DUPLICATE

Short-range Forecasting Research

Short Range Forecasting Division

Technical Report No 5

SEA- ICE DATA FOR THE OPERATIONAL GLOBAL MODEL

by

C P JONES

November 1991

Meteorological Office
London Road
Bracknell
Berkshire
RG12 2SZ
United Kingdom

SHORT RANGE FORECASTING

RESEARCH DIVISION

TECHNICAL REPORT No. 5

SEA-ICE DATA FOR THE OPERATIONAL GLOBAL MODEL

C P JONES

November 1991

Short Range Forecasting Research
Meteorological Office
London Road
BRACKNELL
Berkshire
RG12 2SZ

CONTENTS

1. INTRODUCTION

This document describes the method by which sea-ice concentration and sea-ice thickness fields are created for use by both the operational global atmospheric model and the operational global wave model. The system is based upon automatically decoding bulletins which originate at the Joint Ice Center, Washington and are sent on the Global Telecommunications System.

Section 2 describes the format of the data and how it is decoded, section 3 describes the programs involved and section 4 gives the operational details.

2. DATA PROCESSING

2.1 Data Source

Sea-ice analyses are performed routinely at the Navy/NOAA Joint Ice Center, Washington with much of the information being derived from satellite data. Several bulletins are produced, including bulletins on icebergs, but only two of the bulletins are of interest here.

The bulletins of used are entitled NPLICE and SPLICE which stand for North Polar Ice and South Polar Ice respectively. The bulletin headers are STAC01 for the NPLICE bulletin and STAA01 for the SPLICE bulletin. The issue of these bulletins is weekly, on a Tuesday or Wednesday. However, the receipt of these bulletins is slightly unreliable and the validity date is normally the previous Friday. These bulletins are also received on the OMNET system along with other bulletins issued by the JIC.

An example of the bulletins is given in appendix 1. As can be seen, they consist of simply a list of coordinates where the sea-ice edge has been identified, although the sea-ice concentration criteria for this sea-ice edge is not known. In the model, the only permitted values of sea-ice concentration are 0 and 1, ie no sea-ice or sea-ice and so if a grid point is covered by sea-ice then the sea-ice concentration is set to 1. The bulletins both start and end at Greenwich, a repeated coordinate denotes that the sea-ice terminates against a land mass. The resolution of the data is 30 nautical miles and the sea-ice is always to the left of the line.

2.2 Decoding of Data.

The decoding of the data is simply transforming the given coordinates to the model grid. This transformation has been designed to work for any regular lat-long grid resolution.

There are three approximations:-

1) The model grid boxes are perfectly square.
2) The sea-ice edge is straight between the reported coordinates.
3) The earth is locally flat in the area of the reported coordinates.

These approximations have been made to enable use of elementary geometry. Since we are only concerned whether a model grid point is covered with sea-ice or not, all of these approximations are reasonable and it is unlikely that large errors will be introduced, even when there is a large distance between coordinates. As there are slight differences in the working in the two hemispheres, they are described separately below.

In the equations, ϕ denotes latitude, λ denotes longitude and subscripts r, i, o and c denote grid resolution, reported ice edge location grid origin and current location on grid respectively. Variables c and r are used to denote the index to the grid columns and grid rows respectively. When an index is calculated, only the integer part of the number is considered. All longitudes have been converted to degrees east, ie in the range 0 to 360, and latitudes are given in degrees north and south, ie in the range 90 to -90 with the northern hemisphere being positive. In the operational global model the sea-ice concentration is specified on pressure points, therefore $\lambda_o = 0$, $\phi_o = 90.0$ and the current grid resolution is $\lambda_r = 1.25^\circ$ and $\phi_r = 0.8333^\circ$.

2.2.1 Northern Hemisphere

The data start and ends at the Greenwich Meridian and proceeds in a general easterly direction around the pole with the sea-ice always to the left of the line. The first task is to map the sea-ice edge and the second task is to fill in sea-ice between the pole and the sea-ice edge. The principle behind mapping the sea-ice edge is to set sea-ice at the most equatorward grid point that is behind the reported sea-ice edge.

