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USERS MANUAL FOR A POLAR ICE FORECAST SUBSYSTEM - ARCTIC.(U)

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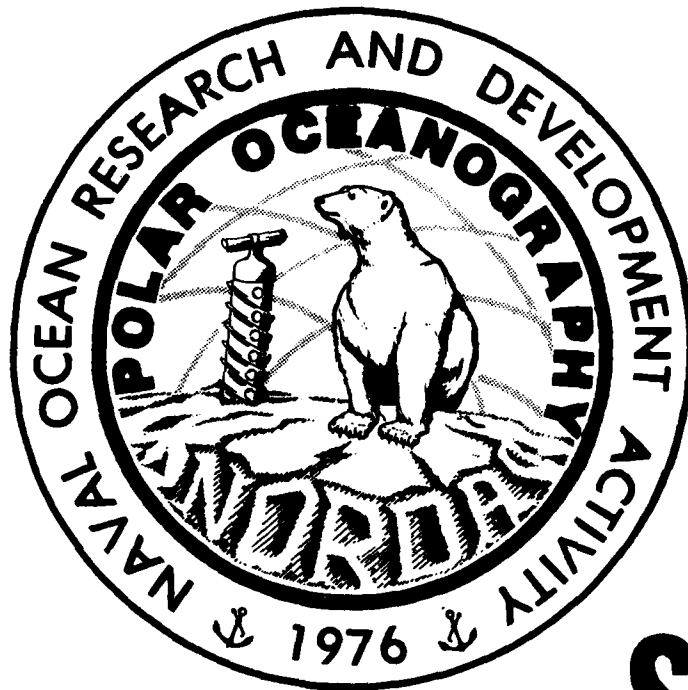


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Naval Ocean Research and
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NSTL Station, Mississippi 39529



Users Manual for a Polar Ice Forecast Subsystem - Arctic



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ABSTRACT

This manual describes the Polar Ice Forecast Subsystem - Arctic for non-ADP users. The intent is to provide all the information necessary to use the system effectively.

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SECTION 1.0 GENERAL

1.1 Purpose of the Users Manual

The objective of the Users Manual for the Polar Ice Forecast Project Subsystem - Arctic is to provide the users non-ADP personnel with the information necessary to effectively use the system.

1.2 Project references

Current forecasting products of Arctic ice conditions have been proven to be inadequate. A sample ice drift model has been run at Fleet Numerical Oceanography Center (FNOC). This model is labeled the SKILES model. Recently a number of more sophisticated, technically more complete models have been made available.

The Polar Oceanography Branch of the Naval Ocean Research and Development Activity (NORDA) was tasked by the Naval Air Systems Command (NAIR - 270G) to bring the Arctic basin model, developed by Dr. W. D. Hibler (Hibler, 1979) to an operational state at FNOC.

The following documents are pertinent to this project:

- i) Hibler, W. D., 1979: A Dynamic Thermodynamic Sea Ice Model. J. Phys. Oceanogr., 9, 815-846.
- ii) Maintenance Manual, Operations Manual, and Functional Description for the Polar Ice Forecast Subsystem - Arctic.

1.3 Security and Privacy

Neither the sea ice model nor any of its components are classified.

SECTION 2.0 SYSTEM SUMMARY

2.1 System Application

The sea ice model utilized in this system is designed to provide forecasts of ice drift, thickness, concentration, strength, growth and decay. This ice forecasting system was defined to provide an improvement in the forecasting of these ice parameters. The current model forecasts ice drift based on an empirical relation between atmospheric winds, ocean currents and ice drift.

The sea ice model utilizes environmental data, available at FNOC and maintains a data base containing the forecast parameters.

2.2 System Operation

The sea ice model operates by using FNOC environmental data. These data are used to define the atmospheric parameters used to define the heat budget components plus wind currents. This data is maintained by FNOC in the operational data base. This data base is maintained on several machines and the necessary data is transferred to the CY203 for use by the ice model.

The output module of the ice model creates a file containing forecast data of ice thickness, drift, concentration, strength and growth. The output data is also transferred to another machine for plot preparation. The output of the sea ice model is distributed to the Naval Polar Oceanography Center (NPOC). This center can then utilize the data for their own analysis of ice conditions.

