ARCHIVAL OF DATA OTHER THAN IN IMMT FORMAT:
The International Maritime Meteorological Archive (IMMA) Format

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Note: References in the text to ICOADS electronic documentation appear in *italics*; Supps. C-E are also available separately in *R2.5imma*

Introduction

1. With increasing recognition of the importance of upgrading and maximizing the data available for analyses of the climate record (e.g. Trenberth et al. 2002), efforts have intensified to digitize additional historical ship data (and metadata) that exist in many national logbook collections (Diaz and Woodruff 1999, Woodruff et al. 2004). Ongoing efforts are focused on data during major gaps in the existing record, such as the two world wars, and adding 19th century and earlier data (e.g. Elms et al. 1993, Manabe 1999, García-Herrera et al. 2005, Woodruff et al. 2005, Brohan et al. 2009, Wilkinson et al. 2010).

2. At present, however, there is no effective, internationally agreed format for exchange of keyed historical data. The format needs flexibility to preserve crucial original data elements and metadata. This will help facilitate analyses of data biases and discontinuities arising from changes in instrumentation and observing practices. Moreover, the format should be expandable, to meet new requirements that are not presently anticipated, but also simple enough that it is practical to implement by Member countries.

3. This document describes an International Maritime Meteorological Archive (IMMA) format meeting these requirements, which is proposed for wider adoption by JCOMM. In addition to the exchange of newly digitized data, the format should also be useful for reformatting and more effective exchange (and archival) of existing national digital archives, including contemporary marine data. The format is already in use for the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) (Woodruff et al. 2010), and for the Climatological Database for the World's Ocean (CLIWOC) project (García-Herrera et al. 2005). The format is also helping meet requirements for managing data from the JCOMM Voluntary Observing Ship (VOS) Scheme, including from its enhanced class of VOS Climate (VOSClim) ships.

4. Following its introduction to the Subgroup on Marine Climatology (JCOMM 2000), the JCOMM-I (WMO 2001) Data Management plan tasked the Expert Team on Marine Climatology (ETMC) to finalize the format, with a view to eventual submission to the Commission for formal adoption (JCOMM 2004a). The Second JCOMM Workshop on Advances in Marine Climatology (CLIMAR-II) (Parker et al. 2004), and the First and Second Workshops on Advances in the Use of Historical Marine Climate Data (MARCDAT) (Diaz et al. 2002, Kent et al. 2007b) have recommended continued usage and expansion of the format, and it has remained under review by ETMC (JCOMM 2007, Woodruff 2007, JCOMM 2010).

5. The Background section of this document (together with Supps. A-B) describes the evolution of meteorological codes, and a variety of existing formats used for exchange and archival of marine data. This material also discusses strengths and weaknesses in these formats that helped define the requirements for the new IMMA format. The existing Format Structure and technical options considered for Format Implementation are discussed in the following sections. Finally Supps. C-E document in detail the IMMA format as presently implemented for ICOADS.

Background

6. International agreement to systematically record weather observations in ships' logbooks was reached at the 1853 Maritime Conference held at Brussels (Maury 1854, JCOMM 2004b), but large quantities of earlier ship logbook records (largely pre-instrumental) are available extending back to about 1600 (Diaz and Woodruff 1999, García-Herrera et al. 2005). Around 1951, WMO took over from its predecessor International Meteorological Organization (IMO) the VOS Scheme (WMO 1973), including an early International Maritime Meteorological (IMM) punched card format (Yoshida 2004, WMO 1952). The international exchange of digitized logbook data in IMM formats was further formalized by WMO (1963) Resolution 35 (Cg-IV).

7. However, maritime nations had earlier programs to digitize historical ship logbook data, and copies of many of the available digital collections of historical logbook data were exchanged (e.g. on punched cards in national formats; Verploegh 1966) through bilateral agreements (Woodruff et al. 2005). Many of these historical (plus real-time) data sources have been compiled into global collections such as the Comprehensive Ocean-Atmosphere Data Set (COADS) (Slutz et al. 1985, hereafter *Release 1*; Woodruff et al. 1987), thus making marine data, presently covering more than 300 years (Woodruff et al. 2010), widely available to the climate research community (Worley et al. 2010). In

recognition of its broad multinational basis, COADS was renamed the *International* COADS (ICOADS; Diaz et al. 2002, Parker et al. 2004).

8. By the 1920s ships started to transmit meteorological reports by wireless telegraph, and the Global Telecommunication System (GTS) was completed near the end of 1972. Telecommunicated data apparently were preserved (or survive) in digital form only starting about 1966, but since then GTS data from ships (and buoys) have evolved to form an increasingly important portion of the data mixture. It is important to note, however, that earlier changes in the telecommunication codes also heavily influenced the form of data as recorded in ships' logbooks. Major changes included the "Copenhagen Code" established by IMO in 1929 (WMO 1994), and an international code effective starting in 1949 (Met Office 1948). Vestiges of the codes dating back to 1929, and of even earlier (primarily land-based) codes (NCDC 1960), persist in the SHIP (now FM 13) Traditional Alphanumeric Code (TAC) used over GTS (WMO 2009a).

9. Manabe (2000) surveyed the documentation for changes in the SHIP code (and IMM formats) since about 1949 (see Annex VI in JCOMM 2000). This work was updated and expanded, with results now accessible via the web[1] (Yoshida 2004, Yoshida and Woodruff 2007). In addition, it would be highly desirable to locate documentation for earlier codes and observing practices, and make it digitally available. Reports from WMO predecessor organizations such as IMO may provide information on the Copenhagen and earlier codes. National instructions for marine observers (Elms et al. 1993, Folland and Parker 1995) will also form crucial metadata, which appear increasingly important to describe the practices of earlier years (e.g. prior to the 1949 code change). For example, 19th century observing practices appear to have been based generally on the 1853 Brussels Maritime Conference (JCOMM 2004b), but with some major national variations (see Supp. A).

10. Supplements A-B discuss a variety of internationally recognized or widely used formats for marine data, and compare these with the requirements for IMMA. Although valuable concepts and features can be derived from many of these formats, none provided a satisfactory solution.

11. This conclusion extended to more recently defined Table-Driven Code Forms (TDCF): the Binary Universal Form for the Representation of meteorological data (BUFR) and the Character form for the Representation and EXchange of data (CREX) (WMO 2009b). Under the new WMO Information System (WIS) the requirement has been expressed to move all observational GTS traffic (and possibly some other data exchanges) to use TDCF. However, TDCF are optimized for contemporary and operational data requirements, and the need to store all possible forms of meteorological data leads to a high degree of complexity—moreover the suitability of TDCF for permanent archival is undemonstrated. Nevertheless, over the longer term, it may be useful to explore some limited convergence between IMMA and appropriate features of TDCF (e.g. establish cross-references with IMMA field names; and ensure standardized record export capabilities, so that data from TDCF can be merged with historical records in ICOADS).

[1] Available at: http://goos.kishou.go.jp/ws/ETMC/code_task/. Reports available there through 1970 from the Commission for Synoptic Meteorology (e.g. WMO 1953), and spanning 1976-2006 from its successor the present WMO Commission for Basic Systems (CBS), may allow reconstruction of many SHIP and other TAC code changes.

Format structure

12. A new internationally agreed format is needed to help facilitate data entry, provide for the more effective exchange of existing national archives, and ensure that the data and metadata are preserved as accurately and completely as possible. Drawing on features from the existing formats discussed in Supps. A-B, the IMMA format provides a flexible solution to the problem of storing both contemporary and historical marine data.
13. Following were additional goals, which the current IMMA design attempts to balance in terms of costs and benefits:

(a) The format should be practical for Member countries to implement, and end-users to read and manipulate, using a variety of computer technology. This includes making computer input and output of fields more straightforward by elimination, where practical, of complex data encoding and mixtures of numeric and other symbols (e.g. the solidus "/").

(b) The fields within the format should be organized into logical groupings to bring related data and metadata together. A field layout that will facilitate sorting records, e.g. into synoptic order is also a consideration.

(c) It is impractical to anticipate in advance all the storage requirements for older historical data, much less for future observing systems and reporting practices. Therefore, the format should be flexible in providing space for supplemental data (to be defined by Member countries). A related issue (not addressed in detail in this report) is the need for a system by which Members would provide documentation (preferably in electronic form) for the origin and configuration of the supplemental data.

(d) The format should also be expandable in more general terms to meet future or modern data requirements. Careful version control will therefore be required.

(e) Many end-user requirements can be satisfied from a small number of fields, thus an abbreviated, fixed-length record type is attractive as one option. On the other hand, archival requirements include the retention of all useful fields, and may best be satisfied in some cases by variable-length records.

(f) Progress has been made in linking ship platform and instrumental metadata (WMO 1955–) to individual marine reports (e.g. Kent et al. 2007a, Berry et al. 2009), and the format should allow for anticipated metadata storage requirements (e.g. anemometer heights).

(g) Important additional considerations are storage efficiency, and format documentation logistics.

14. The design of the format proceeded as follows: A wide range of fields was considered for IMMA based on comparisons of existing codes and formats (e.g. Supps. A-B). Fields suggested for international standardization, plus those already managed by WMO, are described in Supp. D. Selected fields were assembled as described in Supp. C into an IMMA "Core," which provides the common front-end for all IMMA record types. The Core was divided into two sections:

- "location" section: for report time/space location and identification elements, and other key metadata
- "regular" section: for standardized data elements and types of data that are frequently used for climate and other research

15. Supp. C further describes “attachments” (attm) that may follow the Core to produce different IMMA record types. One attm, for example, is used to store supplemental data of indeterminate type, and of fixed- or variable-length. In addition to the abbreviated record formed by the Core itself, three example record types, with the first two widely in use for ICOADS, are described in Supps. C-D (with further ICOADS implementation details available in Supp. E):

- ICOADS-standard record
- NCDC-variant record
- historical record (proposed)

Variations on these record types can also be constructed by attaching different mixtures of the defined attachments to the Core.

Format implementation

16. Some of the field configurations, field assignments, and record designs are already in use—others are preliminary. Additional fields not listed in Supps. C-D, particularly for older historical data (e.g. Tables A1-A2 in Supp. A), may also be desirable after further planning and research. The entire plan should benefit from discussion and feedback from Member nations. However, even if a revised approach is chosen internationally, the existing design should still provide a starting point for defining the overall data and metadata content that is needed to address both historical and contemporary requirements, with appropriate consideration of data continuity issues of key importance to climate and global change research.

17. The unification of major data elements into modern units is crucial to make data easily usable for research applications. However, questions arise about how to standardize conversions and ensure that they are correctly implemented. In some cases it may be preferable for Member nations to provide only the original observations (e.g. as supplemental data), and leave the regular data elements missing awaiting a uniform conversion through WMO Members and international projects. A complementary approach may be to make standardized units conversion software more widely available (e.g. a Fortran software library for this purpose, which is under development as part of the ICOADS project for data adjustments and time conversions, is available at http://icoads.noaa.gov/software/lmrlib).

18. For some major data types the IMMA field structure proposes separate fields in the historical attm for older codes (e.g. cloud amount in tenths), as well as including space in the regular data section for the data element converted to modern codes (oktas). In other cases, only modern codes are, thus far, provided, e.g. time converted from historical Local Standard Time (LST) to UTC. Potentially, however, some indicators could be expanded to indicate the presence of pre-standardized data. For example, the configuration of the time indicator (*TI*) could possibly be expanded to include a new value indicating that *YR*, *MO*, *DY*, and *HR* are LST. Alternatively, the LST values could be stored as supplemental data.

19. Currently IMMA has been defined (Supp. C) using a fixed-field format, similarly to WMO’s existing IMM formats. Another possibility under consideration was a delimited (by spaces, commas, quotes, tabs, etc.) format, which can integrate more easily with database and spreadsheet applications (e.g. for digitization of new data). However, the delimited approach does not set limits on the sizes of fields, and thus is susceptible to

errors in those sizes and other problems. In the longer-term, emerging technologies such as the Extensible Markup Language (XML) might also become relevant (XML may begin to supersede HTML for the next generation web; and it offers a defined syntax, parsing software, and powerful self-descriptive capabilities).

20. The IMMA format is intended for long-term archival and wide exchange of data; therefore, stability, ease of documentation, and wide machine-portability all need to be important considerations. A fixed-field approach, using blank as the universal representation for missing data (for technical reasons as discussed in Supp. D), has been adopted as the most efficient and robust solution available at this time. Conversion of data in other forms to the uniform IMMA format is recommended if practical prior to data exchanges, but it is possible e.g. that additional generalized software could be developed to help facilitate translations by Member countries.

21. The current IMMA design has been influenced by VOSClim requirements for access to different types of data and metadata, including GTS and IMMT reports, plus comparisons (output in BUFR) of the reported GTS data against a UK numerical weather prediction (NWP) model. The ICOADS-standard record type includes space for all the fields anticipated necessary for VOSClim (although it has not yet been possible to populating these fields into a unified VOSClim dataset), together with the complete original input format data string in the supplemental attm of each report (total record-length depending on data source). This supplementary approach provides a reliable mechanism for data recovery in the event of conversion errors, and storage for any data elements not carried across into other IMMA fields. The full IMMA records including the attached original supplemental data are planned for permanent archival.

22. For the GTS message strings we are using a variable-length supplemental attm, terminated by a line feed (Unix-style line termination). However, variable-length records need not necessarily be provided to users; instead, for example, a fixed-length record type can be created from the variable-length records.

23. Storage in IMMA of binary (e.g. BUFR) data may require a scheme like “base64” encoding (Borenstein and Freed 1993) to obtain well-behaved, printable Ascii data. Base64 encoding, however, has the disadvantage of increasing data volume by about 33%. Simple “base36” alphanumeric (0-Z) encoding is being used to reduce the storage requirements for some record control or secondary data elements (Table 1).

Table 1. Base36 encoding. Decimal numbers and base36 equivalents. The complete set of 1-character encodings (0-35) is listed on the left, and examples of 2-character encodings (0-1295) are given on the right. Note that the subset 0-F of base36 is the same as hexadecimal.

1-character encoding:								**E.g. 2-character encoding:**	
dec.	base36	dec.	base36	dec.	base36	dec.	base36	dec.	base36
0	0	10	A	20	K	30	U	0	0
1	1	11	B	21	L	31	V	1	1
2	2	12	C	22	M	32	W	2	2
3	3	13	D	23	N	33	X	.	.
4	4	14	E	24	O	34	Y	.	.
5	5	15	F	25	P	35	Z	.	.
6	6	16	G	26	Q			1293	ZX
7	7	17	H	27	R			1294	ZY
8	8	18	I	28	S			1295	ZZ
9	9	19	J	29	T				

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Available in digital form from:

* http://www.wmo.int/pages/prog/amp/mmop/publications.html
** http://www.wmo.int/pages/prog/www/WMOCodes.html
*** http://goos.kishou.go.jp/ws/ETMC/code_task/
† http://icoads.noaa.gov/
†† http://icoads.noaa.gov/etmc/
††† http://icoads.noaa.gov/reclaim/

Supplement A: Existing Formats and Codes

The following sections describe major existing formats and codes used for: (a) early historical ship logbook data, including the first internationally agreed logbook design (see Maury 1854); (b) digitization and exchange of logbook data; (c) GTS transmission; and (d) storage and archival of contemporary and historical marine data. The existing formats are contrasted with the requirements for IMMA. Additional archival formats with similar characteristics have been defined nationally, but are not discussed in further detail, e.g. the Deutscher Wetterdienst (DWD) archive, the Russian Marine Meteorological “MORMET” archive, and the UK Main Marine Data Bank.

Early historical logbook formats

Table A1 provides examples of the data and metadata elements that were specified in the “Abstract Log” defined in Maury (1854), or were available in ship logbook examples from different collections. In addition to the listed elements, 19th century and some earlier logbooks generally had latitude/longitude observed (or by dead reckoning) once a day (at local noon), and were laid out for meteorological observations at regular intervals (see also García-Herrera et al. 2005, Woodruff et al. 2005). Many early logbooks (including 18th century examples in Table A1) contained columns labeled “H, K, F”, where H=hour, K=knots, and F=fathoms (knots and its subunit fathoms measured the amount of line run out with the log to determine the ship’s speed).

Table A1. Data and metadata elements present (“•”) in early ship logbook data. An example logbook was examined from each of five different collections, plus published “Abstract Log” specifications from the 1853 Brussels meeting. The columns are labeled as follows including the year of the example logbook (or of the Maury, 1854 publication):

WWI: US Merchant 1912-46 Collection (US Form No. 1201-Marine, 1910).
MMJ: US Marine Met. Journals (1878-94) (Woodruff et al. 1987, Fig. 1).
Nor.: Norwegian Logbooks (1867-99) (Diaz and Woodruff 1999, pp. 100/102).
M(2): Maury (1854) Abstract Log specifications.
M(1): Maury Collection (Diaz and Woodruff 1999, title page).
EIC: British East India Company (EIC) logbook (ibid. p. 70).

Note that some additional elements are not listed, and logbook forms and contents varied widely in some of the collections. The two 18th-century examples had textual remarks about wind and weather (García-Herrera et al. 2005), and ship name was assumed available from other metadata. Weather entries with 18 or more symbols are variants of the Beaufort weather system (e.g. WMO 1994, p. III-1).

Data elements:	*WWI* *1918*	*MMJ* *1887*	*Nor.* *1873*	*M(2)* *1854*	*M(1)* *1797*	*EIC* *1734*
observations per day (maximum)	1	12	6	14	24	24
ship’s speed and courses		•			•	•
wind direction (M=magnetic; T=true)	T	M	T (?)	M	M	M
wind force (code range or text)	0-12	0-12	0-6	0-11	text	text
weather (number of symbols or text)	>18	18	5	4	text	text
remarks	•	•	•	•	•	•
current direction/rate (daily in MMJ)		•		•		
barometer and attached thermometer	•	•	•	•		
sea surface and air (dry bulb) temperature	•	•	•	•		
wet-bulb temperature	•	•		•		
form/direction of clouds	•	•		•		
tenths of sky clear (X) or cloudy (C)	C	X	C	X		
sea state (number of symbols or numeric code)		9	0-9	(?)		

Metadata elements:	*WWI* *1918*	*MMJ* *1887*	*Nor.* *1873*	*M(2)* *1854*	*M(1)* *1797*	*EIC* *1734*
ship name	•	•	•	•	•	•
type of vessel (e.g. sailing, steamer, bark)	•	•	•			
instrumental characteristics	•	•	•	•		

WMO International Maritime Meteorological (IMM) formats

The International Maritime Meteorological Punched Card (IMMPC) format was introduced around 1951 (Yoshida 2004; see also WMO 1952). With advances in computer technology beyond e.g. 80-character Hollerith punched cards, an expanded International Maritime Meteorological Tape (IMMT) format was initiated starting in 1982, as an alternative to IMMPC. Those two formats (referred to collectively as "IMM") were designed primarily to facilitate the exchange of keyed logbook ship data starting around 1963 to support implementation of the Marine Climatological Summaries Scheme (MCSS) as established under WMO (1963) Resolution 35 (Cg-IV).

The IMM formats have been modified a number of times to keep pace with changes in the SHIP (presently FM 13–XIV) code (Yoshida 2004; see also Supp. B). Changes effective 2 November 1994, for example, brought IMMT-1 (as the 2 November 1994 version is termed) into close, but not identical, agreement in content with the then current SHIP code version. Subsequently (WMO 2001, JCOMM 2005), changes were made (IMMT-2 and IMMT-3) mainly in response to VOSClim requirements (e.g. to retain relative wind data and other new elements, so that true wind speed and direction could be revalidated in delayed mode). Further revisions to the format were recently adopted by the Third Session of JCOMM (2009), such that the new version (IMMT-4) is to be implemented generally for all data collected as from 1 January 2011.

Supplementary punching procedures (see Supp. B) were also devised with the view towards exchange of "deviating codes or additional data" including some earlier historical codes (e.g. Appendix F, Part B of WMO 1959). But it is not clear whether the supplementary procedures were widely used, and they fail to adequately address present-day requirements for retention of the original form of data and more complete metadata.

Additional historical (1889-1940) data from Japan's Kobe Collection have been digitized (Manabe 1999, JWA and JMA 2003). However, owing to the lack of an international historical format for data exchange, IMMT-1 format was used. Table A2 provides examples of the types of historical Kobe information that it was not possible to store in IMMT-1, but that IMMA seeks to retain.

Table A2. Examples of elements that were omitted, or subject to conversion to modern codes, in the 1998 edition of Kobe Collection data (Manabe 1999). Original information generally was recorded in an "interim" format, and Manabe (1999) documented the conversion of elements. The final JWA and JMA (2003) edition stored similar information in a separate "metadata" format.

