**9 April 2015**
**Translation Specifications (transpec) into IMMA1 format:**
**Second *Fram* Expedition (1898-1902) Marine Meteorological Observations**
**Digitized by Environment Canada**

*A. Data provenance and background*

"In 1898, Otto Sverdrup led a scientific expedition to the Canadian Arctic islands. *Fram* was slightly modified for this journey, its freeboard being increased. *Fram* left harbour on 24 June 1898, with 17 men on board. Their aim was to chart the lands of the Arctic Islands, and to sample the geology, flora and fauna. The expeditions lasted till 1902, leading to charts covering 260,000 km$^2$, more than any other Arctic expedition." (from Wikipedia 2013). Reference sketches from Mohn 1907of the geographic area can be found in Appendices A and B.

Earlier data for 1893-96 from the First (North Polar) expedition of the *Fram* were previously included in ICOADS (also within deck 734, Arctic Drift Stations, but assigned to *SID*=68) at Release 2, specifically data North of 76ºN (8K reports) were obtained from Volker Wagner at the Deutscher Wetterdienst (German Weather Service), and with the assistance of the US National Snow and Ice Data Center (NSIDC) (Arctic Climatology Project, 2000; see also http://icoads.noaa.gov/r1c.html).

In 2010, Environment Canada (Xiaolan Wang) provided digitized climate data from the Mohn (1907), including land station data, plus "sea-observations (3-6 times per day) of wind, sea-level pressure, air temperature, humidity, clouds, weather and sea surface temperature, taken in the period from July 1898 to Sept. 1902 at different locations (with lat./long. recorded)."

*B. Input format*

Microsoft Excel Spreadsheets converted to csv format.
Input fields:

| Field Number | Field Description | Units |
|---|---|---|
| 1 | Year | yyyy |
| 2 | Month | mm |
| 3 | Day | dd |
| 4 | Hour | hh (some hhmm) |
| 5 | Latitude | degrees minutes |
| 6 | Longitude | degrees minutes |
| 7 | Wind Direction (True) | 32-Point Alpha |
| 8 | Wind Velocity | meters per second |
| 9 | Sea Level Pressure | mm of Hg |
| 10 | Dry Bulb Temperature | Tenths °C |
| 11 | Vapor Tension (pressure) | mm of Hg |
| 12 | Relative Humidity | percent |
| 13 | Cloud – Amount | 0-10; sky covered |

| | | |
|---|---|---|
| 14 | Cloud – Type | |
| 15 | Cloud – Direction (True) | 32-Point Alpha |
| 16 | State of Weather | Descriptors - Rain, Snow, Hail, Fog and Haze with '-' or '+' followed the phenomenon. |
| 17 | Swell or Sea – Direction | 32-Point Alpha |
| 18 | Swell or Sea – State | 0-9 scale (see waves below for more info) |
| 19 | Sea Surface Temperature | Tenths °C |

*C. Individual data field translation actions*

Note: fields omitted from this list have no corresponding input data, and are left missing (blank), similarly with any reported data elements that are missing in the published data.

Corrections to original data values are noted in Appendix F.

*Table C0*. IMMA *Core*

1 *YR* year UTC
Input field(s): 1. Year
Translation action: YR=Year, transformed if applicable into UTC

2 *MO* month UTC
Input field(s): 2. Month
Translation action: *MO*=Month, transformed if applicable into UTC

3 *DY* day UTC
Input field(s): 3. Day
Translation action: *DY*=Day, transformed if applicable into UTC

4 *HR* hour UTC
Input field(s): 4. H.l.t. [Mohn (1907) p. 355 states "ship's local time, civil date"]
Translation action: *HR*=H.l.t. transformed if applicable into UTC.

5 *LAT* latitude
Input field(s): 5. Lat.N
Translation action: *LAT*=Lat.N, after transformation of reported degrees and minutes into 0.01°
Blank Latitudes filled according to locations in Appendix C.

6 *LON* longitude
Input field(s): 6. Long.W

Translation action: *LON*=360 – Long.W after transformation of reported degrees and minutes into 0.01°
Blank longitudes filled according to locations listed in Appendix C.

See Appendix C for latitude and longitudes of towns or other geographic locations named in the data spreadsheets, but no values recorded.

7 *IM* IMMA version=1

8 *ATTC* attm count= 2 or 3 depending on if IMMT attm is included with Relative Humidity.

