hour	0	-2048	12		
0	20	004	Past weather (1)	Code table	0	0	5	W1	(2)
0	20	023	Other weather phenomena	Flag table	0	0	18		
0	20	024	Intensity of phenomena	Code table	0	0	3		
0	20	005	Past weather (2)	Code table	0	0	5	W2	(2)
0	20	023	Other weather phenomena	Flag table	0	0	18		
0	20	024	Intensity of phenomena	Code table	0	0	3		

Notes:

1. When encoding present weather reported from an automatic weather station, the appropriate combination of descriptors in the precipitation component (0-20-021, 0-20-022), weather component (0-20-023, 0-20-024) and in the horizontal visibility component (0-20-025, 0-20-026 and 0-20-027) should be used and preferred. A descriptor 0-20-003 should be used only when descriptors mentioned above are not applicable.
2. When encoding past weather reported from an automatic weather station, the appropriate combination of descriptors in the precipitation component (0-20-021, 0-20-022), weather component (0-20-023, 0-20-024) and in the horizontal visibility component (0-20-025, 0-20-026 and 0-20-027) should be used and preferred. Descriptors 0-20-004 or 0-20-005 should be used only when descriptors mentioned above are not applicable.

3-02-207: Precipitation data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	07	032	Height of sensor above local ground (or deck of marine platform)	m	2	0	16		
0	07	033	Height of sensor above water surface	m	1	0	12		
0	13	023	Total precipitation past 24 hours	kg m^{-2}	1	-1	14		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	06	001	Replication of 6 descriptors 1 time						(1)
0	04	024	Time period or displacement	Hour	0	-2048	12		
0	13	011	Total precipitation/total water equivalent	kg m^{-2}	1	-1	14		

0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	20	021	Type of precipitation	Flag table	0	0	30		(2)
0	20	022	Character of precipitation	Code table	0	0	4		
0	04	024	Time period or displacement	Hour	0	-2048	12		(3)
0	07	032	Height of sensor above local ground (or deck of marine platform)	m	2	0	16		(4)
0	07	033	Height of sensor above water surface	m	1	0	12		(4)

Notes:

1. This groups the following 4 descriptors together over which the time period applies.
2. This and the next field are used with automated weather systems and instead of reporting this information through present or past weather.
3. Set this value=”0”
4. Set to missing to cancel the previous value.

3-02-208: Ice data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	20	031	Ice deposit (thickness)	m	2	0	7		
0	20	032	Rate of ice accretion	Code table	0	0	3		
0	20	033	Cause of ice accretion	Flag table	0	0	4		
0	20	034	Sea ice concentration	Code table	0	0	5		
0	20	035	Amount and type of ice	Code table	0	0	4		
0	20	036	Ice situation	Code table	0	0	4		
0	20	037	Ice development	Code table	0	0	5		
0	20	038	Bearing of ice edge	Degrees true	0	0	12		(1)

Notes:

1. A bearing of ice edge value 0 shall indicate “Ship in shore or flaw lead”.

3-02-209: Non-directional spectral wave data (by frequency)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	046	Wave measurement instrumentation	Code table	0	0	4		(1)
0	02	044	Indicator for method of calculating spectral wave data	Code table	0	0	4		
0	25	043	Wave sampling interval (time)	s	4	0	15		

0	22	078	Duration of wave record	s	0	0	12		
0	22	070	Significant wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	071	Spectral peak wave period	s	1	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	073	Maximum wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	074	Average wave period	s	1	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	08	000	Delayed replication of 8 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		(2)
0	22	082	Maximum non-directional spectral wave density (frequency)	m^2 s	2	0	20		
0	22	094	Total number of wave bands	Numeric	0	0	7		
0	22	084	Band containing maximum non-directional spectral wave density	Numeric	0	0	7		
1	03	000	Delayed replication of 3 descriptors	Numeric	0	0	1		
0	31	001	Delayed descriptor replication factor	Numeric	0	0	8		(3)
0	22	080	Waveband central frequency	Hz	3	0	10		
0	22	096	Spectral band width (time)	s^{-1}	3	0	4		
0	22	085	Spectral wave density ratio	Numeric	0	0	7		(4)

Notes:

1. See note 1 of 3-02-205: Wave property data
2. If no spectral information is to be provided, set this to 0, otherwise set to 1. If set to 0, there is no data (no fill values required) reported.
3. Set this value equal to the value reported in 0-22-094
4. Values are reported as spectral wave density / Max spectral wave density as a percentage.

