

AD-A262 794



IC
TE

2 1993

C

D

2



Naval Research Laboratory

Stennis Space Center, MS 39529-5004

NRL/MR/7322-93-7020

Monthly Mean Sea Ice Data from the Polar Ice Prediction System (PIPS), the Regional Polar Ice Prediction System – Barents Sea (RPIPS-B), the Regional Polar Ice Prediction System – Greenland Sea (RPIPS-G), and the Polar Ice Prediction System 2.0 (PIPS2.0)

P. G. POSEY
R. H. PRELLER

*Ocean Dynamics and Prediction Branch
Oceanography Division*

February 1993

93-07689



1291

027

Approved for public release; distribution is unlimited.

REPORT DOCUMENTATION PAGE

Form Approved
OBM No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. Agency Use Only (Leave blank).		2. Report Date. February 1993		3. Report Type and Dates Covered. Final	
4. Title and Subtitle. Monthly Mean Sea Ice Data from the Polar Ice Prediction System (PIPS), the Regional Polar Ice System - Barents Sea (RPIPS-B), the Regional Polar Ice Prediction System - Greenland Sea (RPIPS-G), and the Polar Ice Prediction System 2.0 (PIPS2.0)				5. Funding Numbers. Program Element No 0603207N Project No X0513 Task No 100 Accession No DN894428 Work Unit No 73509303	
6. Author(s). P. G. Posey and R. H. Preller					
7. Performing Organization Name(s) and Address(es). Naval Research Laboratory Ocean Dynamics and Prediction Branch Stennis Space Center, MS 39529-5004				8. Performing Organization Report Number. Memorandum Report 7020	
9. Sponsoring/Monitoring Agency Name(s) and Address(es). Naval Research Laboratory Oceanography Division Stennis Space Center, MS 39529-5004				10. Sponsoring/Monitoring Agency Report Number. Memorandum Report 7020	
11. Supplementary Notes.					
12a. Distribution/Availability Statement. Approved for public release; distribution is unlimited. Naval Research Laboratory, Washington, DC 20375-5320.				12b. Distribution Code.	
13. Abstract (Maximum 200 words). The Polar Ice Prediction System (PIPS), the Regional Polar Ice Prediction System - Barents (RPIPS-B) and the Regional Polar Ice Prediction System - Greenland Sea (RPIPS-G) are all operational sea ice forecasting systems that have been run daily at the Fleet Numerical Oceanography Center (FNOC) since September 1987, June 1989, and October 1991, respectively. The basis for all three models is the Hibler ice model (Hibler, W. D. (1979). A Dynamic Thermodynamic Sea Ice Model. <i>Journal of Physical Oceanography</i> 9:815-846; Hibler, W. D. (1980). Modeling a Variable Thickness Sea Ice Cover. <i>Monthly Weather Review</i> 108:1944-1973). The ice models are driven by monthly mean ocean currents and deep ocean heat fluxes derived from the Hibler and Bryan (A Diagnostic Ice-Ocean Model. <i>Journal of Physical Oceanography</i> 17:987-1015 (1987) coupled ice-ocean model. They are also driven by atmospheric forcing from the Navy Operational Global Atmospheric Prediction System (NOGAPS) (Rosmond, T. E. (1981). NOGAPS: Navy Operational Global Atmospheric Prediction System. In Fifth Conference on Numerical Weather Prediction (Monterey, California), American Meteorological Society, Boston, Massachusetts, preprint volume, 74-79; Hogan et al. (1990). The Description of the Navy Operational Global Atmospheric Prediction System's Forecast Model. Naval Research Laboratory, Monterey, California, NOARL Report 13). Each day a 24-hour forecast of PIPS, RPIPS-B, and RPIPS-G is submitted and archived by the Naval Research Laboratory. This memorandum report contains monthly mean values of geostrophic winds, ice drift, ice thickness, and ice concentration from the PIPS, RPIPS-B, and RPIPS-G 24-hour forecasts from 1991 to 1992. Also included in this report are monthly mean values of geostrophic wind, ice drift, ice thickness, and ice concentration derived from a higher resolution version of PIPS called PIPS2.0. PIPS2.0 is a modified spherical coordinate version of PIPS coupled to a multilevel baroclinic ocean model (Cox, M. (1984). A primitive equation, 3-dimensional model of the ocean. GFDL Ocean Group Tech. Report 1, Geophysical Fluid Dynamics Laboratory, Princeton, NJ) and extended to include most of the sea ice-covered areas in the Northern Hemisphere (Cheng, A. and R. H. Preller (1992). An Ice-Ocean Coupled Model for the Northern Hemisphere. <i>Geophysical Research Letters</i> , Vol. 19, No. 9:901-901).					
14. Subject Terms. Sea Ice Forecasting, Sea Ice Models, Sea Ice Analysis				15. Number of Pages. 127	
				16. Price Code.	
17. Security Classification Unclassified		18. Security Classification of Report. Unclassified		19. Security Classification of This Page. Unclassified	
				20. Limitation of Abstract of Abstract. SAR	

MONTHLY MEAN SEA ICE DATA FROM THE POLAR ICE PREDICTION SYSTEM (PIPS), THE REGIONAL POLAR ICE PREDICTION SYSTEM - BARENTS (RPIPS-B), THE REGIONAL POLAR ICE PREDICTION SYSTEM - GREENLAND SEA (RPIPS-G) AND THE POLAR ICE PREDICTION SYSTEM 2.0 (PIPS2.0)

The Polar Ice Prediction System (PIPS), the Regional Polar Ice Prediction System - Barents Sea (RPIPS-B) and the Regional Polar Ice Prediction System - Greenland Sea (RPIPS-G) are all operational sea ice forecasting systems which have been run daily at the Fleet Numerical Oceanography Center (FNOC) since September 1987, June 1989, and October 1991, respectively. The basis for all three models is the Hibler ice model (Hibler, 1979; 1980). The Hibler ice model calculates ice drift, ice thickness, ice concentration (ice edge) and the growth/decay of ice based on both dynamic and thermodynamic effects. The ice models are driven by monthly mean ocean currents and deep ocean heat fluxes derived from the Hibler and Bryan (1987) coupled ice-ocean model. They are also driven by atmospheric forcing from the Navy Operational Global Atmospheric Prediction System (NOGAPS) (Rosmond, 1981; Hogan et al., 1990). The Polar Ice Prediction System 2.0 (PIPS2.0), a new version of PIPS, is presently undergoing the final testing phase. PIPS2.0 has been modified into a spherical coordinate version of PIPS and coupled with an ocean model (Cox, 1984). Similar to the operational models, daily atmospheric NOGAPS forcing is used to produce a 24-hour forecast.

PIPS forecasts over the entire Arctic basin, the Barents Sea and the Greenland/Norwegian Sea using a grid resolution of 127 km (Fig. 1). RPIPS-B, a higher resolution version of PIPS, forecasts over the Barents Sea and the western part of the Kara Sea using a grid resolution of 25 km (Fig. 2). RPIPS-G, another higher resolution version of PIPS, forecasts over the region adjacent to the East Greenland coast using a grid resolution of 20 km (Fig. 3). PIPS 2.0 forecasts over most of the ice-covered regions in the northern hemisphere using a variable grid resolution ranging from 34.5 km to 63.5 km at the north pole (Fig. 4). The timestep used by all four ice models is 6 hours. The length of the daily operational PIPS, RPIPS-B and RPIPS-G forecast, 120 hours, is based on the length of the NOGAPS forecast. Each model is restarted daily using its own 24-hour forecast. Once per week, the PIPS, RPIPS-B and RPIPS-G ice concentration is initialized (updated) by the digitized hand analysis of ice concentration from the Naval Polar Oceanography Center (NPOC). If these restart fields are not available, each model initializes from a model derived climatology. To create these climatological data bases, each model was run for 3 years, using 1986 NOGAPS forcing for each year until a "cyclic" equilibrium was reached. A detailed description of PIPS may be found in Preller and Posey (1989a) and Preller (1985). A detailed description of PIPS-B may be found in Preller et al. (1989). A preliminary study of RPIPS-G may be found in Preller et al. (1990). Unlike the operational models, PIPS2.0 was run daily on a Cray-YMP located at Stennis Space Center. This model is not run operationally, which means that no type of initializing (updating) of ice concentration occurs. The model was initialized from a 5 year "spin up" run driven by 1986 monthly mean NOGAPS forcing. A 24 hour "forecast" simulation was performed each day on the Cray YMP using the real time NOGAPS forcing available through the IPOPS. A more detailed description of the ice-ocean model may be found in Cheng and Preller (1992).

The following report, the fourth in a series (Preller and Posey, 1989c; Posey and Preller, 1990; Posey and Preller, 1991), contains monthly mean values of geostrophic wind, ice drift, ice thickness and ice concentration derived from PIPS, RPIPS-B and RPIPS-G 24-hour forecast from October 1991 through December 1992 and the 24-hour "forecast" from

For
CRA&I
TAB
Guided
Location

Distribution /

Availability Code

Dist	Avail and/or Special
A-1	

the PIPS2.0 from March 1992 through December 1992.