Figure 1 illustrates the sea ice model operation.

2.3 System Configuration

The sea ice model is run on the CDC CYBER 203 at FNOC. Resultant forecast fields are plotted on the VARIAN plotter at FNOC.

2.4 System Organization

The sea ice model is designed to operate in three modules. These are input, processing, and output modules. All modules are contained within the one main program. ICEMDL, and associated subroutines.

The input module accesses input information which perform the following functions;

- i) Define all controlling parameters;
- ii) Define atmospheric conditions.

All control information is defined by the user in the respective data base. The atmospheric data are supplied from the FNOC data base.

The processing module performs the calculations necessary for evaluating the model equations. This module solves the momentum equations using a relaxation technique. Thermodynamic continuity equations are used to adjust ice thickness and concentration by growth, decay and advection.

The output module is used to maintain a data base containing resulting forecast fields. The data is placed on this file for restart purposes and for transfer to other machines for plotting and distribution.

2.5 Performance

The performance of the sea ice model is greatly dependent upon the input data. Two input data bases are required as previously defined. These data define the size of the grid, the location of the grid, and how long the model shall run. The quality of the FNOC environmental data also influences the model performance. Irregular and noisy wind data can cause the model to run much longer than normal.

One output file is maintained by the model. Forecast fields are written to the output field for every four time steps of processing.

The current version of the sea ice model is limited to a grid size of 28 by 28 points.

Fixed parameters, contained within the model are set up to be valid for this size of grid. The boundary mask data are also fixed parameters which limit the coastline configuration held within the grid. If a new geographical area is required, new boundary masks need to be made. The model is also limited to a square grid. The grid system is computed from a set of definition points supplied by the user. The subroutine which computes the grid mesh is designed to create a square grid system.

The sea ice model is capable of detecting errors in input/output operations to the FNOC environmental data base and output file. Error conditions, within the CRANDIO software, are routinely checked for by the software

package. These error conditions will result in abnormal termination of the model. Corrections to these error conditions are self explanatory and detailed explanations of these error conditions are contained within the FNOC software description for CRANDIO.

The processing time of the ice model lies between 50 and 100 seconds per time step. The processing time is extremely dependent upon the input data.

Verification of model forecast fields are being carried out to establish a reliability factor to the resultant forecast values.

2.6 Data Base

A total of 4 data bases are referenced by the sea ice model. Three of these are used for input while one is an output file.

Two of the input files, labeled TAPE7 and TAPE8 are defined by the user. These files provide controlling information to the model. Controlling information is defined as;

- i) number of time steps to be run; (TAPE8)
- ii) date time group (DTG) of
current time steps; (TAPE8)
- iii) grid size; (TAPE8)
- iv) grid location; (TAPE7)
- v) boundary masks; (TAPE8)
- vi) ocean current data. (TAPE7)

This information is used by the model to control processing.

The third input file is maintained by FNOC on an operational basis. This file contains environmental data fields, defined on the FNOC hemispheric grid. Fields required for use by the sea ice model are transferred from the complete data base, maintained on other machines, to the CY203.

The output file is written in the same format, at the FNOC data base. This data base is written by the model to store the resultant forecast fields.

2.7 General Description of Inputs, Processing, Outputs

a) Input

Two types of input field are used. One type defines all controlling information necessary for model processing. The other type holds the atmospheric data needed to calculate the forecast fields.

The controlling data is maintained on files labeled TAPE7 and TAPE8. TAPE7 contains the following information in the presented order;

- i) grid size in terms of the number of points;
- ii) grid location - I, J grid points on the FNOC hemispheric grid which will be the location of the bottom right and upper left corners of the grid;
- iii) boundary mask defines the coast line configuration for the momentum, thermodynamic and outflow grids;
- iv) ocean current data - The current data, interpolated from the SKILES ice model is input. Ocean current directions are rounded to the nearest 10 degrees.

TAPE8 contains the following data;

- i) number of time steps to be run;
- ii) DTG of days (time step) on which new input data is read from the FNOC data base.

