Draft

World Meteorological Organization

FORMAT TO EXCHANGE OPERATIONAL AND ARCHIVED DATA ON SEA ICE (CONTOUR-2)

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Annex 5

A PROPOSAL FOR CODING THE POSITIONS OF THE POINTS IN THE RECTANGULAR COORDINATES, RATHER THAN IN THE GEOGRAPHICAL COORDINATES

1. Introduction.

The SIGRID-2 format was approved by WMO CMM and recommended for use by all national ice services (a letter of Mr. J.Rasmussen, Director WWWD, No. 42.276/W/MA/MS-SI of July 29, 1994). This format allows addressing the goals of the World Climate Program, but not the objectives of providing direct support to shipping and other activities at seas, as well as scientific studies of polar areas. Hence all national ice services use their own contour formats for practical application.

Increased international transport shipping in the Arctic and the Antarctic, joint experiments in these regions within the framework of international programs and agreements make a more detailed exchange of operational and regime information (as compared to SIGRID-2) quite important. Hence the development of one common international format for such an exchange is equally significant.

The proposed format Contour-2 is to be used for transfer of data on ice situation in the seas and the oceans from the processing centers of different levels to users (icebreakers, ships, drilling platforms), creation of databases and sea-ice data exchange between the national and international processing centers and databases.

The format provides for storage and transfer of all data on the ice charts compiled using the WMO Sea-Ice Nomenclature and allows the list of variables to be extended by using additional letter designations for their identification. The accuracy of delineating the boundaries of the zones and the position of linear and point objects is completely preserved. It is envisaged to use coding of only available information without the term "undetermined/unknown" and other methods for reducing the volume of letter-digital ice charts.

The individual (area and en-route) and composite ice charts coded in this format can be displayed on computer without any preliminary preparation (with hard copies printed or plotted) or converted into any rectangular grid.

2. LAY-OUT OF THE FORMAT

Each individual or a composite ice chart consists of nine sections composing one file:

- header-record, also including the boundaries of data acquisition.
- sets of ice characteristics in the main zones with the assigned ordinal numbers and of the information points of the zones,
- boundaries of the main zones,
- additional zones,
- linear objects,
- point objects,
- ice drift,
- data of en-route observations.
- text message.

Each section begins with the corresponding text constant which is situated on a separate line: **CONTOUR-2, IF, BOUND, ZONE, LINE, POINT, DRIFT, ROUTE, TEXT**.

If there is no information on some section or other, its constant is not indicated. The constant END which is written on a separate line, is an indication of the end of the letter-digital ice chart.

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3. HEADER-RECORD OF THE ICE CHART

All modern methods of ice observations have limitations regarding the characteristics to be determined and accuracy. Hence for a sufficiently complete description of the ice cover properties it is necessary to use a complex of means operating in different ranges of electromagnetic waves on different media and with respectively different spatial and temporal resolutions, different accuracy and reliability. Therefore, practically all ice centers issue composite ice charts.

The methodological principle for compiling a composite chart of ice situation is to use all available information taking into account the information properties and the accuracy of geolocation of data of each specific instrument. Individual charts serve as input information for operational composite ice charts. They are based on TV (IR in wintertime) satellite imagery, airborne radar and SLAR imagery, visual ice observations (in the form of en-route charts), as well as shipborne data, data from polar stations and automated ice stations prepared for use.

Each file of an individual or a composite ice chart recorded on magnetic tape or transmitted via communication channels begins with the header-record. As current information of the composite chart which is constantly updated, can contain data of varying individual charts in its separate parts based on different remote sensing means, information in the header-record should provide the possibility to determine the date, means and methods of information collection. The header-record is written in the following format:

```
CONTOUR-2
AAFF
f......f; NNNN
MMMMLLLLL1 MMMMLLLLL2 MMMMLLLLL3 MMMMLLLLL4 MMMMLLLLL1
YYMMDD YYMMDD
MAP
PPrn1 CCCCC1 BBBB YYMMDD /MMMMLLLLL/
..... ......
PPrnn CCCCCn BBBB YYMMDD /MMMMLLLLL/
LIMIT
MMMMLLLLL MMMMLLLLL ........ MMMMLLLLL: MMMMLLLLL ........
MMMMLLLLL
ROUTE
PPrn CCCCC BBBB YYMMDD
MMMMLLLLL MMMMLLLLL  ......... MMMMLLLLL
9999999999
```

where
AA - originating country;
FF - originating Service (institution);
f..f - type of information indicated on the ice chart, coded by the constants:

- **OBSERVATION** - data of direct observations,
- **CALCULATED** - calculated data,
- **FORECAST** - prognostic chart,

NNNN - ordinal or archived No. of the chart (defined by the National Center or institution),
MMMMLLLLL with indices 1 - 4 - geographical coordinates (degrees and minutes of latitude

and longitude) of the rectangular which contours the observation region most closely,
YYMMDD with indices 1 and 2 - year, month and date of the start and end of the observations used to construct the chart or the forecasting period.
After the **MAP** constant which is written on a separate line:

PP - methods and means of observations **(code table 1), r** - meaningful ground resolution digit in m, **n** - power indicator 10.

Thus the resolution of each remote sensing means is determined by the expression **R=r10^n.** For example, the airborne radar survey with a ground resolution of 7 m is coded as **AR70,** satellite observations in the IR range with a resolution of 1 km as **PI113.**

CCCCC - type of satellite (NOAA. METEOR, etc.) or aircraft,
BBBB - No. of the turn or the ice reconnaissance flight,
YYMMDD - date of the survey or receiving the satellite image (but not the date of issuing an individual chart based on these data),
/MMMMLLLLL/ in symbols / / - geographical coordinates of the information point within the observation region of the given individual chart.

After the constant **LIMIT** the geographical coordinates of the turning points of the general boundary of the composite chart and boundaries of the individual charts are enumerated.

The general boundary of a composite or individual chart should be closed (the first and the last points are repeated). Its description includes the points of joining of the boundaries of zones and for a composite chart also the points of joining of the boundaries of the individual charts. Separate segments of the boundaries are separated by the symbol **:** .

Thus a system of closed polygons with the information points is formed. It allows us to determine for each part of the ice chart the date, means and methods of observations and therefore make conclusions about the completeness, reliability and accuracy of data presented on the chart and use them as input information for producing the calculated and prognostic ice charts.

If data of airborne visual observations, including profile observations by means of the radar thickness meter and a laser profiler were used for issuing the chart, then the subsection **ROUTE** is added to the header-record. In this subsection the information point is not given on the line with the description of the observation means and date, but on the new line the geographic coordinates of the turning points of the route are enumerated.

The header-record of an individual chart includes only one date of observation or receiving satellite information and one information point (observations are uniform over the entire area of the chart).

In the header-records of the calculated and prognostic charts the sections **MA** and **ROUTE,** including the constants themselves are omitted.

YYMMDD1 for the calculated charts is the date of the start of observations which as a result of calculations are given for the moment **YYMMDD2**. This is thus the date from which information on the chart becomes old. For prognostic charts: **YYMMDD1** - date of preparing the forecast, **YYMMDD2** - date when according to the forecast the ice cover attains the predicted state.

The section **LIMIT** of the calculated and prognostic charts enumerates the coordinates of only the external boundary of the ice chart including the joining points of the boundaries of the zones.

The header-record of the ice chart can be used as a base file of the ice chart identifiers allowing retrieval of required information by region, observation time and means at the requests of users.

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4. CODING OF GEOGRAPHICAL COORDINATES

The position of the boundaries of the zones, linear and point objects is governed by their geographical coordinates (degrees and minutes of latitude and longitude). Two methods of longitude indication are used. According to the first traditionally widespread method, in particular for all geographical topographic and base charts, reading of longitudes is from the Greenwich meridian in the western and eastern directions from 0° to 180°. For coding, western longitudes are assigned the sign minus or a fifth digit is introduced into the group of latitudes - an indication of the hemisphere of latitude or longitude (1 for eastern longitudes and 7 for western longitudes in the Northern Hemisphere and 3 and 5, respectively, in the Southern Hemisphere). To facilitate manual typing and visual reading of the code, the five-digit groups of latitude and longitude are usually separated by a gap. According to the second method, reading of longitudes is only in the western direction from 0° to 360°.

In view of desirability to reduce to the maximum the volume of coded information, especially, for transmitting via the communication channels, as well as of the possibility to use computers for coding and decoding, the description of longitudes in the CONTOUR-2 format is only in the eastern direction from 0° to 360°. For each point there is one nine-digit group where the first 4 digits are degrees and minutes of latitude and the last five digits - degrees and minutes of longitudes. Thus the coordinates of one point are described by only 9 digits and not by 10 digits and one symbol. That is, the volume of coded information is 10% reduced. For example, the point 75°37'N 103°28'W would be coded as **75377 10328** according to the first version and in the CONTOUR-2 format as **753725632.**

If greater accuracy in describing the coordinates (drift vector, large-scale charts of the unloading sites on fast ice, ice situation in the vicinity of the drilling platforms, etc.) is required, the format allows latitude to be coded by five digits by increasing the number of digits up to 11 in the group with an accuracy up to 0.1', not even mentioning this in the text.

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5. CONTENT OF ICE CHARTS, CODING OF ICE CHARACTERISTICS

All ice charts compiled from data of direct observations can be subdivided into 3 classes; large-scale charts and plans, operational ice charts and review ice charts. Large-scale charts and plans are based on data of high resolution remote sensing means with the aim of a maximum detailed depiction of the ice cover state along the route of icebreakers, convoys and separate vessels. Such charts mainly consist of the ice formations which are important in terms of navigation (giant and sometimes vast floes of old or thick first-year ice, leads and fractures, stamukhas, icebergs, etc.). Only parts of sea surface where ice cakes and small floes and ice floes less than 100 km in diameter were observed, are depicted as zones of different total and partial concentration. By the term "zone" one understands closed space on the chart within which the values of all characteristics of the ice cover are assumed equal.