9 *TI* time indicator
Input field(s): none
Translation action: *TI*=0 (nearest whole hour), or in rare cases *TI*=2 (hours plus minutes)

10 *LI* latitude/long. indic.
Input field(s): none
Translation action: *LI*= 4 (degrees and minutes)

14 *II* *ID* indicator
Input field(s): none
Translation action: *II*= 10 (composite information from early ship data)

15 *ID* identification/call sign
Input field(s): none
Translation action: *ID*=FRAM

17 *DI* wind direction indic.
Input field(s): none
Translation action: *DI*=1 (32-point compass)

18 *D* wind direction (true)
Input field(s): 7. Direction.True
Translation action: Parse the alphabetic direction True codes and transform them into the appropriate (Table D2) numeric *D* value in whole degrees; or store D=361 (calm) or D=362 (variable) is applicable. [Midpoints taken from {lmirlib} function {ixdcdd}]

19 *WI* wind speed indicator
Input field(s): none [note: Mohn (1907) indicates hand held anemometer 6m above sea]
Translation action: *WI*=1 (meter per second, obtained from anemometer (measured))

20 *W* wind speed
Input field(s): 8. Vel.(m.p.s)
Translation action: *W*= Vel.(m.p.s)

For fields 17-20 (DI,D,WI,W) the observer notes that all reports of '0' wind speed are 'Calm' and should be translated appropriately: D=361,W=0

**WIND.**

The direction of the wind was observed at the winter quarters, reckoned from the *true* meridian. The following Tables give the observed directions of the wind and the velocity, in metres per second, for each even hour and for the different months. 0 indicates Calm.

The velocity of the wind was measured with MOHNS hand-anemometer, friction-coefficient one metre per second.

23 *WW* present weather
Input field(s): 16. Weather [Note: Actually a symbolic, not textual, code appears in Mohn (1907), which may be explained somewhere in that report with a mapping defined to the textual values?]
Translation action: *WW* Field not translated to IMMA1 format due to time constraints and difficulty mapping to modern WW codes.

25 *SLP* sea level pressure
Input field(s): Press.St.Gr.Sea-Lev. (mm)
Translation action: SLP= Press.St.Gr.Sea-Lev. as translated from mm into hPa [conversion formula adapted to java from {fxmmmb} from http://icoads.noaa.gov/software/lmrlib]

28 *IT* indic. for temperatures
Input field(s): none? [appears to be 0.1°C, including for *SST*; confirming metadata/info in Mohn (1907)?]
Translation action: *IT*=0 (tenths° C)

29 *AT* air temperature
Input field(s): Temp.of.Air
Translation action: *AT*=Temp.of.Air

30 *WBTI* *WBT* indic.
Input field(s): none
Translation action: *WBTI*=blank

31 *WBT* wet-bulb temperature
Input field(s): 10. Dry Bulb Temp, 11. Vap.Tens. (mm) and 12. Rel.Hum
Translation action: None*

*Currently unable to reproduce exact results due to either observer methodology, rounding or possible use of constants. While it is possible to solve for Wet Bulb temperature with available information, RH values tend to differ by 2-3% in most cases:

- using E = e - A(T-t) where
    - E = Vapor pressure (or 'tension' as the observer reported in mm) (mb)
    - e = Sat. Vapor pressure (mb) Not available –
        - e = $E_0$ x 10^(7.5T / 237.7+T) [$E_0$=6.11 constant?]
    - A = .8 (constant used?)
    - T = dry bulb (c)
    - t = wet bulb (c) Not available, it is not possible to fully replicate the observer's method.

NOC recommends not calculating Tw, but rather calculating dwpt (DWPT) instead with the available fields. See Field 33 descriptions below for info on DPT calculations.

32 *DPTI Dew point temperature indicator*
Input field(s): none
Translation action: *DPTI = 1 - Computed*

33 *DPT Dew point temperature*
Input field(s): 11 (Vapor Tension), and 9 (SLP)
Translation action: DPT is calculated using 'Formulae for the computation of measures of humidity' taken from WMO 2008 (See appendix E).

1) Convert Vapor Tension and slp to hPa.
2) Calculate f(p):
3) $f(p) = 1.0016 + 3.15 \cdot 10^{-6}\, p - 0.074\, p^{-1}$ (sat. vap. pressure)
   Where p = slp in hPa.
4) Calculate dwpt:
   $td = 243.12 \cdot \ln[e' / 6.112\, f(p)] / 17.62 - \ln[e' / 6.112\, f(p)]$
   Where e' is vapor tension in hPa

Note – There are 2 methods possible to calculate dwpt with information provided by the observer, but both methods yield different results. Method #1 is preferred and mentioned above (using slp and vapor tension [vapor pressure]) and the second method uses RH and air temp. Method #1 using Vapor Tension (Vapor Pressure) and SLP is used for DPT calculations here since Vapor Tension is reported to a higher precision than RH and is most likely represents the best choice.

