Environment Canada / Environnement Canada

Style Definition: Heading 3,H3: Indent: Left: 0 cm

MANUPP

Manual of Upper Air Standards

Fourth Edition

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Canada

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Foreword

This manual prescribes the standards of the Meteorological Service of Canada (MSC) for aerological observations and applies to all radiosonde data collected at upper air stations across Canada and supersedes the *Manual of Upper Air Observations, Third Edition*, 2003.

Since the upper air data is used on a world-wide basis, care has been taken to ensure that the procedures comply with the guidelines on instruments and observing practices and coding regulations set down by the World Meteorological Organization (WMO).

All methodology contained in MANUPP is consistent with that stipulated by the WMO and adapted for the Canadian Upper Air Network.

Amendments will be issued when warranted. All holders of the manual are responsible for keeping their copies current. When amendments have been entered, this fact should be recorded on the page headed Record of Amendments.

Inquiries on the content of this manual should be directed to the Meteorological Service of Canada through appropriate channels.

This supplement contains the amendments adopted by the MANUPP Working Group.

The following typographical and stylistic conventions are used in this manual:

- Standard practices and procedures are denoted by the word “shall” emphasized in bold print.
- Symbolic forms of code, code excerpts and code values have been printed in dark blue.
- Notes have been printed in aqua shaded boxes, preceded by the bolded indication “**Note.**”
- Blank table cells have been marked with a single dash “-” to indicate to assistive technology users that these cells may be ignored.

Record of amendments

Number	Effective date	Entered by	Date of entry

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Chapter 1 Introduction

1.1 International Upper Air Network

The original sounding equipment for aerology was carried aloft by kites or balloons. The data observed was scratched on a smoke plate using a special pen. Some of the balloons used would attain heights of 16 km or more and then burst. The instrument would float to the ground with the assistance of an attached parachute. A large number of these instruments were found and returned to the originator where the information recorded was analyzed. The average recovery time of one week for the balloon launched instruments was too slow for practical purposes.

Since that time, various methods have been attempted. Aircraft proved very successful. A recording instrument was taken along on military reconnaissance or transport flights and recorded information en route. In some instances, military bombers made dropsonde flights with a parachute to conduct an aerological sounding in reverse. This proved expensive for daily use and often the desired location could not be reached. Rockets came into prominent use following World War II and are still in use today to probe the higher reaches of the atmosphere.

Radio proved to be the answer in developing a satisfactory and economical sounding device (radiosonde). Instant communication could be provided between the elements that sensed the weather parameters and the ground equipment which received and recorded them. This allowed the use of the data in real time to provide a profile of the current atmospheric conditions around a particular area.

The radiosonde instrument is now used by weather agencies around the world to collect information. There are more than 1,100 radiosonde sites or aerological stations worldwide. The United States of America (USA) currently lists 102 stations and Canada operates 31 permanent aerological facilities from coast to coast. A radiosonde flight or sounding is performed simultaneously by all the aerological stations, twice per day at pre-arranged times. A single radiosonde sounding provides a good vertical cross section of the atmosphere. When this data is combined with other stations on earth, it creates a global photographic effect of the state of the atmosphere.

Most radiosondes are carried aloft by lighter than airhydrogen or helium filled balloons to measure and simultaneously transmit recorded data which includes, pressure, temperature and humidity. The wind direction and speed are determined by using an instrument which tracks the radio signal transmitted by the radiosonde.

Aerological balloons may reach altitudes in excess of 40,000 m prior to bursting (approximately 90 minutes) after release. The horizontal distance traveled by an aerological balloon may vary due to the nature of the winds in the upper atmosphere. The atmosphere, which encircles the earth, flows in vast rivers, and winds often show tremendous variations in direction and speed as the balloon rises. During a balloon ascent, the winds may completely reverse in direction or range from calm to 300 km/h in high altitude jet streams.

Data on pressure, temperature, humidity and winds help forecasters to predict cloud cover, precipitation and the path of major storms. Aerological data is also critical in the prediction of a variety of severe weather events such as defining the locations where the threat of tornadoes, thunderstorms or high winds exist.

In spite of advances in satellite and computer technology, the aerological balloon and radiosonde still play a significant role in the observation, analysis and prediction of the world's weather.

In Canada, information from the radiosonde is received and interpreted by equipment at the aerological station. The data is then coded and transmitted to the station's regional office which houses a large computer. Some of the data received by the regional computer is used immediately to produce representations of local weather conditions. In general, the regional computer's function is to relay the aerological data to the Canadian Meteorological Centre (CMC) in Montreal, Quebec.

The CMC's computers are programmed with a fully automated forecast production system which ingests a large number of observations (radiosonde, land, buoys, ships, aircraft and satellite). The location, movement and strength of weather systems are analyzed from this data. Using mathematical equations and a sequential series of computer jobs, the future state of the atmosphere is predicted on global, national and regional scales. A wide assortment of charts and numerical data are produced at the CMC then relayed back to the regional offices where they are interpreted by meteorologists to produce local forecasts. These are then disseminated via radio, television, newspapers, etc. for commercial and public use.

The CMC also distributes the aerological data it receives to various other users within and outside Canada. Institutions such as the United States National Center for Environmental Prediction (NCEP), in Washington, D.C. receive Canadian data, where it is then made available to other world meteorological centres such as Melbourne, Australia and Moscow, Russia.

The World Meteorological Organization (WMO) has assigned a five-character index number to each aerological station. The index number is coded into the upper air bulletins by the equipment at the aerological station, prior to transmission. In this manner, the origin of the data may be easily determined by national and international users.

1.2 History of the aerological network – National Upper Air Program

During the 1930's, the development and testing of radiosonde instruments took place in many countries, including Canada. During the Second International Polar Year (1932-33), several "Moltchanoff" radiosondes were flown in Coppermine, Northwest Territories. These instruments radioed back temperature and pressure data. The highest ascent reached an altitude of 8,500 m before succumbing to battery failure.

The Meteorological Service of Canada (MSC) developed a radiosonde which operated on a chronometric, or time cycle, principle. The first operational radiosonde station using the MSC radiosonde was located at Gander, Newfoundland in June, 1941.

As near as can be determined, the first formal upper air training course in Canada was given in the fall of 1942. There were four students and the course was conducted by Mr. R.C. Jacobsen in the attic of the then headquarters of the MSC, at 315 Bloor Street West, in Toronto, Ontario.

Through co-operation with the USA, a rapid expansion of the radiosonde network took place during World War II. By 1945 there were 25 radiosonde stations in Canada, 12 of which were operated by the United States Army Air Force. These stations used a United States Weather Bureau (USWB) radiosonde.

By the early 1960's, use of the MSC radiosonde was replaced in favour of the USWB instrument. Prior to 1980, most data calculations were performed manually through the use of charts, tables and slide rule type calculators. The volume of computations (over 10 thousand) essential to complete an aerological observation, required the services of two observers working together.

With the introduction of computers in the late 1970's, a station-based minicomputer called the Aerological Data Reduction System (ADRES) eliminated most of the routine manual computations required. It then became possible for one observer to complete a radiosonde observation.

Computer systems of the 1980s evolved rapidly with respect to the use of microprocessor technology. This had a major impact on the development of upper air measurement techniques. By the late 1980's, Canada initiated a replacement of the ADRES computer with a more sophisticated sounding system called Navigational Aid (NAVAID). Using the NAVAID systems (Vaisala and VIZ), almost all of the routines for radiosonde observations were automated. The VIZ equipment was phased out at the end of 1999 in favour of the DigiCORA II sounding processor, followed by the DigiCORA III in 2007.

Figure1–1: Type and location of Upper Air Network stations (as of 2013-05-08)

In 2014, MSC operated 31 permanent aerological facilities (refer Figure 1-1). The MSC also deploys portable ground-based stations during emergencies or special research projects. In addition to upper air observations, most aerological stations maintain a variety of supplementary programs.

Chapter 2 Upper Air standards

2.1 Performance standards

2.1.1 Termination pressure

The following criteria must be met to fulfil the needs of the Meteorological Service of Canada (MSC) clients:

- 60% of flights must attain a pressure of 10 hPa or less
- 90% of flights must attain a pressure of 30 hPa or less

2.1.2 Official time of observation

The official time of observation refers to the actual time of release as determined by the meteorological service of a particular country. By international agreement, this time will fall between H-45 minutes and H, where H equals any of the four main synoptic hours (00:00, 06:00, 12:00, and 18:00 UTC). The MSC has chosen a time of H-45 as the official time of observation, therefore the official times of observation are 11:15 UTC and 23:15 UTC.

Every effort **shall** be made to perform the release at precisely the official time of observation (i.e. H-45 minutes). Deviations from the official times are not permitted without approval from national headquarters. Because conditions beyond the control of the observer may cause short delays in performing the release, actual release times between H-45 and H-31 **shall** be considered “normal.”

Radiosonde releases **shall not** be made in advance of H-45 or after H+1:45.

Table 2–1: Examples of official times of observation

Observation	Normal	Delayed
2315 UTC	(23:15 to 23:29 UTC)	(23:30 to 01:45 UTC)
1115 UTC	(11:15 to 11:29 UTC)	(11:30 to 13:45 UTC)

2.1.3 Surface observation

The surface observation **shall** be performed, as close as possible to the time and place of release, using approved MSC meteorological instruments.

2.1.4 Ascent rate

The target ascent rate for an aerological sounding is normally calculated from the surface to 200 hPa and should be between 250 and 325 m/min.

2.1.5 Successful observation

An aerological sounding (flight) is considered successful if acceptable pressure and temperature data are obtained up to and including the 400 hPa level. Second release attempts **shall not** normally be made due to missing relative humidity. In such cases, a regional support desk or forecast office must be contacted for further instructions. These instructions may include a request for another sounding. Second releases **shall** not be attempted for missing wind data unless there is a local requirement.

Comment [D1]: NOTE: Discussion for TWG. Determine what is an acceptable level (consider 400 hPa to 200 hPa) or other options.

2.1.6 Second release time window

If a first release is unsuccessful, a second release **shall** be attempted provided it is no later than H+1:45. Third releases **shall** not be attempted.

2.1.7 Bulletin transmissions

The first bulletin transmission **shall** occur when data up to and including the 100 hPa level has been obtained. The second bulletin transmission **shall** occur when data up to and including the termination level of the sounding has been obtained. If at H+1:20 transmission has not occurred all available data will be transmitted in any circumstance.