The scale factor for the geostrophic wind velocities, located in the lower right-hand corner of each figure is 20 m/sec for the PIPS results, 30 m/sec for the RPIPS-B and RPIPS-G results, and 50 m/sec for the PIPS2.0 results. The scale factor for all the model's ice drift velocities, located in the lower right-hand corner, is 30 cm/sec. Both, RPIPS-B and PIPS2.0, ice drift values are plotted at every other point, RPIPS-G at every 4th point and PIPS at every point. The ice thickness contours for PIPS and PIPS2.0 begin at 0.5 m and are incremented by 0.5 m. The ice thickness contours for RPIPS-B begin at 0.1 m and are incremented by 0.1 m. The ice thickness contours for RPIPS-G have two contour intervals, the first begins at 0.1 m and incremented by 0.1 m until the 0.4 m is reached; the second begins at 0.5 m and is incremented by 0.5 m. The ice concentration contours for PIPS, PIPS2.0 and RPIPS-G begin at 0.2 (20%) and are incremented by 0.05 (5%). For the RPIPS-B ice concentration results, the contours begin at 0.2 (20%) and are incremented by 0.1 (10%).

SPECIFIC COMMENTS ON EACH YEAR

PIPS 1991 RESULTS

The PIPS 1991 results, a continuation of our last report, begin with October 1991. The 1991 PIPS monthly means were calculated from the 24-hour forecasts. Each day a 24-hour PIPS forecast was submitted by Naval Research Laboratory (NRL) to run on the FNOC Cyber 205. The output from this forecast was brought back to NRL and archived. In the past several years, PIPS has often forecast excessive ice growth in the marginal ice zones during the winter season. During 1990, both corrections to NOGAPS and the ice model code resulted in more realistic ice concentrations and ice thickness in the PIPS forecasts. Also during this period, NPOC, with the assistance of FNOC, incorporated a more fully automated technique of transmitting and quality controlling the ice concentration update to FNOC. As a direct result, the PIPS model's ice concentration was updated 13 out of 13 weeks.

PIPS 1992 RESULTS

The 1992 monthly means were also calculated from the 24-hour forecast fields in the same way as the 1991 results. As seen before, the "Odden", a formation of very thin ice that protrudes east of Greenland coast, appeared from February through April.

During July 1991, PIPS was upgraded to use high resolution wind stresses, a new product produced by the NOGAPS model. In order to remain consistent with the previous reports, we have plotted the geostrophic wind calculated from the NOGAPS surface pressures even though the NOGAPS surface stresses were used to calculate the ice drift. A comparison study of PIPS driven by NOGAPS wind stresses versus PIPS driven by stresses derived from NOGAPS geostrophic winds using a constant turning angle and drag coefficient, show the resultant values of ice drift to be similar in both cases.

Geostrophic winds and the resultant PIPS ice drift show the Arctic to be dominated by a clockwise circulation in the Beaufort and Chukchi Sea regions for most of the year. This pattern begins to decay and reverses to a counter clockwise circulation in the summer. This reversal of the dominant anticyclonic gyre, usually occurring in August or September, appears to be due to an increase in the number of low pressure systems in this region during the late

summer (Preller and Posey, 1989b). A return to normal clockwise circulation usually begins in October. During 1992, the reversal of this circulation did not conform to the pattern described above. The first observation of the reversal occurred during the month of May. In June, the counter clockwise circulation moves along the Soviet Coast while the central Arctic returns to a normal pattern. From August through September, the reversal slowly appears as in previous years. The ice motion reverts back to a clockwise circulation in the Beaufort and Chukchi Sea regions during November and December.

From January through December of 1992, the PIPS model was updated by the NPOC ice concentration 47 out of 52 weeks.

RPIPS-B 1991 RESULTS

RPIPS-B was designed, at higher resolution than PIPS, in order to predict a more accurate location of the ice edge, obtain better resolution of straits, and to better define land and island boundaries. Similar to PIPS, the RPIPS-B results are a continuation from our previous report. Along with PIPS, each day a 24-hour RPIPS-B forecast was submitted by NRL to run on the FNOC computer. The output from this forecast was brought back and archived at NRL. All of the RPIPS-B results shown were calculated from the 24-hour forecast field. Similar to PIPS, RPIPS-B was updated each week with ice concentration data from NPOC.

In May of 1991, RPIPS-B was upgraded to use the high resolution surface stresses from the NOGAPS model. As with the PIPS results, the RPIPS-B ice drift results were improved by using the higher resolution stresses.

As in the PIPS results, RPIPS-B during this time compared well with observed ice concentrations as a direct result of the regular weekly updating of the ice concentration (13 out of 13 weeks).

RPIPS-B 1992 RESULTS

During 1992, RPIPS-B was updated 47 out of 52 weeks with the NPOC analysis, which assisted in the realistic forecasts in the Barents Sea.

RPIPS-G 1991 RESULTS

RPIPS-G was also designed at higher resolution than PIPS, in order to predict a more accurate location of the ice edge to obtain better resolution of the Fram Strait and to better define land and island boundaries. Along with PIPS and RPIPS-B, each day a 24 hour RPIPS-G forecast was submitted by NRL to run on the FNOC computer. The output from this forecast was brought back and archived. All of the RPIPS-G results were calculated from the 24-hour forecast field. Similar to both PIPS and RPIPS-B, RPIPS-G was updated each week with ice concentration data from NPOC. This includes a correction to the thickness field as well. If the data indicated that no ice actually existed in a grid cell that contained ice, the ice was removed and heat was added to the mixed layer to keep ice from immediately growing back. If the data indicated that ice actually existed in a grid cell that contained only open water, ice was added to the cell according to the following equation:

If $A \geq 0.5$ $H = 0.4$ m
If $A < 0.5$ $H = 0.2$ m

where A is the ice concentration ($0.5 = 50\%$) and H is the ice thickness.

As in the PIPS and RPIPS-B results, RPIPS-G during this time compared well with observed ice concentrations as a direct result of the regular weekly updating of the ice concentration (13 out of 13 weeks).

RPIPS-G 1992 RESULTS

The 1992 RPIPS-G monthly means were calculated from the 24-hour forecast fields in the same way as the 1991 results. During the first part of the year (January-July), an error in the operational job stream of RPIPS-G caused the model not to accept the ice concentration update from the NPOC analysis. During this time, RPIPS-G was restarted from climatology three times, mid-February, May 21 and September 5. The problem was corrected and then the updating procedure was successful the rest of the year (14 out of the remaining 16 weeks).

As seen in the PIPS model, the "Odden" appeared in RPIPS-G but with greater detail than PIPS. The feature started to occur in late January, peaking during February and then slowly disappearing in March. This is earlier than seen in recent years.

PIPS2.0 1992 RESULTS

Unlike the operational models, PIPS2.0 was run daily on a Cray YMP at Stennis Space Center, MS. The output from this forecast was archived at NRL. The 1992 monthly means (March thru December) were calculated from the 24-hour forecast fields in the same way as all the operational models. A major difference between PIPS2.0 and operational models, is that PIPS 2.0 is never initialized (updated) by observations. In addition, the resolution of the PIPS2.0 model has recently been doubled from approximately 0.6 degrees to 0.3 degrees. This higher resolution version forecasts a more accurate ice edge in the marginal ice zones. In general, PIPS2.0 results are consistent with the JIC weekly analysis, except in the marginal ice zones where excessive amounts of ice can appear. When PIPS2.0 becomes operational, and the updating occurs, a more realistic ice edge can be expected.

ACKNOWLEDGEMENTS

Funding for this work came from the U.S. Space and Naval Warfare Systems Command through program element 0603207N, CDR Peter Ranelli, Program Manager. We would also like to thank Lt. Greg Lundeen for assisting in the plotting of the monthly means and Ms. Tammy Smith for typing the manuscript.

REFERENCES

Cheng, A. and R.H. Preller (1992). An Ice-Ocean Coupled Model for the Northern Hemisphere. *Geophysical Research Letters*, Vol. 19, No. 9: 901-901.

Cox, M. (1984). A primitive equation, 3-dimensional model of the ocean. GFDL Ocean Group Tech. Report 1, Geophysical Fluid Dynamics Laboratory, Princeton, NJ.

Hibler, W.D. (1979). A Dynamic Thermodynamic Sea Ice Model. *Journal of Physical Oceanography* 9:815-846.

Hibler, W.D. (1980). Modeling a Variable Thickness Sea Ice Cover. *Monthly Weather Review* 108:1944-1973.

Hibler, W.D. and K. Bryan (1987). A Diagnostic Ice-Ocean Model. *Journal of Physical Oceanography* 17:987-1015.

Hogan, T.F., T.E. Rosmond and R. Gelaro (1990). The Description of the Navy Operational Global Atmospheric Prediction System's Forecast Model. Naval Research Laboratory, Monterey, California, NOARL Report 13.

Posey, P.G. and R.H. Preller (1991). Monthly Mean Sea Ice Data from the Polar Ice Prediction System, the Regional Polar Ice Prediction System - Barents Sea, and the Regional Ice Prediction System - Greenland Sea. Naval Research Laboratory, Stennis Space Center, Mississippi, NOARL Technical Note 196.

Posey, P.G. and R.H. Preller (1990). Monthly Mean Sea Ice Data from the Polar Ice Prediction System, the Regional Polar Ice Prediction System - Barents Sea, and the Regional Ice Prediction System - Greenland Sea. Naval Research Laboratory, Stennis Space Center, Mississippi, NOARL SP 014:322:91.

Preller, R.H. (1985). The NORDA/FNOC Polar Ice Prediction System (PIPS) - Arctic: A Technical Description. Naval Research Laboratory, Stennis Space Center, Mississippi, NORDA Report 108.

Preller, R.H. and P.G. Posey (1989a). The Polar Ice Prediction System - A Sea Ice Forecasting System. Naval Research Laboratory, Stennis Space Center, Mississippi, NORDA Report 212.

Preller, R.H. and P.G. Posey (1989b). A Numerical Model Simulation of a Summer Reversal of the Beaufort Gyre. *Geophysical Research Letters* Vol. 16, No. 1, p.69-72.

