The International Maritime Meteorological Archive (IMMA) Format

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Introduction

With continuing recognition of the importance of upgrading and maximizing the data available for analyses of the climate record (e.g., Trenberth et al. 2002), efforts intensified over the last 15 years to digitize additional historical ship data (and metadata) that exist in many national logbook collections (Diaz and Woodruff 1999, Woodruff et al. 2004). Efforts over that period have 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. 2011, Kaspar et al. 2015). Many of these rescue and digitization activities have been organized and facilitated under the international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative (Allan et al. 2011).

At present, however, there is no effective—and formally internationally approved—format for exchange of keyed historical data, or for exchange of more modern (e.g., non ship) data/metadata types that are also rescued or made newly available. 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.

In addition to the exchange of newly digitized data, the format should be useful for reformatting, exchanging, and archiving existing national digital marine datasets, including contemporary marine data and metadata. 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. The International Maritime Meteorological Archive (IMMA) format described herein meets these requirements.

This document describes a new version of the IMMA format, IMMA1, that has been implemented for Release 3.0 (R3.0; Freeman et al. 2016) of the International Comprehensive Ocean-Atmosphere Data Set (ICOADS; Woodruff et al. 2011). The initial version of IMMA, i.e., IMMA0, was used to distribute and archive Release 2.5 (R2.5) ICOADS observational data (see http://icoads.noaa.gov/e-doc/imma/R2.5-imma.pdf). IMMA0 has also been used for the Climatological Database for the World's Ocean (CLIWOC) project (García-Herrera et al. 2005), as an alternative output from the JCOMM Global Collecting Centres (GCCs), and is helping meet requirements for managing data from the JCOMM Voluntary Observing Ship (VOS) Scheme, including from its enhanced class of VOS Climate (VOSClim) ships.

Following its introduction to the Subgroup on Marine Climatology (JCOMM 2000), development of the initial IMMA0 version has been reviewed periodically by JCOMM's successor group, the Expert Team on Marine Climatology (ETMC) (JCOMM 2007, Woodruff 2007, JCOMM 2010, JCOMM 2012a, JCOMM 2015b, JCOMM 2016a).
Moreover, the Second, Third, and Fourth "CLIMAR" Workshops on Advances in Marine Climatology (Parker et al. 2004, Charpentier et al. 2008, JCOMM 2015a), and the First, Second, Third, and Fourth "MARCDAT" Workshops on Advances in the Use of Historical Marine Climate Data (Diaz et al. 2002, Kent et al. 2007b, JCOMM 2016b), have all discussed the format, and regularly endorsed continued usage and expansion of the format.

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 IMMA format. The *format structure* and technical options considered for *format implementation* for the original IMMA0 format are then discussed followed by an introduction to the current IMMA format(hereafter IMMA1). Supps. C-E document in detail the IMMA1 format as presentlyimplemented for ICOADS, and lastly Supp. F looks to the future by outlining additional storage structures that appear desirable, in subsequent IMMA versions, to further advancethe format to meet marine climate data stewardship objectives.

Background

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).

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 were 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. 2011), widely available to the climate research community (Worley et al. 2010, Woodruff et al. 2011, Freeman et al. 2016). In recognition of its broad multinational basis, COADS was renamed the *International* COADS (ICOADS; Diaz et al. 2002, Parker et al. 2004).

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, various "flavors" of which are currently used to extend ICOADS in near-real-time (NRT) and/or delayed-mode, including from NOAA's National Centers for Environmental Prediction (NCEP) and for Environmental Information (NCEI), and from the UK Met Office.

A study by ETMC (JCOMM 2010) noted that different National Meteorological Services (NMSs) collecting marine reports from the GTS often have unexplained differences in their collections when compared to other GTS-collecting NMS, allowing each to ingest unique reports that other NMS may not have captured. With direct access to both NCEP and NCEI GTS streams, ICOADS has recently developed a new NRT product by blending both those two sources that will provide an additional ~5% unique reports.

Additionally, blending the NCEP and NCEI GTS streams recovers nearly 70% of real callsigns. Since Dec. 2007, many real ship callsigns have been unavailable in publicly available GTS data, owing to commercial and security concerns (e.g., by shipping companies). In response, NCEP then began setting all ship callsigns to a non-unique string "MASKSTID," and now still only releases a fraction of the real callsigns, or other JCOMM-assigned unique "MASK" constructs. Moreover, some ships reports (e.g., from Japan and USA) are still also circulated over public GTS with the non-unique *ID* "SHIP." For further information on these issues, and the new NRT blend product, see http://icoads.noaa.gov/merge.html.

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 (AWS 1960), persist in the SHIP (now FM 13) Traditional Alphanumeric Code (TAC) used over GTS (WMO 2015).

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 (Yoshida 2004, Yoshida and Woodruff 2007, and subsequent JMA work completed by early 2016), with results now accessible via WMO[1]. 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).

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

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 2014). Under the new WMO Information System (WIS) the requirement has been established to move all time-critical 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 (although BUFR e.g., is not intended by WMO for archival). Nevertheless, over the longer term, it may be useful to explore some limited convergence between IMMA

[1] Available at: http://www.wmo.int/pages/prog/amp/mmop/documents/publications-history/history/SHIP.html. 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.

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).

Original IMMA0 format structure

Drawing on features from the existing formats discussed in Supps. A-B, the IMMA0 format has for over 15 years provided ICOADS users with a flexible solution to the problem of storing both contemporary and historical marine data—and effectively serving those data to the science community and the public through modern electronic data services.

Following are the goals that the IMMA0 design attempted to balance in terms of costs and benefits:

1. 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 "/").
2. 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.
3. Since it is impractical to anticipate in advance all the storage requirements for older historical data, much less for future observing systems and reporting practices, 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 IMMA0) 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.
4. The format should also be expandable in more general terms to meet future or modern data requirements. Careful version control will therefore be required.
5. 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.
6. 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).
7. Important additional considerations are storage efficiency, and format documentation logistics.

The design of IMMA0 proceeded as follows: A wide range of fields was considered for IMMA0 based on comparisons of existing codes and formats (e.g., Supps. A-B). Fields suggested for international standardization, plus those already managed by WMO, were included in both IMMA0 and IMMA1 (see 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:

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

IMMA0 introduced the concept of "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. These attms have been expanded and modified between IMMA0 and IMMA1 and are listed in Table 2. Field configurations for each attm are provided in Supp. D. Additional attms have been proposed for future expansion of IMMA (Supp. F), but have not been fully designed or implemented.

Original IMMA0 format implementation

Development of IMMA0 resulted in a number of conventions that are applied to the storage of data values in this condensed ASCII format. Most the features described in this section have been carried forward into IMMA1.

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 is to make standardized units conversion software more widely available. A Fortran software library for this purpose (http://icoads.noaa.gov/software/lmrlib) is under continuing development as part of the ICOADS project, for selected historical units adjustments, time conversions, etc. Alternative language versions of this critical library have also been developed (https://github.com/oldweather/IMMA).

For some major data types, the IMMA field structure allocates separate fields in the proposed historical attm (Supp. F) 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.

IMMA0 was defined (Supps. C and D) 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, the user community may require additional formats, with the Network Common Data Form (NetCDF) growing in popularity in the marine climate community. The use of database technology and semantic web services could also support dynamic data search, sub-setting, and user-selectable output formats.

Overall, 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.

The original IMMA0 design was 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 populate 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 for ICOADS, including the attached original supplemental data, are permanently archived at the US National Center for Atmospheric Research (NCAR) with plans to fully mirror the collection at NCEI. Currently, NCEI archives the IMMA output data from Releases 2.0, 2.4, 2.5, 2.5.1 and 2.5.1 "intermediate," 2.5.2, and 3.0 (abbreviated hereafter as R2.0, R2.4, R2.5, R2.5.1, R2.5.1i, R2.5.2, and R3.0, respectively), with plans to backfill the archive—to include both original source data and translated input/output IMMA records—from all Releases going back to COADS Release 1.

To support the permanent preservation of variable-length GTS message strings, and any other input formats lacking a fixed record structure, IMMA0 adopted use of 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.

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 showing decimal numbers and base36 equivalent values. 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				

Format Modifications Resulting in IMMA1

Format changes—to yield IMMA version 1—were made prior to use of the new format with R3.0 (Freeman et al. 2016). When significant changes or additions to attm content were needed (i.e., for *Immt*, *Mod-qc*, and *Meta-vos*) a revised attm was created with a new table number and new attachment ID (*ATTI*), but the old configuration was retained as a deprecated attm (Table 2). The *Nocn*, *Ecr*, *Rean-qc*, *Ivad*, *Error*, and *Uida* attms are new to IMMA1 and the *Auto*, *Nocq*, *Alt-qc*, *Track*, and *Hist* attms are proposed (Supp. F). See also Woodruff et al. (2015) for further background on the whole development process behind IMMA1.

Changes implemented for IMMA1 include the following:

1. *Abbreviated structural element names in italics:* To enhance communication the *Core* and attms (e.g., *Icoads*) are all given abbreviated names in *italics*, but with only the first letter in uppercase, to distinguish them from the fully capitalized IMMA field abbreviations.

2. *Switch to attm-internal field numbering:* For example, within the *Icoads* attm, the fields are now numbered 1-51 rather than 49-99. Otherwise documentation maintenance was becoming challenging, and in conjunction with the IVAD project the change is viewed as a more flexible approach. However, the revised Fortran program to read/write IMMA1 ({rwimma1}[2]) still utilizes a linear field numbering approach for assigning array storage across the *Core* and all attms.

3. *Operational and deprecated attms* (Table 2): Rather than change (i.e., add/subtract, or modify, fields) attms, a new attm version is created, with tables for the deprecated attms retained only in the previous-version format documentation (and noting that by itself the field numbering switch, item 2 above, is not considered such a change), i.e., currently with reference to http://icoads.noaa.gov/e-

[2] In this document, {braces} are used to mark the names of software—typically a Fortran program embedded in Unix scripts, or a standalone Fortran library—with {rwimma1} referring specifically to http://icoads.noaa.gov/software/rwimma1. With limited modifications, this program can also write IMMA1. In terms of processing new attms, the current program will process the *Nocn, Ecr, Rean-qc*, *Ivad*, *Error*, and *Uida* attms, including processing of Subsidiary records.

doc/imma/R2.5-imma.pdf for IMMA0. The {rwimma1} program is able to read both the operational and deprecated attms, and the format remains fully backward compatible.

4. *Additional software maintenance considerations:* To make translation software adapted from {rwimma} (e.g., existing adaptations of {rwimma1} used to translate data from other formats into IMMA) more robust over the longer term, usage of field abbreviations (e.g., FTRUE(SST)) rather than hard-coded storage array locations (e.g., FTRUE(35)) has been implemented for {rwimma1} with the advantage that e.g., *W2* is defined in both Tables C2 and C5.

5. *Switch to multi-record "linked-report" approach:* Rather than modifying the *Icoads* attm to include a unique record identifier (*UID)* and associated release-tracking information, these fields are placed in a short new *Uida* attm (see Table C98), which appears both in the Main and (any optional) Subsidiary records, linking them all together. For example:
   a. *Main* IMMA record: *Core* + *Icoads* + *Immt* + *Mod-qc* + *Meta-vos* + *Nocn* + *Ecr* + *Uida* + *Suppl*
   b. *Subsidiary* IMMA record: *Uida* + *Rean-qc* + *Rean-qc* + *Rean-qc* … + *Rean-qc*
   c. *Subsidiary* IMMA record: *Uida* + *Ivad* + *Ivad* + *Ivad* … + *Ivad*
   d. *Subsidiary* IMMA record: *Uida* + *Error* + *Error* + *Error* … + *Error*

   Each complete multi-record construct (i.e., Main plus any Subsidiary records) is referred to below as a "linked-report." Linking information between the Main and Subsidiary records is facilitated in the new *Rean-qc*, *Ivad*, and *Error* attms by including fields for input component number (*ICNR*/*ICNI/ICNE*). In each case the relevant input component number is filled with zero for the *Core* or the *ATTI*, and field number within the input component number (*FNR*/*FNI/FNE*).

   The development of the *Uida* attm supports conveying information such as ship metadata (*Meta-vos*) attms or the proposed alternative QC (*Alt-qc*) attms separately back to ICOADS in a file containing only Subsidiary records (i.e., to be blended with the Main records or possibly into fields in other attms, in the case of *Alt-qc*, before provision to users:
   a. *Subsidiary* IMMA record: *Uida* + *Meta-vos*
   b. *Subsidiary* IMMA record: *Uida* + *Alt-qc* + *Alt-qc* + *Alt-qc* … + *Alt-qc*

   Such Subsidiary-only records thus would not ordinarily be provided directly to users. The linked-report is anticipated to be fully backward compatible. The *Core* has not changed, but {rwimma1} checks the first few characters of each record to determine whether it is a Subsidiary record (i.e., starts with "9815" – the first two fields of the *Uida*).

   A comparison of the different record structures currently available with R2.5, R2.5.1 and R2.5.2, and R3.0 is provided in Table 3.

6. *Software constraints on linked-reports and attm composition:* Processing by {rwimma1} of Main+Subsidiary records (linked-reports), and of the *Ivad* and *Error* attms, presently is being implemented with these fairly loose constraints:
   a. Both Main and Subsidiary records are allowed by {rwimma1} to contain multiples of any attachment in any order; except the *Suppl* attm, if present, must be the last Main attm.

b. In the event of repeating (except *Rean-qc*, *Ivad*, and *Error*) attms, the last attm takes precedence and overwrites information from all previous (e.g., Subsidiary attms take precedence over any repeating Main attms).
c. Subsidiary records must each begin with a *Uida* attm, followed by zero or more attms of any type except *Suppl*.
d. The maximum number of *Ivad* and *Error* attms within a linked-report is set at 100 each. In addition, while by definition of *UID* two (or more) Main records should never appear with the same *UID*, no check is envisioned as feasible at the present time for *UID* uniqueness.

Table 2. Status of IMMA components, attm naming convention, and related information. Shaded components are deprecated.

Component	*Abbrev.*	*Status*	*Reference information*	*Length (char.)*
Core	*Core*	operational	Table C0	108
ICOADS attm	*Icoads*	operational	Table C1	65
IMMT-2/FM 13 attm	(none)	deprecated	Table C2[1]	76
Model quality control attm	(none)	deprecated	Table C3[1]	66
Ship metadata attm	(none)	deprecated	Table C4[1]	67
IMMT-5/FM 13 attm	*Immt*	operational	Table C5	94
Model quality control attm	*Mod-qc*	operational	Table C6	68
Ship metadata attm	*Meta-vos*	operational	Table C7	58
Near-surface ocean attm	*Nocn*	operational	Table C8	102
Edited cloud report attm	*Ecr*	operational	Table C9	32
Reanalyses QC/feedback attm	*Rean-qc*	operational	Table C95	61
IVAD attm	*Ivad*	operational	Table C96	53
Error attm	*Error*	Operational[2]	Table C97	variable
Unique report ID attm	*Uida*	operational	Table C98	15
Supplemental data attm	*Suppl*	operational	Table C99	variable
Automated instrument. attm	*Auto*	proposed	Table CP1	41
Near-surface ocean QC attm	*Nocq*	proposed	Table CP2	28
Alternative QC attm	*Alt-qc*	proposed	Table CP3	TBD
Platform tracking attm	*Track*	proposed	Table CP4	TBD
Historical attm	*Hist*	proposed	Table CP5	TBD
Buoy metadata attm	*Meta-buoy*	proposed	TBD	TBD
Daily observational (Daily) attm	*Daily*	proposed	TBD	TBD

1. For details on these deprecated attm, see http://icoads.noaa.gov/e-doc/imma/R2.5-imma.pdf
2. Operational in IMMA1 and {rwimma1}, but no such attms exist in R3.0 of ICOADS.

Table 3. IMMA record structures currently operational for R2.5, R2.5.1, and R2.5.2, and the "linked-report" Main + Subsidiary (optional) record structure implemented for R3.0. 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.[1]

Release	*Record structure*	*Len. (char.)*[2]
R2.5	*Core* + *Icoads* + *Immt*[3] + *Mod-qc*[3] + *Meta-vos*[3] [+ *Suppl*]	372
R2.5.1 & R2.5.2	*Core* + *Icoads* + *Immt*[4] + *Mod-qc*[4] + *Meta-vos*[4] + *Uida*[4] [+ *Suppl*]	408
R3.0:		
Main	*Core* + *Icoads* + *Immt* + *Mod-qc* + *Meta-vos* + *Nocn* + *Ecr* + *Uida* [+ *Suppl*]	544
Subsid.	*Uida* + *Rean-qc* + *Rean-qc* + … (any number of attms; type may vary)	(var.)
Subsid.	*Uida* + *Ivad* + *Ivad* + … + *Ivad*	(var.)
(…)	(…any number of additional Subsidiary records…)	(var.)
Subsid.	*Uida* + *Error* + *Error* + … + *Error*	(var.)

1. In addition, the IMMA format is designed so that attms containing no data (not relevant to a given data source) can be omitted to reduce data volume.
2. Not counting the *Suppl* attm, which varies in length depending on data source (see Table 2).
3. Earlier, now deprecated, versions of these attms (see Table 2).
4. Status of new-field content in the prototype IMMA1 datasets R2.5.1 and R2.5.2: In the revised attms (*Immt*, *Mod-qc*, and *Meta-vos*) newly defined fields generally will not be populated, with the exception of field *MDS* in the *Meta-vos* attm (see also related discussion in Annex C). In the new *Uida* attm, *UID* is set as discussed below Table C98, and the Release number fields are set as *RN1*=2, *RN2*=5, *RN3*=1, i.e., this is considered R2.5.1, to distinguish it from the original R2.5.

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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 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. A plus sign ("+") designates that information may exist in the original logbook images but was not digitized and is not available in ICOADS through that source. A pound ("#") denotes that the barometer data was digitized, but attached thermometer observations were rare and not digitized.

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* *<u>1918</u>*	*MMJ* *<u>1887</u>*	*Nor.* *<u>1873</u>*	*M(2)* *<u>1854</u>*	*M(1)* *<u>1797</u>*	*EIC* *<u>1789</u>*
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	•	•	•	•		#
Sympeisometer pressure						•

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	(?)		text

Metadata elements:	*WWI* <u>*1918*</u>	*MMJ* <u>*1887*</u>	*Nor.* <u>*1873*</u>	*M(2)* <u>*1854*</u>	*M(1)* <u>*1797*</u>	*EIC* <u>*1789*</u>
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). At the Third Session of JCOMM (2009), a fourth version (IMMT-4) was approved and implementation began in January 2011 which included new fields such as relative humidity, and additional metadata fields to identify Automatic Weather Stations (AWS) and International Maritime Organization ship identifiers for better metadata linkages. Further revisions to the format were adopted at the Fourth Session of JCOMM (2012b) and IMMT-5 is the current exchange format used internationally, effective June 2012. The IMMT-5 format did not include any new data fields, but incorporated updates to existing fields such as e.g., the addition of newer FM 13 code versions being used by VOS ships and minor editorial changes.

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 includingindicators 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 (AWS 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).[3]

[3] 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 2015) 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).[4] 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. NCEI has made it an operational practice to archive the raw TAC GTS marine reports starting in 1999.

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 2014) planned (originally by 2012, but significantly delayed) 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 2014) 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; AWS 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.

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

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

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.

During 2015-16, significant efforts are being made by NMSs to comply with the longstanding WMO mandate to move from TAC to TDCF. This process has been swift and many NMSs are now distributing ship and buoy reports in BUFR format. While a mixture of TAC and TDCF data is still being distributed, the overall goal is to move over tostrictly using TDCF for circulation of applicable marine and oceanographic reports on theGTS. As yet however, the transition from TAC to TDCF has not been sufficiently validated,e.g., it is unclear if adequate overlaps between the two sources have been provided (andhow long TDCF overlaps will continue) for cross-validation purposes, to avoid potential problematic data inhomogeneity situations such as discussed above.

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.

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

Much of the data included in COADS *Release 1* prior to 1970 were obtained from NCDC (note: now part of NCEI) 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 IMMA with WMO's SHIP Code and IMM Formats

The evolution of the SHIP code as circulated over the GTS (or predecessor telecommunications systems) from 1954 through the present FM 13 code is illustrated in Table B1. Over time, the availability of these selected fields has varied, as in some cases have the associated national practices for reporting the data. While the SHIP code and the delayed-mode IMM formats are governed separately[5], historically they have always had a fairly close relationship, with the IMM formats essentially tracking changes in the SHIP code, but also building on the more limited GTS code forms with additional fields and field configurations, since the delayed-mode formats have offered additional flexibility for storage of amplified information.

Table B1. Comparison of the availability and form of selected fields in the GTS SHIP code. The selected fields are: wind speed indicator (I_w), sea surface temperature (*SST*), air temperature (*AT*), dew-point temperature (*DPT*), wet bulb temperature (*WBT*), station/weather indicator (I_x; initiated with the 1982 SHIP code changes), radio callsign, and recruiting country code (*C1*; which may differ from ship flag nationality, which usually can be determined from callsign). (Notes: Initially drafted by J. Elms and S. Woodruff in 1994 and updated by S. Woodruff and E. Freeman in 2016.IMMA variable names are shown as usual in italics, whereas the GTS code figures are in ordinaryfont with subscripts.)

SHIP code	I_w (*WI*)	*SST*	*AT*	*DPT*	*WBT*	I_x (*IX*)	call	*C1*
FM 21.A (1954)[1]	no	1C[2]	1C	1C[2]	no	N/A	?	no
FM 21.D (1963)	yes	1/.1C[3]	1/.1C[3]	1C[3]	no	N/A	yes[5]	no
FM 21.E (1971/72)	yes	1/.1C[3]	1/.1C[3]	1C[3]	no	N/A	yes[5]	no
FM 21-V (1974)	yes	1/.1C[3]	1/.1C[3]	1C[3]	no	N/A	yes[5]	no
FM 13-VII(1982/84)	yes	0.1C	0.1C	0.1C[4]	no	yes[6]	yes	no
FM 13-VIII (1987)	yes	0.1C	0.1C	0.1C	no	yes	yes	no
FM 13-IX (1989)	yes	0.1C	0.1C	0.1C	no	yes	yes	no
FM 13-X (1993)	yes	0.1C	0.1C	0.1C	yes	yes[7]	yes	no
FM 13-XI (1997)	yes	0.1C	0.1C	0.1C	yes	yes	yes	no
FM 13-XII (2003)	yes	0.1C	0.1C	0.1C	yes	yes	yes	no
FM 13-XIII (2008)	yes	0.1C	0.1C	0.1C	yes	yes	yes	no
FM 13-XIV (2011)	yes	0.1C	0.1C	0.1C	yes	yes	yes	no

1. Code included octant, day of the week, and UTC (time would have either 30 or 60 added to indicate certain elements were not reported). Since 1963 the code included quadrant, day, and UTC (30 or 60 was still added to the time as an indicator until 1974).
2. Optional group—dependent on national instructions.
3. *SST* and the tenths position of *AT* formed an optional group. Another option was a group with *SST* and *DPT* to whole °C. (i.e., ($0T_sT_sT_dT_d$) and ($1T_wT_wT_{wt}t_T$) where often both groups would be included (e.g., 0//08 11234) providing *AT* and *SST* to 0.1°C.
4. Some countries (e.g., US and Canada) may have continued to report *DPT* in whole degrees for unknown periods following the 1982 SHIP code change
5. According to US national practice (at least), callsign was not part of the SHIP code, but included in the Radio Header Message.
6. Part of the SHIP code although not included in NOAA/NMC (now NCEP) data until April 1984 and in the IMMT code until March 1985.
7. In the SHIP Code at this time, I_x could only be coded as 1 or 3.