2.1.8 No observation attempt

If environmental conditions are such that there is a risk to the observer's safety, damage to property, or the integrity of the data is compromised, an observation shall not be attempted.

2.2 Ground check standards

Prior to release, the radiosonde pressure, temperature, and humidity shall be checked against Meteorological Service of Canada (MSC) approved instruments to ensure the radiosonde functions accurately, within the following standards:

- radiosonde pressure plus "+" or minus "–" 3.0 hPa vs. station barometer
- radiosonde temperature plus "+" or minus "–" 1.0 °C vs. ground check box thermistor
- radiosonde humidity plus "+" or minus "–" 4% vs. ground check box chamber

If the radiosonde data falls outside the above limits, the instrument **shall not** be used for the observation.

2.3 Coding level standards

By international agreement (WMO), the MSC reports altitude, temperature, dew point depression, and wind velocity at determined mandatory levels in the atmosphere.

2.3.1 Pressure levels

The following are the mandatory pressure levels:

- 1,000 hPa
- 925 hPa
- 850 hPa
- 700 hPa
- 500 hPa
- 400 hPa
- 300 hPa
- 250 hPa
- 200 hPa
- 150 hPa
- 100 hPa
- 70 hPa
- 50 hPa
- 30 hPa
- 20 hPa
- 10 hPa
- 7 hPa
- 5 hPa
- 3 hPa

2.3.2 Wind levels

As with mandatory pressure levels, the WMO has identified (and MSC must report) a set of fixed regional wind levels where wind speed and direction are required and, if available, **shall** be reported.

Table 2–2: Altitude of fixed wind levels

Feet	Metres
Surface	
1,000 ft	305 m
2,000 ft	610 m
3,000 ft	914 m
4,000 ft	1,219 m
6,000 ft	1,829 m
7,000 ft	2,134 m
8,000 ft	2,438 m
9,000 ft	2,743 m
12,000 ft	3,658 m
14,000 ft	4,267 m
16,000 ft	4,877 m
20,000 ft	6,096 m
25,000 ft	7,620 m
30,000 ft	9,144 m
35,000 ft	10,668 m
50,000 ft	15,240 m
70,000 ft	21,336 m
90,000 ft	27,432 m
100,000 ft	30,480 m
110,000 ft	33,528 m
140,000 ft	42,672 m

2.3.3 **Temperature levels**

The following are criteria for the selection of significant temperature levels:

1) departure from linearity of 1 °C or more from the surface up to and including 100 hPa
2) departure from linearity of 2 °C or more above 100 hPa

2.3.4 **Relative humidity levels**

Departure from linearity of 10% between surface and termination is criteria for the selection of significant relative humidity levels.

2.3.5 **Additional levels**

Further levels selected as significant for coding include the following:

- surface level
- termination level
- missing temperature data boundaries
- level within a missing temperature stratum
- the base and top of inversions having a thickness of 20 hPa or more
- the first and second tropopause

2.3.6 **Wind data**

The following are selected as significant wind levels:

- surface level
- highest 1,000 ft (305 m) level
- boundary levels of missing wind data stratum
- level within a missing wind data stratum
- levels adjacent to a calm wind stratum
- level of maximum wind above 500 hPa if it equals or exceeds 60 knots
- departure from linearity of 10 knots for speed and 10 degrees for direction
- if the wind speed is less than 10 knots (5 m/sec) significant levels are not chosen for direction
- lower and upper boundaries of calm stratum

Chapter 3 Upper Air coded messages

3.1 General

Upper air coded messages are used for international exchange of meteorological information. The upper air data is transmitted from Canadian aerological stations based on two general formats established by the World Meteorological Organization (WMO) for Region IV. These formats are:

- Radiosonde observations of altitude, pressure, temperature, dew point depression and wind speed and direction are coded using WMO Code FM 35-XI Ext. TEMP for land based stations, WMO Code FM 36-XI Ext. TEMP SHIP for sea based stations and WMO Code FM 38-XI Ext. TEMP MOBIL for mobile land stations.
- Upper wind observations are coded using WMO Code FM 32-XI Ext. PILOT for land based stations, WMO Code FM 33-XI Ext. PILOT SHIP for sea based stations and FM 34-XI Ext. PILOT MOBIL for mobile land stations.

Comment [D2]: Roman numeral identifies the session of the CSM/CBS (Commission for Basic Systems) approval or amendment.

3.2 Message section, part and header

3.2.1 Message sections

The data contained in the messages are grouped into sections. The TEMP, TEMP SHIP and TEMP MOBIL messages may contain up to 10 sections depending on WMO Regional and National practices.

These sections are:

Section 1: identification and position data (latitude, longitude, height, height confidence)
Section 2: data for surface and mandatory levels
Section 3: data for tropopause level(s)
Section 4: data for maximum wind level(s) and vertical wind shear
Section 5: data for significant levels with respect to temperature and/or relative humidity
Section 6: data for significant levels with respect to wind
Section 7: data on sounding system and sea surface
Section 8: cloud data
Section 9: regional code groups
Section 10: national code groups

Canadian aerological stations do not include all sections in their transmitted messages. TEMP, TEMP SHIP and TEMP MOBIL messages consist of sections 1, 2, 3, 4, 5, 7, 9 and 10. PILOT, PILOT SHIP, and PILOT MOBIL messages consist of sections 1 and 4.

3.2.2 Message parts

The data contained in the coded messages are divided into parts A, B, C, and D. For Canadian TEMP, TEMP SHIP and TEMP MOBIL messages contain:

Part A: the data up to and including the 100 hPa level for sections 1, 2, 3, and 4
Part B: the data up to and including the 100 hPa for sections 1, 5, 7, 9, and 10
Part C: the data above the 100 hPa level for sections 1, 2, 3, and 4
Part D: the data above the 100 hPa level for sections 1, 5, 9 and 10

The TEMP MOBIL message contains elevation data in Section 1 (section 3.2.3.1).

3.2.3 Message headers

The data contained in the coded message are also divided into message headers. For Canadian TEMP and PILOT messages, headers contain:

US Bulletin: TEMP data for mandatory pressure levels.
UK Bulletin: TEMP data for significant levels as determined by the ground equipment.
UG Bulletin: contains PILOT data for fixed and significant wind levels. The format is not changed.
UL Bulletin: TEMP data for mandatory pressure levels.
UE Bulletin: TEMP data for significant levels as determined by the ground equipment.
UQ Bulletin: contains PILOT data for fixed and significant wind levels. The format is not changed.

3.3 Message code form

3.3.1 TEMP or TEMP SHIP message, Part A (US)

Below are symbolic code forms of Part A of the first transmission of a radiosonde message used by land and ship stations.

3.3.1.1 Section 1: identification and position data

Identification groups for land stations:

$M_iM_iM_jM_j$ $YYGGI_d$ IIiii

or

Identification position groups for ship stations:

$M_iM_iM_jM_j$ D . . . . D $YYGGI_d$ $99L_aL_aL_a$

$Q_cL_oL_oL_oL_o$ $MMMU_{La}U_{Lo}$

3.3.1.2 Section 2: surface and mandatory levels

Surface data:

$99P_oP_oP_o$ $T_oT_oT_{ao}D_oD_o$ $d_od_of_of_of_o$

Mandatory levels:

00hhh	TTT_aDD	ddfff
92hhh	TTT_aDD	ddfff
85hhh	TTT_aDD	ddfff
70hhh	TTT_aDD	ddfff
50hhh	TTT_aDD	ddfff
40hhh	TTT_aDD	ddfff
30hhh	TTT_aDD	ddfff
25hhh	TTT_aDD	ddfff
20hhh	TTT_aDD	ddfff
15hhh	TTT_aDD	ddfff
10hhh	TTT_aDD	ddfff

3.3.1.3 Section 3: tropopause level(s)

Tropopause data:

$88P_tP_tP_t$ $T_tT_tT_{at}D_tD_t$ $d_td_tf_tf_tf_t$

or

88999

3.3.1.4 Section 4: maximum wind level(s) and vertical wind shear

Maximum wind data:

$77P_mP_mP_m$

or

$d_md_mf_mf_mf_m$

$66P_mP_mP_m$

or

77999

3.3.2 TEMP or TEMP SHIP message, Part B (UK)

Below are symbolic code forms of Part B of the first transmission of a rawisonde message used by land and ship stations.

3.3.2.1 Section 1: identification and position data

Identification groups for land stations:

$M_iM_iM_jM_j$ $YYGGa_4$ IIiii

or

Identification position groups for ship stations:

$M_iM_iM_jM_j$ D . . . . D $YYGGa_4$ $99L_aL_aL_a$

$Q_cL_oL_oL_oL_o$ $MMMU_{La}U_{Lo}$

3.3.2.2 Section 5: significant temperature and/or relative humidity

Surface data:

$00P_oP_oP_o$ $T_oT_oT_{ao}D_oD_o$

11PPP TTT_aDD

and significant levels:

22PPP TTT_aDD

33PPP TTT_aDD

etc.

3.3.2.3 Section 7: sounding system and sea surface data

Sounding system data and sea surface data:

31313 $s_rr_ar_as_as_a$ 8GGgg $9s_nT_wT_wT_w$

3.3.2.4 Section 9: regional code groups

Regional codes - additional data:

51515 $101A_{df}A_{df}$

3.3.2.5 Section 10: national code groups

National codes - additional data:

61616 $101A_{df}A_{df}$

3.3.3 TEMP or TEMP SHIP message, Part C (UL)

Below are symbolic code forms of Part C of the second transmission of a radiosonde message used by land and ship stations.

3.3.3.1 Section 1: identification and position data

Identification groups for land stations:

$M_iM_iM_jM_j$ $YYGGI_d$ IIiii

or

Identification position groups for ship stations:

$M_iM_iM_jM_j$ D . . . . D $YYGGI_d$ $99L_aL_aL_a$

$Q_cL_oL_oL_oL_o$ $MMMU_{La}U_{Lo}$

3.3.3.2 Section 2: surface and mandatory levels

Mandatory levels:

70hhh	TTT_aDD	ddfff
50hhh	TTT_aDD	ddfff
30hhh	TTT_aDD	ddfff
20hhh	TTT_aDD	ddfff
10hhh	TTT_aDD	ddfff
07hhh	TTT_aDD	ddfff
05hhh	TTT_aDD	ddfff
03hhh	TTT_aDD	ddfff
02hhh	TTT_aDD	ddfff
01hhh	TTT_aDD	ddfff

3.3.3.3 Section 3: tropopause level(s)

Tropopause data:

$88P_tP_tP_t$ $T_tT_tT_{at}D_tD_t$ $d_td_tf_tf_tf_t$

or

88999

3.3.3.4 Section 4: maximum wind level(s) and vertical wind shear

Maximum wind data:

$77P_mP_mP_m$

or

$d_md_mf_mf_mf_m$

$66P_mP_mP_m$

or

77999

3.3.4 TEMP or TEMP SHIP message, Part D (UE)

The symbolic code forms of Part D of the second transmission of a radiosonde message are used by land and ship stations.