The operational ice charts are to be used by navigators and the headquarters of marine operations for supporting an escort of ships through the ice zones, studies of the ice regime of the seas, as well as for subsequent preparation of the calculated and prognostic ice charts. Unlike the large-scale charts, the operational charts mainly depict zones of ice of varying concentration, age categories, forms, surface structure, melting stages, etc. Of separate ice objects the operational charts show: giant ice floes, leads and fractures, ridged ice and pressure ridges, stamukhas, icebergs, drift divides and drift vectors.

The review ice charts allow the general state of the ice cover over the area of the entire Arctic Ocean or the Southern Ocean, their seas, as well as of the ice-covered seas of temperate latitudes to be assessed. They are based on generalization in time and space of the operational composite ice charts.

The CONTOUR-2 format provides coding with the aim to create the databases and transfer all listed types of charts to users via the communication lines.

Each variable (characteristic) of a zone or an ice object is coded by a two-letter identifier. The first letter defines its belonging to some information block or other (code table) and the second - a specific variable value, i.e. the term from the WMO Nomenclature defining it. Then the code numbers of relative areas, estimates in conventional units or true values (size, thickness, azimuth, etc.) are reported. Thus the proposed system for coding ice characteristics clearly separates designation of notions and quantitative characteristics.

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6. CODING OF ICE CHARACTERISTICS IN THE MAIN ZONES

By the main zones we mean zones delineated by total concentration and age categories (studies of development). The section begins with the constant **INF** on a separate line. The variables and their numerical values of one or several zones identified by the main characteristics, are described on separate lines and are written in the following format:

```
=nnnCPffSPffFPffZPff ....... SPff:FPffZPffZPff /MMMMLLLLL: ......
.... MMMMLLLLL/
```

where:
= - a symbol defining the beginning of the record of a set of ice characteristics, nnn - the ordinal number of the set of characteristics;
C, S, F, Z - identifiers of separate blocks (code tables);
P with the corresponding indices are identifiers of specific variables in tenths of the total area of the zones or in arbitrary units of the corresponding scales;
: - a separating symbol after which data on the forms and additional characteristics refer to the ice of all age stages;
/...... / - symbols / / restricting the description of the geographical coordinates of the information points of the zones with a given set of ice characteristics;
MMMMLLLLL - geographical coordinates of the information points which are separated from each other by the symbol :.

If in small zones the conventional designations cannot be placed, then after the information point of such a zone, the coordinates of the drawing point can be indicated, i.e. of the point where these conventional designations should be depicted (on the shore, beyond the boundary of data collection or in the adjacent extensive zone). At displaying or plotting the chart, the information point and the point of drawing are connected by a direct line. The information point and the point of drawing are separated by a gap.

The description of a set of variables begins with the identifier characterizing ice distribution **(code table 2).** After the identifiers **CW** and **CU** no characteristics are given and then the coordinates of the information points of the zones where open water was observed or of the zones where observations were not made due to weather conditions or other reasons are reported. After **CI** the total ice concentrations can be given. In this case this is also partial iceberg concentration. Partial concentration is not usually large (less than 1/10). It is coded using common indications of total and partial concentration: at partial concentration <5/100 **ff=0**, at large concentration **ff** is given in tenths according to **code table 9.** At instrumental observations, if partial concentration of icebergs is determined with an accuracy up to 1/100 and less than 1/10, the code table 9 provides a possibility for indicating its accurate value. Then the identifier **FI** (iceberg size) and the numerical value of the variable are reported according to table 16 or by a two-digit number in hundred meters without a distinguishing letter **"T".** Even if a relative area of icebergs and their mean size are determined, it is very important from the viewpoint of shipping to know their relative amount per unit area and distribution over the sea which determines the probability of encounter. Therefore it is also recommended, if possible, to indicate in addition to relative area and mean size the relative number of icebergs in the delineated zone. For this purpose the identifier **ZI** and **code table 17** are used. For example:

`CI02FI25ZIT5`

- in the zone "iceberg water" the relative area of icebergs is 2%, mean size is 2.5 km, the number of icebergs within a 20 km radius is 9-16 or mean distance between icebergs is 5-7 miles.

Let us once again note that identifiers and their relative values are only used for those variables which are observed.

After **CT** total ice concentration **(code table 9)** is given. If ice distribution within the delineated zone (or zones) is non-uniform, then after total concentration the identifier CS (strips, patches) and concentration are given. For example,

`=nnnCT40CS60`

- that is in the zones with a set of characteristics nnn total concentration is 4/10, concentration in strips and patches is 6/10.

After the identifier **CF** (fast ice) total concentration is not given.

Then after **CTff** and **CF** stages of development and partial concentration of the observed age stages are recorded beginning from the most old ice. If ice of land origin (icebergs) was observed in the drifting or fast ice, the description of the age categories begins from them. Single (separate) icebergs are not included into the description of the main zones, but are coded as point objects*.

If mean ice thickness of some age category is determined in the zone, then after the age stage category and partial concentration the identifier SV is given and then a two-digit value of the ice thickness in decimeters. For example,

`SK40SV11` **-** medium first-year ice whose partial concentration is 4/10, the measured mean thickness is 110 cm.

Sometimes, the remote sensing means and observation conditions do not allow subdivision of ice belonging to different main development stages (nilas, young, first-year, old). In this case a double identifier can be written and then total concentration of this ice. For example,

SISW40 - thin and grey-white first-year ice of total partial concentration 4/10.

If some ice in the zone can be estimated as ice of a definite age stage and more old, then after the identifier of this initial age stage the SX identifier is written, and then partial concentration of this ice. For example,

SKSX80 - medium first-year and more old ice of total partial concentration of 8/10.

If only one age stage is indicated (uniform ice), then its partial concentration is not given. For example,

=CT91ST - thick first-year ice with concentration of 9-10/10.

In addition to total concentration and age categories, the characteristics of the ice cover of the main zones include, if observed, the forms **(code table 4)** and additional generalized characteristics **(code table 5)**. If these data are given after partial concentration of ice of a definite age category, they refer to the ice of the indicated age within the boundaries of the main zone. If the forms and additional characteristics are given after the symbol ":", they refer to all ice in the zone. In particular, ice rafting is typical only of nilas and young stages. even if ice of this age was observed, some ice can have rafting and other ice not. Hence the ZR identifier is given after the corresponding age category. The quantitative estimate if it is determined, is expressed in tenths of the total area of the zone. For example:

=nnnCT99SI50SG40ZR20SL10

- total concentration is 10/10, thin first-year ice is 5/10, gray ice - 4/10, 2/10 being rafted ice, light nilas -1/10. The situation with determination of the forms is quite different. The drifting ice cover of the seas presents, as a rule, ice breccia of different age categories. Only the most old ice has the form of the floes, all other ice presents ice-free water zones, fractures and leads frozen at different time after the onset of ice formation. Hence in terms of the methods it is more correct to indicate average or prevailing size (forms) of the most old ice and at the end after the symbol ":" the size of the breccia floes restricted by cracks, leads and fractures of the most young ice or ice-free water (if total concentration is less than 10/10. For example,

= nnnCT99SM20FMST50SK20SN10:FV

- total concentration is 10/10, multiyear ice 2/10 medium floes, thick first-year ice 5/10, medium first-year ice 2/10, nilas 1/10, vast breccia floes of multiyear, thick and medium first-year ice.

Concentration of hummocks and ridges can be characterized either by a relative area occupied by hummocks in hundredths or by a number of pressure ridges per nautical mile. For these cases different identifiers **(ZH** and **ZI)** are envisaged. The characteristics of the snow cover depth, stages of melting, pollution on the ice, surface relief of multiyear ice are reported if observed, by the identifier assigned to each characteristic and conventional units according to the corresponding scales (**code tables 12-15).** Zones of pressures and discontinuities in the ice cover are, as a rule, not related to age boundaries and hence are coded as separate zones delineated on the basis of these additional characteristics. The order of their description is presented in **Section 8.**

The section **INF** ends like the other sections, by a group **999999999**, which is situated on a separate line.

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7. CODING OF THE BOUNDARIES OF THE MAIN ZONES

The section of the boundaries of the main zones begins with the constant **BOUND** on a separate line. The position of the boundaries of the zones is approximated by the segments of the straight lines between the turning points. The order of forming the nine character groups determining the position of some point at the chart in the geographical coordinates is described in **Section 4.**

The number and position of the turning points of the boundaries should be optimal for describing the contours of the zones. The deviation of the observed, as a rule, curvilinear boundary on the chart from the segment of a straight line between the two turning points can serve as a criterion. Taking into account that the position of the turning points is described with an accuracy of 1' by latitude and longitude, this deviation should not, probably, exceed 3 km for operational charts and 5 km at the exchange of archived data. This conditions allows automated selection of the points describing the contours of the zones.

The closed boundaries begin and end with one and the same point. The boundaries of the zones can be partly or completely the shores, the boundary of data collection (ice chart) and earlier coded boundaries of the other zones. The contour of each zone should be closed from all sides without gaps. The joining points of the boundaries of other zones except for the points adjoining the coastline, should be repeated for describing each of these zones.

The coordinates of the coastline points are stored in a separate permanent database. To avoid this condition is possible by indicating the joining point not on the coastline, but on the shore itself at the continuation of the first or the last segment of the boundary.

Thus the boundaries of the zones are described by lines - broken segments of the boundaries between the joining points with other lines. The lines are separated by the symbol: (division). The line can consist of only two joining points, but in the general case the number of the points on the line is not limited. The lines include nodes - the joining points of the boundaries of other zones and points - simple turning points. Such a subdivision into lines, nodes and points allows, if necessary, a rational editing or conversion to the calculation-analytical charts of the letter-digital ice charts in the CONTOUR-2 format.