Elements omitted	*Elements subject to conversion/adjustment*
temperature of barometer's attached thermometer	Fahrenheit temperatures
barometer height (meters above sea level)	barometric pressure
type of barometer	Beaufort wind force
specific gravity of sea surface water	32-point wind directions
direction and speed of sea surface current	early wave/swell codes
weather and visibility	cloud amount in tenths

Omission of important data and metadata elements that do not fit into the current SHIP code and IMMT format is undesirable in case the elements are ever needed. For example, an indicator for the type of barometer would permit stratification of data from mercurial and aneroid barometers. Some conversions to modern codes (e.g. of temperatures from Fahrenheit or Réaumur to Celsius) are relatively straightforward and computationally reversible (if properly implemented). In such cases the complexity of IMMA can be reduced by converting and storing the temperature elements in Celsius, but also including indicators to preserve information about the original units and form (e.g. whole degrees) of the data (plus possible reference to conversion algorithms used on the data).

In contrast, the conversion of cloud amounts from tenths to lower-resolution oktas is not fully reversible (WMO 1994 discusses this and other conversion biases), and the original tenths values should therefore be retained. Inadvertent conversion (software) errors should be noted as another potential source of data biases and irreversible conversions. Preserving original data is particularly important for complex conversions, in case better algorithms are developed in the future. Two examples: (a) Mapping of Beaufort wind force numbers, and estimated wind speeds in knots or meters per second (not necessarily following recognized midpoints of the Beaufort equivalence scale), to a new equivalence scale. (b) Recalculation of complex mercurial barometer adjustments (instrument error, temperature, gravity, and height if available).

Alphanumeric telecommunication codes

Marine reports (and many other meteorological data) are still transmitted over GTS in Traditional Alphanumeric Codes (TAC), with roots in early synoptic telecommunication codes (NCDC 1960). The form and content of ship logbook data is also closely related to the telecommunication codes, so documentation of their evolution (e.g. since Met Office 1948) represents key metadata to seek to ensure data continuity. Only recently, however, have efforts begun to locate and assess the documentation (e.g. WMO 1953) for these code changes (Yoshida 2004, Yoshida and Woodruff 2007).[2]

[2] As an example of a code change made with unanticipated climatological impacts, FM 13 was modified effective 1 Jan. 1982 so that non-significant weather, cloud, and wave data were no longer reported. However, "to improve marine data availability and quality for climatological purposes" (WMO 1993a), FM 13 was again modified effective 2 Nov. 1994 so that data without significance shall be reported (WMO 1993b).

For TAC, individual weather elements, each described by one or more symbolic letters, are assembled into "code groups," each generally five digits in length. For example, s_S and $T_WT_WT_W$ are the symbolic letters for the sign and type of measurement of sea surface temperature (SST), and the SST measurement proper. When replaced by actual numeric data (or with the solidus "/" used generally to represent missing data), and prefixed by an identifying zero, these are assembled into the 5-digit code group $0s_ST_WT_WT_W$. Note that the symbolic letters serve an important role in providing a precise mechanism for communication among people about the data, although subscripts for many of the symbolic letters render them more difficult to employ, e.g. for labeling a computer printout.

A specified (WMO 2009a) sequence of code groups then composes an individual report in a given "code form," such as FM 13. Lastly, collectives of reports are assembled into larger "bulletins" for transmission, adding information such as the UTC day and time of bulletin preparation in an overlying message envelope. Note that FM 13 reports include only the day of the month and UTC hour; year and month are not defined in the FM 13 message and must be derived by the GTS receiving center. These and other technical features served to optimize the format for GTS transmission, e.g. by minimizing data volume. Perhaps as a consequence, however, few raw GTS messages have been archived. Instead data have been decoded into subsidiary archive formats. For example, NOAA's National Centers for Environmental Prediction (NCEP) for many years translated marine GTS data into a format known as Office Note 124 (ON124).[3] The downside of this approach is that any errors made, or data omitted, in the process of such a conversion may be unrecoverable unless the raw data are permanently archived.

WMO Table-Driven Code Forms (BUFR/CREX)

The Binary Universal Form for the Representation of meteorological data (BUFR) and the Character form for the Representation and EXchange of data (CREX) are Table-Driven Code Forms (TDCF; WMO 2009b) planned (by 2012) to replace the earlier TAC, including FM 13, for data circulating over GTS. BUFR is a binary code generally limited to storage of data in SI units (e.g. temperatures are stored in Kelvin). In contrast, CREX is an alphanumeric code that allows more flexibility on data units. Reports encoded into these formats are self-descriptive in that a hierarchy of tables (WMO 2009b) is referenced to indicate which data elements are included.

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.

[3] Documentation available at: http://www.emc.ncep.noaa.gov/mmb/data_processing/on124.htm

Data continuity is of critical importance for climate research. Plans under the new WMO Information System (WIS) to transition to TDCF from TAC such as FM 13 should anticipate a long period of overlap and careful cross-validation to ensure that no data resolution, elements, or configurations are lost. The experience in 1997 of NCEP in transitioning to BUFR was instructive. Initially for marine data in NCEP's version of BUFR, some data elements were omitted, and some data resolution was lost, e.g. in temperatures (Table A3). Several known problems have now been addressed (Woodruff 2004), but additional thorough checks still appear needed to ensure that all elements of FM 13 (and FM 18 BUOY and other relevant codes) are adequately retained in BUFR. Fortunately, NCEP retains the input raw GTS report(s) as part of the resultant BUFR message, thus providing a means for recovery of any missing or inaccurately converted data.

Table A3. Examples of initial data continuity problems in NCEP's version of BUFR marine GTS data, based on comparisons for March 1997 data.[1]

Temperature biases (0.1°C)	Usage of the standard factor 273.15 for conversion of Celsius temperatures, and rounding to tenths Kelvin precision (which until approximately 17 Feb. 1999 was the maximum precision available), lead to some unrecoverable temperature errors of 0.1°C.
Wind speed indic. (measured/est.)	Indicator omitted until approximately 21 October 1997.
Wind codes	Incomplete conventions to store originally reported FM 13 code combinations for calm and variable winds.
Cloud amounts	Oktas converted to percent, such that BUFR did not preserve the distinction between code figures 9 (sky obscured by fog, snow, or other meteorological phenomena), "/" (cloud cover indiscernible for reasons other than code figure 9, or observation is not made), and a missing code group.

1. Starting in March 1997, data are available processed by NCEP into BUFR. In addition, overlapping data were processed into NCEP's previous ON124 format until 19 April 1997. Limited comparisons were made between the overlapping BUFR and ON124 data, and also against BUFR data encoded by the US Navy (http://icoads.noaa.gov/real-time.html). Some of the data continuity problems were later alleviated, as noted. Woodruff (2004) provided a set of updated comparisons.

Historical Sea Surface Temperature (HSST) Data Project formats

The Historical Sea Surface Temperature (HSST) Data Project (Verploegh 1966), begun in 1964 (WMO 1984), designated a highly abbreviated "Exchange" format (WMO 1985; see also *Release 1*, supp. I) for "collection and summarizing of marine climatological data for the period 1861 to 1960" (WMO 1990). The project was focused on SST and a few other key variables. That focus plus technological limitations at the time of format design lead to the omission of important data and metadata elements (e.g. weather, cloud types, waves, and ship identification). Some data may have been digitized especially for the HSST project, and large amounts of data in the HSST format are still included in ICOADS. To some extent, therefore, national archives may still contain more complete marine reports than are presently available internationally. Efforts to exchange such data in the future may be warranted to extend and complete portions of the archive, which has been one important design motivation for the IMMA format.

Dual-record digitization formats

Some Norwegian, UK, and US digitization projects have used a "dual-record" approach for keying historical records (e.g. Elms et al. 1993). This is as opposed to a "single-record" approach, in which one physical record is created for each marine "report" (i.e. the collective of observations reported by a ship at one time and place). The single-record approach is followed in the IMM formats, and IMMA. In contrast, the dual-record approach closely follows the organization of paper logbook (or log sheet) records, which frequently are organized into metadata that describes the ship or voyage(s), and then meteorological records taken one or more times a day. Each record of the first type, referred to as a "header" record, is then linked to multiple "observational" records via a "control number." Although it is not always feasible to key all entries in the logbooks (e.g. free-form Remarks), as many elements as possible have been included because of the difficulty and expense of handling paper (or microfilm) records, including the possibility that they will no longer be accessible (e.g. in the event of media degradation).

An important feature of the dual-record efforts has been the inclusion of reports without latitude and longitude, which typically were recorded only at local noon in early records due to navigational constraints. During conversion into a single-record format, interpolation is performed and a flag set to distinguish interpolated from originally reported (or port) positions. For instance, in the US 1878-94 Marine Meteorological Journal Collection, digitized by China, meteorological observations were entered at local 2-hourly intervals (2, 4, 6, 8, 10, 12 a.m., and p.m.), thus omission of the intervening observations would yield only 1/12 of the recorded data. The frequency of observations should make this Collection attractive for studies of diurnal variations.

The dual-record approach has advantages of reducing keying and data volume, and also organizes a given voyage or stream of data into a sequence for "track" checking and other quality controls. While the transformations from dual-record formats to a single-record format are conveniently handled and cross-checked with computer software, the requirement for two types of records can lead to problems if not carefully implemented (e.g. if an error occurs in assigning control numbers, this represents a single point of failure that could lead to the non-usability of an entire voyage). Therefore, we recommend the dual-record format approach for possible initial preparation and quality control of digitized historical ship data, but felt that a more easily standardized single-record approach should be used in IMMA for the exchange of quality controlled data.

ICOADS Long Marine Report (LMR) formats

For past ICOADS "delayed-mode" processing, input individual marine reports in a variety of formats were converted to the Long Marine Report (LMR, latest version 6; LMR6) format (http://icoads.noaa.gov/e-doc/lmr). This variable-length packed-binary format comprised a fixed-length portion, followed by a variable-length portion. The fixed-length portion contained commonly used marine data elements (from ships, buoys, etc.), and was divided into a "location" and "regular" section. The location section included elements such as time/space location and source identification of the report. The regular section included the observational data (e.g. sea surface and air temperatures, humidity, wind, air pressure, cloudiness, and waves). (A fixed-length version of LMR, LMRF, was distributed to users.)

The variable-length portion of LMR contained a series of "attachments" (e.g. containing detailed quality control information), of which two, the supplemental and error attachments, varied in size. The supplemental attachment was used to store elements from the original (input) format (character or binary data) that would not fit into the location or regular sections, or whose conversion was questionable. The error attachment stored fields from the original format that contained errors (e.g. illegal characters or values out of range) when an attempt was made to convert them into regular LMR fields. The attachment feature of the LMR format was designed to be extensible, in that new attachments could be added as required. These flexible features served as a useful model for designing the IMMA format.

US National Climatic Data Center (NCDC) TD-11 formats

Much of the data included in COADS *Release 1* prior to 1970 were obtained from NCDC in Tape Data Family-11 (TDF-11) format (NCDC 1968). This Ascii format had a fixed record-length of 140 characters. Positions 64-140 within the 140-character record-length were set aside for supplemental data fields. The supplemental fields varied in content and length (with trailing blanks as needed to extend through 140 characters) according to source "deck" (originally named for punched card decks). By this method, data elements that were unique to a given deck, or whose conversion might be questionable, could be preserved for future reference. This feature served as a useful model originally for development of a similar LMR capability, and subsequently for the IMMA format. *Release 1* (1854-1979) data were made available at NCDC in similar formats (NCDC 1989a, NCDC 1989b).

Supplement B: Comparison of WMO IMM Formats with IMMA

Table B1 compares upcoming (IMMT-4), current (IMMT-3), and recent (IMMT-2 and IMMT-1) formats, with selected past IMMT and IMMPC formats, thus illustrating the evolution of the (collectively) "IMM" formats since their wide adoption around 1963 (prior to 1982 there were only the 80-character punched card formats; in 1982 the tape format was added as an alternative).

Some fields were relatively stable over the time period since 1963 (e.g. clouds and temperatures), whereas others were subject to significant change (e.g. wave fields). Table B1 also indicates fields that were present in the SHIP code at least since the 1940s (Met Office 1948), in addition to those currently present in IMMA. Table B2 lists the quality control (QC) flags currently available or planned for availability in IMMT-4.

IMM formats such as those surveyed in Table B1 were primarily defined for exchange of then contemporary data under WMO's (1963; Cg-IV) Resolution 35. In addition, supplementary punching procedures were defined for "exchange of cards with deviating codes or additional data." Table B3 provides examples of the earlier codes and other information that could be represented by using the 1963 version of the supplementary procedures.

The IMMT-4 format was adopted in 2009 (JCOMM-III Rec. 12/1[4]), and is to be implemented generally for all data collected as from 1 January 2011. As part of developing that latest version, the IMMT documentation was modernized, and some corrections and modifications were made in longstanding (but ambiguous or confusing) field configurations.

Table B1. The planned IMMT-4 format (to become effective 1 Jan. 2011) comprises the 105 elements listed in this table (172-character record length). The IMMT-3 format (JCOMM 2005; effective 1 Jan. 2007) is a subset of IMMT-4 consisting of its first 101 elements (159-character length); the IMMT-2 format (WMO 2001; effective 1 Jan. 2003) is a subset consisting of its first 94 elements (151-character length); and the IMMT-1 format (WMO 1993a; effective 2 Nov. 1994) is a subset consisting of its first 85 elements (131-character length).† The columns in this table contain the following information:

> 1-4: Field number (No.), field width (Chars.), code (symbolic letters, or "•" for a field without assigned symbolic letters), and element description (blank indicates missing).
> 5: Corresponding IMMA field abbreviation, if any (indirectly related fields are listed in parentheses). IMMA field names followed by "Δ" include additional resolution or information, in comparison to IMM.
> 6-8: These columns contain "•" if the specified earlier IMM format contained approximately the same information. Different symbolic letters are listed in the event of changes, or "Δ" marks some significant field changes that are known to exist. An arrow ("→") in the 1963 column indicates that approximately the same information was defined in the "full message" as reported from Selected Ships (Met Office 1948).

Selected fields unique to the current IMMA format, or to the IMMPC formats, are interleaved for reference (alternative and additional fields were available under supplementary IMMPC procedures; see Table B3). Temperature sign positions and other information in IMMPC formats were specified using card over-punches, as indicated by "op." Wind speeds were earlier represented only as whole knots (kts), and more recently either as whole kts or whole m s^{-1}.

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[4] Preliminary IMMT-4 documentation available from: http://icoads.noaa.gov/etmc/documents.html.

Additional IMMPC formats were defined as far back as 1951 (Yoshida 2004), and there were also intermediate format changes not shown, such as effective 1 March 1985 (adding i_X, which had been added to the GTS code in 1982).

No.	Chars.	Code	Element description	IMMA	IMMT 1982	IMMPC 1968	IMMPC 1963
1	1	i_T	format/temp. indic.	*IT* Δ	•	Δ	•
2	2-5	AAAA	year UTC	*YR*	AA	•	•
3	6-7	MM	month UTC	*MO*	•	•	•
4	8-9	YY	day UTC	*DY*	•	•	• →
5	10-11	GG	time of obs. UTC	*HR* Δ	•	•	• →
			time indicator	*TI*			
6	12	Q_c (Q)[1]	quadrant (octant)		Q	•	• →
			10° and 1° box numbers	*B10, B1*			
7	13-15	$L_aL_aL_a$	latitude	*LAT* Δ	•	•	•
8	16-19	$L_oL_oL_oL_o$	longitude	*LON* Δ	$L_oL_oL_o$	•	•
			latitude/longitude indicator	*LI*			
9	20	•	h and VV indic.	*HI + VI*	•	op[2]	•
10	21	h	height of clouds	*H*	•	•	•
11	22-23	VV	visibility	*VV*	•	•	• →
12	24	N	cloud amount	*N*	•	•	• →
			wind direction indicator	*DI*			
13	25-26	dd	wind direction (true)	*D*	•	•	• →
14	27	i_W	wind speed indicator	*WI* Δ	•	Δ[3]	Δ***
15	28-29	ff	wind speed (whole kts/m s^{-1})	*W* Δ	•	Δ (kts)	• →
			Beaufort wind force			•	•
16	30	s_n	sign of TTT	*(AT)*	•	op	•
17	31-33	TTT	air temperature	*AT*	•	•	• →
18	34	s_t	sign of $T_dT_dT_d$	*(DPT)+ DPTI*	•	op	•
19	35-37	$T_dT_dT_d$	dew-point temp.	*DPT*	•	•	• →
20	38-41	PPPP	air pressure	*SLP*	•	•	• →
21	42-43	ww	present weather	*WW*	•	•	• →
22	44	W_1	past weather	*W1*	•	W	• →
23	45	W_2	past weather	*W2*	•		
24	46	N_h	amt. of lowest clouds	*NH*	•	•	• →
25	47	C_L	genus of C_L clouds	*CL*	•	•	• →
26	48	C_M	genus of C_M clouds	*CM*	•	•	• →
27	49	C_H	genus of C_H clouds	*CH*	•	•	• →
			significant cloud amount	*SGN*			→
			significant cloud type	*SGT*			→
			significant cloud height	*SGH*			→
28	50	s_n	sign of SST	*(SST)*	•	op	•
29	51-53	$T_wT_wT_w$	sea surface temperature	*SST*	•	•	•
			air-sea temp. difference			•	• →
30	54	•	indic. for SST meas.	*SI* Δ	•	op	
31	55	•	indic. for wave meas.	*WMI*	•		
			wave period indicator	*WX*			
			wave direction	*WD*		•[4]	→[6]
32	56-67	P_WP_W	per. wind waves/meas.	*WP*	•	•	P_W →
33	58-59	H_WH_W	ht. wind waves/meas.	*WH*	•	•	• →

No.	Chars.	Code	Element description	IMMA	IMMT 1982	IMMPC 1968	IMMPC 1963
			swell period indicator	*SX*			
34	60-61	$d_{W1}d_{W1}$	dir. of predom. swell	*SD*	•	$d_W d_W$	#
35	62-63	$P_{W1}P_{W1}$	per. of predom. swell	*SP*	•	P_W	•
36	64-65	$H_{W1}H_{W1}$	ht. of predom. swell	*SH*	•	•	•
37	66	I_s	ice accretion on ship	*IS*	•		
38	67-68	E_sE_s	thickness of I_s	*ES*	•		
39	69	R_s	rate of I_s	*RS*	•		
40	70	•	observation source	*OS*	•		
41	71	•	observation platform	*OP*	•		
			deck	*DCK*			
			source ID	*SID*			
			platform type	*PT*			
			ID indicator	*II*			
42	72-78	•	ship identifier	*ID* Δ	•	Δ[7]	Δ[7]
43	79-80	•	country recruited ship[8]	*C1*	•	•[9]	•
			2nd country code	*C2*			
44	81	•	(national use)	*(NID)*	•		
45	82	•	quality control indic.	*QCI*	•		
46	83	i_X	station/weather indic.	*IX*			
47	84	i_R	indic. for precip. data	*IR*	•		
48	85-87	RRR	amount of precip.	*RRR*	•		
49	88	t_R	duration of per. RRR	*TR*	•		
50	89	s_w	sign of $T_bT_bT_b$	*(WBT)+ WBTI*	•	op	op
51	90-92	$T_bT_bT_b$	wet-bulb temperature	*WBT*	•	•	•
52	93	a	characteristic of PPP	*A*	•		→
53	94-96	ppp	amt. pressure tend.	*PPP*	•		→
54	97	D_s	true direction of ship	*DS*	•		→
55	98	v_s	ship's average speed	*VS*	•		→
56	99-00	$d_{W2}d_{W2}$	dir. of second. swell	*SD2*	•		
57	101-2	$P_{W2}P_{W2}$	per. of second. swell	*SP2*	•		
58	103-4	$H_{W2}H_{W2}$	ht. of second. swell	*SH2*	•		
59	105	c_i	concentration of sea ice	*IC1*	•		
60	106	S_i	stage of development	*IC2*	•		
61	107	b_i	ice of land origin	*IC3*	•		
62	108	D_i	true bearing ice edge	*IC4*	•		
63	109	z_i	ice situation/trend	*IC5*	•		
64	110	•	FM code version			Δ[10]	Δ[10]
65	111	•	IMMT version				
			IMMA version	*IM*			
66-85	112-131	Q_1-Q_{20}	QC indicators (see Table B2) *(note: end of IMMT-1)*	*QI1-QI20*	•		
86	132	Q_{21}	QC indicator (see Table B2)	*QI21*			

No.	Chars.	Code	Element description	IMMA	IMMT 1982	IMMPC 1968	IMMPC 1963
87	133-5	HDG	ship's heading	*HDG*			
88	136-8	COG	course over ground	*COG*			
89	139-40	SOG	speed over ground	*SOG*			
90	141-2	SLL	max.ht.>Sum. load ln.	*SLL*			
91	143	s_L	sign of hh[11]	*(SLHH)*			
92	144-5	hh	dep. load ln.: sea lev.[11]	*SLHH*			
93	146-8	RWD	relative wind direction	*RWD*			
94	149-51	RWS	relative wind speed	*RWS*			
			(note: end of IMMT-2)				
95-101	152-9	Q_{22}-Q_{29}	Additional QC indicators (see Table B2)				
			(*note : end of IMMT-3)*				
102	160-3	RH	relative humidity				
103	164	RHi	relative humidity indicator				
104	165	AWSi	AWS indicator				
105	166-72	IMOno	IMO number				

1. Initially available IMMT-1 documentation (WMO 1993a) inadvertently listed octant instead of quadrant, and some data were exchanged using octant until Member countries were informed via correspondence.
2. Overpunches on h and VV for measured data; an additional overpunch on VV for fog present but VV not reported.
3. In the 1968 version, a separate field indicated estimated or measured (36-point compass) wind data. In the 1963 version, an overpunch on wind direction indicated measured data.
4. Field allotted but: "Not reported. Not to be punched."
6. WMO Code 0885 with symbolic letters d_Wd_W is listed for 1963 (documentation has not yet been located for this code). WMO Code 0877 with the same symbolic letters is listed for the 1968 version forward (only to be used for swell direction), but the symbolic letters changed to $d_{W1}d_{W1}$ in 1982.
7. In the 1968 version, there was an optional field for ship or log number. In the 1963 version, ship or log number could be entered according to supplementary punching procedures (Part B).
8. Change from numeric to alphabetic ISO codes effective 1 January 1998.
9. Overpunch for auxiliary ships (not part of the 1963 format).
10. A "Card indicator" field: punched according to the WMO Codes effective in year AA, or according to supplementary punching procedures (Part B).
11. Elements 91-92 in IMMT-4 appeared as a single element 91 in IMMT-3 and IMMT-2, thus the element numbering following differs between IMMT-4 and the earlier versions (and corresponding changes were made in the QC flags, ref. Table B2).