Method #1 (Using SLP and Vapor Tension):

$f(p) = 1.0016 + 3.15 \cdot 10^{-6}\, p - 0.074\, p^{-1}$ AND $t_d = \dfrac{243.12 \cdot \ln\left[e'/6.112 f(p)\right]}{17.62 - \ln\left[e'/6.112 f(p)\right]}$

Method #2 (Using Relative Humidity and Dry Bulb):

$e' = \dfrac{U e'_w(p,t)}{100}$ AND $e'_w(p,t) = f(p) \cdot e_w(t)$ AND $t_d = \dfrac{243.12 \cdot \ln\left[e'/6.112 f(p)\right]}{17.62 - \ln\left[e'/6.112 f(p)\right]}$

34 *SI* *SST* meas. method
Input field(s): none
Translation action: *SI*= 0

Method of SST measurement is not explicitly reported in Mohn (1907), but the following is an excerpt from pg. 355, where instrumentation for air temperature and sea temperature are noted. The observer states that Kuchler thermometers #3 and #12 were used for sea temperature, which implies that a bucket measurement was taken. Therefore SI is set to SI=0 (bucket).

Thermometers Küchler Nos. 1, 3, 4, 6, 10, 12, 18 and 21. They were divided into fifths of a degree centigrade, and were swung by a whirling mechanism when used for taking the temperature of the air or as a psychrometer. The corrections found in Kristiania in 1898, and applied, were

| | No. 1. | No. 3. | No. 4. | No. 6. | No. 10. | No. 12. | No. 18. | No. 21. |
|---|---|---|---|---|---|---|---|---|
| at + 8° | 0.0 | + 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| „ 0° | + 0.0 | + 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| „ − 13° | − 0.2 | + 0.2 | − 0.25 | 0.0 | − 0.07 | − 0.1 | − 0.3 | 0.0 |

No. 3 and No. 12 were used only for the sea temperature.

35 *SST* sea surface temp.
Input field(s): 19. Temp.of.Sea-surf. [Celsius]
Translation action: *SST*= Temp.of.Sea-surf.

36 *N* total cloud amount
37 *NH* lower cloud amount
38 *CL* low cloud type
39 *HI* *H* indic.

40 *H* cloud height
41 *CM* middle cloud type
42 *CH* high cloud type

Input field(s): [for the above, 13. Clouds:am. and 14. Clouds:form may be usable to fill some fields; 15. Clouds:Dir.true however appears not usable, but should still be stored as Supplemental data.]

Translation action: Cloud amount (*N*) converted from 0-10 amount of sky covered to oktas (using java method based on lmrlib.f function {ixt1ok} based on WMO code 2700). In cases where ranges were reported, e.g. '9-10', the higher value will be used for the conversion to oktas for the IMMA field *N*.

Note - Values reported as '10-Sep' in the spreadsheets are Excel formatting issues and should be considered '9-10', as were originally reported in Mohn 1907. Same for values such as '3-Feb' should be considered '2-3'.

Cloud type (form) mappings to IMMA (See Appendix D for corresponding WMO Codes for CL, CM, CH). Note – numerical values were originally subscripts related to notes taken in Mohn 1907 and should be disregarded as they are not directly related to cloud type or amount values:

| **Originally Reported Cloud Types (Mohn 1907)** | **CL mapping in IMMA Field No. 38 (WMO Code 0513)** | **CM mapping in IMMA Field No. 41 (WMO Code 0515)** | **CH mapping in IMMA Field No. 42 (WMO Code 0509)** |
|---|---|---|---|
| Fr-Nb, Nb, Nb&Fr-Nb | Blank | Blank | Blank |
| Ci-St, \Ci-St, Ci-St3 | Blank | Blank | 7 |
| A-Cu | Blank | 3 | Blank |
| A-Cu&St, A-Cu-St | 6 | 3 | Blank |
| Ci | Blank | Blank | 1 |
| Ci&St | 6 | Blank | 1 |
| Ci-Cu | Blank | Blank | 9 |
| Ci-Cu&St | 6 | Blank | 9 |
| Ci-St&St, Ci-St1&St1, Ci-St2&St2, Ci-St2&St3, Ci-St2&St7, Ci-St3&St1, Ci-St4&St1, Ci-St4&St3, Ci-St5&St3, Ci-St7&St1, Ci-St7&St3 | 6 | Blank | 7 |
| Ci-StSt-Cu | 5 | Blank | 7 |

| | | | |
|---|---|---|---|
| Ci2&St-Cu1 | 5 | Blank | 1 |
| Cu | 1 | Blank | Blank |
| Cu-Nb | 3 | Blank | Blank |
| Fr-St | 7 | Blank | Blank |
| St | 6 | Blank | Blank |
| St&Fr-St, St3&Fr-St0-1, St4&Fr-St | 6 | Blank | Blank |
| St&St-Cu, St-Cu&St, St6&St-Cu3 | 6 | Blank | Blank |
| St-Cu | 5 | Blank | Blank |
| St-Cu&Nb | 5 | Blank | Blank |
| St-Cu2&Cu-Nb7 | 9 | Blank | Blank |
| St-Cu2&Cu-Nb7 | 9 | Blank | Blank |
| St7&Cu2 | 6 | Blank | Blank |

43 *WD* wave direction
44 *WP* wave period
45 *WH* wave height
46 *SD* swell direction
47 *SP* swell period
48 *SH* swell height

Input field(s): [for the above, 17. Swell.or.Sea:Direction and 18. Swell.or.Sea:State

Translation action: Distinction between sea and swell is not made by the observer, therefore values not translated to IMMA, but carried forward in the Supplemental Attm.