Separate lines contouring some zone or other are, as a rule, described in different places of the section **BOUND**. Hence closed contours of all zones are obtained only after the entire section is displayed or plotted.

The presence of an information point given in the **INF** section in each zone, enables us not to form separate files of the closed contours of each zone when data are gridded. This makes the conversion procedure much more simple.

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8. DESCRIPTION OF THE ZONES DELINEATED BY ADDITIONAL CHARACTERISTICS

Zones delineated by the additional generalized characteristics present separate layers of the ice chart, each of them being identified using only one characteristic. Its identifier (code table 5) follows directly the symbol =. For describing such zones no other characteristics are presented.

In the practice of compiling the ice charts such an approach is most frequently used for describing the dynamic processes and their results (zones of pressures, fractures, cracks and leads or zones of leads). As mentioned, the boundaries of such zones in the general case are not connected with the age categories and hence can be situated within large main zones or cross the boundaries of the zones of different age categories.

The zones of pressure (compacting) are coded by the **ZC** identifier followed by a two-character code symbol which characterizes the degree of pressure (**code table 11)**. For example,

=ZC20

- zone of considerable pressure (compacting).

According to the Nomenclature, the strength of pressure (compacting) is described by three gradations - slight, considerable and strong. However, observers often assess it by intermediate values 1-2 and 2-3. The use of a two-digit group in the code allows the initial estimate to be preserved.

Non-uniform ice drift results in mutual shears, break-up of the solid ice cover and formation of cracks and leads. The presence of such zones in the drifting ice is usually related to the boundaries of the ice drift in different directions and is quite interesting for selecting the motion route through the ice and studies of the ice cover dynamics. Formation of cracks and leads in fast ice, their amount and orientation characterize the onset and the extent of fast ice break-up and should be by all means indicated on the ice charts.

The zones of fracturing (cracks and leads) are coded by the **ZF i**dentifier followed by one or two (according to the number of the observed systems of approximately parallel cracks and leads) four-character groups **LLAA** where **LL** - mean distance between the cracks and leads in km, **AA** - azimuth, relative to meridian of the information point in tenths of degrees. For describing the zone of leads after the **ZL** identifier one or two (according to the number of the observed lead systems) six character groups **LL..AA..TK..LL..AA..TK..** groups are recorded where the values **LL** and **AA** are similar to the preceding ones, **T** - a distinguishing feature of the subsequent indication of the width of the leads by code **(code table 11)**, **K** - code value of the width of the leads.

After each of these groups, if possible, the identifier of the age category of ice formed at the surface of the leads of this system, is written. For example,

=ZL 1512T3SG 2005T2SN /812015400/

- zone of two systems of leads: in the first - mean distance between the leads is 15 km, the azimuth relative to meridian is 154 120 , the width is 1.5-3 km, covered by gray ice; in the second - mean distance between the leads is 20 km, azimuth - 50, mean width is 0.5-1.5 km, nilas was formed on the surface.

Fractures usually represent leads deformed as a result of shears. Due to non-linearity, each lead at shears expands in some places and closes in other places and thus a chain of fractures is formed, whereas a series of roughly parallel chains is formed of the system of leads..

The zone of fractures is described by the **ZP** identifier after which a six character group **LLAAYY** is written where **LL** - mean distance between the chains of fractures in km, **AA** - azimuth relative to meridian of the information point, **YY** - mean distance between the fractures in the chains in hundred meters. Such additional characteristics as concentration of hummocks and ridges, snow depth, stages of melting are usually reported for describing the main zones delineated by concentration or age. It is assumed that the boundaries of the zones of main and additional characteristics coincide. However, sometimes it is necessary to show the actual boundaries of the zones of increased concentration of hummocks and ridges or vice versa level ice, zones of varying stages of melting or other additional characteristics. In these cases after the symbol **"="** the corresponding identifier **(code table 5)** and a quantitative estimate of this characteristic are written. After describing the additional generalized characteristic by which a zone was delineated, the coordinates of the information point between the symbols **/ /** are written and then on a new line the coordinates of the turning points of the zone contour which are coded according to the general rule.

The contours of additional zones should be closed (the first and the last points are repeated) or can be closed to the coastline, the boundary of data collection of the ice chart, the boundary of the zone of a similar additional characteristic which has a different numerical value. For example, the boundary of the zone of slight compacting can be closed to the boundary of considerable or strong compacting. The boundaries of the zones delineated by additional characteristics cannot be closed to the boundaries of the main zones, additional zones delineated by other characteristics or to linear targets.

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9. A SECTION OF LINEAR OBJECTS

The linear objects whose identifiers are given in **code table 6**, mainly describe ice-free water zones among ice and characterize the dynamic state of the ice cover. Such objects as flaw, ridged ice and a crack do not require information on the ice age category and width. However, for a complete description of the leads and flaw and shore leads it is necessary to indicate the ice age category at their surface and width (by two characters in hundred meters). For example,

```
=LL03SG
```

- a lead 300 m wide covered by grey ice.

When it is impossible to determine the width of the lead accurately, in particular from satellite low and medium resolution imagery as well as for coding of several leads, their width is indicated according to **code table 11.** The ice edge, i.e. the boundary between ice-free water and sea ice of any age category, is usually described as a boundary between the zones whose description begins with the identifiers **CW** and **CT** or **CF**. Hence the identifier **LE** is used only for visual observations if observer can determine the geographical position of the ice edge to the side of the route, but cannot distinguish any characteristics of the ice behind it. After the characteristics of the linear object the information point is not given, but from the new line the coordinates of its turning points are presented which are coded according to the general rule. If several linear objects with the same characteristics are plotted on the chart, then this characteristic is coded only once after which the turning points of each object of this type are reported on a new line. The groups of coordinates of separate ice formations are separated by the symbol :. The description of the coordinates of the next linear object after the symbol : can start on the same line. For example,

```
=LLT3SW
721205430 721605445:771307012 770406930 763506820 .......
=LLT2SN
741307500 752007100 ..........
```

If there are no data on the age categories or width or simultaneously on both characteristics, they are not given.

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10. A SECTION OF POINT OBJECTS

The point objects that should be indicated on the ice charts (depending on their scale and purpose), include icebergs, stamukhas, separate ice floes, as well as the ice thickness measured at a point. For describing the point objects, on a separate line there are given in succession the identifier of the object (code table 7), the age identifier (for ice floes) and by a two-digit group the size by the largest section in hundreds of meters. If the size of the object exceeds 10 km, the geographical coordinates of the ends of the segment of the largest section are reported instead of the size in the symbols / / without the separating symbol between the groups of coordinates. For example,

=PL/821516435 822116511/

- a drifting ice island whose size (about 14 km) and position are reported by the coordinates of the ends of its large axis.

For iceberg coding after the identifier **PI** or **PT** defining the main iceberg types, their size can be indicated in hundred meters or according to **code table 16.**

After the identifier **PV** (ice thickness measured at a point) a two-digit group indicates the measured ice thickness in decimeters with rounding off up to whole values, i.e. with an accuracy of 5 cm. After characterizing the object the geographical coordinates of the information point defining its position (for objects less than 10 km in diameter) are reported by one nine-digit group in the symbols / /.

In case of describing several point objects with similar characteristics (for example, stamukhas or icebergs, if their size is not given) the identifier is written only once and the coordinates of the information points defining the position of the objects are separated by the symbol :. For example:

/761414215:772514356 ....../

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11. A SECTION OF THE ICE DRIFT

The terms and notions presented in table 8: ice fracturing, ice shearing, ice diverging and their identifiers are used as a rule for characterizing the dynamic state of the ice cover in the main zones or in local regions without indication of any numerical values. Hence their application does not require special explanation. However, automated processing of successive satellite or instrumental airborne surveys allows us to obtain quite a detailed field of the drift vectors. In order to avoid too much information on the general ice situation chart and facilitate its reading, all the determined drift vectors are usually depicted only at special drift charts or at the charts of the dynamic state of the ice cover. However, information about separate drift vectors allows an objective analysis of the changes in the distribution and characteristics of the ice cover to be performed. Hence information on the drift of separate ice floes, icebergs, automated buoys should be included to the digital ice chart.

Coding of the drift parameters is performed in the form of separate records grouped by observation means and periods. Each record starts after the symbol **"="** with the identifier of the methods and means of observation followed by the observation time:

```
=RRr'n:MMDDtt..-MMDDtt..,
```

where **PP** - observation method **(code table 1)**, **r**.. - a meaningful digit of the route-mean-square (rms) error of determining the coordinates using the indicated observation means and method in a specific region in meters, **n** - power indicator 10, **MMDD** - date (month, date), **tt** - hours (UTC time). The indices 1 and 2 correspond to the start and end of the observation time interval of observations for the drifting formations of this group.

Methods and means of observations were enumerated in the header-record of the ice chart. However there the resolution was indicated and in the ice drift section which begins with the constant **DRIFT**, the root-mean-square error of coordinate determination which also depends on the accuracy of navigation, processing method, the presence of reference points, etc. being always worse than the resolution, i.e. **r'>r**. Only for buoys and automated ice stations in both cases the accuracy of positioning and **r'=r** are given. Then on a new line using ten-digit groups the geographical coordinates of the start and end of each vector of this group, (i.e. for one period and by one means) are recorded. First five digits denote latitude with an accuracy up to 0.1', the six to ten digits - longitude with an accuracy (by rounding off) up to 1'. Data on each vector occupying two groups are separated by the symbol :. On one line 6 ten-digit groups should be situated which corresponds to three drift vectors. For example,

```
DRIFT
=P143:022614-030215
8116415618 8123715553: ...... ........
```

- the drift based on satellite observation data in the IR range, the rms error of coordinate determination plus-minus 4 km, first determination of coordinates is on February 26, at 14 UTC, second - on March 2 at 15 UTC, the coordinates 81°16.4' 156°18' - 81°23.7' 155°53'.