[5] In recent decades the GTS codes (SHIP and other codes such as BUOY) have been governed largely by WMO's Commission for Basic Systems (CBS), whereas the IMM formats have been governed through JCOMM.

Table B2 compares IMMT-5 (the latest revision) 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 B2 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 B3 lists the quality control (QC) flags currently available in IMMT-5.

IMM formats such as those surveyed in Table B2 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 B4 provides examples of the earlier codes and other information that could be represented by using the 1963 version of the supplementary procedures.

The IMMT-5 format was adopted in 2012 (JCOMM-IV Rec. 6[6]), and implemented generally for all data collected as from 1 June 2012. As part of developing that latest version, the IMMT documentation was modernized, and included mostly minor updates to code tables and field descriptions.

Table B2. The latest IMMT-5 format comprises the 105 elements listed in this table (172-character record length), with no new fields added since the adoption of IMMT-4 (1 Jan. 2011). 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: IMMT-5 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 B4). 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. 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).

[6] IMMT-5 documentation available from: https://www.wmo.int/pages/prog/amp/mmop/documents/IMMT-5-JCOMM-4.pdf.

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[3]
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]	→[5]
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	•

No.	Chars.	Code	Element description	IMMA	IMMT 1982	IMMPC 1968	IMMPC 1963
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[6]	Δ[6]
43	79-80	•	country recruited ship[7]	*C1*	•	•[8]	•
			2nd country code	*C2*			
44	81	•	(national use)	*(NID, NU)*	•		
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	*FM*		Δ[9]	Δ[9]
65	111	•	IMMT version	*IMMV*			
			IMMA version	*IM*			
66-85	112-131	Q_1-Q_{20}	QC indicators (see Table B3)	*QI1-QI20*	•		
			(note: end of IMMT-1)				
86	132	Q_{21}	QC indicator (see Table B3)	*QI21*			
87	133-5	HDG	ship's heading	*HDG*			
88	136-8	COG	course over ground	*COG*			
89	139-40	SOG	speed over ground	*SOG*			

No.	Chars.	Code	Element description	IMMA	IMMT 1982	IMMPC 1968	IMMPC 1963
90	141-2	SLL	max.ht.>Sum. load ln.	*SLL*			
91	143	s_L	sign of hh[10]	*(SLHH)*			
92	144-5	hh	dep. load ln.: sea lev.[10]	*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 B3)	*QI22-QI29*			
			(*note : end of IMMT-3)*				
102	160-3	RH	relative humidity	*RH*			
103	164	RHi	relative humidity indicator	*RHI*			
104	165	AWSi	AWS indicator	*AWSI*			
105	166-72	IMOno	IMO number	*IMONO*			

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.”
5. 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.
6. 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).
7. Change from numeric to alphabetic ISO codes effective 1 January 1998.
8. Overpunch for auxiliary ships (not part of the 1963 format).
9. A “Card indicator” field: punched according to the WMO Codes effective in year AA, or according to supplementary punching procedures (Part B).
10. Elements 91-92 in IMMT-4/IMMT5 appeared as a single element 91 in IMMT-3 and IMMT-2, thus the element numbering differs between IMMT-4/IMMT-5 and the earlier versions (and corresponding changes were made in the QC flags, ref. Table B3).

Table B3. Quality control (QC) indicators for IMMT-5, which are the same as those included in IMMT-3 and IMMT-4. Those through 86 were included in IMMT-2 (and IMMA0), and through 85 in IMMT-1 (whereas 18 such indicators were included in the 1982 IMMT format, and none were available in IMMPC). IMMA1 now accommodates all these (see Table C3), and additionally has space for a variety of ICOADS QC flags (Table C1) and model QC feedback information (Table C6).

No.	Chars.	Code	Applicable element(s) (from Table B2)
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. Elements 91-92 in IMMT-4 appeared as a single element 91 in IMMT-3 and IMMT-2 (ref. Table B2), 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 B4. 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 (e.g., http://www.wmo.int/pages/prog/amp/mmop/documents/publications-history/cmm/CMM03Rec23A.pdf) 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_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)
significant cloud data	N_S, C, h_Sh_S (WMO Codes 2700, 0500, and 1577)
special phenomena	regional codes (i.e., WMO Code 169, 268, 383, 483, 668, or 768)
ship or log number	3-digit code for Ship Number (i.e., 001-999)[1]

1. In many cases it appears likely that nationally defined numbers and most of the associated details linking with ship names etc. have unfortunately been lost. Some of the original card deck reference manuals (predating TDF-11; NCDC 1968) however might provide some information, e.g., ship numbers noted in http://icoads.noaa.gov/reclaim/pdf/dck128b.pdf

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. At the time of Release 3.0 of ICOADS, in addition to the *Core*, the following attms have been defined:

Table C0: Core (*Core*)	(108 characters)
Table C1: ICOADS (*Icoads*) attm	(65 characters)
Table C5: IMMT-5/FM 13 (*Immt*) attm	(94 characters)
Table C6: Model quality control (*Mod-qc*) attm	(68 characters)
Table C7: Ship metadata (*Meta-vos*) attm	(58 characters)
Table C8: Near-surface oceanographic (*Nocn*) attm	(102 characters)
Table C9: Edited cloud report (*Ecr*) attm (see Annex E)	(32 characters)
Table C95: Reanalyses QC/feedback (*Rean-qc*) attm	(61 characters)
Table C96: ICOADS Value-added Database (*Ivad*) attm	(53 characters)
Table C97: Error (*Error*) attm	(32 characters)
Table C98: Unique report ID (*Uida*) attm	(15 characters)
Table C99: Supplemental data (*Suppl*) attm	(source-dep. length)

including three deprecated attms:

Table C2: IMMT-2/FM 13 attm	(76 characters)
Table C3: Model quality control attm	(66 characters)
Table C4: Ship metadata attm	(57 characters)

whose documentation can be found in http://icoads.noaa.gov/e-doc/imma/R2.5-imma.pdf.

Additionally, the following attms have been proposed (CP):

Table CP1: Automated instrumentation (*Auto*) attm	(41 characters)
Table CP2: Near-surface oceanographic QC (*Nocq*) attm	(28 characters)
Table CP3. Alternative QC (*Alt-qc*) attm	(proposed)
Table CP4: Platform tracking (*Track*) attm	(proposed)
Table CP5: Historical (*Hist*) attm	(proposed)

The proposed attms are discussed in Supp. F, but have not been implemented at the time of R3.0. In addition, the following attms are envisioned as further possibilities, but without any suggested content in Supp. F:

Buoy metadata (*Meta-buoy*) attm	(proposed, no table)
Daily observational (*Daily*) attm	(proposed, no table)

Throughout Supp. C, each table contains these columns:

1. Field number (No.). Field numbering is attm-internal beginning with field number 1 and ending with the last field indicated in each table.
2. Length (Len.) in characters (i.e., 8-bit bytes[1]).

[1] “Character” fields in IMMA should be limited to the printable set of ASCII characters i.e., 32=space, 33=“!”, ..., 126=“~” (ref. http://en.wikipedia.org/wiki/ASCII#ASCII_printable_code_chart).

3,4 Abbreviation (Abbr.) for each element (or field), and a brief Element Description.

5,6 For fields with a bounded numeric range (either decimal or base36), the minimum (Scaled Min.) and maximum (Scaled Max.) are indicated in decimal (and/or in base36 in [square brackets]). When values are provided for Scaled Min./Max., they represent the field value multiplied by the numeric part of the Units field (if applicable). In other cases, the range and configuration are listed as: "a" for alphabetic (A-Z), "b" for alphanumeric (strictly 0-Z with no leading blanks), "c" for alphanumeric plus other printable characters, or "u" for undecided form (only for fields that are currently unused). Base36 fields include "[b36]" in the Units column, and, as for decimal numeric fields, any leading missing positions are blank (vs. zero) filled (note: as a consequence, base36 is not always interpretable as alphanumeric). For Base36 encoded fields both the numeric range and Base36 range (in [ ]) are listed for the Scaled Min./Max.

Base36 encoding showing decimal numbers and base36 equivalent values (reproduced from Table 1 in main text above). 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				

7 Units of data and related WMO codes. Information in parentheses usually relates the IMMA field to a field from Supp. B, Table B2 (if applicable): WMO code symbolic letters are listed, or "•" followed by a field number from Table B2 in the absence of symbolic letters. This information is prefixed by "∆" to highlight field configurations that are extended in range or modified in form from presently defined WMO representations.

Table C0. IMMA *Core*.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
			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	(obsolete NCDC-variant)
7	2	*IM*	IMMA version	0	99	(Δ •65)
8	1	*ATTC*	attm count	0 [0]	35 [Z]	[b36]
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	11	
15	9	*ID*	identification/callsign	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	10	(Δ i_W)
20	3	*W*	wind speed	0	99.9	0.1 m/s (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)
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 [0]	10 [A]	(Δ C_L) [b36]
39	1	*HI*	*H* indic.	0	1	(Δ •9)

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
40	1	*H*	cloud height	0 [0]	10 [A]	(Δ h) [b36]
41	1	*CM*	middle cloud type	0 [0]	10 [A]	(Δ C_M) [b36]
42	1	*CH*	high cloud type	0 [0]	10 [A]	(Δ C_H) [b36]
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 obsolete NCDC-variant format (see Supps. D-E for further details). For *MO*, *DY*, and *HR*, the NCDC-variant format used leading zeros as an exception to the "blank left-fill" aspect of the ICOADS-standard representation for numeric data.

Table C1. ICOADS (*Icoads*) attm.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=1
2	2	*ATTL*	attm length			Note: set *ATTL*=65
			Box elements (6 characters):			
3	1	*BSI*	box system indicator	u	u	(currently set to missing)
4	3	*B10*	10° box number	1	648	(ICOADS BOX10 system)
5	2	*B1*	1° box number	0	99	
			Processing elements (17 characters):			
6	3	*DCK*	deck	0	999	
7	3	*SID*	source ID	0	999	
8	2	*PT*	platform type	0	21	[Note: Max.=15 in IMMA0 documentation was error]
9	2	*DUPS*	dup status	0	14	
10	1	*DUPC*	dup check	0	2	
11	1	*TC*	track check	0	1	
12	1	*PB*	pressure bias	0	2	
13	1	*WX*	wave period indicator	1	1	
14	1	*SX*	swell period indicator	1	1	
15	2	*C2*	2nd country code	0	40	
			QC elements (38 characters):			
16-27	1×12	*SQZ-DQA*[1]	adaptive QC flags	1 [1]	35 [Z]	(12 flags)[2] [b36]

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
28	1	*ND*	night/day flag	1	2	
29-34	1×6	*SF-RF*[1]	trimming flags	1 [1]	15 [F]	(6 flags)[2] [b36]
35-48	1×14	*ZNC-TNC*[1]	NCDC-QC flags	1 [1]	10 [E]	(14 flags)[2] [b36]
49	2	*QCE*[3]	external (e.g., OSD)	0	63	integer encoding (6 flags)
50	1	*LZ*	2°×2° landlocked flag	1	1	
51	2	*QCZ*[3]	source exclusion flags	0	31	integer encoding (5 flags)

1. A set of flags (elaborated briefly here and in Table C1a; see *R3.0-stat_trim* for detailed information: http://icoads.noaa.gov/e-doc/R3.0-stat_trim.pdf) is stored in 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, except as noted, to field abbreviations from Table C0): *A*=*AT*, *B*=*VV*, *C*=clouds[4] (*N*, …, *CH*), *D*=*DPT*, *E*=wave, *F*=swell, *G*=*WBT*, *P*=*SLP*, *R*=humidity variables (relative humidity, *DPT*, and/or *WBT*, depending on QC scheme), *S*=*SST*, *T*=*A* and *PPP*, *U* or *V*=wind U- or V-component (monthly summary variables not in Table C0), *W*=wind, *X*=*WW*, *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. *R3.0-stat_trim* (http://icoads.noaa.gov/e-doc/R3.0-stat_trim.pdf) provides further information about how to convert the coded (base36) values stored in these flags into true (floating-point) values (handled automatically by {rwimma1}).
3. Handled as a single element by {rwimma1}, but actually holds a set of flags (elaborated as follows, and in Table C1a), 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. *R3.0-stat_trim* (http://icoads.noaa.gov/e-doc/R3.0-stat_trim.pdf) provides further information about how to decode the information stored within *QCE* and *QCZ*.
4. Further details on the NCDC-QC (e.g., noting which parameters are considered in the cloud group) can be found in *Release 1*, supp. J (http://icoads.noaa.gov/Release_1/suppJ.html).

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Table C1a lists the QC elements available (some presently obsolete or unused, as noted) as part of the *Icoads* attm.

Table C1a (note: Table 1 in *R3.0-stat_trim:* http://icoads.noaa.gov/e-doc/R3.0-stat_trim.pdf). QC elements within the *Icoads* attm (fields 1-15 of that attm are described in Table C1). Grey shaded flags presently are unused.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code)
			QC elements (38 characters):			
			Adaptive QC flags (12 characters; only *SQZ-SQA* in use):			
16	1	*SQZ*	*SST*: z flag	1	35	base36 (obsolete)
17	1	*SQA*	*SST*: alpha flag	1	21	base36 (obsolete)
18	1	*AQZ*	*AT*: z flag			(unused)
19	1	*AQA*	*AT*: alpha flag			(unused)

No.	*Len.*	*Abbr.*	*Element description*	*Scaled Min.*	*Scaled Max.*	*Units (Code)*
20	1	*UQZ*	U-wind: z flag			(unused)
21	1	*UQA*	U-wind: alpha flag			(unused)
22	1	*VQZ*	V-wind: z flag			(unused)
23	1	*VQA*	V-wind: alpha flag			(unused)
24	1	*PQZ*	SLP: z flag			(unused)
25	1	*PQA*	SLP: alpha flag			(unused)
26	1	*DQZ*	Humidity: z flag			(unused)
27	1	*DQA*	Humidity: alpha flag			(unused)
			Night/day flag (1 character):			
28	1	*ND*	night/day flag	1	2	
			Trimming flags (6 characters):			
29	1	*SF*	*SST* flag	1	15 [F]	base36
30	1	*AF*	*AT* flag	1	15 [F]	base36
31	1	*UF*	U-wind flag	1	15 [F]	base36
32	1	*VF*	V-wind flag	1	15 [F]	base36
33	1	*PF*	*SLP* flag	1	15 [F]	base36
34	1	*RF*	*RH* (& *WBT*/*DPT*) flag	1	15 [F]	base36
			NCDC-QC flags (14 characters):			
35	1	*ZNC*	report-status flag (ship position)	1	10 [A]	base36
36	1	*WNC*	wind flag	1	10 [A]	base36
37	1	*BNC*	visibility (*VV*) flag	1	10 [A]	base36
38	1	*XNC*	present weather (*WW*) flag	1	10 [A]	base36
39	1	*YNC*	past weather (*W1*) flag	1	10 [A]	base36
40	1	*PNC*	*SLP* flag	1	10 [A]	base36
41	1	*ANC*	*AT* flag	1	10 [A]	base36
42	1	*GNC*	*WBT* flag	1	10 [A]	base36
43	1	*DNC*	*DPT* flag	1	10 [A]	base36
44	1	*SNC*	*SST* flag	1	10 [A]	base36
45	1	*CNC*	cloud flag	1	10 [A]	base36
46	1	*ENC*	wave flag	1	10 [A]	base36
47	1	*FNC*	swell flag	1	10 [A]	base36
48	1	*TNC*	pressure tendency (*A* and *PPP*) flag	1	10 [A]	base36
49	2	*QCE*	**External flags (i.e., 2-char. *QCE* when decoded into six flags[1]):**	0	63	integer encoding (6 flags)
		ZE	report-status flag	1	1	1 = erroneous (based on OSD quality control)

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code)
		SE	*SST* flag	1	1	"
		AE	*AT* flag	1	1	"
		WE	wind flag	1	1	"
		PE	*SLP* flag	1	1	"
		RE	*RH* (*WBT*/*DPT*) flag	1	1	(unused)
			Landlocked flag (1-character):			
50	1	*LZ*	2°×2° landlocked flag	1	1	
51	2	*QCZ*	**Source exclusion flags (i.e., 2-char. *QCZ* when decoded into five flags[1]):**	0	31	integer encoding (5 flags)
		SZ	*SST* flag	1	1	data excluded from enhanced or standard trimmed IMMA/MSG (in addition to other QC flag criteria, see Table 8)
		AZ	*AT* flag	1	1	"
		WZ	wind flag	1	1	"
		PZ	*SLP* flag	1	1	"
		RZ	*RH* (*WBT*/*DPT*) flag	1	1	"

1. The Appendix describes about how to convert the coded (base36) values stored in these flags into true (floating-point) values (handled automatically by {rwimma1}).

Note: Tables C2, C3, and C4 are assigned to deprecated attms (IMMT-2/FM 13, Model quality control, and Ship metadata, respectively) associated with R2.5. Documentation for these tables and deprecated attms can be found http://icoads.noaa.gov/e-doc/imma/R2.5-imma.pdf.

Table C5. IMMT-5/FM 13 (*Immt*) attm. This attm includes data fields that are widely applicable to Voluntary Observing Ship (VOS) data reported in formats other than IMMT and FM 13.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=5
2	2	*ATTL*	attm length			Note: set *ATTL*=94
			Common for IMMT-2/3/4/5 (49 characters):			
3	1	*OS*	observation source	0	6	(•40)
4	1	*OP*	observation platform	0	9	(•41)
5	1	*FM*	FM code version	0 [0]	35 [Z]	(Δ •64) [b36]

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
6	1	*IMMV*	IMMT version	0 [0]	35 [Z]	[b36]
7	1	*IX*	station/weather indic.	1	7	(i_X)
8	1	*W2*	2nd past weather	0	9	(W_2)
9	1	*WMI*	indic. for wave meas.	0	9	(•31)
10	2	*SD2*	dir. of second. swell	0	38	($d_{W2}d_{W2}$)
11	2	*SP2*	per. of second. swell	0	30, 99	($P_{W2}P_{W2}$)
12	2	*SH2*	ht. of second. swell	0	99	($H_{W2}H_{W2}$)
13	1	*IS*	ice accretion on ship	1	5	(I_s)
14	2	*ES*	thickness of I_s	0	99	cm (E_sE_s)
15	1	*RS*	rate of I_s	0	4	(R_s)
16	1	*IC1*	concentration of sea ice	0 [0]	10 [A]	(Δ c_i) [b36]
17	1	*IC2*	stage of development	0 [0]	10 [A]	(Δ S_i) [b36]
18	1	*IC3*	ice of land origin	0 [0]	10 [A]	(Δ b_i) [b36]
19	1	*IC4*	true bearing ice edge	0 [0]	10 [A]	(Δ D_i) [b36]
20	1	*IC5*	ice situation/trend	0 [0]	10 [A]	(Δ z_i) [b36]
21	1	*IR*	indic. for precip. data	0	4	(i_R)
22	3	*RRR*	amount of precip.	0	999	(RRR)
23	1	*TR*	duration of per. *RRR*	1	9	(t_R)
24	1	*NU*	national use	c	c	(national practice)
25	1	*QCI*	quality control indic.	0	9	(•45)
26-45	1×20	*QI1-20*	QC indic. for fields	0	9	(Q_1-Q_{20})
			New for IMMT-2/3/4/5 (41 characters):			
46	1	*QI21*	MQCS version	0	9	(Q_{21})
47	3	*HDG*	ship's heading	0[1]	360	0, ° (HDG)
48	3	*COG*	course over ground	0	360	0, ° (COG)
49	2	*SOG*	speed over ground	0	99	kt (SOG)
50	2	*SLL*	max.ht.>Sum. load ln.	0	99	m (SLL)
51	3	*SLHH*	dep. load ln.: sea lev.	–99	99	m ($s_L$hh)
52	3	*RWD*	relative wind direction	1	362	°, 361-2[2] (ref. *D*)
53	3	*RWS*	relative wind speed	0	99.9	0.1 m/s (ref. *W*)
54-61	1×8	*QI22-29*	QC indic. for fields	0	9	(Q_{22}-Q_{29})[3]
62	4	*RH*	relative humidity	0.0	100.0	0.1%
63	1	*RHI*	relative humidity indic.	0	4	(RHi)
64	1	*AWSI*	AWS indicator	0	2	(AWSi)
65	7	*IMONO*	IMO number	0	9999999	(IMOno)

1. Zero is documented to mean "no movement," but has been suggested should not be used (see Supp. D).
2. 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).
3. As from IMMT-4 and IMMT-5, usage of Q_{26} is discontinued, see Table B3 and IMMT-5 documentation (https://www.wmo.int/pages/prog/amp/mmop/documents/IMMT-5-JCOMM-4.pdf): "now Q_{27} serves as the indicator for both S_L and HH."

Table C6. Model quality control (*Mod-qc*) attm. For reference, the Units column also includes (following any units information) the current UK Met Office BUFR element names.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=6
2	2	*ATTL*	attm length			Note: set *ATTL*=68
			GTS bull. header fields (10 characters):			
3	4	*CCCC*	collecting center	a	a	COLTN_CNTR
4	6	*BUID*	bulletin ID	b	b	BLTN_IDNY
			Model comp. elements (54 characters):			
5	1	*FBSRC*	Feedback source	0	0	(0=operational)
6	5	*BMP*	background (bckd.) *SLP*	870.0	1074.6	0.1 hPa; BCKD_MSL_PESR
7	4	*BSWU*	bckd. wind U-comp.	–99.9	99.9	0.1 m/s; BCKD_SRFC_WIND_U
8	4	*SWU*	derived wind U-comp.	–99.9	99.9	0.1 m/s; SRFC_WIND_U
9	4	*BSWV*	bckd. wind V-comp.	–99.9	99.9	0.1 m/s; BCKD_SRFC_WIND_V
10	4	*SWV*	derived wind V-comp.	–99.9	99.9	0.1 m/s; SRFC_WIND_V
11	4	*BSAT*	bckd. air temperature	–99.9	99.9	0.1°C; BCKD_SRFC_AIR_TMPR
12	3	*BSRH*	bckd. relative humidity	0	100	%; BCKD_SRFC_RLTV_HUMDY
13	3	*SRH*	(derived) relative humidity	0	100	%; SRFC_RLTV_HUMDY
14	5	*BSST*	bckd. *SST*	–99.99	99.99	0.01°C; BCKD_SEA_SRFC_TMPR
15	1	*MST*	model surface type	0	9	(UK 008204); MODL_SRFC_TYPE
16	4	*MSH*	model height of surface	-999	9999	m; MODL_SRFC_HGHT
17	4	*BY*	bckd. year	0	9999	year; BCKD_YEAR
18	2	*BM*	bckd. month	1	12	month; BCKD_MNTH
19	2	*BD*	bckd. day	1	31	day; BCKD_DAY
20	2	*BH*	bckd. hour	0	23	hour; BCKD_HOUR
21	2	*BFL*	bckd. forecast length (time period or displacement minute)	0	99	hours BCKD_FRCT_LNGH

Table C7. Ship metadata (*Meta-vos*) attm. For more information, including other fields available in WMO Pub. 47 but not selected for this attm, see Berry et al. (2009; http://icoads.noaa.gov/e-doc/imma/WMO47IMMA_1966_2007-R2.5.pdf).