Preller, R.H. and P.G. Posey (1989c). Monthly Mean Ice Data from the Polar Ice Prediction System. Naval Research Laboratory, Stennis Space Center, Mississippi, NOARL SP 077:322:89.

Preller, R.H., S.H. Riedlinger, and P.G. Posey (1989). The Regional Polar Ice Prediction System - Barents (RPIPS-B): A Technical Description. Naval Research Laboratory, Stennis Space Center, Mississippi, NORDA Report 182.

Preller, R.H., A. Cheng, and P.G. Posey (1990). Preliminary Testing of a Sea Ice Model for the Greenland Sea Ice Properties and Processes from proceedings of the W.F. Weeks Sea Ice Symposium. CRREL Monograph 90-1, pp. 259-277.

Rosmond, T.E. (1981). NOGAPS: Navy Operational Global Atmospheric Prediction System. In Fifth Conference on Numerical Weather Prediction (Monterey, California), American Meteorological Society, Boston, Massachusetts, preprint volume, 74-79.

PIPS MODEL GRID

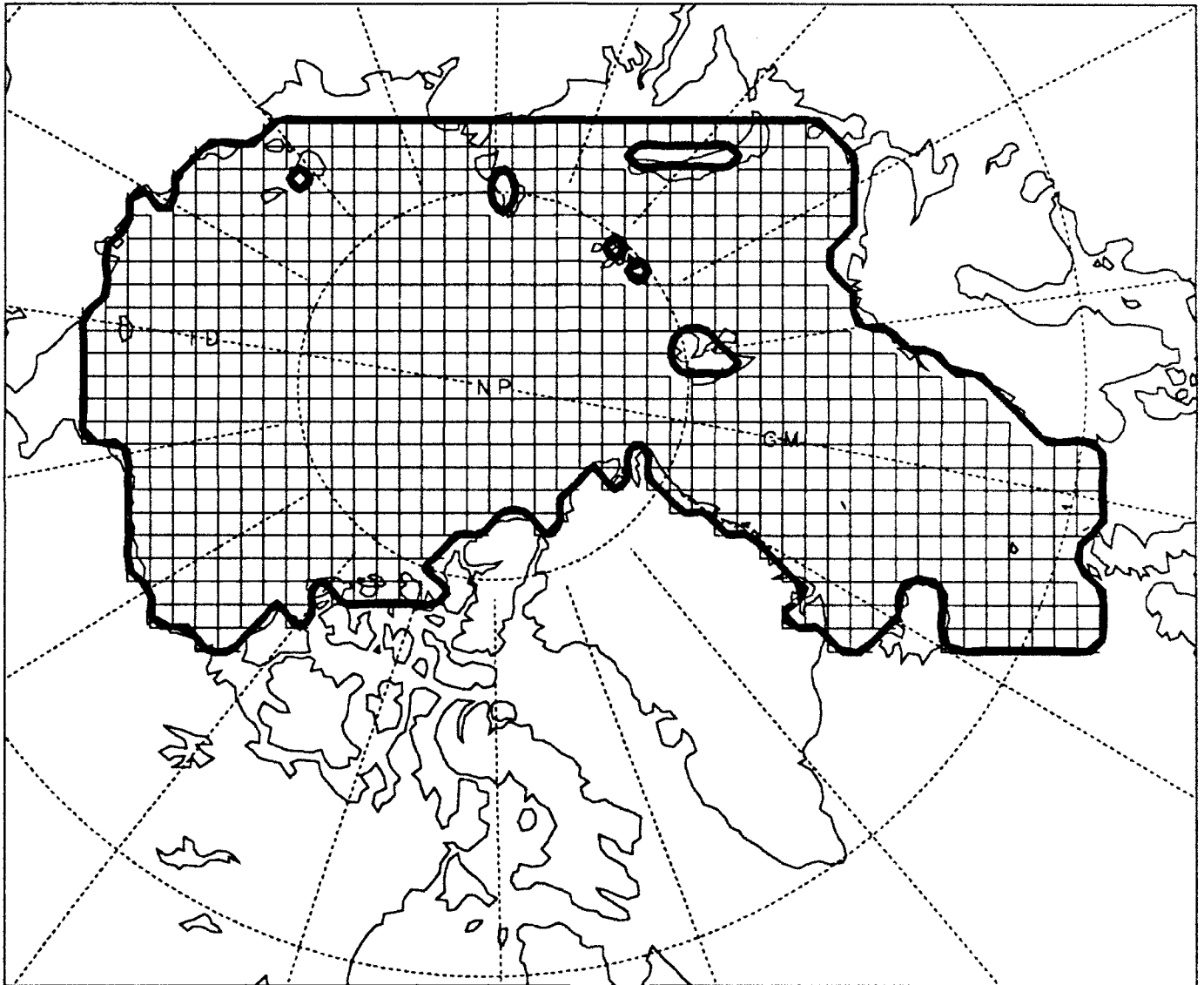


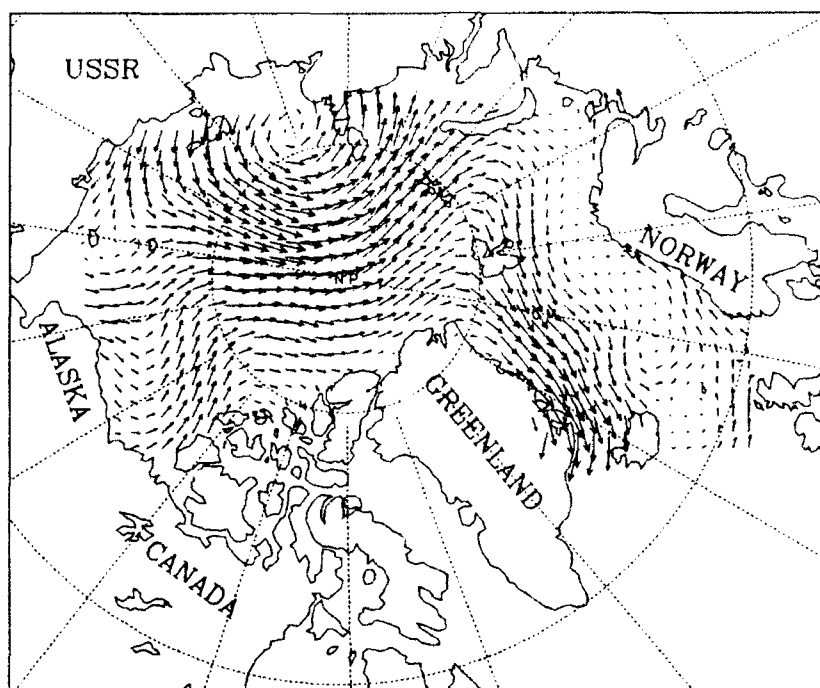
Figure 1. PIPS domain with the 127 km resolution grid overlaid.