---

12. CODING OF DATA OF EN-ROUTE OBSERVATIONS

Visual airborne observations allow almost all ice cover characteristics to be estimated. If aircraft or helicopter was equipped by a radar ice thickness meter and laser profiler, then it is also possible to obtain objective data on the thickness of ice varying age categories per unit route which can be used for specifying model calculations and the models themselves. Therefore, if at the time of compiling a composite chart there are data of en-route observations they are included to a letter-digital composite ice chart in a separate section. The ice thickness and surface relief are directly observed under aircraft. The width of the strip of visual observations for determining other main characteristics does not exceed several kilometers and also presents a line at the chart scale. Hence data are coded as route segments which are assigned some set or other of the main and additional characteristics. The section begins with the constant **ROUTE** on a separate line. Then the geographical coordinates of the point of the start of observations are reported (crossing the coastline, boundaries of information collection of the ice chart, take off from board the icebreaker or runway at the drifting ice). For this purpose the identifier **CU** or **CL** are used. It is followed by the coordinates of the start of observations within the chart under preparation. Then the ice characteristics on the route segments are coded in succession according to the rules presented in Section 6 using same code tables and the order of describing the numerical values of variables, separating and service symbols. The route segments are not numbered and right after the symbol = the identifier **CP** is written.

All additional generalized characteristics at each route segment are described with the main ones and not in a separate block. Therefore at the change in any main or additional characteristic or numerical values of some characteristic a separate route segment is delineated.

After describing all ice characteristics in the symbols / / the geographical coordinates of the end of the route segment with these characteristics are indicated by one nine-digit. This point is simultaneously the start of the next route segment. Thus each route segment with the assigned set of characteristics is restricted by the coordinates of the end of earlier coded segment written in the symbols / / on the previous line and the coordinates of the end of the given segment.

If ice characteristics did not change at the turning points of the route (when turning to the next rectilinear segment), first the coordinates of the turning point and then after a "gap" the coordinates of the end of the route segment are reported in the symbols / /.

The linear objects observed along the route are coded in a separate block which is reported on a separate line by the constant **LINE OF ROUTE**. Each linear object is also written on a separate line. For coding a lead after the symbol = the identifier **LL** is written. It is followed by its azimuth relative to meridian of the crossing point of the lead by the route in tens of degrees, the width in hundred meters and age category of the ice formed at its surface. For flaws and hummocks, drift divides and boundaries only azimuth is recorded.

After characteristics of the linear object the geographical coordinates of its crossing point by the ice reconnaissance route are indicated in the symbols / /. If the linear object was situated aside from the segment and parallel to it and therefore was not crossed by the route, the coordinates of the object during its observation period are indicated in the symbols / / by two or three groups. In these cases the azimuth and the age category of the ice formed at the surface of the lead are not determined and the width is indicated by code **(code table 11)**.

For example:

```
LINE OF ROUTE
=LL1604SG /723415042/
=LLT2 /724315124 732515146/
```

- a lead whose azimuth relative to meridian 150° is equal to 160°, the width to 400 m covered by grey ice, was crossed by the ice reconnaissance route at the point of 72°34' and 150°42'.

Point objects are described in the block **POINT OF ROUTE** fully preserving the methods presented in Section 10. In the symbols / / there are indicated the coordinates of the objects which depending on their position can be both on the route and aside from it. The ice drift even at successive en-route surveys in one and the same region is not observed. Thus in the section **ROUTE** the crossings of the main zones are described including all additional characteristics, linear and point objects.

---

13. TEXT REPORT

In the section TEXT, if necessary, information is presented in plain language which is considered necessary for a correct understanding and use of the coded ice chart. This information includes observation conditions, failures in operation of the equipment on board, reception distortions, non-standard processing methods, the use of previous observation data or calculations, etc.

14. DISSEMINATION OF OPERATIONAL ICE INFORMATION, EXCHANGE OF ARCHIVED DATA

Operational ice information is reported to users via communication channels in the form of separate letter-digital charts with the addition of the address block which is formed according to the national or international communication rules and is not considered here.

When a cable-chart is transmitted via a communication line, for users not having computers with corresponding software and code tables, the letter symbols (identifiers) of ice characteristics can automatically be replaced by the terms of the Nomenclature in the user's language. For example: instead of CF - fast ice, SM multiyear, etc.

It is planned that the exchange of archived data between the Ice Services and Data Banks will be by sending the magnetic tapes with the recorded ice charts. It is desirable that every tape included a set of uniform ice charts from one Ice Service covering approximately one and the same region.

Each tape should contain the header-record and files of the ice charts.

The header-record of the tape is recorded in the following format:

```
CONTOUR-2:
INF AAFF:NNN
MMLLL1 MMLLL2
YYMMDD1 YYMMDD2
```

where: **AA** - originating country, **FF** - originating Service, **NNN** - total number of digitized charts on a tape, **MMLLL** with indices 1 and 2 - minimum and maximum latitude and longitude of the observation region in degrees, **YYMMDD** with indices 1 and 2 - year (two last digits), month and date of the first and last chart by time recorded on the tape.

After coding the service information, if necessary, any other information pertinent to the entire tape is included as a free text. In particular, new additional terms and their definition, deviations from the agreed coding procedures and other messages necessary for correct data use are reported.

Annex 1 CODE TABLES

For information coding the code tables 1-8 are used. They contain two-letter identifiers which provide non-ambiguous determination of each ice variable (characteristic) in the zones or ice objects and tables 9-17 presenting scales for a quantitative or qualitative assessment of these characteristics.

For a more complete and objective description of the ice cover, code tables 1-8 include some terms which are absent in the WMO Sea-Ice Nomenclature (residual first-year ice, rough ice, drift divide, etc.). These additional terms which are used in the Russian Federation for some years, are explained in Annex 2.

The format CONTOUR-2 envisages, if possible, indication of the true numerical values of the variables (total and partial concentration in tenths and hundredths, size in hundred meters, thickness in decimeters, etc.). The recommendations of the format and the Nomenclature do not always coincide. In particular, the WMO Nomenclature envisages indication of the area of hummocks in tenths. However, this is not statistically justified, as the maximum relative area of hummocks does not, as a rule, exceed 20-25%. Hence CONTOUR-2 proposes to indicate it in hundredths.

The scales in code tables 9-17 are mainly used for a qualitative assessment (ice compacting, surface relief of multiyear ice) or if the quantitative assessment is not given in accurate values but within some limits (mean widths of leads in the zone, number of icebergs, etc.).

The scale of the stage of melting has significant shortcomings (code table 15). It does not characterize on the whole the stage of melting of the ice cover, non-uniform by the age category, but requires to indicate the stage of melting of each age gradation. This scale, like some other scales, is mainly to be used for visual observations which currently have a very limited application. However, to formulate the objective indications of different stages of melting based on remote sensing data in varying ranges, it is necessary to carry out joint international studies to specify this and some other scales. Hence here the scale given in WMO Nomenclature is presented.

Code table 1. Observation methods and means

Observation methods and means	Identifier
Satellite observations in the visible range	PV
Satellite observations in the IR range	PI
Satellite radar observations	PR
Satellite passive microwave observations	PS
Visual observations from aircraft	AV
Survey in the IR range from aircraft	AI
Radar survey from aircraft	AR
Visual shipborne and coastal observations	LV
Observations by means of coastal radars	LR
Data from buoys and automated ice stations	LA
Interpolation data	DI
Averaged gridded data	DA
Actual data at the grid point	DP

Code table 2. Ice distribution

No. from the WMO Sea-Ice Nomenclature	Characteristic	Identifier
3.1.	Fast ice	CF
4.2.	Total concentration	CT
-	Concentration in strips and patches	CS
4.2.7.	Bergy water	CI
4.2.8.	Ice free water	CW
4.3.2.1.	Giant ice floe whose contour is then described	CP

-	**Region where observations were not performed by meteorological or other reasons.**	**CU**

Note:

1. **CS** *is only used as an additional characteristic after* **CT.**
2. *After* **CW** *and* **CU** *there can be no characteristics.*
3. *After* **CI** *concentration and number of icebergs can be reported.*

Code table 3. Stage of development

No. from the WMO Sea-Ice Nomenclature	Characteristic	Identifier
2.1.	New ice	SA
2.1.2.	Grease ice	SQ
2.1.3	Slush	SC
2.2.	Nilas	SN
2.2.1.	Dark nilas	SD
2.2.2.	Light nilas	SL
2.2.3.	Ice rind	SR
2.3	Pancake ice	SP
2.4.	Young ice	SY
2.4.1.	Grey ice	SG
2.4.2	Grey-white ice	SW
2.5.	First-year ice	SF
2.5.1.	Thin first-year ice	SI
2.5.1.1	Thin first-year ice/first stage	SJ
2.5.1.2.	Thin first-year ice/second stage	SE
2.5.2.	Medium first-year ice	SK
2.5.3	Thick first-year ice	ST
2.6.	Old ice	SO
2.6.0	Remaining first-year ice	SH
2.6.1	Second-year ice	SS
2.6.2	Multiyear ice	SM
10.4.2	Ice of land origin	SB
	Ice more old than earlier indicated	SX
	Thickness of uniform ice in the zone	SV
	Ice of undetermined age	SU

Note:

1. *It is permitted to indicate two age stages which are not even included into one main age gradation, and then their total partial concentration. For example:* **SWSIff.**
2. **SX** *is used only after the specific age stage.*