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=7
2	2	*ATTL*	attm length			Note: set *ATTL*=58
			Ship metadata elements (54 characters):			
3	1	*MDS*	metadata source	0	1	(0=WMO Pub. 47; 1=COAPS)
4	2	*C1M*	recruiting country	a	a	(Δ •43)
5	2	*OPM*	type of ship (program)	0	99	(code unlike *OP)*
6	2	*KOV*	kind of vessel	c	c	
7	2	*COR*	country of registry	a	a	(Δ •43)
8	3	*TOB*	type of barometer	c	c	
9	3	*TOT*	type of thermometer	c	c	
10	2	*EOT*	exposure of thermometer	c	c	
11	2	*LOT*	screen location	c	c	
12	1	*TOH*	type of hygrometer	c	c	
13	2	*EOH*	exposure of hygrometer	c	c	
14	3	*SIM*	*SST* meas. method	c	c	(code unlike *SI)*
15	3	*LOV*	length of vessel	0	999	M
16	2	*DOS*	depth of *SST* meas.	0	99	M
17	3	*HOP*	height of visual observation platform	0	999	M
18	3	*HOT*	height of *AT* sensor	0	999	M
19	3	*HOB*	height of barometer	0	999	M
20	3	*HOA*	height of anemometer	0	999	M
21	5	*SMF*	source metadata file	0	99999	e.g., “19911” 1st Q 1991
22	5	*SME*	source meta. element	0	99999	line number in file
23	2	*SMV*	source format version	0	99	(see Berry et al. 2009[1])

Table C8. Near-surface oceanographic data (*Nocn*) attm. Field contents are tailored to the specialized requirements of capturing data deemed most relevant to marine meteorology from the World Ocean Database (e.g., WOD13; http://www.nodc.noaa.gov/OC5/WOD13/).

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=8
2	2	*ATTL*	attm length			Note: set *ATTL*=102 [2U] [b36]
			Near-surface oceanographic data and metadata (98 characters):			
3	5	*OTV*	temperature value	–3.000	38.999	0.001°C[1]
4	4	*OTZ*	temperature depth	0.00	99.99	0.01 m
5	5	*OSV*	salinity value	0.000	40.999	0.001 (unitless)
6	4	*OSZ*	salinity depth	0.00	99.99	0.01 m
7	4	*OOV*	dissolved oxygen	0.00	12.99	0.01 milliliter/liter
8	4	*OOZ*	dissolved oxygen depth	0.00	99.99	0.01 m
9	4	*OPV*	phosphate value	0.00	30.99	0.01 micromole/liter
10	4	*OPZ*	phosphate depth	0.00	99.99	0.01 m
11	5	*OSIV*	silicate value	0.00	250.99	0.01 micromole/liter
12	4	*OSIZ*	silicate depth	0.00	99.99	0.01 m
13	5	*ONV*	nitrate value	0.00	500.99	0.01 micromole/liter
14	4	*ONZ*	nitrate depth	0.00	99.99	0.01 m
15	3	*OPHV*	pH value	6.20	9.20	0.01 (unitless)
16	4	*OPHZ*	pH depth	0.00	99.99	0.01 m
17	4	*OCV*	total chlorophyll value	0.00	50.99	0.01 microgram/liter
18	4	*OCZ*	total chlorophyll depth	0.00	99.99	0.01 m
19	3	*OAV*	alkalinity value	0.00	3.10	0.01 milliequivalent/liter
20	4	*OAZ*	alkalinity depth	0.00	99.99	0.01 m
21	4	*OPCV*	partial pressure of carbon dioxide value	0.0	999.0	0.1 microatmosphere
22	4	*OPCZ*	partial pressure of carbon dioxide depth	0.00	99.99	0.01 m
23	2	*ODV*	dissolved inorganic carbon value	0.0	4.0	0.1 millimole/liter
24	4	*ODZ*	dissolved inorganic carbon depth	0.00	99.99	0.01 m
25	10	*PUID*	provider's unique record Identification	c	c	

1. The *SST* min. and max. limits in the *Core* (Table C0) are -99.0 to 99.0°C with a precision of 0.1°C, this attachment has greater precision as is appropriate for modern oceanographic profile data, with a max. value based roughly on QC limits from the GOSUD program.

Table C9. "Edited Cloud Report" (*Ecr*) attm. Elements as outlined originally in Hahn and Warren (1999). Cloud variables *Ne*, *NHe*, *He*, *CLe*, *CMe*, and *CHe* correspond (i.e., abbreviations without trailing "e") to variables in the IMMA *Core*, but may be "edited" as described in Supp. D.

No.	Len	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=9
2	2	*ATTL*	attm length			Note: set *ATTL*=32
			EECR Basic Cloud Elements (15 characters):			
3	1	*CCe*	change code	0 [0]	13 [D]	[b36]
4	2	*WWe*	present weather	0	99	(*WW*)
5	1	*Ne*	total cloud amount	0	8	(*N*; *N*=9 edited)
6	1	*NHe*	lower cloud amount	0	8	(*NH*; *NH*=9 edited)
7	1	He	lower cloud base height	0	9	(H)
8	2	*CLe*	low cloud type	0	11	(*CL* edited)
9	2	*CMe*	middle cloud type	0	12	(*CM* edited)
10	1	*CHe*	high cloud type	0	9	(*CH* edited)
			EECR Derived Cloud Elements (8 characters):			
11	3	*AM*	middle cloud amount	0	8.00	0.01 oktas
12	3	*AH*	high cloud amount	0	8.00	0.01 oktas
13	1	*UM*	NOL middle amount	0	8	oktas
14	1	*UH*	NOL high amount	0	8	oktas
			EECR Sky Brightness Elements (9 characters):			
15	1	*SBI*	sky-brightness indicator	0	1	
16	4	*SA*	solar altitude	−90.0	90.0	0.1 degrees
17	4	*RI*	relative lunar illuminance	−1.10	1.17	hundredths

Table C95. Reanalyses QC/feedback (*Rean-qc*) attm. Intended to store selected QC and feedback information on the ICOADS observations, as made available from reanalysis projects.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=95
2	2	*ATTL*	attm length	b	b	Note: set *ATTL*=61
			Reanalysis QC/ feedback data and metadata (57 characters):			
3	2	*ICNR*	input component number—*Rean-qc*	0	99	IMMA component number
4	2	*FNR*	field number—*Rean-qc*	1	99	IMMA field no. within *ICNR*
5	2	*DPRO*	data provider—reanalysis: lead organization	1	99	lead organization ID (e.g., 1=ECMWF, 2=NOAA-NCEP, 3=NASA, 4=JMA)

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
6	2	*DPRP*	data provider—reanalysis: project	1	99	project ID (e.g., 1=ERA-20C, 2=CFSRv2, 3=MERRA, 4=JRA-55)
7	1	*UFR*	usage flag—reanalysis	1	6	1=assimilated and used, 2=assimilated and rejected, 3=blacklisted[1], 4=whitelisted[2], 5=available but unused, 6=none apply
8	7	*MFGR*	model-collocated first guess value or representative value in the case of ensemble methods	*(inh.[3])*	*(inh.[3])*	Inherited from *ICNR* & *FNR*, with numerical precision increased by one (additional) position right of the decimal to better accommodate numerical precision used in the assimilation process
9	7	*MFGSR*	model-collocated first guess spread[4]	–999999[5]	9999999[5]	" "
10	7	*MAR*	model-collocated analysis value or representative value in the case of ensemble methods	*(inh.[3])*	*(inh.[3])*	" "
11	7	*MASR*	model-collocated analysis spread[4]	–999999[5]	9999999[5]	" "
12	7	*BCR*	bias corrected value	*(inh.[3])*	*(inh.[3])*	" "
13	4	*ARCR*	author reference code—*Rean-qc*[6]	b	b	(alphanumeric)
14	8	*CDR*	creation date—*Rean-qc*[7]	20140101	2nnn1231	ISO-8601, YYYYMMDD
15	1	*ASIR*	access status indic.—*Rean-qc*	0	1	0=active, 1=inactive

1. Determined *a priori* to be erroneous and is not used.
2. Determined *a priori* to be used regardless of assimilation assessment.
3. The range, numeric precision, and units of measurement are all inherited from *ICNR* & *FNR*, e.g., *ICNR*=0 and *FNR*=29 refer to *AT*, which can range from –99.9 to 99.9, with precision and units of 0.1°C. Thus feedbacks on *AT* stored in this attm in *MFGR, MAR* and *BCR* have precision increased to 0.01°C, with range –99.99 to 99.99.
4. Optional field, used in the case of ensemble reanalyses.
5. Note: these ranges differ from those specified in other tables (e.g., –99.9 to 99.9 for *AT*) in that they represent scaled values (i.e., no decimal points are listed, if applicable).
6. *ARCR* as an optional field that is intended to point to a publication or technical report.
7. To be set by the external developer, as to when they produced the attm, ref.: http://en.wikipedia.org/wiki/ISO_8601.

Table C96. ICOADS Value-Added Database (*Ivad*) attm. Intended to store adjusted fields associated with *INCI* and *FNI*, whereas the unadjusted data will continue to be stored in the *Core*/other attms.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI=96*
2	2	*ATTL*	attm length			Note: set *ATTL*=53
			Value-added data and metadata (49 characters):			
3	2	*ICNI*	input component number—*Ivad*	0	99	IMMA component number
4	2	*FNI*	field number—*Ivad*	1	99	IMMA field no. within *ICNI*
5	1	*JVAD*	scaling factor for *VAD*	0 [0]	35 [Z]	10^{JVAD} ([b36])[1]
6	6	*VAD*	value-added data	*(inh.)*	*(inh.)*	10^{-JVAD} (units inherited)[2]
7	1	*IVAU1*	type indicator for *VAU1*	1 [1]	35 [Z]	([b36])
8	1	*JVAU1*	scaling factor for *VAU1*	0 [0]	35 [Z]	10^{JVAU1} ([b36])[1]
9	6	*VAU1*	uncertainty of type *IVAU1*	–99999	999999	10^{-JVAU1} (units inherited)[2]
10	1	*IVAU2*	type indicator for *VAU2*	1 [1]	35 [Z]	([b36])
11	1	*JVAU2*	scaling factor for *VAU2*	0 [0]	35 [Z]	10^{JVAU2} ([b36])[1]
12	6	*VAU2*	uncertainty of type *IVAU2*	–99999	999999	10^{-JVAU2} (units inherited)[2]
13	1	*IVAU3*	type indicator for *VAU3*	1 [1]	35 [Z]	([b36])
14	1	*JVAU3*	scaling factor for *VAU3*	0 [0]	35 [Z]	10^{JVAU3} ([b36])[1]
15	6	*VAU3*	uncertainty of type *IVAU3*	–99999	999999	10^{-JVAU3} (units inherited)[2]
16	1	*VQC*	value-added QC flag	1	4, 9	(see Supp D., Table C96a)
17	4	*ARCI*	author reference code–*Ivad*	b	b	(alphanumeric)
18	8	*CDI*	creation date—*Ivad*	20140101	2nnn1231	ISO-8601, YYYYMMDD (as for *CDR*, ref. Table C95)
19	1	*ASII*	access status indic.—*Ivad*	0	1	0=active, 1=inactive

1. Scaling factor applied to convert "*FVAD*," an input floating-point value, into *VAD* (i.e., representing also *VAU1*, *VAU2*, or *VAU3)* according to $VAD = FVAD \times 10^{JVAD}$. Then the original un-scaled value is reconstructed according to $FVAD = VAD \times 10^{-JVAD}$.
2. Only the units of measurement are inherited from *ICNI* & *FNI* (e.g., *ICNI*=0 and *FNI*=29 refer to *AT*, which has units of °C); the scaled range is as specified, and the numeric precision is determined (e.g., at run time by {rwimma1}) from the scaling factor (e.g., again taking the *AT* case: 0 = whole °C, 1 = 0.1°C, 2 = 0.01°C, etc.).

Table C97. Error (*Error*) attm. Designed to support correction of erroneous IMMA elements. Errors (e.g., callsign garbling) for a given *ICNE* and *FNE* will be stored by ICOADS in the *Core*/other attms, whereas uncorrected data will be stored in this *Error* attm—this is an inversion of the planned handling of data adjustments using the *Ivad* attm.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=97

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
2	2	*ATTL*	attm length			Note: set *ATTL*=32
			Corrected erroneous data and metadata:			
3	2	*ICNE*	input component number—*Error*	0	99	IMMA component number
4	2	*FNE*	field number—*Error*	1	99	IMMA field no. within *ICNE*
5	1	*CEF*	corrected/erroneous field flag	0	1	0: *ERRD* is the corrected value; 1: *ERRD* is the erroneous value
6	10	*ERRD*	corrected/erroneous field value	c[1]	c[1]	(units & numeric precision inherited from *ICNE* & *FNE*)
7	4	*ARCE*	author reference code–*Error*	b	b	(alphanumeric)
8	8	*CDE*	creation date—*Error*	20140101	2nnn1231	ISO-8601, YYYYMMDD (as for *CDR*, ref. Table C95)
9	1	*ASIE*	access status indic.—*Track*	0	1	0=active, 1=inactive

1. {rwimma1} initializes *ERRD Min., Max.* to c c but these values are changed to *(inh.)* after *ICNE* and *FNE* are known; fields are right-justified, e.g., *ID* is left-justified in *ERRD* characters two through ten.

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Table C98. Unique report ID (*Uida*) attm.

No.	Len.	Abbr.	Element description	Scaled Min.	Scaled Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=98
2	2	*ATTL*	attm length			Note: set *ATTL*=15
			Processing elements (10 characters):			
3	6	*UID*	unique report ID	b	b	(alphanumeric[1])
4	1	*RN1*	Release no.: primary	0 [0]	35 [Z]	e.g., 3 [b36]
5	1	*RN2*	Release no.: secondary	0 [0]	35 [Z]	e.g., 0 [b36]
6	1	*RN3*	Release no.: tertiary	0 [0]	35 [Z]	e.g., 0 (thus 3.0.0 together) [b36]
7	1	*RSA*	Release status indicator	0	2	0=Prelim., 1=Aux., 2=Full
8	1	*IRF*	intermediate reject flag	0	2	0=Retain in Intermediate, Reject from Final dataset; 1=Retain in both Intermediate and Final datasets; 2=Reject from both Intermediate and Final datasets

1. While it represents a base36 number, this field is handled by {rwimma1} as strictly (i.e., without leading spaces, e.g., 35=00000Z) alphanumeric, and thus is not fully translated into an integer or floating-point (REAL) number (ref. {rwimma1} comments: "For character […] fields, note that ITRUE and FTRUE contain the ICHAR of the first character of the field…"). Separate from {rwimma1} however, this Fortran library is available to transform *UID* into an integer (and vice versa): http://icoads.noaa.gov/software/base36.f. Users interested in handling *UID* as a number should be aware of possible finite precision issues arising in the representation of large numbers on computers:

- In the integer case, the largest 6-character base36 number is ZZZZZZ (2,176,782,335); however, if one bit is reserved for sign, the largest positive integer representable in 32 bits is only 2^{31}–1 (2,147,483,647; ZIK0ZJ in base36). As noted below the current maximum of *UID* is $m_{R2.5i}$ (~295M) and thus well below this threshold.
- Whereas, in the floating-point case it is not even possible to accurately represent $m_{R2.5i}$ as a 32-bit single precision REAL number.

Table C99. Supplemental data (*Suppl*) attm. This attm stores the original input data string, with recommended settings *ATTL*=0 (unspecified length) and *ATTE*=missing (ASCII). For processing via {rwimma1}, this attm must appear at the end of the record, and the record must terminate with a line feed.

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI*=99
2	2	*ATTL*	attm length			Note: set *ATTL*=0[1]
3	1	*ATTE*	attm encoding	0	1	Note: set *ATTE*=missing[2]
			Supplemental data (format determined by data source):			
4		*SUPD*[1]	supplemental data	c	c	

1. The length of the supplemental data is unspecified if *ATTL*=0, and may be variable. Thus far, *ATTL* in bytes has not been supported in the read/write IMMA programs (e.g., {rwimma1}).
2. Thus far, *ATTE*=1 (hexadecimal) has been used only for MORMET (deck 732) data (to represent binary input). This printable representation, which {rwimma1} treats identically to ASCII, was undocumented in previously available (i.e., IMMA0) Suppl. D information. In addition, while the *ATTE*=0 (base64 encoding; unprintable) representation is documented in Suppl. D, currently it is unused and not fully implemented in {rwimma1}.

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 LMR (http://icoads.noaa.gov/e-doc/lmr). Further detailed technical notes related more specifically to ICOADS, and to its current Release 3.0 (R3.0; Freeman et al. 2016) 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[2]). 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 ("rwimma1") is available (http://icoads.noaa.gov/software/).

Field configurations for proposed IMMA attms (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 are outlined in Supp. F and may warrant modification or

[2] As an exception, the (obsolete) 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.

expansion after international consideration.

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)[3]

Background: As for IMMT-5 except *HR*. In the NCDC-variant record, no longer produced (as well as in IMMT-5), 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 (2015) 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, now obsolete).

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-5 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-5) or octant numbers (WMO 2015 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

0 – version 0 (2010, http://icoads.noaa.gov/e-doc/imma/R2.5-imma.pdf)
1 – version 1 (the current version, 2016, this document)
2 – version 2
etc.

8) *ATTC* attm count

ATTC provides the attm count:

[3] Throughout Supp. D, floating-point ranges, if applicable, are provided as values would appear after applying the units scaling from the appropriate table in Supp. C to the integer values stored in the IMMA format.

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

Background: *IM* and *ATTC* 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 configuration of *IM* is similar to the IMMT-5 field "IMMT version" with a valid range 0-99. For IMMA1, the range of *ATTC* is extended to 10 and the representation is now base36.

9) *TI* time indicator
10) *LI* latitude/longitude indicator

TI preserves the incoming precision of the hour (*HR*) field. *TI* should always be extant when hour (*HR*) information exists; whereas *TI* should always be missing if hour (*HR*) is missing:

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. *LI* should always be extant when *LAT* and/or *LON* information exists; whereas *LI* should always be missing if *LAT* and *LON* are missing:

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 "nonrandom 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.

Note: In some cases, primarily in DCK 700, Ship Speed and Direction are populated with speed/directions from ships AND moored buoys. They were not populated for the drifting buoys from that DCK.

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 B2), 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/NCEI) for identified VOSClim ships, or to missing otherwise. [Note: Presently in R3.0 not all VOSClim ships were identified in all data sources, such that this indicator was set only sporadically. R3.0 VOSClim data obtained in the ICOADS-standard format should be identifiable by *NID*=1.]

14) *II* *ID* indicator

15) *ID* identification/callsign

II indicates whether a callsign or some other sort of identification is contained in the *ID* field (and in R3.0 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 callsign
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 (assigned by US NDBC or other organizations)
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
11 – 7-digit buoy ID

Background: *ID* is extended to nine characters (versus e.g., seven in IMMT-5). In platform track checking, for example, consideration should be given to using a combination of *II* and *ID*, since identical *ID*s 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 callsign 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 (see Table B4). Documentation of the format of such numbers generally appears to be unavailable (but could potentially be sought from individual countries), thus *II*=9 has generally been assigned only for earlier (pre-IMM) card decks for which the format of the information was known.] II=11 is new for ICOADS Release 3.0.2 as 7-digit buoy IDs are being decoded from BUFR for near-real-time monthly updates, but are not presently marked as such in R3.0/R3.1 major releases of ICOADS. Future expansion of the list of II values is likely with the advent of new WMO identifiers (e.g., WIGOS).

16) *C1* country code

The country that recruited a ship, which may differ from the country of immediate receipt (*C2*, field 15) 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 (http://icoads.noaa.gov/e-doc/lmr).]

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. *DI* should always be extant when *D* information exists; whereas *DI* should always be missing if *D* is missing:

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

Note: ICOADS convention for direction when the wind is calm, where reported wind direction is D=00 (WMO Code 1877) and wind speed is W=0, is different from that of WMO in that calm winds in ICOADS are reported as D=361 and W = 0. The WMO FM-13 format only allows for 2-digit wind directions 00-36.

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

Background: IMMT-5 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 2015). 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) for storage of wind direction in *D*. *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, see Table F2-1 in http://icoads.noaa.gov/Release_1/suppF.html).

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				

WMO Code 0877		*DI*				
Code	*Range*	*0*	*1*	*2*	*3*	*4*
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). W*I* should always be extant when *W* information exists; whereas *WI* should always be missing if *W* is missing:

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.]

9 – kilometer per hour, measured
10 – kilometer per hour, estimated

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). *VI* should always be extant when *VV* information exists; whereas *VI* should always be missing if *VV* is missing:

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-5 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 B2) as translated into the TDF-11 format.]

<u>23) *WW* present weather</u>
<u>24) *W1* past weather</u>

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* (*C5*, field 7).

Background: WMO Code 4561 also applies to *W2* (*C5*, field 8). 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 2015). Those alternative Codes have the same numerical ranges as *WW* (00-99) and *W1*/*W2* (0-9) but different meanings, and *IX* must be used to determine which codes are being utilized.

Table D3. WMO Code 4677 for present weather (*WW*) (after WMO 2015). Leading zero is omitted in IMMA. Large multi-line braces (“{” and “}”) as appear in WMO (2009a) are reproduced in this table by denoting the code groups to which text characteristics given in the first column (e.g., “No meteors except photometeors”) or last column apply by listing the codes in square [brackets] (e.g., “[00-03]”).

	Code		
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		
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,	04	Visibility reduced by smoke, e.g., veldt or forest fires, industrial smoke or volcanic ashes	

	Code		
sand or smoke [04-09]	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 meters on land or 10 meters at sea
	12	More or less continuous	
	13	Lightning visible, no thunder heard	
	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	Slight or moderate duststorm or sandstorm – has decreased during the preceding hour	
	31	Slight or moderate duststorm or sandstorm – no appreciable change during the preceding hour	
	31	Slight or moderate duststorm or sandstorm – has begun or has increased during the preceding hour	
	33	Severe duststorm or sandstorm – has decreased during the preceding hour	
	34	Severe duststorm or sandstorm – no appreciable change during the preceding hour	
	35	Severe duststorm or sandstorm – 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	

	Code		
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	
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	Shower(s) of snow pellets or small hail, with or –	Slight

	Code		
		without rain or rain and snow mixed	
	88	Shower(s) of snow pellets or small hail, with or – without rain or rain and snow mixed	Heavy
	89	Shower(s) of hail[4], with or without rain or rain and snow mixed, not associated with thunder	Slight
	90	Shower(s) of hail[4], with or without rain or rain and snow mixed, not associated with thunder	Heavy
	91 92 93 94	Slight rain at time of observation Moderate or heavy rain at time of observation Slight snow, or rain and snow mixed or hail[3] at time of observation Moderate or heavy snow, or rain and snow mixed or hail[3] at time of observation	[91-94] Thunderstorm during the preceding hour but not at time of observation
	95 96 97 98 99	Thunderstorm, slight or moderate, without hail[3], but with rain and/or snow at time of observation Thunderstorm, slight or moderate, with hail[3] at time of observation Thunderstorm, heavy, without hail[3], but with rain and/or snow at time of observation Thunderstorm combined with duststorm or sandstorm at time of observation Thunderstorm, heavy, with hail[3] at time of observation	[95-99] Thunderstorm 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-5 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 2015).