3.3.4.1 Section 1: identification and position data

Identification groups for land stations:

$M_iM_iM_jM_j$ YYGG/ IIiii

or

Identification position groups for ship stations:

$M_iM_iM_jM_j$ D . . . . D $YYGGa_4$ $99L_aL_aL_a$

$Q_cL_oL_oL_oL_o$ $MMMU_{La}U_{Lo}$

3.3.4.2 Section 5: significant temperature and/or relative humidity levels

Significant levels:

11PPP TTT_aDD

22PPP TTT_aDD

33PPP TTT_aDD

44PPP TTT_aDD

etc.

3.3.4.3 Section 9: regional groups

Regional codes - additional data:

51515 $101A_{df}A_{df}$

3.3.4.4 Section 10: national groups

National codes - additional data:

61616 $101A_{df}A_{df}$

3.4 TEMP message content

3.4.1 Section 1: identification and position data

The purpose of Section 1 is to identify the type, origin and time of the message, and is included in each part.

3.4.1.1 Message indicator $M_iM_iM_jM_j$

This four-letter group contains identification data and is the first group in the coded message.

M_iM_i: Symbolic code for identifying a radiosonde or radiosonde message originating from a land or ship station. A TEMP message is coded as TT, a TEMP SHIP is coded as UU and a TEMP MOBIL is coded as II.

M_jM_j: Symbolic code for identifying the part of the message that is to follow (i.e. parts A, B, C or D) Part A is coded as AA, Part B as BB, etc.

3.4.1.2 Date indicator $YYGGI_d$ (parts A, C, D) and $YYGGa_4$ (Part B)

YY: Identifies the day of the month and the unit of wind speed (i.e. knots or meters per second) used in the message.

The day of the month is reported through the use of code figures 01 to 31, inclusive, where code figure 01 means the first day of the month, 02 means second day of the month, etc.

The unit of wind speed is reported as follows:

- When wind speeds are reported in knots, 50 is added to YY (Canadian upper air messages always use knots);
- When wind speeds are reported in meters per second, YY is not modified.

GG: Identifies the time of observation in whole hours, coordinated universal time (UTC), based on the twenty-four hour clock (i.e. 00 to 23).

The standard hour of observation, H, is coded for GG whenever the release time is within the time range of H-45 to H+29 inclusive (e.g. If the release time is 2315, GG is coded as 00).

If the release time is outside of the range of H-45 to H+29, GG is coded to the nearest hour UTC (e.g. if the release time is 0030, GG is coded as 01).

I_d: Identifies the last mandatory level for which wind data is reported.

Table 3–1: Table for selection of code figure I_d – WMO code table 1734

Code figure	Pressure of mandatory level – Part A	Pressure of mandatory level – Part C
1	100 or 150 hPa	10 hPa
2	200 or 250 hPa	20 hPa
3	300 hPa	30 hPa
4	400 hPa	-
5	500 hPa	50 hPa
6	-	-
7	700 hPa	70 hPa
8	850 hPa	-
9	925 hPa	-
0	1000 hPa	-
/	No wind group included for any mandatory level.	No wind group included for any mandatory level.

3.4.1.3 International index number IIiii

This five-figure group constitutes the international index number.

II: Identifies the block number which defines the area in which the reporting station is situated. Each block contains 1000 station numbers and is allocated to one or more countries within a WMO region. All stations within Canada use the block number 71.

iii: Refers to the three digit number allocated to Meteorological Services in one or more countries within a WMO Region.

3.4.2 Section 2: surface and mandatory levels

The purpose of Section 2 is to report temperature, dew point depression, altitude and wind data corresponding to the mandatory pressure levels. The data for a mandatory level is normally coded into three consecutive groups. The first group contains the level identifier and the altitude expressed in geopotential meters; the second group contains temperature and dew point depression data; while the third group is the coded wind direction and speed.

3.4.2.1 Mandatory levels (pressure) $99P_oP_oP_o$

99: The digits 99 indicate that surface level data is to follow.

$P_oP_oP_o$: The hundreds, tens and units digits corresponding to the surface pressure expressed in hPa.

3.4.2.2 Mandatory levels (height) XXhhh

XX: Level identifier (refer to Tables 3–2 and 3–3).

hhh: Indicates whole geopotential metres for the altitudes of the 1000, 925, 850 and 700 hPa levels; and indicates the hundreds, tens and ones digits and indicates the thousands, hundreds and tens digits of the altitude in geopotential metres for the 500 hPa level and higher

Example (1): 700 hPa at 3034 gpm is coded as 034

Example (2): 500 hPa at 5560 gpm is coded as 556.

Example (3): 100 hPa at 16280 gpm is coded as 628.

Note: When the altitude of the 1,000 hPa level is computed to be below sea level (i.e. a negative number), 500 is added to its value.

Comment [D3]: Steve confirmed that this is the correct geopotential (below sea level) calculations. Feedback?

Example (1):1000 hPa at a negative (-)75 gpm (below sea level) is coded as 10575.

Example (2): 1000 hPa at a negative (-)125 gpm (below sea level) is coded as 00375.

Table 3–2: Pressure corresponding to level identifiers XX – Part A

Part A	Level
00	1000 hPa
92	925 hPa
85	850 hPa
70	700 hPa
50	500 hPa
30	300 hPa
25	250 hPa
20	200 hPa
15	150 hPa
10	100 hPa

Table 3–3: Pressure corresponding to level identifiers XX – Part C

Part C	Level
70	70 hPa
50	50 hPa
30	30 hPa
20	20 hPa
10	10 hPa
07	7 hPa
05	5 hPa

3.4.2.3 Mandatory levels (temperature) $T_oT_oT_{ao}D_oD_o$ and TTT_aDD

These groups contain temperature and dew point depression data corresponding to the mandatory level, XX, in the immediately preceding group. The subscript "$_o$" in the symbolic code indicates surface level data.

T_oT_o and TT: Represent the tens and unit's value of the temperature.

T_{ao} and T_a: Represent the approximate tenths value and the sign (i.e. positive or negative) of the values for TT and T_oT_o. When this digit is an odd number, the temperature is negative and when this digit is an even number, the temperature is positive (refer to Table 3–4).

D_oD_o and DD: Represent the dew point depression with respect to water, (i.e. the difference between the air temperature and the dew point temperature expressed in degrees Celsius, refer to Table 3–5).

Table 3–4: Table for selection of code figure $T_aT_{ao}T_{at}$ – WMO code table 3931

Tenths figure of observed air temperature	Code figure positive temperature	Code figure negative temperature
0	0	1
1	0	1
2	2	3
3	2	3
4	4	5
5	4	5
6	6	7
7	6	7
8	8	9
9	8	9

Table 3–5: Determining code figures for the dew point depression – WMO code table 0777

Dew point depression °C	Code figure	Dew point depression °C	Code figure	Dew point depression °C	Code figure
0.0	00	3.4	34	18	68
0.1	01	3.5	35	19	69
0.2	02	3.6	36	20	70
0.3	03	3.7	37	21	71
0.4	04	3.8	38	22	72
0.5	05	3.9	39	23	73
0.6	06	4.0	40	24	74
0.7	07	4.1	41	25	75
0.8	08	4.2	42	26	76
0.9	09	4.3	43	27	77
1.0	10	4.4	44	28	78
1.1	11	4.5	45	29	79
1.2	12	4.6	46	30	80
1.3	13	4.7	47	31	81
1.4	14	4.8	48	32	82
1.5	15	4.9	49	33	83
1.6	16	5	50	34	84
1.7	17	not used	51	35	85
1.8	18	not used	52	36	86
1.9	19	not used	53	37	87
2.0	20	not used	54	38	88
2.1	21	not used	55	39	89
2.2	22	6	56	40	90
2.3	23	7	57	41	91
2.4	24	8	58	42	92
2.5	25	9	59	43	93
2.6	26	10	60	44	94
2.7	27	11	61	45	95
2.8	28	12	62	46	96
2.9	29	13	63	47	97
3.0	30	14	64	48	98
3.1	31	15	65	49	99
3.2	32	16	66	-	-
3.3	33	17	67	-	-

3.4.2.4 Mandatory levels (wind) $d_od_of_of_of_o$ and ddfff

This group contains wind direction and speed data for the mandatory level XX. The subscript "o", in the symbolic form, indicates surface data.

dd: The hundreds and tens digits of the wind direction.

fff: The first digit represents the units value of the wind direction rounded to the nearest five degrees. The final two digits represent the tens and units value of the wind speed. If, however, the wind speed is 100 knots or greater, the hundreds digit of the wind speed is added to the value of the first digit.

Example (1):
Wind direction: 291
Wind speed: 55 knots
Coded value: 29055

Example (2):
Wind direction: 293
Wind speed: 55 knots
Coded value: 29555

Example (3):
Wind direction: 289
Wind speed: 106 knots
Coded value: 29106

Example (4):
Wind direction: 304
Wind speed: 201 knots
Coded value: 30701

3.4.3 Section 3: tropopause level(s), Part A and Part C

This section reports tropopause data in parts A and C of the message.

3.4.3.1 Tropopause (pressure) $88P_tP_tP_t$

88: The digits 88 indicate that tropopause data are to follow.

$P_tP_tP_t$: The hundreds, tens and units digits corresponding to the pressure at the tropopause level.

88999: Indicates the message does not contain tropopause data.

3.4.3.2 Tropopause (temperature) $T_tT_tT_{at}D_tD_t$

Tropopause temperature and dew point depression data. These are coded in the same manner as TTT_aDD (refer to 3.4.2.3).

