**WORLD METEOROLOGICAL ORGANIZATION**

**GLOBAL CRYOSPHERE WATCH**

**REPORT No. 23/ 2020**

**Minimum Observing Requirements**

**GCW Surface Observing Component**

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**Insert title of report .......**

**TECHNICAL REPORT No. 2013- xx**

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Minimum Observing Requirements for the GCW Surface observing component

Developed under the guidance of the GCW Observations WG

The 5th session of the GCW Steering group (2017) agreed on [minimum observing requirement](https://globalcryospherewatch.org/cryonet/variables/recommended_variables.html) of 110 cryospheric variables for the CryoNet Program. This was intended to support the consistency of observations at all stations included in the GCW Surface observing network and to provide a basis for consistency of observations to all cryosphere observing activities. The variables were identified as recommended (R ) or desirable (D). The frequency of observation and the general observing method (whether automatic or manual) were included for each variable.

Since then, GCW has moved to update and formalize the variable names and definitions in conjunction with the documentation of observing methods, with the goal of transferring these to the WIGOS Metadata Standard, as a formal repository, for use by OSCAR/Surface database as represented in the [WIGOS Metadata Representation](http://codes.wmo.int/wmdr) (WMDR).

The purpose of this document is to update the Minimum Observing Requirements of the GCW Surface observing component, reflecting the cryosphere variables approved and included in the WIGOS Metadata Standard. Table 1 provides the 2017 names in column B and agreed upon names and definitions in column D. Column E provides the WIGOS Metadata variable names and definition differing from those in column D. The date of approval within the WIGOS Metadata process is provided in column F. Corresponding minimum observing frequency is recommended in column G.

The variables names in column B are considered as obsolete if a valid name is available in column D (and, thus, greyed out).

To ensure a systematic approach and dissemination, GCW will update and publish this list minimum once a year.

GCW will strive to use a GitHub process to track the development of variable names and definitions to be submitted to WIGOS Metadata Standard. Details yet to be developed.

Furthermore, during the registration of the first 153 GCW stations, it has become evident that the observations at these stations include variables which are not, currently directly traceable to the minimum observing requirements of the GCW surface observing component. To enable their further consideration, these are summarized in the Table 2 to this document. This includes 39 cryospheric variables, and an initial assessment of their relevance with variables in the 2017 list are shown in the last column if there’s any.

|  |
| --- |
| ***SNOW/SOLID PRECIPITATION*** |
| ***GLACIERS and ICE CAPS*** |
| ***ICE SHEETS*** |
| ***ICE SHELVES*** |
| ***ICEBERGS*** |
| ***PERMAFROST***  ***SEASONALLY FROZEN GROUND***  ***SEA ICE***  ***LAKE ICE***  ***RIVER ICE*** |