Code	Definition	Additional definition related to codes in brackets [ ].
0	Increasing, then decreasing; atmospheric pressure the same or higher than three hours ago	
1 2 3	Increasing, then steady; or increasing, then increasing more slowly Increasing (steadily or unsteadily)[1] Decreasing or steady, then increasing; or increasing, then increasing more rapidly	[1-3] Atmospheric pressure now higher than three hours ago
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	[6-8] Atmospheric pressure now

	more slowly	lower than three hours ago
7	Decreasing (steadily or unsteadily)[1]	
8	Steady or increasing, then decreasing; or decreasing, then decreasing more rapidly	

1. 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 *Core* temperature elements were translated from. *IT* should always be extant when any or all *AT, DPT, WB* and/or *SST* information exists; whereas *IT* should always be missing if *AT, DPT, WB* and *SST* are missing:

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-5; 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. *WBTI* should always be extant when *WB* information exists and *DPTI* should always be extant when *DP* information exists; whereas *WBTI* should always be missing if W*B* is missing and *DPTI* should always be missing if DP is missing:

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-5. [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. For R3.0, we are now translating more *RH* data into the IMMA1 *Immt* attm, both from modern GTS and IMMT sources.]

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-5 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.]

<u>36) *N* total cloud amount (cover)</u>
<u>37) *NH* lower cloud amount</u>

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 2015 (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).]

<u>38) *CL* low cloud type</u>

Codes 0 to 10 [A in base36 encoding] show characteristics observed of clouds of the genera Stratocumulus, Stratus, Cumulus, and Cumulonimbus (WMO Code 0513; see also background notes following *CH*, field 42).

<u>39) *HI* cloud height indicator</u>

HI shows if cloud height *H* was:

0 – estimated
1 – measured

Background: The "Cloud height and visibility measuring indicator" from IMMT-5 is separated into independent indicators in IMMA format, *HI* and *VI* (see field 21).

<u>40) *H* cloud height</u>

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
10 [A in base36 encoding] – 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 2015) concern *H* data reported from automatic stations.

<u>41) *CM* middle cloud type</u>

Codes 0 to 10 [A in base36 encoding] show characteristics observed of clouds of the genera Altocumulus, Altostratus, and Nimbostratus (WMO Code 0515).

<u>42) *CH* high cloud type</u>

Codes 0 to 10 [A in base36 encoding] 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-5, 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 2015, 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* ≤ 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 D5a, with *WX* (*C1*, field 13) 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 defined in IMMA, but not in use in R3.0. Future work should seek to recover confused sea information from original formats. Some NDBC wave data currently are transformed for storage in Table C5 fields (potentially inappropriate). Specifically, ICOADS contains increasing amounts of measured wave data from NOAA National Data Buoy Center (NDBC) moored buoys in the vicinity of the US coastline. These variables, in the NCDC (2003) TD-1171 format (ftp://ftp.ncdc.noaa.gov/pub/data/documentlibrary/tddoc/td1171.pdf, Note: no longer produced, since NDBC and NCEI have adopted a netCDF format going forward from ~2012), have been translated into IMMA variables (with a loss of data resolution, at least in the case of *WD*, which is represented in degrees in TD-1171 (e.g., 0-360) as compared to coded units of ten degrees in IMMA, e.g., 0-36):

WD = principal wave direction (pos. 84-86 in TD-1171)
WH = significant wave height (pos. 75-77 in TD-1171)
WP = dominant wave period (pos. 78-80 in TD-1171)]

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 (1968-1982), *SP* was reported as a code, which was converted into whole seconds per Table D5a (Table D5b), with *SX* (*C1*, field 14) 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 and ending in 1982.

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 (*Icoads*) attm (C1)

1) *ATTI* attm ID
2) *ATTL* attm length

Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=1 for *Icoads*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes.

Box elements

3) *BSI* box system indicator
4) *B10* 10° box number
5) *B1* 1° box number

10° and 1° box numbers (see *Release 1*, supp. G; http://icoads.noaa.gov/Release_1/suppG.html) 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

6) *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 C1, field 7 for additional information about the relationship between these two fields, and with the format of supplemental data).

Table D6a. Deck assignments (adapted regarding R2.5 from Table AII in Woodruff et al. 2011). For each deck number, the description, starting and ending years, and number of reports (in thousands) are listed for R2.5 and R3.0 output (blanks in these columns indicate that no data were input and/or output[1]). Decks replaced or augmented in R3.0, are listed in **bold**. ICOADS also offers preliminary data (now based on a blend of decks 792-797 and 992-995) extending beyond 2014, but not reflected in the last three columns.

		R2.5			*R3.0*		
Deck	*Description*	*Start*	*End*	*Rpts K*	*Start*	*End*	*Rpts K*
110	US Navy Marine	1945	1951	633	1945	1951	633
116	US Merchant Marine	1945	1963	6 866	1945	1963	6 860
117	**US Navy Hourlies**	**1952**	**1964**	**11**	**1950**	**1964**	**2 535**
118	Japanese Ships No. 1 (Kobe Collection Data keyed in 1961)	1930	1953	1 727	1930	1953	1 727
119	Japanese Ships No. 2 (Kobe Collection Data keyed in 1961)	1951	1961	904	1951	1961	904
128	International Marine (US- or foreign-keyed ship data)	1950	1978	14 537	1950	1978	14 440
143	Pacific Marine Environmental Laboratory (PMEL) Buoys	1976	1977	13	1976	1977	13
144	TAO/TRITON and PIRATA Buoys (from PMEL & JAMSTEC)[2]	1985	2004	7 192	1985	2004	496
145	PMEL (Daily) Equatorial Moorings and Island Stations[2]	1979	1991	17			
146	**Global Tropical Moored Buoy Array (GTMBA) from PMEL via NOC**				**1977**	**2014**	**13 852**
150	Pacific (US Responsibility) HSST Netherlands Receipts	1939	1961	85	1939	1961	85
151	Pacific (US Responsibility) HSST German Receipts	1862	1960	206	1862	1960	206
152	Pacific (US Responsibility) HSST UK Receipts	1855	1961	15	1855	1961	15
155	Indian (Netherlands Responsibility) HSST	1861	1960	1 068	1861	1960	1 068
156	Atlantic (German Responsibility) HSST	1852	1961	5 564	1852	1961	5 564
184	Great Britain Marine (194 extension)	1953	1961	344	1953	1961	344
185	USSR Marine IGY	1957	1958	111	1957	1958	111
186	USSR Ice Stations	1950	1970	20	1950	1970	20
187	Japanese Whaling Fleet	1946	1956	10	1946	1956	10
188	Norwegian Antarctic Whaling Factory Ships	1932	1939	2	1932	1939	2
189	Netherlands Marine	1939	1959	232	1939	1959	232
192	Deutsche Seewarte Marine	1855	1939	5 944	1855	1939	5 941
193	Netherlands Marine	1800	1938	6 276	1800	1938	6 276
194	Great Britain Marine	1856	1955	457	1856	1955	457
195	US Navy Ships Logs	1941	1946	598	1941	1946	598
196	Deutsche Seewarte Marine (192 extension)	1949	1954	143	1949	1954	143

197	Danish (and Other) Marine (Polar)	1871	1956	23	1871	1956	23
201-255[3]	UK Met. Office (MetO) Main Marine Data Bank (MDB)	1854	1994	15 212	1699	1944	18 003
281	US Navy Monthly Aerological Record (MAR)	1926	1945	187	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	1926	1945	187
666	Tuna Boats	1970	1975	17	1970	1975	17
667	Inter-American Tropical Tuna Commission (IATTC)	1971	1997	1 148	1971	1997	1 148
700	**UK Met. Office GTS BUFR Data**	2003	2007	10	**2000**	**2012**	**13 402**
701	US Maury Collection	1784	1863	1 346	1784	1863	1 345
702	Norwegian Logbook Collection	1867	1889	201	1784	1863	1784
703	**US Lightship Collections**				**1931**	**1980**	**201**
704	US Marine Meteorological Journals Collection (1878-94)	1878	1894	1 761	1878	1894	1 761
705	US Merchant Marine Collection (1912-46) (500 series)	1910	1946	1 014	1910	1946	1 014
706	US Merchant Marine Collection (1912-46) (600 series)	1910	1944	2 062	1910	1944	2 062
707	US Merchant Marine Collection (1912-46) (700 series)	1913	1941	425	1913	1941	425
708	**US Navy Marine (US-keyed ship data; hourly METAR format)**				**2001**	**2012**	**387**
709	**US Navy Marine (IMMA formatted by US Navy)**				**2004**	**2006**	**8**
710	**US Arctic Logbooks (OldWeather)**				**1870**	**1946**	**165**
711	**Weather Detective Crowdsourcing**				**1889**	**1899**	**36**
714	**Canadian Oceanography and Scientific Data (OSD; formerly ISDM/MEDS) Buoys**	1978	2007	57 274	**1978**	**2014**	**132 741**
715	German Deep Drifter Data (via OSD; originally from IfM/Univ. Kiel)	1980	1996	1 031			
720	**Deutscher Wetterdienst (DWD) Marine Met. Archive**	1876	1914	976	**1868**	**1988**	**2 100**
721	**German Maury Collection**				**1845**	**1868**	**538**
730	Climatological Database for the World's Oceans (CLIWOC)	1662	1855	261	1662	1855	261
731	Russian S.O. Makarov Collection	1804	1891	3	1662	1855	261

732	Russian Marine Met. Data Set (MORMET) (rec'd at NCAR)	1888	1995	7 873	1888	1995	7 527
733	Russian AARI North Pole (NP) Stations	1937	1991	98	1937	1991	98
734	**Arctic Drift Stations**	1893	1924	12	**1893**	**1924**	**13**
735	Russian Research Vessel (R/V) Digitization	1936	2000	1 789	1936	2000	1 789
736	Byrd Antarctic Expedition (keyed by Hollings Scholars)	1929	1934	1	1929	1934	1
740	**Research Vessel (R/V) Data Quality-Evaluated by FSU/COAPS**	1990	1998	56	**1990**	**2014**	**771**
749	First GARP Global Experiment (FGGE) Level IIb	1978	1979	6	1978	1979	6
750	**Australian Navy Vessels: SST Data (1972-77)**				**1974**	**1977**	**4**
761	Japanese Whaling Ship Data (CDMP/MIT digitization)	1946	1984	20	1946	1984	20
762	Japanese Kobe Collection Data (keyed after decks 118-119)	1889	1940	3 135	1889	1940	3 135
780	**NOAA/NCEI World Ocean Database (WOD) (and formerly Atlas, WOA)**	1800	2015	15 200	**1770**	**2014**	**12 000**
781	**Chinese/Global Ocean Data Archeology and Rescue (GODAR) Ships**				**1968**	**1993**	**382**
782	**Global Ocean Surface Underway Data (GOSUD)**				**1980**	**2014**	**1 578**
792	**US Natl. Cntrs. for Environ. Pred. (NCEP) BUFR GTS: Ship Data**	1998	2007	5 889	**1998**	**2014**	**1 351**
793	**NCEP BUFR GTS: Buoy Data (transmitted in FM 13 "SHIP" code)**	1998	2007	10 545	**1998**	**2014**	**21 876**
794	**NCEP BUFR GTS: Buoy Data (transmitted in FM 18 "BUOY" code)**	1998	2007	1 950	**1998**	**2014**	**2 800**
795	**NCEP BUFR GTS: Coastal-Marine Automated Network (C-MAN code) Data**	2005	2007	4 056	**2008**	**2014**	**6 768**
796	NCEP BUFR GTS: Miscellaneous (OSV, plat, and rig) Data						
797	**NCEP BUFR GTS: CREX code**				**2008**	**2014**	**2 824**
798	**NCEI BUFR GTS**				2015		
799	**Saildrones**				2015		
849	First GARP Global Experiment (FGGE)	1978	1979	250	1978	1979	250
850	German FGGE	1978	1979	146	1978	1979	146
874	**Shipboard Environmental (Data) Acquisition System (SEAS)**	1991	2007	504	**1995**	**2014**	**67**
875	**US TurboWin (e-Logbook) Voluntary Observing Ship (VOS) Receipts**				**2012**	**2014**	**2**

876-882[4]	US National Data Buoy Center (NDBC) Data	1972	1979	315	1972	1979	315
883[4]	**US National Data Buoy Center (NDBC) Data**	1980	2004	20 538	**1980**	**2012**	**49 763**
888	US Air Force Global Weather Central (GWC)	1973	1997	5 993	1973	1997	5 987
889	Autodin (US Dept. of Defense Automated Digital Network)	1972	1995	1 039	1972	1995	1 038
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	1980	1997	9 190
893	NCEP Moored Buoy Data	1986	1997	2 225	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	1980	1997	575
897	*Eltanin*	1962	1963	1	1962	1963	1
898	Japanese	1954	1974	121	1954	1974	121
899	South African Whaling	1900	1955	64	1900	1955	64
900	Australian	1931	1979	386	1931	1979	386
901	FOSDIC Reconstructions (card images from 16mm film)	1868	1963	7	1931	1979	386
902	Great Britain Marine (184 extension)	1957	1961	99	1957	1961	99
926	**International Maritime Meteorological (IMM) Data**	1954	2007	25 372	**1954**	**2014**	**30 612**
927	**International Marine (US- or foreign-keyed ship data)[5]**	1970	2007	11 138	**1970**	**2012**	**11 160**
928	Same as 927 including Ocean Station Vessels (OSV)	1970	1974	4	1970	1974	4
992	**NCEI GTS: Ship Data**				**1999**	**2014**	**14 231**
993	**NCEI GTS: Buoy Data (transmitted in FM 13 “SHIP” code)**				**1999**	**2014**	**8 019**
994	**NCEI GTS: Buoy Data (transmitted in FM 18 “BUOY” code)**				**1999**	**2014**	**1 428**
995	**NCEI GTS: Coastal-Marine Automated Network (C-MAN code) Data**				**1999**	**2014**	**16 054**
996	NCEI GTS: Miscellaneous (OSV, plat, and rig) Data						
997	NCEI GTS: CREX code						
999	US Air Force Environ. Technical Applications Center (ETAC)	1967	1969	37	1967	1969	37

1. Some of these decks (ref. http://icoads.noaa.gov/e-doc/lmr) were used in ICOADS prior to R3.0; others have not been used (e.g. deck 500 was input for Release 1a, but not output). LMR documentation also defined

for real-time data processing unofficial deck numbers 001-009, which have not actually been 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) are listed for R2.5 and R3.0 output (blanks in the last three columns indicate that no data were input and/or output). Decks entirely new to (or replaced in) R3.0, are listed in **bold**. 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.

		R2.5			*R3.0*		
Deck	*Description*	*Start*	*End*	*Rpts K*	*Start*	*End*	*Rpts K*
201	All Ships (1930 code) (1850-1920)	1854	1956	1 403	1854	1956	1 403
202	All Ships (1921 code) (1921-29)	1915	1938	1 170	1915	1938	1 170
203	Selected Ships (1930 code) (1920-39)	1929	1961	416	1929	1961	416
204	British Navy (HM) Ships (1930 code) (1930-48)	1929	1949	115	1929	1949	115
205	Scottish Fishery Cruisers MARIDS (1930 code) (1946-56)	1945	1956	17	1945	1956	17
206	Ocean Weather Stations (OWS) (1930 code) (1947-49)	1947	1948	2	1947	1948	2
207	Selected Ships (1930 code) (1945-48)	1945	1953	390	1945	1953	390
208	Light Vessels (1949-56)						
209	Selected Ships (including some foreign ships) (1951-56)	1951	1956	458	1951	1956	458
210	OWS (including Dutch "J") (1950-56)	1950	1956	4	1950	1956	4
211	Scottish Fishery Cruisers MARIDS (1956-61)	1956	1961	41	1956	1961	41
212	Light Vessels (1956-61)						
213	Selected Ships (1956-61)	1953	1962	1 133	1953	1962	1 133
214	OWS (1956-61)	1956	1961	8	1956	1961	8
215	German Marine (1860-1938)[1]	1860	1940	802	1860	1940	802
216	UK Merchant Ship Logbooks (METFORMS; keyed in 1996) (1935-39)	1935	1939	457	1935	1939	457
218	US OWS (1953-)	1953	1963	9	1953	1963	8
221	MARIDS and Trawlers (1961-)	1962	1988	60	1962	1988	60
222	Light Vessels (1961-)						
223	Selected Ships (1961-81)	1962	1982	416	1962	1982	416
224	OWS (1961-81)	1976	1981	2	1976	1981	2
225	Norwegian Format (1953-)						
226	OWS (1949 code) (1949-52)	1949	1952	3	1949	1952	3
227	Selected Ships (1949-53)	1947	1954	479	1947	1954	479
229	British Navy (HM) Ships (1961-)	1953	1981	50	1953	1981	50
230	Int. Maritime Met. Punched Card (IMMPC) Data (1960-81)	1962	1971	1 102	1962	1971	1 102
233	Selected Ships (1982-)	1982	1994	48	1982	1994	48

234	OWS (1982-)	1982	1994	1	1982	1994	1
235	RIGG, PLAT, Automatic Weather-Observing System (AWS; buoy) (1982-)						
239	British Navy (HM) Ships (1982-)	1953	1993	42	1953	1993	42
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	1936	1955	1 423
246	**Atmospheric Circ. Reconstructions over the Earth (ACRE) Digitized Data: Print./Published Expeditions (held at Met. Office)**				**1699**	**1940**	**128**
247	**ACRE Digitized Data: *Challenger* Expedition**				**1872**	**1876**	**16**
248	**English East India Co. (EEIC) Ship Logs**				**1789**	**1834**	**247**
249	**Extended WW1 UK Royal Navy Ship's Logs (OldWeather)**				**1912**	**1925**	**983**
254	Int. Maritime Met. (IMM) Data (foreign or unknown origin)	1860	1994	6 561	1860	1994	6 556
255	Undocumented TDF-11 Decks or MDB Series	1857	1994	23	1857	1994	23

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) are listed for R2.5 and R3.0 output (blanks in the last three columns indicate that no data were input and/or output[1]).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.

		R2.5			*R3.0*		
Deck	*Description*	*Start*	*End*	*Rpts K*	*Start*	*End*	*Rpts K*
876	NDBC Data (High Capability Buoy; HCB)	1972	1977	36	1972	1977	36
877	NDBC Data (Limited Capability Buoy; LCB)	1973	1976	5	1973	1976	5
878	NDBC Data (Prototype Environmental Buoy; PEB)	1974	1978	43	1974	1978	43
879	NDBC Data (5-meter Continental Shelf Buoys)	1974	1978	46	1974	1978	46
880	NDBC Data (10-meter Continental Shelf Buoys)	1976	1978	8	1976	1978	8
881	NDBC Data (Offshore Platforms)	1976	1977	1	1976	1977	1
882	NDBC Data	1978	1979	175	1978	1979	175
883	**NDBC Data (latest version from NCDC)**	1980	2004	20 538	**1980**	**2012**	**49 763**

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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7) *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. 2011). For each *SID* number, the description, starting and ending years, and number of reports (in thousands, where "<1" signifies a report count falling in the range 1-499) are listed for R2.5 and R3.0 output (blanks in the last three columns indicate that no data were input and/or output[1]). *SIDs* entirely new to (or replaced in) R3.0, are listed in **bold**. ICOADS also offers preliminary data (presently based on a blend of *SIDs* 103 and 114) extending beyond 2014, but not reflected in the last three columns.

		R2.5			*R3.0*		
SID	*Description*	*Start*	*End*	*Rpts K*	*Start*	*End*	*Rpts K*
0	*[reserved]*						
1	Atlas	1800	1969	32 713	1800	1969	32 651
2	HSST Pacific	1855	1961	405	1855	1961	404
3	HSST Indian	1861	1960	1 068	1861	1960	1 068
4	HSST Atlantic	1852	1961	5 564	1852	1961	5 564
5	Old TDF-11 Supplement B	1854	1975	2 694	1854	1975	2 652
6	Old TDF-11 Supplement C	1855	1978	2 625	1855	1978	2 625
7	Monterey Telecommunications	1966	1969	661	1966	1969	661
8	Ocean Station Vessels (OSV)	1945	1973	822	1945	1973	819
9	OSV Supplement	1947	1973	57	1947	1973	49
10	MSQ 486 and 105 Omissions	1854	1968	172	1854	1968	171
11	US National Oceanographic Data Center (NODC) Surface						
12	US NODC Surface Supplement						
13	*Eltanin*	1962	1963	1	1962	1963	1
14	Japanese	1954	1974	121	1954	1974	121
15	South African Whaling	1900	1955	64	1900	1955	64
16	Australian	1931	1970	192	1931	1970	192
17	International Maritime Meteorological (IMM) Data	1956	1979	224	1956	1979	224
18	'70s Decade	1970	1979	12 183	1970	1979	12 163
19	IMM '70s	1978	1979	<1	1978	1979	<1
20	OSV Z ('70s)	1970	1974	1	1970	1974	1
21	Australian ('70s)	1971	1979	194	1971	1979	194
22[2]	NCDC: 1980-84 Annual Receipts	1982	1987	135	1982	1987	135
23	'70s Mislocated Data	1973	1979	2	1973	1979	2
24	Buoy Data	1972	1979	192	1972	1979	192
25-28[3]	NCDC: 1980-85 Annual Receipts	1962	1985	1 534	1962	1985	1 534
29	NCDC: US Nat. Met. Center (NMC, now NCEP) Reconversion (1980-92)	1980	1992	8 201	1980	1992	8 189
30	NCDC: 1980-84 Period of Record	1965	1984	4 192	1965	1984	4 185
31	Corrected Canadian Data						
32-33[3]	NCDC: Annual Receipts (and duplicates; starting in 1986)	1974	1997	4 440	1974	1997	4 435
34-45[3]	NCDC: 1986-97 Receipts (delayed)	1969	1996	1 251	1969	1996	1 251
46-47[3]	International Maritime Met. (IMM) Tape Archive (1982-)	1969	1995	7 117	1969	1995	7 116