For any coordinate (λ,ϕ), the grid reference of the top left grid point, P, is given by,

$$P_{row} = (\phi_o - \phi)/\phi_r + 1$$
$$P_{col} = (\lambda_o - \lambda)/\lambda_r + 1 \tag{2.1}$$

Assuming that the sea-ice edge is straight, the slope of the sea-ice edge between coordinates i and i+1 is given by,

$$S = (\phi_{i+1} - \phi_i)/(\lambda_{i+1} - \lambda_i) \tag{2.2}$$

Let P_{col} of λ_i be c_1 and P_{col} of λ_{i+1} be c_2, then there exists three possible situations:-

i) $c_1 = c_2$ ie. the sea-ice progression is either poleward or equatorward.

If $\phi_{i+1} < \phi_i$ then the progression is equatorward and the sea-ice edge is set at the coordinate $P(c_2,r_2)$ where r_2 is given by

$$r_2 = (\phi_o - \phi_{i+1})/\phi_r + 1 \tag{2.3}$$

If however $\phi_{i+1} > \phi_i$ then the progression is poleward and the sea-ice edge is set at the coordinate $P(c_1,r_1)$ where r_1 is given by

$$r_1 = (\phi_o - \phi_i)/\phi_r + 1 \tag{2.4}$$

ii) $c_1 < c_2$ ie. the sea-ice is progressing in the normal easterly direction. In this instance, the procedure is to work between c_1 and c_2 and calculate the latitude at which the sea-ice intersects with each column of the grid. For each of these columns, c, the sea-ice edge is set at the coordinate P(c,r) where r is given by,

$$r = (90 - (S(\lambda_c - \lambda_i) + \phi_i))/\phi_r + 1 \qquad (c_1+1) \le c \le c_2 \tag{2.5}$$

iii) $c_1 > c_2$ ie. the sea-ice is progression in a westerly direction. The sea-ice edge is set at the coordinate P(c,r) where r is given by,

$$r = (90 - (S(\lambda_c - \lambda_i) + \phi_i))/\phi_r + 2 \qquad (c_2+1) \le c \le c_1 \qquad (2.6)$$

When all coordinates have been processed, a sea-ice edge location should have been set in every grid column. However, a check is made to ensure that this is a case and if any column does not have a sea-ice edge set then it is set equal to column immediately adjacent to the west.

The second stage is to fill in with sea-ice all those points between the reported sea-ice edge and the pole. This stage is different depending on whether an odd or and even number number of sea-ice locations have been assigned to each column in the first stage.

i) Odd number of sea-ice locations identified.

A switch is used, which when on, indicates that a point is to be assigned sea-ice. This switch is initialized to be on and, working from the pole to equator, this switch alternates between on and off at every sea-ice edge location encountered. This ensures that all points from the pole to the most poleward sea-ice edge location are set to sea-ice and all points from the most equatorward sea-ice edge location remain free of sea-ice.

ii) Even number of sea-ice locations identified.

In this case, the row numbers of the most poleward and most equatorward sea-ice locations are identified. All points between the pole and the most poleward sea-ice edge location are set to be sea-ice and all points between the most equatorward sea-ice location and the equator remain free of sea-ice. Then the switch, as discussed above, is initialized to be off and working between the rows identified above, the switch alternates between on and off and points set to be sea-ice accordingly.

2.2.2 Southern Hemisphere

The data start and ends at the Greenwich Meridian and proceeds in a general westerly direction around the pole with the sea-ice always to the left of the line. The principle is the same as for the northern hemisphere but the orientation is different as we require the reference of the bottom right grid point releative to the sea-ice coordinate.

The slope of the sea-ice is calculated using equation 2.2. If again P_{col} of λ_i be c_1 and P_{col} of λ_{i+1} be c_2, then the three possible situations are:-

i) $c_1 = c_2$ ie. the sea-ice progression is either poleward or equatorward.

