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

Rapporteur: Scott Woodruff
NOAA Earth System Research Laboratory (ESRL), Boulder, CO, USA
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Introduction

1. With increasing recognition of the importance of upgrading and maximizing the data available for analyses of the climate record (Barnett et al. 1999), 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). Current 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).

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), for the Climatological Database for the World's Ocean (CLIWOC) project (García-Herrera et al. 2005), and helping to meet requirements of the Voluntary Observing Ship (VOS) Climate (VOSClim) project.

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). Publication of the format through a JCOMM Technical Report also has been suggested, most recently by the Second Session of the JCOMM Data Management Coordination Group (JCOMM 2007). Furthermore, 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.

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 alternative technical options for Format Implementation are discussed in the following sections.

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). WMO introduced an International Maritime Meteorological (IMM) punched card format around 1951 (Yoshida 2004), and the international exchange of digitized logbook data in IMM formats was formalized by WMO (1963) Resolution 35 (Cg-IV). 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 unique national formats) through bilateral agreements. Many of these historical (plus real-time) data sources have been compiled into global collections such as the Comprehensive Ocean-Atmosphere Data Set (COADS; Woodruff et al. 1987, Woodruff et al. 1998), thus making marine data, presently covering more than 200 years, widely available to the climate research community. In recognition of its broad multinational basis, COADS was renamed the *International* COADS (ICOADS; Diaz et al. 2002, Parker et al. 2004, Worley et al. 2005).

7. 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 the International Meteorological Organization (IMO) in 1929 (WMO, 1994), and an international code effective starting in 1949 (MetO, 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) code used over GTS.

8. 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 has been updated and expanded, with the results now available in digital form for Web access (Yoshida 2004, 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).

9. 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.

10. This conclusion extended to more recently defined Table-Driven Codes (TDCs): the Binary Universal Form for the Representation of meteorological data (BUFR) and the Character form for the Representation and EXchange of data (CREX) (WMO 1995). 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 TDCs. However, TDCs 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 TDCs for permanent archival is undemonstrated. Therefore, over the longer term, it may be useful to explore some limited convergence between IMMA and appropriate features of TDCs (e.g., establish cross-references with IMMA field names; and ensure standardized record export capabilities, so that data from TDCs can be merged with historical records in ICOADS).

Format Structure

11. A new 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 seeks to provide a flexible solution to the problem of storing both contemporary and historical marine data. Following are additional goals, which the proposed 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 character and numeric data.

(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 supplementary 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 metadata (WMO 1955–) to individual marine reports (e.g., Josey et al. 1998, Kent et al. 2007a), and the format should allow for anticipated metadata requirements (e.g., anemometer heights).
(g) Important additional considerations are storage efficiency, and format documentation logistics.

12. 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 controlled 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

13. Supp. C further describes "attachments" (attm) that may follow the core to produce different IMMA record types. One attm, for example, can be used to store supplementary data of indeterminate type, and of fixed- or variable-length. In addition to the abbreviated record formed by the core itself, two additional record types are outlined in Supp. C:

- VOSClim record
- historical record (proposed)

(variations on these record types are currently being constructed by attaching different mixtures of the defined attachments to the core).

Format Implementation

14. 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, 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.

15. 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 old codes (e.g., as supplementary data), and leave the regular data elements missing awaiting a uniform conversion through WMO Members or at a World Data Center. 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 this website: icoads.noaa.gov/software/lmrlib).

16. 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 supplementary data.

17. 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 might integrate more easily with PC-based 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).

18. The IMMA format is proposed 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 discussed in Supp. D), is suggested as the most efficient and robust solution available at this time. Conversion of data in other forms to a uniform IMMA format is recommended prior to data exchanges, but it is possible that generalized software could be developed for this purpose to facilitate translations by Member countries of delimited data, for example, to a fixed-field format.

19. We are using VOSClim data requirements as one initial test-bed for prototyping IMMA. VOSClim is utilizing GTS and IMMT reports, plus comparisons (output in BUFR) of the reported GTS data against a UK numerical weather prediction (NWP) model. The VOSClim record type includes all the data fields anticipated necessary for VOSClim (315 characters), plus 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.

20. 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.

21. 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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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 German Seewetteramt archive, the Russian Marine Meteorological "MARMET" 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:						
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). With advances in computer technology beyond 80-character Hollerith punched cards, an expanded International Maritime Meteorological Tape (IMMT) format was initiated starting in 1982, as an alternative to IMMPC. These two formats (referred to collectively as "IMM") were designed with the primary purpose of the exchange of keyed logbook ship data starting around 1963 for implementation of the Marine Climatological Summaries Scheme (MCSS) 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-XI) code (Yoshida 2004, 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 SHIP code. More recently (WMO 2001, JCOMM 2005), changes were made (IMMT-2 and IMMT-3) mainly in response to the VOSClim project (e.g., to retain relative wind data and other new elements, so that true wind speed and direction could be revalidated in delayed mode). Currently, further proposed revisions to the format (IMMT-4) are under discussion.

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 were recently digitized (Manabe 1999, JWA and JMA 2003). 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 should seek 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 IMM 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 alphanumeric formats, 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 MetO 1948) represents key metadata to seek to ensure data continuity. Only recently, however, have efforts begun to locate and assess the documentation for these code changes (Yoshida 2004, 2007).

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, and the SST measurement proper. When replaced by actual numeric 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 1995) 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). 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 Codes (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 Codes (TDCs; WMO 1995) proposed eventually to replace the earlier alphanumeric codes, including FM 13. BUFR is a binary code generally limited to storage of data in SI units (e.g., temperatures are stored in Kelvins). 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 is referenced to indicate which data elements are included, and their exact form. This introduces some volume overhead into each message, but provides flexibility in the data structure, and the master table definitions can be modified and tracked in the WMO (1995) *Manual on Codes*.