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	1980	1997	12 770
51-52[3]	Russian AARI North Pole (NP) Stations	1937	1991	98	1937	1991	98
53	First GARP Global Experiment (FGGE) Level IIb: Surface Marine Data	1978	1979	6	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	1804	1891	3
57	Russian Marine Meteorological Data Set (MORMET) (rec'd at NCAR)	1888	1993	7 873	1888	1993	7 527
58	French International Maritime Met. (IMM) Uncorrected (1954-88)						
59	UK IMM Corrections (1982-89)	1982	1989	1 552	1982	1989	1 552
60	French International Maritime Met. (IMM) Corrected	1954	1988	159	1954	1988	159
61	Canadian Oceanography and Scientific Data (OSD; formerly ISDM/MEDS) Buoys						
62	OSD (formerly ISDM/MEDS) World Ocean Circulation Experiment (WOCE) Buoys						
63	**Canadian OSD (formerly ISDM/MEDS) Buoys (July 2005 archive extended by Dec. 2008, & by May 2015 for 2008-14)**	1978	2007	57 274	**1978**	**2014**	**132 741**
64	Russian Research Vessel (R/V) Digitization: Marine Surface	1936	2000	1 153	1936	2000	1 153
65	Russian Research Vessel (R/V) Digitization: Marine Actinometric	1947	2000	637	1947	2000	637
66	Pacific Marine Environmental Lab. (PMEL) TOGA/TAO Buoys	1985	1992	236	1985	1992	188
67	PMEL (Daily) Equatorial Moorings and Island Stations	1979	1991	17			
68	Arctic Drift Stations	1893	1924	12	1893	1924	12
69	US Maury Collection	1784	1863	1 346	1784	1863	1 345
70	Inter-American Tropical Tuna Comm. (IATTC) Porpoise Obs. Logs	1979	1997	736	1979	1997	736
71	IATTC Fishing Logs	1971	1997	413	1971	1997	413
72	IMM Tape Archive from WMO Global Collecting Centre (GCC) (1994 format)	1982	1997	3 808	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)						
76	NCDC MOPS: Supplementary or Correction Data						
77	NCDC: US National Cntrs. for Environ. Pred. (NCEP) Reconversion (1994-97)	1994	1997	2 609	1994	1997	2 605
78	NCDC: US-keyed Logbook Data Reconversion (TD-9972; keyed during 1996-97)	1987	1997	307	1987	1997	307
79	US Air Force Global Weather Central (GWC): DATSAV2 format	1980	1997	1 469	1980	1997	1 465
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	1910	1944	1 927
85	US Merchant Marine Collection (1912-46): Partial QC	1910	1946	1 246	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	1856	1994	9 267
91	MetO MDB: Flatfile 1A (Flatfile plus cardimage data)	1854	1979	5 413	1854	1979	5 413
92	MetO MDB: Flatfile 1B (no Flatfile match; data derived from cardimage)	1855	1978	69	1855	1978	68
93	MetO Historical Metforms (1935-39): Flatfile 1C (data from cardimage)	1935	1939	457	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	1889	1940	3 135
96	Norwegian Logbook Collection	1867	1889	201	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	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	1998	1999	1 706
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	**1999**	**2014**	**33 912**
104-108	*[reserved]*						
109	**US Navy Marine (US-keyed ship data; hourly METAR format)**				**2001**	**2012**	**387**
110	**UK Met. Office VOSClim GTS BUFR Data**	2003	2007	10	**2000**	**2010**	**10 593**
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	**1982**	**2014**	**13 238**
113	**International Marine (US-keyed ship data)**	1992	2007	533	**1992**	**2012**	**575**
114	**NCEI TAC GTS**				**1999**	**2014**	**39 823**
115	Japanese Whaling Ship Data (CDMP digitization)	1946	1984	20	1946	1984	20

116	Japanese Whaling Ship Data (MIT digitization)	1951	1976	<1	1951	1976	<1
117	PMEL TAO/TRITON and PIRATA Research Archive Hourly Average Data	1990	2001	3 394	1990	2001	3
118	PMEL TAO/TRITON and PIRATA Research Archive 10-Minute Average Data	1996	2004	2 746	1997	2004	5
119	JAMSTEC TRITON Hourly Average Data	1998	2004	595	1998	2004	299
120	PMEL TAO/TRITON and PIRATA Research Archive Hourly Average SLP Data	2000	2004	222	2001	2004	<1
121	**US National Data Buoy Center (NDBC) Data (obtained from NCDC 2005-2012)**	**1998**	**2004**	**7 768**	**1998**	**2012**	**13 085**
122	**US NDBC data (NODC f291 archive version translated by NCDC 2008)**				**1980**	**2008**	**23 908**
123	*[reserved]*						
124	Climatological Database for the World's Oceans (CLIWOC; Release 2.0)						
125	US Marine Meteorological Journals Collection	1878	1894	1 761	1878	1894	1 761
126	Royal Navy Ship's Logs (keyed by 2007)	1936	1955	1 423	1936	1955	1 423
127	Antarctic Expeditions: Print./Published (held at Met Office)	1898	1940	35	1898	1940	25
128	**North Polar Expedition of the Fram (digitized by Environment Canada**				**1898**	**1902**	**1**
129	Byrd Antarctic Expedition (keyed by Hollings Scholars)	1929	1934	1	1929	1934	1
130	Research Vessel (R/V) Data Quality-Evaluated by FSU/COAPS: WOCE ver.3.0	1990	1998	56	1990	1998	56
131	**Research Vessel (R/V) Data Quality-Evaluated by FSU/COAPS: SAMOS**				**2005**	**2014**	**714**
132	Research Vessel (R/V) Data Quality-Evaluated by FSU/COAPS: Other						
133	Climatological Database for the World's Oceans (CLIWOC; Release 2.1, limited edition)	1662	1855	261	1662	1855	261
134	Deutscher Wetterdienst (DWD) Marine Meteorological Archive: Compo Subset	1884	1914	580	1884	1914	580
135	DWD Marine Meteorological Archive: Newly Digitized Data	1876	1902	395	1876	1902	395
136	DWD Marine Meteorological Archive: HISTOR Data	1882	1899	<1	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	1872	1876	16
139	German Deep Drifter Data (via OSD; originally from IfM/Univ. Kiel)	1980	1996	1 031			
140	**US Navy Hourlies: Deck 117 in TD-1100 format**				**1950**	**1964**	**15**
141	**US Navy Hourlies: Original card deck 117 format (from FOSDIC)**				**1951**	**1964**	**3**
142	**US Navy Hourlies: Original card deck 117 format (from NCEI DSI-1117)**				**1951**	**1964**	**2 516**
143	**Chinese/Global Ocean Data Archeology and Rescue (GODAR) Ships**				**1968**	**1993**	**382**
144	**US Lightship Collection: Woods Hole Oceanographic Institution**				**1931**	**1980**	**201**
145[4]	US Lightship Collection: National Archives and Records Admin.						
146	**UK Met. Office & NOC: VOSClim-compliant GTS BUFR Data: Historical ship/buoy (FM 13)**				**2010**	**2012**	**1 938**

147	**UK Met. Office & NOC: VOSClim-compliant GTS BUFR Data: Historical buoy (FM 18)**				**2000**	**2012**	**871**
148	**English East India Co. (EEIC) Ship Logs (containing instrumental data)**				**1789**	**1834**	**247**
149	**NOAA/NCEI 2013 World Ocean Database (WOD13) updated through 24-02-2015**				**1770**	**2014**	**11 974**
150	**Shipboard Environmental (Data) Acquisition System (SEAS9.1): IMMT-5 format**				**2013**	**2014**	**<1**
151	**US TurboWin (TurboWin 5.0) (e-Logbook) VOS Receipts: IMMT-4 format**				**2012**	**2014**	**2**
152	**German Maury Collection**				**1845**	**1868**	**538**
156	**Australian Navy Vessels: SST Data (1972-77)**				**1974**	**1977**	**4**
157	**US Navy Marine (IMMA formatted by US Navy)**				**2004**	**2006**	**8**
158	**US TurboWin+ (e-logbook) VOS Receipts: IMMT-5**				**2014**	**2014**	**<1**
159	**Global Ocean Surface Underway Data (GOSUD v2) from NCEI in WOD format received 19 May 2015**				**1980**	**2013**	**539**
160	**DWD Marine Meteorological Archive: HISTOR Data (receipts in 2015)**				**1868**	**1907**	**167**
161	**DWD German Light Vessels (receipts in 2014)**				**1929**	**1988**	**925**
162	**GOSUD v3 real-time data from NCEI in WOD format received 30 April 2015**				**2014**	**2014**	**10**
163	**GOSUD v3 near real-time data from NCEI in WOD format received 30 April 2015**				**2000**	**2014**	**838**
164	**GOSUD delayed-mode French research vessels and sailing ship data from NCEI in WOD format received 30 April 2015**				**2001**	**2014**	**191**
165	**World War I (WW1) UK Royal Navy Logbooks (OldWeather) (1914-23) (Accessed 29 May 2015)**				**1912**	**1925**	**983**
166	**US Navy Arctic Logbooks (OldWeather) (Accessed 29 May 2015)**				**1870**	**1946**	**165**
167	**ACRE Historical Digitised (expeditionary and other spreadsheets) - Translated by UK Met Office**				**1699**	**1930**	**98**
168	**ACRE Historical Digitised (expeditionary and other spreadsheets) - Translated by NCEI**				**1816**	**1872**	**5**
169	**Global Tropical Moored Buoy Array (GTMBA) from PMEL via NOC RT**				**1998**	**2014**	**1 990**
170	**Global Tropical Moored Buoy Array (GTMBA) from PMEL via NOC DM**				**1977**	**2014**	**11 862**
171	**Australian Abstract Logs (Wragge Collection) from Weather Detective Crowdsourcing (Accessed 29 May 2015)**				**1889**	**1899**	**36**
172	**NCEI BUFR GTS**				**2015**		
173	**Saildrones in IMMA from Earth & Space Research**				**2015**		

1. Some of these SIDs (ref. http://icoads.noaa.gov/e-doc/lmr) 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.

8) *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 (or mobile) 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).

9) *DUPS* dup status

Indicates duplicate status (Table D8). For the final R3.0 product, reports with *DUPS*>2 were not output (and landlocked *LZ*=1 reports were eliminated; see *R3.0-stat_trim:* http://icoads.noaa.gov/e-doc/R3.0-stat_trim.pdf). However, to allow for more detailed analysis of the processing results and possible adjustments, all those flagged reports were retained in R3.0 "total" datasets (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. Prior to R3.0 processing, settings marked by footnotes apply only to pre-1980 data. For R3.0 processing, *DUPS*=3, 5, 6, and 7 were no longer used (indicated by grey shading).

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 R2.0, applied to 1784-1979 data; for R2.5, applied to 1662-1979 data.
2. For *Release 1*, applied to 1854-1969 data; for R2.0, applied to 1784-1969 data; for R2.5, applied to 1662-1969 data.

___

10) *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 – no GTS and logbook match was encountered

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

11) *TC* track check

TC, if set, indicates if a report was:

0 – not track checked
1 – track checked

Background: This indicator, which refers exclusively to track-checking procedures performed by external data providers, was unused prior to Release 2.0, and remains missing in most data. Specifically, only these decks were set to have *TC*=1 (either for R2.0, or for deck 721 for R3.0):

701	US Maury Collection
702	Norwegian Logbook Collection
704	US Marine Meteorological Journals Collection (1878-94)
721	German Maury Collection (set for R3.0)
733	Russian AARI North Pole (NP) Stations

Consequently, records from these decks with *TC*=1 are also available in R3.0.

12) 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, http://icoads.noaa.gov/e-doc/lmr, for additional information).

13) *WX* wave period indicator

14) *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

15) *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 code tables and additional information).

QC elements

16-27) *SQZ-DQA* adaptive QC flags

28) *ND* night/day flag

ND is extant when HR information is available, but can be present when DY is missing:

The night/day report flag was set to indicate whether the report fell in local nighttime or daytime (as determined in Release 1, supp. A, calculated based on day-length calculated from mid-month declination):

1 = report time is local nighttime

2 = report time is local daytime

29-34) *SF-RF* trimming flags

35-48) *ZNC-TNC* NCDC-QC flags

Table D9a below contains the abbreviation and flag name for each NCDC QC field. Table D9b provides the flag values associated with each NCDC-QC flag. More information on these flags can be found at http://icoads.noaa.gov/e-doc/R3.0-stat_trim.pdf.

Table D9a. NCDC-QC flag names and abbreviations.

IMMA1 Abbreviation	**Flag Description**
ZNC	Ship position flag
WNC	Wind flag
BNC	VV flag
XNC	WW flag
YNC	W1 flag
PNC	SLP flag
ANC	AT flag
GNC	WBT flag
DNC	DPT flag
SNC	SST flag
CNC	Cloud flag
ENC	Wave flag
FNC	Swell flag
TNC	Pressure tendency flag

Table D9b. NCDC-QC flags and associated values.

IMMA1 Flag Value	**Meaning**	**Reason**

1	Correct	-
2	Correctable	Legality
3	Correctable	Internal Consistency
4	Suspect	Internal Consistency
5	Suspect	Time
6	Suspect	Extreme (outside +/- 4.8σ)
7	Erroneous	Legality
8	Erroneous	Internal Consistency
9	Erroneous	Extreme (outside +/- 5.8σ)
10	Missing	-

49) *QCE* external (e.g., OSD)
50) *LZ* landlocked flag
51) *QCZ* source exclusion flags
Quality control and related flags, are described in more detail in *R3.0-stat_trim* (http://icoads.noaa.gov/e-doc/R3.0-stat_trim.pdf).

IMMT-5/FM 13 (*Immt*) attm (C5)

The fields described below are as they appear in IMMT-5. Many reports in R3.0 however come from older IMMT (or IMMPC) versions (see Supp. B) and may not contain data for every field within the *Immt* attm.

1) *ATTI* attm ID
2) *ATTL* attm length
Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=5 for *Immt*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes.

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

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, the IMMT version (see Supp. B, Table B2) has been added to IMMA (see C5, field 6) to allow proper interpretation of the observation source. [Note: Formerly in IMMT versions 0-3 (usage now discontinued): codes 1-3 also referred to “National data exchange," and codes 4-6 also referred to "International data exchange"; distinction added between paper and electronic logbook].

4) *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 – 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 B2) has been added to IMMA (see C5, field 6) to allow proper interpretation of the observation source. [Note: Formerly in IMMT versions 0-3 (usage now discontinued): code 4 referred to "Automated station/data buoy;" and codes 7-8 referred to "Aircraft" and "Satellite," respectively].

5) *FM* FM code version

GTS traditional alphanumeric SHIP code "FM" version (see WMO 2015).

0 – previous to FM 24-V
1 – FM 24-V
2 – FM 24-VI Ext.
3 – FM 13-VII
4 – FM 13-VIII
5 – FM 13-VIII Ext.
6 – FM 13-IX
7 – FM 13-IX Ext.
8 – FM 13-X
9 – FM 13-XI
A – FM 13-XII Ext.
B – FM 13-XIII
C – FM 13-XIV Ext.

Background: A 1-character field in IMMT (see Supp. B, Table B2), which is stored in IMMA1 as a 1-character base36 value (see Table 1) to allow for expansion (in IMMA0 *FM* was a 2-character field). Yoshida (2004) describes use at least back to 1949 of the "FM" notation (e.g., in FM 21 SHIP and FM 22 SHIP). [Note: While the IMMT-5 range of this input field is only 0-C, and the IMMA0 range of this field was tightly constrained to 0-8 (reflecting the legal range of the input data at IMMT-2), the IMMA0 range was not increased to account for expansions in the range of this field associated with the intermediate IMMT-3/4 updates. Thus increasing the *FM* max. for IMMA1 accommodates future IMMT field adjustments without requiring adjustment in the IMMA1 configuration (but conversely offers less stringent control on the legality of the *FM* data).]

6) *IMMV* IMMT version

Indicates the applicable IMMT version within the attm, which accommodates some format evolution problems, e.g., in that some IMMT fields changed meaning between IMMT-3 and IMMT-4.

- 0 – IMMT version just prior to version number being included
- 1 – IMMT-1 (in effect from 2 Nov. 1994)
- 2 – IMMT-2 (in effect from Jan. 2003)
- 3 – IMMT-3 (in effect from Jan. 2007)
- 4 – IMMT-4 (in effect from Jan. 2011)
- 5 – IMMT-5 (in effect from June 2012)

7) *IX* station/weather indicator
8) *W2* second past weather

IX (WMO Code 1860) indicates both whether the station is manned or automatic, and the status of present (*WW*, see C0, field 23) and past (*W1*, *W2*; WMO Code 4561, see C0, field 24) weather data. *IX* should always be extant when *WW, W1* and/or *W2* information exists; whereas *IX* should always be missing if *WW, W1* and *W2* are missing:

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 2015, 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.]

9) *WMI* indicator for wave measurement

WMI corresponds to the IMMT-5"indicator for wave measurement". *WMI* should always be extant when *SD2, SP2,* and/or *SH2* information exists; whereas *WMI* should always be missing if *SD2, SP2,* and *SH2* are missing:

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.]

<u>10) *SD2* swell direction (2nd)</u>
<u>11) *SP2* swell period (2nd)</u>
<u>12) *SH2* swell height (2nd)</u>
Configurations as for *SD*, *SP*, and *SH* (C0, 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.]

<u>*13) IS* ice accretion</u>
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

<u>*14) ES* ice thickness</u>
Ice accretion thickness on the ship in centimeters.

<u>*15) RS* ice accretion rate</u>
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

<u>16) *IC1* concentration of sea ice</u>
<u>17) *IC2* stage of development</u>
<u>18) *IC3* ice of land origin</u>
<u>19) *IC4* true bearing ice edge</u>
<u>20) *IC5* ice situation/trend</u>
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-5 except for use of “A” (10 in base36) in place of “/.”

Background: Separate fields (or a 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 B4 of Supp. B). Ice codes used at least for early telecommunicated data from ~1947-82 can be found at http://icoads.noaa.gov/reclaim/pdf/Met_O_509.pdf. [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.]

21) *IR* indicator for precipitation data

Values from WMO Code 1819

22) *RRR* amount of precipitation

Values from WMO Code 3590

23) *TR* duration of period of reference for amount of precipitation

Values from WMO Code 4019

IR should always be extant when *RRR* and/or *TR* information exists; whereas *IR* should always be missing if *RRR* and *TR* are missing

Configurations are as in IMMT-5.

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.]

24) *NU* National use

A field available for national use in identifying data subsets copied from IMMT format.

25) *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-5 (https://www.wmo.int/pages/prog/amp/mmop/documents/IMMT-5-JCOMM-4.pdf):

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 CMas correct (1), but according to MQCS still appears suspect (2-4) or 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: For values from formats IMMT0-3, code meanings for values 6-8 have changed multiple times over the course of the IMMT format evolution. For IMMT1-3, values 6-8 were termed 'Reserved'. For IMMT-0, 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.]

26) *QI1* QC indicator for height of clouds
27) *QI2* QC indicator for visibility
28) *QI3* QC indicator for clouds
29) *QI4* QC indicator for wind direction
30) *QI5* QC indicator for wind speed
31) *QI6* QC indicator for air temperature
32) *QI7* QC indicator for dew-point temperature

33) *QI8* QC indicator for air pressure
34) *QI9* QC indicator for weather
35) *QI10* QC indicator for sea surface temperature
36) *QI11* QC indicator for period of wind waves or of measured waves
37) *QI12* QC indicator for height of wind waves or of measured waves
38) *QI13* QC indicator for swell
39) *QI14* QC indicator for precipitation
40) *QI15* QC indicator for characteristic of pressure tendency
41) *QI16* QC indicator for amount of pressure tendency
42) *QI17* QC indicator for true direction of ship
43) *QI18* QC indicator for ship's average speed
44) *QI19* QC indicator for wet-bulb temperature
45) *QI20* QC indicator for ship's position

Twenty quality control (QC) indicators applicable to individual fields or field groups (further details are available in Supp. B, Table B3; which also lists additional QC indicators available in IMMT-3/4/5). Configuration as in IMMT-5 (https://www.wmo.int/pages/prog/amp/mmop/documents/MQCS-7-JCOMM-4.pdf), indicating QC as applied by the Contributing Member (CM) and/or by the Global Collecting Centres (GCCs). Indicator values include the following:

0 -- No quality control (QC) has been performed on this element
1 -- QC has been performed; element appears to be correct
2 -- QC has been performed; element appears to be inconsistent with other elements
3 -- QC has been performed; element appears to be doubtful
4 -- QC has been performed; element appears to be erroneous
5 -- The value has been changed as a result of QC
6 -- The original flag is set "1" (correct) and the value will be classified by MQCS as inconsistent, dubious, erroneous or missing
7 -- The original flag is set "5" (amended) and the value will be classified by MQCS as inconsistent, dubious, erroneous or missing
8 – [reserved]
9 -- The value of the element is missing

Values 6 and 7 are set when the original flag settings were amended by the GCCs using the Minimum Quality Control Standard (MQCS).

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.]

46) *QI21* MQCS version

Version identification for the Minimum QC Standard (MQCS), with this expanded configuration defined for IMMT-5:

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 (Version 6, January 2011): JCOMM-III)
7 – MQCS-VII (Version 7, June 2012): JCOMM-IV

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.]

47) *HDG* ship's heading

Direction to which the ship's bow is pointing, referenced to true North (001-360°; e.g., 360° = North, 90° = East).

Background: According to IMMT-2/-3/-4 documentation, 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*). According to the IMMT-5 documentation (https://www.wmo.int/pages/prog/amp/mmop/documents/IMMT-5-JCOMM-4.pdf) valid range for heading is 001-360; the indicator for no movement has been removed.

48) *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).

49) *SOG* speed over ground

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

50) *SLL* maximum height > Summer load line

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

51) *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.

52) *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. *RWD*=0 when wind is calm relative to the deck (platform).

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). Special code of 361 for calm no longer used in IMMT-5.

53) *RWS* relative wind speed

Reported in either whole knots or whole meters per second (e.g., 10 knots or 5 m/s), with units established by *WI* (C0, field 19). RWS is a 3-character field to store values of RWS larger than *W* (C0, field 20; if WI indicates knots), e.g., *W*=98 knots, RWS=101 knots.

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.]

54) *QI22* QC indicator for ship's heading

55) *QI23* QC indicator for course over ground

56) *QI24* QC indicator for speed over ground

57) *QI25* QC indicator for maximum height > Summer load line

58) *QI26* Blank for IMMT-4/5, QC indicator for S_L in earlier IMMT versions

59) *QI27* QC indicator for departure of Summer max. load line from actual sea level

60) *QI28* QC indicator for relative wind direction

61) *QI29* QC indicator for relative wind speed

Eight additional quality control indicators applicable to individual fields or field groups from IMMT-3/4/5 (further details are available in Supp. B, Table B3). Indicator values are the same as for C5, fields 26-45.

> Background: As from IMMT-4, usage of Q_{26} is discontinued, ref. IMMT-4 documentation: "now Q_{27} serves as the indicator for both S_L and HH." [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/-5.]

62) *RH* relative humidity

63) *RHI* relative humidity indicator

Relative humidity is stored in tenths of a percent. *RHI* shows the reported data precision and whether the *RH* was directly measured or computed according to the following. *RHI* should always be extant when *RH* information exists; whereas *RHI* should always be missing if RH is missing:

- 0 – Relative humidity in tenths of Percentage, measured and originally reported
- 1 – Relative humidity in whole Percentage, measured and originally reported
- 2 – [Reserved]
- 3 – Relative humidity in tenths of Percentage, computed
- 4 – Relative humidity in whole Percentage, computed

64) *AWSI* AWS indicator

An indicator of whether or not measurements are made using an automated weather station (AWS). AWSI may be blank in cases where the AWS information is not available/discernable:

- 0 – No AWS
- 1 – AWS
- 2 – AWS plus manual observations

65) *IMONO* IMO number

Seven-digit unique ship identification number issued by the International Maritime Organization.

Model quality control (*Mod-qc*) attm (C6)

1) *ATTI* attm ID
2) *ATTL* attm length
Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=6 for *Mod-qc*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes.

GTS bulletin header fields

3) *CCCC* collecting center
4) *BUID* bulletin ID
These two fields are part of the "abbreviated heading" (WMO 2009), 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 center 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" ($T_1T_2A_1A_2ii$; see Background, and WMO 2009 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:

$T_1T_2A_1A_2ii$ 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

5) *FBSRC* Feedback source
An indicator of whether or not measurements are made using an automated weather station (AWS):

0 – operational

Background: [Note: Any additional values are to be determined, e.g., for use with reanalyses.