PIPS 1991

MONTHLY MEANS

WIND VELOCITIES

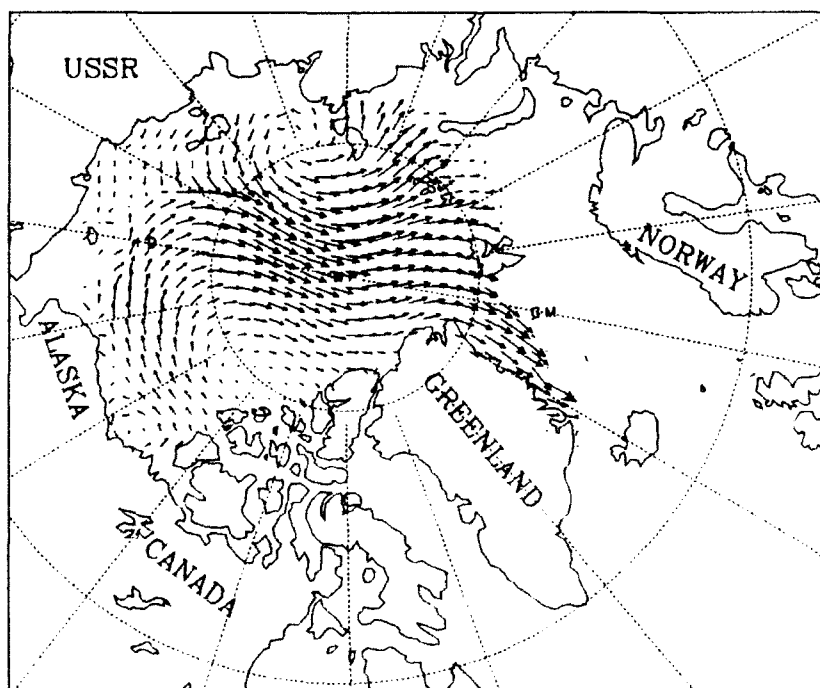
1991 OCTOBER



0.200E+02
MAXIMUM VECTOR

ICE VELOCITIES

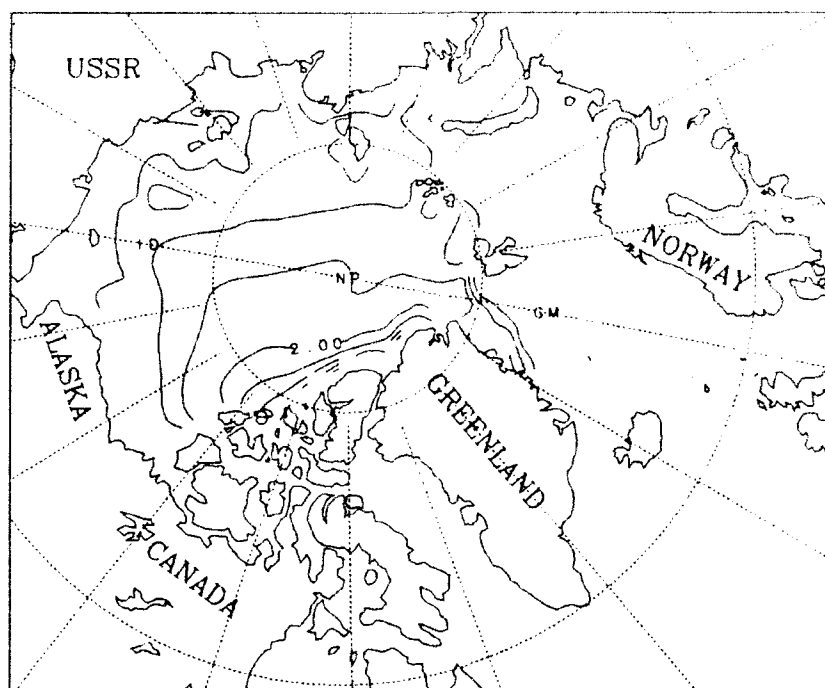
1991 OCTOBER



0.300E+00
MAXIMUM VECTOR

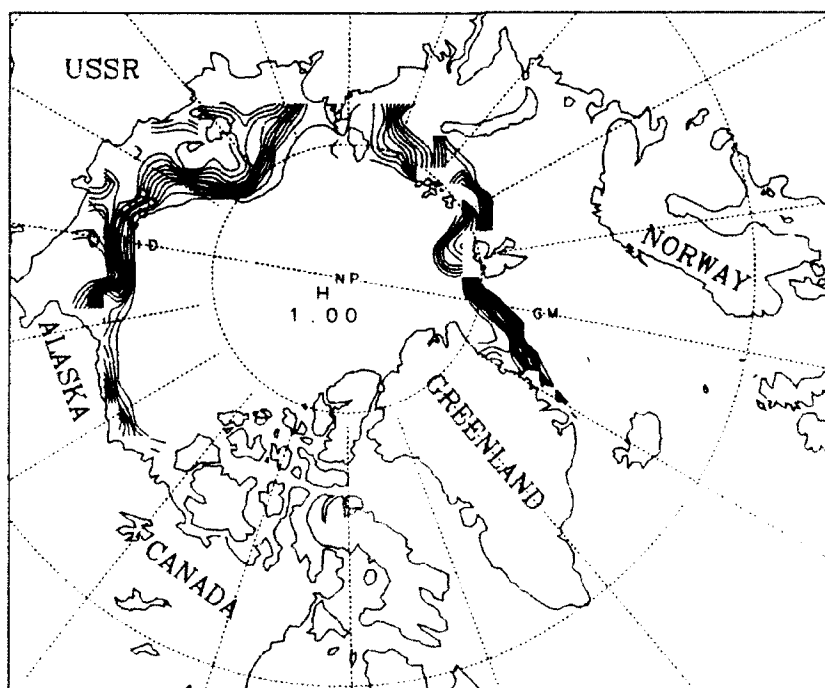
ICE THICKNESS

1991 OCTOBER



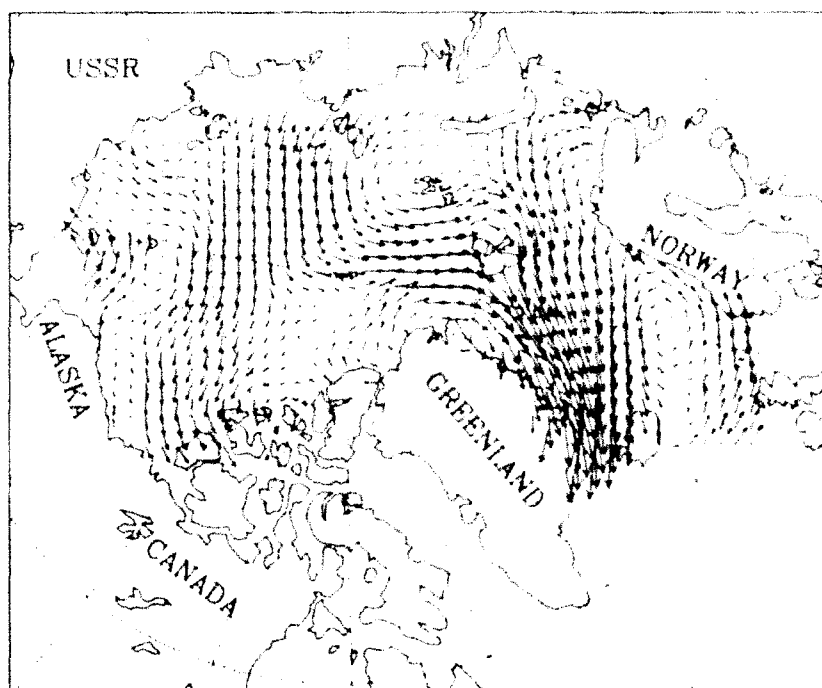
ICE CONCENTRATION

1991 OCTOBER



WIND VELOCITIES

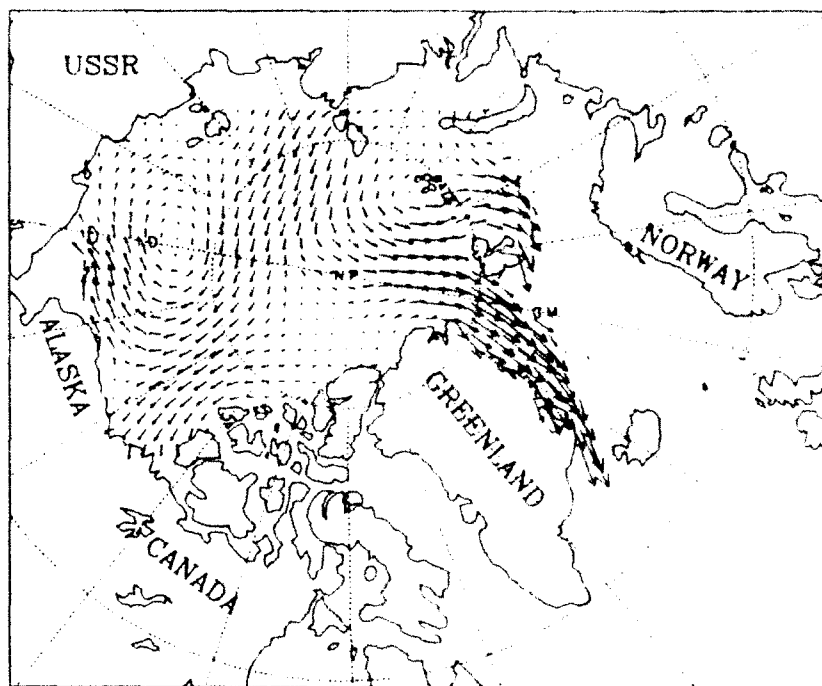
1991 NOVEMBER



0 3000-80
MAXIMUM VECTOR