Table 1: Minimum Observing Requirements of the GCW Surface Observing component

| **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **GCW variables agreed in 2017(updated by ones approved by TT-WMD, bold)** | **Definitions submitted by GCW and approved by TT-WMD** | **Approval Date by TT-WMD** | **Recommended (R)/Desired (D) variable** | **Recommended min. frequency of obs: method (var)-timescale** | **GCW variables agreed in 2017** | **Variable name and definition in code list of WMDR differing from column B or C** |
| 1 | **snow depth** | Vertical distance from the snow surface to a stated reference level. | 26 April 2018 | R | A(S, G, SI, LRI)-h, M(S)-d, M(SI, LRI)-bw, M(G, IS)-y | Snow depth (including stake farms and snow courses) | / |
| 1+ | **snow depth** | Vertical distance from the snow surface to a stated reference level. | 26 April 2018 | D | A(IS, P)-h, M(P)-d, M(S)-bw | Snow depth (including stake farms and snow courses) | / |
| 2 | **water equivalent of snow cover** | The vertical depth of the water that would be obtained if the snow cover melted completely, which equates to the snow-cover mass per unit area. | 26 April 2018 | R | A(S)-h, M(S)-bw, M(G, IS)-y | Snow Water Equivalent | / |
| 3 | **depth of snowfall** | The vertical depth of freshly fallen snow that has accumulated during a specific period. | 26 April 2018 | D | M(S)-d | Depth of snowfall | / |
| 4 | **water equivalent of snowfall** | Vertical depth of the water that would be obtained if the freshly fallen snow melted completely, which equates to the new snow mass per unit area. | 26 April 2018 | D | M(S)-d | Water equivalent of snowfall | / |
| 5 | **snow cover extent** | The area of snow-covered ground, ice, or firn based on the fractional threshold used to define presence of snow. | 26 April 2018 | D | A(SI, LRI)-h, M(SI, LRI)-bw | Snow cover extent | / |
| 6 | **snow surface state** | Binary product (dry or wet) expressing the presence of liquid water at the surface of the snow cover. | 26 April 2018 | / | / | / | / |
| 7 | **presence of snow** | A binary observation of the presence of snow cover at the measurement location. | 26 April 2018 | / | / | / | / |
| 8 | Snow on the ground (According to WMO code 0975: State of ground with snow or measurable ice cover.) | / | / | R | M(S)-d | Snow on the ground (According to WMO code 0975: State of ground with snow or measurable ice cover.) | / |
| 9 | Solid precipitation (Requires both amount and type of precipitation to be measured) | / | / | R | A(S)-h | Solid precipitation (Requires both amount and type of precipitation to be measured) | / |
| 10 | Snow profiles (density, grain shape & size, hardness, liquid water content, salinity, temperature) | / | / | R | M(S) –bw, M(IS) -y | Snow profiles (density, grain shape & size, hardness, liquid water content, salinity, temperature) | / |
| 10+ | Snow profiles (density, grain shape & size, hardness, liquid water content, salinity, temperature) | / | / | D | M(SI, LRI)-bw | Snow profiles (density, grain shape & size, hardness, liquid water content, salinity, temperature) | / |
| 11 | Snow chemistry | / | / | D | M(S, IS)-bw | Snow chemistry | / |
| 12 | Snow surface temperature | / | / | D | A(S, SI)-h, M(SI) -bw | Snow surface temperature | Snow temperature (top of snow): Snow temperature (top of snow) |
| 13 | Snow temperature | / | / | D | A(S)-h | Snow temperature | Snow temperature |
| 14 | Drifting snow | / | / | D | A(S)-h, M(S)-d | Drifting snow | / |
| 15 | Specific surface area | / | / | D | M(S)-bw, M(IS)-y | Specific surface area | / |
| 16 | **surface accumulation at a point** | The mass added to the glacier at a point on its surface expressed over a stated period of time. | 23 Sep. 2019 | R | A-h, M-s | Surface accumulation (point) | / |