In CREX, for example, table references “B 11 011” and “B 11 012” 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 TDCs. Moreover, the complexity of TDCs 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) would raise software reliability questions and potentially lead to data continuity problems.

Data continuity is of critical importance for climate research. Plans under the new WMO Information System (WIS) to transition from alphanumeric formats such as FM 13 to TDCs should anticipate a long period of overlap and careful cross-validation to ensure that no data resolution, elements, or configurations are lost. The experience of NCEP in transitioning to BUFR in 1997 is 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) are adequately retained in BUFR. Fortunately, NCEP included the input raw GTS report 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.*

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 figure.

* 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 (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, begun in 1964 (WMO 1985), designated a highly abbreviated "Exchange" format (see supplement I in Slutz et al. 1985) 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 technical 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 were included, e.g., 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, and the design of the IMMA format should keep that possibility in mind.

Dual-record digitization formats

Recent 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. However, the requirement for two types of records can lead to problems if not carefully implemented, which are probably best resolved by the digitizing country (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 to countries for possible initial preparation and quality control of digitized historical ship data, but feel that a more easily standardized single-record approach should be used in IMMA for the exchange of quality controlled data. The transformations from dual-record formats to a single-record format are conveniently handled and cross-checked with computer software programs.

ICOADS Long Marine Report (LMR) formats

For past ICOADS "delayed-mode" production processing, input individual marine reports in a variety of formats have all been converted to the Long Marine Report (LMR, currently version 6; LMR6) format. This is a variable-length packed-binary format, containing a fixed-length portion, followed by a variable-length portion. The fixed-length portion contains commonly used marine data elements (from both ships and buoys), and is divided into a "location" and "regular" section. The location section contains elements such as time/space location and source identification of the report. The regular section contains the observational data (e.g., sea surface and air temperatures, humidity, wind, air pressure, cloudiness, and waves). (A fixed-length version of LMR, LMRF, is distributed for research applications.)

The variable-length portion of LMR contains a series of "attachments" (e.g., containing detailed quality control information). Two of these, the supplemental and error attachment, vary in size. The supplemental attachment is used to store elements from the original (input) format (character or binary data) that will not fit into the location or regular sections, or whose conversion is questionable. The error attachment stores 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 can be added as needed.

Supp. B compares fields from the LMR regular and location sections, with fields available in the IMM formats. Some fields or expanded field configurations defined for LMR appeared desirable to carry forward into IMMA. In addition, the LMR attachment feature provided a valuable model for flexible retention of data that is utilized in a somewhat different form for IMMA.

Note: LMR documentation is referred to in the following Supps. Current documentation (at this writing dated 18 July 2006) can be reviewed at website:
icoads.noaa.gov/e-doc/lmr

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

Much of the data included in COADS Release 1 (Slutz et al. 1985) 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 supplementary data fields. The supplementary 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 in development of the LMR supplementary attachment. COADS Release 1 (1854-1979) data were made available at NCDC in similar formats (NCDC 1989a, NCDC 1989b).

Supplement B: Comparison of WMO IMM and ICOADS LMR Formats

Table B1 compares two of JCOMM's more recent IMMT formats (IMMT-2 and IMMT-1) 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 portions of the code 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 (MetO 1948). Fields from the ICOADS LMR formats also are compared in Table B1. Table B2 lists the quality control flags available in IMMT-2 and IMMT-1.

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.

Table B1. The IMMT-2 format (WMO 2001) comprises the 93 elements (151-character record-length) listed in this table. The IMMT-1 format, which became effective 2 November 1994, is a subset of IMMT-2 consisting of its first 85 elements (131-character record 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 LMR6 field abbreviation, if any (indirectly related fields are listed in parentheses). 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 (MetO 1948).

Selected fields unique to the LMR formats, 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 ms^{-1}. 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	LMR	IMMT 1982	IMMPC 1968	IMMPC 1963
1	1	i_T	format/temp. indic.	*T1* 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^*)	quadrant (octant)		Q	•	• →
			10° box	*B10*			
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/long. indic.	*LI*			
9	20	•	h and VV indic.	*HI + VI*	•	op**	•
10	21	h	height of clouds	*H*	•	•	•
11	22-23	VV	visibility	*VV*	•	•	• →
12	24	N	cloud amount	*N*	•	•	• →
			wind direction indic.	*DI*			
13	25-26	dd	wind direction (true)	*D*	•	•	• →
14	27	i_W	wind speed indicator	*WI* Δ	•	Δ***	Δ***
15	28-29	ff	wind speed (kts/m s^{-1})	*W*	•	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)+ T2*	•	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*	•	•	• →

No	Chars	Code	Element description	LMR	IMMT 1982	IMMPC 1968	IMMPC 1963
26	48	C_M	genus of C_M clouds	*CM*	•	•	• →
27	49	C_H	genus of C_H clouds	*CH*	•	•	• →
28	50	s_n	sign of SST	*(SST)*	•	op	•
29	51-53	$T_wT_wT_w$	sea surface temp.	*SST*	•	•	•
			air-sea temp. diff			•	• →
30	54	•	indic. for SST meas.	*SI* Δ	•	op	
31	55	•	indic. for wave meas.		•		
			wave period indicator	*WX*			
			wave direction	*WD*		•****	# →
32	56-67	P_WP_W	per. wind waves/meas.	*WP*	•	•	P_W →
33	58-59	H_WH_W	ht. wind waves/meas.	*WH*	•	•	• →
			swell period indicator	*SX*			
34	60-61	$d_{W1}d_{W1}$	dir. of predom. swell	*SD*	•	d_Wd_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	•	##	##
43	79-80	•	country recruited ship###	*C1*	•	•####	•
			2nd country code	*C2*			
44	81	•	(national use)		•		
45	82	•	quality control indic.		•		
46	83	i_X	station/weather indic.	*IX*			
47	84	i_R	indic. for precip. data		•		
48	85-87	RRR	amount of precip.		•		
49	88	t_R	duration of per. RRR		•		
50	89	s_w	sign of $T_bT_bT_b$	*(WBT)+ T2*	•	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	*SC*	•		→
55	98	v_s	ship's average speed	*SS*	•		→
56	99-00	$d_{W2}d_{W2}$	dir. of second. swell		•		
57	101-2	$P_{W2}P_{W2}$	per. of second. swell		•		
58	103-4	$H_{W2}H_{W2}$	ht. of second. swell		•		
59	105	c_i	concentration of sea ice		•		