ICE VELOCITIES

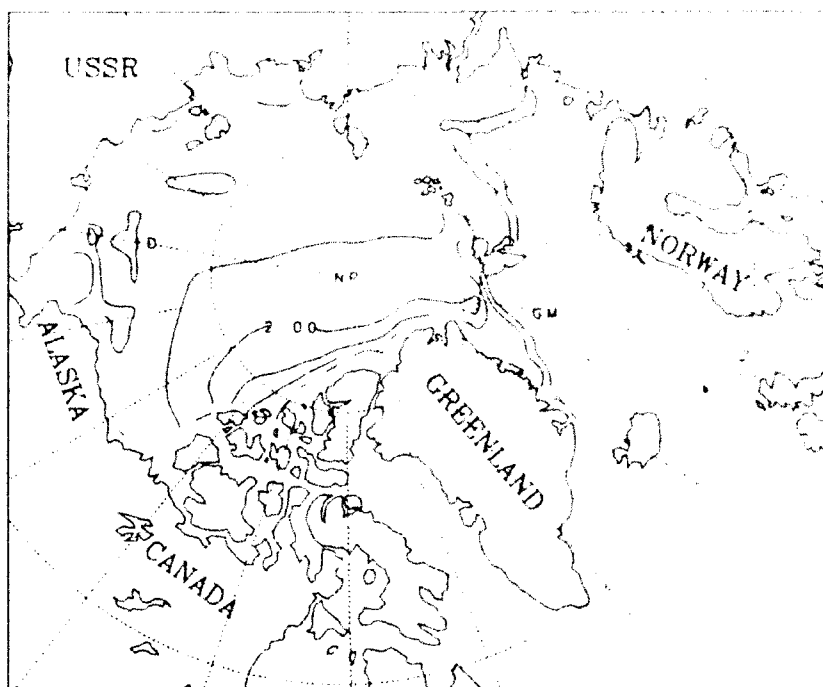
1991 NOVEMBER



0 3000-80
MAXIMUM VECTOR

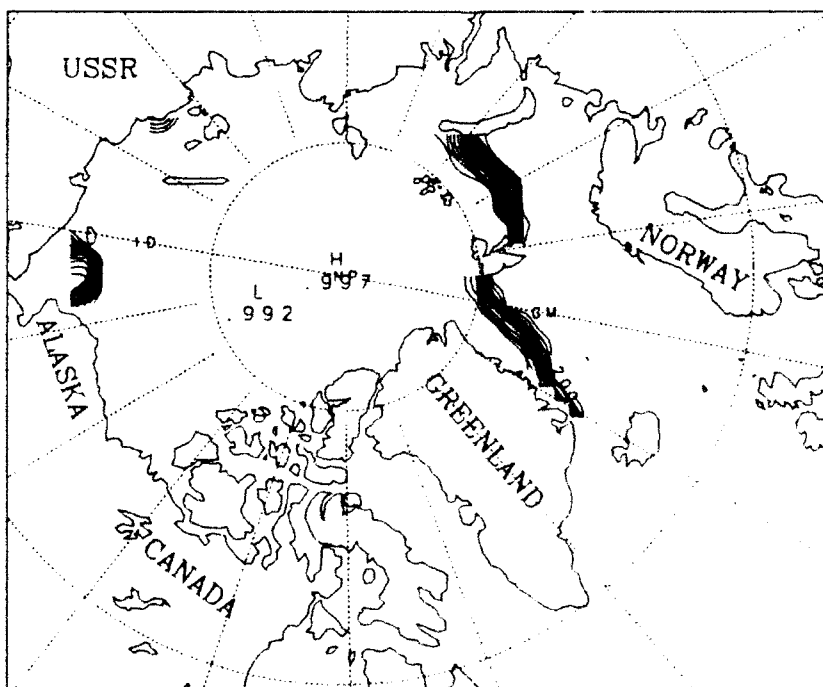
ICE THICKNESS

1991 NOVEMBER



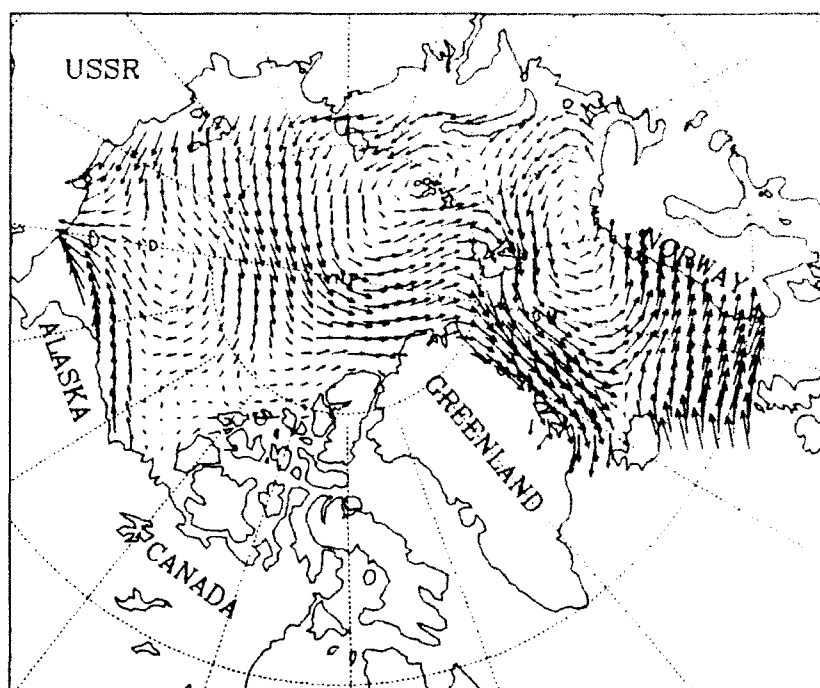
ICE CONCENTRATION

1991 NOVEMBER



WIND VELOCITIES

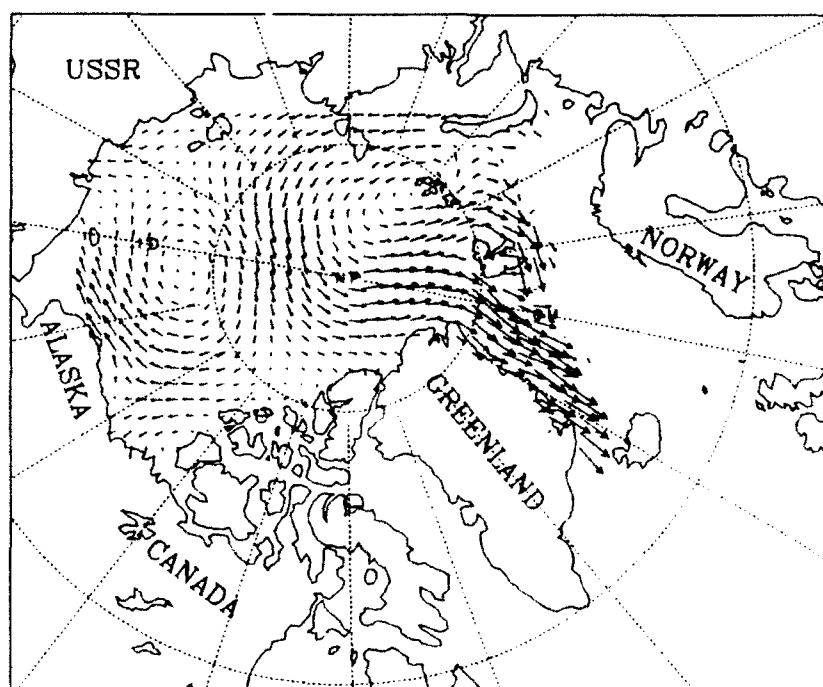
1991 DECEMBER



0 2000 400
MAXIMUM VECTOR

ICE VELOCITIES

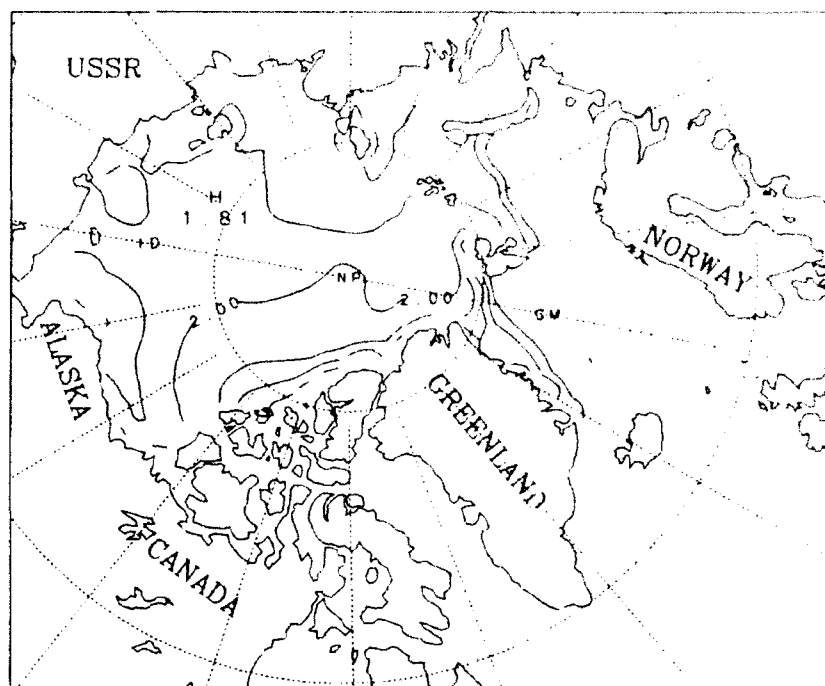
1991 DECEMBER



0 3000 600
MAXIMUM VECTOR