| 17 | **surface ablation at a point** | The mass removed from the glacier at a point on its surface expressed over a stated period of time. | 23 Sep. 2019 | R | A-h, M-y | Surface ablation (point) | / |
| 18 | **glacier-wide mass balance** | The result of all processes adding and removing mass from the glacier at its surface, expressed over a stated period of time and integrated over the entire glacier area. | 23 Sep. 2019 | R | M-y | Surface mass balance (glacier wide) | / |
| 18+ | **glacier-wide mass balance** | The result of all processes adding and removing mass from the glacier at its surface, expressed over a stated period of time and integrated over the entire glacier area. | 23 Sep. 2019 | D | M-y | Surface mass balance (glacier wide) | / |
| 19 | **glacier mass balance at a point** | The result of all processes adding and removing mass from the glacier at a point on its surface, expressed over a stated period of time. | 23 Sep. 2019 | R | A-h, M-y | Surface mass balance (point) | / |
| 20 | **glacier area** | Area enclosed by the projection of the glacier outline onto the surface of an ellipsoid approximating the surface of the Earth or onto a planar horizontal approximation to that ellipsoid. The glacier area excludes nunataks but includes debris-covered parts of the glacier. The glacier outline separates the glacier from unglacierized terrain and from contiguous glaciers.  [Note: it replaces glacier cover] | 23 Sep. 2019 | R | M -my | Glacier area (glacier wide) | / |
| 21 | Ice velocity (point) | / | / | D | A-h, M-y | Ice velocity (point) | Glacier motion: Velocity of the ice measured at the surface of a glacier. |
| 22 | Glacier volume (glacier wide) | / | / | D | M-my | Glacier volume (glacier wide) | / |
| 23 | Surface accumulation (glacier wide) | / | / | D  D | M-y | Surface accumulation (glacier wide) | / |
| 24 | Surface ablation (glacier wide) | / | / | D | M-y | Surface ablation (glacier wide) | / |
| 25 | Basal Ablation (point) | / | / | D | A-h, M-y | Basal Ablation (point) | / |
| 26 | Glacier thickness (point) | / | / | D | M-my | Glacier thickness (point) | / |
| 27 | Glacial runoff | / | / | D | A-h | Glacial runoff | / |
| 28 | Calving flux (point) | / | / | D | A/M-y | Calving flux (point) | / |
| 29 | Ice/firn temperature profile (point) | / | / | D | A-h | Ice/firn temperature profile (point) | / |
| 30 | / | / | / | / | / | / | Glacier topography[[1]](#footnote-1): Map of the height of the glacier surface. |
| 31 | Surface accumulation (point) | / | / | R | A-d | Surface accumulation (point) | / |
| 32 | Surface ablation (point) | / | / | R | A-d | Surface ablation (point) | / |
| 33 | Surface mass balance (point) | / | / | R | A-d, M-y | Surface mass balance (point) | / |
| 34 | Ice sheet thickness (point) | / | / | D | M-d | Ice sheet thickness (point) | / |
| 35 | Ice velocity (point) | / | / | D | A-m | Ice velocity (point) | / |
| 36 | Ice/firn temperature profile (point) | / | / | D | A-h | Ice/firn temperature profile (point) | / |
| 37 | / | / | / | / | / | / | ice sheet topography: Map of ice sheet height over land. |
| 38 | Basal Ablation | / | / | R | A/M-y | Basal Ablation | / |
| 39 | Ice velocity | / | / | R | A-d, M-y | Ice velocity | / |
| 40 | Iceberg position | / | / | R | M-w | Iceberg position | / |
| 41 | Iceberg form, size | / | / | R | M-w | Iceberg form, size | / |
| 42 | Concentration (distance) of icebergs | / | / | R | M-w | Concentration (distance) of icebergs | / |
| 43 | Iceberg motion | / | / | D | A-d, M-d | Iceberg motion | / |
| 44 | Iceberg height (above the sea) | / | / | D | A-d, M-d | Iceberg height (above the sea) | / |