No	Chars	Code	Element description	LMR	IMMT 1982	IMMPC 1968	IMMPC 1963
60	106	S_i	stage of development		•		
61	107	b_i	ice of land origin		•		
62	108	D_i	true bearing ice edge		•		
63	109	z_i	ice situation/trend		•		
64	110	•	FM 13 code version			&	&
65	111	•	IMMT version				
66-86	112-132	Q_1-Q_{21}	QC indicators (see Table B2)		•		
87	133-5	HDG	ship's heading				
88	136-8	COG	course over ground				
89	139-40	SOG	speed over ground				
90	141-2	SLL	max.ht.>sum load ln.				
91	143-5	$s_L$hh	dep. load ln.: sea lev.				
92	146-8	RWD	relative wind direction				
93	149-51	RWS	relative wind speed				

* Initially available IMMT-1 format documentation inadvertently listed octant instead of quadrant, and some data were exchanged using octant until Member countries were informed via correspondence.
** Overpunches on h and VV for measured data; an additional overpunch on VV for fog present but VV not reported.
*** 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.
**** Field allotted but: "Not reported. Not to be punched."
# 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.
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).
Change from numeric to alphabetic ISO codes effective 1 January 1998.
Overpunch for auxiliary ships (not part of the 1963 format).
& A "Card indicator" field: punched according to the WMO Codes effective in year AA, or according to supplementary procedures (Part B).

Table B2. QC indicators included in IMMT-2. All except number 86 were also included in IMMT-1. Detailed QC information is also available in the LMR formats.

No	Chars.	Code	Applicable elements (from Table B1)
66	112	Q_1	h
67	113	Q_2	VV
68	114	Q_3	clouds (12, 24-27)
69	115	Q_4	dd
70	116	Q_5	ff
71	117	Q_6	TTT
72	118	Q_7	$T_dT_dT_d$
73	119	Q_8	PPPP
74	120	Q_9	weather (21-23)
75	121	Q_{10}	$T_wT_wT_w$
76	122	Q_{11}	P_wP_w
77	123	Q_{12}	H_wH_w
78	124	Q_{13}	swell (34-36, 56-58)
79	125	Q_{14}	i_RRRt_R
80	126	Q_{15}	a
81	127	Q_{16}	PPP
82	128	Q_{17}	D_s
83	129	Q_{18}	v_s
84	130	Q_{19}	$T_bT_bT_b$
85	131	Q_{20}	ship's position
86	132	Q_{21}	minimum QC standards (MQCS) version identification

Table B3. Examples of additional and alternative fields 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)."

Field	Code punching alternatives
location	Marsden Square, 1°, and 1/10° or 1/6° units of latitude/longitude
	Ocean station vessel location
visibility	90-99 or 00-89 (WMO Code 4377, 1955)
sea and/or swell	WMO Code 75 (1954)
	Douglas or Copenhagen 1929 scales
	Paris 1919 scale
	Berlin 1939 scale
	WMO Code 1555; 50 added to d_Wd_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_Rt_R (WMO Codes 3577 and 4080)
cloud data	N_S, C, h_Sh_S (WMO Codes 2700, 0500, and 1577)
special phenomena	regional WMO Codes

Supplement C. Record Types (revised 14 March 2007)

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
Table C2: IMMT-2/FM 13 attm
Table C3: Model quality control attm
Table C4: Ship metadata attm
Table C5: Historical attm (proposed)
Table C6: Supplemental data attm

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

- core record:
  core (C0) (108 characters)
- VOSClim record:
  core + C1 + C2 + C3 + C6 (315 characters, before C6)
- historical record:
  core + 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, enable 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: “D” is listed if the field configuration is discussed in Supp. D (proposed for international agreement); “C” if the field configuration is defined for ICOADS (e.g., in LMR documentation); “UK” if the field is defined by the UK; or blank (fields to be described nationally). “D = C” is listed if the ICOADS configuration is adopted provisionally, pending international standardization.
2: The projected length (Len.) in characters (i.e., bytes).
3-4: Proposed abbreviation (Abbr.) for each field, and a brief element description.
5-6: For fields with a tentative 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” if the field is proposed for extension in range or modification in form from the presently defined WMO representation.