If $\phi_i < \phi_{i+1}$ then the progression is equatorward and the sea-ice edge is set at the coordinate $P(c_2, r_2)$ where r_2 is given by

$$r_2 = (\phi_o - \phi_{i+1})/\phi_r + 2 \qquad (2.7)$$

If however $\phi_i > \phi_{i+1}$ then the progression is poleward and the sea-ice edge is set at the coordinate $P(c_1, r_1)$ where r_1 is given by

$$r_1 = (\phi_o - \phi_i)/\phi_r + 2 \qquad (2.8)$$

ii) $c_2 < c_1$ ie. the sea-ice is progressing in the normal westerly direction. In this instance, the procedure is to work between c_1 and c_2 and calculate the latitude at which the sea-ice intersects with each column of the grid. For each of these columns, c, the sea-ice edge is set at the coordinate P(c,r) where r is given by,

$$r = (90 - (\phi_i - (S(\lambda_i - \lambda_c))))/\phi_r + 2 \qquad (c_2+1) \le c \le c_1 \qquad (2.9)$$

iii) $c_2 > c_1$ ie. the sea-ice is progression in a easterly direction. The sea-ice edge is set at the coordinate P(c,r) where r is given by,

$$r = (90 - (\phi_i - (S(\lambda_i - \lambda_c))))/\phi_r + 1 \qquad (c_2+1) \le c \le c_1 \qquad (2.10)$$

When all coordinates have been processed, a sea-ice edge location should have been set in every grid column. However, a check is made to ensure that this is a case and if any column does not have a sea-ice edge set then it is set equal to column immediately adjacent to the east. Due to the nature of the southern hemisphere bulletin, a sea-ice edge is not set in column 1 and sometimes a sea-ice edge is not set in column 2 so both these columns have the same data as column 3.

Sea-ice is set at points between the pole and the reported sea-ice edge in the same way as the northern hemisphere.

2.3 Sea-ice Thickness.

A value of sea-ice thickness is set at all points which have a non-zero value of sea-ice. The values set are 2m for the northern hemisphere and 1m for the southern hemisphere.

3. PROGRAM DESCRIPTION

3.1 ICEDAY

This program is run on the CRAY. Its purpose is to decode the sea-ice bulletins and create the sea-ice field for the current day. The program consists of the following members of M11A.CJSSTLIB.SEAICE: C@FIELD, CICECRTL, DAY@NUMB, ICE@CONV, ICE@INT, ICEDAY, ICEFLD, and READHKI, the following members from M11A.CJSSTLIB.ANCIL: CANCINT, IN@FLDS, OUT@FLDS and the following members from the Unified Model library (M11.HMUCODE.VNXX, where XX is the current model version number) which are not described in this document: CLOOKADD, READFLD1, READHED1, WRITFLD1, WRITHED1, PR@FIXH1, PR@RFLD1, PR@LOOK1, POSERRO1, PP@TITL1, CHKLOOK1, IOERROR1, T@INT, T@INTC, C@MDI.

Index to comdecks:
CANCINT, CICECRTL - both contain necessary variables for reading in datasets.
ICEFLD - holds sea-ice arrays and grid details

Index to program:

```
PROGRAM ICEDAY
  CALL READHK
  CALL IN@FLDS
  CALL ICE_CONV
  CALL DAY_NUMB
  CALL C_FIELD
  CALL ICE_INT
  CALL PR_LOOK
```

CALL PR@RFLD

CALL OUT_FLDS

SUBROUTINE READHK - to read housekeeping file

SUBROUTINE IN@FLDS - to read in the daily sea-ice field

SUBROUTINE ICE_CONV - to read in and convert to CRAY numbers JIC data

SUBROUTINE DAY_NUMB - to calculate the year day number

SUBROUTINE C_FIELD - to transform data onto model grid

SUBROUTINE ICE_INT - to obtain a time interpolated climatological sea-ice field for the current date