Code Table 4 Forms of floating ice

No. from the WMO Sea-Ice Nomenclature No. from the WMO Sea-Ice Nomenclature	Characteristic	Identifier
4.3.2.1.	Giant ice floe	FG
4.3.2.2.	Vast ice floe	FV
4.3.2.3.	Big ice floe	FB
4.3.2.4.	Medium floe Small floe and ice cake	FM FR
4.3.2.5.	Small floe	FS
4.3.3.	Ice cake	FC
4.3.3.1.	Small ice cake	FT
4.3.5.	Ice breccia floes	FW
4.3.6.	Brash ice	FP

Code Table 5. Additional generalized characteristics

No. from the WMO Sea-Ice Nomenclature	Characteristic	Identifier
5.2.	Zone of compacting (pressures)	ZG
6.1.	Zone of fracturing (cracks and leads)	ZF
7.2.	Zone of fractures	ZP
7.3.	Zone of leads	ZL
8.2.1.	Rafted ice	ZR
8.2.1.2.	Rough ice	ZE
8.2.3.1.	Hummocked ice (with areal coverage). Frequency in number of ridges per 1 nautical mile	ZH ZT
8.2.3.2.	Concentration of hillocks of multiyear ice	ZX
8.6.	Snow-covered ice	ZS
8.7	Polluted ice	ZG
9.	Stage of melting	ZM
10.4.2.	Number of bergs	ZI
	Floe size distribution	ZD

Note: *The term "Floe size distribution" is mainly used for coding the archived ice charts of the Russian Federation.*

Code table 6. Linear objects of the ice cover

No. from the WMO Sea-Ice Nomenclature	Term	Identifier
4.4.8.	Ice edge	LE
5.4.1.	Drift divide	LR
7.1.1.	Crack	LC
7.1.1.2.	Flaw	LP
7.3.	Lead	LL
7.3.1.	Flaw and shore leads	LS
8.2.2.6.	Ridged ice	LT

Code Table 7. Point objects of the ice cover

No. from the WMO Sea-Ice Nomenclature	Term	Identifier
3.4.2.	Stamukha	PG
4.3.2.	Separate ice floe (size can be indicated, but the contour is not described)	PF
10.4.2.	Iceberg	PI
10.4.2.2.	Tabular berg	PT
10.4.3.	Drifting ice island Ice thickness measured at a point	PL PV

Code Table 8. Dynamics and deformations of the ice cover

No. from the WMO Sea-Ice Nomenclature	Process	Identifier
5.1.	Ice diverging	DE
5.3.	Ice shearing	DS
5.4.	Ice drift	DP
6.1.	Ice fracturing	DF

Code Table 9. Total and partial concentration

Concentration	Code symbol	Concentration	Code symbol
1/100	01	1/10-3/10	13
2/100	02	4/10-6/10	46
..	...	7/10-8/10	78
9/100	09	9/10-10/10	91
<1/10	00	...	...
1/10	10	91.3/100	92

2/10	**20**	**96.8/100**	**96**
...	**...**	**...**	**...**
9/10	**90**	**97.2/100**	**98**
10/10	**99**	**99.4/100**	**99**

Note:

1. *Ice-free water is coded by the identifier CW.*
2. *At instrumental observations it is possible:*
    1. *a) within the interval 1/100 - 9/100 - to report concentration with an accuracy up to 1/100;*
    2. *b) within the interval 9/10-10/10 - to report concentration with rounding off up to even values of hundredths.*

Code Table 10. Ice compacting (pressures)

Characteristic	Code symbol
Ice compacting, intensity is not reported	**00**
Slight compacting	**10** **12**
Considerable compacting	**20** **23**
Strong compacting	**30**

Note*: Intensity of compacting is reported after the identifier* ***ZC****. It is possible to indicate intermediate values of intensity of 1-2 and 2-3 units (coded by 12 and 23).*

Code Table 11. Width of leads

Width of leads (km)	Code symbol
0.05 - 0.3	**TO**
0.3 - 0.5	**T1**
0.5 - 1.5	**T2**
1.5 - 3	**T3**
3 - 5	**T4**
>5	**T5**

Note: *Code designation of the width of leads is reported after the identifiers* ***ZL*** *or* ***LL****. The observed width of a specific lead can be indicated in hundreds of meters by a two-letter number without the identifying letter T.*

Code table 12. Snow depth

Characteristic	Code symbol
No snow	**TO**
Up to 5 cm	**T1**
Up to 10 cm	**T2**

Up to 20 cm	T3
Up to 30 cm	T4
Up to 50 cm	T5
Up to 75 cm	T6
Up to 100 cm	T8

Note: *The code symbol of the snow depth is reported after the identifier* ***ZS****. It can also be reported in cm by a two digit number without the identifying letter T. If snow depth is unknown, the identifier* ***ZS*** *and its numerical value are omitted.*

Code Table 13. Surface relief of multiyear ice

Characteristic	Code symbol
Smoothed multiyear ice	T1
Moderately hillocky ice	T2
Strongly hillocky ice	T3

Note: *The characteristic of the multiyear ice surface is reported after the identifier ZX.*

Code Table 14. Relative area of polluted ice

Characteristic	Code symbol
Clean ice, traces of pollution	T0
Slight pollution. The area of polluted ice is less than 1/3 of the entire sighted ice area.	T1
Average pollution. From 1/3 to 2/3 of the ice area polluted.	T2
All ice polluted. More than 2/3 of the ice area polluted.	T3

Code Table 15. Stage of melting

Characteristic	Code symbol
No melt	T0
Few puddles	T1
Many puddles	T2
Flooded ice	T3
Few thawholes	T4
Many thaw holes	T5
Dried ice	T6
Rotten ice	T7
Few frozen puddles	T8
All puddles frozen	T9

Code Table 16. Specification of icebergs (as established by the International Ice Patrol Service)

Size	Height (m)	Length (m)	Code
Growler & bergy bit	**up to 5**	**less than 5**	**TO**
Iceberg, small	**6-15**	**16-60**	**T1**
Iceberg, medium	**16-45**	**61-122**	**T2**
Iceberg, large	**46-75**	**123-213**	**T3**
Iceberg, very large	**over 75**	**more than 213**	**T4**

Note: *Sizes refer to the above-water portion only. If the height and length of a berg fall into different size classification, use the larger size. Dimensions of a tabular berg or ice island may be indicated by a two-digit number in hundred meters. If they exceed 10 km - by indication of the coordinates of the ends of the largest section in symbols / / or by contour description.*

Code Table 17. Relative number of icebergs

Number of icebergs in the radius of		Distance between icebergs		Code symbol
20 km	**30 km**	**miles**	**km**	
-	-	-	-	T0
not more than 1	**not more than 1**	**more than 45**	**more than 80**	T1
1 - 2	1 - 7	15 - 45	28 - 80	T2
3 - 4	8 - 15	10 - 15	18 - 28	T3
5 - 8	18 - 34	7 - 10	13 - 18	T4
9 - 16	35 - 65	5 - 7	9 - 13	T5
17 - 44	**more than 65**	3 - 5	6 - 9	T6
more than 44		1 - 3	2 - 6	T7
		0,5 - 1	1 - 2	T8
		less than 0.5	**less than 1**	T9

Annex 2
TERMS ABSENT IN THE WMO SEA-ICE NOMENCLATURE AND INCLUDED TO CODE TABLES

Multiyear experience of using “WMO Sea-Ice Nomenclature” and scales it contains for support of practical activities at seas indicates the need to supplement the Nomenclature by new terms and specify the scales. Such proposals were considered at the Vth session of the WMO CMM WG on Sea Ice (Geneva, August 1988). However, no opinion of the WAG was formulated and no necessary implementation steps were undertaken up to present. As mentioned in the document presented to the WG, the Nomenclature along with a too detailed description of separate ice formations (for example different types of ridges) does not contain definitions of a number of generalized ice cover characteristics, processes and ice formation (age categories, surface topography, ice drift, drift divide, etc.). Some terms describe the process not quite accurately. Thus the term “concentration” is used, as a rule, for estimating pressures in conventional units and not for estimating the decrease in total concentration.

However, the format CONTOUR-2 does not aim at reviewing the WMO Sea-Ice Nomenclature or its complete correction. This Annex contains only the terms and their description which are included to the code tables and are necessary for correct understanding of coded information.

These terms are assigned the numbers of the Nomenclature where they can be included to without breaking its structure.

- **2.6.0**. Remaining first-year ice: First-year ice which has not melted in summer and is in the new cycle of freezing. Its thickness, depending on the region where it was in summer, from 60 to 160-180 cm. After the 1st of January (in the Southern Hemisphere after the 1st of July) this ice is called second-year ice.
- **4.3.0**. Floe size distribution: The extent of ice cover fracturing. Determined from a mean distance between the cracks and leads or from a relative number of the ice floes in the zone.
- **5.2.1**. Ice under pressure: Further stage of ice compacting after reaching a concentration of 9-10/10. At ice pressure its rafting or hummocking usually occurs.
- **5.2.2**. Zone of ice under pressure: Zone where ice under pressure is observed.
- **5.4**. Ice drift: Progressive ice floe motion as a result of wind and current effect.
- **5.4.1.** Drift divide: A boundary between ice massifs or ice zones drifting in different directions or with a different speed. An indication of the drift divide is predominant small floe and ice cake, flaws, ridged ice, leads and zones of diverging.
- **8.2.1.2**. Rough (or irregular non-level) ice: First-year ice subjected to fracturing and hummocking at the young ice stage, formed as a result of pancake ice freezing or freezing of fragments of fresh hummocks collapsed to fractures after the end of compacting and the beginning of ice diverging. The non-homogeneities of this type cover considerable areas where snow accumulation significantly increases and heat conductivity and tangential stress coefficient significantly change. As a result of further freezing, at the end of winter the irregularities at the bottom surface of rough ice are usually completely smoothed and the ice thickness becomes approximately equal to the ice thickness of the same age category of quiet growth. For the period of summer melting all minor irregularities on the surface of the ice floes become smoothed. Hence this topography type is characteristic only of first-year ice. Ice roughness is estimated in tenths as a ratio of the rough ice area to the total area of the zones where assessment is made.
- **8.2.3.2**. Concentration of the hillocky multiyear ice: Characteristic of multiyear ice relief at whose surface as a result of smoothing of pressure ridges and non-uniform melting in the preceding years, the hillocks are formed.
- **8.7**. Polluted ice: Ice which has at its surface or in its stratum varying mineral or organic mixtures which make it look polluted.