3-02-210: Directional spectral wave data (by frequency)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	046	Wave measurement instrumentation	Code table	0	0	4		
0	02	044	Indicator for method of calculating spectral wave data	Code table	0	0	4		
0	25	043	Wave sampling interval (time)	s	4	0	15		
0	22	078	Duration of wave record	s	0	0	12		
0	22	070	Significant wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	071	Spectral peak wave period	s	1	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	073	Maximum wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	074	Average wave period	s	1	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	24	000	Delayed replication of 24 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		(1)
0	22	082	Maximum non-directional spectral wave density (frequency)	m^2 s	2	0	20		
0	22	076	Direction from which dominant waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	077	Directional spread of dominant wave	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	086	Mean direction from which waves are coming	Degree true	0	0	9		

0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	087	Principal direction from which waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	094	Total number of wave bands	Numeric	0	0	7		
0	22	084	Band containing maximum non-directional spectral wave density	Numeric	0	0	7		
1	07	000	Delayed replication of 7 descriptors	Numeric	0	0	1		
0	31	001	Delayed descriptor replication factor	Numeric	0	0	8		(2)
0	22	080	Waveband central frequency	Hz	3	0	10		
0	22	096	Spectral band width (time)	s^{-1}	3	0	4		
1	03	000	Delayed replication of 3 descriptors						
0	31	001	delayed descriptor replication factor	Numeric	0	0	8		
0	22	187	Direction from which individual waves are coming	Degree true	0	0	9		
0	22	095	Directional spread of individual waves	Degree	0	0	8		
0	22	090	Nondirectional spectral estimate by wave	m^2 s	2	0	20		

Notes:

1. If no spectral information is to be provided, set this to 0, otherwise set to 1. If set to 0, there is no data (no fill values required) reported.
2. Set this value equal to the value reported in 0-22-094

3-02-211: Partial directional spectral wave data (by frequency)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	046	Wave measurement instrumentation	Code table	0	0	4		(1)
0	02	044	Indicator for method of calculating spectral wave data	Code table	0	0	4		
0	25	043	Wave sampling interval (time)	s	4	0	15		
0	22	078	Duration of wave record	s	0	0	12		
0	22	070	Significant wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code	0	0	4		

				table					
0	22	071	Spectral peak wave period	s	1	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	073	Maximum wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	074	Average wave period	s	1	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	12	000	Delayed replication of 12 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		
0	22	082	Maximum nondirectional spectral wave density (frequency)	m^2 s	2	0	20		
0	22	076	Direction from which dominant waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	077	Directional spread of dominant wave	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	086	Mean direction from which waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	087	Principal direction from which waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		(2)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	094	Total number of wave bands	Numeric	0	0	7		
0	22	084	Band containing maximum non-directional spectral wave density	Numeric	0	0	7		
1	04	000	Delayed replication of 4 descriptors	Numeric	0	0	1		

0	31	001	Delayed descriptor replication factor	Numeric	0	0	8		(3)
0	22	080	Waveband central frequency	Hz	3	0	10		
0	22	096	Spectral band width (time)	s^{-1}	3	0	4		
0	22	088	First normalized polar coordinate from Fourier coefficients	Numeric	2	0	7		
0	22	089	Second normalized polar coordinate from Fourier coefficients	Numeric	2	0	7		

If this table is used, it is important that integrated quantities such as significant wave height be reported only if the frequency range of the spectrum is sufficiently large so as to resolve ocean wave dynamic ranges.
Notes:

1. See note 1 of 3-02-205: Wave property data
2. If no spectral information is to be provided, set this to 0, otherwise set to 1. If set to 0, there is no data (no fill values required) reported.
3. Set this value equal to the value reported in 0-22-094