| 45 | Iceberg width, length (at waterline) | / | / | D | A-d, M-d | Iceberg width, length (at waterline) | / |
| 46 | Iceberg draft | / | / | D | A-bw | Iceberg draft | / |
| 47 | Underwater 3-D form | / | / | D | A-bw | Underwater 3-D form | / |
| 48 | Ground temperature | / | / | R | A-h | Ground temperature | / |
| 49 | Active layer thickness | / | / | R | A-d, M-y | Active layer thickness | / |
| 50 | Rock glacier creep velocity | / | / | D | M-6m | Rock glacier creep velocity | / |
| 51 | Rock glacier discharge | / | / | D | M-h | Rock glacier discharge | / |
| 52 | Rock glacier spring temperature | / | / | D | M-h | Rock glacier spring temperature | / |
| 53 | seasonal frost heath/subsidence | / | / | D | M-y | seasonal frost heath/subsidence | / |
| 54 | surface elevation change | / | / | D | M-my | surface elevation change | / |
| 55 | ground ice volume | / | / | D | M-y | ground ice volume | / |
| 56 | coastal retreat | / | / | D | M-y | coastal retreat | / |
| 57 | soil moisture | / |  | D | A-d, M-m | soil moisture | / |
| 58 | Ground temperature | / | / | R | A-h | Ground temperature | / |
| 59 | Sea ice thickness | / | / | R | A-h, M-bw | Sea ice thickness | sea-ice thickness: Thickness of an ice sheet. It is related to sea-ice elevation and ice density. |
| 60 | Sea ice freeboard | / | / | R | A-h, M-bw | Sea ice freeboard | / |
| 61 | Sea ice concentration | / | / | R | A-d, M-d | Sea ice concentration | sea-ice cover: fraction of an ocean area where ice is present. |
| 62 | Sea ice class (pack, fast ice) | / | / | R | M-d | Sea ice class (pack, fast ice) | / |
| 63 | Sea ice type (level/rafted/ridged & floe descriptor) | / | / | R | M-d | Sea ice type (level/rafted/ridged & floe descriptor) | sea-ice type: Variable convolving several factors (age, roughness, density, etc.) - Accuracy expressed as number of classes. Actually [ classes^-1 ] is used, so that smaller figure corresponds to better performance as usual. |
| 64 | Form of ice (floe size) | / | / | R | M-w | Form of ice (floe size) | / |
| 65 | Stage of ice development | / | / | R | M-w | Stage of ice development | / |
| 66 | Sea ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up) | / | / | R | A/M-w, M-y | Sea ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up) | / |
| 67 | Sea ice stage of melting | / | / | R | M-d | Sea ice stage of melting | / |
| 68 | Sea ice openings (leads, polynyas, cracks) | / | / | D | A-d | Sea ice openings (leads, polynyas, cracks) | / |
| 69 | Sea ice velocity | / | / | D | A-h, M-d | Sea ice velocity | sea-ice motion: sea-ice motion |
| 70 | Sea ice deformation (divergence/convergence) | / | / | D | A-h, M-d | Sea ice deformation (divergence/convergence) | / |
| 71 | Sea ice ridge height | / | / | D | A-h, M-d | Sea ice ridge height | / |
| 72 | Sea ice ridge cover (concentration of ice ridges) | / | / | D | A-h, M-d | Sea ice ridge cover (concentration of ice ridges) | / |
| 73 | Sea ice draft | / | / | D | M-bw | Sea ice draft | / |
| 74 | Sea ice salinity profile (vertical) | / | / | D | M-bw | Sea ice salinity profile (vertical) | / |
| 75 | Sea ice stratigraphy | / | / | D | M-bw | Sea ice stratigraphy | / |
| 76 | Surface temperature (surface-air interface) | / | / | D | A-h | Surface temperature (surface-air interface) | sea-ice surface temperature: temperature of the surface of sea-ice |
| 77 | Sea ice temperature profile (vertical) | / | / | D | A-h, M-bw | Sea ice temperature profile (vertical) | / |
| 78 | / | / | / | / | / | / | sea-ice elevation: Elevation of the surface of the sea-ice sheet above sea level. |