All user defined input is set up to be read by formatted FCRTAN READ's. TAPE7 usually remains fairly constant between different runs. However, TAPE8 will change for each run. The DTG values need to be updated in order to insure the correct input data is being accessed from the FNOC data base.

b) Processing

Input data is used, by the processing modules to provide controlling information regarding how many iterations of the processing will be carried out plus providing the necessary numeric values of atmospheric structure needed to integrate the model calculations. The following is a brief description of the model processing which defines the area of the model and boundary masks for ice thickness, ice drift.

TAPE8 contains the number of time steps and Day Time Group which specifies the input data set.

Input data from the environmental data base include wind speed, surface pressure, surface air temperature, air humidity, short wave radiation and total heat flux. The model picks up these input data by calling subroutine INITIAL and using TAPE8, the input data are interpolated to each grid point.

The main program ICEMDL creates a mesh grid on FNOC 63 x 63 polar stereographic grid by using subroutine MESH and input data in TAPE7. Subroutine BNDRY sets up boundary masks for ice thickness, ice drifts, and the shape of the model

by using input data on TAPE7. Subroutine OCEAN is called to interpolate ocean current data to every grid point. The main program calls subroutine INITIAL to pick up surface wind data from CRANDIC file which is in the FNOC environmental data base.

Subroutine FORM is called to set up forces, non-linear water drag coefficients and non-linear viscosities for subroutine RELAX which solves linearized momentum balance with spatially varying bulk and shear viscosities for initialization. Subroutine ADJUST estimates thickness and compactness values at the outflow cells.

To carry out the predictor procedure, the time step is halved ($\text{DELTAT} = \text{DELTAT}/2.0$) and FORM is called to linearize the momentum equations. The main forward time steps ($\text{THETA}=1.0$) for the momentum balance is carried out with a full time step ($\text{DELTAT} = \text{DELTAT}$). After finishing the simulation of the dynamic portion, subroutine UVPLCT is called to convert ice drift on the polar stereographic grid to ice direction (DD) and magnitude (FF) and to store them in CRANDIC file for plotting. Then subroutine DIVERG stores convergence/divergence rate on required FNOC format for plotting.

The thermodynamic part of the model is processed by subroutine HEAT which obtains air temperature, solar radiation, surface pressure, and total heat flux from the FNOC data base (CRANDIC file) to calculate thin and thick ice growth. Subroutine GROWTH calculates changes of parameters due to growth and the total water growth. Subroutine HAPLOT stores ice thickness and concentration into CRANDIC file for plotting, and subroutine GROWDEC is called to store the ice growth/decay rate.

Outputs

One output file is created by the sea ice model. This file is in CRANDIC format, which is the same format as the FNOC data base. The following fields are output to this file;

- i) ice drift;
- ii) ice thickness;
- iii) ice concentration;
- iv) ice strength;
- v) ice growth;
- vi) open water growth.

This output file is maintained to provide output to other machines for plotting and to allow the model to restart at a current position. This allows a simulation to be stopped in mid-stream and started at the current position.

Generalized hardcopy output is also created by the model. This output provides diagnostic information regarding the completed run.

SECTION 3.0

STAFF FUNCTIONS RELATED TO TECHNICAL OPERATIONS

3.1 Initiation Procedure

The model is run on the CY203 at FNOC. The model may be run through either batch entry from the front-end machine or interactively directly by the user. For larger runs, operation via batch entry is recommended. This procedure is presented by using the following control cards, submitted from the front-end machine to the CY203.

Jobname, STSAM, U=user no., A=aact.no.	(front-end job card)
RESOURCE(TL=time limit)	
CCREATE(ZY0X1W2,400,1)	(CRANDIC creation of output file)
ICEGO.	(ice model controllee)
DEFINE,ZY0X1W2	(save output file)

This procedure assumes all input data has previously been transferred to the CY203 and is made available to the model.

Also it assumes the user specified input has already been set up.

Information, needed for interactive use, is ready available from the FNOC supplied documentation.

3.2 Staff Input Requirements

Input is required by the model for normal operation. The user specified controlling input information is needed at the start of the current run. This information is accessed prior to any computational processing by the model. The FNOC input is accessed each time step when new atmospheric data is needed. The majority of this data is needed during calculations of the head budget.