Location section (45 characters) :

Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D	4	*YR*	year UTC	1600	2024	(AAAA)
D	2	*MO*	month UTC	1	12	(MM)
D	2	*DY*	day UTC	1	31	(YY)
D = C	4	*HR*	hour UTC	0	23.99	0.01 hour (Δ GG)
D = C	5	*LAT*	latitude	–90.00	90.00	0.01°N (Δ $L_aL_aL_a$)
D = C	6	*LON*	longitude	–179.99	359.99	0.01°E (Δ $L_oL_oL_oL_o$)

Location section (45 characters) :

Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
				0.00	359.99	(ICOADS convention)
				–179.99	180.00	(NCDC convention)
D	2	*IM*	IMMA version	0	99	(Δ •65)
D	1	*ATTC*	attm count	0	9	
D = C	1	*TI*	time indicator	0	3	
D = C	1	*LI*	latitude/long. indic.	0	6	
D	1	*DS*	ship course	0	9	(D_s)
D	1	*VS*	ship speed	0	9	(Δ v_s)
D	2	*NID*	national source indic.	0	99	
D = C	2	*II*	*ID* indicator	0	10	
D	9	*ID*	identification/call sign	c	c	(Δ •42)
D	2	*C1*	country code	b	b	(Δ •43)

Regular section (63 characters):

Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D = C	1	*DI*	wind direction indic.	0	6	
D = C	3	*D*	wind direction (true)	1	362	°, 361-2 (Δ dd)
D = C	1	*WI*	wind speed indicator	0	8	(Δ i_W)
D = C	3	*W*	wind speed	0	99.9	0.1 m s^{-1} (Δ ff)
D = C	1	*VI*	*VV* indic.	0	2	(Δ •9)
D	2	*VV*	visibility	90	99	(VV)
D	2	*WW*	present weather	0	99	(ww)
D	1	*W1*	past weather	0	9	(W_1)
D = C	5	*SLP*	sea level pressure	870.0	1074.6	0.1 hPa (Δ PPPP)
D	1	*A*	characteristic of *PPP*	0	8	(a)
D	3	*PPP*	amt. pressure tend.	0	51.0	0.1 hPa (ppp)
D = C	1	*IT*	indic. for temperatures	0	9	(Δ i_T)
D	4	*AT*	air temperature	–99.9	99.9	0.1°C (Δ s_n, TTT)
D	1	*WBTI*	indic. for WBT	0	3	(Δ s_w)
D	4	*WBT*	wet-bulb temperature	–99.9	99.9	0.1°C (Δ s_w, $T_bT_bT_b$)
D	1	*DPTI*	*DPT* indic.	0	3	(Δ s_t)
D	4	*DPT*	dew-point temp.	–99.9	99.9	0.1°C (Δ s_t, $T_dT_dT_d$)
D = C	2	*SI*	*SST* meas. method	0	12	(Δ •30)
D	4	*SST*	sea surface temp.	–99.9	99.9	0.1°C (Δ s_n, $T_wT_wT_w$)
D	1	*N*	total cloud amount	0	9	(N)
D	1	*NH*	lower cloud amount	0	9	(N_h)
D	1	*CL*	low cloud type	0	9, “A”	(Δ C_L)
D = C	1	*HI*	*H* indic.	0	1	(Δ •9)
D	1	*H*	cloud height	0	9, “A”	(Δ h)
D	1	*CM*	middle cloud type	0	9, “A”	(Δ C_M)
D	1	*CH*	high cloud type	0	9, “A”	(Δ C_H)
D	2	*WD*	wave direction	0	38	
D	2	*WP*	wave period	0	30, 99	seconds (P_WP_W)
D	2	*WH*	wave height	0	99	(H_WH_W)
D	2	*SD*	swell direction	0	38	($d_{W1}d_{W1}$)
D	2	*SP*	swell period	0	30, 99	seconds ($P_{W1}P_{W1}$)
D	2	*SH*	swell height	0	99	($H_{W1}H_{W1}$)

Table C1. ICOADS attm (column descriptions as for Table C0). 10° and 1° box numbers are available for sorting. The box system indicator is currently unused, but provides flexibility in case other box requirements arise (i.e., future extant values of *BSI* could indicate different contents in *B10* and *B1*). Other fields in this attm are carried forward from LMR to ensure that all required LMR information maps into IMMA; LMR fields *IRD* and *A6* are obsolete and have been omitted from IMMA.

Doc.	Len.	Abbr.	Element description			
D	2	*ATTI*	attm ID			Note: set *ATTI*=1
D	2	*ATTL*	attm length			Note: set *ATTL*=65
Box elements (6 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
C	1	*BSI*	box system indicator	u	u	(currently set to missing)
C	3	*B10*	10° box number	1	648	(ICOADS BOX10 system)
C	2	*B1*	1° box number	0	99	
ICOADS processing elements (17 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
C	3	*DCK*	deck	0	999	
C	3	*SID*	source ID	0	999	
C	2	*PT*	platform type	0	15	
C	2	*DUPS*	dup status	0	14	
C	1	*DUPC*	dup check	0	2	
C	1	*TC*	track check	0	1	
C	1	*PB*	pressure bias	0	2	
C	1	*WX*	wave period indicator	1	1	
C	1	*SX*	swell period indicator	1	1	
C	2	*C2*	2nd country code	0	40	
ICOADS QC elements (38 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
C	12	*	adaptive QC flags	1**	35**	6var×2flag×1char.(base36)
C	1	*ND*	night/day flag	1	2	
C	6	*	trimming flags	1	15	base36
C	14	*	NCDC-QC flags	1	10	base36
C	2	*QCE*†	external (e.g., MEDS)	0	63	6 flags encoded in 2 char.
C	1	*LZ*	landlocked flag	1	1	
C	2	*QCZ*†	source exclusion flags	0	31	5 flags encoded in 2 char.

* The first letter of each 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*.
- Trimming flags: *SF*, *AF*, *UF*, *VF*, *PF*, *RF*.
- NCDC-QC flags: *ZNC*, *WNC*, *BNC*, *XNC*, *YNC*, *PNC*, *ANC*, *GNC*, *DNC*, *SNC*, *CNC*, *ENC*, *FNC*, *TNC*.