3.4.3.3 Tropopause (wind) $d_td_tf_tf_tf_t$

Tropopause wind direction and speed. These are coded in the same manner as ddfff (refer to 3.4.2.4).

3.4.4 Section 4: maximum wind level(s) and vertical wind shear, Part A and Part C

This section reports maximum wind data in parts A and C of the message. A level of maximum wind is defined as a level at which the wind speed is greater than at levels adjacent to it (i.e. immediately above and below it). If the highest wind speed occurs in a layer of equal winds, then the level at the top of this layer is considered the maximum wind.

3.4.4.1 Maximum wind (upper level) $77P_mP_mP_m$

77: Indicates that maximum wind data, meeting these criteria, are to follow:

- wind data are available both above and below the level of maximum wind;
- the wind speed is greater than 60 knots;
- Part A of the message, it is the highest wind speed occurring above 500 hPa and up to and including 100 hPa; and
- for Part C of the message, it is the highest wind speed above 100 hPa.

$P_mP_mP_m$: Indicates the pressure at the level of the maximum wind:

- In Part A of the message, this represents the hundreds, tens and units digits corresponding to the pressure at the level of the maximum wind.
- In Part C of the message, this represents the tens, units and tenths digits corresponding to the pressure at the level of the maximum wind.

77999: Indicates the message does not contain maximum wind data.

3.4.4.2 Maximum wind (sounding) $66P_mP_mP_m$

66: The digits 66 indicate that maximum wind data, meeting these criteria, are to follow:

- It is at the terminating level of the wind sounding;
- The wind speed is greater than 60 knots;
- It is the highest wind speed in the sounding; and

- It occurs above the 500 hPa level.

$P_mP_mP_m$: Indicates the pressure at the level of the maximum wind:

- In Part A of the message, this represents the hundreds, tens and units digits corresponding to the pressure at the level of the maximum wind.
- In Part C of the message, this represents the tens, units and tenths digits corresponding to the pressure at the level of the maximum wind.

3.4.4.3 Wind direction $d_md_mf_mf_mf_m$

dd: The hundreds and tens digits of the wind direction.

fff: The first digit represents the units value of the wind direction rounded to the nearest five degrees. The final two digits represent the tens and units value of the wind speed. If, however, the wind speed is 100 knots or greater, the hundreds digit of the wind speed is added to the value of the first digit.

3.4.5 Section 5: significant temperature and/or relative humidity

The purpose of Section 5 is to report significant levels selected for coding on the basis of temperature and humidity.

3.4.5.1 Surface level $00P_oP_oP_o$

00: The digits 00 indicate that surface level data is to follow.

$P_oP_oP_o$: Indicates the hundreds, tens and units values corresponding to the surface pressure.

3.4.5.2 Significant levels (pressure) XXPPP

XX: These are the indicator figures used to identify the significant levels selected for coding. The significant levels are numbered in consecutive order with respect to height (i.e. 11, 22, 33, 44, etc.). After 99, the numbers restart at 11 (i.e. 99, 11, 22, etc.).

PPP: Indicates the pressure of the significant levels.

All pressures up to and including the 100 hPa level are reported to the nearest whole hPa using the hundreds, tens and units digits (e.g. 1023.4 hPa would be coded 023, 991.7 as 992).

All pressures above the 100 hPa level are reported to 0.1 hPa using the tens, units and tenths digits (e.g. 76.0 hPa would be coded 760, 9.6 as 096).

3.4.5.3 Significant levels (temperature) TTT_aDD and $T_oT_oT_{ao}D_oD_o$

These groups are coded in the same manner as their corresponding groups in Section 2 (refer to 3.4.2).

3.4.6 Section 7: sounding system and sea surface data

The purpose of this section is to report additional data about the sounding, i.e.: type of radiosonde, type of tracking system, time of launch, (release) and sea surface data, (if applicable).

31313: This is the indicator for Section 7.

s_r: This is the indicator for the solar radiation correction that is applied to the sounding (refer to Table 3–6).

r_ar_a: Radiosonde sounding system used (refer to Table 3–7 – WMO code table 3685).

s_as_a: Tracking technique/status of system used (refer to Table 3–8).

8GGgg: Actual time of launch (release) of the radiosonde (hours and minutes: UTC).

$9_{sn}T_wT_wT_w$: Report of sea surface temperature in tenths of degrees Celsius, its sign being given by s_n (optional group).

Table 3–6: Solar and infrared radiation correction – s_r – WMO code table 3849

Code figure	s_r – Specification
0	No correction
1	CIMO solar corrected and CIMO infrared corrected
2	CIMO solar corrected and infrared corrected
3	CIMO solar corrected only
4	Solar and infrared corrected automatically by radiosonde system
5	Solar corrected automatically by radiosonde system
6	Solar and infrared corrected as specified by country
7	Solar corrected as specified by country

Table 3–7: Type of radiosonde/sounding system in use – r_ar_a – WMO code table 3685

Code figure	r_ar_a – Specifications
02	No radiosonde/passive target (e.g. balloon plus reflector, etc.)
03	No radiosonde/active target (e.g. balloon plus transponder)
04	No radiosonde/passive temperature – humidity profiler
05	No radiosonde/active temperature – humidity profiler
06	No radiosonde/radio – acoustic sounder
07	No radiosonde/reserved
08	No radiosonde/reserved
09	No radiosonde/sounding system not specified or unknown
10	RS VIZ Type A pressure commutated (USA)
11	RS VIZ Type B time commutated (USA)
12	RS SDC (Space Data Corporation – USA)
13	Astor (no longer made – Australia)
14	VIZ Mark 1 Microsonde (USA)
15	EEC company Type 23 (USA)
16	Elin (Austria)
17	Graw G. (Germany)
18	Reserved for allocation of radiosondes
19	Graw M60 (Germany)
20	Indian Meteorological Service MK3 (India)
21	VIZ/Jin Yang Mark 1 Microsonde (South Korea)
22	Meisei RS2-80 (Japan)
23	Mesural FM0 1950A (France)
24	Mesural FM0 1945A (France)
25	Mesural MH73A (France)
26	Meteolabor Basora (Switzerland)
27	AVK – MRZ (Russian Federation)
28	Meteorit Marz 2-1 (Russian Federation)
29	Meteorit Marz 2-2 (Russian Federation)
30	Oki RS 2-80 (Japan)
31	VIZ/Valcom Type A pressure commutated (Canada)

Code figure	$r_a r_a$ – Specifications
32	Shanghai Radio (China)
33	UK Meteorological Office MK3 (UK)
34	Vinohrady (Czechoslovakia)
35	Vaisala RS18 (Finland)
36	Vaisala RS21 (Finland)
37	Vaisala RS80 (Finland)
38	VIZ LOCATE Loran – C (USA)
39	Sprenger E076 (Germany)
40	Sprenger E084 (Germany)
41	Sprenger E085 (Germany)
42	Sprenger E086 (Germany)
43	AIR - IS - 4A - 1680 (USA)
44	AIR - IS - 4A - 1680 (USA)
45	RS MSS (USA)
46	AIR - IS - 4A - 403 (USA)
47	Meisei RS2-91 (Japan)
48	Valcom (Canada)
49	VIZ MARK II (USA)
50	GRAW DFM-90 (Germany)
51	VIZ-B2 (USA)
52	Vaisala RS80 – 57H
53	AVK – RF95 (Russian Federation)
54	GRAW DFM-97 (Germany)
55-59	Reserved for allocation of radiosondes
60	Vaisala RS80/MicroCora (Finland)
61	Vaisala RS80/Loran/Digicora I, II or Marvin (Finland)
62	Vaisala RS80/PCCora (Finland)
63	Vaisala RS80/Star (Finland)
64	Orbital Sciences Corporation, Space Data Division Transponder Radiosonde, Type 909-11-XX, where XX corresponds to the model of the Instrument (USA)
65	VIZ Transponder Radiosonde, Model # 1499-520 (USA)

Code figure	$r_a r_a$ – Specifications
66	Vaisala RS80/Autosonde (Finland)
67	Vaisala RS80/Digicora III (Finland)
68-70	Reserved for additional automated sounding systems
71	Vaisala RS90/Loran/Digicora I, II or Marvin (Finland)
72	Vaisala RS90/PC-Cora (Finland)
73	Vaisala RS90/Autosonde (Finland)
74	Vaisala RS90/Dstar (Finland)
75	AVK-MRZ-ARMA (Russian Federation)
76	AVK-RF95-ARMA (Russian Federation)
77	GEOLINK GPSonde GL98 (France)
78	Vaisala RS90/Digicora III (Finland)
79-81	Reserved for additional automated sounding systems
82	Sippican MK2 GPS/Star (USA)
83	Sioppican MK2 GPS/W9000 (USA)
84-89	Reserved for additional automated sounding systems
90	Radiosonde not specified or unknown
91	Pressure only radiosonde
92	Pressure only radiosonde plus transponder
93	Pressure only radiosonde plus radar reflector
94	No pressure radiosonde plus transponder
95	No pressure radiosonde plus radar reflector
96	Descending radiosonde
97-99	For allocation of sounding systems with incomplete sondes

Table 3–8: Tracking system/status of system used – $s_a s_a$ – WMO code table 3872

Code figure	$s_a s_a$ – Specification
00	No windfinding
01	Automatic with auxiliary optical direction finding
02	Automatic with auxiliary optical direction finding
03	Automatic with auxiliary ranging
04	Not used
05	Automatic with multiple VLF – omega frequencies

06	Automatic cross chain loran – C
07	Automatic with auxiliary wind profiler
08	Automatic satellite navigation
09-18	Reserved
19	Tracking technique not specified
20-29	Ship systems – reserved for ASAP
30-39	Sounding systems – reserved for ASAP
40-49	Launch facilities – reserved for ASAP
50-59	Data acquisition systems – reserved for ASAP
60-69	Communications – reserved for ASAP
70	All systems in normal operations – reserved for ASAP

3.4.7 **Section 9: regional groups**

The purpose of this section is to report regionally developed code groups.

51515: This is the indicator group for Section 9.

$101A_{df}A_{df}$: This is the form of additional regional data reported

101: The three digit indicator 101 identifies the additional data group.

$A_{df}A_{df}$: This two-digit group identifies the additional data as specified in Table 3–9.