Table B2. Quality control (QC) indicators planned for IMMT-4, which are the same as those included in IMMT-3. Those through 86 were included in IMMT-2 (and IMMA), and through 85 in IMMT-1 (whereas 18 such indicators were included in the 1982 IMMT format, and none were available in IMMPC). IMMA additionally has space for a variety of ICOADS QC flags (Table C1) and model QC feedback information (Table C3).

No.	*Chars.*	*Code*	*Applicable element(s) (from Table B1)*
66	112	Q_1	h (10): height of clouds
67	113	Q_2	VV (11): visibility
68	114	Q_3	N, N_h, C_L, C_M, C_H (12, 24-27): clouds
69	115	Q_4	dd (13): wind direction
70	116	Q_5	ff (15): wind speed
71	117	Q_6	s_n, TTT (16-17): air temperature
72	118	Q_7	s_t, $T_dT_dT_d$ (18-19): dew-point temperature
73	119	Q_8	PPPP (20): air pressure
74	120	Q_9	ww, W_1, W_2 (21-23): weather
75	121	Q_{10}	s_n, $T_wT_wT_w$ (28-29): sea surface temperature
76	122	Q_{11}	P_WP_W (32): period of wind waves or of measured waves
77	123	Q_{12}	H_WH_W (33): height of wind waves or of measured waves
78	124	Q_{13}	$d_{W1}d_{W1}$, $P_{W1}P_{W1}$, $H_{W1}H_{W1}$, $d_{W2}d_{W2}$, $P_{W2}P_{W2}$, $H_{W2}H_{W2}$ (34-36, 56-58): swell
79	125	Q_{14}	i_R, RRR, t_R (47-49): precipitation
80	126	Q_{15}	a (52): characteristic of PPP
81	127	Q_{16}	ppp (52): amount of pressure tendency
82	128	Q_{17}	D_s (54): true direction of ship
83	129	Q_{18}	v_s (55): ship's average speed
84	130	Q_{19}	s_w, $T_bT_bT_b$ (50-51): wet-bulb temperature
85	131	Q_{20}	Q_c, $L_aL_aL_a$, $L_oL_oL_oL_o$ (6-8): ship's position
			(note: end of IMMT-1)
86	132	Q_{21}	version identification for Minimum QC Standard (MQCS)
			(note: end of IMMT-2; presently IMMA also only includes Q_1-Q_{21})
95	152	Q_{22}	HDG (87): ship's heading
96	153	Q_{23}	COG (88): course over ground
97	154	Q_{24}	SOG (89): speed over group
98	155	Q_{25}	SLL (90): max. in meters of height of deck cargo above Summer max. load line
	156		(blank; formerly Q_{26} for s_L in IMMT-3 and IMMT-2)[1]
99	157	Q_{27}	s_L, hh (91-92): dep. of ref. level (Summer Max. load line) from actual sea level[1]
100	158	Q_{28}	RWD (93): relative wind direction in degrees off the bow
101	159	Q_{29}	RWS (94): relative wind speed indicated by i_W (knots or m s^{-1})

1. Elements 91-92 in IMMT-4 appeared as a single element 91 in IMMT-3 and IMMT-2 (ref. Table B1), but also with two separate QC flags Q_{26} and Q_{27} (for s_L and hh, respectively), thus the element numbering following differs between IMMT-4 and the earlier versions.

Table B3. Examples of deviating codes or additional data defined under supplementary punching procedures (Part B) in the 1963 version of the IMMPC format. If indicator fields were set, portions of the regular 80-character punched card held different forms of information such as listed. The documentation regarding Part B seemed to discourage use of the supplementary procedures in stating: “data for former years which have not yet been punched should wherever possible be put in the international maritime meteorological punched card (Part A).”

Data types	*Code punching alternatives (selected examples)*
location	Marsden Square, 1°, and 1/10° or 1/6° units of latitude/longitude; Anchored location; Ocean station vessel location
visibility	90-99 or 00-89, both under WMO Code 4377 (1955)
sea and/or swell	WMO Code 75 (1954 or November 1957) Douglas or Copenhagen 1929 scales Paris 1919 scale Berlin 1939 scale WMO Code 1555; 50 added to $d_W d_W$ to indicate $H_W > 9$ half-meters
ice data	c_2, K, D_i, r, and e (WMO Codes 0663, 2100, 0739, 3600, and 1000)
Beaufort weather	German and British systems
ship course/speed	D_s, v_s (WMO Codes 0700 and 4451)
pressure tendency	a (WMO Code 0200) and pp
precipitation data	RR, $t_R t_R$ (WMO Codes 3577 and 4080)
significant cloud data	N_S, C, $h_S h_S$ (WMO Codes 2700, 0500, and 1577)
special phenomena	regional codes (i.e. WMO Code 169, 268, 383, 483, 668, or 768)

Supplement C. Record Types

The IMMA Core (Table C0) forms the common front-end for all record types. By itself, the Core, which is divided into location and regular sections, forms a useful abbreviated record type incorporating many of the most commonly used data elements in standardized form (drawn from the fields to be agreed internationally, listed in Supp. D). Concatenating one or more “attachments” (attm) after the Core creates additional record types. So far, the following attms have been defined (or proposed):

Table C1: ICOADS attm	(65 characters)
Table C2: IMMT-2/FM 13 attm	(76 characters)
Table C3: Model quality control attm	(66 characters)
Table C4: Ship metadata attm	(57 characters)
Table C5: Historical attm	(proposed)
Table C6: Supplemental data attm	(length may vary)

The following are examples of the record types that can be constructed from the Core plus these attachments (where Table numbers are used to indicate the corresponding attm):

- Core:
  C0 (108 characters)
- ICOADS-standard structure (used for Release 2.5, see Supp. E):
  C0 + C1 + C2 + C3 + C4 + C6 (372 characters, before C6)
- NCDC-variant structure (used alternatively for Release 2.5, see Supp. E):
  C0 + C1 + C2 + C3 + C6 (315 characters, before C6)
- historical record:
  C0 + C5 + C6 (proposed)

Inclusion of the attm count (*ATTC*) field in the Core, and of the attm ID (*ATTI*) and attm data length (*ATTL*) fields at the beginning of each attm, enables computer parsing of the records. Thus additional variations on these basic record types are implemented by inclusion or omission of attms, and new attms can be defined in the future as needed for new data or metadata requirements.

Table C0. IMMA Core. The columns in this table contain the following information:

1: Field number. Field numbering runs consecutively from Table C0 through Table C6 (except the proposed Table C5 fields) to correspond with data structures in the rdimma0 software.
2: Length (Len.) in characters (i.e. bytes).
3-4: Abbreviation (Abbr.) for each element (or field), and a brief description.
5-6: For fields with a numeric range, the minimum (Min.) and maximum (Max.) are indicated. In other cases the range and configuration are listed as: “a” for alphabetic (A-

Z), "b" for alphanumeric (strictly 0-Z), "c" for alphanumeric plus other characters, or "u" for undecided form (only for fields that are currently unused).
7: Units of data and related WMO Codes. Information in parentheses usually relates the proposed field to a field from Supp. B, Table B1 (if applicable): WMO Code symbolic letters are listed, or "•" followed by a field number from Table B1 in the absence of symbolic letters. This information is prefixed by "Δ" to highlight field configurations that are extended in range or modified in form from presently defined WMO representations.

No.	*Len.*	*Abbr.*	*Element description*	*Min.*	*Max.*	*Units (Code)*
			Location section (45 characters):			
1	4	*YR*	year UTC	1600	2024	(AAAA)
2	2	*MO*	month UTC[1]	1	12	(MM)
3	2	*DY*	day UTC[1]	1	31	(YY)
4	4	*HR*	hour UTC[1]	0	23.99	0.01 hour (Δ GG)
5	5	*LAT*	latitude	–90.00	90.00	0.01°N (Δ $L_aL_aL_a$)
6	6	*LON*	longitude[1]	–179.99	359.99	0.01°E (Δ $L_oL_oL_oL_o$)
				0.00	359.99	(ICOADS convention)
				–179.99	180.00	(NCDC-variant convention)
7	2	*IM*	IMMA version	0	99	(Δ •65)
8	1	*ATTC*	attm count	0	9	
9	1	*TI*	time indicator	0	3	
10	1	*LI*	latitude/long. indic.	0	6	
11	1	*DS*	ship course	0	9	(D_s)
12	1	*VS*	ship speed	0	9	(Δ v_s)
13	2	*NID*	national source indic.[1]	0	99	
14	2	*II*	*ID* indicator	0	10	
15	9	*ID*	identification/call sign	c	c	(Δ •42)
16	2	*C1*	country code	b	b	(Δ •43)
			Regular section (63 characters):			
17	1	*DI*	wind direction indic.	0	6	
18	3	*D*	wind direction (true)	1	362	°, 361-2 (Δ dd)
19	1	*WI*	wind speed indicator	0	8	(Δ i_W)
20	3	*W*	wind speed	0	99.9	0.1 m s^{-1} (Δ ff)
21	1	*VI*	*VV* indic.	0	2	(Δ •9)
22	2	*VV*	visibility	90	99	(VV)
23	2	*WW*	present weather	0	99	(ww)
24	1	*W1*	past weather	0	9	(W_1)
25	5	*SLP*	sea level pressure	870.0	1074.6	0.1 hPa (Δ PPPP)
26	1	*A*	characteristic of *PPP*	0	8	(a)
27	3	*PPP*	amt. pressure tend.	0	51.0	0.1 hPa (ppp)
28	1	*IT*	indic. for temperatures	0	9	(Δ i_T)
29	4	*AT*	air temperature	–99.9	99.9	0.1°C (Δ s_n, TTT)
30	1	*WBTI*	*WBT* indic.	0	3	(Δ s_w)
31	4	*WBT*	wet-bulb temperature	–99.9	99.9	0.1°C (Δ s_w, $T_bT_bT_b$)
32	1	*DPTI*	*DPT* indic.	0	3	(Δ s_t)
33	4	*DPT*	dew-point temperature	–99.9	99.9	0.1°C (Δ s_t, $T_dT_dT_d$)
34	2	*SI*	*SST* meas. method	0	12	(Δ •30)

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
35	4	*SST*	sea surface temp.	–99.9	99.9	0.1°C (Δ s_n, $T_wT_wT_w$)
36	1	*N*	total cloud amount	0	9	(N)
37	1	*NH*	lower cloud amount	0	9	(N_h)
38	1	*CL*	low cloud type	0	9, "A"	(Δ C_L)
39	1	*HI*	*H* indic.	0	1	(Δ •9)
40	1	*H*	cloud height	0	9, "A"	(Δ h)
41	1	*CM*	middle cloud type	0	9, "A"	(Δ C_M)
42	1	*CH*	high cloud type	0	9, "A"	(Δ C_H)
43	2	*WD*	wave direction	0	38	
44	2	*WP*	wave period	0	30, 99	seconds (P_WP_W)
45	2	*WH*	wave height	0	99	(H_WH_W)
46	2	*SD*	swell direction	0	38	($d_{W1}d_{W1}$)
47	2	*SP*	swell period	0	30, 99	seconds ($P_{W1}P_{W1}$)
48	2	*SH*	swell height	0	99	($H_{W1}H_{W1}$)

1. Fields differing from the ICOADS-standard representation in the NCDC-variant format (see Supps. D-E for further details). For *MO*, *DY*, and *HR*, the NCDC-variant format uses leading zeros as an exception to the "blank left-fill" aspect of the ICOADS-standard representation for numeric data.

Table C1. ICOADS attm (column descriptions as for Table C0).

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
49	2	*ATTI*	attm ID			Note: set *ATTI*=1
50	2	*ATTL*	attm length			Note: set *ATTL*=65
			Box elements (6 characters):			
51	1	*BSI*	box system indicator	u	u	(currently set to missing)
52	3	*B10*	10° box number	1	648	(ICOADS BOX10 system)
53	2	*B1*	1° box number	0	99	
			Processing elements (17 characters):			
54	3	*DCK*	deck	0	999	
55	3	*SID*	source ID	0	999	
56	2	*PT*	platform type	0	15	
57	2	*DUPS*	dup status	0	14	
58	1	*DUPC*	dup check	0	2	
59	1	*TC*	track check	0	1	
60	1	*PB*	pressure bias	0	2	
61	1	*WX*	wave period indicator	1	1	
62	1	*SX*	swell period indicator	1	1	
63	2	*C2*	2nd country code	0	40	

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
			QC elements (38 characters):			
64-75	1×12	*SQZ-DQA*[1]	adaptive QC flags	1	35	base36 (12 flags)[2]
76	1	*ND*	night/day flag	1	2	
77-82	1×6	*SF-RF*[1]	trimming flags	1	15	base36 (6 flags)[2]
83-96	1×14	*ZNC-TNC*[1]	NCDC-QC flags	1	10	base36 (14 flags)[2]
97	2	*QCE*[3]	external (e.g. MEDS)	0	63	integer encoding (6 flags)
98	1	*LZ*	landlocked flag	1	1	
99	2	*QCZ*[3]	source exclusion flags	0	31	integer encoding (5 flags)

1. A set of flags (elaborated briefly as follows; see *R2.5qc* [note: in preparation] for detailed information) is stored each of these element lengths. The first letter of each such QC flag indicates the applicable fields(s) (or if the QC applies to an entire report), according to the following general scheme (referring to field abbreviations from Table C1): *A*=*AT*, *B*=*VV*, *C*=clouds, *D*=*DPT*, *E*=wave, *F*=swell, *G*=*WBT*, *P*=*SLP*, *R*=relative humidity (or possibly other humidity variables for *RE*†), *S*=*SST*, *T*=*A* and *PPP*, *U* or *V*=wind U- or V-component, *W*=wind, *X*=*WX*, *Y*=*W1*, Z=entire report. The lists of flag abbreviations are then:
    - Adaptive QC flags: *SQZ*, *SQA*, *AQZ*, *AQA*, *UQZ*, *UQA*, *VQZ*, *VQA*, *PQZ*, *PQA*, *DQZ*, *DQA* (two flags × 12 variables).
    - Trimming flags: *SF*, *AF*, *UF*, *VF*, *PF*, *RF* (one flag × six variables).
    - NCDC-QC flags: *ZNC*, *WNC*, *BNC*, *XNC*, *YNC*, *PNC*, *ANC*, *GNC*, *DNC*, *SNC*, *CNC*, *ENC*, *FNC*, *TNC* one flag × 14 variables).
2. *R2.5qc* provides further information about how to convert the coded (base36) values stored in these flags into true (floating-point) values (handled automatically by rdimma0).
3. Handled as a single element by the rdimma0 program, but actually holds a set of flags (elaborated as follows), which must be decoded separately. Using the 1st-letter naming scheme described in the first footnote, the abbreviations for the flags stored in *QCE* are: *ZE*, *SE*, *AE*, *WE*, *PE*, *RE*; and those stored in *QCZ* are: *SZ*, *AZ*, *WZ*, *PZ*, *RZ*. Flag *RE*, presently unused, has been set aside for possible future use. *R2.5qc* provides further information about how to decode the information stored within *QCE* and *QCZ*.

Table C2. IMMT-2/FM 13 attm (column descriptions as for Table C0).

No.	*Len.*	*Abbr.*	*Element description*	*Min.*	*Max.*	*Units (Code)*
100	2	*ATTI*	attm ID			Note: set *ATTI*=2
101	2	*ATTL*	attm length			Note: set *ATTL*=76
			Common for IMMT-2/-1 (52 characters):			
102	1	*OS*	observation source	0	6	(•40)
103	1	*OP*	observation platform	0	9	(•41)
104	2	*FM*	FM code version	0	8	(Δ •64)
105	1	*IX*	station/weather indic.	1	7	(i_X)
106	1	*W2*	2nd past weather	0	9	(W_2)
107	1	*SGN*[1]	significant cloud amount	0	9	(N_S; ref. Table B3)
108	1	*SGT*[1]	significant cloud type	0	9, "A"	(C; ref. Table B3)
109	2	*SGH*[1]	significant cloud height	0	99	($h_S h_S$; ref. Table B3)
110	1	*WMI*	indic. for wave meas.	0	9	(•31)
111	2	*SD2*	dir. of second. swell	0	38	($d_{W2}d_{W2}$)
112	2	*SP2*	per. of second. swell	0	30, 99	($P_{W2}P_{W2}$)
113	2	*SH2*	ht. of second. swell	0	99	($H_{W2}H_{W2}$)
114	1	*IS*	ice accretion on ship	1	5	(I_s)
115	2	*ES*	thickness of I_s	0	99	cm (E_sE_s)
116	1	*RS*	rate of I_s	0	4	(R_s)
117	1	*IC1*	concentration of sea ice	0	9, "A"	(Δ c_i)
118	1	*IC2*	stage of development	0	9, "A"	(Δ S_i)
119	1	*IC3*	ice of land origin	0	9, "A"	(Δ b_i)
120	1	*IC4*	true bearing ice edge	0	9, "A"	(Δ D_i)
121	1	*IC5*	ice situation/trend	0	9, "A"	(Δ z_i)
122	1	*IR*	indic. for precip. data	0	4	(i_R)
123	3	*RRR*	amount of precip.	0	999	(RRR)
124	1	*TR*	duration of per. *RRR*	1	9	(t_R)
125	1	*QCI*	quality control indic.	0	9	(•45)
126-145	1×20	*QI1-20*	QC indic. for fields	0	9	(Q_1-Q_{20})
			New for IMMT-2 (20 characters):			
146	1	*QI21*	MQCS version	0	9	(Q_{21})
147	3	*HDG*	ship's heading	0[2]	360	0, ° (HDG)
148	3	*COG*	course over ground	0	360	0, ° (COG)
149	2	*SOG*	speed over ground	0	99	kt (SOG)
150	2	*SLL*	max.ht.>Sum. load ln.	0	99	m (SLL)
151	3	*SLHH*	dep. load ln.: sea lev.	–99	99	m ($s_L$hh)
152	3	*RWD*	relative wind direction	1	362	°, 361-2[3] (ref. *D*)
153	3	*RWS*	relative wind speed	0	99.9	0.1 m s^{-1} (ref. *W*)

1. These (strictly historical) fields should always be missing (see Supp. D).
2. Zero is documented to mean “no movement,” but has been suggested should not be used (see Supp. D).
3. Special code 362 for “variable, or all directions” is allocated in IMMA, but IMMT does not presently contain a corresponding configuration for RWS (see Supp. D).

Table C3. Model quality control attm (column descriptions as for Table C0). For reference, the Units column also includes (following any units information) the current UK Met Office BUFR element names.