From page 355 (Volume No. 4):

The *direction of swell or sea* was observed by compass and reduced to true direction.

The *state of sea* was estimated in accordance with the usual scale,

| | | |
|---|---|---|
| 0 = dead calm | 4 = moderate | 7 = high |
| 1 = very smooth | 5 = rather rough | 8 = very high |
| 2 = smooth | 6 = rough | 9 = tremendous. |
| 3 = slight | | |

*Table C1. Icoads* attm

1 *ATTI* attm ID=1
2 *ATTL* attm length=65

6 *DCK* Deck=*734*

7 *SID* source ID=*128*

8 *PT* platform type
Input field(s): none
Translation action: PT=5 (ship) when underway
PT=9 (ice station) when overwintering
See Appendix C for more information on winter stations regarding setting PT=9 rather than PT=5.

*Table C5*: IMMT-5/FM 13 (*Immt*) attm
[Note: The only reason to include this attm appears to be to offer derived *RH* data (all other data fields missing). However, Mohn (1907) pp. 254-255 states that “The *force of vapour* [i.e. 11. Vap.Tens.] and the *relative humidity* (12. Rel.Hum.) have been computed from the dry and wet thermometers by means of Jelinek’s Psychrometric Tables…”. One fairly clean solution might be to omit this attm, if a reasonable approximation of the originally reported *WBT* could be recovered and stored in the *Core*.]

1 *ATTI* attm ID=5
2 *ATTL* attm length=94

62 *RH* relative humidity
Input field(s): 12. Rel.Hum. (p.c.)
Translation action: *RH*=Rel.Hum.

63 *RHI* relative humidity indic.
Input field(s): none Metadata info in Mohn (1907) indicates the values were calculated using psychrometer or dry and wet bulb temperatures from ‘thermometers suspended in the thermometer-screen’ [from pg 122

(Volume No.4) "Moisture of the Atmosphere"]. Additional information on readings taken above -10°C and wet bulb temp corrections:

> **MOISTURE OF THE ATMOSPHERE.**
>
> In summer and autumn the observations for determining the force or tension of aqueous vapour in the atmosphere and the relative humidity, were made by the psychrometer or dry and wet-bulb thermometers suspended in the thermometer-screen. When the temperature was above – 10° C., the force of vapour and the relative humidity were computed by means of Jelinek's Psychrometer Tables, the readings of the wet bulb having been corrected by Ekholm's rule for temperatures below zero.

Translation action: RHI = 4 (Relative humidity in whole Percentage, computed

*Table C6*: Model quality control (*Mod-qc*) attm: not applicable
*Table C7*: Ship metadata (*Meta-vos*) attm: not applicable
*Table C8*: Near-surface oceanographic (*Nocn*) attm: not applicable
*Table C9*: Near-surface oceanographic QC (*Nocq*) attm: not applicable
*Table C10*: Edited cloud report information (*Ecr*) attm: not applicable
*Table C96*: ICOADS Value-added Database (*Ivad*) attm: not applicable
*Table C97*: Error (*Error*) attm: not applicable
*Table C98*: Unique ID (*Uida*) attm: not applicable

*D. Supplemental data (Suppl; Table C99) attm layout*
Values converted to comma-separated value (CSV) format and filename appended as the last field of supplemental record.