Table 3–9: Additional data code figures 40-99 – $A_{df}A_{df}$ – WMO code table 0421

Code figure	$A_{df}A_{df}$ – Specification
40-59	Reason for no report or incomplete report
40	Report not filed
41	Not used
42	Ground equipment failure
43	Observation delayed
44	Power failure
45	Unfavourable weather conditions
46	Low maximum altitude (less than 500 m above ground)
47	Leaking balloon
48	Ascent not authorized for this period
49	Alert
50	Ascent did not ascend above 400 hPa
51	Balloon forced down by icing conditions
52	Balloon forced down by precipitation
53	Atmospheric interference
54	Local interference
55	Fading signal
56	Weak signal
57	Preventive maintenance
58	Flight equipment failure
59	Any reason not listed above
60-64	Miscellaneous
60	Not used
61	Not used
62	Radiosonde report precedes
63	Not used
64	Not used
65-69	Doubtful data

Code figure	$A_{df}A_{df}$ – Specification
65	Geopotential and temperature data are doubtful between the following levels $0P_nP_nP_nP_n$
66	Geopotential data doubtful between the following levels $0P_nP_nP_nP_n$
67	Temperature data doubtful between the following levels $0P_nP_nP_nP_n$
68	Dew point depression is missing for reasons other than motor boating between the following levels $0P_nP_nP_nP_n$ (not used when T_nT_n is also missing)
69	Not used
70-74	Not allocated
75-89	Corrected data
75	Not used
76	Not used
77	Not used
78	Corrected tropopause data section follows
79	Corrected maximum wind section follows
80	Corrected report for the entire report (first plus second transmission) precedes
81	Corrected report for the entire first transmission precedes
82	Corrected report for entire second transmission precedes
83	Corrected data for mandatory levels follows
84	Corrected data for significant levels follows
85	Minor errors in this report: correction follows
86	Significant levels not included in original report follow
87	Corrected data for surface follow
88	Corrected additional data groups follow
90	Extrapolated geopotential data follows
91	Extrapolated surface data precede (used only in dropsonde)
92	Termination altitude data follows
93	Not used
94	Averaged wind for the surface to 1500 m layer and the 1500 – 3000 m layer follows

Code figure	$A_{df}A_{df}$ – Specification
95	Early transmission of 850 and 500 hPa data and stability index follows
96	Early transmission of 850, 700 and 500 hPa data and stability index follows
97	Early transmission of 500 hPa data and stability index follow
98	Early transmission of 700 hPa data and stability index follow
99	Not to be allocated

3.4.8 Section 10: national code groups

The purpose of this section is to report nationally developed code groups.

61616: Indicates data in national code follows.

$101A_{df}A_{df}$: This is coded in the same manner as in Section 9 (refer to 3.4.7).

3.5 TEMP SHIP message content

The TEMP SHIP message is coded the same as a TEMP message with the exception of Section 1. Therefore, only the differences in the coding of Section 1 will be explained.

3.5.1 Section 1: identification and position data

3.5.1.1 Location – latitude $99L_aL_aL_a$

99: This is the group identifier.

$L_aL_aL_a$: These three digits represent the latitude of the point of observation. The latitude is reported in tens, units and tenths of degrees (e.g. 74.15 N is coded as 741).

3.5.1.2 Location – longitude $Q_cL_oL_oL_oL_o$

Q_c: Represents the quadrant of the globe where the point of observation is located (refer to Table 3–10). If the ship is located on the equator or a prime meridian, two possible values occur, either one of which is acceptable.

$L_oL_oL_oL_o$: These digits represent the longitude of the point of observation. The longitude is reported in hundreds, tens, units and tenths of degrees (e.g. 103.65 is coded as 1036).

Table 3–10: Values of Q_C in each quadrant of the earth – WMO code table 3333

Latitude	Longitude	Qc
North	East	1
South	East	3
South	West	5
North	West	7

Note: The choice is left to the observer in the following cases:

- When the ship is on the Greenwich meridian or 180th Meridian ($L_oL_oL_oL_o$ = 0000 or 1800 respectively)
  - Q_C = 1 or 7 (Northern Hemisphere); or
  - Q_C = 3 or 5 (Southern Hemisphere).
- When the ship is on the equator ($L_aL_aL_a$ = 000)
  - Q_c = 1 or 7 (eastern longitude); or
  - Q_c = 3 or 5 (western longitude).

3.5.1.3 Location – SHIP $MMMU_{La}U_{Lo}$

This is the ship position verification group and is used to check the position of the ship in ship station messages.

MMM: This represents the Marsden square number in which the ship is located at the time of observation. The Marsden square number is determined from Figure 3–1 by using the latitude and longitude corresponding to the ship's position (e.g. If the ship's position is 46.0 N and 146.1 W, the Marsden square number is 159).

U_{La}: This is the units digit from the latitude corresponding to ship's position (e.g. If the latitude is 45.9 N, U_{La} is coded as 5).

U_{Lo}: This is the units digit from the longitude corresponding to the ship's position (e.g. If the longitude is 145 W, U_{Lo} is coded as 5).

3.5.2 Marsden squares

When the latitude and longitude of the ship's position places the ship at the common intersection point of four Marsden squares, or the common side of two adjacent squares orientated East-West or North-South, the Marsden square number to be coded is determined by using the appropriate grid of the four grids shown in Figure 3–2. Each grid shows the 10-degree Marsden square divided into one-degree sub squares with a number assigned to each sub square (only a pattern of numbers is shown). The grid labeled "A" is used for Marsden squares in the North latitudes and West longitudes, i.e., Q_C = 7, and the grid labeled "B" is used for Marsden squares in the North latitudes and East longitudes, i.e. Q_C = 1, etc. It will be noted that the number of any sub square corresponds to the $U_{La}U_{Lo}$ for a ship positioned in the sub square. When the latitude and longitude values of the ship's position place the ship on the common side of two adjacent squares orientated North-South, the Marsden square number **shall** be determined as illustrated by the following example.

Example: Assume the ship's position to be 50.0 N and 145.0 W. This position is on the boundary line of Marsden squares 195 and 159 (refer to Figure 3–1).

Determine the $U_{La}U_{Lo}$ value from the ship's position. In the example $U_{La}U_{Lo}$ is 05; Superimpose the appropriate grid which, in this example, is Grid A, (refer to Figure 3–2), on the adjacent Marsden squares, 195 and 159, and select the Marsden square which, when so subdivided, displays the sub square numbered 05 adjacent to the ship's position. In the example the Marsden square is 195; code 195 for MMM.

The procedure for determining the Marsden square number of a ship's position that places it on the common side of two squares which have oriented East-West is the same as that used for the squares orientated North-South. When the latitude and longitude values of the ship's position place the ship at a common intersection of four squares, the appropriate grid must be applied to the four adjacent Marsden squares to determine the correct Marsden number. If the ship's position is on the equator, or on the 0 degree or 180 degree meridian, the number selected for Q_C **shall** determine the relevant Marsden square.