6) *BMP* background (bckd.) *SLP*
7) *BSWU* bckd. wind U-component
8) *SWU* derived wind U-component
9) *BSWV* bckd. wind V-component
10) *SWV* derived wind V-component
11) *BSAT* bckd. air temperature
12) *BSRH* bckd. relative humidity
13) *SRH* (derived) relative humidity
14) *BSST* bckd. *SST*
15) *MST* model surface type
16) *MSH* model height of surface
17) *BY* bckd. year
18) *BM* bckd. month
19) *BD* bckd. day
20) *BH* bckd. hour
21) *BFL* bckd. forecast length (hours)

Model quality control feedback information.

Background: Upon receipt of each GTS report from a VOS ship or moored/drifting buoy, the UK Real Time Monitoring Centre (RTMC – UK Met Office) appends co-located parameters (and related information) from the Met Office forecast model for six variables—*SLP*, wind U- and V-components, 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/NCEI), which converts them into IMMA1 format, including this attachment. [Additional technical notes:

(1) In R2.5 data, *BFL* was discovered to be subject to a conversion error and should not be used. Additionally, the original BUFR field that provides *BFL* is in minutes. *BFL* values for R3.0 have been corrected and are being reported in hours, when available.

(2) For *BSRH* and *SRH*, values appeared in the input data at least as high as 107%. While actual *RH* can't be that high, this raises the question whether the ranges of these model-generated fields should be increased in the future e.g., to 107%. Currently, ICOADS format translation or QC procedures remove any such values outside of the range 0-100%. On the other hand, the width of *MSH* has been expanded in IMMA1 to a 4-character field, since negative values (such as –152.0 and less than –99) have been detected (plus larger positive values than previously allowed).

(3) *BSST* is translated to SI units at the Met Office using constant 273.15K, whereas a lower-precision 273.1K constant is used for *BSAT*, the only other temperature field presently being made available by the Met Office. To keep its resultant higher precision, *BSST* has been expanded to 5 characters. Explanation from Colin Parrett at the RTMC (28 September 2011):

> "As far as I know, the conversions depend on the precision of the received data, using 273.0, 273.1 or 273.15 for 0, 1 or 2 (or more) decimal places. I've enquired with our MetDB Team for confirmation and I'll let you know if things have changed. The

background SST does come from a different source, so that might explain the greater precision."

(4) The referenced encoding constant 273.0 does not appear to apply to the temperature elements currently received from the Met Office, but in the event such data were received in the future a 4-character field configuration like that for *BSAT* would be sufficient (however, to accurately translate temperature data back from Kelvin to °C, it is crucial to know what constant has been used for encoding originally reported °C temperatures to Kelvin for storage in BUFR).]

Ship metadata (*Meta-vos*) attm (C7)

1) *ATTI* attm ID
2) *ATTL* attm length

Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=6 for *Mod-qc*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes.

Ship metadata elements

3) *MDS* Metadata source

An indicator of source/provider of the metadata:

0 – WMO Publication No. 47
1 – Center for Ocean-Atmospheric Prediction Studies, Tallahassee, USA

Background: Originally designed to store metadata from WMO publication 47, the attm is also used by other data providers to submit metadata for vessels within their respective datasets.

4) *C1M* recruiting country

AD – ANDORRA
AE – UNITED ARAB EMIRATES
AF – AFGHANISTAN
AG – ANTIGUA AND BARBUDA
AI – ANGUILLA
AL – ALBANIA
AM – ARMENIA
AN – NETHERLANDS ANTILLES
AO – ANGOLA
AQ – ANTARCTICA
AR – ARGENTINA
AS – AMERICAN SAMOA
AT – AUSTRIA
AU – AUSTRALIA
AW – ARUBA
AX – ÅLAND ISLANDS
AZ – AZERBAIJAN
BA – BOSNIA AND HERZEGOVINA
BB – BARBADOS
BD – BANGLADESH
BE – BELGIUM
BF – BURKINA FASO
BG – BULGARIA
BH – BAHRAIN
BI – BURUNDI
BJ – BENIN
BL – SAINT BARTHÉLEMY
BM – BERMUDA
BN – BRUNEI DARUSSALAM
BO – BOLIVIA
BR – BRAZIL
BS – BAHAMAS
BT – BHUTAN
BV – BOUVET ISLAND
BW – BOTSWANA
BY – BELARUS
BZ – BELIZE
CA – CANADA
CC – COCOS (KEELING) ISLANDS
CD – CONGO, THE DEMOCRATIC REPUBLIC OF THE
CF – CENTRAL AFRICAN REPUBLIC
CG – CONGO
CH – SWITZERLAND
CI – CÖTE D'IVOIRE
CK – COOK ISLANDS
CL – CHILE
CM – CAMEROON
CN – CHINA
CO – COLOMBIA
CR – COSTA RICA
CS – SERBIA AND MONTENEGRO
CU – CUBA
CV – CAPE VERDE
CX – CHRISTMAS ISLAND
CY – CYPRUS
CZ – CZECH REPUBLIC
DD – GERMAN DEOMCRATIC REPUBLIC
DE – GERMANY
DJ – DJIBOUTI

DK – DENMARK
DM – DOMINICA
DO – DOMINICAN REPUBLIC
DZ – ALGERIA
EA – KENYA, UGANDA, TANZANIA
EC – ECUADOR
EE – ESTONIA
EG – EGYPT
EH – WESTERN SAHARA
ER – ERITREA
ES – SPAIN
ET – ETHIOPIA
EU – EUMETNET
FI – FINLAND
FJ – FIJI
FK – FALKLAND ISLANDS (MALVINAS)
FM – MICRONESIA, FEDERATED STATES OF
FO – FAROE ISLANDS
FR – FRANCE
GA – GABON
GB – UNITED KINGDOM
GD – GRENADA
GE – GEORGIA
GF – FRENCH GUIANA
GG – GUERNSEY
GH – GHANA
GI – GIBRALTAR
GL – GREENLAND
GM – GAMBIA
GN – GUINEA
GP – GUADELOUPE
GQ – EQUATORIAL GUINEA
GR – GREECE
GS – SOUTH GEORGIA AND THE SOUTH SANDWICH ISLANDS
GT – GUATEMALA
GU – GUAM
GW – GUINEA-BISSAU
GY – GUYANA
HK – HONG KONG
HM – HEARD ISLAND AND MCDONALD ISLANDS
HN – HONDURAS
HR – CROATIA
HT – HAITI
HU – HUNGARY
ID – INDONESIA
IE – IRELAND
IL – ISRAEL
IM – ISLE OF MAN
IN – INDIA
IO – BRITISH INDIAN OCEAN TERRITORY
IQ – IRAQ
IR – IRAN, ISLAMIC REPUBLIC OF
IS – ICELAND
IT – ITALY
JE – JERSEY
JM – JAMAICA
JO – JORDAN
JP – JAPAN
KE – KENYA
KG – KYRGYZSTAN
KH – CAMBODIA
KI – KIRIBATI
KM – COMOROS
KN – SAINT KITTS AND NEVIS
KP – KOREA, DEMOCRATIC PEOPLE'S REPUBLIC OF
KR – KOREA, REPUBLIC OF
KW – KUWAIT
KY – CAYMAN ISLANDS
KZ – KAZAKHSTAN
LA – LAO PEOPLE'S DEMOCRATIC REPUBLIC
LB – LEBANON
LC – SAINT LUCIA
LI – LIECHTENSTEIN
LK – SRI LANKA
LR – LIBERIA
LS – LESOTHO
LT – LITHUANIA
LU – LUXEMBOURG
LV – LATVIA
LY – LIBYAN ARAB JAMAHIRIYA
MA – MOROCCO
MC – MONACO
MD – MOLDOVA, REPUBLIC OF
ME – MONTENEGRO
MF – SAINT MARTIN
MG – MADAGASCAR
MH – MARSHALL ISLANDS
MK – MACEDONIA, THE FORMER YUGOSLAV REPUBLIC OF
ML – MALI
MM – MYANMAR
MN – MONGOLIA
MO – MACAO
MP – NORTHERN MARIANA ISLANDS
MQ – MARTINIQUE
MR – MAURITANIA
MS – MONTSERRAT
MT – MALTA
MU – MAURITIUS
MV – MALDIVES
MW – MALAWI
MX – MEXICO
MY – MALAYSIA
MZ – MOZAMBIQUE
NA – NAMIBIA
NC – NEW CALEDONIA
NE – NIGER
NF – NORFOLK ISLAND
NG – NIGERIA
NI – NICARAGUA
NL – NETHERLANDS
NO – NORWAY
NP – NEPAL
NR – NAURU
NU – NIUE
NZ – NEW ZEALAND
OM – OMAN
OT – OTHER
PA – PANAMA

PE – PERU
PF – FRENCH POLYNESIA
PG – PAPUA NEW GUINEA
PH – PHILIPPINES
PK – PAKISTAN
PL – POLAND
PM – SAINT PIERRE AND MIQUELON
PN – PITCAIRN
PR – PUERTO RICO
PS – PALESTINIAN TERRITORY, OCCUPIED
PT – PORTUGAL
PW – PALAU
PY – PARAGUAY
QA – QATAR
RE – REUNION
RO – ROMANIA
RS – SERBIA
RU – RUSSIAN FEDERATION
RW – RWANDA
SA – SAUDI ARABIA
SB – SOLOMON ISLANDS
SC – SEYCHELLES
SD – SUDAN
SE – SWEDEN
SG – SINGAPORE
SH – SAINT HELENA
SI – SLOVENIA
SJ – SVALBARD AND JAN MAYEN
SK – SLOVAKIA
SL – SIERRA LEONE
SM – SAN MARINO
SN – SENEGAL
SO – SOMALIA
SR – SURINAME
ST – SAO TOME AND PRINCIPE
SV – EL SALVADOR
SY – SYRIAN ARAB REPUBLIC
SZ – SWAZILAND
TC – TURKS AND CAICOS ISLANDS
TD – CHAD
TF – FRENCH SOUTHERN TERRITORIES
TG – TOGO
TH – THAILAND
TJ – TAJIKISTAN
TK – TOKELAU
TL – TIMOR-LESTE
TM – TURKMENISTAN
TN – TUNISIA
TO – TONGA
TR – TURKEY
TT – TRINIDAD AND TOBAGO
TV – TUVALU
TW – TAIWAN, PROVINCE OF CHINA
TZ – TANZANIA, UNITED REPUBLIC OF
UA – UKRAINE
UG – UGANDA
UM – UNITED STATES MINOR OUTLYING ISLANDS
US – UNITED STATES
UY – URUGUAY
UZ – UZBEKISTAN
VA – HOLY SEE (VATICAN CITY STATE)
VC – SAINT VINCENT AND THE GRENADINES
VE – VENEZUELA
VG – VIRGIN ISLANDS, BRITISH
VI – VIRGIN ISLANDS, U.S.
VN – VIET NAM
VU – VANUATU
WF – WALLIS AND FUTUNA
WS – SAMOA
XX – AMBIGUOUS CODE
YE – YEMEN
YT – MAYOTTE
ZA – SOUTH AFRICA
ZM – ZAMBIA
ZW – ZIMBABWE
ZY – NONE / SELF RECRUITED
ZZ – THIRD PARTY SUPPORT SHIPS

5) *OPM* type of ship (program)

10 – Selected ships
15 – Selected ships (AWS)
30 – VOSClim
35 – VOSClim (AWS)
40 – Supplementary ships
45 – Supplementary ships (AWS)
70 – Auxiliary ships
75 – Auxiliary ships (AWS)
99 – Unknown

6) K*OV* kind of vessel

BA – Barge
BC – Bulk Carrier
CA – Cable ship
CG – Coast Guard Ship
CS – Container Ship
DR – Dredger
FE – Passenger ferries
FP – Floating production and storage units
FV – Other Fishing Vessel
GC – General Cargo
GT – Gas Tanker
IC – Icebreaking vessel
IF – Inshore Fishing Vessel
LC – Livestock carrier
LT – Liquid Tanker
LV – Light Vessel
MI – Mobile installation including mobile offshore drill ships, jack-up rigs and semi-submersibles
MS – Military Ship
OT – Other
OW – Ocean Weather Ship
PI – Pipe layer
PS – Passenger ships and cruise liners
RF – Ro/Ro Ferry
RR – Ro/Ro Cargo
RS – Refrigerated cargo ships including banana ships
RV – Research Vessel
SA – Large sailing vessels
SV – Support Vessel
TR – Trawler
TU – Tug
VC – Vehicle carriers
YA – Yacht / Pleasure Craft

7) *COR* country of registry

Encoding same as *C1M*.

8) *TOB* type of barometer

AN – Aneroid barometer (issued by Port Meteorological Officer or Meteorological Agency)

DA – Digital Aneroid Barometer
ELE – electronic digital barometer
MER – Mercury Barometer
SAN – Ship's Aneroid Barometer
OT – Other

9) *TOT* type of thermometer

ALC – Alcohol Thermometer
ELE – Electric (resistance) Thermometer
MER – Dry Bulb Mercury Thermometer

10) *EOT* exposure of thermometer

A – Aspirated (Assmann type)
S – Screen (not ventilated)
HH – Hand-held digital thermometer / humidity sensor
RS – Radiation shield (e.g. cylindrical / Gill multi-plate)
SG – Ship's Sling
SL – Sling
SN – Ship's screen
US – Unscreened
VS – Screen (ventilated)
W – Whirling

11) *LOT* screen location

1 – Bridge wing port
2 – Bridge wing starboard
3 – Bridge wing both sides
4 – Bridge wing windward side
5 – Wheelhouse top port
6 – Wheelhouse top starboard
7 – Wheelhouse top both
8 – Wheelhouse top center
9 – Wheelhouse top windward side
10 – Mainmast
11 – Foremast
12 – Mast on Wheelhouse top
13 – Main deck port side
14 – Main deck starboard side
15 – Main deck both sides
OT – Other (specify in footnote)

12) *TOH* type of hygrometer

1 – Hygristor
2 – Chilled Mirror
3 – Other
C – Capacitance
E – Electric
H – Hair hygrometer
P – Psychrometer
T – Torsion

13) *EOH* exposure of hygrometer

Encoding same as *EOT*.

14) *SIM* SST measurement method

BTT – Bait tanks thermometer
BU – Bucket thermometer
C – Thermometer in condenser intake on steam ships, or inlet engine cooling system on motor ships
HC – Hull contact sensor
HT – “Through hull” sensor
OT – Other
RAD – Radiation thermometer
TT – Trailing thermistor

15) *LOV* length of vessel
16) *DOS* depth of SST measurement
17) *HOP* height of visual observation platform
18) *HOT* height of air temperature sensor
19) *HOB* height of barometer
20 *HOA* height of anemometer
Height and depth elements 15 – 20 are stored to the nearest whole meter.

21) *SMF* source metadata file

WMO Pub. 47 source file for the metadata encoded as 4-digit year and 1-digit quarter (e.g., 19991 = 1st quarter of 1999).

22) *SME* source metadata element

Line number from source file.

23) *SMV* source format version

1 – Output from digitization project, semi-colon delimited format (1955)
2 – Output from digitization project, semi-colon delimited format (1956)
3 – Output from digitization project, semi-colon delimited format (1957 – 1967)
4 – Output from digitization project, semi-colon delimited format (1968–69)
5 – Fixed format (1970–94)
6 – Semicolon delimited format (1995–2001)
7 – Semicolon delimited format (2002–2007 q1)
8 – Semicolon delimited format (2007 - 2008)
9 – Semicolon delimited format (2009 - 2014)

Background: See Kent et. al (2007a) for details on version information.

Fields 4 – 23 contain 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. Tables defining select field have been reproduced from Berry et al. 2009 (http://icoads.noaa.gov/e-doc/imma/WMO47IMMA_1966_2007-R2.5.pdf).

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.

Near-surface oceanographic data (*Nocn*) attm (C8)

1) *ATTI* attm ID

2) *ATTL* attm length

Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=8 for *Nocn*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes (*ATTL=102* [2U in base36] for *Nocn*).

Near-surface oceanographic data and metadata elements

3) *OTV* temperature value

4) OTZ temperature depth

Temperature of water is stored in thousandths of a degree Celsius along with the associated depth of the measurement to the nearest hundredth of a meter.

Background: The *SST* min. and max. limits in the *Core* (Table C0) are -99.0 to 99.0°C with a precision of 0.1°C, this attachment has greater precision as is appropriate for modern oceanographic profile data, with a max. value based roughly on QC limits from the Global Ocean Surface Underway Data (GOSUD) program (http://www.gosud.org).

5) *OSV* salinity value

6) OSZ salinity depth

Salinity of water is stored as a unit-less value (commonly known as the practical salinity unit) to the nearest thousandths along with the associated depth of the measurement to the nearest hundredth of a meter.

7) *OOV* dissolved oxygen value
8) OOZ dissolved oxygen depth
Dissolved oxygen concentration is stored in hundredths of a milliliter per liter along with the associated depth of the measurement to the nearest hundredth of a meter.

9) *OPV* phosphate value
10) OPZ phosphate depth
Phosphate concentration is stored in hundredths of a micromole per liter along with the associated depth of the measurement to the nearest hundredth of a meter.

11) *OSIV* silicate value
12) OSIZ silicate depth
Silicate concentration is stored in hundredths of a micromole per liter along with the associated depth of the measurement to the nearest hundredth of a meter.

13) *ONV* nitrate value
14) ONZ nitrate depth
Nitrate concentration is stored in hundredths of a micromole per liter along with the associated depth of the measurement to the nearest hundredth of a meter.

15) *OPHV* salinity value
16) OPHZ salinity depth
pH of water is stored as a unit-less value to the nearest hundredth along with the associated depth of the measurement to the nearest hundredth of a meter.

17) *OCV* total chlorophyll value
18) OCZ total chlorophyll depth
Total chlorophyll concentration is stored in hundredths of a microgram per liter along with the associated depth of the measurement to the nearest hundredth of a meter.

19) *OAV* alkalinity value
20) OAZ alkalinity depth
Alkalinity concentration is stored in hundredths of a milliequivalent per liter along with the associated depth of the measurement to the nearest hundredth of a meter.

21) *OPCV* partial pressure of carbon dioxide value
22) OPCZ partial pressure of carbon dioxide depth
Partial pressure of carbon dioxide is stored in tenths of a microatmosphere along with the associated depth of the measurement to the nearest hundredth of a meter.

23) *ODV* dissolved inorganic carbon value
24) ODZ dissolved inorganic carbon depth
Dissolved inorganic carbon concentration is stored in tenths of a micromole per liter along with the associated depth of the measurement to the nearest hundredth of a meter.

25) *PUID* provider's unique record identification
A unique identifier associated with the record that was assigned by the data provider.

Edited Cloud Report (*Ecr*) attm (C9)

Background: This attm is based on previous work of Carole Hahn. Element descriptions are summarized below. Additional details are provided in Hahn et al. (1995) and Hahn and Warren (1999).

Hahn, C.J. and S.G. Warren, 1999: Extended Edited Synoptic Cloud Reports from Ships and Land Stations Over the Globe, 1952-1996. NDP-026C, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, doi:10.3334/CDIAC/cli.ndp026c.
Hahn, C.J., S.G. Warren and J. London, 1995: The effect of moonlight on observation of cloud cover at night, and application to cloud climatology. *J. Climate*, **8**, 1429-1446, doi: 10.1175/1520-0442(1995)008<1429:TEOMOO>2.0.CO;2.

1) *ATTI* attm ID
2) *ATTL* attm length
Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=9 for *Ecr*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes (*ATTL=32* for *Ecr*).

Extended Edited Cloud Report (EECR) basic elements
3) *CCe* Change code
Indicator of whether the original report was changed (edited) during processing. Code values are defined in Table C9a (and previously in sec. 3.3 of Hahn and Warren [1999]). Table C9b gives definitions of cloud and weather conditions used in Table C9a, for example "fog" or "showers".

Table C9a. Change codes (*CCe*) and their associated descriptions, cases categorizations, and field changes made (from Table 3 of Hahn and Warren (1999)). The *CCe* ordering in this table (0-13) also reflects the order in which changes to the cloud fields must be made during processing.

CCe[1]	*Description*	*Case*	*Changes made*
0	No changes required		None
1	Cause of *N*=9 determined from *WW* Set *Ne*=8, *NHe*=8, and *He*=0 If *CL* missing, then set *CLe*=0 If foggy, then set *CLe*=11 If showers, then set *CLe*=10 If drizzle/rain/snow, then set *CMe*=10	*N*=9 with precipitation or fog	*Ne*=8 *NHe*=8 *He*=0 *CLe*=10,11 or *CMe*=10
2	*NH* is amount of sky covered by medium cloud if no low cloud is present. If *NH*=0 with *CM* present and *CL*=0; then if *CH* present, set *NHe* missing else, set *NHe*=N	*NH*=0 with *CM*>0 and *CL*=0 and *CH*≤0 *NH*=0 with *CM*>0 and *CL*=0 and *CH*>0	*NHe*=N *NHe*=missing
3	If *NH*=*N* or missing and only high cloud present, set *NHe*=0	*NH*=*N* with *CH*>0 and *CL*=*CM*=0	*NHe*=0
4	If *NH*<*N* and only low cloud is present, then set *NHe*=missing If *NH*<*N* and only mid cloud is present, then set *NHe*=missing If *NH*≠*N* and only high cloud present, set *NHe*=missing	*NH*<*N* where it should be *NH*=*N* *NH*<*N* where it should be *NH*=*N* *NH*≠*N* with *CH*>0 and *CL*=*CM*=0	*NHe*=missing *NHe*=missing *NHe*=missing

5	If low cloud information (*NH* or *CL*) is missing and *CM* or *CH* present, then set *CMe*=*CHe*=missing	*CL*="/" with *CM* or *CH* not "/"	*CMe*,*CHe*=missing
6	If (*N*=*NH*=*8* or *N*=*NH*=7) and *CM*=0, then set *CMe*=missing If (*N*=*NH*=*8* or *N*=*NH*=7) and *CH*=*0,* then set *CHe*=missing	*CM* or *CH* miscoded as 0	*CMe* or *CHe*=missing
7	If *CM*=7 when drizzle/rain/snow, then set *CMe*=11 If *CM*=2 when drizzle/rain/snow, then set *CMe*=12	*CM*=7 or 2 identified as *Ns*	*CMe*=11 or 12
8	If drizzle/rain/snow and *CM* is missing and *CL* is present; and *CL*≠1,2,3 or 9; then if either *WW*≥60 or *CL*=7 or *CL*=0; set *CMe*=10	*CM*="/" for *Ns*	*CMe*=10
9	If *CM* is missing and both *CL* and *CH* present, then set *CMe*=0 If *N*≤4, *N*=*NH*, *CL* is present, *CM*=missing, and *CCe*=0, then *CMe*=0 If *N*≤4, *N*=*NH, CL* is present, *CH*=missing, and *CCe*=0, then set *CHe*=0	*CM* or *CH* miscoded as "/"	*CMe* or *CHe*=0
10	*N*=9 not explainable by *WW*		all parameters set missing
11	*NH*>*N*		all parameters set missing
12	*N*=0 accompanied by precipitation		all parameters set missing
13	N>0 and *CL*=*CM*=*CH*=0		all parameters set missing

1. Also order in which changes are made, but *CCe*=9 is recorded only if no previous change occurred (this conflict can occur only with *CCe*=7 or 8).