SUBROUTINE OUT_FLDS - to write out the daily sea-ice field

ICEDAY is the controlling program. The return codes for the routines called and control switches are initialized and then the housekeeping file is read. The previous day's sea-ice dataset, the format is described below, is read and a land sea mask formed for use later in the program. The JIC data transferred from the HDS is read in and converted to ASCII using ICE_CONV. A check is first made of whether a new bulletin has been received for either hemisphere, if one has then it is processed in C_FIELD otherwise a check is made of the age of the current data. If the data for either hemisphere is more than 21 days old then the climatological file is read and that hemisphere set to the climatological field. If new data has not been received and the data is not older than 21 days then no changes are made to the data. The dates in the headers are altered and the field is written to a new dataset. A character map is created and written out of the current sea-ice field which is subsequently copied to the HDS and reformatted by ICEFMT.

Several of the routines have return codes which are non-zero if an error has occurred. Normally a message is written out explaining the cause of the error. The routines capable of giving a non-zero return code and the subsequent action by ICEDAY are given in the table below.

SUBROUTINE	ACTION BY ICEDAY
READHK	ABORT program
IN@FLDS	ABORT program
ICE_CONV	program continues and age of current data is checked.
OUT_FLDS	ABORT program

Program I/O

Unit 10 - housekeeping file

Unit 11 - current daily sea-ice dataset

Unit 12 - climatological sea-ice dataset

Unit 13 - sea-ice data transferred from HDS

Unit 21 - new daily sea-ice dataset

Unit 30 - character map of sea-ice distribution

3.2 ICEFMT

The character map created by ICEDAY is written out using a format statement of 255A1 because the CRAY cannot handle formatted files with a record length longer than 255 characters. ICEFMT is a simple program on the HDS which reads in the transferred character map as 255A1, rewinds the dataset and rewrites the character map as 288A1 so that it can be browsed more easily.

Program I/O:

Unit 6 - output messages

Unit 10 - character map of sea-ice distribution.

4. OPERATIONAL JOBS AND DATASETS

HDS Datasets:

SDB.ICEDATA - direct access dataset of record length 4096. The SPLICE bulletin is on record 3 and the NPLICE bulletin is on record 4. The DCB information is RECFM=F, LRECL=4096, BLKSIZE=4096.

COP.SEAICE - character map of the current sea-ice concentration field. There is a header of CHEADER,HDSRUN which is read using the format of (A27,L1) where CHEADER is a variable of CHARACTER*27 containing the validity date of the data and HDSRUN is a LOGICAL variable which is set to .TRUE. if the data needs to be reformatted on the HDS.

The remainder of the dataset is an array of 288 columns by 217 rows with the legend of 'I' = sea-ice, '*' = land point, ' '=open sea.

The DCB information is RECFM=FB, LRECL=288, BLKSIZE=288.

CRAY Datasets:

/u/opfc/op2/op/dataw/qwgl.hkfile - housekeeping file

/u/opfc/op2/op/dataw/qwgl.daily.ice - current daily sea-ice dataset*

/u/opfc/op1/op/datar/qrgl.clim.ice - climatological sea-ice dataset*

/u/opfc/op3/op/datat/qtice.jic.data - sea-ice bulletin transferred from HDS

/u/opfc/op3/op/datat/qtgl.daily.ice - new daily sea-ice dataset*

/u/opfc/op3/op/datat/qticemap - character map to transfer to HDS

*These datasets are in the format described by Unified Model Documentation Paper No. F3.

Running of ICEDAY

Operational source: /u/opfc/op1/op/source/qcice.daily

Operational executable: /u/opfc/op1/op/libs/qxice.daily

The executable forms part of script SURF which is run in the QG06 run of the model only. The dataset SDB.ICEDATA is copied across to DATAT/qtice.jic.data and in doing so becomes a sequential dataset, each line being 40 characters long. The program is executed and if the run is successful the new, temporary daily sea-ice dataset is copied to the permanent daily sea-ice dataset. Finally, the character map is copied to the HDS dataset COP.SEAICE.