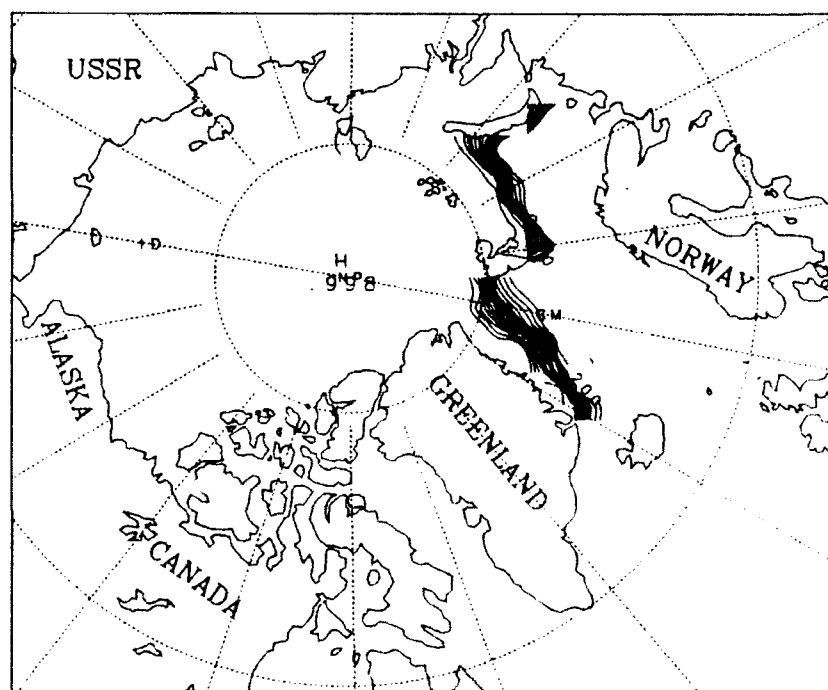
ICE THICKNESS

1991 DECEMBER



ICE CONCENTRATION

1991 DECEMBER

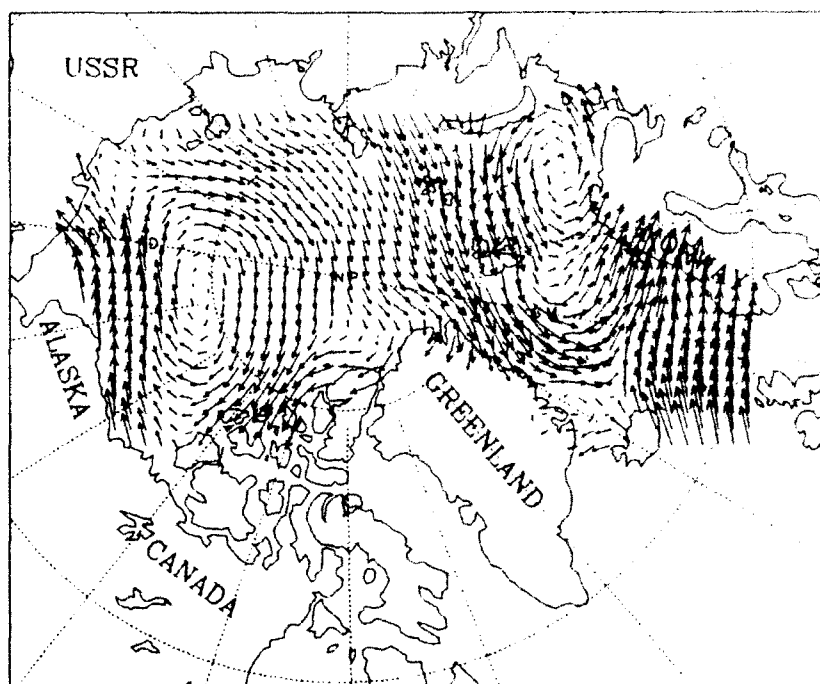


PIPS 1992

MONTHLY MEANS

WIND VELOCITIES

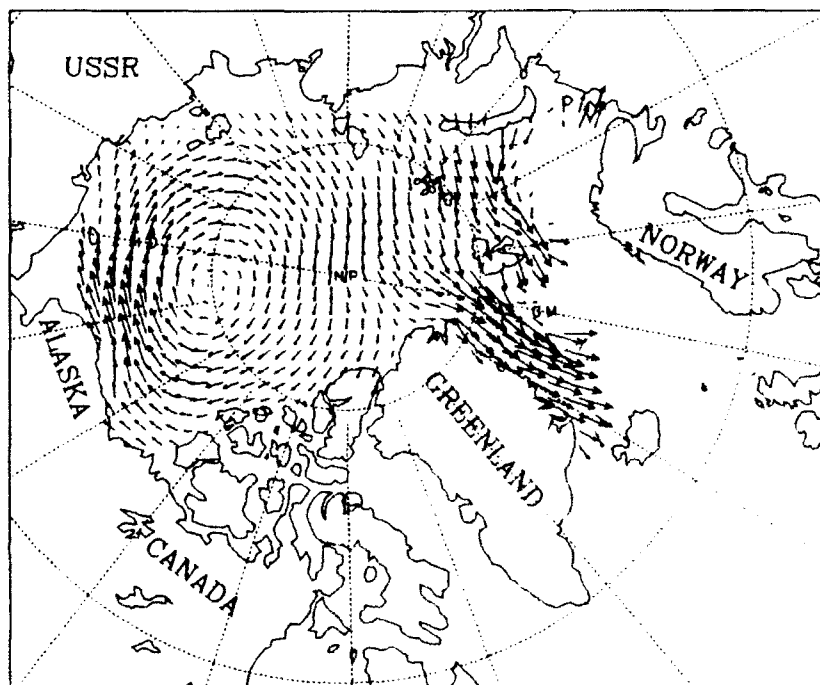
1992 JANUARY



0 200E-92
MAXIMUM VECTOR

ICE VELOCITIES

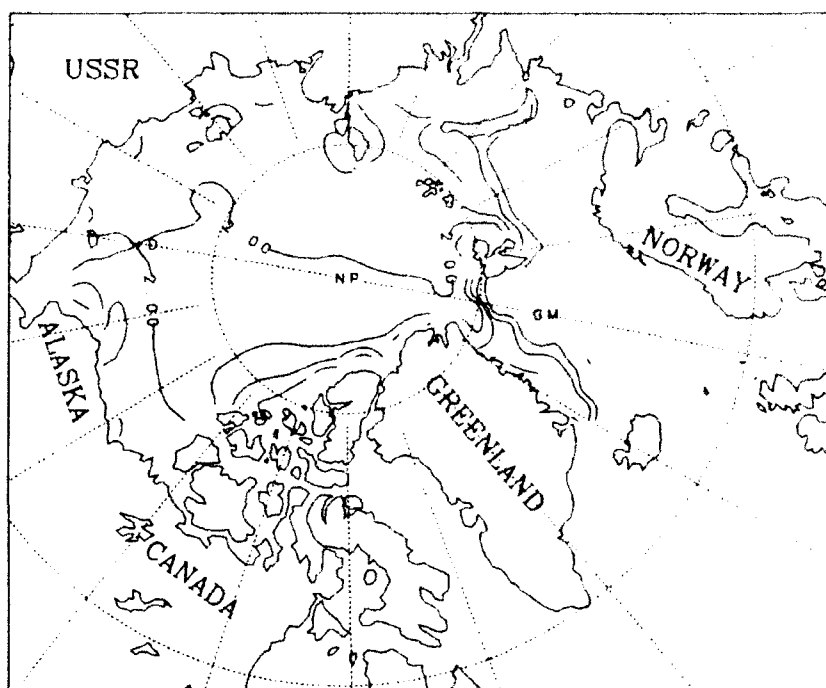
1992 JANUARY



0 300E-90
MAXIMUM VECTOR

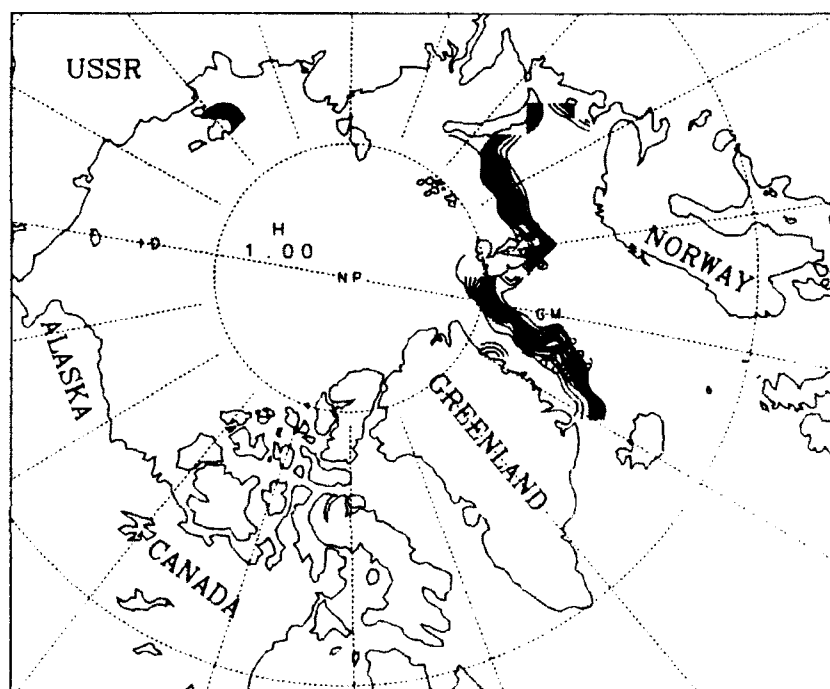
ICE THICKNESS

1992 JANUARY



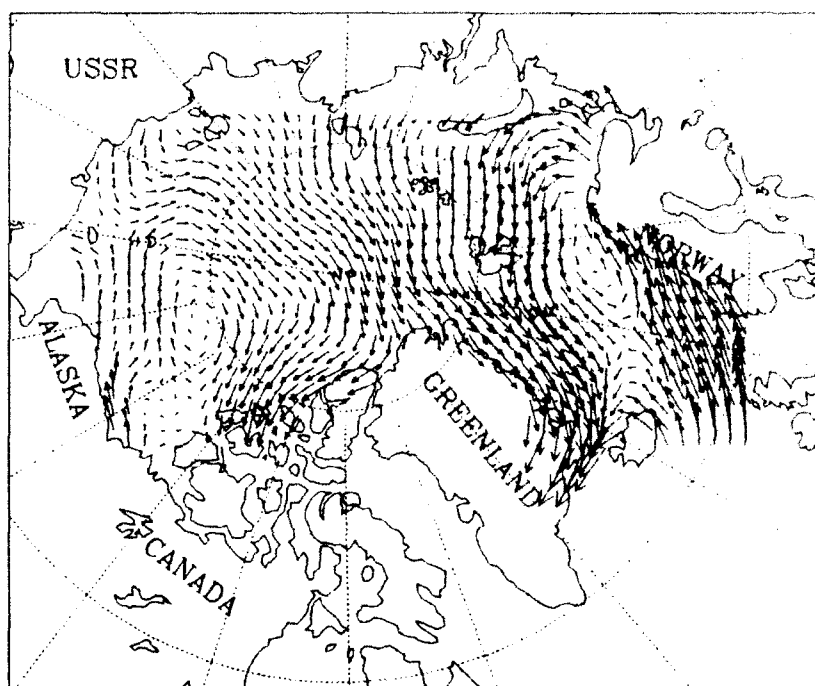