3-02-212: Solar Radiation data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	192	Type of solar radiation instrument						(1)
1	05	001	Replication of 5 descriptors 1 time						(2)
0	08	021	Time significance	Code table	0	0	5		(3)
0	04	024	Time period or displacement	Hour	0	-2048	12		(4)
0	14	021	Global solar radiation, integrated over period specified	$J\ m^{-2}$	-4	0	15		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	25	028	Operator or manufacturer defined parameter (#1)	Numeric	1	-16384	15		
0	25	028	Operator or manufacturer defined parameter (#2)	Numeric	1	-16384	15		
0	25	028	Operator or manufacturer defined parameter (#3)	Numeric	1	-16384	15		
0	04	024	Time period or displacement	Hour	0	-2048	12		(5)

Notes:

1. A new entry in code table 0 02 192 is required for solar radiation observations. The proposed entry is as follows:
   0-02-192: *Solar Radiation Instrumentation*

Code	Meaning
0	Reserved for future use
1	Pyronometer
2	Reserved for future use

3 Missing value.

2. This is used to group the following 3 descriptors for which time significance and period apply.
3. Set this to value=3 to indicate the time is accumulated.
4. Provide the accumulation time in hours prior to the reporting time.
5. Set this value="0"

3-02-213: Non-directional spectral wave data (by wavenumber)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	046	Wave measurement instrumentation	Code table	0	0	4		(1)
0	02	044	Indicator for method of calculating spectral wave data	Code table	0	0	4		
0	25	044	Wave sampling interval (space)	m	2	0	14		
0	22	079	Length of wave record	m	0	0	16		
0	22	070	Significant wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	072	Spectral peak wave length	m	0	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	073	Maximum wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	075	Average wave length	m	0	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	08	000	Delayed replication of 8 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		(2)
0	22	083	Maximum non-directional spectral wave density (wave number)	m^3	2	0	20		
0	22	094	Total number of wave bands	Numeric	0	0	7		
0	22	084	Band containing maximum non-directional spectral wave density	Numeric	0	0	7		
1	03	000	Delayed replication of 3 descriptors	Numeric	0	0	1		

0	31	001	Delayed descriptor replication factor	Numeric	0	0	8		(3)
0	22	081	Waveband central wave number	m^{-1}	5	0	13		
0	22	177	Spectral band width (space)	m^{-1}	3	0	4		
0	22	085	Spectral wave density ratio	Numeric	0	0	7		(4)

Notes:

1. See note 1 of 3-02-205: Wave property data
2. If no spectral information is to be provided, set this to 0, otherwise set to 1. If set to 0, there is no data (no fill values required) reported.
3. Set this value equal to the value reported in 0-22-094
4. Values are reported as spectral wave density / Max spectral wave density as a percentage.

3-02-214: Directional spectral wave data (by wavenumber)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	046	Wave measurement instrumentation	Code table	0	0	4		(1)
0	02	044	Indicator for method of calculating spectral wave data	Code table	0	0	4		
0	25	044	Wave sampling interval (space)	m	2	0	14		
0	22	079	Length of wave record	m	0	0	16		
0	22	070	Significant wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	072	Spectral peak wave length	m	0	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	073	Maximum wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	075	Average wave length	m	0	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	24	000	Delayed replication of 24 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		(2)
0	22	083	Maximum non-directional spectral wave density	m^3	2	0	20		

			(wave number)						
0	22	076	Direction from which dominant waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	077	Directional spread of dominant wave	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	086	Mean direction from which waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	087	Principal direction from which waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	094	Total number of wave bands	Numeric	0	0	7		
0	22	084	Band containing maximum non-directional spectral wave density	Numeric	0	0	7		
1	07	000	Delayed replication of 7 descriptors	Numeric	0	0	1		
0	31	001	Delayed descriptor replication factor	Numeric	0	0	8		(3)
0	22	081	Waveband central wave number	m^{-1}	5	0	13		
0	22	177	Spectral band width (space)	m^{-1}	3	0	4		
1	03	000	Delayed replication of 3 descriptors						
0	31	001	delayed descriptor replication factor	Numeric	0	0	8		
0	22	187	Direction from which individual waves are coming	Degree true	0	0	9		
0	22	095	Directional spread of individual waves	Degree	0	0	8		
0	22	090	Nondirectional spectral estimate by wave	m^2 s	2	0	20		

Notes:

1. See note 1 of 3-02-205: Wave property data
2. If no spectral information is to be provided, set this to 0, otherwise set to 1. If set to 0, there is no data (no fill values required) reported.
3. Set this value equal to the value reported in 0-22-094