** Table C7 provides further information about the adaptive QC flags.

† Using the 1st-letter naming scheme described in the first footnote, the abbreviations for the flags decoded from *QCE* are: *ZE*, *SE*, *AE*, *WE*, *PE*, *RE*; and those from *QCZ* are: *SZ*, *AZ*, *WZ*, *PZ*, *RZ*. Flag *RE*, presently unused, has been set aside for possible future use.

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

Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D	2	*ATTI*	attm ID			Note: set *ATTI*=2
D	2	*ATTL*	attm length			Note: set *ATTL*=76
Common for IMMT-2/-1 (52 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D	1	*OS*	observation source	0	6	(•40)
D	1	*OP*	observation platform	0	9	(•41)
D	2	*FM*	FM code version	0	8	(Δ •64)
D	1	*IX*	station/weather indic.	1	7	(i_X)
D	1	*W2*	2nd past weather	0	9	(W_2)
D	1	*SGN*	sig. cloud amount	0	9	ref. *N*
D	1	*SGT*	sig. cloud type	0	9, "A"	
D	2	*SGH*	significant cloud ht.	0	99	(0-50, 56-99)
D	1	*WMI*	indic. for wave meas.	0	9	(•31)
D	2	*SD2*	dir. of second. swell	0	38	($d_{W2}d_{W2}$)
D	2	*SP2*	per. of second. swell	0	30, 99	($P_{W2}P_{W2}$)
D	2	*SH2*	ht. of second. swell	0	99	($H_{W2}H_{W2}$)
D	1	*IS*	ice accretion on ship	1	5	(I_s)
D	2	*ES*	thickness of I_s	0	99	cm (E_sE_s)
D	1	*RS*	rate of I_s	0	4	(R_s)
D	1	*IC1*	concentration of sea ice	0	9, "A"	(Δ c_i)
D	1	*IC2*	stage of development	0	9, "A"	(Δ S_i)
D	1	*IC3*	ice of land origin	0	9, "A"	(Δ b_i)
D	1	*IC4*	true bearing ice edge	0	9, "A"	(Δ D_i)
D	1	*IC5*	ice situation/trend	0	9, "A"	(Δ z_i)
D	1	*IR*	indic. for precip. data	0	4	(i_R)
D	3	*RRR*	amount of precip.	0	999	(RRR)
D	1	*TR*	duration of per. *RRR*	1	9	(t_R)
D	1	*QCI*	quality control indic.	0	9	(•45)
D	1×20	*QI1-20*	QC indic. for fields	0	9	(Q_1-Q_{20})
New for IMMT-2 (20 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D	1	*QI21*	MQCS version	0	9	(Q_{21})
D	3	*HDG*	ship's heading	0	360	° (HDG)
D	3	*COG*	course over ground	0	360	° (COG)
D	2	*SOG*	speed over ground	0	99	kt (SOG)
D	2	*SLL*	max.ht.>sum load ln.	0	99	m (SLL)
D	3	*SLHH*	dep. load ln.: sea lev.	-99	99	m (s_Lhh)
D = C	3	*RWD*	relative wind dir.	1	362	°, 361-2 (ref. *D*)
D = C	3	*RWS*	relative wind speed	0	99.9	0.1 m s^{-1} (ref. *W*)

Table C3. Model quality control attm (column descriptions as for Table C0).

Doc.	Len.	Abbr.	Element description			
D	2	*ATTI*	attm ID			Note: set *ATTI*=3
D	2	*ATTL*	attm length			Note: set *ATTL*=66
GTS bulletin header fields (10 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
UK	4	*CCCC*	collecting centre	a	a	
UK	6	*BUID*	bulletin ID	b	b	
UK model comparison elements (52 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
UK	5	*BMP*	background (bckd.) *SLP*	870.0	1074.6	0.1 hPa
UK	4	*BSWU*	bckd. wind U comp.	−99.9	99.9	0.1 m s^{-1}
UK	4	*SWU*	derived wind U comp.	−99.9	99.9	0.1 m s^{-1}
UK	4	*BSWV*	bckd. wind V comp.	−99.9	99.9	0.1 m s^{-1}
UK	4	*SWV*	derived wind V comp.	−99.9	99.9	0.1 m s^{-1}
UK	4	*BSAT*	bckd. air temperature	−99.9	99.9	0.1°C
UK	3	*BSRH*	bckd. relative humidity	0	100	%
UK	3	*SRH*	derived relative humidity	0	100	%
UK	1	*SIX*	derived stn./wea. indic.	2	3	(subset of i_X)
UK	4	*BSST*	bckd. *SST*	−99.9	99.9	0.1°C
UK	1	*MST*	model surface type	0	9	(UK 008204)
UK	3	*MSH*	model height of land sfc.	0	999	m
UK	4	*BY*	bckd. year	0	9999	year
UK	2	*BM*	bckd. month	1	12	month
UK	2	*BD*	bckd. day	1	31	day
UK	2	*BH*	bckd. hour	0	23	hour
UK	2	*BFL*	bckd. forecast length	0	99	hours

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

Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D	2	*ATTI*	attm ID			Note: set *ATTI*=4
D	2	*ATTL*	attm length			Note: set *ATTL=57*
Ship metadata elements (>14 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D	2	*C1M*	recruiting country	a	a	(Δ •43)
D	2	*OPM*	type of ship (programme)	0	99	(code unlike *OP)*
D	2	*KOV*	kind of vessel	c	c	
D	2	*COR*	country of registry	a	a	(Δ •43)
D	3	*TOB*	type of barometer	c	c	
D	3	*TOT*	type of thermometer	c	c	
D	2	*EOT*	exposure of thermometer	c	c	
D	2	*LOT*	screen location	c	c	
D	1	*TOH*	type of hygrometer	c	c	
D	2	*EOH*	exposure of hygrometer	c	c	
D	3	*SIM*	*SST* meas. method	c	c	(code unlike *SI)*
D	3	*LOV*	length of vessel	0	999	m
D	2	*DOS*	depth of *SST* meas.	0	99	m
D	3	*HOP*	height of visual observation platform	0	999	m
D	3	*HOT*	height of *AT* sensor	0	999	m
D	3	*HOB*	height of barometer	0	999	m
D	3	*HOA*	height of anemometer	0	999	m
D	5	*SMF*	source metadata file	0	99999	e.g. "19991" 1st Q 1991
D	5	*SME*	source meta. element	0	99999	line number in file
D	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* to be decided (*tbd*).

Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D	2	*ATTI*	attm ID			Note: set *ATTI*=5
D	2	*ATTL*	attm length			Note: set *ATTL=tbd*
Historical data elements (> 19 characters):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
D	1	*WFI*	*WF* indic.	u	u	
D	2	*WF*	wind force	0	12	
D	1	*XWI*	*XW* indic.	u	u	
D	3	*XW*	wind speed (ext. *W*)	0	99.9	0.1 m s^{-1}
D	1	*XDI*	*XD* indic.	u	u	
D	2	*XD*	wind dir. (ext. *D*)	u	u	
D	1	*SLPI*	*SLP* indic.	u	u	
D	1	*TAI*	*TA* indic.	u	u	
D	4	*TA*	*SLP* att. thermometer	–99.9	99.9	ref. *AT*
D	1	*XNI*	*XN* indic.	u	u	
D	2	*XN*	cloud amt. (ext. *N*)	u	u	
(plus additional elements to be decided)						

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.)

Doc.	Len.	Abbr.	Element description			
D	2	*ATTI*	attm ID			Note: set *ATTI*=99
D	2	*ATTL*	attm length			Note: set *ATTL*=0
D	1	*ATTE*	attm encoding			Note: set *ATTE*=missing
Supplemental data (format determined nationally, or by data source):						
Doc.	Len.	Abbr.	Element description	Min.	Max.	Units (Code)
	*	*SUPD*	supplemental data	c	c	

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

Table C7. A pair of adaptive QC flags is provided for each variable, ending in *Z* and *A* (e.g., *SQZ* and *SQA* for *SST*). These refer to the z* and alpha** values resulting from the comparison of the observation to the adaptive QC limits. If an observation is missing, or exceeds physical limits (e.g., for *SST*: outside the range −5.0°C to 40°C), the flags are set to missing. The technical details of the flag encoding/decoding (handled by the data access software) are described by this table.†

Value (flag 3rd letter):	True value: Min.	True value: Max.	Units	Base	Coded: Min.	Coded: Max.
z (*Z*)	−8.5σ	8.5σ	0.5	-18	1	35
alpha (*A*)	0.0	1.0	0.05	-1	1	21

* z: indicates the relationship of an individual observation to the adaptive standard deviation (σ) limits in 0.5σ steps. The extremes are open-ended in that any values < −8.5σ or > 8.5σ are mapped to ±8.5σ. Other σ values represent intervals of approximately ±0.25σ around the reported values because of rounding to the nearest 0.5σ. E.g., −3.5σ represents the approximate interval −3.75σ to −3.25σ.

** alpha: provides a measure of the reliability of the QC: it has a roughly inverse relationship with the number of observations available nearby (smaller alpha values indicate more data).

† A 2-stage encoding is applied: 1) The floating-point true value is divided by the "units" (the smallest increment of the data being encoded). Then the base is subtracted to produce, after rounding, a coded positive integer. 2) The integer is transformed into a base36 character. Decoding reverses this process by transforming the base36 value back into the coded value, and then the true value is reconstructed by:

true value = (coded + base) * units

Supplement D. Field Configurations

IMMA fields proposed for, or already subject to, international standardization are described here. These are ordered according to their appearance in Supp. C. Note: Supp. C also lists additional (ICOADS- or nationally-defined) fields, which are not described here.

The suggested field abbreviations are simple alphabetic strings (plus in some cases numeric suffixes), based generally on GTS 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 that are 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). 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 format contains different field-widths so a single numeric value is unworkable. A convention such as all nines filling each indicated field width doesn't work either, e.g., because many of the 1-character fields have extant numeric values covering the range 0-9.

Therefore, blanks are used as the universal representation for missing data. However, it is important to note that Fortran (by default) considers blanks 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-portable Fortran software to help read (and optionally write) the IMMA data ("rdimma0") is available (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 additional options that are noted for some fields). In other cases existing LMR configurations are proposed. These provisional configurations may warrant modification or expansion after international consideration.

Location section

YR year UTC
MO month UTC
DY day UTC
HR hour UTC
As for IMMT-1, except *HR* (range: 00.00 to 23.99 UTC). Ship data typically are reported to whole hour, but the extended resolution is needed, e.g., for storage of drifting buoy data.

LAT latitude
LON longitude

Reversed in order from LMR. 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). Extended resolutions are needed, e.g., for storage of drifting buoy data. The longitude range (−179.99° to 359.99°) specified in Supp. C encompasses two distinct longitude conventions (0° to 359.99° and −179.99° to 180.00°), which are desirable for different applications and archival requirements (0° to 359.99° is strongly recommended for use, because it is the simplest formulation and thus helps to reduce the likelihood of location errors). 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 when IMMA records are stored in mixed conventions, all longitude values can be accurately interpreted because the overall range for longitude reserves negative for the western hemisphere. Note: organizing *YR*, *MO*, *DY*, *HR*, *LAT*, *LON* in sequence can facilitate synoptic sort operations.

> Options: Characters (N, S, E, W) could be used in place of sign for both latitude and longitude, but this complicates computer I/O and is therefore not recommended. Usage of quadrant or octant numbers also is not recommended, because a strictly numeric system is much more straightforward.