FNOC environmental input data is maintained upon disk, accessible via a number of machines. However, the CY203 and the front-end do not have direct access to this rather huge disk file. Fields, necessary for the operation of the model will routinely be supplied to the CY203 by FNOC.

3.2.1 Input Formats

The user specified input file is set up to be accessed by formatted FORTRAN READ's. The following formats are needed as defined.

i)	time step number	I5
ii)	grid dimensions	I5
iii)	valid DTG	A10
iv)	defining grid points for grid	F10.1
v)	boundary masks	F2.0
vi)	ocean currents	F3.0.

3.2.2 Composition Rules

The majority of the input variables, specified above have no special composition rules. Input arrays such as the boundary masks and ocean currents are dependent upon the size of the grid for the run. Boundary masks are a series of 1's and 0's. Zero values define the coastline boundaries of the grid. Ocean current data is rounded to the nearest 10. Therefore a direction of 275.0 is represented 27. in the input file.

All FNOC data plus the output file are in the standard CRANDIO format. This format is defined as the standard product data base at FNOC.

To properly use the boundary masks for momentum and thermodynamic grids, they must be properly matched with the grid created in the model. The grid creation routine computes points as follows.

U _{1,1}	U _{2,1}	U _{3,1}
.	.	.
U _{1,2}	U _{2,2}	U _{3,2}
.	.	.
U _{1,3}	U _{2,3}	U _{3,3}
.	.	.

The boundary mask data, on TAPE7 must be established as follows.

U _{1,1}	U _{1,2}	U _{1,3}
.	.	.
U _{2,1}	U _{2,2}	U _{2,3}
.	.	.
U _{3,1}	U _{3,2}	U _{3,3}
.	.	.

3.2.3 Sample Input

TAPE7 and TAPE8 must be created in a proper format as in the following example to fit the grid mesh established by the model.

<u>TAPE7:</u>		<u>Format</u>
0000025.000000034.00	I ₀ , I ₁	2F10.2
0000026.000000035.00	J ₀ , J ₁	2F10.2
00007	N	I5
0.0.0.0.0.	UVM	5F2.1
0.1.1.1.0.		
0.1.1.1.0.		
0.1.1.1.0.		
0.0.0.0.0.		
0.0.0.0.0.0.	HEFFM	6F2.1
0.1.1.1.1.0.		
0.1.1.1.1.0.		
0.1.1.1.1.0.		
0.1.1.1.1.0.		
0.0.0.0.0.0.		
0.0.0.0.0.0.	OUT	6F2.1
0.1.1.1.1.0.		
0.1.1.1.1.0.		
0.1.1.1.1.0.		
0.0.0.0.0.0.		
0.00.00.020.0.0.	WATD	5F3.0
0.010.05.02.0.0.		
01.02.10.04.02.		
03.04.0.014.06.		
0.002.0.00.003.		
<u>TAPE8</u>		<u>Format</u>
00005	I5	ITSTEP
81091500 81091512 81091600	A8,2X,A8,2X,A8	DTG

3.3 Output Requirements

Output of the sea ice model is stored on the CRANDIO output file. The resultant output file. The resultant output fields are stored in this file every four time steps. This is variable and may be changed to match any desired output frequency.

The output is also transferred from the CY203 to the satellite processing machine where it may be plotted.

Hardcopy printouts are also created. Diagnostic variables are printed, again at a frequency of every four time steps.

3.3.1 Output Formats

The main output file is stored in CRANDIC format. This is a standard data base format at FNOC. The file is composed of a number of records, each containing one data field. Each record is headed with an identification block. This ID block contains information pertaining to the contents and form of the data record. Detailed information concerning the composition of the ID block and CRANDIO format is found in the FNOC product documentation.