Annex 3
EXAMPLE OF CODING A COMPOSITE ICE CHART

```
CONTOUR-2
OBSERVATION: 0156
784606600 811005400 820009723 783609328
950317 950322
MAP
PV33 METEOR 6718 950317 /803008915/
PI13 NOAA 0841 950322 /804507415/
PR21 ERS 1416 950321 /802206743/
LIMIT
783609335 791908253 790007500 792707000 792106829 791706736 793506650
794406632 800006238 802206200 811806057 812706452 813306854 813608132
813508225 815709738 785409355 783609335 : 813508225 801408305 790007500 :
794406632 804506338 810606812 793507130 792707000
ROUTE
AV10 AN26 0027 950318
```

795309150 804608132 791007854
999999999
INF
=001CFST / 801209118 : 810706328 /
=002CT99SN / 804009037 : 804807845 : 792807548 : 791707900 : 791607748 /
=003CT99SN / 803008800 /
=004CT99SO70FMST20SG10 / 811508632 /
=005CT99ST60SK30SG10 / 794708350 /
=006CT91SO34ST40SG20 / 800407303 /
=007CT99SO60SF40 /801206400 /
=008CT99SO80ST20 / 804406730 /
=009CT99SO50ST30SK20 / 800406647 /
=010CT99SO20ST50SK30 / 794006838 - 792006550 /
=011CT99ST50SK40SG10 / 793707025 - 790006855 /
999999999
BOUND
811209515 810609342 810509240 811009118 810009035 805309130 804009135
800509016 794508957 792109037 790709138 790009228 785409355:810809015
810608850 810308827 805708830 804708925 794508838 792408940 791509023
790709138:805708830 803508705 802208638 801108700 795408656 794508740
792708822 792408940:802208638 801508500 802308257 801608300 801907930
802507428 803207131 803807028 803706928 810506820 805206514:812706452
812006525 811506515 804206426 803706400 802206200:801907930 801307841
800907650 795007535 793907336 794507134 794507110 795507052 802906934
803706920:802906934 802506912 802706600 804606441:795507052 800006840
793506650 794406632 803706400:794507110 794207115 793806949 792106829
:804808012 804307915 804207745 804807750 805507912 804808012:792707738
792007545 792507500 793707605 792707738:791608000 791407845 791807835
792107945 791608000
999999999
ZONE
=ZL 2004T3SN 1512T2SG /812207500/
813608132 811807828 810507235 811706933 813306854
999999999
LINE
=LLT4SN
814208447 812808316 812508322 812008230:811508235 810207902 804207555:
805507410 804007244 803507256 801207100 795006916 793706730
=LLT3SG
812206645 811406815 804707118:805507232 803907347 803407443 801507608
801207634 795707750:795407142 794107316 792207446
=LL04SL
802106947 793306650
=LR
811209630 814808742
999999999
POINT
=PIT2 /803706534/
=PT05 /800606830/
=PG80 /791807953/
DRIFT
=LA52:031114-031715
8139509457 8144309316
=PV63:031110-031715
8119608923 8119808817:8052409426 8050009317:7935408631 7932508556
PI33:031214-032211
8056707634 8050407523:7953207822 7946107715:7922807324 7918307239
ROUTE
=CL /795309115/
=CFST /800409008/
=CT90SL50SD40ZR10 /801008847/
=CT99SW30SG50ZR20SL20 /802308648/
=CT99SM40ST30SV16SISW30 /803408431/
=CT99SM80ST20SV18 /804608132 801508046/

```
=CT99ST60SV15SK40SV09:ZH05 /792107918/
=CT90SN /791507900/
=CT99ST60SV15SK40SV09:ZH05 /790007838/
```
LINE OF ROUTE
```
=LL0602SW /803008512/
=LL1405SL /793907936/
```
TEXT

In the regions of individual charts PV and PI the stages of development and boundaries of the main zones are plotted from data of preceding observations and drift. The area of pressure ridges is in hundredths.

END

Example of a composite ice chart.

Annex 4
INFORMATION PROPERTIES OF REMOTE SENSING MEANS

The format CONTOUR-2 provides a possibility to determine time, methods and means for information acquisition for each part of the composite chart or for the whole individual chart. In order to estimate completeness, reliability and accuracy of the information of the ice chart on distribution and characteristics of the ice cover it is necessary to know information properties of the remote sensing means used. These properties are known to personnel of the Ice Centers and DataBases. However low-level information users - navigators, heads of sea operations and shelf activities are not always sufficiently well acquainted with them. Hence information on the possibilities and accuracy of determining ice cover characteristics by modern remote sensing means which is presented here, will be probably useful for them.

Determination of the parameters characterizing the state of the ice cover by remote sensing means and accuracy depend on the range and the region of the spectrum of electromagnetic waves, sensitivity and resolution. For addressing the operational goals, instrumental observations in the visible and IR ranges are made from satellites and in the visible range also by means of visual ice observations from aircraft. Surveys by active microwave (SAR, SLAR) and passive microwave instruments (microwave radiometers) are performed both from satellites and aircraft. However, in this case the carrier type mainly governs the tactical possibilities of the survey, rather than the information properties.

1. Satellite observations in the visible range

At present for ice observations there are used multichannel scanning devices in the visible range (380-760 nm) of high (0.2-1.0 km) and low (1.5-3 km) resolution. From these images one can determine the position of the ice edge of more than 3/10 in concentration, fast ice and its boundaries, flaw polynyas, total concentration with an accuracy in the winter-spring season of 1.5/10 (low resolution images) and 1/10 (medium resolution images). In summer during intense melting the accuracy of determining this characteristic considerably decreases.

Approximate determination of the ice age categories is possible only in the large zones up to the stage of grey-white ice. Older ice is, as a rule, covered by snow and its albedo is not already related to thickness. Some stages of melting can also be determined ("flooded ice", "dried ice"). The drift data can provide indirect estimates about ice compacting or diverging for the period between observations.

The leads are distinguished if their width exceeds 1/3-1/2 resolution elements, it is possible to determine it at a width of the leads more than 2-3 resolution elements.

Satellite images clearly manifest the effect of integrating which allows us to identify the objects and zones which present a number of ice formations, each of them being much less than the image resolution area. Contrast targets (ice floes at the background of open water or vice versa fractures in solid ice) with the size by the largest section less than half the resolution element are not depicted. However, several closely situated targets enhance or reduce the total brightness of the corresponding resolution elements proportionally to their area. This typical feature is used for determining total concentration and only due to this effect the drift divides are detected.

A comparison of the enumerated possibilities with the list of the navigation characteristics of the ice cover shows that although by using the scanning visual range radiometers of low and medium resolution many important characteristics are determined (total distribution, systems of large leads, drift divides, ice drift), the total amount of data is still insufficient and incomplete. Ice age categories, rafting, concentration of hummocks and ridges, the character of the snow cover cannot be determined. Only the largest leads and only some stages of melting are observed.

However, the main shortcoming of this information is its dependence on light and meteorological conditions (presence of cloudiness). The survey can be made only at the height of the Sun more than 5 degrees above the horizon. Hence observations in the Arctic are possible only from February to October and in the Antarctic from August to April.

As to cloudiness it is found that satellite ice observations in the visible range are possible not only in the complete absence of clouds over the observation region, but at sufficiently dense but transparent cloudiness. Probably, this is influenced by the known effect of the "water sky" and "ice blink". As a result, the cloud cover over the ice floes is additionally illuminated due to diffused reflected light and over water area its illumination is much lower. Hence sometimes at continuous clouds (although the accuracy and reliability of determining concentration and the boundaries of zones considerably decreases or even impossible) it is still possible to distinguish flaw polynyas and large leads and even contours of giant floes among ice of less than 9/10 in concentration. Only in the event of thick stratified clouds the details of the ice situation are completely non-discernible on images.

Experience has shown that in the Arctic at daily reception of 3-5 satellite turns at different time, it is possible to obtain information for each region with an average interval of 5 days. Hence the ice charts of large areas based on visible or IR-range imagery present, as a rule, a mosaic of individual charts for different time intervals.

2. Satellite observations in the IR range

For satellite ice observations in the IR range the scanning radiometers in the complexes MSU-S and MSU-M operating in the region 10.5 - 12 um which corresponds to the atmospheric transparency window, are used. Observations are possible only at below freezing air temperatures, i.e. in the Arctic from October to May.

Whereas in summer ice concentration is the main navigation characteristic, in winter, when ice concentration is equal everywhere to 10/10, age category (especially the amount of young ice) becomes the main characteristic. Also important are the position and characteristics of leads and fractures, flaw polynyas, drift divides, concentration of hummocks and ridges, snow cover, dynamic state (drift, compacting and diverging).