| 79 | / | / | / | / | / | / | sea-ice surface characteristics: Sea-ice surface characteristics (albedo, meltpond, dust, snow properties, temperature). |
| 80 | Ice thickness | / | / | R | A-h, M-bw | Ice thickness | ice thickness |
| 81 | Ice concentration | / | / | R | A-d, M-d | Ice concentration | / |
| 82 | Ice class (pack, fast ice) | / | / | R | M-d | Ice class (pack, fast ice) | / |
| 83 | Ice type (level/rafted/ridged & floe descriptor) | / | / | R | M-d | Ice type (level/rafted/ridged & floe descriptor) | / |
| 84 | Form of ice (floe size, fast ice width) | / | / | R | M-w | Form of ice (floe size, fast ice width) | / |
| 85 | Stage of ice development | / | / | R | M-w | Stage of ice development | / |
| 86 | Ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up) | / | / | R | A/M-w, M-y | Ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up) | / |
| 87 | Ice stage of melting | / | / | R | M-d | Ice stage of melting | / |
| 88 | Areal extent of floating/grounded ice | / | / | D | M-w | Areal extent of floating/grounded ice | / |
| 89 | Ice surface temperature | / | / | D | A-h | Ice surface temperature | / |
| 90 | Ice openings (leads, polynyas, cracks) | / | / | D | A-d | Ice openings (leads, polynyas, cracks) | / |
| 91 | Ice velocity | / | / | D | A-h, M-d | Ice velocity | / |
| 92 | Ice deformation (divergence/convergence) | / | / | D | A-h, M-d | Ice deformation (divergence/convergence) | / |
| 93 | Ice ridge height | / | / | D | A-h, M-d | Ice ridge height | / |
| 94 | Ice ridge cover (concentration of ice ridges) | / | / | D | A-h, M-d | Ice ridge cover (concentration of ice ridges) | / |
| 95 | Ice stratigraphy | / | / | D | M-bw | Ice stratigraphy | / |
| 96 | Ice temperature profile (vertical) | / | / | D | A-h, M-bw | Ice temperature profile (vertical) | / |
| 97 | Ice thickness | / | / | R | A-h, M-bw | Ice thickness | ice thickness |
| 98 | Ice concentration | / | / | R | A-d, M-d | Ice concentration | / |
| 99 | Ice class (pack, fast ice) | / | / | R | M-d | Ice class (pack, fast ice) | / |
| 100 | Ice type (level/rafted/ridged & floe descriptor) | / | / | R | M-d | Ice type (level/rafted/ridged & floe descriptor) | / |
| 101 | Form of ice (floe size, fast ice width) | / | / | R | M-w | Form of ice (floe size, fast ice width) | / |
| 102 | Stage of ice development | / | / | R | M-w | Stage of ice development | / |
| 103 | Ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up) | / | / | R | A/M-w, M-y | Ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up) | / |
| 104 | Ice stage of melting | / | / | R | M-d | Ice stage of melting | / |
| 105 | River ice jams and dams | / | / | R | M-d | River ice jams and dams | / |
| 106 | Flooding extent caused by jams and dams | / | / | R | M-d | Flooding extent caused by jams and dams | / |
| 107 | River icings (aufeis) | / | / | R | M-d | River icings (aufeis) | / |
| 108 | Maximum level | / | / | R | M-d | Maximum level | / |
| 109 | Areal extent of floating/grounded ice | / | / | D | M-w | Areal extent of floating/grounded ice | / |
| 110 | Ice surface temperature | / | / | D | A-h | Ice surface temperature | / |
| 111 | Ice openings (leads, polynyas, cracks) | / | / | D | A-d | Ice openings (leads, polynyas, cracks) | / |
| 112 | Ice deformation (divergence/convergence) | / | / | D | A-h, M-d | Ice deformation (divergence/convergence) | / |
| 113 | Ice ridge height | / | / | D | A-h, M-d | Ice ridge height | / |
| 114 | Ice ridge cover (concentration of ice ridges) | / | / | D | A-h, M-d | Ice ridge cover (concentration of ice ridges) | / |
| 115 | Ice stratigraphy | / | / | D | M-bw | Ice stratigraphy | / |
| 116 | Ice temperature profile (vertical) | / | / | D | A-h, M-bw | Ice temperature profile (vertical) | / |