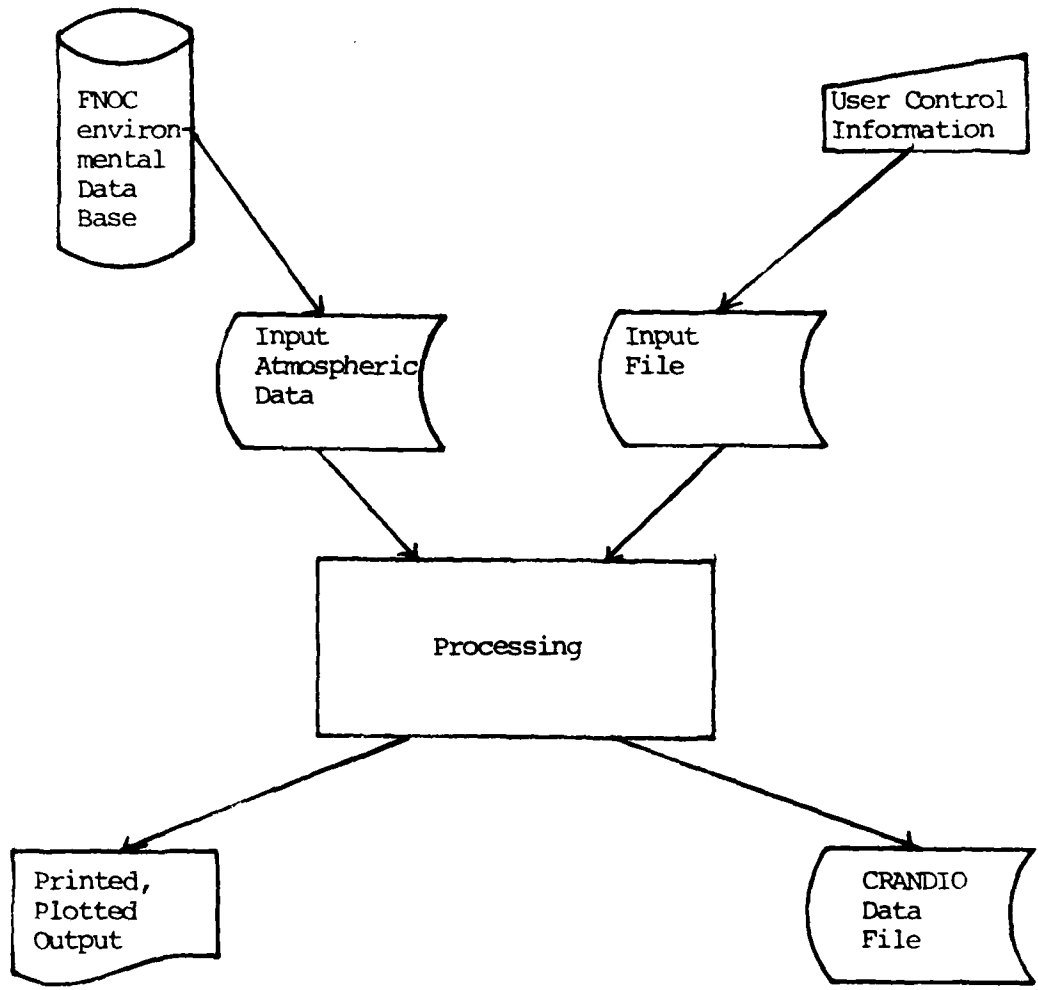
3.4 Utilization of System Outputs

The sea ice model creates plotted output which is used by NPOC in their determination of Arctic ice conditions. the output is in a form which can readily be examined and used, by NPCC for documentation to their users.

3.5 Recovery and Error Correction Procedures

A list of error codes generated by the program is presented as follows:

<u>Routine</u>	<u>Error Message</u>	<u>Meaning</u>	<u>Correction</u>
ICEMDL	'OPEN ERROR'	CRANDIO file not opened	Check CRANDIO
INITIAL	'CHECKNC NO DATA INITIAL'	CHECKNC finds no initial data	obtain missing data
RELAX	'NC CONVERGENCE AFTER 800 ITERATIONS'	Ice velocities are not convergent after 800 iterations	check wind data input
DIVERG	'BAD WRITE IN DIVERG	CWRITER cannot write into CRANDIC file	check CRANDIO
UVPLOT	'BAD WRITE IN UVPLCT'	" "	check CRANDIO
HAPLOT	'BAD WRITE IN HAPLOT'	" "	check CRANDIC
GROWDEC	'BAD WRITE IN GRODEC'	" "	check CRANDIC



NPOC

Figure 1. Sea Ice Model Operational Data Flow

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