*References*

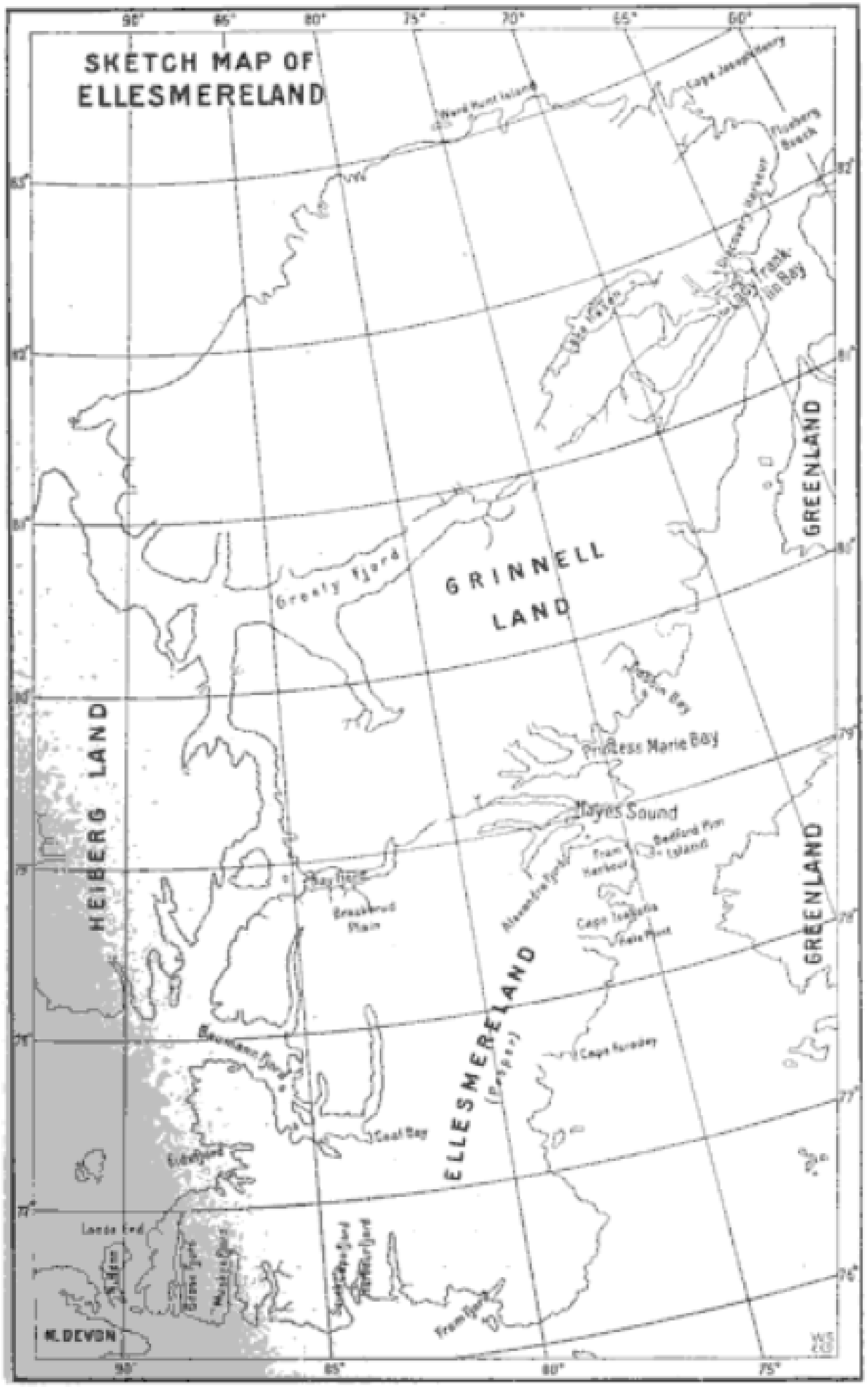
Arctic Climatology Project, 2000: Environmental Working Group Arctic Meteorology and Climate Atlas. Edited by F. Fetterer and V. Radionov. Boulder, CO: National Snow and Ice Data Center. CD-ROM.

Mohn, H., 1907: Meteorology. No. 4 in Vol. 1 of *Report of the Second Norwegian Arctic expedition in the "Fram" 1898-1902* [available on-line at: http://archive.org/details/reportsecondnor00oslogoog].

Wikipedia, 2013: *Fram* - Sverdrup's 1898–1902 Canadian Arctic islands expedition (http://en.wikipedia.org/wiki/Fram)

WMO, 2008: WMO Manual No. 8 – Guide to Meteorological Instruments and Methods of Observation, 7th Edition. (https://www.wmo.int/pages/prog/gcos/documents/gruanmanuals/CIMO/CIMO_Guide-7th_Edition-2008.pdf)

Appendix A. Figure from Mohn 1907 (pg 19, Volume No. 2) showing Ellesmereland map.



Appendix B. Geological Sketch Map of Ellesmere and Heiberg from Mohn 1907 (Figure 1, Pg 5, Volume No. 1)


Fig. 1. Geologische Kartenskizze der Ellesmere- und Heiberg-Inseln.