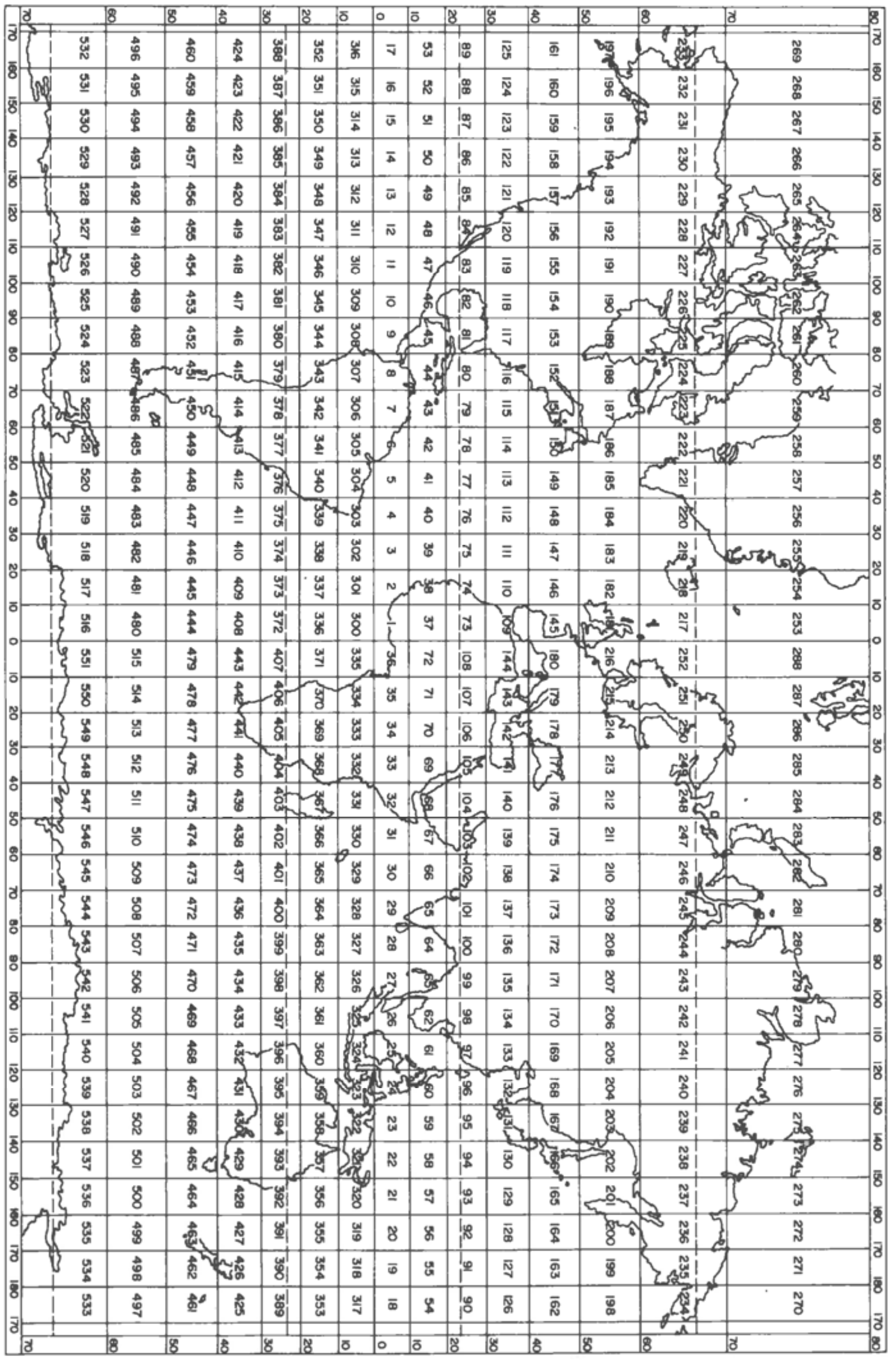

Figure 3–1: Marsden ten degree squares

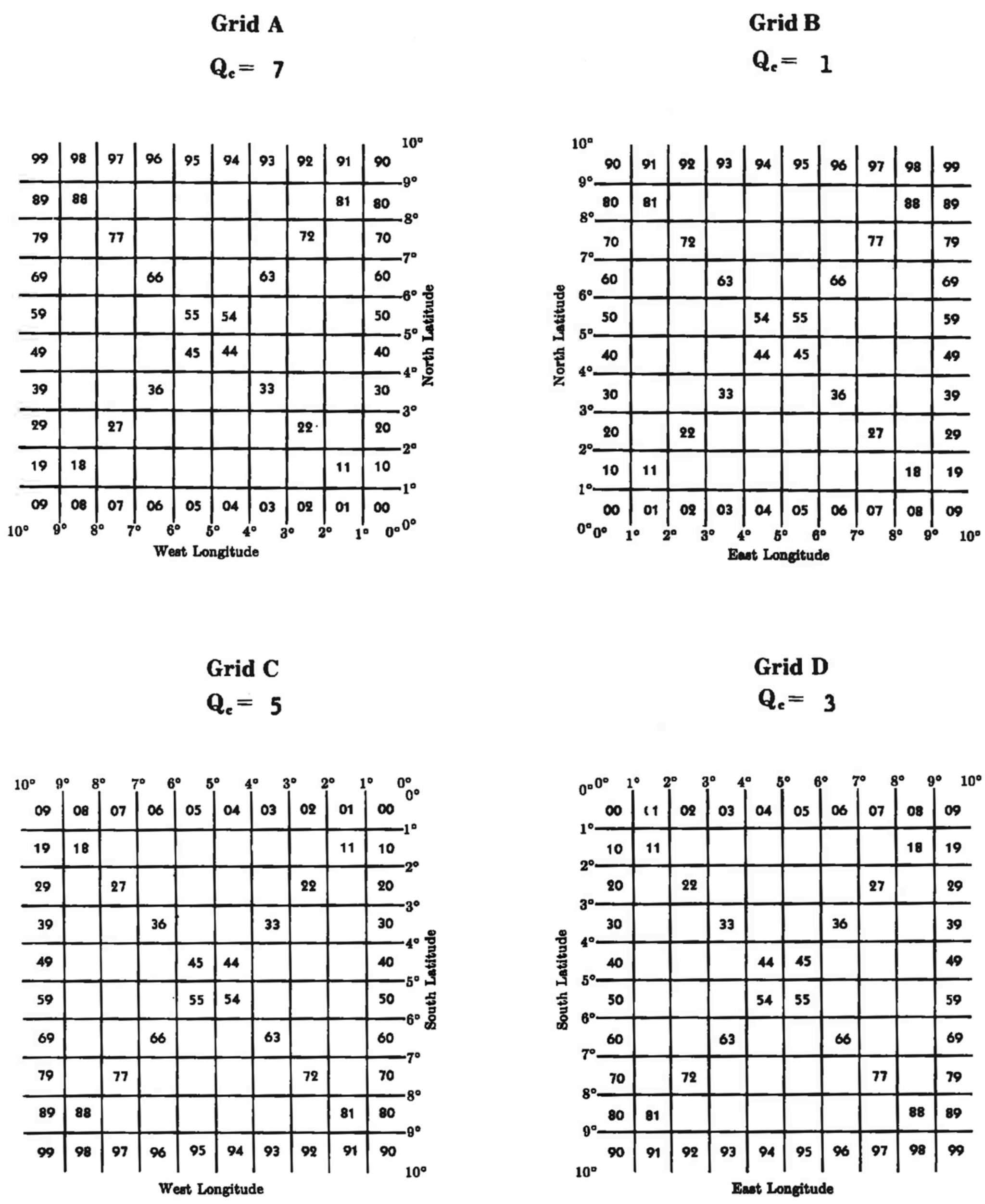

Figure 3–2: Marsden ten degree squares divided into one degree sub-squares

3.6 TEMP MOBIL message content

Comment [D4]: Further description for the Environmental Emergency Response.

The Environmental Emergency Response (EER) message is coded the same as a TEMP message with the exception of Section 1.

Situations arise in which an aerological ascent is required from a location other than a fixed site. The hardware used to perform the ascent is identical to a fixed land station; however the coding of the messages generated contains differences.

3.6.1 Section 1: identification and position data

3.6.1.1 Location – latitude $99L_aL_aL_a$

99: This is the group identifier.

$L_aL_aL_a$: These three digits represent the latitude of the point of observation. The latitude is reported in tens, units and tenths of degrees (e.g. 74.15 N is coded as 741).

3.6.1.2 Location – longitude $Q_cL_oL_oL_oL_o$

Q_c: Represents the quadrant of the globe where the point of observation is located (refer to Table 3–11). If the mobile land station is located on the equator or a prime meridian, two possible values occur, either one of which is acceptable.

$L_oL_oL_oL_o$: These digits represent the longitude of the point of observation. The longitude is reported in hundreds, tens, units and tenths of degrees (e.g. 103.65 is coded as 1036).

Table 3–11: Values of Q_c in each quadrant of the earth – WMO code table 3333

Latitude	Longitude	Q_c
North	East	1
South	East	3
South	West	5
North	West	7

Note: The choice is left to the observer in the following cases:

- When the mobile land station is on the Greenwich meridian or 180th Meridian ($L_oL_oL_oL_o$ = 0000 or 1800 respectively):
    - Q_c = 1 or 7 (Northern Hemisphere); or
    - Q_c = 3 or 5 (Southern Hemisphere).
- When the mobile land station is on the equator ($L_aL_aL_a$ = 000)

- o Q_c = 1 or 7 (eastern longitude); or
- o Q_c = 3 or 5 (western longitude).

3.6.1.2 Location – land $MMMU_{La}U_{Lo}$

This is the ship position verification group and is used to check the position of the mobile land station messages.

MMM: This represents the Marsden square number in which the mobile land station is located at the time of observation. The Marsden square number is determined from Figure 3–1 by using the latitude and longitude corresponding to the mobile land station's position (e.g. If the mobile land station's position is 46.0 N and 146.1 W, the Marsden square number is 159).

U_{La}: This is the units digit from the latitude corresponding to the mobile land station's position (e.g. If the latitude is 45.9 N, U_{La} is coded as 5).

U_{Lo}: This is the units digit from the longitude corresponding to the mobile land station's position (e.g. If the longitude is 145 W, U_{Lo} is coded as 5).

3.6.1.3 Elevation – land $h_0h_0h_0h_0i_m$

$h_0h_0h_0h_0$: Indicates the thousands, hundreds, tens and units elevation of the station in metres above sea level.

i_m: Indicates accuracy of the elevation (on a scale of 0-4 where 0 equals good and 4 equals poor).

3.7 PILOT message content

3.7.1 Section 1: identification and position data

The purpose of Section 1 is to identify the type, origin and time of the pilot message, and is included in each part.

3.7.1.1 Message indicator $M_iM_iM_jM_j$

This four-letter group contains identification data and is the first group in the coded message.

M_iM_i: The symbolic code for identifying a radiosonde or radiosonde message originating from a land or ship station A PILOT message is coded as PP and a PILOT SHIP is coded as QQ.

M_jM_j: The symbolic code for identifying the part of the message that is to follow (i.e. parts A, B, C or D). Part B is coded as BB and Part D is coded as DD.

3.7.1.2 Date indicator – $YYGGa_4$

YY: Identifies the day of the month and the unit of wind speed (i.e. knots or metres per second) that are used in the message.

The day of the month is reported through the use of code figures 01 to 31, inclusive, where code figure 01 means the first day of the month, 02 means second day of the month, etc.

When wind speeds are reported in knots, 50 is added to YY. (Canadian upper air messages always use knots); when wind speeds are reported in metres per second, YY is not modified.

GG: Identifies the time of observation in whole hours UTC, based on the twenty-four hour clock (i.e. 00 to 23). The standard hour of observation, “H”, is coded for GG whenever the release time is within the time range of H-45 to H+29 inclusive (e.g. If the release time is 2315, GG is coded as 00).

If the release time is outside of the range of H-45 to H+29, GG is coded to the nearest hour UTC, (e.g. If the release time is 0030, GG is coded as 01).

a_4: Indicates the type of equipment used during the ascent to measure upper winds (refer to Table 3–12 – WMO code table 0265).

Table 3–12: Type of measuring equipment used – WMO code table 0265

Code figure	a_4 – Specification
0	Pressure instrument associated with wind-measuring equipment
1	Optical theodolite
2	Radiotheodolite
3	Radar
4	Pressure instrument associated with wind-measuring equipment but pressure element failed during flight
5	VLF – Omega
6	Loran – C
7	Wind profiler
8	Satellite navigation
9	Reserved

3.7.1.3 International index number – IIiii

This five-figure group constitutes the international index number (refer to 3.4.1.3).

II: Identifies the block number which defines the area in which the reporting station is situated. Each block contains 1,000 station numbers and is allocated to one or more countries within a WMO region. All stations within Canada use the block number 71.

iii: Refers to the three digit number allocated to meteorological services in one or more countries within a WMO region.

3.7.2 Section 4: maximum wind level(s) and vertical wind shear

The purpose of Section 4 is to report wind direction and speed at selected 1,000 foot (300 m) intervals above mean sea level (MSL). These intervals are selected along two different sets of criteria and then combined into a single message.

The direction and speed curves (in function of the log of pressure or altitude) can be reproduced with their prominent characteristics:

- These curves can be reproduced with an accuracy of at least 10° for direction and five metres per second for speed; and
- The number of significant levels is kept strictly to a necessary minimum.