ICE CONCENTRATION

1992 JANUARY



WIND VELOCITIES

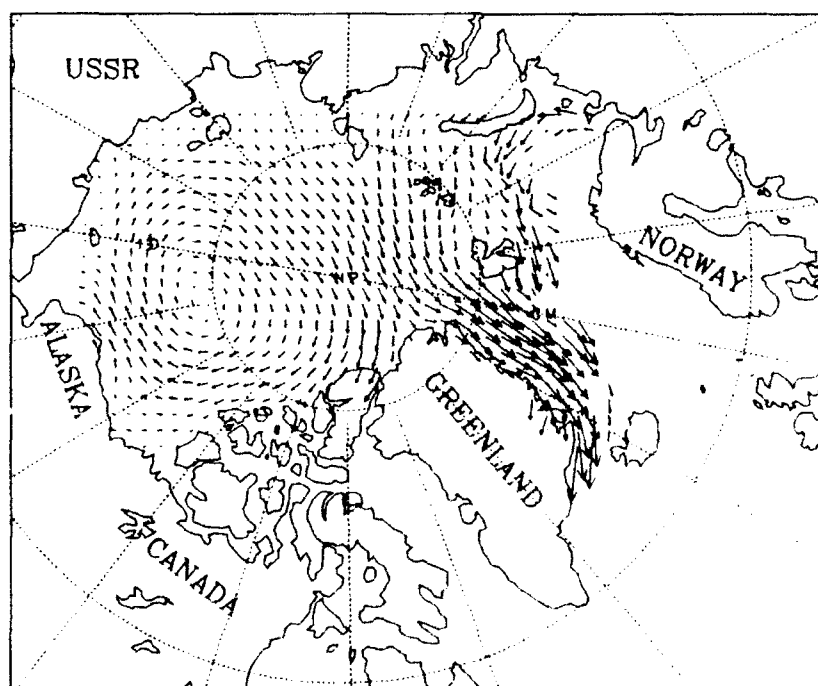
1992 FEBRUARY



0 2000-80
MAXIMUM VECTOR

ICE VELOCITIES

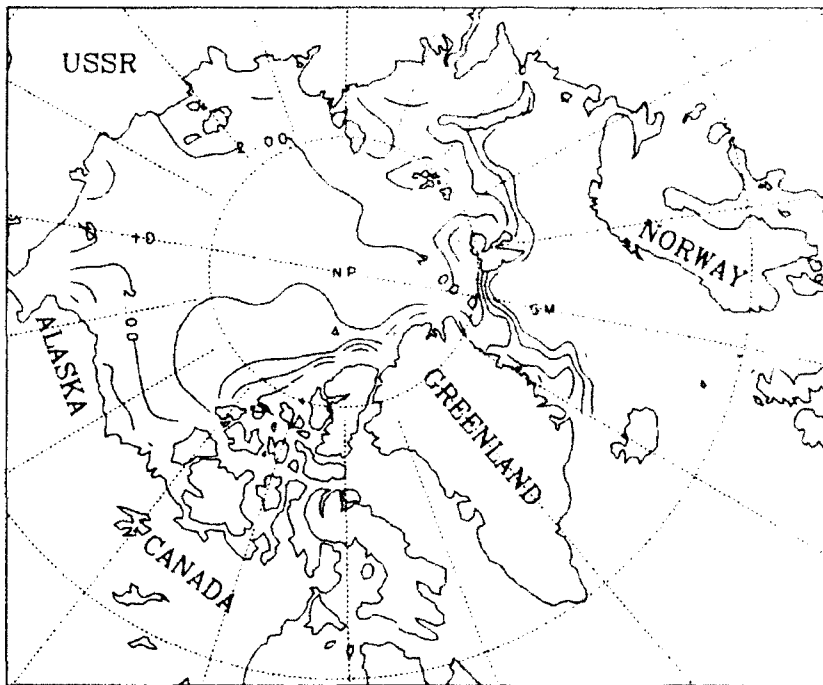
1992 FEBRUARY



0 3000-80
MAXIMUM VECTOR

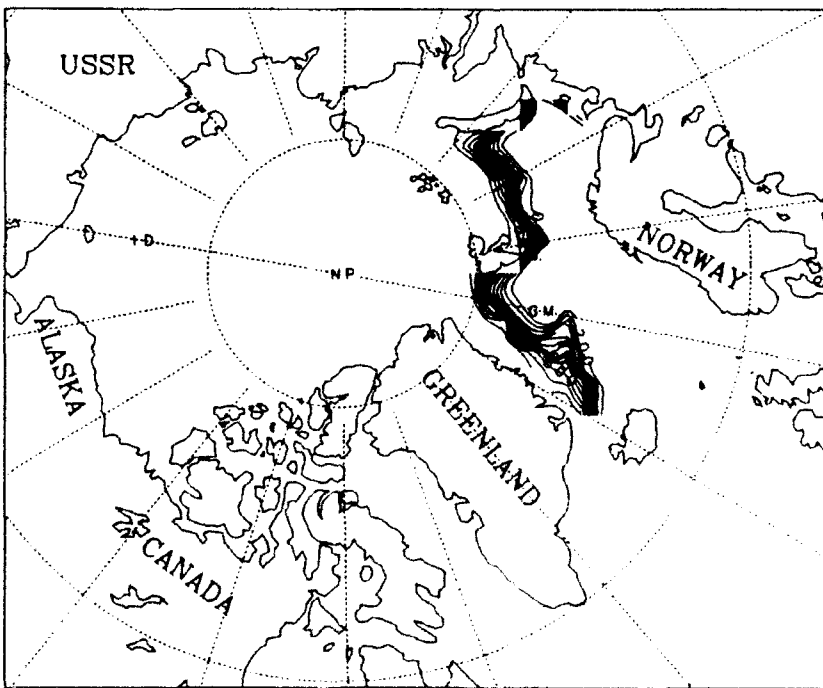
ICE THICKNESS

1992 FEBRUARY



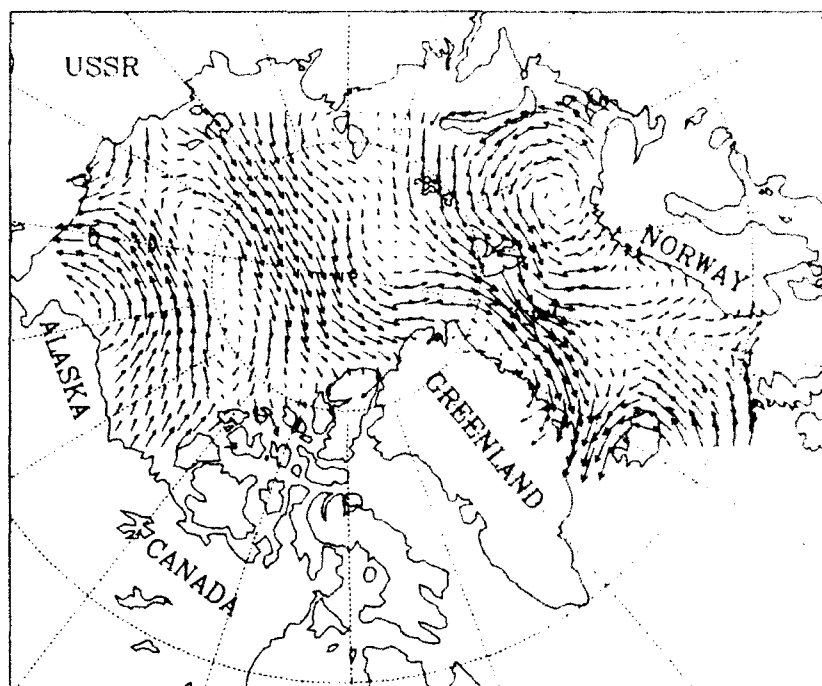
ICE CONCENTRATION

1992 FEBRUARY



WIND VELOCITIES

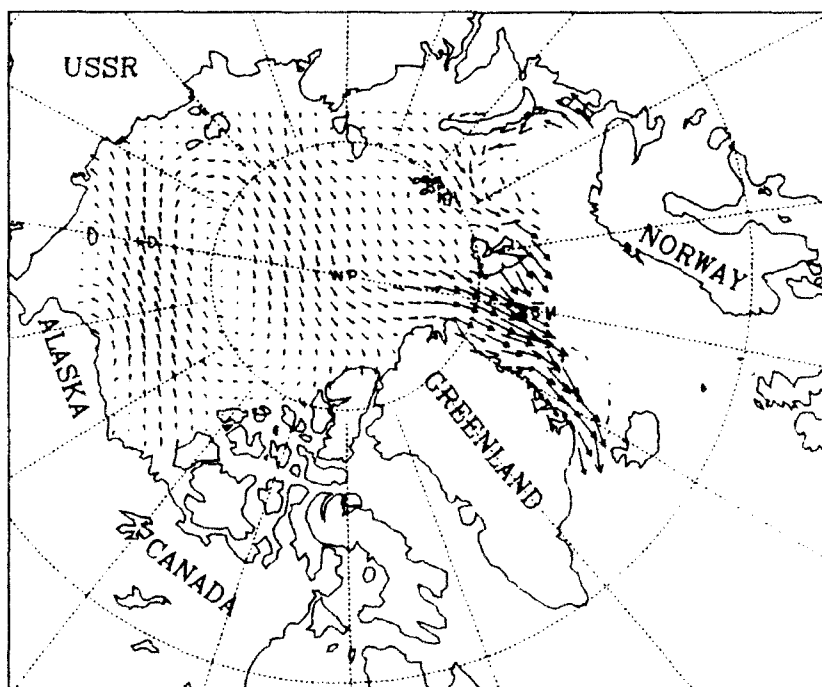
1992 MARCH