No.	*Len.*	*Abbr.*	*Element description*	*Min.*	*Max.*	*Units (Code)*
154	2	*ATTI*	attm ID			Note: set *ATTI*=3
155	2	*ATTL*	attm length			Note: set *ATTL*=66
			GTS bull. header fields (10 characters):			
156	4	*CCCC*	collecting centre	a	a	COLTN_CNTR
157	6	*BUID*	bulletin ID	b	b	BLTN_IDNY
			Model comp. elements (52 characters):			
158	5	*BMP*	background (bckd.) *SLP*	870.0	1074.6	0.1 hPa; BCKD_MSL_PESR
159	4	*BSWU*	bckd. wind U-comp.	–99.9	99.9	0.1 m s^{-1}; BCKD_SRFC_WIND_U
160	4	*SWU*	derived wind U-comp.	–99.9	99.9	0.1 m s^{-1}; SRFC_WIND_U
161	4	*BSWV*	bckd. wind V-comp.	–99.9	99.9	0.1 m s^{-1}; BCKD_SRFC_WIND_V
162	4	*SWV*	derived wind V-comp.	–99.9	99.9	0.1 m s^{-1}; SRFC_WIND_V
163	4	*BSAT*	bckd. air temperature	–99.9	99.9	0.1°C; BCKD_SRFC_AIR_TMPR
164	3	*BSRH*	bckd. relative humidity	0	100	%; BCKD_SRFC_RLTV_HUMDY
165	3	*SRH*	(derived) relative humidity	0	100	%; SRFC_RLTV_HUMDY
166	1	*SIX*	derived stn./wea. indic.	2	3	(subset of *IX*, field 105; unused)
167	4	*BSST*	bckd. *SST*	–99.9	99.9	0.1°C; BCKD_SEA_SRFC_TMPR
168	1	*MST*	model surface type	0	9	(UK 008204); MODL_SRFC_TYPE
169	3	*MSH*	model height of surface	0	999	m; MODL_SRFC_HGHT
170	4	*BY*	bckd. year	0	9999	year; BCKD_YEAR
171	2	*BM*	bckd. month	1	12	month; BCKD_MNTH
172	2	*BD*	bckd. day	1	31	day; BCKD_DAY
173	2	*BH*	bckd. hour	0	23	hour; BCKD_HOUR
174	2	*BFL*	bckd. forecast length	0	99	hours (note: erroneous); BCKD_FRCT_LNGH

Table C4. Ship metadata attm (column descriptions as for Table C0).

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
175	2	*ATTI*	attm ID			Note: set *ATTI*=4
176	2	*ATTL*	attm length			Note: set *ATTL=57*
			Ship metadata elements (53 characters):			
177	2	*C1M*	recruiting country	a	a	(Δ •43)
178	2	*OPM*	type of ship (programme)	0	99	(code unlike *OP)*
178	2	*KOV*	kind of vessel	c	c	
180	2	*COR*	country of registry	a	a	(Δ •43)
181	3	*TOB*	type of barometer	c	c	
182	3	*TOT*	type of thermometer	c	c	
183	2	*EOT*	exposure of thermometer	c	c	
184	2	*LOT*	screen location	c	c	
185	1	*TOH*	type of hygrometer	c	c	
186	2	*EOH*	exposure of hygrometer	c	c	
187	3	*SIM*	*SST* meas. method	c	c	(code unlike *SI)*
188	3	*LOV*	length of vessel	0	999	m
189	2	*DOS*	depth of *SST* meas.	0	99	m
190	3	*HOP*	height of visual observation platform	0	999	m
191	3	*HOT*	height of *AT* sensor	0	999	m
192	3	*HOB*	height of barometer	0	999	m
193	3	*HOA*	height of anemometer	0	999	m
194	5	*SMF*	source metadata file	0	99999	e.g. "19991" 1st Q 1991
195	5	*SME*	source meta. element	0	99999	line number in file
196	2	*SMV*	source format version	0	99	to be defined

Table C5. Historical attm (proposed; column descriptions as for Table C0). *ATTI* is assigned, and *ATTL* and field numbering to be decided (*tbd*).

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
(tbd)	2	*ATTI*	attm ID			Note: set *ATTI*=5
"	2	*ATTL*	attm length			Note: set *ATTL=(tbd)*
			Historical data fields (>19 characters):			
"	1	*WFI*	*WF* indic.	u	u	
"	2	*WF*	wind force	0	12	
"	1	*XWI*	*XW* indic.	u	u	
"	3	*XW*	wind speed (ext. *W*)	0	99.9	0.1 m s^{-1}
"	1	*XDI*	*XD* indic.	u	u	
"	2	*XD*	wind dir. (ext. *D*)	u	u	
"	1	*SLPI*	*SLP* indic.	u	u	
"	1	*TAI*	*TA* indic.	u	u	
"	4	*TA*	*SLP* att. thermometer	–99.9	99.9	ref. *AT*
"	1	*XNI*	*XN* indic.	u	u	
"	2	*XN*	cloud amt. (ext. *N*)	u	u	
(plus additional elements tbd)						

Table C6. Supplemental data attm (column descriptions as for Table C0). If *ATTL*=0 (unspecified length), this attm must appear at the end of the record, and the record terminate with a line feed. For the VOSClim record type, this attm stores the original input data string in Ascii with *ATTL*=0 and *ATTE*=missing. (Note: if future requirements arise within the VOSClim record type, or for other record types, *ATTL* and *ATTE* can be adjusted accordingly.)

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
197	2	*ATTI*	attm ID			Note: set *ATTI*=99
198	2	*ATTL*	attm length			Note: set *ATTL*=0
199	1	*ATTE*	attm encoding			Note: set *ATTE*=missing
			Supplemental data (format determined by data source):			
200		*SUPD*[1]	supplemental data	c	c	

1. The length of the supplemental data is *ATTL* – 5 if *ATTL* > 0, or it may be variable if *ATTL* = 0.

Supplement D. Field Configurations

This supplement provides configuration details for the individual fields listed in Supp. C. References to external information include the WMO *Manual on Codes* (2009a) and its Codes and Regulations governing e.g. the SHIP (FM 13) GTS code. Background notes indented below field descriptions provide additional usage or technical information, e.g. comparing field configurations with other formats, such as IMMT (Supp. B), COADS *Release 1* (Slutz et al. 1985), or more recent LMR (http://icoads.noaa.gov/e-doc/lmr). Further detailed technical notes related more specifically to ICOADS, and its current Release 2.5 (R2.5) (Woodruff et al. 2010) appear enclosed in [square brackets].

The IMMA field abbreviations are simple alphabetic strings (plus in some cases numeric suffixes), based generally on GTS (or IMMT) symbolic letters (if defined) but without subscripts. These are listed in *UPPER-CASE*, for broad computer portability. As discussed in Supp. A, symbolic abbreviations already provide an important means of communication about the fields and data among Member countries and end-users. However, a transition away from subscripts is recommended to facilitate computerized implementation (e.g. headings for listings of the data).

The configurations of numeric fields were developed on the basis of representations readily input and output by computer software. Fields are right justified within the specified field-widths (Supp. C), and to reduce data-volume decimal points are implicit (e.g. –99.9 is represented as –999). For signed numeric data, the plus sign ("+") is omitted, and the minus sign ("–") immediately prefixes the numeric portion (i.e. blank left-fill[5]). These conventions have the advantage that numeric data can be readily input without separate steps to handle IMM sign positions (0=positive, 1=negative), and without parsing to ensure that a field does not contain non-numeric characters (e.g. "/").

In a delimited format, a universal missing value (e.g. –9999.99) could be selected outside the range of all data (except possibly for alphanumeric fields). In contrast, the fixed-field IMMA format contains different field-widths so a single numeric value is unworkable. A convention such as all nines filling each indicated field width also is impractical, e.g. because many of the 1-character fields have extant numeric values covering the range 0-9.

Therefore, blanks are used in IMMA as the universal representation for missing data. However, it is important to note that Fortran for example considers blanks (by default) to be equivalent to zero, thus to ensure correctness the processing must first parse a field as characters to ensure that it is not entirely blank. Machine-transportable Fortran software to help read (and optionally write) the IMMA data ("rdimma0") is available (http://icoads.noaa.gov/software/).

Some field configurations (e.g. for the historical attm) are undecided, and will benefit from future feedback and discussion (including possible alternative implementation options noted as part of the background information for some fields). In other cases existing (originally LMR-based) configurations have been utilized. These provisional configurations may warrant modification or expansion after international consideration.

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[5] As an exception, the NCDC-variant record uses leading zeros in fields *MO*, *DY*, and *HR*. Additional differences between the NCDC-variant record and the ICOADS-standard record are described in Supp. E.

Core (C0)

Location section

1) *YR*	year UTC	(four digits)
2) *MO*	month UTC	(1=January, 2=February, …, 12=December)
3) *DY*	day UTC	(1-31)
4) HR	hour UTC	(0.00 to 23.99)

Background: As for IMMT-4, except *HR*. In the NCDC-variant record (as well as in IMMT-4), MO, DY, and HR will include leading zero-fill, as applicable (e.g. 01=January). VOS data typically are reported to nearest whole hour, but the extended resolution is needed, e.g. for storage of drifting buoy data. For VOS data, WMO (2009a) Reg. 12.1.6 states: "The actual time of observation shall be the time at which the barometer is read."

5) *LAT* latitude
6) *LON* longitude

Position to hundredths of a degree +N or –S (measured north or south of the equator) and +E or –W (measured east or west of the Greenwich Meridian). The longitude range (–179.99° to 359.99°) specified in Supp. C (Table C0) encompasses two distinct longitude conventions: 0° to 359.99° (i.e. 0°E, 0.01°E, …, 359.98°E, 359.99°E; ICOADS convention) and –179.99° to 180.00° (i.e. 179.99°W, 179.98°W, …, 179.99°E, 180.00°E; NCDC-variant convention).

Background: The two longitude conventions are desirable for different applications and archival requirements. However 0° to 359.99° is generally recommended, because it is the simplest formulation and thus helps reduce the likelihood of location errors. Extended resolutions are needed in comparison to the IMMT-4 format, e.g. for drifting buoy data. Disallowing 360.00 and –180.00° ensures that meridians are uniquely represented within the convention range (i.e. avoiding: 0°/360.00°; 180.00°/–180.00°). However, even if IMMA records are stored in a mixture of these conventions, all longitude values can be accurately interpreted because the overall range for longitude reserves negative for the western hemisphere. Organizing *YR*, *MO*, *DY*, *HR*, *LAT*, and *LON* in sequence can facilitate synoptic sort operations. Characters (N, S, E, W) could alternatively have been used in place of sign for both *LAT* and *LON*, but this complicates computer processing and therefore was deemed not advisable, as was usage of conventions for quadrant (WMO Code 3333 as used in IMMT-4) or octant numbers (WMO 2009a notes under Code 3333 how the choice of quadrant is left to the observer under specific circumstances such as along the Equator).

7) *IM* IMMA version
8) *ATTC* attm count

0 – provisional version (the current version)
1 – first internationally agreed version
2 – second internationally agreed version
etc.

ATTC provides the attm count:

0 – abbreviated record (no attm)
1 – one attm
2 – two attms
etc.

Background: These fields are positioned near the front of the record to allow computerized input and interpretation (e.g. of different IMMA versions), but after *LON* so as not to interfere with sort operations. The proposed configuration is similar to the IMMT-4 field "IMMT version."

9) *TI* time indicator

10) *LI* latitude/longitude indicator

TI preserves the incoming precision of time fields:

0 – nearest whole hour
1 – hour to tenths
2 – hour plus minutes
3 – high resolution (e.g. hour to hundredths)

LI preserves the precision at which *LAT* and *LON* were recorded or translated from, or if they were derived later by interpolation between known positions:

0 – degrees and tenths
1 – whole degrees
2 – mixed precision
3 – interpolated
4 – degrees and minutes
5 – high resolution data (e.g. degrees to seconds)
6 – other

Background: *TI* and *LI* match original LMR configurations, except that *LI*=2 was described there as "non random tenths" (a type of mixed precision; see *Release 1*, supp. F). [Note: No indication is available in *TI* for quasi-instantaneous vs. time-period averaged data (e.g. daily averages from PMEL deck 145).]

11) *DS* ship course

12) *VS* ship speed

WMO Code 0700 for true direction of resultant displacement of the ship during the three hours preceding the time of observation (i.e. ship's course (true) made good):

0 – stationary (ship hove to)	5 – SW
1 – NE	6 – W
2 – E	7 – NW
3 – SE	8 – N
4 – S	9 – unknown

WMO Code 4451 for ship's average speed made good during the three hours preceding the time of observation (beginning 1 January 1968):

0 – 0 knots	5 – 21-25 knots
1 – 1-5 knots	6 – 26-30 knots
2 – 6-10 knots	7 – 31-35 knots
3 – 11-15 knots	8 – 36-40 knots
4 – 16-20 knots	9 – over 40 knots

Prior to 1 January 1968 a different code for *VS*, also with range 0-9, applied (Met Office 1948):

0 – 0 knots	5 – 13-15 knots
1 – 1-3 knots	6 – 16-18 knots
2 – 4-6 knots	7 – 19-21 knots
3 – 7-9 knots	8 – 22-24 knots
4 – 10-12 knots	9 – over 24 knots

Background: As was originally the case in LMR, both the old and new *VS* codes are stored in the same field, to be differentiated by date (but *DS* and *VS* were named *SC* and *SS* in LMR). In IMMPC format documentation, Code 4451 may have been used to refer to both the old and new *VS* codes. Further research is needed to clarify the timing and details of that apparent code change.

13) *NID* national source indicator

A field available for national use in identifying data subsets.

Background: IMMT has a similar 1-character field for "national use" (see Supp. B, Table B1), which thus far has not been translated into this (or another) IMMA field. *NID* was set to "1" by the Data Assembly Center (DAC; at NOAA/NCDC) for identified VOSClim ships, or to missing otherwise. [Note: Presently in R2.5 not all VOSClim ships were identified in all data sources, such that this indicator was set only sporadically. For internal NCDC processing purposes, R2.5 data distributed by NCDC have been reformatted (with respect to the ICOADS-standard data) to set all reports with *NID*=missing, to *NID*=2; and all reports with *NID*=1, to *NID*=3. R2.5 data obtained in the NCDC-variant format should therefore be identifiable by *NID*=2 or *NID*=3, whereas R2.5 data obtained in the ICOADS-standard format should be identifiable by *NID*=missing or *NID*=1 (not applicable to other marine data obtained from NCDC, which will have *NID*=missing or *NID*=1).]

14) *II* *ID* indicator

15) *ID* identification/call sign

II indicates whether a call sign or some other sort of identification is contained in the *ID* field (and in R2.5 data, *II* should always be extant when *ID* information exists; whereas *II* should always be missing if *ID* is missing):

0 – ID present, but unknown type
1 – ship, Ocean Station Vessel (OSV), or ice station call sign
2 – generic ID (e.g. SHIP, BUOY, RIGG, PLAT)
3 – WMO 5-digit buoy number
4 – other buoy number (e.g. Argos or national buoy number)
5 – Coastal-Marine Automated Network (C-MAN) ID (US NDBC operated)
6 – station name or number
7 – oceanographic platform/cruise number
8 – fishing vessel psuedo-ID
9 – national ship number
10 – composite information from early ship data

Background: ID is extended to nine characters (versus e.g. seven in IMMT-4). In platform track checking, for example, consideration should be given to using a combination of II and ID, since identical IDs can sometimes have different II values and thus may represent different platforms. [Note: ICOADS processing normally left-justifies extant information stored within ID (with right blank-fill). GTS reports generally contain a radio call sign or WMO buoy identification number (http://www.wmo.int/pages/prog/amp/mmop/wmo-number-rules.html), but early IMM logbook reports sometimes contained IDs such as national ship numbers and "log" numbers. Documentation of the format of such numbers generally appears to be unavailable (but could potentially be sought from individual countries), thus PT=9 has generally been assigned only for earlier (pre-IMM) card decks for which the format of the information was known.]

16) *C1* country code

The country that recruited a ship, which may differ from the country of immediate receipt (*C2*, field 63) and may also differ from the ship's registry. WMO transitioned from the older numeric code values 0-40 (Table D1) to the current 2-character ISO 3166 (http://www.iso.org/iso/country_codes.htm) alphabetic codes effective 1 Jan. 1998.

Background: Both the older numeric codes for historical data, and the alphabetic codes for more recent data, are stored in this field (since e.g. the old numeric codes include the USSR and other former country names). [Note: The older numeric codes were "according to numbers assigned by WMO" (see IMMT-1 documentation in WMO 1993a). Some deficiencies in NCDC's processing many years ago of early IMM receipts, involving missing country codes and card "overpunch" handling, are discussed in the LMR documentation.]

Table D1. WMO numeric country codes (now obsolete).

C1	Country	C1	Country	C1	Country	C1	Country
0	Netherlands	10	Ireland	20	Sweden	30	Spain
1	Norway	11	Philippines	21	FRG	31	Thailand
2	US	12	Egypt	22	Iceland	32	Yugoslavia
3	UK	13	Canada	23	Israel	33	Poland
4	France	14	Belgium	24	Malaysia	34	Brazil
5	Denmark	15	South Africa	25	USSR	35	Singapore
6	Italy	16	Australia	26	Finland	36	Kenya
7	India	17	Japan	27	Rep. of Korea	37	Tanzania
8	Hong Kong	18	Pakistan	28	New Caledonia	38	Uganda
9	New Zealand	19	Argentina	29	Portugal	39	Mexico
						40	GDR

Regular section

17) *DI* wind direction indicator
18) *D* wind direction

DI gives the compass (and approximate precision) used for reporting the wind direction:

0 – 36-point compass
1 – 32-point compass
2 – 16 of 36-point compass
3 – 16 of 32-point compass
4 – 8-point compass
5 – 360-point compass
6 – high resolution data (e.g. tenths of degrees)

D is the direction (true) from which wind is blowing (or will blow), stored in whole degrees (i.e. 360-point compass; range: 1-360°), or special codes:

361 – calm
362 – variable, or all directions

Table D2 lists the standard mappings used in ICOADS of contemporary (WMO Code 0877) and historical ship wind direction codes into degrees.

Background: IMMT-4 follows WMO Code 0877 (including 00 for calm, and 99 for variable). In FM 13, stations within 1° of the North Pole instead use Code 0878 (WMO 2009a). In designing D to store both high- and low-resolution directions, an unambiguous and numerically closed range (i.e. 1-362, rather than e.g. 0-360, 999=variable) was deemed advantageous for computational reasons (e.g. range checking).

Table D2. Translation of contemporary (*DI*=0; WMO Code 0877) and some historical (shaded) ship wind direction codes (*DI*=1-3 as represented in NCDC 1968) into degrees (blank indicates an undefined conversion). *Release 1*, supp. F provides the original rationale for the degree values shown in this table and further background information (including uncertainties associated with past usage of *DI*=4 in ICOADS).

WMO Code 0877		*DI*				
Code	*Range*	*0*	*1*	*2*	*3*	*4*
01	5-14	10	11			?
02	15-24	20	23	25	23	?
03	25-34	30	34			?
04	35-44	40	45		45	?
05	45-54	50	56	45		?
06	55-64	60	68		68	?
07	65-74	70	79	65		?
08	75-84	80	90		90	?
09	85-94	90	101	90		
10	95-104	100	113		113	
11	105-114	110	124	115		
12	115-124	120	135		135	
13	125-134	130	146			
14	135-144	140	158	135	158	
15	145-154	150	169			
16	155-164	160	180	155	180	
17	165-174	170	191			
18	175-184	180	203	180	203	
19	185-194	190	214			
20	195-204	200	225	205	225	
21	205-214	210	236			
22	215-224	220	248		248	
23	225-234	230	259	225		
24	235-244	240	270		270	
25	245-254	250	281	245		
26	255-264	260	293		293	
27	265-274	270	304	270		
28	275-284	280	315		315	
29	285-294	290	326	295		
30	295-304	300	338		338	
31	305-314	310	349			
32	315-324	320	360	315	360	
33	325-334	330				
34	335-344	340		335		
35	345-354	350				
36	355-4	360		360		
00 (calm)		361	361	361	361	
99 (variable)		362	362	362	362	

19) *WI* wind speed indicator

20) *W* wind speed

Wind speed is stored in tenths of a meter per second (to retain adequate precision for winds converted from knots, or high-resolution data). *WI* shows the units in which and/or the method by which *W* was originally recorded (0, 1, 3, 4 follow WMO Code 1855):

0 – meter per second, estimated

1 – meter per second, obtained from anemometer (measured)
2 – estimated (original units unknown)
3 – knot, estimated
4 – knot, obtained from anemometer (measured)
5 – Beaufort force (based on documentation)
6 – estimated (original units unknown)/unknown method
7 – measured (original units unknown)
8 – high-resolution measurement (e.g. hundredths of a meter per second)

Background: No indication is given as to the incoming units and precision of *W*, e.g. whole knots. For reports derived from e.g. TDF-11 format (NCDC 1968), the meaning of *WI*=6 either is "estimated (units unknown)," or "both method and units unknown" (i.e. the indicator was missing). This unfortunate ambiguity derives from the dual meaning present in some original archive formats, including IMMPC (ref. Supp. B). [Note: In earlier ICOADS processing, *WI*=2 and *WI*=7 were used for reconversion of deck 555 from the original "SPOT" format; however, no missing value was available in the SPOT format, thus both those *WI* settings should be interpreted with caution.]