Table C9b. Cloud and Weather Type Definitions Used in ECRs (modified from Table 2 of Hahn and Warren (1999)). Note that "/" has been coded in IMMA format as "A", interpreted as "10".

Level	Shorthand notation	Meaning	Synoptic Codes	Extended Ecr Codes[1]
	TC	Total cloud cover	N = 0-9	*Ne*=0-8
	Cr	Completely clear sky	N = 0	*Ne*=N
	Ppt	Precipitation	WW= 50-75, 77, 79, 80-99	
	D	Drizzle	50-59	
	R	Rain	60-69	
	S	Snow	70-75, 77, 79	
	Ts	Thunderstorm or Shower	80-99	
Low			CL=	
	Fo	Sky obscured by fog	/ with N=9 and ww=10-12,40-49	*CLe*=11
	St	Stratus	6, 7	*CLe*=*CL*

	Sc	Stratocumulus	4, 5, 8	*CLe=CL*
	Cu	Cumulus	1, 2	*CLe=CL*
	Cb	Cumulonimbus	3, 9,	*CLe=CL*
			or N=9 with ww=Ts	*CLe=10*
Mid			CM =	
	Ns	Nimbostratus	2,7, or N=9 with ww=DRS	*CMe*=12,11,10
			/ with ww=DRS and CL=0,7	*CMe*=10
			/ with ww= RS and CL=4-8	*CMe*=10
	As	Altostratus	1; 2 if ww not DRS	*CMe=CM*
	Ac	Altocumulus	3,4,5,6,8,9;	*CMe=CM*
			7 if ww not DRS	*CMe=CM*
High			CH =	
	Hi	Cirriform clouds	1-9	*CHe=CH*

1. In the processing for the extended code both "/" ("A" in IMMA) and missing (blank in IMMA) are treated in the same way.

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4) *WWe* present weather
5) *Ne* total cloud amount
6) *NHe* lower cloud amount
7) *He* lower cloud base height
8) *CLe* low cloud type
9) *CMe* middle cloud type
10) *CHe* high cloud type

Weather and cloud variables coded as specified by WMO and as documented in the Core for elements WW, N, NH, H, CL, CM, and CH (C0, fields 23, 36, 37, 40, 38, 41, and 42, respectively) except that CLe and CMe have been "extended" as indicated in Tables C9c and C9d, respectively. Also, cases of N=9 with fog or precipitation have been converted to N=8 (defined in Table C9b). Any such conversion is recorded in the change code (CCe, Table C9a).

NOTE: An *Ecr* attachment is provided only if N is given in the original report.

Table C9c. Low cloud type (*CLe*) coding information.

Code	*WMO (or EECR) Code*	*Description*
0	Code 0513	no stratocumulus, stratus, cumulus or cumulonimbus
1	Code 0513	cumulus with little vertical extent and seemingly flattened, or ragged cumulus, other than of bad weather, or both
2	Code 0513	cumulus of moderate or strong vertical extent, generally with protuberances in the form of domes or towers, either accompanied or not by other cumulus or stratocumulus, all having bases at the same level
3	Code 0513	cumulonimbus, the summits of which, at least partially, lack sharp outlines but are neither clearly fibrous (cirriform) nor in the form of an anvil; cumulus, stratocumulus or stratus may also be present
4	Code 0513	stratocumulus formed by the spreading out of cumulus; cumulus may also be present
5	Code 0513	stratocumulus not resulting from the spreading out of cumulus
6	Code 0513	stratus in a more or less continuous later, or in ragged shreds, or both but no stratus fractus of bad weather
7	Code 0513	stratus fractus of bad weather or cumulus fractus of bad weather, or both (pannus), usually below altostratus or nimbostratus

8	Code 0513	cumulus and stratocumulus other than that formed from the spreading out of cumulus; the base of the cumulus is at a different level from that of the stratocumulus
9	Code 0513	cumulonimbus, the upper part of which is clearly fibrous (cirriform) often in the form of an anvil; either accompanied or not by cumulonimbus without anvil or fibrous upper part, by cumulus, stratocumulus, stratus or pannus
10	(EECR code)	cumulonimbus, identified from sky obscured (*N*=9) accompanied by showery precipitation or thunderstorm (WW≥80)
11	(EECR code)	fog, identified from sky obscured (*N*=9) accompanied by *WW* indicating fog (*WW*=10-12 or 40-49)

Table C9d. Medium cloud type (CMe) coding information.

Code	*WMO (or EECR) Code*	*Description*
0	Code 0515	no altocumulus, altostratus or nimbostratus
1	Code 0515	altostratus, the greater part of which is semi-transparent; through this part the sun or moon may be weakly visible, as through ground glass
2	(EECR code)	altostratus, the greater part of which is sufficiently dense to hide the sun or moon
3	Code 0515	altocumulus, the greater part of which is semi-transparent; the various elements of the cloud change only slowly and are all at a single level
4	Code 0515	patches (often in the form of almonds or fish) of altocumulus, the greater part of which is semi-transparent; the clouds occur at one or more levels and the elements are continually changing in appearance
5	Code 0515	semi-transparent altocumulus in bands, or altocumulus, in one or more continuous layer (semi-transparent or opaque), progressively invading the sky; these generally thicken as a whole
6	Code 0515	altocumulus resulting from the spreading out of cumulus or cumulonimbus
7	(EECR code)	altocumulus in two or more layers, usually opaque in places, and not progressively invading the sky; or opaque layer of altocumulus, not progressively invading the sky; or altocumulus together with altostratus
8	Code 0515	altocumulus with sproutings in the form of small towers or battlements, or altocumulus having the appearance of cumuliform tufts
9	Code 0515	altocumulus of a chaotic sky, generally at several levels
10	(EECR code)	nimbostratus, identified from sky obscured (*N*=9) accompanied by drizzle, or non-showery precipitation
11	(EECR code)	nimbostratus, identified from *CM*=7 accompanied by *WW* indicating rain
12	(EECR code)	nimbostratus, identified from *CM*=2 accompanied by *WW* indicating rain

EECR derived cloud elements

11) *AM* middle cloud amount

12) *AH* high cloud amount

These variables give the "actual" amounts of middle and high clouds, derived from *N* and *NH* with use of the random overlap equation, if necessary (see sec. 3.5 of Hahn and Warren [1999]).

13) *UM* *NOL* middle amount

14) *UH* *NOL* high amount

These variables, derived from *N* and *NH*, give the "non-overlapped" (NOL) amounts of middle and high clouds; i.e., the amounts visible from below (see sec. 3.5 of Hahn and Warren [1999]).

EECR sky brightness elements

15) *SBI* sky-brightness indicator

The sky-brightness indicator has a value of "1" (light) if the illuminance criterion described in Hahn et al. (1995) was satisfied at the time and place of the report, suggesting that there was adequate light for visual observation of cloud cover and cloud types (if not, then *SBI*=0; dark). This variable can be used in lieu of *SA* and *RI* if one accepts the criterion recommended in Hahn et al. (1995).

SBI should always be extant when *N* information exists; whereas *SBI* should always be missing if *N* is missing.

16) *SA* solar altitude

17) *RI* relative lunar illuminance

The solar and lunar parameters needed to determine the illuminance provided by the sun or moon for the date, time and location of the report (see sec. 3.6 of Hahn and Warren (1999)). *SA* is the altitude of the sun above the horizon. *RI* is the relative lunar illuminance, defined in Hahn et al. (1995), which depends on the lunar altitude and phase, and the earth-moon distance. The illuminance criterion of Hahn et al. (1995) is satisfied (*SBI*=1) when *SA*≥-9° or *RI*>0.11. A negative value of RI means the moon was below the horizon.

Reanalysis QC/feedback (*Rean-qc*) attm (C95)

1) *ATTI* attm ID

2) *ATTL* attm length

Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=95 for *Rean-qc*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes (*ATTL=61* for *Rean-qc*).

Reanalysis QC/feedback data and metadata elements

3) *ICNR* Input component number-*Rean-qc*

Component within the IMMA record for which the reanalysis QC/feedback applies (e.g., 0=*Core* or appropriate *ATTI* for other attm).

4) *FNR* Field number – *Rean-qc*

Field number from the referenced IMMA component (*ICNR*) for which the reanalysis QC/feedback applies (e.g., for sea temperature in the *Core*, *FNR* = 35 and for sea temperature from the *Nocn*, *FNR* = 3).

5) *DPRO* Data provider – reanalysis: lead organization
An indicator of lead organization providing the QC/feedback:

1 – ECMWF
2 – NOAA-NCEP
3 – NASA
4 – JMA

6) *DPRP* Data provider – reanalysis: project
An indicator of the project providing the QC/feedback:

1 – ERA-20C
2 – CFSRv2
3 – MERRA
4 – JRA-55

7) *UFR* Usage flag - reanalysis
An indicator of whether or not the record was used in the reanalysis:

1 – Assimilated and used
2 – Assimilated and rejected
3 – Blacklisted
4 – Whitelisted
5 – Available but not used
6 – None apply

Background: Blacklisted records (*UFR*=3) are determined *a priori* to be erroneous and are not used. Whitelisted records (*UFR*=4) are determined *a priori* to be used regardless of assimilation assessment.

8) *MFGR* Model-collocated first guess value/representative value in case of ensemble methods
Value of model-collocated first guess or a representative value in case ensemble methods are used.

Background: The range of minimum and maximum values, numeric precision, and units of measurement are all inherited from *ICNR* & *FNR*, with numerical precision increased by one (additional) position right of the decimal to better accommodate numerical precision used in the assimilation process. For example, *ICNR*=0 and *FNR*=29 refer to *AT*, which can range from –99.9 to 99.9, with precision and units of 0.1°C. Thus feedbacks on *AT* stored in this attm in *MFGR, MAR* and *BCR* have precision increased to 0.01°C, with range –99.99 to 99.99.

9) *MFGSR* Model-collocated first guess spread
Spread of model-collocated first guess. This is an optional field only used in the case of ensemble reanalyses.

10) *MAR* Model-collocated analysis value/representative value in case of ensemble methods
Model-collocated analysis value or a representative value in case ensemble methods are used.

Background: The range of minimum and maximum values, numeric precision, and units of measurement are all inherited from *ICNR* & *FNR*, with numerical precision increased by one (additional) position right of the decimal to better accommodate numerical precision used in the assimilation process. For example, *ICNR*=0 and *FNR*=29 refer to *AT*, which can range from –99.9 to 99.9, with precision and units of 0.1°C. Thus feedbacks on *AT* stored in this attm in *MFGR, MAR* and *BCR* have precision increased to 0.01°C, with range –99.99 to 99.99.

11) *MASR* Model-collocated analysis spread

Spread of model-collocated analysis value. This is an optional field only used in the case of ensemble reanalyses.

12) *BCR* Bias corrected value

Bias corrected value from model.

Background: The range of minimum and maximum values, numeric precision, and units of measurement are all inherited from *ICNR* & *FNR*, with numerical precision increased by one (additional) position right of the decimal to better accommodate numerical precision used in the assimilation process. For example, *ICNR*=0 and *FNR*=29 refer to *AT*, which can range from –99.9 to 99.9, with precision and units of 0.1°C. Thus feedbacks on *AT* stored in this attm in *MFGR, MAR* and *BCR* have precision increased to 0.01°C, with range –99.99 to 99.99.

13) *ARCR* Author reference code – *Rean-qc*

The author reference code is an optional alphanumeric value that is intended to point to a publication or technical report describing the reanalysis QC/feedback provided in the *Rean-qc* attm. The following *ACRC* has been assigned:

PH13 – ERA-20C, 2013 (Poli, P., H. Hersbach, D. Tan, D. Dee, J.-N. Thépaut, A. Simmons, C. Peubey, P. Laloyaux, T. Komori, P. Berrisford, R. Dragani, Y. Trémolet, E. Holm, M. Bonavita, L. Isaksen and M. Fisher, 2013: The data assimilation system and initial performance evaluation of the ECMWF pilot reanalysis of the 20th-century assimilating surface observations only (ERA-20C). ERA Report Series no. 14, ECMWF, 59 pp.

14) *CDR* Creation date – *Rean-qc*

Date conforming to ISO 8601 (YYYYMMDD) that identifies when the reanalysis QC/feedback for the given record was created. Set by the external developer that produced the *Rean-qc* attm.

15) *ASIR* Access status indicator – *Rean-qc*

An indicator of the status of the access to the record within ICOADS, such that only active records are still available within ICOADS:

0 – Active
1 – Inactive

ASIR should always be extant when the Rean-qc attachment is populated in an IMMA record.

ICOADS Value-Added Database (*Ivad*) attm (C96)

1) *ATTI* attm ID
2) *ATTL* attm length

Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=96 for *Ivad*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes (*ATTL=53* for *Ivad*).

ICOADS value-added data and metadata elements

3) *ICNI* Input component number-*Ivad*

Component within the IMMA record for which the value-added data, uncertainties, and/or quality control applies (e.g., 0=*Core* or appropriate *ATTI* for other attm).

4) *FNI* Field number – *Ivad*

Field number from the referenced IMMA component (*ICNI*) for which the value-added data, uncertainties, and/or quality control applies (e.g., for sea temperature in the *Core*, *FNI* = 35 and for sea temperature from the *Nocn*, *FNI* = 3).

5) *JVAD* Scaling factor for *VAD*

Scaling factor applied to convert "*FVAD*," an input floating-point value, into *VAD* (i.e., representing also *VAU1*, *VAU2*, or *VAU3)* according to $VAD = FVAD \times 10^{JVAD}$. Then the original un-scaled value is reconstructed according to $FVAD = VAD \times 10^{-JVAD}$.

[Note: Future versions of IMMA may lower the max to a value more likely to be realistic considering current data characteristics, e.g., 5 (i.e., scaling factor max becomes 10^5, thus again taking the *AT* case numeric precision of *FVAD* becomes 0.00001°C).]

6) *VAD* Value-added data value

Adjusted data value (e.g., bias-corrected) associated with field defined by *ICNI* and *FNI*.

Background: The adjusted value will be stored in this *Ivad* attm, whereas the unadjusted data will be stored in the *Core*/other attms as noted by *ICNI* and *FNI*. *VAD* units are inherited from *ICNI* and *FNI* (e.g., *ICNI*=0 and *FNI*=29 refer to *AT*, which has units of °C); the scaled range and the numeric precision is determined (e.g., at run time by {rwimma1}) from the scaling factor (e.g., taking the *AT* case: *JVAD*=0 yields whole °C, *JVAD*=1 yields 0.1°C, *JVAD*=2 yields 0.01°C, etc.). [Note that the storage of the adjusted value in this attm is an inversion of the planned handling, after blending into ICOADS, of straightforward data corrections using the *Error* attm (see Table C97).]

7) *IVAU1* Type indicator for *VAU1*
8) *JVAU1* Scaling factor for *VAU1*
9) *VAU1* Uncertainty of type *IVAU1*
10) *IVAU2* Type indicator for *VAU2*
11) *JVAU2* Scaling factor for *VAU2*
12) *VAU2* Uncertainty of type *IVAU2*
13) *IVAU3* Type indicator for *VAU3*
14) *JVAU3* Scaling factor for *VAU3*
15) *VAU3* Uncertainty of type *IVAU3*

Indicators *IVAU1, IVAU2, IVAU3* define the type of uncertainty provided:

0 – To be determined in prototype
1 – To be determined in prototype

IVAU1-IVAU3 will be extant when associated reports of uncertainty in VAU1-VAU3 are extant.

Scale factor *JVAU1, JVAU2, JVAUE* for *VAU1, VAU2, VAU3*, respectively, and defined identically to *JVAD*.

Uncertainty, *VAU1, VAU2,* and *VAU3,* associated with field defined by *ICNI* and *FNI*.

Background: Uncertainty value units are inherited from *ICNI* and *FNI* (e.g., *ICNI*=0 and *FNI*=29 refer to *AT*, which has units of °C); the scaled range is as specified, and the numeric precision is determined (e.g., at run time by {rwimma1}) from the scaling factor (e.g., taking the *AT* case: *JVAU1*=0 yields whole °C, *JVAU1*=1 yields 0.1°C, *JVAU1*=2 yields 0.01°C, etc.).

16) *VQC* Value-added quality control flag

The *VQC* is designed to store externally derived and provided data QC information. The provider of QC information is required to map their flags to the *VQC* configuration (Table C96a) and describe their mapping method in external documentation as linked via *ARC* (also original QC flags, prior to mapping to *VQC*, can be stored in the *Suppl* attm together with original data).

Table C96a. Configuration of the value-added QC Flag (*VQC*), following primary-level quality flag (QF) codes and definitions from IOC (2013)[1], which also recommends that any QC tests must be well documented in metadata that accompany the data.

Code	*Primary level flag's short name*	*Definition*

1	Good	passed documented required QC tests
2[2]	Not evaluated, not available or unknown	used for data when no QC test performed or the information on quality is not available
3	Questionable/suspect	failed non-critical documented metric or subjective test(s)
4	Bad	failed critical documented QC test(s) or as assigned by the data producer
9	Missing data	used as placeholder when data are missing

1. IOC, 2013: Ocean Data Standards, Vol. 3: Recommendation for a Quality Flag Scheme for the Exchange of Oceanographic and Marine Meteorological Data. IOC Manuals and Guides 54, Vol. 3., 12 pp. (English.)(IOC/2013/MG/54-3). [http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=10762].
2. Explanation for the placement of flag value 2, from IOC (2013): 'The quality of verified "Good" (flag 1) is considered higher (smaller flag value) compared to "Not evaluated" (flag 2), as the latter could turn out to be of any quality from good to bad, once the quality checks have been performed. Consequently, the neutral "Not evaluated" (flag 2) is placed between verified "Good" and verified "Questionable/suspect".'

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17) *ARCI* Author reference code – *Ivad*

The author reference code is a required alphanumeric value that is intended to direct the user to a publication or technical report describing value-added data, uncertainties, and/or quality control provided in the *Ivad* attm. The *ARCI* values defined for the IVAD prototype are the following:

BKT – National Oceanography Center, Berry, Kent, and Taylor, created 2015
FS01 – Florida State University, Smith et al. 2015

18) *CDI* Creation date – *Ivad*

Date conforming to ISO 8601 (YYYYMMDD) that identifies when the value-added data, uncertainties, and/or quality control for the given record was created. Set by the external developer that produced the *Ivad* attm.

19) *ASII* Access status indicator – *Ivad*

An indicator of the status of the access to the *Ivad* record within ICOADS:

0 – Active
1 – Inactive

Error (*Error*) attm (C97)

1) *ATTI* attm ID
2) *ATTL* attm length
Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=97 for *Error*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes (*ATTL=32* for *Error*).

Corrected erroneous data and metadata elements
3) *ICNE* Input component number-*Error*
Component within the IMMA record for which corrected erroneous data or metadata applies (e.g., 0=*Core* or appropriate *ATTI* for other attm).

4) *FNE* Field number – *Error*
Field number from the referenced IMMA component (*ICNE*) for which the error correction applies (e.g., for sea temperature in the *Core*, *FNE* = 35 and for sea temperature from the *Nocn*, *FNE* = 3).

5) *CEF* Corrected or erroneous field flag
An indicator of whether or not the *ERRD* field contains the corrected or uncorrected value.
0 - *ERRD* is the corrected value
1 - *ERRD* is the uncorrected value

Background: It is envisioned that when external providers submit *Error* attm, they will provide the corrected value in the attm and set *CEF=0.* To simplify the user interface, corrections for straightforward errors (e.g., callsign garbling) will ultimately be stored by ICOADS in the *Core*/other attms, whereas uncorrected data will be stored in this *Error* attm—this is an inversion of the planned handling of bias adjustments using the *Ivad* attm. The swapping of the information from externally provided *Error* attms, to final inverted storage in IMMA1 (i.e., from *CEF*=0 to *CEF*=1, and interchanging the data fields), will likely be handled by the ICOADS data team at NCEI; however, the *CEF* flag settings should allow this inversion to be handled externally instead if desired (i.e., through the provision of both Main and Subsidiary records).

6) *ERRD* Corrected or uncorrected value
Adjusted data value (e.g., bias-corrected) associated with field defined by *ICNE* and *FNE*.

Background: The numeric precision and units of measurement are inherited from *ICNE* and *FNE.* [Note: In {rwimma1}, the *Min.* and *Max.* of *ERRD* are initialized to character (i.e., "c" and "c") but these values are changed to "*(inh.)*" after *ICNE* and *FNE* are known. Moreover, all fields are right-justified, e.g., *ID* is left-justified in *ERRD* characters two through ten.]

7) *ARCE* Author reference code – *Error*
The author reference code is a required alphanumeric value that is intended to direct the user to a publication or technical report describing error correction provided in the *Error* attm. At the time of R3.0, no *Error* attm had been created.

8) *CDE* Creation date – *Error*
Date conforming to ISO 8601 (YYYYMMDD) that identifies when the error correction for the given record was created. Set by the external developer that produced the *Error* attm.

9) *ASIE* Access status indicator – *Error*
An indicator of the status of the access to the *Error* record within ICOADS:

0 – Active
1 – Inactive

Unique report identifier (*Uida*) attm (C98)

1) *ATTI* attm ID
2) *ATTL* attm length
Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=98 for *Uida*), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes (*ATTL=15* for *Uida*).

Report elements
3) *UID* Unique report identifier (ID)
A unique ID for each record in ICOADS represented as a base36 number of length 6. Development considerations for *UID* are discussed in Annex B of Woodruff et al. (2015; http://icoads.noaa.gov/ivad/IMMA-Rev.pdf).

Background: The *intermediate* Release 2.5 product (R2.5*i*), containing available duplicates and other reports excluded from the normal user product (R2.5), was used as the starting point for assigning *UID.* R2.5*i* contains ~295M (specifically: 294,725,525) reports ($m_{R2.5i}$), so all those records (in predefined temporal archive sequence) had *UID* assigned from 1, …, $m_{R2.5i}$. During preparation of R3.0, new and historical records were numbered starting from $m_{R2.5i}$+1 to $m_{R3.0t}$ (specifically 1,233,945,192; where the "t" subscript refers to the *total* file output from R3.0). After blending the old and new records into R3.0, all the *UIDs* are no longer sequential (i.e., new *UIDs* have been interleaved into the old purely numeric sequence; see http://icoads.noaa.gov/ivad/IMMA-Rev.pdf for further discussion).

While *UID* is a base36 number, this field is handled by {rwimma1} as strictly (i.e., without leading spaces, e.g., 35=00000Z) alphanumeric, and thus is not fully translated into an integer or floating-point (REAL) number (ref. {rwimma1} comments: "For character […] fields, note that ITRUE and FTRUE contain the ICHAR of the first character of the field…"). Separate from {rwimma1} however, this Fortran library is available to transform *UID* into an integer (and vice versa): http://icoads.noaa.gov/software/base36.f. Users interested in handling *UID* as a number should be aware of possible finite precision issues arising in the representation of large numbers on computers:

- In the integer case, the largest 6-character base36 number is ZZZZZZ (2,176,782,335); however, if one bit is reserved for sign, the largest positive integer representable in 32 bits is only 2^{31}–1 (2,147,483,647; ZIK0ZJ in base36). However, the current maximum of *UID* is $m_{R3.0t}$ (~1.234B) and thus below this threshold.
- Whereas, in the floating-point case it is not even possible to accurately represent $m_{R3.0t}$ as a 32-bit single precision REAL number.