IM IMMA version
ATTC attm count

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 "IMMT version":

0 = provisional 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.

TI time indicator
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

[Note: This is a direct mapping from the LMR configuration, except that *LI*=2 is described there as “non random tenths” (a type of mixed precision; see p. F4 of Slutz et al., 1985).]

DS ship course
VS ship speed
WMO Codes 0700 and 4451 for contemporary data. A different code for *VS*, also with range 0-9, applied to data prior to 1 January 1968 (MetO, 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

Beginning 1 January 1968 (Code 4451):

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

As in LMR, both the old and new *VS* codes are stored in the same field, to be differentiated by date (*DS* and *VS* are named *SC* and *SS* in LMR). Note: 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 this code change.

NID national source indicator
A field for national use in identifying data subsets.

[Note: For the VOSClim record type in the provisional format, this is set to 1 for ships that can be identified as part of the VOSClim Project, or missing otherwise.]

II *ID* indicator
ID identification/call sign
ID is extended to nine characters (versus seven in IMMT-2). In LMR, *II* indicates whether a call sign or some other sort of recognizable identification is contained in the *ID* field:

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

C1 country code
The country that recruited a ship, which may differ from the country of immediate receipt (field *C2* in Supp. C) and may also differ from the ship’s registry. Numeric code values 00-40 were documented by WMO, which transitioned to 2-character ISO alphabetic

codes effective 1 January 1998. We envision storage of the numeric codes for historical data, or of the alphabetic codes for recent data, in this field (since, e.g., the old numeric codes include the USSR and other countries no longer named as such by ISO).

Regular section

DI wind direction indicator
D wind direction
DI gives the compass (and approximate precision) used for reporting the wind direction (in LMR, directions are mapped to degrees according to Table 8 of the LMR documentation):

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, stored in whole degrees (i.e., 360-point compass; range: 1-360°), or special codes:

361 = calm
362 = variable

Options: Alternatively, 0 could be used for calm (00 is used in IMMT-2). Similarly, a value such as 999 could be used for variable (99 is used in IMMT-2, but 99 indicates 99° here). However, an unambiguous and numerically closed range (1-362, rather than 0-360, 999) is also advantageous for computational reasons (e.g., range checking).

WI wind speed indicator
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, measured
2 = estimated (original units unknown)
3 = knot, estimated
4 = knot, 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)

For reports derived from, e.g., TDF-11 format, the meaning of *WI*=6 is either "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).

VI visibility indicator
VV visibility
The "Cloud height and visibility measuring indicator" from IMMT-2 is separated into independent indicators *H* and *VV*. *VI* shows whether *VV* was:

0 = estimated (or unknown method of observation)

1 = measured
2 = fog present

The “fog present” value is not defined in IMMT-2, but stems from early IMMPC definitions (see Supp. B).

WW present weather
W1 past weather

WMO Codes 4677 and 4561. For use of weather data after 1982, refer to *IX*.

SLP sea level pressure
A barometric tendency
PPP amount of SLP change

SLP and *PPP* in tenths of hPa (i.e., millibars), and *A* according to WMO Code 0200. IMMT-2 contains a 4-character (PPPP) representation of *SLP* in IMMT-2 (dropping the leading digit).

IT indicator for temperatures
AT air temperature (i.e., dry bulb)
WBTI *WBT* indicator
WBT wet bulb temperature
DPTI *DPT* indicator
DPT dew point temperature
SI *SST* method indicator
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 (0-2 match i_T=3-5 in IMMT-2; the full configuration matches *T1* in LMR):

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

[Note: Early historical temperatures were also reported in degrees Réaumur, or mixed units. Additional fields may be desirable in the historical attm to record these details.]

WBTI and *DPTI* indicate which of *WBT* or *DPT* was measured or computed, and ice bulb conditions (derived from sign positions s_t and s_w in IMMT-2):

0 = measured
1 = computed
2 = iced measured
3 = iced computed

[Note: For data translated e.g. from IMMT-2 format, *T2* from LMR provides a subset of information derived from s_t and s_w, plus information about whether *DPT* was computed during ICOADS processing (such that for data translated from LMR to IMMA, we set *DPTI*=1 or 3). Future work should seek to recover more complete information from original formats, and consider new configurations to separately document ICOADS processing.]

SI shows the method by which *SST* was taken (0-7 follow the IMMT-2 code):

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

[Note: Except for omitting *SI*=8 (“unknown”), an unintended setting applicable only to decks 705-705), this is a direct mapping from the LMR configuration. In translation from LMR, *SI*=8 is made missing.]

N total cloud amount
NH lower cloud amount
CL low cloud type
HI cloud height indicator
H cloud height
CM middle cloud type
CH high cloud type

Configurations as in IMMT-2, except for use of “A” (10 in base36) in place of “/” (LMR uses 10 in place of “/”), with ordering of *N*,…,*CH* as in LMR. The “Cloud height and visibility measuring indicator” from IMMT-2 is separated into independent indicators *H* and *VV*. *HI* (not presently part of the GTS SHIP code) shows if cloud height *H* was:

0 = estimated
1 = measured

WD wave direction
WP wave period
WH wave height

Historically, the (wind) wave and swell fields have been subject to complicated code changes. Both the wave and swell fields were reported in descriptive terms according to the SHIP code, and thus are expected to be missing, prior to 1949 (and the swell fields are expected to be missing prior to 1 July 1963, as discussed below). *WD* codes 00 to 36 (WMO Code 0877) show the direction (if any) from which (wind) waves come, in tens of degrees (e.g., 00 = calm, 01 = 005°-014°,…, 36 = 355°-004°). Codes 37-38 (99 in WMO Code 0877) show “waves confused, direction indeterminate” under *WH* conditions explained in the LMR documentation. Starting in 1968, *WD* was no longer reported and *WP* was reported in seconds. Prior to 1968, period was reported as a code, which was converted into whole seconds per Table 10 of the LMR documentation, with *WX* (ref. Table C1) set accordingly. *WH* is wave height in 1/2 meter increments, i.e., 1=0.5 m, 2=1 m, etc.