21) *VI* visibility indicator
22) *VV* visibility

VV (horizontal visibility at the surface in kilometers) according to WMO Code 4377 from which, in reporting visibility at sea, WMO (2009a; Reg. 12.2.1.3.2) states that the decile 90-99 shall be used (moreover Reg. 12.2.1.3.1: when the horizontal visibility is not the same in different directions, the shortest distance shall be given for VV):

90 – less than 0.05 kilometer
91 – 0.05
92 – 0.2
93 – 0.5
94 – 1
95 – 2
96 – 4
97 – 10
98 – 20
99 – 50 or more

VI shows whether *VV* was:

0 – estimated (or unknown method of observation)
1 – measured
2 – fog present (obsolete)

Background: The "Cloud height and visibility measuring indicator" from IMMT-4 is separated into independent indicators in IMMA format, *HI* (see field 39) and *VI*. [Note: When *VI*=2, and *VV*=93, it meant that fog was present and visibility was not reported (NCDC 1968). This "fog present" combination of *VI*=2 with *VV*=93 appears to originate from "overpunch" procedures that took effect in the IMMPC format around 1966 (see Table B1) as translated into the TDF-11 format.]

23) *WW* present weather
24) *W1* past weather

WMO Codes 4677 (Table D3) for *WW*, and 4561 for *W1*:

0 – Cloud covering 1/2 or less of the sky throughout the appropriate period
1 – Cloud covering more than 1/2 of the sky during part of the appropriate period and covering 1/2 or less during part of the period
2 – Cloud covering more than 1/2 of the sky throughout the appropriate period

3 – Sandstorm, duststorm or blowing snow
4 – Fog or ice fog or thick haze
5 – Drizzle
6 – Rain
7 – Snow, or rain and snow mixed
8 – Shower(s)
9 – Thunderstorm(s) with or without precipitation

For use of weather data starting 1 Jan. 1982, also refer to *IX* (field 105).

Background: WMO Code 4561 also applies to *W2* (field 106). WMO Codes 4680 (W_aW_a) and 4531 (W_{a1}/W_{a2}) (not shown) are used instead for reporting present and past weather from an automatic weather station (see WMO 2009a). Those alternative Codes have the same numerical ranges as *WW* (00-99) and *W1*/*W2* (0-9) but different meanings.

Table D3. WMO Code 4677 for present weather (*WW*) (after WMO 2009a). Leading zero is omitted in IMMA. Large braces ("{" and "}") as appear in WMO (2009a) were not available in the preparation of this document, thus the code figure groups to which text characteristics given in the first column (e.g. "No meteors except photometeors") or last column apply, have been listed in square [brackets] associated with a small brace (e.g. "{[00-03]").

	Code figure		
WW = 00-49		*No precipitation at the station at the time of observation*	
WW = 00-19		No precipitation, fog, ice fog (except for 11 and 12), duststorm, sandstorm, drifting or blowing snow at the station[1] at the time of observation or, except for 09 and 17, during the preceding hour	
	Code figure		
No meteors except photo-meteors {[00-03]	00	Cloud development not observed or not observable	[00-03]} Characteristic change of the state of sky during the past hour
	01	Clouds generally dissolving or becoming less developed	
	02	State of sky on the whole unchanged	
	03	Clouds generally forming or developing	
Haze, dust, sand or smoke {[04-09]	04	Visibility reduced by smoke, e.g. veldt or forest fires, industrial smoke or volcanic ashes	
	05	Haze	
	06	Widespread dust in suspension in the air, not raised by wind at or near the station at the time of observation	
	07	Dust or sand raised by wind at or near the station at the time of observation, but no well-developed dust whirl(s) or sand whirl(s), and no duststorm or sandstorm seen; or, in the case of ships, blowing spray at the station	
	08	Well-developed dust whirl(s) or sand whirl(s) seen at or near the station during the preceding hour or at the time of observation, but no duststorm or sandstorm	
	09	Duststorm or sandstorm within sight at the time of observation, or at the station during the preceding hour	
	10	Mist	
	11	Patches	[11-12]} shallow fog or ice fog at the station, whether on land or sea, not deeper than about 2 metres on land or 10 metres at sea
	12	More or less continuous	
	13	Lightning visible, no thunder heard	

	Code figure		
	14	Precipitation within sight, not reaching the ground or the surface of the sea	
	15	Precipitation within sight, reaching the ground or the surface of the sea, but distant, i.e. estimated to be more than 5 km from the station	
	16	Precipitation within sight, reaching the ground or the surface of the sea, near to, but not at the station	
	17	Thunderstorm, but no precipitation at the time of observation	
	18	Squalls	[18-19]} at or within sight of the station during the preceding hour or at the time of observation
	19	Funnel cloud(s)[2]	
WW = 20-29		Precipitation, fog, ice fog or thunderstorm at the station during the preceding hour but not at the time of observation	
	20	Drizzle (not freezing) or snow grains	[20-24]} not falling as shower(s)
	21	Rain (not freezing)	
	22	Snow	
	23	Rain and snow or ice pellets	
	24	Freezing drizzle or freezing rain	
	25	Shower(s) of rain	
	26	Shower(s) of snow, or of rain and snow	
	27	Shower(s) of hail[3], or of rain and hail[3]	
	28	Fog or ice fog	
	29	Thunderstorm (with or without precipitation)	
WW = 30-39		Duststorm, sandstorm, drifting or blowing snow	
	30	[30-32]} Slight or moderate duststorm or sandstorm {	– has decreased during the preceding hour
	31		– no appreciable change during the preceding hour
	32		– has begun or has increased during the preceding hour
	33	[33-35]} Severe duststorm or sandstorm {	– has decreased during the preceding hour
	34		– no appreciable change during the preceding hour
	35		– has begun or has increased during the preceding hour
	36	Slight or moderate drifting snow	[36-37]} generally low (below eye level)
	37	Heavy drifting snow	
	38	Slight or moderate blowing snow	[38-39]} generally high (above eye level)
	39	Heavy blowing snow	
WW = 40-49		Fog or ice fog at the time of observation	
	40	Fog or ice fog at a distance at the time of observation, but not at the station during the preceding hour, the fog or ice fog extending to a level above that of the observer	
	41	Fog or ice fog in patches	
	42	Fog or ice fog, sky visible	[42-43]} has become thinner during the preceding hour
	43	Fog or ice fog, sky invisible	
	44	Fog or ice fog, sky visible	[44-45]} no appreciable change during the preceding hour
	45	Fog or ice fog, sky invisible	
	46	Fog or ice fog, sky visible	[46-47]} has begun or has become thicker during the preceding hour
	47	Fog or ice fog, sky invisible	
	48	Fog, depositing rime, sky visible	
	49	Fog, depositing rime, sky invisible	

	Code figure		
WW = 50-99		*Precipitation at the station at the time of observation*	
WW = 50-59		Drizzle	
	50	Drizzle, not freezing, intermittent	[50-51]} slight at time of observation
	51	Drizzle, not freezing, continuous	
	52	Drizzle, not freezing, intermittent	[52-53]} moderate at time of observation
	53	Drizzle, not freezing, continuous	
	54	Drizzle, not freezing, intermittent	[54-55]} heavy (dense) at time of observation
	55	Drizzle, not freezing, continuous	
	56	Drizzle, freezing, slight	
	57	Drizzle, freezing, moderate or heavy (dense)	
	58	Drizzle and rain, slight	
	59	Drizzle and rain, moderate or heavy	
WW = 60-69		Rain	
	60	Rain, not freezing, intermittent	[60-61]} slight at time of observation
	61	Rain, not freezing, continuous	
	62	Rain, not freezing, intermittent	[62-63]} moderate at time of observation
	63	Rain, not freezing, continuous	
	64	Rain, not freezing, intermittent	[64-65]} heavy (dense) at time of observation
	65	Rain, not freezing, continuous	
	66	Rain, freezing, slight	
	67	Rain, freezing, moderate or heavy	
	68	Rain or drizzle and snow, slight	
	69	Rain or drizzle and snow, moderate or heavy	
WW = 70-79		Solid precipitation not in showers	
	70	Intermittent fall of snowflakes	[70-71]} slight at time of observation
	71	Continuous fall of snowflakes	
	72	Intermittent fall of snowflakes	[72-73]} moderate at time of observation
	73	Continuous fall of snowflakes	
	74	Intermittent fall of snowflakes	[74-75]} heavy (dense) at time of observation
	75	Continuous fall of snowflakes	
	76	Diamond dust (with or without fog)	
	77	Snow grains (with or without fog)	
	78	Isolated star-like snow crystals (with or without fog)	
	79	Ice pellets	
WW = 80-99		Showery precipitation, or precipitation with current or recent thunderstorm	
	80	Rain shower(s), slight	
	81	Rain shower(s), moderate or heavy	
	82	Rain shower(s), violent	
	83	Shower(s) of rain and snow mixed, slight	
	84	Shower(s) of rain and snow mixed, moderate or heavy	
	85	Snow shower(s), slight	
	86	Snow shower(s), slight	
	87	[87-88]} Shower(s) of snow pellets or small hail, with or – without rain or rain and snow mixed {	**–** Slight
	88		**–** Heavy
	89	[89-90]} Shower(s) of hail[4], with or without rain or rain and snow mixed, not associated with thunder {	**–** Slight
	90		**–** Heavy
	91	Slight rain at time of observation	[91-94]} Thunderstorm during the preceding hour but not at time of observation
	92	Moderate or heavy rain at time of observation	
	93	Slight snow, or rain and snow mixed or hail[3] at time of observation	
	94	Moderate or heavy snow, or rain and snow mixed or hail[c] at time of observation	
	95	Thunderstorm, slight or moderate, without hail[3], but with rain and/or snow at time of observation	[95-99]} Thunderstorm at time of observation
	96	Thunderstorm, slight or moderate, with hail[3] at time of observation	

	Code figure		
	97	Thunderstorm, heavy, without hail[3], but with rain and/or snow at time of observation	
	98	Thunderstorm combined with duststorm or sandstorm at time of observation	
	99	Thunderstorm, heavy, with hail[3] at time of observation	

1. The expression "at the station" refers to a land station or a ship.
2. Tornado cloud or water-spout.
3. Hail, small hail, snow pellets. French: grêle, grésil ou neige roulée.
4. French: grêle.

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25) *SLP* sea level pressure
26) *A* barometric tendency
27) *PPP* amount of pressure tendency

SLP and *PPP* (amount of pressure tendency at station level during the three hours preceding the time of observation) in tenths of hPa (i.e. millibars), and *A* according to WMO Code 0200 (Table D4).

Background: IMMT-4 contains a 4-character (PPPP) representation of *SLP* in (dropping the leading digit). WMO (2009a) Reg. 12.1.3.7, Note (3) describes how for auxiliary ships *SLP* (similarly to *AT*, as discussed below) still may be reported to whole hPA (using the solidus "/" for the tenths position, which was probably generally set to zero in translated GTS data, with a resulting loss of precision information).

Table D4. WMO Code 0200 for characteristic of pressure tendency during the three hours preceding the time of observation (*A*) (after WMO 2009a).

Code figure		
0	Increasing, then decreasing; atmospheric pressure the same or higher than three hours ago	
1	Increasing, then steady; or increasing, then increasing more slowly	[1-3]} Atmospheric pressure now higher than three hours ago
2	Increasing (steadily or unsteadily)[1]	
3	Decreasing or steady, then increasing; or increasing, then increasing more rapidly	
4	Steady; atmospheric pressure the same as three hours ago[1]	
5	Decreasing, then increasing; atmospheric pressure the same or lower than three hours ago	
6	Decreasing, then steady; or decreasing, then decreasing more slowly	[6-8]} Atmospheric pressure now lower than three hours ago
7	Decreasing (steadily or unsteadily)[1]	
8	Steady or increasing, then decreasing; or decreasing, then decreasing more rapidly	

* For reports from automatic stations, see Reg. 12.2.3.5.3.

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28) *IT* indicator for temperatures
29) *AT* air temperature (i.e. dry bulb)
30) *WBTI* *WBT* indicator
31) *WBT* wet-bulb temperature
32) *DPTI* *DPT* indicator
33) *DPT* dew-point temperature
34) *SI* *SST* method indicator

35) *SST* sea surface temperature

Temperatures are stored in tenths of a degree Celsius. *IT* provides information about the precision and/or units that the temperature elements were translated from:

0 – tenths °C
1 – half °C
2 – whole °C
3 – whole or tenths °C (mixed precision among temperature fields)
4 – tenths °F
5 – half °F
6 – whole °F
7 – whole or tenths °F (mixed precision among temperature fields)
8 – high resolution data (e.g. hundredths °C)
9 – other

> Background: For *IT*, 0-2 match i_T=3-5 in IMMT-4; the full configuration matches predecessor field *T1* in LMR. Early historical temperatures may have also been reported in degrees Réaumur, mixed units, etc.; additional fields may be desirable in the historical attm to record such details. WMO (2009a) Reg. 12.1.3.7, Note (3) describes how for auxiliary ships *AT* (similarly to *SLP*, as discussed above) still may be reported to whole degrees (using the solidus "/" for the tenths position, which was probably generally set to zero in translated GTS data, with a resulting loss of precision information). Only starting in 1982 could *DPT* be reported to tenths in the SHIP code, and only starting 2 Nov. 1994 did it become possible to report *WBT* (to tenths) in FM 13.

WBTI and *DPTI* indicate which of *WBT* or *DPT* was measured or computed, and ice bulb conditions:

0 – measured
1 – computed
2 – iced measured
3 – iced computed

> Background: *WBTI* and *DPTI* are derived from sign positions s_w and s_t in IMMT-4. [Note: For data originally translated into LMR from IMMT formats, the predecessor LMR field *T2* preserved only a subset of information derived from s_w and s_t, coupled with whether *DPT* was computed during ICOADS processing. Future work should seek to recover more complete information for data that were translated to IMMA from LMR, and consider new configurations to separately document ICOADS processing. WMO (2009a) Reg. 12.2.3.3.1 specifies when (e.g. owing to instrument failure) relative humidity (RH) is available and may be reported in FM 13 instead of *DPT* in an alternative group 29UUU. Thus far such RH data have generally not been recovered into ICOADS).]

SI shows the method by which *SST* was taken:

0 – bucket
1 – condenser inlet (intake)
2 – trailing thermistor
3 – hull contact sensor
4 – through hull sensor
5 – radiation thermometer
6 – bait tanks thermometer
7 – others
9 – unknown or non-bucket
10 – "implied" bucket [note: applicable to early ICOADS data]
11 – reversing thermometer or mechanical sensor

12 – electronic sensor

Background: 0-7 follow the IMMT-4 code. Except for omitting *SI*=8 ("unknown"), this is a direct mapping from the LMR configuration. *SI* values should be used with extreme caution in earlier data (see discussion of "bucket indicators" in sec. 4 of *Release 1*). [Note: In translation from LMR, *SI*=8 was made missing (*SI*=8 indicated that no information was available; it resulted from a conversion error applicable only to decks 705-707). For data translated from IMM formats effective since 1982, *SI*=7 refers to "other than 0-6," because the only other extant values were 0-6. For FM 13 data reported since 2 Nov. 1994 (when *SI* information first became available on GTS), in contrast, *SI*=7 refers to "other than 0-1 or 3," because the only other extant values were equivalent to 0-1 or 3. *SI*=9 arose because a distinct missing value was not available in some earlier IMM and archive formats, e.g. in NCDC (1968) a blank in the SST indicator field for deck 128 meant "determined by other than bucket method," but blank also generally signified a missing field in that format.]

36) *N* total cloud amount (cover)

37) *NH* lower cloud amount

For *N*, codes 0 to 9 (WMO Code 2700) show the total fraction of the celestial dome covered by clouds (irrespective of their genus). For *NH* (also WMO Code 2700) they show the amount of all the low (*CL*) cloud present or, if no *CL* cloud is present, the amount of all the middle (*CM*) cloud present:

0 – clear
1 – 1 okta or less, but not zero
2-6 – 2-6 oktas
7 – 7 oktas or more, but not 8 oktas
8 – 8 oktas
9 – sky obscured by fog and/or other meteorological phenomena

Background: In WMO 2009a (WMO Code 2700), *N* is termed "total cloud cover." This description adopts the current WMO Code 2700 definition of code 9, which in LMR was defined as "sky obscured or cloud amount cannot be estimated" (as in Met Office 1948). The solidus ("/") is defined as a further possibility in WMO Code 2700 as "Cloud cover is indiscernible for reasons other than fog or other meteorological phenomena, or observation is not made," which should have been translated into missing data in IMMA. [Note: Historically "/" was omitted e.g. from Met Office 1948 and NCDC 1968, and thus also not included in *Release 1* or current LMR configurations for *N* and *NH*. In contrast *CL*, *H*, *CM*, and *CH* have always had an ICOADS configuration ("A" in IMMA) corresponding to "/" separate from missing data (see also background notes following *CH*, field 42).]

38) *CL* low cloud type

Codes 0 to 10 show characteristics observed of clouds of the genera Stratocumulus, Stratus, Cumulus, and Cumulonimbus (WMO Code 0513; see also background notes following *CH*, field 42).

39) *HI* cloud height indicator

HI shows if cloud height *H* was:

0 – estimated
1 – measured

Background: The "Cloud height and visibility measuring indicator" from IMMT-4 is separated into independent indicators in IMMA format, *HI* and *VI* (see field 21).

40) *H* cloud height

Codes 0 to 9 and "A" (following WMO Code 1600) show the height above surface of the base of the lowest cloud seen (such that a height exactly equal to one of the values at the ends of the ranges shall be coded in the higher range, e.g. a height of 600 m shall be reported by code 5):

0 – 0 to 50 m
1 – 50 to 100 m
2 – 100 to 200 m
3 – 200 to 300 m
4 – 300 to 600 m
5 – 600 to 1000 m
6 – 1000 to 1500 m
7 – 1500 to 2000 m
8 – 2000 to 2500 m
9 – 2500 m or more, or no clouds
"A" – height of base of cloud not known or base of clouds at a level lower and tops at a level higher than that of the station

Background: Further notes regarding WMO Code 1600 (WMO 2009a) concern *H* data reported from automatic stations.

41) *CM* middle cloud type

Codes 0 to 10 show characteristics observed of clouds of the genera Altocumulus, Altostratus, and Nimbostratus (WMO Code 0515).

42) *CH* high cloud type

Codes 0 to 10 show characteristics observed of clouds of the genera Cirrus, Cirrocumulus and Cirrostratus (WMO Code 0509).

Background: Configurations for *CL*, *H*, *CM*, and *CH* are as in IMMT-4, except for use of "A" (10 in base36) in place of "/" (LMR used 10 in place of "/"). Analyses of cloud types may be impacted by a 1 Jan. 1982 GTS code change: When *N*=0, the types *CM*, *CH*, and *CL* were reported as missing (i.e. the FM 13 $8NhC_LC_MC_H$ group was omitted), whereas previously these types may have been reported zero (see Hahn et al. 1992). However, to improve climatological data quality, starting 2 Nov. 1994 FM 13 was again modified so that all cloud observations at sea including no cloud observation shall be reported (see WMO 2009a, Reg. 12.2.7.1). [Note: For historical reasons (see background under *NH*, field 37), an inconsistency exists in IMMA in how solidus ("/") is translated for *N* and *NH* (i.e. to missing data) versus for *CL*, *H*, *CM*, and *CH* (i.e. to "A"). A related complication (i.e. in terms of preserving information about whether data were explicitly reported as "/" versus omitted from transmission) is that group Nddff in FM 13 is mandatory, whereas $8NhC_LC_MC_H$ can be omitted (Reg. 12.2.7.1).]

43) *WD* wave direction

Starting in 1968, *WD* was no longer reported in the SHIP code. Codes 00 to 36 (note: leading zero is omitted in IMMA) show the direction (if any) from which (wind) waves come, in tens of degrees (following WMO Code 0877; ref. Code and Range columns in Table D2). Codes 37 and 38 show:

37 – waves confused, direction indeterminate ($WH \leq 4.75$ m)
38 – waves confused, direction indeterminate ($WH > 4.75$ m; or irrespective of wave height, corresponding to 99 in WMO Code 0877)

44) *WP* wave period

Period of wind waves, in seconds. Starting in 1968, *WP* was reported in seconds; prior to 1968 the period was reported as a code, which was converted into whole seconds following Table D5, with *WX* (field 61) set accordingly.

45) *WH* wave height

Height of wind waves, in units of 0.5 m (i.e. 1=0.5 m, 2=1 m, etc.).