3-02-215: Partial directional spectral wave data (by wavenumber)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	046	Wave measurement instrumentation	Code table	0	0	4		(1)
0	02	044	Indicator for method of calculating spectral wave data	Code table	0	0	4		
0	25	044	Wave sampling interval (space)	m	2	0	14		
0	22	079	Length of wave record	m	0	0	16		
0	22	070	Significant wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	072	Spectral peak wave length	m	0	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	073	Maximum wave height	m	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	075	Average wave length	m	0	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
1	12	000	Delayed replication of 12 descriptors						
0	31	000	Short delayed descriptor replication factor	Numeric	0	0	1		(2)
0	22	083	Maximum nondirectional spectral wave density (wave number)	m^3	2	0	20		
0	22	076	Direction from which dominant waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	077	Directional spread of dominant wave	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	086	Mean direction from which waves are coming	Degree true	0	0	9		

0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	087	Principal direction from which waves are coming	Degree true	0	0	9		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	094	Total number of wave bands	Numeric	0	0	7		
0	22	084	Band containing maximum non-directional spectral wave density	Numeric	0	0	7		
1	04	000	Delayed replication of 4 descriptors	Numeric	0	0	1		
0	31	001	Delayed descriptor replication factor	Numeric	0	0	8		(3)
0	22	081	Waveband central wave number	m^{-1}	5	0	13		
0	22	177	Spectral band width (space)	m^{-1}	3	0	4		
0	22	088	First normalized polar coordinate from Fourier coefficients	Numeric	2	0	7		
0	22	089	Second normalized polar coordinate from Fourier coefficients	Numeric	2	0	7		

If this table is used, it is important that integrated quantities such as significant wave height be reported only if they wavenumber range of the spectrum is sufficiently large so as to resolve ocean wave dynamic ranges.
Notes:

1. See note 1 of 3-02-205: Wave property data
2. If no spectral information is to be provided, set this to 0, otherwise set to 1. If set to 0, there is no data (no fill values required) reported.
3. Set this value equal to the value reported in 0-22-094

3-06-200: Surface water temperature data (high precision)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	038	Method of water temperature and/or salinity measurement	Code table	0	0	4		
0	07	063	Depth below sea water surface	m	2	0	20		(1)
0	04	080	Averaging period for following value	Code table	0	0	4		
0	22	045	Sea/water temperature	K	3	0	19		
0	08	080	Qualifier for quality class	Code table	0	0	6		(2)
0	33	050	GTSPP quality class	Code table	0	0	4		

Notes:

1. In the case of hull or flow through systems, this will indicate the depth of the water at which the temperature was sampled. Note that this is consistent with the recently approved XBT template

2. Set to qualifier = 11 for temperature

3-06-201: Water temperature profile data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	038	Method of water temperature and/or salinity measurement	Code table	0	0	4		
0	02	032	Indicator for digitization	Code table	0	0	2		
0	22	067	Instrument type for water temperature profile measurement	Code table	0	0	10		
0	02	171	Instrument serial number for water temperature profile measurement	CCITT IA5	0	0	64		
0	22	068	Water temperature profile recorder type	Code table	0	0	7		
0	25	061	Data acquisition software type (or name) and version number	CCITT IA5	0	0	96		
0	02	195	Length of cable of the instrument string	m	0	0	10		(1)
0	25	086	Depth correction indicator	Code table	0	0	2		
0	08	080	Qualifier for quality class	Code table	0	0	6		(2)
0	33	050	GTSPP quality class	Code table	0	0	4		
1	07	000	Delayed replication of 7 descriptors						
0	31	002	Extended delayed descriptor replication factor						
0	07	063	Depth below sea surface	m	2	0	20		(3)
0	07	065	Pressure below sea surface	Pa	-3	0	17		(3)
0	08	080	Qualifier for quality class	Code table	0	0	6		(4)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	045	Subsurface sea temperature	K	3	0	19		
0	08	080	Qualifier for quality class	Code table	0	0	6		(5)
0	33	050	GTSPP quality class	Code table	0	0	4		

Notes:
1. This is a new descriptor
2. Set to qualifier = 1 for total water temperature profile
3. Some instruments report depth and others report pressure. The one that is not used should be set to fill values.
4. Set to qualifier = 13 if depth is reported or = 10 if pressure is reported
5. Set to qualifier = 11 for temperature