As a result of interpretation and geolocation of IR imagery in the regions open from clouds, the following can be determined:

- the position of the ice edge older (depending on air temperature) than grey and grey-white ice with concentration more than 3/10,
- fast ice and its boundaries,
- boundaries of uniform ice zones with 5-6 gradations in the thickness range from 0 to 100-120 cm, but without the accurate determination of absolute thickness values,
- in dynamic regions such as the Greenland and the Barents Seas, giant floes and compact blocks of floes in the ice massifs alternate with the space between them filled by fractured ice of different age categories and open water zones. In these regions partial concentration of first-year and older ice can be determined with an accuracy of 2-3/10 from low resolution images and 1-2/10 from medium resolution images,
- the possibility for detecting the leads and determining their width at the air temperatures of -30 to -50 C is approximately similar as from the visible range images. At higher temperatures the minimum width of the detected leads increases and the accuracy decreases,
- ice drift from motion of the giant floes, large fractures, characteristic points of leads is determined with an accuracy of 5-6 km using low resolution images and 3-4 km - medium resolution images.

The drift divides and the remaining navigation characteristics cannot be determined from IR imagery.

3. Ice observations in the microwave band.

3.1. Use of passive microwave instruments

The scanning microwave multichannel radiometers which record their own underlying surface radiation in separate regions of the range 0.1-40 cm, allow one (as a result of combined processing of their signals) to determine the position of the ice edge at the background of both calm and rough sea surface with an accuracy of 20 km, delineate zones of prevailing young, first-year and old ice and determine the position of their boundaries with an accuracy of 40-50 km and total concentration with an accuracy of 2-3/10.

Due to low resolution (at present at the surveys at satellite altitudes not better than 10 km for a very high frequency channel) no ice formations can be detected and distinguished on microwave radiometer images.

On the whole, this information is more of climatic and not of an operational character for shipping support. However, in combination with other satellite remote sensing means, it allows supplementing their information by data on multiyear ice boundary on the charts based on visible and IR imagery, and data on the ice edge position which is often not discernible at the background of rough sea.

As additional information which is used for ice forecasting, sea surface temperature and wind speed in the surface air layer can be determined from data of microwave radiometry.

3.2. Radar sounding of sea ice.

In addition to passive microwave instruments (scanning and trace microwave radiometers), active microwave instruments including synthesized aperture radar (SAR) and side-looking airborne radars with real aperture (SLAR) are widespread for satellite and airborne ice observations.

SAR surveys ("Almaz", ERS, RADARSAT) are performed with a very high (15-20 m) and high (20-100 m) resolution and SLAR ("Okean") with a low (1.5-3 km) resolution. Both SAR and SLAR surveys from aircraft are performed with very high and high resolutions.

Based on amplitudes of the signals or optical densities of radar images with a wavelength of 0.8-5 cm, it is possible to determine ice age stages by main gradations (young, first-year, old) and their partial concentrations. With the increase in the wavelength up to 10-30 cm the contrast between first-year and old ice decreases and ice age determination becomes difficult. In summer the amplitudes of the signals from first-year and multiyear ice in all microwave range regions become equal and ice age determination is impossible without using the texture and structural indications.

From radar imagery the ice edge position, fast ice boundaries, concentration and boundaries of the zones of varying concentration can be determined. Ice of land origin (glaciers and icebergs) and river ice, drift divides and flaws are distinguished quite well.

During surveys with a high spatial resolution in zones of young ice, rafted ice can be observed and its relative area can be determined and at the background of level first-year ice - separate ridges. However, in zones of rough ice which has a very high backscattering coefficient during the entire winter and spring seasons, pressure ridges are not distinguished and the number of ridges or their relative area is impossible to determine.

Leads and fractures if their width exceeds 1/2 resolution elements, are depicted at the background of first-year ice only during the period of grey and grey-white ice formation at its surface and in multiyear ice zones - during the entire period of existence of leads, even after medium or thick first-year ice is formed at its surface.

Since radar images do not depend on illumination and weather conditions and high resolution, they are most effectively used for regular ice drift determination, change in the position of the delineated zones, their configuration and areas.

Thus based on radar images, especially with high and low resolutions, most navigation parameters of the ice cover can be determined. The limitations of this method are that age gradations of first-year and old ice are not distinguished (it is impossible to subdivide it into thin, medium, thick remaining, second-year and multiyear). Also, snow cover, presence of pollution on ice, the process of ice compacting are not observed. In spite of the existing preconditions (change of the character of radar images in summertime) the interpretation indications of the stages of melting are not yet formulated.

In spite of these restrictions, complete independence on weather conditions and illumination, a sufficient contrast between ice of different age categories and different surface structure and high resolution allow us already now to consider SAR and SLAR the main means of satellite and airborne ice observations.

4. Visual observations from aircraft

Visual ice observations are carried out from light motor aircraft and helicopters of varying types from a height of 100-600 m. At flights at these altitudes the human eye ground resolution can be assumed to be equal to 0.1 m.

Such a high resolution allows an observer using such parameters as surface relief, snow cover state, type of rafting and hummocked formations, ice thickness in fractured ice, size and form of puddles, colour shades of the surface of ice floes, medium floes and puddle bottoms (i.e., mainly by indirect indications), to determine all major characteristics of the ice cover - position of the drifting and fast ice, ice concentration, its age categories, forms, rafting and concentration of hummocks and ridges, stages of melting, open water zones among ice, thickness and character of the snow cover, pressures, pollution on the ice, amount and forms of ice of land origin.

Observations were performed in a strip from 1-20 flight heights (ice edge, boundaries of zones of varying concentration) up to 2-3 heights (age categories). This is attributed to different reliability and in general to the possibility for determining some characteristics or others at large viewing angles. The accuracy and reliability of assessing the ice cover parameters and characteristics significantly depend on illumination conditions, horizontal visibility, weather conditions and the right choice of the flight height for specific conditions.

In connection with the non-uniform character of the ice cover, the process for determining each characteristic includes two stages:

- delineation (identification) of ice of a given type or of ice having the given characteristic,
- a quantitative estimate of the area of this ice with regard to other ice or to the total sea area observed.

During visual ice observations the qualitative and approximate (eye's measurement) quantitative estimate of ice distribution and its state is made by observer for all characteristics simultaneously. The observer analyzes and generalizes varying indications (with rejection of less reliable), determines the boundaries of zones and makes the necessary statistical processing in mind. In view of the limited time of flying over each zone, it is obvious that the observer cannot process all information.

Actually, as a result of investigating the accuracy of visual airborne observations, significant errors in quantitative estimates (under unfavourable conditions in the characteristics themselves) were found. Thus it was found that total and partial concentrations are determined even by the most experienced observers with a root-mean-square error of 1.2-2/10. In addition to random mistakes, there is systematic overestimating of total and partial concentration of multiyear ice also within up to 2/10.

Due to a limited observation strip at observations from low heights only 12-20% of the area under consideration is directly observed which results in considerable errors at interpolation and extrapolation of boundaries.

Therefore already at present, visual ice observations play a supplementary role - a detailed additional examination from icebreaker's helicopters of the recommended route, as well as observation of some characteristics which cannot yet be observed instrumentally. In perspective, the need and desirability (including commercial benefits) of equipping even light aircraft and helicopters with portable SLAR and SAR, radar thickness meters and other modern remote sensing means is quite obvious. It will enable the maximum use of the positive properties of visual and instrumental methods. Such a combination of methods is already now quite widespread.

If aircraft or a helicopter is equipped by radar thickness meters, then profile (along the flight route) measurements of thickness of first-year ice in the 45-250 cm are made with an accuracy of 10% of thickness. By the character of signals young ice gradations are assessed, multiyear ice, ice of river origin and regions of intense hummocking are identified.

Additional equipping of aircraft by laser profilers allows objective estimates of the surface relief of multiyear and first-year ice and determination of the number of the e ridges per unit route.

5. Combined use of information

Data of previous sections allow us to assess the composition and accuracy of determining the variables characterizing the ice cover state on individual charts based on satellite visible and IR imagery, satellite and airborne SLAR and SAR data and of visual ice observations data.

Operational individual ice charts are directly used for shipping support. However, more or less full understanding of the ice situation can be obtained only from their combination. Hence in the processing centers composite ice charts are issued on the basis of individual charts and available additional information (data of ships, polar stations, expeditions, buoys).

In accordance with the methods for their preparation, if observations in some observation region were performed using several remote sensing mans, the largest accuracy can be assumed to be the accuracy of determination of separate variables. Hence it is reasonable to present data on the possibility and accuracy of determining ice cover characteristics in the form of summarized tables.

The accuracy of determining the age gradation (thickness) of the ice floes depends on the range and resolution. The range governs the amplitudes of the signals from ice of different age categories and resolution - the possibility of its use for interpretation of textural, structural and indirect indications (table 1).

The accuracy of estimating the main generalized characteristics, the possibility for detecting and interpretation of ice formations (tables 2 and 3) at their contrast depiction at the background of other ice or open water mainly depends on resolution.

Table 1. Possibility and accuracy of determining age (thickness) of the ice floes (cm)

		Range, resolution, method						
Characteristic	**Limits of**	**Visible**		**IR**	**Microwave**			**Radar**
	values	**0.1-2 m**	**0.2- 3 km**	**0.2-3 km**	**5-20 m**	**20-100m**	**1.5-3km**	**thickness**
	(cm)	**AV**	**PV**	**PI**	**AR, PR**		**PR**	**meter**
New ice	0	+	-	-	-	-	-	X
Nilas	10	3	10	3	3	5	8	X
Grey	10 - 15	8	15	3	3	8	10	XX
Grey-white	15 - 30	8	15	5	8	15	X	XX
Thin first-year	30 - 70	20	X	15	X	X	X	6
Medium first-year	70 - 120	30	X	30	X	X	X	10
Thick first-year	120 - 140	60	X	X	X	X	X	20
Second-year	> 200	+	X	X	+	+	XX	+
Multiyear	> 300	+	X	X	+	+	XX	+

Note:

1. *+ observed as a specific type, - unobserved,*
2. *x or xx - no differences in the signals from ice of these gradations are observed, however, they can be separated from all other stages of development,*
3. *Data in the IR range correspond to temperatures less than -20- -30 C in the microwave range during winter and springs periods.*

Table 2. Possibility and accuracy of determining the main generalized characteristics (tenths or conventional scale units).