Background: Historically, the (wind) wave and swell codes have been subject to complex changes. Prior to 1949 both sets of fields were apparently reported descriptively in the SHIP code, and thus are expected to be missing (and the swell fields are expected to be missing prior to 1 July 1963, as discussed below). Codes 37-38 arise from earlier historical codes (see Met Office 1948). Starting in 1968, *WD* was no longer reported and *WP* was reported in seconds. [Note: *WP*=99, indicating a confused sea, is not presently defined in IMMA. Future work should seek to recover this information from original formats, and consider an expanded IMMA configuration.]

46) *SD* swell direction
47) *SP* swell period
48) *SH* swell height

Configurations similar to the corresponding wave fields *WD*, *WP*, and *WH*. Prior to 1968 (1982), *SP* was reported as a code, which was converted into whole seconds per Table D5a (Table D5b), with *SX* (field 62) set accordingly.

Background: Beginning 1 July 1963 both sea (i.e. wind wave) and swell were reported. Prior to that date only the higher of sea and swell was reported. Starting in 1982, *SP* was reported in seconds.

Table D5a. Conversion for *WP* always, and for *SP* prior to 1968.

Seconds	*Code*	*Interval*
5	2	5 seconds or less
7	3	6-7 seconds
9	4	8-9 seconds
11	5	10-11 seconds
13	6	12-13 seconds
15	7	14-15 seconds
17	8	16-17 seconds
19	9	18-19 seconds
21	0	20-21 seconds
22	1	over 21 seconds
0	–	calm or period not determined

Table D5b. Conversion for *SP* beginning 1 January 1968.

Seconds	*Code*	*Interval*
10	0	10 seconds
11	1	11 seconds
12	2	12 seconds
13	3	13 seconds
14	4	14 seconds or more
5	5	5 seconds or less
6	6	6 seconds
7	7	7 seconds
8	8	8 seconds
9	9	9 seconds
0	–	calm or period not determined

ICOADS attm (C1)

49) *ATTI* attm ID
50) *ATTL* attm length
(See fields 197-198.)

Box elements

51) *BSI* box system indicator
52) *B10* 10° box number
53) *B1* 1° box number
10° and 1° box numbers (see *Release 1*, supp. G) are available e.g. for use in sorting operations. The box system indicator is currently unused.

Background: *BSI* provides flexibility in case other box requirements arise (i.e. future extant values of *BSI* could indicate different contents in *B10* and *B1*). *Release 1*, supp. G also describes the obsolete Marsden Square (MSQ) system.

Processing elements

54) *DCK* deck
Number of the deck from which the report came (Table D6a), with Tables D6b and D6c providing additional information about selected *DCK* ranges. "Deck" originally referred to a punched card deck, but is now used as the primary field to track ICOADS data collections. Each deck may contain a single Source ID (*SID*) or a mixture of *SIDs* (see field 55 for additional information about the relationship between these two fields, and with the format of supplemental data).

Table D6a. Deck assignments (adapted in part from Table AII in Woodruff et al. 2010). For each deck number, the description, starting and ending years, and number of reports (in thousands) after final R2.5 processing (1662-2007), are listed (blanks in the last three columns indicate that no data were input and/or output[1]). Decks entirely new to (or replaced in) R2.5, are numbered in **bold** (except within range 201-255). ICOADS also offers preliminary data (presently based exclusively on decks 792-795) extending beyond 2007, but not reflected in the last three columns.

Deck	*Description*	*Start*	*End*	*Rpts K*
110	US Navy Marine	1945	1951	633
116	US Merchant Marine	1945	1963	6 866
117	US Navy Hourlies	1952	1964	11
118	Japanese Ships No. 1 (Kobe Collection Data keyed in 1961)	1930	1953	1 727
119	Japanese Ships No. 2 (Kobe Collection Data keyed in 1961)	1951	1961	904
128	International Marine (US- or foreign-keyed ship data)	1950	1978	14 537
143	Pacific Marine Environmental Laboratory (PMEL) Buoys	1976	1977	13
144	TAO/TRITON and PIRATA Buoys (from PMEL & JAMSTEC)[2]	1985	2004	7 192
145	PMEL (Daily) Equatorial Moorings and Island Stations[2]	1979	1991	17
150	Pacific (US Responsibility) HSST Netherlands Receipts	1939	1961	85
151	Pacific (US Responsibility) HSST German Receipts	1862	1960	206
152	Pacific (US Responsibility) HSST UK Receipts	1855	1961	15
155	Indian (Netherlands Responsibility) HSST	1861	1960	1 068
156	Atlantic (German Responsibility) HSST	1852	1961	5 564
184	Great Britain Marine (194 extension)	1953	1961	344

Deck	*Description*	*Start*	*End*	*Rpts K*
185	USSR Marine IGY	1957	1958	111
186	USSR Ice Stations	1950	1970	20
187	Japanese Whaling Fleet	1946	1956	10
188	Norwegian Antarctic Whaling Factory Ships	1932	1939	2
189	Netherlands Marine	1939	1959	232
192	Deutsche Seewarte Marine	1855	1939	5 944
193	Netherlands Marine	1800	1938	6 276
194	Great Britain Marine	1856	1955	457
195	US Navy Ships Logs	1941	1946	598
196	Deutsche Seewarte Marine (192 extension)	1949	1954	143
197	Danish (and Other) Marine (Polar)	1871	1956	23
201-255[3]	UK Met. Office (MetO) Main Marine Data Bank (MDB)	1854	1994	15 212
281	US Navy Monthly Aerological Record (MAR)	1926	1945	187
500	Gulf Offshore Weather Observing Network (GOWON) (plat data)			
555	US Navy Fleet Num. Met. and Oceano. Center (FNMOC; Monterey) Telecom.	1966	1973	2 213
666	Tuna Boats	1970	1975	17
667	Inter-American Tropical Tuna Commission (IATTC)	1971	1997	1 148
700	UK Met. Office VOSClim GTS BUFR Data	2003	2007	10
701	US Maury Collection	1784	1863	1 346
702	Norwegian Logbook Collection	1867	1889	201
703	US Lightship Collection			
704	US Marine Meteorological Journals Collection (1878-94)	1878	1894	1 761
705	US Merchant Marine Collection (1912-46) (500 series)	1910	1946	1 014
706	US Merchant Marine Collection (1912-46) (600 series)	1910	1944	2 062
707	US Merchant Marine Collection (1912-46) (700 series)	1913	1941	425
714	Canadian Integrated Science Data Mgmt. (ISDM; formerly MEDS) Buoys	1978	2007	57 274
715	German Deep Drifter Data (via ISDM; originally from IfM/Univ. Kiel)	1980	1996	1 031
720	Deutscher Wetterdienst (DWD) Marine Met. Archive	1876	1914	976
730	Climatological Database for the World's Oceans (CLIWOC)	1662	1855	261
731	Russian S.O. Makarov Collection	1804	1891	3
732	Russian Marine Met. Data Set (MORMET) (rec'd at NCAR)	1888	1995	7 873
733	Russian AARI North Pole (NP) Stations	1937	1991	98
734	Arctic Drift Stations	1893	1924	12
735	Russian Research Vessel (R/V) Digitization	1936	2000	1 789
736	Byrd Antarctic Expedition (keyed by Hollings Scholars)	1929	1934	1
740	Research Vessel (R/V) Data Quality-Evaluated by FSU/COAPS	1990	1998	56
749	First GARP Global Experiment (FGGE) Level IIb	1978	1979	6
761	Japanese Whaling Ship Data (CDMP/MIT digitization)	1946	1984	20
762	Japanese Kobe Collection Data (keyed after decks 118-119)	1889	1940	3 135
780	NODC/OCL World Ocean Database (WOD) (and formerly Atlas, WOA)	1772	2005	7 738
781	Chinese/Global Ocean Data Archeology and Rescue (GODAR) Ships			
792	US Natl. Cntrs. for Environ. Pred. (NCEP) BUFR GTS: Ship Data	1998	2007	5 889
793	NCEP BUFR GTS: Buoy Data (transmitted in FM 13 “SHIP” code)	1998	2007	10 545
794	NCEP BUFR GTS: Buoy Data (transmitted in FM 18 “BUOY” code)	1998	2007	1 950
795	NCEP BUFR GTS: Coastal-Marine Automated Network (C-MAN	2005	2007	4 056

Deck	Description	Start	End	Rpts K
	code) Data			
796	NCEP BUFR GTS: Miscellaneous (OSV, plat, and rig) Data			
797	NCEP BUFR GTS: CREX code			
849	First GARP Global Experiment (FGGE)	1978	1979	250
850	German FGGE	1978	1979	146
874	Shipboard Environmental (Data) Acquisition System (SEAS)	1991	2007	504
876-882[4]	US National Data Buoy Center (NDBC) Data	1972	1979	315
883[4]	US National Data Buoy Center (NDBC) Data	1980	2004	20 538
888	US Air Force Global Weather Central (GWC)	1973	1997	5 993
889	Autodin (US Dept. of Defense Automated Digital Network)	1972	1995	1 039
890	US National Met. Center (NMC, now NCEP) Data (obsolete)			
891	US National Oceanographic Data Center (NODC) Surface Data			
892	US Natl. Centers for Environmental Pred. (NCEP) Ship Data	1980	1997	9 209
893	NCEP Moored Buoy Data	1986	1997	2 225
894	NCEP Drifting Buoy Data			
895	NCEP Coastal-Marine Automated Network (C-MAN) Data			
896	NCEP Miscellaneous (OSV, plat, and rig) Data	1980	1997	575
897	*Eltanin*	1962	1963	1
898	Japanese	1954	1974	121
899	South African Whaling	1900	1955	64
900	Australian	1931	1979	386
901	FOSDIC Reconstructions (card images from 16mm film)	1868	1963	7
902	Great Britain Marine (184 extension)	1957	1961	99
926	International Maritime Meteorological (IMM) Data	1954	2007	25 372
927	International Marine (US- or foreign-keyed ship data)[5]	1970	2007	11 138
928	Same as 927 including Ocean Station Vessels (OSV)	1970	1974	4
992	NCDC GTS: Ship Data			
993	NCDC GTS: Buoy Data (transmitted in FM 13 "SHIP" code)			
994	NCDC GTS: Buoy Data (transmitted in FM 18 "BUOY" code)			
995	NCDC GTS: Coastal-Marine Automated Network (C-MAN code) Data			
996	NCDC GTS: Miscellaneous (OSV, plat, and rig) Data			
997	NCDC GTS: CREX code			
999	US Air Force Environ. Technical Applications Center (ETAC)	1967	1969	37

1. Some of these decks (ref. LMR documentation) were used in ICOADS prior to R2.5; others have not been used. LMR documentation also defines for real-time data processing unofficial deck numbers 001-009, which are not used for ICOADS.
2. Deck 145 contains daily-averaged data, and up to the early 1990's TAO deck 144 contains average estimates for 2-8 hours depending on the buoy instrument package and power requirements.
3. See Table D6b.
4. See Table D6c.
5. A mixture of US- and foreign-keyed data exists in deck 927 prior to 1980; starting about 1980 deck 927 is believed to contain only US-keyed ships.

Table D6b. UK Met. Office (MetO) Main Marine Data Bank (MDB) deck assignments (equivalent to MDB "series" numbers). For each deck number, the description, starting and ending years, and number of reports (in thousands) after final R2.5 processing, are listed ("*(n/a)*" in the last column indicates output report count not yet available; or blanks in the last three columns indicate that no data were input and/or output). Assignments falling in the range 201-255 not listed below (217, 219-220, etc.) are not yet assigned. Approximate time periods are also given in the description column from earlier MDB or other external documentation.

Deck	*Description*	*Start*	*End*	*Rpts K*
201	All Ships (1930 code) (1850-1920)	1854	1956	*(n/a)*
202	All Ships (1921 code) (1921-29)	1915	1938	*(n/a)*
203	Selected Ships (1930 code) (1920-39)	1929	1961	*(n/a)*
204	British Navy (HM) Ships (1930 code) (1930-48)	1929	1949	*(n/a)*
205	Scottish Fishery Cruisers MARIDS (1930 code) (1946-56)	1945	1956	*(n/a)*
206	Ocean Weather Stations (OWS) (1930 code) (1947-49)	1947	1948	*(n/a)*
207	Selected Ships (1930 code) (1945-48)	1945	1953	*(n/a)*
208	Light Vessels (1949-56)			
209	Selected Ships (including some foreign ships) (1951-56)	1951	1956	*(n/a)*
210	OWS (including Dutch "J") (1950-56)	1950	1956	*(n/a)*
211	Scottish Fishery Cruisers MARIDS (1956-61)	1956	1961	*(n/a)*
212	Light Vessels (1956-61)			
213	Selected Ships (1956-61)	1953	1962	*(n/a)*
214	OWS (1956-61)	1956	1961	*(n/a)*
215	German Marine (1860-1938)[1]	1860	1940	*(n/a)*
216	UK Merchant Ship Logbooks (METFORMS; keyed in 1996) (1935-39)	1935	1939	*(n/a)*
218	US OWS (1953-)	1953	1963	*(n/a)*
221	MARIDS and Trawlers (1961-)	1962	1988	*(n/a)*
222	Light Vessels (1961-)			
223	Selected Ships (1961-81)	1962	1982	*(n/a)*
224	OWS (1961-81)	1976	1981	*(n/a)*
225	Norwegian Format (1953-)			
226	OWS (1949 code) (1949-52)	1949	1952	*(n/a)*
227	Selected Ships (1949-53)	1947	1954	*(n/a)*
229	British Navy (HM) Ships (1961-)	1953	1981	*(n/a)*
230	Int. Maritime Met. Punched Card (IMMPC) Data (1960-81)	1962	1971	*(n/a)*
233	Selected Ships (1982-)	1982	1994	*(n/a)*
234	OWS (1982-)	1982	1994	*(n/a)*
235	RIGG, PLAT, Automatic Weather-Observing System (AWS; buoy) (1982-)			
239	British Navy (HM) Ships (1982-)	1953	1993	*(n/a)*
241	MetO GTS Receipts (primarily SHIP code; from MDB format)[2]			
242	MetO GTS Receipts (SHIP code; raw messages from MetDb)[3]			
245	Royal Navy Ship's Logs (keyed by 2007) (1938-47)	1936	1955	1 423
246	Antarctic Expeditions: Print./Published (held at Met. Office)	1898	1940	35
247	Atmospheric Circ. Reconstructions over the Earth (ACRE) Data	1872	1876	16
254	Int. Maritime Met. (IMM) Data (foreign or unknown origin)	1860	1994	*(n/a)*
255	Undocumented TDF-11 Decks or MDB Series	1857	1994	*(n/a)*

1. Believed to be derived from the same original German punched cards as deck 192 (see Table D6a).
2. 1 Jan 1982-26 Jun 1998 (missing: Apr-Jun 82; Mar, Jun, Sep 85; Sep 88). Some non-SHIP (e.g. BUOY) data may also be included in earlier years.
3. 21 Dec 1996-23 Feb 1998.

Table D6c. Deck assignments for early US National Data Buoy Center (NDBC) data (decks 876-882), and the latest version from NCDC of NDBC data (deck 883). For each deck number, the description, starting and ending years, and number of reports (in thousands) after final R2.5 processing, are listed ("*(n/a)*" in the last column indicates output report count not yet available). Initially, separate deck numbers 876-880 were assigned to indicate hull design, etc.[1] At a later date, this convention was abandoned, such that decks 882 and 883 were used for all data.

Deck	*Description*	*Start*	*End*	*Rpts K*
876	NDBC Data (High Capability Buoy; HCB)	1972	1977	*(n/a)*
877	NDBC Data (Limited Capability Buoy; LCB)	1973	1976	*(n/a)*
878	NDBC Data (Prototype Environmental Buoy; PEB)	1974	1978	*(n/a)*
879	NDBC Data (5-meter Continental Shelf Buoys)	1974	1978	*(n/a)*
880	NDBC Data (10-meter Continental Shelf Buoys)	1976	1978	*(n/a)*
881	NDBC Data (Offshore Platforms)	1976	1977	*(n/a)*
882	NDBC Data	1978	1979	*(n/a)*
883	NDBC Data (latest version from NCDC)	1980	2004	20 538

1. Hull design information is based on informal NCDC documentation (NCDC 1972a and 1972b) and D. Gilhousen (NDBC) personal correspondence (13 Dec. 1995).

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55) *SID* source ID

Number of the source ID from which the report came (Table D7). Each *SID* may contain a single deck or a mixture of decks, but each *SID* is generally constrained to a single input format. This helps to identify the format of data stored in the supplemental attachment. However, exceptions include UK Marine Data Bank (MDB) data, for which both *DCK* (201-255) and *SID* (90-93) may be required to determine the supplemental format.

Table D7. Source ID (*SID*) assignments (adapted in part from Table AIII in Woodruff et al. 2010). For each *SID* number, the description, starting and ending years, and number of reports (in thousands) after final R2.5 blending, are listed (blanks in the last three columns indicate that no data were input and/or output[1]). *SIDs* entirely new to (or replaced in) R2.5, are numbered in **bold**. ICOADS also offers preliminary data (presently based exclusively on *SID* 103) extending beyond 2007, but not reflected in the last three columns.

SID	*Description*	*Start*	*End*	*Rpts K*
0	*[reserved]*			
1	Atlas	1800	1969	32 713
2	HSST Pacific	1855	1961	405
3	HSST Indian	1861	1960	1 068
4	HSST Atlantic	1852	1961	5 564
5	Old TDF-11 Supplement B	1854	1975	2 694
6	Old TDF-11 Supplement C	1855	1978	2 625
7	Monterey Telecommunications	1966	1969	661
8	Ocean Station Vessels (OSV)	1945	1973	822
9	OSV Supplement	1947	1973	57
10	MSQ 486 and 105 Omissions	1854	1968	172
11	US National Oceanographic Data Center (NODC) Surface			
12	US NODC Surface Supplement			
13	*Eltanin*	1962	1963	1
14	Japanese	1954	1974	121

SID	*Description*	*Start*	*End*	*Rpts K*
15	South African Whaling	1900	1955	64
16	Australian	1931	1970	192
17	International Maritime Meteorological (IMM) Data	1956	1979	224
18	’70s Decade	1970	1979	12 183
19	IMM ’70s	1978	1979	<1
20	OSV Z (’70s)	1970	1974	1
21	Australian (’70s)	1971	1979	194
22[2]	NCDC: 1980-84 Annual Receipts	1982	1987	135
23	’70s Mislocated Data	1973	1979	2
24	Buoy Data	1972	1979	192
25-28[3]	NCDC: 1980-85 Annual Receipts	1962	1985	1 534
29	NCDC: US Nat. Met. Center (NMC, now NCEP) Reconversion (1980-92)	1980	1992	8 201
30	NCDC: 1980-84 Period of Record	1965	1984	4 192
31	Corrected Canadian Data			
32-33[3]	NCDC: Annual Receipts (and duplicates; starting in 1986)	1974	1997	4 440
34-45[3]	NCDC: 1986-97 Receipts (delayed)	1969	1996	1 251
46-47[3]	International Maritime Met. (IMM) Tape Archive (1982-)	1969	1995	7 117
48	NODC/OCL 1994 World Ocean Atlas (WOA94; Mar. 93 NODC archive data)			
49	NODC/OCL 1994 World Ocean Atlas (WOA94; non-NODC archive)			
50	US National Data Buoy Center (NDBC) Data	1980	1997	12 770
51-52[3]	Russian AARI North Pole (NP) Stations	1937	1991	98
53	First GARP Global Experiment (FGGE) Level IIb: Surface Marine Data	1978	1979	6
54	FGGE Level IIb: Oceanographic Data			
55	FGGE Level IIb: Drifting Buoy Data			
56	Russian S.O. Makarov Collection	1804	1891	3
57	Russian Marine Meteorological Data Set (MORMET) (rec'd at NCAR)	1888	1993	7 873
58	French International Maritime Met. (IMM) Uncorrected (1954-88)			
59	UK IMM Corrections (1982-89)	1982	1989	1 552
60	French International Maritime Met. (IMM) Corrected	1954	1988	159
61	Canadian Integrated Science Data Management (ISDM; formerly MEDS) Buoys			
62	ISDM (formerly MEDS) World Ocean Circulation Experiment (WOCE) Buoys			
63	Canadian ISDM (formerly MEDS) Buoys (July 2005 archive extended Dec. 2008)	1978	2007	57 274
64	Russian Research Vessel (R/V) Digitization: Marine Surface	1936	2000	1 153
65	Russian Research Vessel (R/V) Digitization: Marine Actinometric	1947	2000	637
66	Pacific Marine Environmental Lab. (PMEL) TOGA/TAO Buoys	1985	1992	236
67	PMEL (Daily) Equatorial Moorings and Island Stations	1979	1991	17
68	Arctic Drift Stations	1893	1924	12
69	US Maury Collection	1784	1863	1 346
70	Inter-American Tropical Tuna Comm. (IATTC) Porpoise Obs. Logs	1979	1997	736
71	IATTC Fishing Logs	1971	1997	413
72	IMM Tape Archive from WMO Global Collecting Centre (GCC) (1994 format)	1982	1997	3 808
73	NCDC Marine Obs. Processing System (MOPS): Pre-MOPS (TD-9973)			
74	NCDC MOPS: Duplicate File (TD-9974)			
75	NCDC MOPS: Original Observations (TD-9980)			