3-06-202: Surface salinity data (high precision)

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	038	Method of water temperature and/or salinity measurement	Code table	0	0	4		
0	07	063	Depth below sea water surface	m	2	0	20		(1)
0	04	080	Averaging period for following value	Code table	0	0	4		
0	22	176	Salinity	PSU	3	0	19		
0	08	080	Qualifier for quality class	Code table	0	0	6		(2)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	13	081	Water conductivity	Siemens m^{-1}	3	0	14		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		

Notes:

1. In the case of hull or flow through systems, this will indicate the depth of the water at which the salinity was sampled.
2. Set to qualifier = 12 for salinity

3-06-203: Salinity profile data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	038	Method of water temperature and/or salinity measurement	Code table	0	0	4		
0	02	032	Indicator for digitization	Code table	0	0	2		
0	22	033	Method of salinity/depth measurement	Code table	0	0	3		
0	08	080	Qualifier for quality class	Code table	0	0	6		(1)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	02	195	Length of cable of the instrument string	m	0	0	10		
0	25	086	Depth correction indicator	Code table	0	0	2		
1	10	000	Delayed replication of 10 descriptors						
0	31	002	Extended delayed descriptor replication factor						
0	07	063	Depth below sea surface	m	2	0	20		(2)
0	07	065	Pressure below sea surface	Pa	-3	0	17		(2)
0	08	080	Qualifier for quality class	Code table	0	0	6		(3)
0	33	050	GTSPP quality class	Code	0	0	4		

				table					
0	22	176	Salinity	PSU	3	0	19		
0	08	080	Qualifier for quality class	Code table	0	0	6		(4)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	13	081	Water conductivity	Siemens m^{-1}	3	0	14		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		

Notes:
1. Set to qualifier = 2 for total water salinity profile
2. Some instruments report depth and others report pressure. The one that is not used should be set to fill values.
3. Set to qualifier = 13 if depth is reported or = 10 if pressure is reported
4. Set to qualifier = 12 for salinity

3-06-204: Surface water current data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	030	Method of current measurement	Code table	0	0	3		
0	07	063	Depth below sea water surface	m	2	0	20		(1)
0	04	080	Averaging period for following value	Code table	0	0	4		
0	02	042	Indicator for sea surface current speed	Code table	0	0	2		
0	22	031	Speed of current	m s^{-1}	2	0	13		
0	22	004	Direction of current	Degree true	0	0	9		(2)
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		

Notes:
1. In the case of hull or flow through systems, this will indicate the depth of the water at which the current was sampled.
2. Descriptor 0 22 004: the direction given in this entry is the direction towards which the current is flowing.

3-06-205: Water current profile data

F	X	Y	Name	Unit	Scale	Ref value	Data Width (bits)	JCOMM field abbrev.	Note
0	02	030	Method of current measurement	Code table	0	0	3		
0	02	031	Duration and time of current measurement	Code table	0	0	5		
0	02	032	Indicator for digitization	Code table	0	0	2		
0	02	040	Method of removing velocity and motion of platform	Code table	0	0	4		

			from current						
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		
0	02	195	Length of cable of the instrument string	m	0	0	10		
0	25	086	Depth correction indicator	Code table	0	0	2		
1	08	000	Delayed replication of 8 descriptors						
0	31	002	Extended delayed descriptor replication factor						
0	07	063	Depth below sea surface	m	2	0	20		(1)
0	07	065	Pressure below sea surface	Pa	-3	0	17		(1)
0	08	080	Qualifier for quality class	Code table	0	0	6		(2)
0	33	050	GTSPP quality class	Code table	0	0	4		
0	22	004	Direction of current	Degrees true	0	0	9		(3)
0	22	031	Speed of current	$m\ s^{-1}$	2	0	13		
0	08	080	Qualifier for quality class	Code table	0	0	6		
0	33	050	GTSPP quality class	Code table	0	0	4		

Notes:

1. Some instruments report depth and others report pressure. The one that is not used should be set to fill values.
2. Set to qualifier = 13 if depth is reported or = 10 if pressure is reported
3. The direction given in this entry is the direction towards which the current is flowing.