Characteristic	Limits of values	Ground resolution				
		0,1 - 2 m	5 - 20 m	20 - 100 m	0,2 - 1 km	1,5 - 3 km
Total concentration	1 - 3	1,0	0,5	0,5	-	-
	4 - 8	1,9	1,0	1,0	1,0	1,5
	9 - 10	0,5	0,2	0,5	1,0	1,0
Partial concentration	0 - 10	1,5	1,0	1,0	1,0	1,5
Rafting	0 - 10	2,0	1,0	1,0	-	-
Area of hummocks	0 - 100	5 - 6	3 - 4	5 - 6	-	-
Snow cover	0 - 8	2 - 3	1 - 2	-	-	-
Stages of melting	0 - 9	1 - 2	1 - 2	2	2 - 3	2 - 3
Ice concentration	0 - 3	1,0	1,0	1 - 2	-	-

Table 3. The accuracy of determining the boundaries, ice drift vectors, the possibility for detecting ice formations.

Boundaries , drift,	Ground resolution				
ice targets	**0.1-2 m**	**5-20 m**	**20-100 m**	**0.2-1 km**	**1.5-3 km**
Position of the boundaries, km					
Fast ice, floes, leads	2	0,5	0,5	2,0	6,0
Zones	4	2 - 3	2 - 3	4	6 - 8
Ice drift, km	-	1,0	1,0	2,0	5,0
Minimum observed size, m					
Floes	2 - 20	50	200	2000	500
Leads, cracks with a width of	2	5	30	300	500
Icebergs	5	15	200	2000	5000
Drift divides	-	+	+	+	+
Ridged ice	+	+	+	+	-
Ridges	+	+	+	-	-

Note:

1. *+ observed, - unobserved*
2. *The ice drift and drift divides can be observed at the survey swath more than 50 km.*

At comparatively detailed field of the drift vectors some comparatively slowly changing characteristics and stable formations earlier observed using the means operating in other spectral ranges or the means with a small spatial coverage, but high resolution (SAR and SLAR, thickness meters, laser profilers, visual observations), can accumulate taking into account shifts of some ice cover zones for the period from observation to issuing an ice chart.

For this purpose the composite chart under preparation is compared to the preceding one. In the zones whose configuration and area has insignificantly changed it is supplemented by data on stable characteristics and formations which in this case can be considered directly observed. The following can be plotted on the chart:

- zones of varying partial concentration of old ice,
- age gradations, thickness and partial concentration of first-year ice,
- ice age at the surface of the preserved leads, fractures and polynyas (taking into account the ice growth),
- icebergs, stamukhas, zones of hummocking, ridges on fast ice,
- surface structure (hummocks, snow, pollution on the ice).

Unstable characteristics such as pressures, open water among ice, position of the ice edge and boundaries of the zones of different total concentration should not be taken from the previous chart.

These data on the information properties of remote sensing means provide a guaranteed possibility and accuracy of determining the ice cover characteristics at the present time which should not be considered constant for the future.

With the development of new technical means operating in the other regions of the electromagnetic wave spectrum with other polarizations and their combinations, increasing resolution, validation observations, development and improvement of methods for automated interpretation they will be probably supplemented and specified.

This evidence is based on the experience of only the Arctic and Antarctic Research Institute. At the other ice centers varying processing algorithms and software and additional interpretation indications are used. Hence currently it is probably advisable to discuss and if necessary to supplement or correct the presented data.

Annex 5
A PROPOSAL FOR CODING THE POSITIONS OF THE POINTS IN THE RECTANGULAR COORDINATES, RATHER THAN IN THE GEOGRAPHICAL COORDINATES

Determination of the position of the boundaries of zones, linear and point objects by their geographical coordinates has significant shortcomings (different accuracy of determining the coordinates by latitude and longitude, especially in the near-pole regions, formation of the files of databases in the form of different size trapeze).

In processing of satellite and airborne video information: geolocation, transformation of images to cartographic projections and display, maintenance of operational databank (complexing, updating, calculations and forecasting, etc.) one has to constantly convert the geographical coordinates to rectangular ones and vice versa. As a rule, all procedures are performed in the rectangular coordinates which are then converted to geographical for storage or dissemination to users.

A question arises why the position of the boundaries and ice formations is not coded at once in rectangular coordinates? This would allow an additional 10% reduction of transmitted data, as compared to the CONTOUR-2 format and would significantly simplify all algorithms and data conversion software.

This proposal was generally discussed at the Vth session of the WG of specialists on the WMO Project *"Global Digital Sea-Ice Data Bank"* (September 24-28, 1995, St. Petersburg, Russia). The WG requested Prof. A.V. Bushuyev to prepare specific proposals for further discussion at the WG GDSIDB and the WMO CMM.

1. Proposed chart parameters

- The position of the ice chart points (information, boundaries, objects) is governed by the rectangular coordinates of the chart in a polar stereographic projection, the scale by parallels of the section 70° of the Northern and Southern Hemisphere of 1:1000000 or in 1 resolution element (1 mm at the geographical chart) 1 km at the ground.
- The Earth is assumed to be a ball with a radius R = 6371 km.
- The start of coordinates in the points of the projection of the North and South Poles is at the section plane.
- The OX axis is directed from pole to equator along meridian 180°, the OY axis likewise along meridian 270°.
- To eliminate the need to indicate the digits, the coordinates of the pole are assumed to be equal X = Y = 5000. The width of the angles of the working square with longitudes 45°, 135°, 225° and 315° is equal to 30, 444°.

2. Solution of standard problems

Transfer from geographical to rectangular coordinates is made using the following system of formulas:

The relative direction or conventional longitude from meridian 180° is calculated

where l - eastern longitude within the range from 0° to 360°,

[R(1 + cos(20°)) / m] = D = 12357,784 - constant, F - latitude.

Coordinates of the points are coded in the whole values of X and Y with rounding off or rejection of tenths by one eight-digit group where the first 4 figures denote coordinate X and the last 4 - coordinate Y.

For example: the point F=81°18' and l = 115°36' is coded as 54064152.

If higher accuracy is required, for example, for the drift vectors from buoy data, D is multiplied by 10 and coordinates are coded by a 10-digit group in hundred meters.

After conversion of geographical coordinates into rectangular, the coordinates of the points at a computer screen or in plotter work space are calculated by deducting coordinates X, Y of the initial point and multiplying the obtained differences by the scale coefficient. Data gridding to any rectangular grid point is also simple.

Data in operational and regime banks are advisable to store in the form of files of squares of a certain size, for example, 500 x 500 cells which considerably expedites the search for necessary information. This is also realized by the proposed system of coding in rectangular coordinates. The numbers of the least coordinate lines restricting the square in hundreds of the resolution cells should be assumed to be the numbers of the squares.

Thus the point 54064152 is located in square 5040.

When forming the files of squares the description of the boundaries and linear objects should include the points of their crossing with the boundaries of the squares.

The reverse conversion from rectangular coordinates X, Y at the chart to geographical is by using the formulas:

where ( ) - the obtained by formulae (4) value.

If this proposal is considered valid, the transfer from the geographical coordinates to rectangular will not require changes in the general layout of the CONTOUR-2 format, code tables, constants, identifiers, service and separating symbols.

However, to implement this proposal it is necessary to agree upon the projection, scale, section parallel, coordinate axes, coordinates of the initial point (pole) of the chart in whose system of rectangular coordinates information will be transmitted. Also the earth's parameters should be agreed upon - the radius if it is assumed to be a ball, large axis, eccentricity if it is assumed to be a rotation ellipsoid.

In view of a complex character of this procedure, the proposal for transfer from the geographical coordinates to rectangular is contained in the Annex to be further discussed.

3. Justification of the proposed chart parameters

The stereographic projection by its properties is considered the most suitable for depicting ice situation for the entire Arctic or the Southern Oceans at one chart. This projection is actually used by the Ice Services of all countries. When constructing a chart, the Earth can be assumed to be a ball or an ellipsoid. Depending on this, as well as on the assumed Earth's parameters (mean radius, large semi-axis, eccentricity) at one and the same main scale, the distance from the pole to the points located at equal latitudes will be different. However, the maximum difference of distances (at latitude of about 50°) at the chart constructed for the sphere with a radius of 6371 km and for an ellipsoid with a large semi-axis a = 6378.273 km, the eccentricity E = 0.0818161 and equal parallels of the section 70° does not exceed 13 km. Both methods provide an unambiguous conversion of geographical coordinates to rectangular and vice versa, of contour data to regular grid points and equalizing at geolocation by reference points. Thus in our opinion, to construct a chart for the Earth as an ellipsoid does not have significant advantages.

However, conversion of the geographical coordinates to rectangular coordinates of the earth's chart as a spheroid is based on more sophisticated formulas and the reverse conversion is not resolved at all in the explicit form and can be performed only by a gradual approximation method. In view of the fact that operational detailed charts and review charts of large areas can include several thousands of the points, data processing even by modern high-performance computers will take much time. Hence it is proposed to assume the earth to be a ball.

The second problem, probably, to be also discussed, is location of the coordinate axes. In the Ice Service of the RF meridians 200° and 290° are assumed to be axial, in the USA - 45° and 135°. As mentioned, meridians 180 and 270 are proposed to be used. The southernmost regions of sea ice (Hokkaido Island, Newfoundland) are included to the coordinate grid. Also, continuation of Greenwich meridian, as initial, is used. Scale, the section parallel and coordinates of the initial point (pole) are optimal and do not require justification.