**Note:**

**Blue and red shading/fill indicate recommended and desired measurements, respectively.**

**A: automatic, M: manual**

**S: snow, G: glaciers, IS: ice sheets, ISV: ice shelves, P: permafrost, SFG: seasonally frozen ground, SI: sea ice, LRI: lake and river ice**

**h: hourly; d: daily; w: weekly; bw: bi-weekly; m: monthly; s: seasonally; 6m: half-yearly; y: yearly; my: multi-year**

Table 2: Variables observed by GCW stations, not identified by GCW in the 2017 list

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***No.*** | ***Cryo. variables not in GCW 2017 list*** | ***OSCAR/WIGOS current names*** | ***OSCAR/WIGOS current definitions*** | ***Links to existing variables*** |
| ***SNOW AND SOLID PRECIPITATION*** | | | |  |
| 1 | snow albedo | N/A | N/A | WMDR includes “Snow Albedo”, “”Snow free albedo”, “Maximum snow albedo” |
| 2 | snow density | N/A | N/A | Snow profiles |
| 3 | ground surface temperature | N/A | N/A | WMDR includes “ground temperature” and “land surface temperature” |
| 4 | snow temperature profile | N/A | N/A | Snow temperature; Snow profiles |
| ***GLACIERS AND ICE CAPS*** | | | | |
| 5 | Annual mass balance | N/A | N/A | glacier-wide mass balance;  glacier mass balance at a point |
| 6 | Winter mass balance | N/A | N/A | glacier-wide mass balance;  glacier mass balance at a point |
| 7 | Surface topography | Glacier topography | Map of the height of the glacier surface. | WMDR has “Land Surface Topography” |
| 8 | Surface albedo | N/A | N/A | WMDR “Albedo”, “Single scattering albedo”, “Surface albedo” |
| 9 | Facies, snowline | N/A | N/A |  |
| 10 | Surface temperature | N/A | N/A | Ice/firn temperature profile (point) |
| 11 | Front variation | N/A | N/A |  |
| 12 | Snout position | N/A | N/A |  |
| 13 | Ice thickness change | N/A | N/A | Ice thickness |
| ***ICE SHEETS*** | | | | |
| 14 | Ice margin | N/A | N/A |  |
| 15 | Grounding line | N/A | N/A |  |
| 16 | Surface elevation | N/A | N/A | ice thickness |
| 17 | Internal layering | N/A | N/A |  |
| 18 | Basal melting, including ice shelves | N/A | N/A | basal ablation |
| 19 | Gravity field | N/A | N/A |  |
| 20 | Ice morphology | N/A | N/A |  |
| 21 | Surface temperature | N/A | N/A | Ice/firn temperature profile (point) |
| 22 | Surface albedo | N/A | N/A |  |
| ***ICE SHELVES*** | | | | |
| 23 | grounding line | N/A | N/A |  |
| 2r | ice thickness | N/A | N/A |  |
| ***PERMAFROST*** | | | | |
| 25 | thermal state | N/A | N/A |  |
| 26 | thickness | N/A | N/A | active layer thickness? |
| 27 | distribution (local or regional) | N/A | N/A |  |
| 28 | downslope velocity | N/A | N/A |  |
| 29 | duration of thaw | N/A | N/A | seasonal frost heath/subsidence |
| 30 | onset of seasonal freezing | N/A | N/A | seasonal frost heath/subsidence |
| 31 | depth of seasonal freezing | N/A | N/A | seasonal frost heath/subsidence |
| ***SEASONALLY FROZEN GROUND*** | | | |  |
| 32 | thickness | N/A | N/A |  |
| 33 | distribution (local or regional) | N/A | N/A |  |
| 34 | soil moisture | N/A | N/A |  |
| ***SEA ICE*** | | | | |
| 35 | sea ice albedo | N/A | N/A |  |
| 36 | melt onset | N/A | N/A | sea ice phenomena; similarly, lake/river ‘ice phenomena’ |
| 37 | sea ice chemistry | N/A | N/A |  |
| 38 | sea ice extent |  |  |  |
| 39 | sea ice age |  |  |  |

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1. See also “surface topography” under glaciers and ice caps in [Table 2](#Annex2) of this document. [↑](#footnote-ref-1)