SID	*Description*	*Start*	*End*	*Rpts K*
76	NCDC MOPS: Supplementary or Correction Data			
77	NCDC: US National Cntrs. for Environ. Pred. (NCEP) Reconversion (1994-97)	1994	1997	2 609
78	NCDC: US-keyed Logbook Data Reconversion (TD-9972; keyed during 1996-97)	1987	1997	307
79	US Air Force Global Weather Central (GWC): DATSAV2 format	1980	1997	1 469
80	US Navy FNMOC Monterey Telecom: NCAR: Kunia (OPCON) format			
81	US Navy FNMOC Monterey Telecom: NCAR: NEDN format			
82	US Navy FNMOC Monterey Telecom: NCAR: Surface Ship (SPOT) format			
83	US Navy FNMOC Monterey Telecom: NCDC: Surface Ship (SPOT) format (TD-9769)			
84	US Merchant Marine Collection (1912-46): Full QC	1910	1944	1 927
85	US Merchant Marine Collection (1912-46): Partial QC	1910	1946	1 246
86	Pacific Marine Environ. Lab. (PMEL) TOGA/TAO Buoys: RAM Data			
87	Pacific Marine Environ. Lab. (PMEL) TOGA/TAO Buoys: SPOT Data			
88	NODC/OCL 1998 World Ocean Database (WOD98; Mar. 94 NODC archive data)			
89	NODC/OCL 1998 World Ocean Database (WOD98; non-NODC archive)			
90	UK Met. Ofc. (MetO) Main Marine Data Bank (MDB): Flatfile 1 (no cardimage)	1856	1994	9 272
91	MetO MDB: Flatfile 1A (Flatfile plus cardimage data)	1854	1979	5 413
92	MetO MDB: Flatfile 1B (no Flatfile match; data derived from cardimage)	1855	1978	69
93	MetO Historical Metforms (1935-39): Flatfile 1C (data from cardimage)	1935	1939	457
94	MetO GTS Receipts (primarily SHIP code; from MDB format)			
95	Japanese Kobe Collection Data (IMMT format; 2003 Edition)	1889	1940	3 135
96	Norwegian Logbook Collection	1867	1889	201
97	Japanese Kobe Collection Data (IMMT format; 1998 Edition)			
98	US Merchant Marine Collection (1912-46): Full QC (CLICOM system)	1914	1944	328
99	Japanese Kobe Collection Data (IMMT format; 2001 Edition)			
100	NCEP BUFR GTS: Operational Tanks: Converted from Original Message	1998	1999	2 198
101	NCEP BUFR GTS: Operational Tanks: Converted from BUFR			
102	NCEP BUFR GTS: Dumped Data: Converted from Original Message			
103	NCEP BUFR GTS: Dumped Data: Converted from BUFR	1999	2007	20 241
104-109	*[reserved]*			
110	UK Met. Office VOSClim GTS BUFR Data	2003	2007	10
111	Shipboard Environmental (Data) Acquisition System (SEAS)	1991	2007	438
112	IMM Tape Archive from WMO GCC (IMMT-2 or IMMT-3 format)	1982	2007	7 990
113	International Marine (US-keyed ship data)	1992	2007	533
114	NCDC GTS			
115	Japanese Whaling Ship Data (CDMP digitization)	1946	1984	20
116	Japanese Whaling Ship Data (MIT digitization)	1951	1976	<1
117	PMEL TAO/TRITON and PIRATA Research Archive Hourly Average Data	1990	2001	3 394
118	PMEL TAO/TRITON and PIRATA Research Archive 10-Minute Average Data	1996	2004	2 746
119	JAMSTEC TRITON Hourly Average Data	1998	2004	595

SID	*Description*	*Start*	*End*	*Rpts K*
120	PMEL TAO/TRITON and PIRATA Research Archive Hourly Average SLP Data	2000	2004	222
121	US National Data Buoy Center (NDBC) Data (obtained from NCDC 2005-2007)	1998	2004	7 768
122	US NDBC data (NODC f291 archive version translated by NCDC 2008)			
123	*[reserved]*			
124	Climatological Database for the World's Oceans (CLIWOC; Release 2.0)			
125	US Marine Meteorological Journals Collection	1878	1894	1 761
126	Royal Navy Ship's Logs (keyed by 2007)	1936	1955	1 423
127	Antarctic Expeditions: Print./Published (held at Met Office)	1898	1940	35
128	*[reserved]*			
129	Byrd Antarctic Expedition (keyed by Hollings Scholars)	1929	1934	1
130	Research Vessel (R/V) Data Quality-Evaluated by FSU/COAPS: WOCE ver.3.0	1990	1998	56
131	Research Vessel (R/V) Data Quality-Evaluated by FSU/COAPS: SAMOS			
132	Research Vessel (R/V) Data Quality-Evaluated by FSU/COAPS: Other			
133	Climatological Database for the World's Oceans (CLIWOC; Release 2.1)	1662	1855	261
134	Deutscher Wetterdienst (DWD) Marine Meteorological Archive: Compo Subset	1884	1914	580
135	DWD Marine Meteorological Archive: Newly Digitized Data	1876	1902	395
136	DWD Marine Meteorological Archive: HISTOR Data	1882	1899	<1
137	NODC/OCL 2005 World Ocean Database (WOD05) updated through 13 Dec. 2007	1772	2005	7 738
138	ACRE Data: *Challenger* Expedition	1872	1876	16
139	German Deep Drifter Data (via ISDM; originally from IfM/Univ. Kiel)	1980	1996	1 031
140	US Navy Hourlies: Deck 117 in TD-1100 format			
141	US Navy Hourlies: Original card deck 117 format (from FOSDIC)			
142	US Navy Hourlies: Original card deck 117 format (from DSI1117)			
143	Chinese/Global Ocean Data Archeology and Rescue (GODAR) Ships			
144	US Lightship Collection: Woods Hole Oceanographic Institution			
145[4]	US Lightship Collection: National Archives and Records Admin.			

1. Some of these SIDs (ref. LMR documentation) were used in ICOADS prior to R2.5; others have not been used.
2. Originally SID 22 was assigned to *Islas Orcadas* (see *Release 1*, supp. F), but the data were never translated.
3. LMR documentation provides a breakdown of descriptions for SID range.
4. Tentative source ID assignment—data are not yet available.

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56) *PT* platform type

The type of observing platform:

- 0 – US Navy or "deck" log, or unknown
- 1 – merchant ship or foreign military
- 2 – ocean station vessel—off station or station proximity unknown
- 3 – ocean station vessel—on station
- 4 – lightship
- 5 – ship
- 6 – moored buoy
- 7 – drifting buoy

8 – ice buoy [note: currently unused]
9 – ice station (manned, including ships overwintering in ice)
10 – oceanographic station data (bottle and low-resolution CTD/XCTD data)
11 – mechanical/digital/micro bathythermograph (MBT)
12 – expendable bathythermograph (XBT)
13 – Coastal-Marine Automated Network (C-MAN) (NDBC operated)
14 – other coastal/island station
15 – fixed ocean platform (plat, rig)
16 – tide gauge
17 – high-resolution Conductivity-Temp.-Depth (CTD)/Expendable CTD (XCTD)
18 – profiling float
19 – undulating oceanographic recorder
20 – autonomous pinneped bathythermograph
21 – glider

Background: *PT* settings 0-4 are derived from the "OSV or Ship Indicator" in NCDC (1968); *PT* settings 0-1 are very poorly documented and probably should be regarded as equivalent to ship data (*PT*=5).

57) *DUPS* dup status

Indicates duplicate status (Table D8). For the final R2.5 product, reports with *DUPS*>2 were not output (and landlocked *LZ*=1 reports were eliminated; see *R2.5qc* [note: in preparation]). However, to allow for more detailed analysis of the processing results and possible adjustments, all those flagged reports were retained in the R2.5 "intermediate" product (see Supp. E).

Background: Matches predecessor field *DS* in LMR format.

Table D8. Duplicate status (*DUPS*) assignments. In previous Releases, "certain" (C) duplicates were eliminated from the LMR output, and then "uncertain" (U) duplicates were eliminated from LMRF. Settings marked by footnotes apply only to pre-1980 data.

DUPS	*U/C*	*Description*
0		unique
1		best duplicate
2		best duplicate with substitution
3	U	worse duplicate: uncertain weather element match with hour cross[1]
4	U	worse duplicate: uncertain weather element match with no cross
5	U	worse duplicate: uncertain weather element match with day cross[2]
6	U	worse duplicate: time/space match with *ID* mismatch (unused until 1950)
7	U	worse duplicate: certain weather element match with hour cross[1]
8	C	worse duplicate: certain weather element match with no cross
9	C	worse duplicate: combined *DUPS* 4 and 6
10	C	worse duplicate: combined *DUPS* 6 and 8
11	C	worse duplicate: time/space/ID match
12	C	worse duplicate: combined *DUPS* 4 and 11
13	C	worse duplicate: combined *DUPS* 8 and 11
14	C	automatic data rejection

1. For *Release 1*, applied to 1854-1979 data; for Release 2.0 applied to 1784-1979 data.
2. For *Release 1*, applied to 1854-1969 data; for Release 2.0 applied to 1784-1969 data.

58) *DUPC* dup check

The presence of a duplicate match between a Global Telecommunication System (GTS) and logbook (or other delayed-mode) report may provide some location verification, with greater credibility if *SLP* and *SST* match under “allowances.” *DUPC* indicates whether such matches were detected during duplicate elimination processing (either the GTS or delayed-mode report is retained in the output data mixture), in case users might wish to make use of this information for independent quality control purposes:

0 – GTS and logbook match with *SLP* and *SST* match
1 – GTS and logbook match without *SLP* and *SST* match
2 – not GTS and logbook match

Background: Matches predecessor field *DC* in LMR format.

59) *TC* track check

TC, if set, indicates if a report was:

0 – not track checked
1 – track checked

Background: Indicator unused prior to Release 2.0; still missing in most data.

60) PB pressure bias

PB, if set, indicates questionable sea level pressure data:

0 – questionable *SLP*: level 0: individual platform (unused)
1 – questionable *SLP*: level 1: deck
2 – questionable *SLP*: level 2: deck

Background: All indicator settings unused prior to Release 2.0; still missing in most data (see LMR documentation for additional information).

61) *WX* wave period indicator
62) *SX* swell period indicator

Unless missing, *WX* and *SX* indicate that the wave and swell periods were converted from code into whole seconds:

1 – period converted from code into whole seconds

63) *C2* 2nd country code

The country of immediate receipt (*C2*), which may differ from the recruiting country (*C1*) and may also differ from the ship’s registry.

Background: *C2* was tracked for some earlier receipts of International Maritime Meteorological (IMM) logbook data, but IMM data are now generally received via Global Collecting Centres (GCCs; in Germany and UK). Thus this field is generally missing (see *C1*, field 16 for additional information).

QC elements

64-75) *SQZ-DQA* adaptive QC flags
76) *ND* night/day flag
77-82) *SF-RF* trimming flags
83-96) *ZNC-TNC* NCDC-QC flags
97) *QCE* external (e.g. MEDS)
98) *LZ* landlocked flag
99) *QCZ* source exclusion flags

Quality control and related flags, described in detail in *R2.5qc* [note: in preparation].

IMMT-2/FM 13 attm (C2)

100) *ATTI* attm ID
101) *ATTL* attm length
(See fields 197-198.)

Common for IMMT-2/-1

102) *OS* observation source

For International Maritime Meteorological (IMM) logbook data, *OS* shows the observation source:

0 – unknown		
1 – logbook	national	
2 – telecommunication channels	national	
3 – publications	national	
4 – logbook	international data exchange	
5 – telecommunication channels	international data exchange	
6 – publications	international data exchange	

For IMMT-4 this modified configuration is planned:

0 – unknown
1 – logbook (paper)
2 – national telecommunication channels
3 – national publications
4 – logbook (electronic)
5 – global telecommunication channels (GTS)
6 – international publications

Background: Because the modified IMMT-4 configuration (developed because of deficiencies in the existing configuration) is not backward compatible, IMMT version (see Supp. B, Table B1; not presently available as a regular field in IMMA) will be required to properly interpret the revised information, if stored in this same field.

103) *OP* observation platform

For International Maritime Meteorological (IMM) logbook data, *OP* shows the observation platform:

0 – unknown
1 – Selected ship
2 – Supplementary ship
3 – Auxiliary ship
4 – automated station/data buoy
5 – fixed sea station
6 – coastal station
7 – aircraft
8 – satellite
9 – others

For IMMT-4 this modified configuration is planned:

0 – unknown
1 – Selected ship
2 – Supplementary ship
3 – Auxiliary ship
4 – registered VOSClim ship

5 – fixed sea station (e.g. rig or platform)
6 – coastal station
7 – *[reserved]*
8 – *[reserved]*
9 – others/data buoy

Background: Because the modified IMMT-4 configuration (developed because of deficiencies in the existing configuration) is not backward compatible, IMMT version (see Supp. B, Table B1; not presently available as a regular field in IMMA) will be required to properly interpret the revised information, if stored in this same field.

<u>104) *FM* FM code version</u>

GTS traditional alphanumeric SHIP code "FM" version (see WMO 2009a).

Background: A 1-character field in IMMT (see Supp. B, Table B1) extended to two characters in IMMA to allow for expansion. Yoshida (2004) describes use at least back to 1949 of the "FM" notation (e.g. in FM 21 SHIP and FM 22 SHIP).

<u>105) *IX* station/weather indicator</u>
<u>106) *W2* second past weather</u>

IX (WMO Code 1860) indicates both whether the station is manned or automatic, and the status of present (*WW*, field 23) and past (*W1*, *W2*; WMO Code 4561, see field 24) weather data:

1 – manned	included
2 – manned	omitted (no significant phenomenon to report)
3 – manned	omitted (no observation, data not available)
4 – automatic	included [using WMO Codes 4677 and 4561]
5 – automatic	omitted (no significant phenomenon to report)
6 – automatic	omitted (no observation, data not available)
7 – automatic	included using WMO Codes 4680 and 4531

Background: Starting 1 Jan. 1982, the procedure for reporting present (*WW*) and past (*W1*, *W2*) weather in FM 13 was altered significantly by adding *IX*, which allowed the "7 group" ($7wwW_1W_2$ for manual stations, and usually $7w_aw_aWa_1Wa_2$ for automatic stations) to be omitted when there was no significant present or past weather to report (see Hahn et al. 1992). However, to improve climatological data quality, starting 2 Nov. 1994 FM 13 was again modified so that any present and past weather including phenomena without significance shall be reported (see WMO 2009a, Reg. 12.2.6.2). [Note: Refer to the LMR documentation for more information regarding use of *IX* with present and past weather data, and unforeseen complications attending its introduction in 1982 (e.g. *IX* was not included in IMMT until 1 March 1985). *IX*=4 was initially defined (WMO 1981) without the Code references (hence brackets above), and *IX*=7 was introduced at a later date. The *IX*=7 value was not included in LMR, thus future work should seek to recover this information for data that were translated to IMMA from LMR.]

<u>107) *SGN* significant cloud amount</u>
<u>108) *SGT* significant cloud type</u>
<u>109) *SGH* significant cloud height</u>

Use of "A" (10 in base36) in place of "/."

Background: These significant cloud fields are listed in Met Office (1948), but appear to have been omitted from regular IMM fields (see Table B3) and the current FM 13 code; in presently available ICOADS data they should always be missing [Note: Since these appear to be strictly historical fields, deletion from this attachment and possible repositioning within Table C5 is suggested for future consideration).]

110) *WMI* indicator for wave measurement

WMI corresponds to the IMMT-4 “indicator for wave measurement”:

0 – wind sea and swell estimated	shipborne wave recorder
1 – wind sea and swell measured	shipborne wave recorder
2 – mixed wave measured, swell estimated	shipborne wave recorder
3 – other combinations measured and estimated	shipborne wave recorder
4 – wind sea and swell measured	buoy
5 – mixed wave measured, swell estimated	buoy
6 – other combinations measured and estimated	buoy
7 – wind sea and swell measured	other measurement system
8 – mixed wave measured, swell estimated	other measurement system
9 – other combinations measured and estimated	other measurement system

Background: Note: Field not included in the LMR regular section, thus future work should seek to recover this information for data that were translated into IMMA from LMR.]

111) *SD2* swell direction (2nd)
112) *SP2* swell period (2nd)
113) *SH2* swell height (2nd)

Configurations as for *SD*, *SP*, and *SH* (fields 46-48).

Background: [Note: Fields not included in the LMR regular section, thus future work should seek to recover this information for data that were translated into IMMA from LMR.]

114) IS ice accretion

Accretion on the ship according to WMO Code 1751:

1 = icing from ocean spray
2 = icing from fog
3 = icing from spray and fog
4 = icing from rain
5 = icing from spray and rain

115) ES ice thickness

Ice accretion thickness on the ship in centimeters.

116) RS ice accretion rate

Accretion rate on the ship according to WMO Code 3551:

0 = ice not building up
1 = ice building up slowly
2 = ice building up rapidly
3 = ice melting or breaking up slowly
4 = ice melting or breaking up rapidly

117) *IC1* concentration of sea ice
118) *IC2* stage of development
119) *IC3* ice of land origin
120) *IC4* true bearing ice edge
121) *IC5* ice situation/trend

The fields changed dramatically in 1982 (field names reflect the 1982 Codes):

pre-1982	*starting 1 Jan. 1982*
description of ice type	concentration of ice (WMO Code 0639)
effect of ice on navigation	stage of ice development (WMO Code 3739)
bearing of principal ice edge	ice of land origin (WMO Code 0439)
distance to ice edge	true bearing principal ice edge (WMO Code 0739)
orientation of ice edge	ice situation/trend (WMO Code 5239)

IMMA stores the old/new information as listed above in the same field, thus making it critical that users be aware of the code change. Configurations are as in IMMT-4, except for use of “A” (10 in base36) in place of “/.”

Background: Separate fields (or an Code indicator) could be considered in the future. Earlier historical ice codes might also need to be researched for possible consideration. Met Office (1948) lists an Ice Group (c_2KD_ire) that may be similar or identical to the above pre-1982 code (see also Table B3 of Supp. B). [Note: Fields not included in the LMR regular section, thus future work should seek to recover this information for data that were translated into IMMA from LMR.]

122) *IR* indicator for precipitation data
123) *RRR* amount of precipitation
124) *TR* duration of period of reference for amount of precipitation

WMO Codes 1819, 3590, and 4019, respectively. Configurations are as in IMMT-4.

Background: [Note: Fields not included in the LMR regular section, thus future work should seek to recover this information for data that were translated into IMMA from LMR.]

125) *QCI* quality control (QC) indicator

Field *QCI* provides general information about the level of manual and/or automated quality control (QC) that has been applied to the data, including usage if indicated of time sequence checks and possible usage of the standardized Marine QC (MQC) software. Configuration as in IMMT-4 (draft amended documentation):

0 – no QC has been performed
1 – manual QC only
2 – automated QC only (such as using only MQC)
3 – automated QC only (with time sequence checks)
4 – manual and automated QC (superficial)
5 – manual and automated QC: (superficial; with time-sequence checks)
6 – manual and automated QC: (intensive; with time-sequence checks)
7 – *[reserved]*
8 – *[reserved]*
9 – national system of QC (information to be furnished to WMO)

Background: Prior to IMMT-4, values 7-8 were instead termed “not used.” [Note: Field not included in the LMR regular section, thus future work should seek to recover this information for data that were translated into IMMA from LMR.]