[Note: *WP*=99, indicating a confused sea, is not presently defined in LMR. Future work should seek to recover this information from original formats.]

SD swell direction

SP swell period
SH swell height
Configurations similar to the corresponding wave fields *WD*, *WP*, and *WH*. 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. Prior to 1968 (1982), *SP* was reported as a code, which was converted into whole seconds per Table 10 (Table 11) of the LMR documentation, with *SX* (ref. Table C1) set accordingly.

Attm control

ATTI attm ID
ATTL attm length
ATTE attm data encoding
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 supplementary data attm (ref. Table C6) also includes *ATTE*, which indicates whether the supplementary data that follow are in Ascii or encoded:

missing = Ascii
0 = base64 encoding

The "rdimma0" software IMMA 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 supplementary data attm must be the final attm within the record if *ATTL*=0.

IMMT-2/FM 13 attm

OS observation source
OP observation platform
As defined in IMMT-2.

FM FM code version
For *FM*, the corresponding field in IMMT-2 ranges from 0-8, but is extended here to two characters to allow room for expansion.

IX station/weather indicator
W2 second past weather
IX (WMO Code 1860) indicates both whether the station is manned or automatic, and the status of present and past weather data. *IX* is vital for proper interpretation of weather data starting in 1982; see LMR documentation for a detailed discussion, including unforeseen complications that attended its introduction (with *W2*; WMO Code 4561) in 1982 (e.g., *IX* was not included in IMMT until March 1985).

SGN significant cloud amount
SGT significant cloud type
SGH significant cloud height
Use of "A" (10 in base36) in place of "/." The significant cloud fields are listed in MetO (1948), but they were omitted from the IMM formats. Space is allocated for these, but it

is not clear how widely available they would be in logbook data or existing digital archives.

WMI indicator for wave measurement
WMI is the IMMT-2 "indicator for wave measurement" (shipborne wave recorder, buoy, or other measurement systems).

SD2 swell direction (2nd)
SP2 swell period (2nd)
SH2 swell height (2nd)
As defined for IMMT-2 (configurations as for *SD*, *SP*, and *SH*).

IS ice accretion
ES ice thickness
RS ice accretion rate
Fields for ice accretion on the ship, as defined for IMMT-2.

IC1 concentration of sea ice
IC2 stage of development
IC3 ice of land origin
IC4 true bearing ice edge
IC5 ice situation/trend
Configurations as in IMMT-2, except for use of "A" (10 in base36) in place of "/." These are not presently included among LMR regular fields. The fields changed dramatically in 1982 (field descriptions 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)

Like TD-1129, IMMA simply stores the old/new information as listed above in the same field, thus making it critical that users be aware of the code change.

> Options: Separate fields (or an indicator field) could be considered. Earlier historical ice codes might also need to be researched for possible consideration. MetO (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).

IR indicator for precipitation data
RRR amount of precipitation
TR duration of period of reference for amount of precipitation
As defined for IMMT-2. The precipitation fields are not presently included among regular LMR fields.

QCI quality control (QC) indicator
QI1-21 QC indicators for fields
Field *QCI* provides general information about the level of manual or automated QC that has been applied to the data. Twenty *QI* indicators for individual fields or field groups are included in IMMT-2 and IMMT-1 (see Table B2 of Supp. B), whereas 18 were included in the 1982 IMMT format, and none were available in IMMPC. IMMT-2 adds a 21st element to document the QC version.

HDG ship's (bow) heading in degrees (referenced to true North)
COG course over ground (reference to true North)
SOG speed over ground (the speed at which the vessel moves over the fixed earth)
SLL max. height (m) of deck cargo above summer max. load line
SLHH departure of summer max. load line from actual sea level
Fields added to IMMT-2 for VOSClim.

RWD relative wind direction
RWS relative wind speed
Fields added to IMMT-2 for VOSClim.

Ship metadata attm

C1M recruiting country
OPM type of ship (programme)
KOV kind of vessel
COR country of registry
TOB type of barometer
TOT type of thermometer
EOT exposure of thermometer
LOT screen location
TOH type of hygrometer
EOH exposure of hygrometer
SIM SST measurement method
LOV length of vessel
DOS depth of SST measurement
HOP height of visual observation platform
HOT height of air temperature sensor
HOB height of barometer
HOA height of anemometer
SMF source metadata file
SME source metadata element
SMV source format version
Metadata selected from WMO–No. 47 (1955–) by the UK National Oceanography Centre, Southampton (Kent et al. 2007a; additional technical documentation is available at this website: icoads.noaa.gov/e-doc/imma/Pub47_IMMA.pdf). The codes defined in WMO–No. 47, and used in IMMA, for *OPM* and *SIM* differ from the codes used for the similar IMMT-based 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 SOC into the 2-character alphabetic codes.

Options: A possible expansion for LOT would add extra codes for paired screens in unknown locations, etc.

Historical attm (proposed)

WFI wind force indicator
WF wind force
XWI *XW* indicator
XW wind speed (extension field for *W*)
XDI *XD* indicator

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.

SLPI *SLP* indicator
TAI *TA* indicator
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.

XNI *XN* indicator
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).

Document Revision Information

Previous document version: 26 May 2005. No substantive format changes were made as part of this revision. Most of the changes involved updating references, website addresses, and organizational information.