Appendix C. Latitude and Longitudes of towns or other geographic locations named in the data spreadsheets, but with no corresponding numeric values. The numeric values provided in the table below were taken directly from Mohn 1907, except for Godhavn (also known as Qeqertarsuaq) as the location was not noted. Lat/Long for Godhavn taken from Wikipedia: http://en.wikipedia.org/wiki/Qeqertarsuaq
Note that some Latitude/Longitude values noted in the publication are of higher precision than what was keyed into the spreadsheet, e.g. Gaasefjord (I).
Information taken from Page 3 "Observations At The Winter Quarters."

| **File Name** | **Station/City** | **Latitude (N)** | **Longitude (W)** | **Dates noted** |
|---|---|---|---|---|
| sea_1900 | Gaasefjord (I) | 76°48.9' | 88°39.5' | Sept 18 1900 – Aug 12 1901** |
| sea_1902 | Godhavn | 69°14′50" (69° 14.83') | 53°32′00" (53° 32.0') | Aug 18-20, 1902 |
| | | | | |
| sea_Aug_30_to_Oct_23_1899 | Havenfjord | 76°29.4' | 84°3.7' | Oct 23 1899 – Aug 9 1900 |
| | | | | |
| | Rice Strait | 78°45.7' | 74°56.5' | Sept 19 1898 – July 24 1899 |
| | | | | |
| | Gaasefjord (II) | 76°39.8' | 88°38.3 | Sept 6 1901 – July 21 1902 |

** Data in sea_1900 under 'Gaasefjord' assumed to be Gaasefjord I based on observation locations from the previous day, Sept 7, 1900.

Additional information, as noted in Mohn 1907, is below providing dates when the ship was stationary in relation to coordinates given in the table above during winter stations:

The Fram left Kristiania on the 24th June, 1898, called at Egedesminde in Greenland on the 29th of July, left Godhavn on the 2nd of August, and Upernivik on the 5th of August. On the 15th and 16th the Fram was at Foulkefjord, on the 17th at Cocked Hat, and the 18th and 19 h at Rice Strait. At the northern inlet of this strait, the Expedition wintered from September, 1898, to the 23rd of July, 1899.

On the 1st of September, 1899, the Fram reached the second winter-station (Havnefjord), which she left on the 9th of August, 1900.

On the 18th of September the Fram was anchored at her third wintering station at the head of the Gaasefjord. She left it on the 12th of August, 1901, and arrived at the fourth and last wintering station in the Gaasefjord, a little farther from the head of the fjord, on the 5th of September in the same year.

On the 21st of July, 1902, the Fram left this place.

On the 17th of August the Fram dropped anchor at Godhavn. Left Godhavn the 20th. Passed Fair Hill on the 17th of September, and reached Norway on the 19th of September, 1902.

The meteorological observations on board the Fram during the years 1898 to 1902 were made in somewhat different ways according as the ship was under way or stationed at the different winter-quarters.

Appendix D. WMO codes for CL, CM and CH from WMO Publication No. 306 Manual on Codes

CL – WMO Code 0513

0513

$C_L$ *Clouds of the genera stratocumulus, stratus, cumulus and cumulonimbus*

| Code figure | Technical specifications | Code figure | Technical specifications |
|---|---|---|---|
| 0 | No $C_L$ clouds | 0 | No stratocumulus, stratus, cumulus or cumulonimbus |
| 1 | Cumulus humilis or cumulus fractus other than of bad weather,* or both | 1 | Cumulus with little vertical extent and seemingly flattened, or ragged cumulus other than of bad weather,* or both |
| 2 | Cumulus mediocris or congestus, with or without cumulus of species fractus or humilis or stratocumulus, all having their bases at the same level | 2 | 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 by stratocumulus, all having their bases at the same level |
| 3 | Cumulonimbus calvus, with or without cumulus, stratocumulus or Stratus | 3 | 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 | Stratocumulus cumulogenitus | 4 | Stratocumulus formed by the spreading out of cumulus; cumulus may also be present |
| 5 | Stratocumulus other than stratocumulus cumulogenitus | 5 | Stratocumulus not resulting from the spreading out of cumulus |
| 6 | Stratus nebulosus or Stratus fractus other 6 than of bad weather,* or both | 6 | Stratus in a more or less continuous sheet or layer, or in ragged shreds, or both, but no Stratus fractus of bad weather* |
| 7 | Stratus fractus or cumulus fractus of bad weather,* or both (pannus), usually below altostratus or nimbostratus | 7 | Stratus fractus of bad weather* or cumulus fractus of bad weather,* or both (pannus), usually below altostratus or nimbostratus |
| 8 | Cumulus and stratocumulus other than stratocumulus cumulogenitus, with bases at different levels | 8 | 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 | Cumulonimbus capillatus (often with an anvil), with or without cumulonimbus calvus, cumulus, stratocumulus, Stratus or pannus | 9 | 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 |
| / | $C_L$ clouds invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena | / | Stratocumulus, stratus, cumulus and cumulonimbus invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena |

* "Bad weather" denotes the conditions which generally exist during precipitation and a short time before and after.