3.7.2.1 Fixed regional levels

Selection criteria for 1,000 foot (300 m) levels:

- 140,000
- 110,000
- 100,000
- 90,000
- 70,000
- 50,000
- 35,000
- 30,000
- 25,000
- 20,000
- 16,000
- 14,000
- 12,000
- 9,000
- 8,000
- 7,000
- 6,000
- 4,000
- 3,000
- 2,000
- 1,000

3.7.2.2 Altitude of wind data $Xt_nu_1u_2u_3$

X: Indicator figure 9 is reported for altitudes up to but not including 100,000 feet. Indicator figure 1 is reported for altitudes at and above 100,000 feet.

t_n: This is the ten thousands digit of the altitude of the levels for which wind data are being reported (e.g. for 9000 feet, t_n would be reported as 0, for 25,000 feet, t_n would be reported as 2).

$u_1u_2u_3$: These are the thousands digits of the wind levels for which wind data are being reported (e.g. For the 12000, 14000 and 16000-foot levels, $u_1u_2u_3$ would be coded as 246).

Note (1): A maximum of three levels can be reported by a $9t_nu_1u_2u_3$ or $1t_nu_1u_2u_3$ group.

Note (2): Each time that the value of t_n changes, another $9t_nu_1u_2u_3$ or $1t_nu_1u_2u_3$ group is added to the message.

Note (3): A $9t_nu_1u_2u_3$ or $1t_nu_1u_2u_3$ group may specify one, two or three levels and be followed by one, two or three wind data (ddfff) groups.

Note (4): A solidus, “/”, is coded for u_2 and/or u_3 when a second or third wind data group is not included for a given sequence.

3.7.2.3 Wind data at specified altitudes – ddfff

This group contains wind direction and speed data for the levels reported by the preceding $9t_nu_1u_2u_3$ or $1t_nu_1u_2u_3$ group.

dd: The hundreds and tens digits of the wind direction.

fff: The first digit represents the units value of the wind direction rounded to the nearest 5. The final two digits represent the tens and units value of the wind speed. If, however, the wind speed is 100 knots or greater, the hundreds digit of the wind speed is added to the value of the first digit.

Example (1):
Wind direction: 291
Wind speed: 55 knots
Coded value: 29055

Example (2):
Wind direction: 293
Wind speed: 55 knots
Coded value: 29555

Example (3):
Wind direction: 289
Wind speed: 106 knots
Coded value: 29106

Example (4):
Wind direction: 304
Wind speed: 201 knots
Coded value: 30701

3.8 PILOT SHIP message content

The PILOT SHIP message is identical to the PILOT message with the exception of Section 1. In the case of the PILOT SHIP message, the IIiii group of the PILOT message is replaced by the $99L_aL_aL_a$ $Q_cL_oL_oL_o$ $MMMU_{La}U_{Lo}$ group. These groups are coded in the same manner as in the TEMP SHIP message (refer to 3.4.1.1 and 3.4.1.2).

3.8.1 PILOT or PILOT SHIP message, Part B (UG)

3.8.1.1 First transmission: Part B (UG)

Below are the symbolic code forms of Part B (UG) of the first transmission of an upper wind message for land and ship stations (data up to and including 100 hPa).

3.8.1.1.1 Section 1: identification and position data

Identification groups for land stations:

$M_iM_iM_jM_j$ $YYGGa_4$ IIiii

or

Identification-position groups for ship stations:

$M_iM_iM_jM_j$ $YYGGa_4$ $99L_aL_aL_a$

$Q_cL_oL_oL_o$ $MMMU_{La}U_{Lo}$

3.8.1.1.2 Section 4: maximum wind level(s) and vertical wind shear

Fixed regional and significant levels:

$9t_nu_1u_2u_3$ ddfff ddfff ddfff

$9t_nu_1u_2u_3$ ddfff ddfff ddfff

3.8.2 PILOT or PILOT SHIP message, Part D (UQ)

3.8.2.1 Second transmission: Part D (UQ)

Below are the symbolic code forms of Part D (UQ) of the second transmission of an upper wind message for land and ship stations (data above 100 hPa).

3.8.2.1.1 Section 1: identification and position data

Identification groups for land stations:

$M_iM_iM_jM_j$ $YYGGa_4$ IIiii

or

Identification-position groups for ship stations:

$M_iM_iM_jM_j$ $YYGGa_4$ $99L_aL_aL_a$

$Q_cL_oL_oL_oL_o$ $MMMU_{La}U_{Lo}$

3.8.2.1.2 Section 4: maximum wind level(s) and vertical wind shear

Fixed regional and significant levels:

$9t_nu_1u_2u_3$ ddfff ddfff ddfff

$9t_nu_1u_2u_3$ ddfff ddfff ddfff

or

$1t_nu_1u_2u_3$

3.9 Examples of coded messages

Table 3–13: Example of data reported for Part A (US) of the TEMP message

Symbolic form of group	Pressure of mandatory levels (hPa)	Geopotential height of mandatory levels (gpm)	Temperature °C	Dew point depression °C	Wind direction (degrees)	Wind speed (knots)	Code figure for T_a T_o T_{ao}	Coded groups
$M_iM_iM_jM_j$	-	-	-	-	-	-	-	TTAA
$YYGGI_d$	-	-	-	-	-	-	-	72121
IIiii	-	-	-	-	-	-	-	72934
$99P_0P_0P_0$	993.3	-	-	-	-	-	-	99993
$T_0T_0T_{a0}D_0D_0$	-	-	+06.0	1.0	-	-	0	06010
$d_0d_0f_0f_0f_0$	-	-	-	-	010	02	-	01002
oohhh	1000	146	-	-	-	-	-	00146
TTT_aDD	-	-	-	-	-	-	-	/////
ddfff	-	-	-	-	-	-	-	/////
92hhh	925	826	-	-	-	-	-	92826
TTT_aDD	-	-	+04.9	2.7	-	-	9	04927
ddfff	-	-	-	-	185	06	-	18506
85hhh	850	1490	-	-	-	-	-	85490
TTT_nDD	-	-	+04.2	7.3	-	-	2	04273
ddfff	-	-	-	-	235	09	-	23509

Symbolic form of group	Pressure of mandatory levels (hPa)	Geopotential height of mandatory levels (gpm)	Temperature °C	Dew point depression °C	Wind direction (degrees)	Wind speed (knots)	Code figure for T_a T_o T_{ao}	Coded groups
70hhh	700	3034	-	-	-	-	-	70034
TTT_aDD	-	-	-08.9	0.3	-	-	9	08903
ddfff	-	-	-	-	247	20	-	24520
50hhh	500	5558	-	-	-	-	-	50556
TTT_nDD	-	-	-26.4	15.1	-	-	4	26565
ddfff	-	-	-	-	255	30	-	25530
40hhh	400	7141	-	-	-	-	-	40714
TTT_nDD	-	-	-35.9	10.1	-	-	9	35960
ddfff	-	-	-	-	257	44	-	25544
30hhh	300	9079	-	-	-	-	-	30908
TTT_aDD	-	-	-50.1	missing	-	-	-	501//
ddfff	-	-	-	-	253	45	-	25545
25hhh	250	10257	-	-	-	-	-	25026
TTT_aDD	-	-	-52.1	missing	-	-	1	521//
ddfff	-	-	-	-	251	42	-	25042
20hhh	200	11706	-	-	-	-	-	20171
TTT_aDD	-	-	-49.7	missing	-	-	7	497//
ddfff	-	-	-	-	236	35	-	23535

Symbolic form of group	Pressure of mandatory levels (hPa)	Geopotential height of mandatory levels (gpm)	Temperature °C	Dew point depression °C	Wind direction (degrees)	Wind speed (knots)	Code figure for T_a T_o T_{ao}	Coded groups
15hhh	150	13599	-	-	-	-	-	15360
TTT_aDD	-	-	-47.3	missing	-	-	3	473//
ddff	-	-	-	-	247	23	-	24523
10hhh	100	16278	-	-	-	-	-	10628
TTT_aDD	-	-	-50.5	missing	-	-	5	505//
ddfff	-	-	-	-	222	13	-	22013
$88P_tP_tP_t$	273	-	-	-	-	-	-	88273
$T_tT_tT_{at}D_tD_t$	-	-	-54.7	missing	-	missing	7	547//
$d_td_tf_tf_tf_t$	-	-	-	-	253	46	-	25546
$77P_mP_mP_m$	-	-	-	-	missing	missing	-	77999

Table 3–14: Example of data reported for Part B (UK) of the TEMP message

Symbolic form of group	Level number	Pressure (hPa)	Temperature °C	Dew point depression °C	Code figure for T_a T_{ao} T_{ao}	Coded groups
$M_iM_iM_jM_j$	-	-	-	-	-	TTBB
YYGG/	-	-	-	-	-	7212/
IIiii	-	-	-	-	-	72934
$00P_0P_0P_0$	00	993.3	-	-	-	00993
$T_0T_0T_{a0}D_0D_0$	-	-	+0.60	1.0	0	06010
11PPP	11	976	-	-	-	11976
TTT_aDD	-	-	+11.2	11.6	2	11262
22PPP	22	968	-	-	-	22968
TTT_aDD	-	-	+10.8	8.4	8	10858
33PPP	33	928	-	-	-	33928
TTT_aDD	-	-	+9.5	12.4	4	09462
44PPP	44	910	-	-	-	44910
TTT_nDD	-	-	+8.2	7.1	2	08257
55PPP	55	814	-	-	-	55814
TTT_nDD	-	-	+01.6	7.6	6	01658

Symbolic form of group	Level number	Pressure (hPa)	Temperature °C	Dew point depression °C	Code figure for T_a T_{ao} T_{ao}	Coded groups
66PPP	66	793	-	-	-	66793
TTT_nDD	-	-	+00.0	1.7	0	00017
77PPP	77	690	-	-	-	77690
TTT_aDD	-	-	-09.9	0.1	9	09901
88PPP	88	678	-	-	-	88678
TTT_aDD	-	-	-10.6	6.7	7	10757
99PPP	99	656	-	-	-	99656
TTT_aDD	-	-	-10.8	14.6	9	10965
11PPP	11	482	-	-	-	11482
TTT_aDD	-	-	-28.6	15.2	7	28765
22PPP	22	466	-	-	-	22466
TTT_aDD	-	-	-28.8	14.5	9	28965
33PPP	33	370	-	-	-	33370
TTT_aDD	-	-	-39.9	9.8	9	39960
44PPP	44	273	-	-	-	44273
TTT_aDD	-	-	-54.7	missing	7	547//