Location of non-operational jobs etc:

Source library (HDS): M11A.CJSSTLIB.SEAICE

Source listing (CRAY): /u/m11/user1/t11cj/sst_source/qxice.daily

Executable (CRAY): /u/m11/user1/t11cj/sst_programs/qxice.daily

Program Library (CRAY): /u/m11/user1/t11cj/sst_pl/ice.daily1

The following jobs are found on M11A.CJSSTLIB.SSTCNTL

ICCRPL - to make initial program library

ICCRMD - to create a modeck for a program library

ICCREX - to create an executable

ICCRGO - to run executable

ICCREXP - to run executable with a modeck to a program library

ICCRPLU - to create a new program library using a modeck

Running of ICEFMT

ICEFMT is run by job QG06AADS

Load module: COP.CORE.LOADLIB(ICEFMT)

Source code: COP.CORE.SOURCE(ICEFMT)

Job to make load module: COP.CORE.BUILD(ICEFMT)

Appendix 1

Example of the bulletins NPLICE and SPLICE. There is a header which contains the validity date followed by the data.

```
SPLICEC291102507110OWASHINGTON00
550S0000E 550S0010W 557S0042W 555S0070W
560S0090W 554S0108W 557S0135W 554S0150W
555S0177W 555S0197W 560S0216W 557S0240W
550S0250W 545S0270W 540S0286W 534S0300W
544S0300W 555S0316W 560S0341W 566S0358W
570S0384W 574S0410W 580S0420W 587S0441W
590S0470W 596S0492W 604S0517W 612S0525W
615S0530W 624S0520W 621S0541W 626S0560W
620S0570W 613S0573W 617S0588W 623S0597W
630S0597W 635S0612W 633S0623W 625S0638W
624S0660W 623S0662W 621S0670W 627S0690W
627S0715W 630S0760W 636S0770W 636S0790W
642S0822W 647S0840W 650S0861W 656S0893W
656S0918W 657S0950W 660S0975W 660S1000W
664S1013W 663S1035W 670S1064W 680S1103W
680S1130W 685S1152W 686S1167W 681S1162W
680S1170W 675S1180W 668S1200W 667S1215W
660S1220W 657S1235W 658S1250W 654S1265W
648S1286W 645S1302W 644S1310W 643S1322W
640S1330W 637S1346W 638S1360W 635S1372W
630S1384W 625S1405W 621S1423W 620S1434W
625S1450W 633S1454W 640S1476W 640S1488W
640S1502W 643S1513W 650S1515W 654S1530W
657S1546W 662S1550W 665S1567W 662S1578W
660S1590W 662S1600W 660S1616W 665S1632W
666S1650W 666S1682W 660S1695W 661S1710W
660S1722W 654S1730W 652S1742W 648S1757W
656S1767W 662S1780W 660S1791W 653S1794E
646S1787E 640S1780E 640S1764E 634S1733E
636S1710E 634S1690E 630S1673E 628S1657E
621S1640E 615S1628E 610S1616E 610S1604E
614S1596E 620S1592E 622S1573E 620S1560E
618S1537E 617S1520E 623S1514E 627S1500E
623S1483E 628S1485E 632S1477E 635S1462E
633S1446E 633S1418E 634S1402E 632S1392E
640S1363E 640S1340E 636S1314E 643S1290E
641S1264E 647S1220E 645S1185E 637S1157E
631S1153E 623S1140E 620S1125E 620S1113E
611S1100E 610S1078E 603S1063E 604S1042E
600S1024E 590S1013E 586S0990E 585S0968E
580S0946E 588S0927E 595S0900E 600S0868E
600S0848E 596S0833E 582S0833E 566S0801E
567S0783E 576S0756E 580S0723E 590S0690E
587S0654E 584S0630E 590S0600E 590S0568E
591S0531E 592S0494E 590S0458E 590S0424E