CM – WMO Code 0515

0515

$C_M$ *Clouds of the genera altocumulus, altostratus and nimbostratus*

| Code figure | Technical specifications | Code figure | Technical specifications |
|---|---|---|---|
| 0 | No $C_M$ clouds | 0 | No altocumulus, altostratus or nimbostratus |
| 1 | Altostratus translucidus | 1 | 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 | Altostratus opacus or nimbostratus | 2 | Altostratus, the greater part of which is sufficiently dense to hide the sun or moon, or nimbostratus |
| 3 | Altocumulus translucidus at a single level | 3 | 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 | Patches (often lenticular) of altocumulus translucidus, continually changing and occurring at one or more levels | 4 | 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 | Altocumulus translucidus in bands, or one or more layers of altocumulus translucidus or opacus, progressively invading the sky; these altocumulus clouds generally thicken as a whole | 5 | Semi-transparent altocumulus in bands, or altocumulus, in one or more fairly continuous layer (semi-transparent or opaque), progressively invading the sky; these altocumulus clouds generally thicken as a whole |
| 6 | Altocumulus cumulogenitus (or cumulo-nimbogenitus) | 6 | Altocumulus resulting from the spreading out of cumulus (or cumulonimbus) |
| 7 | Altocumulus translucidus or opacus in two or more layers, or altocumulus opacus in a single layer, not progressively invading the sky, or altocumulus with altostratus or nimbostratus | 7 | 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 or nimbostratus |
| 8 | Altocumulus castellanus or floccus | 8 | Altocumulus with sproutings in the form of small towers or battlements, or altocumulus having the appearance of cumuliform tufts |
| 9 | Altocumulus of a chaotic sky, generally at several levels | 9 | Altocumulus of a chaotic sky, generally at several levels |
| / | $C_M$ clouds invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or because of continuous layer of lower clouds | / | Altocumulus, altostratus and nimbostratus invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds |

## CH – WMO Code 0509

0509

$C_H$ *Clouds of the genera cirrus, cirrocumulus and cirrostratus*

| Code figure | Technical specifications | Code figure | Technical specifications |
|---|---|---|---|
| 0 | No $C_H$ clouds | 0 | No cirrus, cirrocumulus or cirrostratus |
| 1 | Cirrus fibratus, sometimes uncinus, not progressively invading the sky | 1 | Cirrus in the form of filaments, strands or hooks, not progressively invading the sky |
| 2 | Cirrus spissatus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a cumulonimbus; or cirrus castellanus or floccus | 2 | Dense cirrus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a cumulonimbus; or cirrus with sproutings in the form of small turrets or battlements, or cirrus having the appearance of cumuliform tufts |
| 3 | Cirrus spissatus cumulonimbogenitus | 3 | Dense cirrus, often in the form of an anvil, being the remains of the upper parts of cumulonimbus |
| 4 | Cirrus uncinus or fibratus, or both, progressively invading the sky; they generally thicken as a whole | 4 | Cirrus in the form of hooks or of filaments, or both, progressively invading the sky; they generally become denser as a whole |
| 5 | Cirrus (often in bands) and cirrostratus, or cirrostratus alone, progressively invading the sky; they generally thicken as a whole, but the continuous veil does not reach 45 degrees above the horizon | 5 | Cirrus (often in bands converging towards one point or two opposite points of the horizon) and cirrostratus, or cirrostratus alone; in either case, they are progressively invading the sky, and generally growing denser as a whole, but the continuous veil does not reach 45 degrees above the horizon |
| 6 | Cirrus (often in bands) and cirrostratus, or cirrostratus alone, progressively invading the sky; they generally thicken as a whole; the continuous veil extends more than 45 degrees above the horizon, without the sky being totally covered | 6 | Cirrus (often in bands converging towards one point or two opposite points of the horizon) and cirrostratus, or cirrostratus alone; in either case, they are progressively invading the sky, and generally growing denser as a whole; the continuous veil extends more than 45 degrees above the horizon, without the sky being totally covered |
| 7 | Cirrostratus covering the whole sky | 7 | Veil of cirrostratus covering the celestial dome |
| 8 | Cirrostratus not progressively invading the sky and not entirely covering it | 8 | Cirrostratus not progressively invading the sky and not completely covering the celestial dome |
| 9 | Cirrocumulus alone, or cirrocumulus predominant among the $C_H$ clouds | 9 | Cirrocumulus alone, or cirrocumulus accompanied by cirrus or cirrostratus, or both, but cirrocumulus is predominant |
| / | $C_H$ clouds invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or because of a continuous layer of lower clouds | / | Cirrus, cirrocumulus and cirrostratus invisible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds |

Appendix E. Formulae for the Computation of Measures of Humidity extracted from WMO 2008, Appendix 4.B.