126) *QI1* QC indicator for height of clouds
127) *QI2* QC indicator for visibility
128) *QI3* QC indicator for clouds
129) *QI4* QC indicator for wind direction
130) *QI5* QC indicator for wind speed
131) *QI6* QC indicator for air temperature
132) *QI7* QC indicator for dew-point temperature
133) *QI8* QC indicator for air pressure

134) *QI9* QC indicator for weather
135) *QI10* QC indicator for sea surface temperature
136) *QI11* QC indicator for period of wind waves or of measured waves
137) *QI12* QC indicator for height of wind waves or of measured waves
138) *QI13* QC indicator for swell
139) *QI14* QC indicator for precipitation
140) *QI15* QC indicator for characteristic of pressure tendency
141) *QI16* QC indicator for amount of pressure tendency
142) *QI17* QC indicator for true direction of ship
143) *QI18* QC indicator for ship's average speed
144) *QI19* QC indicator for wet-bulb temperature
145) *QI20* QC indicator for ship's position

Twenty *QI* indicators applicable to individual fields or field groups (further details are available in Supp. B, Table B2; which also lists additional QC indicators available in IMMT-3/-4). Configuration as in IMMT-4 (draft amended documentation), indicating quality control (QC) as applied by the Contributing Member (CM) and/or by the Global Collecting Centres (GCCs). Values 6-7 are set when the original flag settings were amended by the GCCs using the Minimum Quality Control Standard (MQCS):

0 – no QC has been performed on this element
1 – QC performed; element appears correct
2 – QC performed; element appears inconsistent with other elements
3 – QC performed; element appears doubtful
4 – QC performed; element appears erroneous
5 – QC performed; element changed (possibly to missing) as a result
6 – QC flag amended: element flagged by CM as correct (1), but according to MQCS still appears suspect (2-4) or is missing (9)
7 – QC flag amended: element flagged by CM as changed (5), but according to MQCS still appears suspect (2-4)
8 – *[reserved]*
9 – element is missing

Background: [Note: Fields not included in the LMR regular section, thus future work should seek to recover this information for data that were translated into IMMA from LMR, plus additional QC indicators available in IMMT-3/-4.]

New for IMMT-2

146) *QI21* MQCS version

Version identification for the Minimum QC Standard (MQCS), with this expanded configuration defined for IMMT-4:

1 – MQCS- I (Original version, Feb. 1989): CMM-X
2 – MQCS-II (Version 2, March 1997) CMM-XII
3 – MQCS-III (Version 3, April 2000) SGMC-VIII
4 – MQCS-IV (Version 4, June 2001): JCOMM-I
5 – MQCS-V (Version 5, July 2004): ETMC-I
6 – MQCS-VI (this version, to be agreed)
[Note: etc. for future configurations]

Background: [Note: Field not included in the LMR regular section, thus future work should seek to recover this information for data that were translated into IMMA from LMR.]

147) *HDG* ship's heading

Direction to which the ship's bow is pointing, referenced to true North (0-360°; e.g. 360° = North, 0 = no movement, 90° = East).

> Background: According to IMMT-2/-3 documentation, as well as preliminary documentation for IMMT-4, 0 indicates no movement. However, KNMI has suggested that even if the ship is not moving it always has a heading, and therefore zero should not be reported for *HDG* (in contrast to *COG*).

148) *COG* course over ground

Direction the vessel actually moves over the fixed Earth, referenced to true North (0-360°; e.g. 360° = North, 0 = no movement, 90° = East).

149) *SOG* speed over ground

Speed the vessel actually moves over the fixed Earth, rounded to the nearest whole knot.

150) *SLL* max.ht.>Sum. load ln.

Maximum height of deck cargo above Summer maximum load line (reference level), rounded to the nearest whole meter.

151) *SLHH* departure of Summer max. load line from actual sea level

Departure of reference level (Summer maximum load line) from actual sea level. Difference to the nearest whole meter (0-99) between the Summer maximum load line and the sea level (water line); positive when the Summer maximum load line is above the level of the sea, and negative if below the water line.

152) *RWD* relative wind direction

Relative wind direction in degrees (1-360°) reported in a clockwise direction off the bow of the ship, using 360° when directly on the bow, or special code 361 (as for *D*, field 18) for calm.

> Background: It appears that no guidance currently exists for reporting *RWD* when *D* is reported as "variable, or all directions" (i.e. special code 362).

153) *RWS* relative wind speed

Reported in either whole knots or whole meters per second (e.g. 10 knots or 5 m s^{-1}), with units established by *WI* (field 18). RWS is a 3-character field to store values of RWS larger than ff (if WI indicates knots), e.g. ff=98 knots, RWS=101 knots; see also element 15.

> Background: Fields added to IMMT-2 for VOSClim. [Note: Fields 147-153 were not included in the LMR regular section, thus future work should seek to recover this information for data that were translated into IMMA from LMR.]

Model quality control attm (C3)

154) *ATTI* attm ID
155) *ATTL* attm length
(See fields 197-198.)

GTS bulletin header fields

156) *CCCC* collecting centre
157) *BUID* bulletin ID
These two fields are part of the "abbreviated heading" (WMO 2009c), providing product identification for purposes of transmission and communication handling ref., http://www.nws.noaa.gov/oso/oso1/oso15/oso153/SECC123.htm). Specifically, *CCCC* is the "international four-letter location indicator of the station or centre originating or compiling the bulletin, as agreed internationally, and published in WMO–No.9, Volume C1, *Catalogue of Meteorological Bulletins*;" and *BUID* provides "data designators" ($T_1T_2A_1A_2$ii; see Background, and WMO 2009c for a detailed description).

Background: Using traditional alphanumeric codes, individual (ship or buoy) reports are transmitted over GTS beginning with the identification group $M_iM_iM_jM_j$ (e.g. BBXX or ZZXX used to indicate the SHIP or BUOY code, respectively) and collected together to form the "text" (i.e. content) of a "bulletin" (which when enveloped with an initial line and end-of-message signal constitutes the "message"). The initial information includes an abbreviated heading of the form:

$T_1T_2A_1A_2$ii CCCC YYGGgg (BBB)

where in the context of marine data (see http://www.nws.noaa.gov/tg/head.html):

T_1T_2: Data type and/or form designators

A_1A_2: Geographical and/or data type and/or time designators

ii: Used to differentiate two or more bulletins which contain data in the same code, originate from the same geographical area, and have the same originating center.

CCCC: International 4-letter location indicator of the station originating or compiling the bulletin (e.g. KWBC = Washington, NOAA)

YYGGgg: International date-time group (YY: day of month; GGgg: hour and minute)

(BBB): (optional) for delayed (RR_x) reports, or corrections (CC_x) or amendments (AA_x) to previously relayed reports

The additional elements YYGGgg and BBB making up the abbreviated heading could potentially be important, but are not presently retained e.g. in the UK Met Office VOSClim data. For example, the BBB information could be important to correct information that was not properly relayed initially, and later in the event errors are made in the decoding of the data (e.g. BBB data are not properly handled) there may be no opportunity to reprocess the data properly if header information is not archived. *CCCC* information may be important to determine transmission details (e.g. origination from Local Users Terminals for drifting buoy reports), but the significance of any of this information has not been fully determined.

Model comparison elements

158) *BMP* background (bckd.) *SLP*
159) *BSWU* bckd. wind U-component
160) *SWU* derived wind U-component
161) *BSWV* bckd. wind V-component
162) *SWV* derived wind V-component
163) *BSAT* bckd. air temperature
164) *BSRH* bckd. relative humidity
165) *SRH* (derived) relative humidity
166) *SIX* derived stn./wea. indic. (unused)
167) *BSST* bckd. *SST*
168) *MST* model surface type
169) *MSH* model height of surface
170) *BY* bckd. year
171) *BM* bckd. month
172) *BD* bckd. day
173) *BH* bckd. hour
174) *BFL* bckd. forecast length (do not use; erroneous in R2.5 data)

Model quality control feedback information.

Background: Upon receipt of each GTS report from a VOSClim ship, the VOSClim Real Time Monitoring Centre (RTMC; at the UK Met Office) appends co-located parameters (and related information) from the Met Office forecast model for six variables—*SLP*, wind U- and V-component, air temperature, relative humidity, and *SST*—to a selection (translated into BUFR) of the originally reported GTS data. These augmented ship reports are made available in BUFR format to the VOSClim Data Assembly Center (DAC; at NOAA/NCDC), which converts them into IMMA format, including this attachment. Presently *SIX* is unused (should always be missing) because it is not among the fields in the input UK BUFR format. [Note: In R2.5 data, *BFL* was recently discovered to be subject to a conversion error and should not be used. Additionally, the original BUFR field that provides *BFL* is in minutes, thus future consideration should be given to the possibility, if appropriate, of changing the representation of *BFL* is an improved form.]

Ship metadata attm (C4)

175) *ATTI* attm ID
176) *ATTL* attm length
(See fields 197-198.)

Ship metadata elements

177) *C1M* recruiting country
178) *OPM* type of ship (programme)
178) K*OV* kind of vessel
180) *COR* country of registry
181) *TOB* type of barometer
182) *TOT* type of thermometer
183) *EOT* exposure of thermometer
184) *LOT* screen location
185) *TOH* type of hygrometer
186) *EOH* exposure of hygrometer
187) *SIM* SST measurement method
188) *LOV* length of vessel
189) *DOS* depth of SST measurement
190) *HOP* height of visual observation platform
191) *HOT* height of air temperature sensor
192) *HOB* height of barometer
193 *HOA* height of anemometer
194) *SMF* source metadata file
195) *SME* source metadata element
196) *SMV* source format version

Metadata selected from WMO–No. 47 (1955–) by the UK National Oceanography Centre, Southampton (Kent et al. 2007a, Berry et al. 2009). Some deck 740 (Research Vessel Data Quality-Evaluated by FSU/COAPS) metadata have also been stored in this attachment (see Berry et al. 2009).

Background: The codes defined in WMO–No. 47, and used in IMMA, for *OPM* and *SIM* differ from the codes used for the similar fields *OP* and *SI*. Prior to 1995 a 3-digit numeric code was defined in WMO–No. 47 for *C1M*; starting in 1995, WMO–No. 47 adopted the 2-character ISO alphabetic code, which was in 1998 also adopted for IMMT. For *C1M*, the earlier 3-digit numeric codes were transformed by NOCS into the 2-character alphabetic codes.

Historical attm (proposed) (C5)

tbd) *ATTI* attm ID
tbd) *ATTL* attm length
(See fields 197-198.)

Historical data fields (field numbering to be decided)

tbd) *WFI* wind force indicator
tbd) *WF* wind force
tbd) *XWI* *XW* indicator
tbd) *XW* wind speed (extension field for *W*)
tbd) *XDI* *XD* indicator
tbd) *XD* wind direction code (extension field for *D*)
WFI and *WF* are proposed primarily for 0-12 Beaufort wind force codes, but potentially could be extended to other 2- or 1-digit codes, with *WFI* indicating the type of information, e.g.: 0-6 (half Beaufort code in 19th century Norwegian logbooks), Ben Nevis Observatory code. *XWI* and *XW* are proposed for equivalent wind speed, with *XWI* indicating the scale used to convert from *WF* (e.g. the existing WMO Code 1100 scale or newer alternatives). Similarly, fields *XDI* and *XD* are proposed for older 2- or 1-digit wind direction codes, with *XDI* indicating the type of information, e.g.: 32-, 16-, or 8-point compasses.

tbd) *SLPI* *SLP* indicator
tbd) *TAI* *TA* indicator
tbd) *TA* *SLP* attached thermometer
SLPI is proposed for historical data to indicate the barometer type (e.g. mercurial, aneroid, or metal). *TAI* (configuration undecided, but probably similar to some of the other temperature indicators) and *TA* are proposed for older mercurial barometer data, in which the attached thermometer is critical for data adjustments.

tbd) *XNI* *XN* indicator
tbd) *XN* cloud amount (extended field for *N*)
XN is proposed for historical cloud amount data (e.g. in tenths), with *XNI* indicating the units (e.g. tenths).

Supplemental data attm (C6)

197) *ATTI* attm ID
198) *ATTL* attm length
199) *ATTE* attm data encoding
200) *SUPD* supplemental data

Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents, and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes, or zero for length unspecified (record terminated by a line feed; line feed not counted as part of *ATTL*). The supplemental data attm (C6) also includes *ATTE*, which indicates whether the supplemental data that follow are in Ascii or encoded:

missing – Ascii
0 – base64 encoding

The rdimma0 software tests to determine if each individual IMMA record is properly configured, including checking *ATTC* (ref. Table C0) against the number of attachments present. It requires that duplicate attms (i.e. two attms with the same *ATTI*) not appear in a record. The software does not require that attachments appear in any particular order by *ATTI*, with one exception: the supplemental data attm must be the final attm within the record if *ATTL*=0.

Supplement E: ICOADS Release 2.5 IMMA Status

This supplement provides additional technical information on the IMMA implementation presently used for Release 2.5 (R2.5; 1662-2007), plus for "preliminary" data (based exclusively on NCEP BUFR GTS receipts) extending ICOADS to near-current dates.

As described in Supp. C, the two basic records types used for ICOADS are (see Table E1 for more information about the individual format components):

- ICOADS-standard structure:
  C0 + C1 + C2 + C3 + C4 + C6 (372 characters, before C6)
- NCDC-variant structure:
  C0 + C1 + C2 + C3 + C6 (315 characters, before C6)

However, the attachment structure of IMMA (and rdimma0 software) was designed with the capability to save space through omission of empty attachments (i.e. information not relevant, or not available, for a given dataset). We utilize this feature for the ICOADS-standard structure. Conversely NCDC uses the NCDC-variant structure in a fixed-length form (before C6) for serving ICOADS and other marine data. When R2.5 is written out in that structure total volume size is 106.4 GB (~37% larger than the full archive stored in the dynamic ICOADS-standard structure) (see Table E2).

The NCDC-variant format also has these additional differences with respect to the ICOADS-standard IMMA representation:

(i) Date and time (*MO*, *DY*, and *HR*) are represented with leading zeros (e.g. *YR*, *MO*, *DY*, and *HR*: "200707010000"). This contrasts with the otherwise uniform numeric format model of IMMA, which has no leading zeros (e.g. "2007 7 1   0").

(ii) Longitude is expressed according to the NCDC convention (–179.99° to 180.00°E) as opposed to the ICOADS-standard convention (0.00° to 359.99°E).

(iii) *NID* is set differently for data distributed by NCDC (see Supp. D).

Another new product development for ICOADS at R2.5 is the "intermediate" data product, which includes available duplicates and landlocked reports, flagged so that they can be readily removed to create the "final" R2.4 user product (leading to a ~13% reduction in the number of reports as shown in Table E2). R2.5 contains a number of known unresolved inhomogeneities and data mixture problems (Woodruff et al. 2010; http://icoads.noaa.gov/r2.5.html). Particularly for some of the data mixture issues, the intermediate product is available for further study or potentially to develop improved solutions.

For example, WMO–No. 47 (1955–) metadata (Berry et al. 2009) were blended into the intermediate product, partly in recognition that in some cases only duplicates not selected for final output received the metadata (e.g. due to the lack of a ship call sign in duplicates selected for final output). Another incompletely resolved R2.5 issue for which the intermediate data could be utilized concerns the VOSClim data and metadata, which have not yet been practical to provide in the form of a fully merged dataset (e.g. possibly bringing elements from the GTS and logbook reports, together with the C3 QC feedback information, into composited reports).

Table E1. Sizes of IMMA format components: Core and attachments (attm) (C5 is still under development). For the ICOADS-standard, actual records sizes may be smaller (e.g. for R2.5 final data in Table E2, the average size of ~298B is less than nominal size of Core+C1+C2+C4+C6 = 306B) because of the omission of empty attachments, and because any trailing blanks are omitted at the end of the last attachment.

Abbrev.	*Name*	*Size (B)*	*Cumulative size (B)*	*Comments*
C0	Core	108	108	
C1	ICOADS attm	65	173	
C2	IMMT-2/FM 13 attm	76	249	
C3	Model quality control attm	66	315	
C4	Ship metadata attm	57	372	From WMO–No. 47 for 1966-2007; plus from COAPS (deck 740; 1990-98)[2]
C5	Historical attm	*(tbd)*		
C6	Supplemental data attm[1]	variable		

1. For ICOADS Release 2.4, 1784-1997 IMMA were recreated using LMR to merge important supplemental data (into C6). As resources permit, those supplemental data should be tapped for regular fields not previously defined in ICOADS but now available in IMMA (e.g. sea ice fields), or planned for availability in IMMA in historical attm (e.g. Beaufort wind force numbers).
2. The WMO–No. 47 metadata were blended into the intermediate R2.5 product (see Table E2), whereas the COAPS metadata were blended into the final R2.5 product (see Berry et al. 2009).

Table E2. Status and structure of NCDC and NCEP GTS data (the latter currently forming the exclusive source for the “preliminary” ICOADS extension), compared with R2.5 IMMA (ICOADS-standard) data. The “intermediate” R2.5 product contains flagged duplicates and landlocked reports. Record sizes in bytes, and total sizes (10^9 bytes) uncompressed.

Archive	Period	Reports	Structure	Rec. size	Total size
NCDC GTS	~2003→	n/a	C0+C1+C2+C3+C6	~421[1]	n/a
prelim. (NCEP)	2008→	n/a	C0+C1[+C2]+C6	~322[1]	n/a
R2.5 intermediate	1662-2007	294,725,525	C0+C1[+C2+C3+C4+C6]	~292[2]	86.2 GB
R2.5 (final)	"	260,803,686	C0+C1[+C2+C3+C4+C6]	~298[2]	77.8 GB
R2.5 (Core only)	"	"	C0	108	28.2 GB

1. Average record size. The supplemental (e.g. original GTS message) data (C6) may be variable-length (NCDC average report-length from July 2007 GTS data). Differences also exist in the amounts of original GTS data and bulletin header information retained for NCDC vs. NCEP.
2. Average record-sizes; [square brackets] indicate that C2, C3, C4, and C6 were attached only if they contained extant data/metadata. Thus far, C4 metadata have been attached only back to 1966 and C3 model QC information is only available (in deck 700) for 2003-07.

Document Revision Information

Previous document version: 14 March 2007. In conjunction with ICOADS Release 2.5, this document has been extensively updated, including references and website addresses. The previous VOSClim record type concept has been dropped, and the discussion of record types now emphasizes the ICOADS-standard and NCDC-variant record types. Supp. B was extensively revised to also describe more recent IMMT formats (IMMT-3 and IMMT-4), and to provide field comparison information with respect to the current IMMA format, rather than the obsolete LMR format. Supp. E was added to provide more specific information about ICOADS utilization of the IMMA format.

The basic IMMA field specifications as presented in Tables C0-C6 of Supp. C are substantively unchanged. A few noteworthy changes or corrections were made however:

- Field numbering was adopted in place of the previous "Doc." column; all fields are now described to some extent in Supp. D, with cross-references as required.
- In conjunction with clarifying revisions to Tables C1 and C7, Table C8 is being moved to *R2.5qc* [note: in preparation] and will be amplified to provide more information about the external (*QCE*) and source exclusion (*QCZ*) flags.
- In Table C2, units information for the significant cloud fields was modified to refer to Table B3, and a footnote adding including that those fields should always be missing.
- In Table C3, the units column was amplified by including the current UK Met Office BUFR element names.

Supp. D now includes most legacy documentation and element code details from http://icoads.noaa.gov/e-doc/lmr (revision dated 15 March 2010), as well as some code updates (and selected accompanying Regulations) from WMO (2009a). As part of this revision, the following noteworthy changes were made to existing (or imported from the LMR documentation) individual field and code descriptions in Supp. D (note: additions appear in [square brackets] below):
11-12) *DS* (ship course) and *VS* (ship speed): A minor rearrangement in the description of *DS*=0, per WMO (2009a).
14) *II* (*ID* indicator): Field description changed to omit "recognizable" and to add that in R2.5 *II* should be missing (extant) when *ID* is missing (extant).
18) *D* (wind direction): 362 = variable[, or all directions] (revised according to WMO 2009a, plus addition of the WMO Code 0877 range column to Table D2).
18) *D* (wind direction): "… from which wind is blowing [(or will blow)]…"
19) *WI* (wind speed indicator): The descriptions of *WI*=1 and 4 were amended to read: "…[obtained from anemometer (]measured)…", per WMO (2009a).
23-24) *WW* (present weather) and *W1* (past weather): Text amended to read: "For use of weather data starting 1 Jan. 1982, refer to *IX*" (formerly "after 1982"). The code descriptions for these fields have been updated based on WMO (2009a).
27) *PPP* (amount of pressure tendency): field name changed from "(amount of SLP change)".
54) *DCK* (deck): R2.5 period-of-records and report counts were included from Woodruff et al. (2010). Deck 703 (US Lightship Collection) is new.
55) *SID* (Source ID): R2.5 period-of-records and report counts were included from Woodruff et al. (2010). In Table D7, the descriptions of SIDs 11-12 were amended with respect to LMR documentation to include "US." SIDs 144-145 (US Lightship Collection) are new.
105-106) *IX* (station/weather indic.) and *W2* (past weather): the descriptions of *IX* were amended slightly to agree with WMO (2009a). For *IX*=4, brackets were added instead of "(possibly)" included in LMR documentation.
165) *SRH* ((derived) relative humidity): Parentheses placed around "derived" (also in Table C3) in view of the possibility that RH may have been originally reported.
166) *SIX* (derived stn./wea. indic.): Background added that this field is presently unused (as it does not exist in the BUFR format provided by the UK Met Office), with corresponding changes in Table C3 (additionally the units column there was changed to refer to *IX* (rather than i_X)).
169 *MSH* (model height of surface): removed "land" from description (also in Table C3).
174) BFL (bckd. forecast length): Background added that this field is presently erroneous in R2.5 data, due to a translation error.