580S0400E 586S0371E 588S0353E 597S0348E
597S0330E 588S0316E 580S0292E 575S0266E
564S0260E 558S0236E 552S0214E 546S0190E
550S0167E 550S0153E 550S0140E 550S0111E
550S0090E 550S0065E 550S0043E 552S0021E
550S0000E 9999
NNNN
```

```
STAC01 KWBC 291244
NPLICEC2911025071100WASHINGTON00
788N0000E 790N0013E 793N0023E 795N0033E
800N0034E 802N0053E 802N0080E 801N0114E
800N0134E 798N0140E 798N0140E 780N0234E
780N0267E 780N0300E 780N0324E 773N0358E
771N0375E 770N0401E 771N0432E 773N0452E
774N0480E 778N0487E 780N0500E 775N0516E
774N0541E 772N0570E 770N0590E 770N0615E
770N0640E 767N0660E 767N0660E 750N0605E
751N0620E 751N0630E 752N0656E 754N0678E
747N0687E 740N0694E 734N0695E 730N0686E
722N0680E 716N0672E 711N0664E 707N0667E
707N0667E 724N0790E 728N0773E 731N0773E
732N0793E 732N0803E 732N0802E 732N0803E
732N0803E 756N0905E 761N0875E 764N0846E
770N0813E 775N0811E 772N0842E 771N0860E
773N0888E 780N0896E 783N0900E 790N0924E
793N0933E 793N0933E 755N1137E 754N1165E
753N1184E 751N1214E 756N1228E 761N1235E

766N1260E 770N1273E 776N1278E 780N1290E
786N1320E 788N1346E 790N1366E 792N1390E
795N1422E 800N1460E 800N1474E 794N1488E
787N1495E 780N1505E 772N1535E 767N1550E
762N1562E 757N1576E 750N1590E 741N1610E
743N1636E 746N1655E 744N1674E 740N1695E
736N1706E 731N1713E 730N1730E 734N1753E
732N1767E 733N1768E 730N1780E 725N1793E
720N1791W 718N1796E 714N1782E 706N1784E
700N1791E 693N1797W 687N1781W 684N1772W
680N1767W 680N1767W 670N1734W 674N1743W
682N1756W 685N1764W 693N1777W 700N1784W
706N1786W 710N1785W 710N1785W 712N1768W
718N1765W 724N1761W 730N1737W 734N1703W
733N1685W 730N1675W 724N1668W 722N1670W
718N1665W 716N1653W 712N1644W 710N1640W
708N1627W 710N1615W 710N1613W 710N1596W
710N1590W 710N1590W 712N1567W 715N1563W
720N1558W 720N1550W 720N1532W 716N1518W
715N1502W 710N1490W 710N1477W 712N1451W
710N1440W 710N1424W 705N1413W 707N1393W
710N1376W 710N1362W 712N1343W 714N1330W
720N1317W 720N1306W 720N1290W 720N1268W
716N1254W 713N1242W 710N1231W 710N1227W
703N1236W 700N1243W 700N1243W 717N0934W
720N0927W 725N0916W 732N0900W 737N0900W
737N0900W 700N0880W 702N0890W 707N0902W
713N0906W 720N0908W 725N0902W 730N0896W
735N0883W 735N0882W 735N0882W 720N0733W
723N0736W 732N0750W 737N0760W 742N0766W
750N0757W 750N0747W 750N0723W 750N0697W
750N0675W 750N0660W 755N0644W 760N0630W
758N0615W 753N0596W 747N0570W 747N0570W
700N0220W 700N0213W 696N0213W 692N0210W
691N0203W 695N0201W 700N0200W 701N0197W
704N0200W 707N0192W 710N0187W 715N0185W
720N0181W 724N0170W 730N0160W 732N0156W
735N0160W 740N0150W 741N0137W 745N0127W
748N0127W 748N0117W 750N0120W 751N0117W
753N0107W 755N0102W 757N0106W 758N0084W
760N0067W 762N0060W 765N0057W 766N0037W
766N0030W 770N0021W 770N0012W 770N0022W
773N0037W 778N0026W 780N0024W 783N0018W
787N0013W 788N0000E 9999
```