# ANNEX 4.B

## FORMULAE FOR THE COMPUTATION OF MEASURES OF HUMIDITY

(see also section 4.1.2)

***Saturation vapour pressure:***

| | |
|---|---|
| $e_w(t) = 6.112 \exp[17.62\, t/(243.12 + t)]$ | Water (–45 to 60°C) (pure phase) |
| $e'_w(p,t) = f(p) \cdot e_w(t)$ | Moist air |
| $e_i(t) = 6.112 \exp[22.46\, t/(272.62 + t)]$ | Ice (–65 to 0°C) (pure phase) |
| $e'_i(p,t) = f(p) \cdot e_i(t)$ | Moist air |
| $f(p) = 1.0016 + 3.15 \cdot 10^{-6}\, p - 0.074\, p^{-1}$ | [see note] |

***Dew point and frost point:***

| | |
|---|---|
| $t_d = \dfrac{243.12 \cdot \ln[e'/6.112 f(p)]}{17.62 - \ln[e'/6.112 f(p)]}$ | Water (–45 to 60°C) |
| $t_f = \dfrac{272.62 \cdot \ln[e'/6.112 f(p)]}{22.46 - \ln[e'/6.112 f(p)]}$ | Ice (–65 to 0°C) |

***Psychrometric formulae for the Assmann psychrometer:***

| | |
|---|---|
| $e' = e'_w(p,t_w) - 6.53 \,.\, 10^{-4} \cdot (1 + 0.000\,944\, t_w) \cdot p \cdot (t - t_w)$ | Water |
| $e' = e'_i(p,t_i) - 5.75 \,.\, 10^{-4} \cdot p \cdot (t - t_i)$ | Ice |

***Relative humidity:***

$U = 100\, e'/e'_w(p,t)$ %

$U = 100\, e'_w(p,t_d)/e'_w(p,t)$ %

Units applied:

$t$ = air temperature (dry-bulb temperature);
$t_w$ = wet-bulb temperature;
$t_i$ = ice-bulb temperature;
$t_d$ = dewpoint temperature;
$t_f$ = frost-point temperature;
$p$ = pressure of moist air;
$e_w(t)$ = saturation vapour pressure in the pure phase with regard to water at the dry-bulb temperature;
$e_w(t_w)$ = saturation vapour pressure in the pure phase with regard to water at the wet-bulb temperature;
$e_i(t)$ = saturation vapour pressure in the pure phase with regard to ice at the dry-bulb temperature;
$e_i(t_i)$ = saturation vapour pressure in the pure phase with regard to ice at the ice-bulb temperature;
$e'_w(t)$ = saturation vapour pressure of moist air with regard to water at the dry-bulb temperature;
$e'_w(t_w)$ = saturation vapour pressure of moist air with regard to water at the wet-bulb temperature;
$e'_i(t)$ = saturation vapour pressure of moist air with regard to ice at the dry-bulb temperature;
$e'_i(t_i)$ = saturation vapour pressure of moist air with regard to ice at the ice-bulb temperature;
$U$ = relative humidity.

Note: In fact, $f$ is a function of both pressure and temperature, i.e. $f = f(p, t)$, as explained in WMO (1966) in the introduction to Table 4.10. In practice, the temperature dependency (±0.1%) is much lower with respect to pressure (0 to +0.6%). Therefore, the temperature dependency may be omitted in the formula above (see also WMO (1989*a*), Chapter 10). This formula, however, should be used only for pressure around 1 000 hPa (i.e. surface measurements) and not for upper-air measurements, for which WMO (1966), Table 4.10 should be used.

Appendix F. Corrections to original values due to keying errors as verified in the original Mohn 1907 publication.

| **File Name** | **Change Description** |
|---|---|
| sea_1902.csv | Wind speed on 12 August 2012, hour 24, value was keyed as ‘1.13’ m/s, but the correct value is ’11.3’ m/s. Action - value corrected in CSV file. |
| sea_Aug_30_to_Oct_23_1899.csv | Lat/Lon or geographical location not reported 2 Sep 1899 1200LST through 23 Oct 1899 1200LST. ‘Havnefjord’ reported as location on previous report 2 Sep 1899 0800LST, so assume all reports in remainder of file at that location and lat/lon populated accordingly. |
| sea_Sep_1_to_Sep_19_1898.csv | SST on 15 Sep 1898 1000LST keyed as ‘-1.8 (2)’ due to a footnote. Value changed to ‘-1.8’ for processing. |
| sea_1900.csv | Lat/Lon or geographical location not reported 17 Sep 1900 2200LST through 17 Sep 1900 2400LST. ‘Gaasefjord’ reported as location on previous report 17 Sep 1900 2000LST, so assume all reports in remainder of file at that location and lat/lon populated accordingly. |