5) *RN1* Release number: primary
6) *RN2* Release number: secondary
7) *RN3* Release number: tertiary
Three elements that make up the full release number associated with the record. For example, Release 3.0.0 (1662-2014) is represented with *RN1*=3, *RN2*=0, and *RN3*=0, and R3.0.1 (the 2015-forward GTS blend product, providing a NRT preliminary extension to R3.0) with *RN1*=3,

RN2=0, and *RN3*=1

Background: A uniform policy on the usage of these Release number digits has yet to be developed, but the primary number is envisioned to change only at major full-period Releases, the secondary number at noteworthy incremental Releases, and the tertiary number can describe subsequent Releases associated with a major or incremental Releases (e.g., R3.0.1, R3.1.1).

8) *RSA* Release status indicator

An indicator that specifies whether the record is

0 – Preliminary (Not yet included in an official ICOADS Release)

1 – Auxiliary (Records provided in separate data files in addition to ICOADS official Releases and Preliminary data. This also includes new data sources received, but awaiting blending into an official ICOADS Release)

2 – Full (A record included in an official ICOADS Release)

RSA should always be extant.

9) *IRF* Intermediate reject flag

A flag assigned during processing of a release to indicate whether each report is to be rejected or retained during construction, from the Total output dataset, of the Final user dataset, and also flagging the potential construction of an Intermediate dataset (note: not implemented presently for R3.0, only the Total and Final datasets are available). Values are:

0 – Intermediate (i.e. Retain in Intermediate data file, reject from Final dataset)

1 – Final (i.e. Retain in both Intermediate and Final datasets)

2 – Reject (i.e. Reject from both Intermediate and Final datasets)

Supplemental data (*Suppl*) attm (C99)

1) *ATTI* attm ID

2) *ATTL* attm length

3) *ATTE* attm data encoding

5) *SUPD* supplemental data

Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents, and *ATTL* was allocated (but is presently unused, see below) to provide the total length of the attm (including *ATTI* and *ATTL*) in bytes, or zero for length unspecified (record terminated by the ASCII line feed character; line feed not counted as part of *ATTL*; note all IMMA data from R3.0 currently follow this form). The supplemental data attm (C99) also includes *ATTE*, which indicates whether the supplemental data that follow are in ASCII or encoded:

missing – ASCII

0 – base64 encoding

1 – hexadecimal

The {rwimma1} software tests to determine if each individual IMMA record is properly configured, without checking *ATTC* (ref. Table C0) against the number of attachments present. Also, {rwimma1} sets *ATTC* when an IMMA is written, and it allows duplicate attms (i.e., two attms with the same *ATTI*) to appear in a record, but the second overwrites the first (i.e., in memory) unless they are one of the two-dimensional (i.e., *Rean-qc*, *Ivad*, *Error*) attms. 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 with *ATTL*=0.

Background: Thus far, *ATTL* in bytes has not been supported in the read/write IMMA programs (e.g., {rwimma1}). Also thus far, *ATTE*=1 (hexadecimal) has been used only for MORMET (deck 732) data (to represent binary input). This printable representation, which {rwimma1} treats identically to ASCII, was undocumented in previously available (i.e., IMMA0) Suppl. D information. In addition, while the *ATTE*=0 (base64 encoding; unprintable) representation is documented in Supp. D, currently it is unused and not fully implemented in {rwimma1}.

Supplement E: ICOADS Release 3.0 IMMA Status

This supplement provides additional technical information on the IMMA1 implementation presently used for Release 3.0 (R3.0.0; 1662-2014), plus for monthly "preliminary" data (based on a blend of NCEP and NCEI GTS receipts) extending ICOADS to near-current dates (R3.0.1; 2015-forward). Also discussed is an alternative "Total" output product derived during the creation of R3.0 that some users may wish to access.

New to R3.0 is the implementation of the IMMA1 linked report format, which includes Main and (optional) Subsidiary records, linked together by the unique record identifier (stored in the *Uida* attm). From this approach, the main records may include (see Table E1 for more information about the individual format components):

Main IMMA record: *Core* + *Icoads* + *Immt* + *Mod-qc* + *Meta-vos* + *Nocn* + *Ecr* + *Uida* + *Suppl*

which contains (if all attms are present) 542 characters prior to the variable-length *Suppl*. However, the attachment structure of IMMA (and {rwimma1} software) is designed with the capability to save space through omission of empty attachments (i.e., information not relevant, or not available, for a given dataset). Since we utilize this feature for the main ICOADS records, they may frequently be shorter than 510 characters (e.g. the *Meta-vos* and *Ecr* attms in general are only available for VOS data).

During development of R3.0, ICOADS developed a method to blend GTS data streams from NCEI and NCEP, which will support the near-real-time (NRT) extension of R3.0 from January 2015 to present (updated monthly, up to five days into the next month, and referred to as R3.0.1). In 2007 NCEP began masking all ship call signs, and this product recovers up to 70% of the actual ship radio call signs by blending the NCEI stream. Additionally, approximately 5% unique reports are gained from the merge. More information on this product can be found at http://icoads.noaa.gov/merge.html.

Also available to the user community will be the newly created "Total" output. This product includes available duplicates and landlocked reports, flagged so that they could be readily removed when creating the "Final" R3.0 user product. The Total product additionally contains reports that were rejected during the initial processing because of known and documented errors. R3.0 contains a number of known unresolved inhomogeneities and data mixture problems (Freeman et al. 2016; http://icoads.noaa.gov/r3.html). Particularly for some of the data mixture issues, the Total 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 Total 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 callsign in duplicates selected for final output). Another incompletely resolved R3.0 issue for which the total file 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 Table C6 (*Mod-qc* attm) feedback information, into composited reports).

Following the release of R3.0 in June 2016, enhancements of R3.0 are planned as resources permit. Most immediately, we plan to add *Rean-qc* attms from at least one reanalysis project, and *Ivad* attms from the pilot IVAD project. Longer-term, quality control improvements and other enhancements to ICOADS are needed as soon as practical (as discussed further in Freeman et al. 2016). These additional format elements are also reflected in Table E1.

Table E1. Sizes of IMMA1 format components: Core and attachments (attm). We plan to populate C95 and C96 in an incremental release soon following R3.0.0, and while C97 is fully implemented (e.g. in {rwimma1} it is not yet in use but proposed for use in a future release.

Abbrev.	*Name*	*Size (B)*	*Cumulative size (B)*	*Comments*
C0	Core (*Core*)	108	108	
C1	ICOADS (*Icoads*) attm	65	173	
C5	IMMT5/FM 13 (*Immt*) attm	94	267	
C6	Model quality control (*Mod-qc*) attm	68	335	
C7	Ship metadata (*Meta-vos*) attm	58	393	From WMO–No. 47 for 1966-2014; plus from COAPS (deck 740)[2]
C8	Near-surface oceanographic (*Nocn*) attm	102	495	
C9	Edited cloud report	32	527	
C98	Unique report ID (*Uida*) attm	15	542	
C99	Supplemental data (*Suppl*) attm[1]	variable		
C95	Reanalysis QC/feedback (*Rean-qc*) attm	61	603	To be populated soon after R3.0 in a subsequent release
C96	ICOADS Value-Added Database (*Ivad*) attm	53	656	To be populated soon after R3.0 in a subsequent release
C97	Error (*Err*) attm	32	688	Available for future use

1. For ICOADS Release 2.4, 1784-1997 IMMA were recreated using LMR to merge important supplemental data into the *Suppl* attm (previously "C6," now C99). As resources permit, and as the IMMA format evolves to include additional fields, those and more recently received supplemental data should be tapped for regular fields not previously defined in ICOADS but becoming 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 "Total" R3.0 product (see Table E2) as was done for R2.5 (see Berry et al. 2009), whereas the COAPS metadata were retained from the R2.5.1 input for DCK 740, *SID*=130 (1990-1998) and added to R3.0 for DCK 740, *SID*=131 (2005-2014).

Table E2. Numbers of reports and data volumes for the "Total" and "Final" user products output from R3.0.0. The Total product is a superset of the Final product, in that it also contains flagged duplicates, landlocked reports, and some flagged erroneous "Reject" data. Total product sizes (10^9 bytes) are uncompressed.

Product	Period	Reports	Total product size
Final	1662-2014	455,528,938	149 GB
Total	1662-2014	1,009,511,934	390 GB

Supplement F: Proposed IMMA Attachments

This supplement contains IMMA attachments that are proposed or in development. None of these attachments have been implemented in IMMA1 or in {rwimma1}. Notes related to the proposed attm development are included below each table, with specific fields in the proposed *Hist* attachment fleshed out in additional detail below Table CP5.

Table CP1. Automated instrumentation (*Auto*) attm (proposed)

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI=(tbd)*
2	2	*ATTL*	attm length			Note: set *ATTL*=41
			Automated instrumental metadata (37 characters):			
3	8	*ALAT*	latitude	–90.000	90.000	0.001°N
4	9	*ALON*	longitude	0.000	359.999	0.001°E (ICOADS conv.)
5	1	*INAV*	navigation system indicator	0	9	(controlled vocabulary *tbd*, e.g., 0=GPS, 1=POSMV, 2=INS)
6	6	*APRS*	atmospheric pressure	870.00	1074.60	at barometer height (*HOB*)
7	6	*ARSW*	shortwave radiation	0.00	1600.00	Wm^{-2}
8	1	*IARSW*	shortwave radiation indicator	0	9	(controlled vocabulary *tbd*, e.g., 0=down-, 1=upwelling)
9	5	*ARLW*	longwave radiation	200.00?	800.00?	Wm^{-2}
10	1	*IARLW*	longwave radiation indicator	0	9	(controlled vocabulary *tbd*, e.g., 0=down-, 1=upwelling)

***Auto* attm notes:**

This attm is designed to provide a location to capture meteorological and underway ocean data that are not routinely reported by VOS or in historical ship reports. These values would be derived from automated instrumentation.

This attm could be expanded to include all possible parameters that could be derived at high precision from automated instrumentation. Candidate fields that are included elsewhere in IMMA0 are: Ship's course and speed (*DS*/*VS*, in the *Core*; or *COG/SOG* for the over ground elements, in *Immt*), and ship's heading (*HDG* in *Immt*), wind direction and speed (true *D*/*W*, in the *Core*; or relative *RWD/RWS* in *Immt*), *AT*, *WBT*, *DPT* (*Core*), and *RH* and precipitation (*Immt*). Other possible fields for this table include visibility and cloud height derived from automated sensors, but they are currently very rare on ships or moorings, or possibly surface velocity data (not presently part of ICOADS).

For *ARSW*, it is still not determined if the field should allow for negative values. They are common due to sensor calibration issues (and flagged e.g., by SAMOS), but are not physical.

Storing *APRS* is proposed for two reasons (a) there is no place in IMMA to store atmospheric pressure values not converted to sea level and (b) precision automated barometers can easily record *SLP* (or *APRS*) to 2 or 3 decimal places. However, if the field serves two purposes, an associated indicator may be needed to flag the high-resolution pressure type (i.e., *SLP* or *APRS*)

Radiation could be handled in different ways. The idea above provides for separate shortwave/longwave total radiation variables. If we added a signed range, this could also allow for net radiation. Another other option would allow for multiple radiation values each with an indicator stating whether it is shortwave, longwave, PAR, UV, etc. This may result in a variable-length attachment or one of fixed-length with many empty fields. Also, some indicator of the time period over which the radiation was integrated may be needed. The draft E-SURFMAR Dataformat#100 (http://esurfmar.meteo.fr/doc/o/vos/E-SURFMAR_VOS_formats_v011.pdf) suggests "over the past hour."

Table CP2. Near-surface oceanographic QC (*Nocq*) attm (proposed).

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI=(tbd)*
2	2	*ATTL*	attm length			Note: set *ATTL*=28
			Near-surface oceanographic QC and calibration information (24 characters):			
1	1	*OQCI*	quality control indic.[1]	0	9	(Same as *QCI* in Table C5)
2	1	*OQCFL*	QC flag list[2]	u	u	*(tbd)*
3	1	*OTQC*	*OTV* (temp.) QC flag	0	9	*(tbd)*
4	1	*OTCI*	*OTV* calibration indic.	0	9?	*(tbd)*[3]
5	1	*OSQC*	*OSV* (salinity) QC flag	0	9	*(tbd)*
6	1	*OSCI*	*OSV* calibration indic.	0	9?	*(tbd)*
7	1	*OOQC*	*OOV* (oxygen) QC flag	0	9	*(tbd)*
8	1	*OOCI*	*OOV* calibration indic.	0	9?	*(tbd)*
9	1	*OPQC*	*OPV* (phosphate) QC flag	0	9	*(tbd)*
10	1	*OPCI*	*OPV* calibration indic.	0	9?	*(tbd)*
11	1	*OSIQC*	*OSIV* (silicate) QC flag	0	9	*(tbd)*
12	1	*OSICI*	*OSIV* calibration indic.	0	9?	*(tbd)*
13	1	*ONQC*	*ONV* (nitrate) QC flag	0	9	*(tbd)*
14	1	*ONCI*	*ONV* calibration indic.	0	9?	*(tbd)*
15	1	*OPHQC*	*OPHV* (pH) QC flag	0	9	*(tbd)*
16	1	*OPHCI*	*OPHV* calibration indic.	0	9?	*(tbd)*
17	1	*OCQC*	*OCV* (total chlor.) QC flag	0	9	*(tbd)*
18	1	*OCCI*	*OCV* calibration indic.	0	9?	*(tbd)*
19	1	*OAQC*	*OAV* (alkalinity) QC flag	0	9	*(tbd)*
20	1	*OACI*	*OAV* calibration indic.	0	9?	*(tbd)*
21	1	*OPCQC*	*OPCV* (PaC02) QC flag	0	9	*(tbd)*
22	1	*OPCCI*	*OPCV* calibration indic.	0	9?	*(tbd)*
23	1	*ODQC*	*ODV* (DIC) QC flag	0	9	*(tbd)*
24	1	*ODCCI*	*ODV* indic.	0	9?	*(tbd)*

1. Proposed as an overall QC method flag, the same as *QCI* in the *Immt* attm, which has this configuration:
    - 0 - No quality control (QC)
    - 1 - Manual QC only
    - 2 - Automated QC only /MQC (no time-sequence checks)
    - 3 - Automated QC only (inc. time sequence checks)
    - 4 - Manual and automated QC (superficial; no automated time-sequence checks)
    - 5 - Manual and automated QC (superficial; including time-sequence checks)
    - 6 - Manual and automated QC (intensive, including automated time-sequence checks)
    - 7 & 8 - Not used
    - 9 - National system of QC (information to be furnished to WMO)
2. Proposed indicator that points to different QC flag schemes (e.g., the ODS-based scheme as listed in Table C96a).
3. As agreed at the April 2013 UK EarthTemp meetings, it appears we need at least 4 configurations: (0) not calibrated, (1) calibrated, (2) bottle calibrated, (3) others.

***Nocq* attm notes:**

QC flags and calibration information paralleling the data value (and accompanying depth) fields in the *Nocn* attm (Table C8).

Table CP3. Alternative QC (*Alt-qc*) attm (proposed).

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI=(tbd)*
2	2	*ATTL*	attm length			Note: set *ATTL*=18
			Alternative QC information (14 characters):			
3	2	*ICNQ*	input component number–*Alt-qc*	0	*(tbd)*	IMMA component number
4	6	*FNQ*	field number–*Alt-qc*	1	*(tbd)*	IMMA field no. within *ICNQ*
5	1	*AQCFL*[1]	QC flag list	u	u	(*tbd*; possibly [b36])
6	1	*QCFV*	QC flag value	0	9	(tbd; possibly [b36])
7	4	*ARCQ*	author reference code–*Alt-qc*	b	b	(alphanumeric)

1. See *OQCFL* in the *Nocq* attm (Table CP2).

***Alt-qc* attm notes:**

Envisioned as a means by which data providers could provide QC flag information on a flexible basis, akin to the *Error* attm, but for additional quality control flags for any field number in any attm. The intent of the QC flag list is to allow users to submit data using a range of QC flagging schemes (e.g., 0-9, A-Z, etc). This could be supported by using base36 representation. May also want to consider need for length>1 for the *QCFV*.

Table CP4. Platform tracking (*Track*) attm (proposed).

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI=(tbd)*
2	2	*ATTL*	attm length			Note: set *ATTL=(tbd)*
			Platform track information (~25 characters):			
3	1?	*UIDT*	UID type			(*tbd*; e.g., 1=ICOADS-standard, 2=collection/*SID*-specific,3=platform/voyage-specific)
4	6	*UID1*	UID of previous report	1	*(tbd)*	
5	6	*UID2*	UID of this report	1	*(tbd)*	
6	6	*UID3*	UID of next report	0	*(tbd)*	
7	4	*ARCT*	author reference code–*Track*	b	b	(alphanumeric)

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code) [base36]
8	8	*CDT*	creation date—*Track*	20140101	2nnn1231	ISO-8601, YYYYMMDD (as for *CDR*, ref. Table C95)
8	1	*ASIT*	access status indic.—*Track*	0	1	0=active, 1=inactive

***Track* attm notes:**

Sets aside space for "pointer" fields indicating the UID of the previous (*UID1*) and next (*UID3*) report, with respect to this report (*UID2*), in ship/buoy track sequence (i.e., both forward, and backward, in time and space). If indicated by *UIDT*, this attm could contain collection- (or source ID, *SID*) specific, or even platform/voyage-specific, rather than ICOADS-standard, *UID* information (which thus in a sense can be considered value-added information, if assembled externally).

This could be very useful e.g., for reanalyses to resolve the problem of connecting ship/buoy voyages within ICOADS. Due to effects of dupelim, tracks may consist of records interspersed from a variety of sources, with possibly varying *IDs* for records in track sequence. This proposed attm would provide the storage mechanism for this information, but populating the attm seems likely to be challenging; therefore, as with the *Ivad* attm, ICOADS might consider the *Track* to be metadata and possibly this info could be ingested if somebody else had the resources to implement the ship tracking.

Table CP5. Historical attm (*Hist*) (proposed).

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code) [base36]
1	2	*ATTI*	attm ID			Note: set *ATTI=(tbd)*
2	2	*ATTL*	attm length			Note: set *ATTL=(tbd)*
			Historical data fields (>19 characters):			
3	?	*SN*	ship's name	u	u	[Note: either the full name, or possibly abbreviated with reference to a separately maintained list, to same space?]
4	5	*LCR*	longitude by chronometer	0.00	359.99	0.01°E[1] (ICOADS conv.)
5	5	*LMG*	longitude made good[2]	0.00	359.99	0.01°E[1] (ICOADS conv.)
6	5	*LDR*	longitude by account[3]	0.00	359.99	0.01°E[1] (ICOADS conv.)
7	1	*WFI*	*WF* indic.	u	u	
8	2	*WF*	wind force	0	12	
9	1	*XWI*	*XW* indic.	u	u	
10	3	*XW*	wind speed (ext. *W*)	0	99.9	0.1 m/s
11	1	*XDI*	*XD* indic.	u	u	
12	2	*XD*	wind dir. (ext. *D*)	u	u	
13	1	*SLPI*	*SLP* indic.	u	u	[Note: This or another indicator needed to indicate the presence or absence of *SLP* adjustment (ref. *PB*)?]
14	1	*TAI*	*TA* indic.	u	u	
15	4	*TA*	*SLP* att. thermometer	–99.9	99.9	ref. *AT*
16	5	*SMPR*	sympiesometric pressure	25.000	32.000	0.001 inches of mercury[4]
17	1	*XNI*	*XN* indic.	u	u	
18	2	*XN*	cloud amt. (ext. *N*)	u	u	
19	1	*SGN*	significant cloud amount	0	9	(N_S; ref. Table B4)
20	1	*SGT*	significant cloud type	0	9, "A"	(C; ref. Table B4)
21	2	*SGH*	significant cloud height	0	99	($h_S h_S$; ref. Table B4)

No.	Len.	Abbr.	Element description	Min.	Max.	Units (Code) [base36]
(plus additional elements tbd)						

1. A possible alternative approach for storing these longitudes, such as from the EEIC collection, would be to keep the DDD.MM.SS original format, noting however that original data configurations should be preserved anyway in the *Suppl* attm. Also storing decimal points would violate the standard IMMA representation for numeric data (unless these fields were stored as character strings).
2. With reference to Greenwich Meridian.
3. As calculated by dead reckoning.
4. Due to the erratic nature of the sympiesometer measurements such as observed in the EIC Collection, these values might fall well out of the range specified here.

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Preliminary definitions of fields for within the proposed Hist attm (Table CP5):

1) *ATTI* attm ID
2) *ATTL* attm length
Each attm begins with *ATTI* and *ATTL*. *ATTI* identifies the attm contents with a numeric identifier (*ATTI*=tbd), and *ATTL* provides the total length of the attm (including *ATTI* and *ATTL*) in bytes (*ATTL=tbd*).

Historical data fields (field numbering preliminary)
3) *SN* ship's name
4) *LCR* longitude by chronometer
5) *LMG* longitude made good
6) *LDR* longitude by account

7) *WFI* wind force indicator
8) *WF* wind force
9) *XWI XW* indicator
10) *XW* wind speed (extension field for *W*)
11) *XDI* *XD* indicator
12) *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.

13) *SLPI* *SLP* indicator
14) *TAI* *TA* indicator
15) *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.

16) *SMPR* *Sympiesometric pressure*

17) *XNI* *XN* indicator
18) *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).

19) *SGN* significant cloud amount
20) *SGT* significant cloud type
21) *SGH* significant cloud height
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 B4) 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).]

***Hist* attm notes:**

Fields *SGN*, *SGT*, and *SGH*, which are believed to be purely historical (1960s or earlier), are moved here from the *Immt* attm. Refer to the complete version of the IMMA0 documentation (http://icoads.noaa.gov/e-doc/imma/R2.5-imma.pdf) and Table B4. Among potential additional elements: dead reckoning positions (if preserved additionally to observed positions) and surface current movement (derivable from dead reckoning positions), Leeway, magnetic deviation and variation, etc.

Other examples from recent work on the C19th German Maury Collection:

Cloud form:

Cirrus	CI	Cirrocumulus	CC	Cirrostratus	CS
Altocumulus	AC	Altostratus	AS		
Stratocumulus	SC	Stratus	ST	Nimbostratus	NS
Cumulus	CU	Cumulonimbus	CB		

Present Weather indicated by combinations of the following Beaufort Codes:

b	blue sky	p	passing showers
c	cloudy sky	q	squally
d	drizzle	r	rain, rainy
f	fog	s	snow
g	gloomy	t	thunder
h	hail	u	ugly threatening sky
l	lightning	v	exceptional visibility
m	mist	w	dew
o	overcast, overcast skies	z	haze

Additional historical fields, such as sea state and sea ice will have to be investigated further to determine the feasibility of incorporating them in IMMA. Historically, these are largely non-standardized recordings, recorded in comments possibly embedded in large amounts of text (e.g., greater than 1500 unique state of sea and weather comments in the EEIC collection).

Document Revision Information
Revision 3.0.2

First draft version: February 2022. Updates for clarification on use of indicator fields; additional information on NCDC-QC flags added in Tables D9a and D9b; updates to DCK/SID Tables 6a, 7 and additional text edits.

April 2022: Updates to ID Indicator (*II*) and Wind Speed Indicator (*WI*) information in Table C0 and Supplement D.; updates to Authors and Affiliations.