Symbolic form of group	Level number	Pressure (hPa)	Temperature °C	Dew point depression °C	Code figure for T_a T_{ao} T_{ao}	Coded groups
55PPP	55	195	-	-	-	55195
TTT_aDD	-	-	-48.7	missing	7	487//
66PPP	66	124	-	-	-	66124
TTT_aDD	-	-	-46.3	missing	3	463//
77PPP	77	100	-	-	-	77100
TTT_aDD	-	-	-50.4	missing	5	505//
31313	-	-	-	-	-	-
$S_rr_ar_aS_aS_a$	-	-	-	-	-	-
8GGgg	-	-	-	-	-	-
$(9S_nT_wT_wT_w)$	-	-	-	-	-	-

Table 3–15: Example of data reported for Part C (UL) of the TEMP message

Symbolic form of group	Pressure of mandatory levels (hPa)	Geopotential height of levels (gpm)	**Temperature °C**	**Dew point depression °C**	**Wind direction (degrees)**	**Wind speed (knots)**	**Code figure for T_a**	**Coded groups**
$M_iM_iM_jM_j$	-	-	-	-	-	-	-	TTCC
$YYGGI_d$	-	-	-	-	-	-	-	72121
IIiii	-	-	-	-	-	-	-	72934
70hhh	70	18591	-	-	-	-	-	70859
TTT_aDD	-	-	52.2	missing	-	-	3	523//
ddfff	-	-	-	-	162	05	-	16005
50hhh	50	20777	-	-	-	-	-	50078
TTT_aDD	-	-	-50.4	missing	-	-	5	505//
ddfff	-	-	-	-	0.93	06	-	09506
30hhh	30	24118	-	-	-	-	-	30412
TTT_aDD	-	-	50.0	missing	-	-	1	501//
ddfff	-	-	-	-	088	13	-	09013
20hhh	20	26788	-	-	-	-	-	20679
TTT_aDD	-	-	46.7	missing	-	-	7	467//
ddfff	-	-	-	-	080	13	-	08013
10hhh	10	31457	-	-	-	-	-	10146
TTT_aDD	-	-	-37.6	missing	-	-	7	377//
ddfff	-	-	-	-	072	18	-	07018

Symbolic form of group	Pressure of mandatory levels (hPa)	Geopotential height of levels (gpm)	Temperature °C	Dew point depression °C	Wind direction (degrees)	Wind speed (knots)	Code figure for T_a	Coded groups
07hhh	7	33949	-	-	-	-	-	07395
TTT_aDD	-	-	31.2	missing	-	-	3	313//
ddfff	-	-	-	-	missing	missing	-	/////
$88P_tP_tP_t$	86	-	-	-	-	-	-	88860
$T_tT_tT_{at}D_tD_t$	-	-	53.3	missing	-	-	3	533//
$d_td_tf_tf_tf_t$	-	-	-	-	205	13	-	20513
$77P_mP_mP_m$	-	-	-	-	-	-	-	77999

Table 3–16: Example of data reported for Part D (UE) of the TEMP message

Symbolic form of group	Level number	Pressure (hPa)	Temperature °C	Dew point depression °C	Code figure for T_a	Coded groups
$M_iM_iM_jM_j$	-	-	-	-	-	TTDD
YYGG/	-	-	-	-	-	7212/
IIiii	-	-	-	-	-	72934
11PPP	11	93	-	-	-	11930
TTT_aDD	-	-	-48.7	missing	7	487//
22PPP	22	86	-	-	-	22860
TTT_aDD	-	-	-53.3	missing	3	533//
33PPP	33	40	-	-	-	33400
TTT_aDD	-	-	-49.3	missing	3	493//
44PPP	44	31	-	-	-	44310
TTT_aDD	-	-	-50.3	missing	3	503//
55PPP	55	14	-	-	-	55140
TTT_aDD	-	-	-43.9	missing	9	439//
66PPP	66	6	-	-	-	66060
TTT_aDD	-	-	-28.5	missing	5	285//
51515	-	-	-	-	-	51515
$101A_{df}A_{df}$	-	-	-	-	-	10190
PPhhh	-	5 (altitude 36365 gpm)	-	-	-	05637

Table 3–17: Example of data reported for Part B (UG) of the PILOT message

Symbolic form of group	Altitude (feet)	Wind direction (degrees)	Wind speed (knots)	Coded groups
$M_iM_iM_jM_j$	-	-	-	PPBB
$YYGGa_4$	-	-	-	59000
IIiii	-	-	-	72600
$9t_nu_1u_2u_3$	-	-	-	90012
ddfff	Surface	290	07	29007
ddfff	1000	325	10	32510
ddfff	2000	341	12	34012
$9t_nu_1u_2u_3$	-	-	-	90346
ddfff	3000	336	12	33512
ddfff	4000	352	08	35008
ddfff	6000	338	06	34006
$9t_nu_1u_2u_3$	-	-	-	90789
ddfff	7000	322	03	32003
ddfff	8000	328	04	33004
ddfff	9000	330	08	33008
$9t_nu_1u_2u_3$	-	-	-	91246
ddfff	12000	314	16	31516
ddfff	14000	295	18	29518
ddfff	16000	273	22	27522

Symbolic form of group	Altitude (feet)	Wind direction (degrees)	Wind speed (knots)	Coded groups
$9t_nu_1u_2u_3$	-	-	-	918//
ddfff	18000	255	19	25519
$9t_nu_1u_2u_3$	-	-	-	9205/
ddfff	20000	263	29	26529
ddfff	25000	270	61	27061
$9t_nu_1u_2u_3$	-	-	-	9305/
ddfff	30000	278	91	28091
ddfff	35000	278	120	28120
$9t_nu_1u_2u_3$	-	-	-	94027
ddfff	40000	273	127	27627
ddfff	42000	278	124	28124
ddfff	47000	285	76	28576
$9t_nu_1u_2u_3$	-	-	-	950//
ddfff	50000	283	63	28563

Table 3–18: Example of data reported for Part D (UQ) of the PILOT message

Symbolic form of group	Altitude (feet)	Wind direction (degrees)	Wind speed (knots)	Coded groups
$M_iM_iM_jM_j$	-	-	-	PPDD
$YYGGa_4$	-	-	-	59000
IIiii	-	-	-	72600
$9t_nu_1u_2u_3$	-	-	-	954//
ddfff	54,000	278	41	28041
$9t_nu_1u_2u_3$	-	-	-	96248
ddfff	62,000	299	17	30017
ddfff	64,000	326	13	32513
ddfff	68,000	312	09	31009
$9t_nu_1u_2u_3$	-	-	-	9704/
ddfff	70,000	316	06	31506
ddfff	74,000	343	03	34503
$9t_nu_1u_2u_3$	-	-	-	98369
ddfff	83,000	343	03	34503
ddfff	86,000	099	06	10006
ddfff	89,000	109	07	11007

3.10 Missing data

Missing data are reported in aerological messages through the use of the solidus (/).

3.10.1 Mandatory levels for a TEMP or TEMP SHIP message

When data for a mandatory level are missing, but are available for a higher mandatory level, the missing data for that level are coded as solidi. Note that the level indicator remains unchanged.

3.10.2 Significant levels in a TEMP message

A stratum of missing data in parts B or D of the TEMP (or TEMP SHIP) message is reported by assigning solidi to the temperature, dew point depression and wind data for a level within the stratum of missing data. The levels immediately before and after this level are therefore the boundary levels of the missing data stratum.

3.10.3 Fixed regional and significant levels in a PILOT message

A stratum of missing data in a PILOT (or PILOT SHIP) message is reported by assigning solidi to the wind direction and speed data for a level within a stratum of missing data. The levels immediately before and immediately after this level are therefore the boundary levels of the missing data stratum.

3.10.4 Special circumstances

Other rules for the reporting of missing data are as follows:

- Solidi are not included for missing wind data groups for mandatory levels in the TEMP or TEMP SHIP beyond the highest level specified by I_d (refer to 3.4.1.2);
- If a stratum of missing data prevents identification of a tropopause, the five-figure group is coded as 88999;
- If a stratum of missing data prevents identification of a maximum wind, the five-figure group is coded as 77999; and
- With the NAVAID system, dew point temperature evaluation does not cease because of cold temperatures.

3.11 Binary Universal Form (BUF)

The World Meteorological Organization (WMO) code form FM 94 BUFR (Binary Universal Form for the Representation of meteorological data) is a binary code designed to represent any meteorological data. There is, however, nothing uniquely meteorological about BUFR. The meteorological emphasis is the result of the origin of the code. The BUFR code form may be applied to any numerical or qualitative data type.

The binary nature of BUFR provides a significant advantage over traditional character codes: the ease and speed of converting the message into an internally useful numeric format.

The floating point method is the primary means whereby Numerical Models map meteorological data. With character codes the conversion from ASCII to integer or floating point is expensive relative to the conversion from binary integers to floating point.

In some tests, the European Centre for Medium-Range Weather Forecasts found a speedup of better than 6 times in decoding BUFR messages over the corresponding TEMP messages. The BUFR data also required about half the machine memory as the character data. This significantly increases the data capacity of numerical models and radically improves their processing speed.

The DigiCORA software is not equipped to display the contents of a binary data BUFR file.

For operators, all that is required of them is to confirm these messages are being generated for the sounding and are being transmitted on circuit.

Four BUFR files are generated for each flight. Select the Recent shortcut on the desktop to confirm all .bfr files have been transmitted for the current sounding.

- <Insert graphic of BUFR messages>http://dowshare.ontario.int.ec.gc.ca/sites/NWCN/amop/twc/upperAir/default.aspx?RootFolder=%2fsites%2fNWCN%2famop%2ftwc%2fupperAir%2fShared%20Documents%2fMANUPP%2c%20MUNI%2c%20BUFR&View=%7b2D24B467%2d7582%2d437A%2dB597%2d17818A6A7C4E%7d.

Additional Resources

Additional resources for the Upper Air Network, including operational manuals and documentation, may be requested by contacting:

Upper Air Standards Officer
4905 Dufferin Street
Toronto, ON M3H 5T4

Environment Canada's Intranet contains copies of additional resources:

http://ecollab.ncr.int.ec.gc.ca/org/1275692/wem/SharedDocuments/Forms/EditForm.aspx?ID=178&Source=http%3A%2F%2Fecollab%2Encr%2Eint%2Eec%2Egc%2Eca%2Forg%2F1275692%2Fwem%2FSharedDocuments%2FForms%2FAlldocuments%2Easpx&RootFolder=%2Forg%2F1275692%2Fwem%2FSharedDocuments