0 200E-02
MAXIMUM VECTOR

ICE VELOCITIES

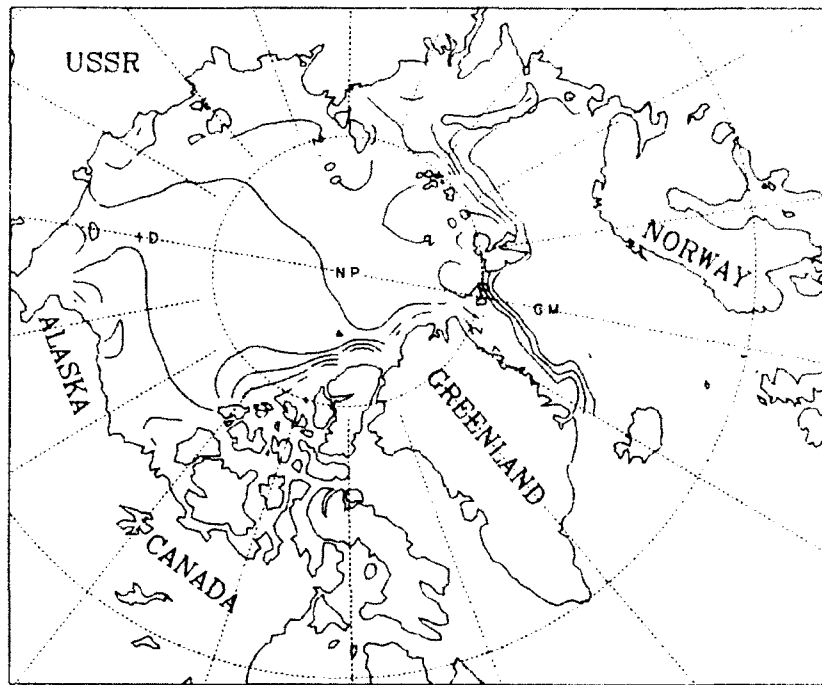
1992 MARCH



0 300E-00
MAXIMUM VECTOR

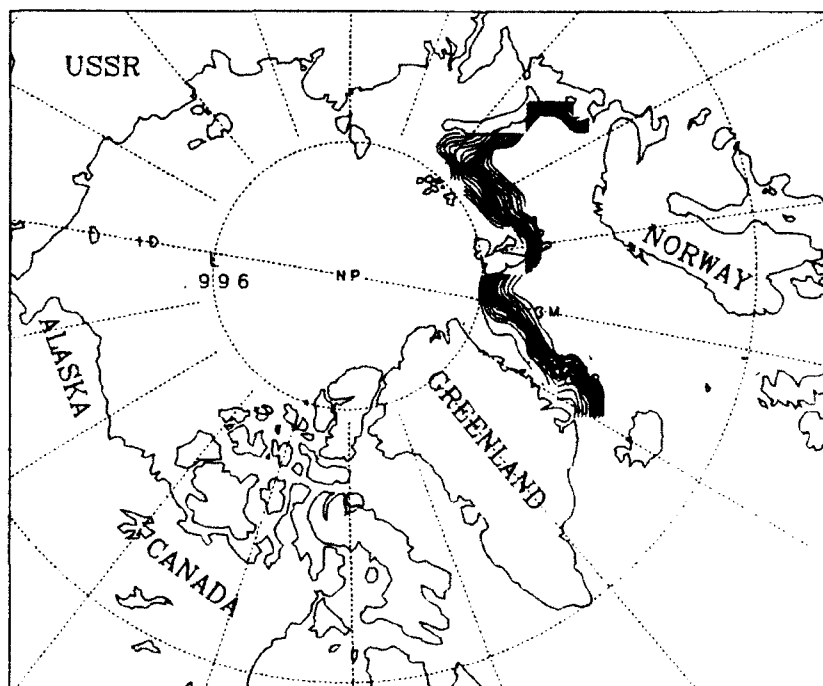
ICE THICKNESS

1992 MARCH



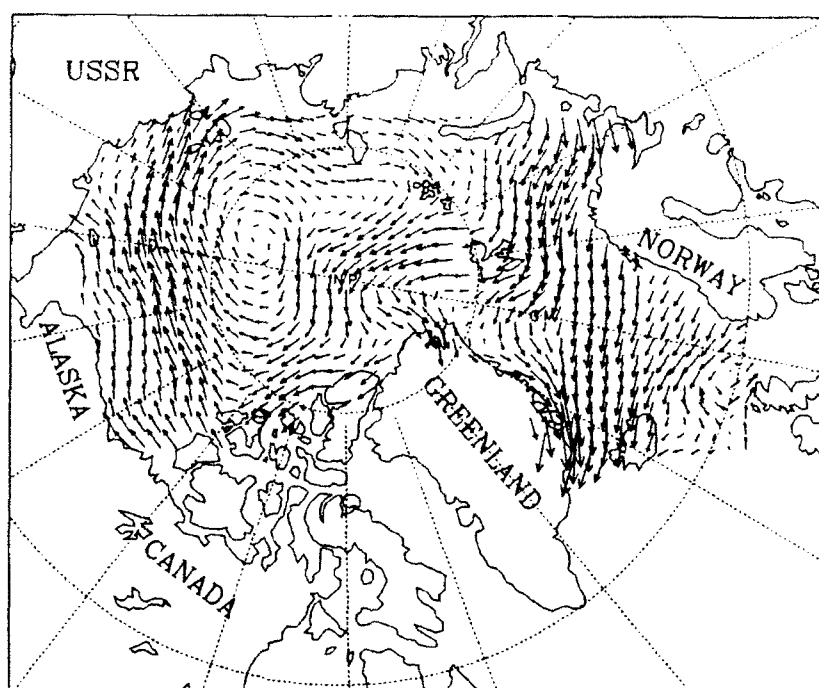
ICE CONCENTRATION

1992 MARCH



WIND VELOCITIES

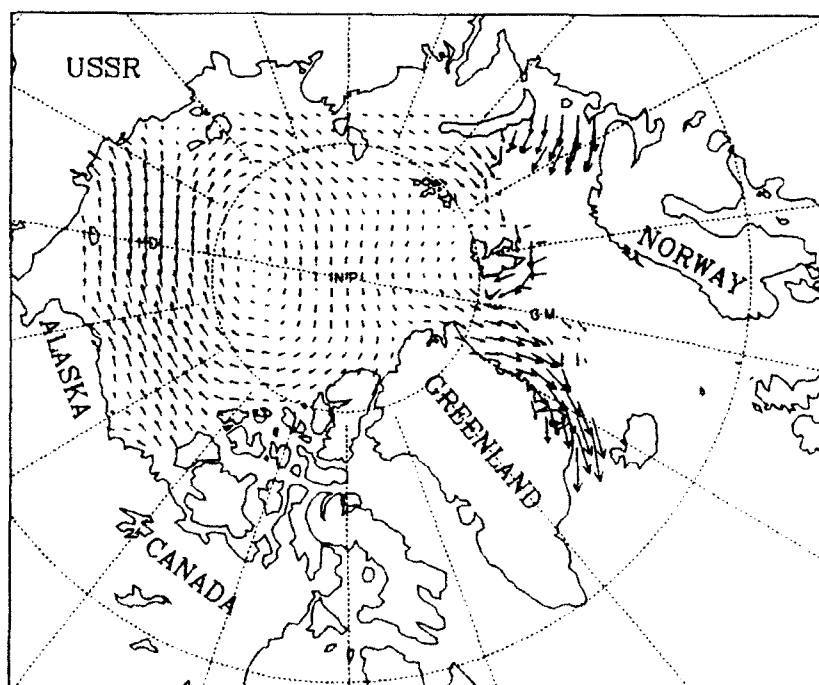
1992 APRIL



0.200E+02
MAXIMUM VECTOR

ICE VELOCITIES

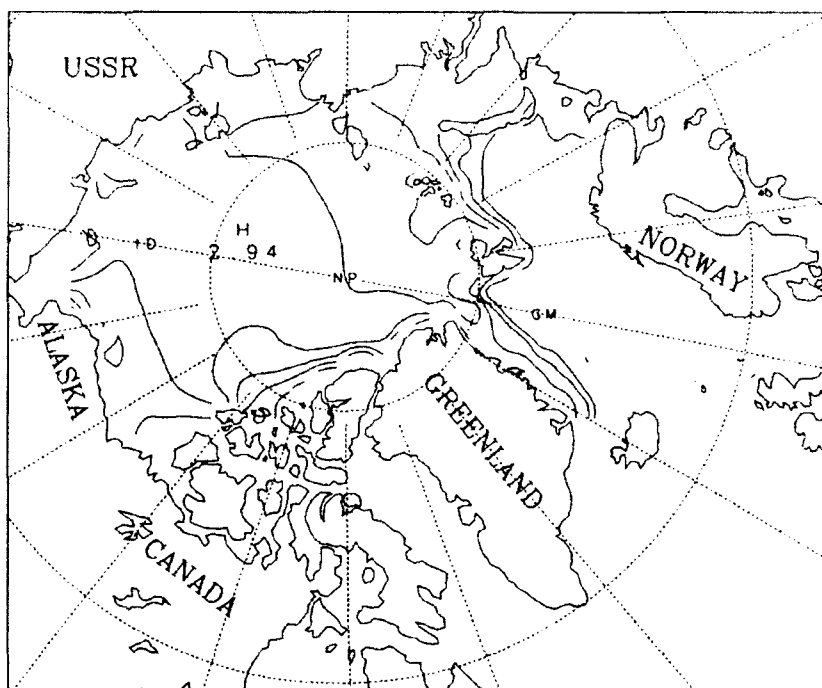
1992 APRIL



0.300E+02
MAXIMUM VECTOR

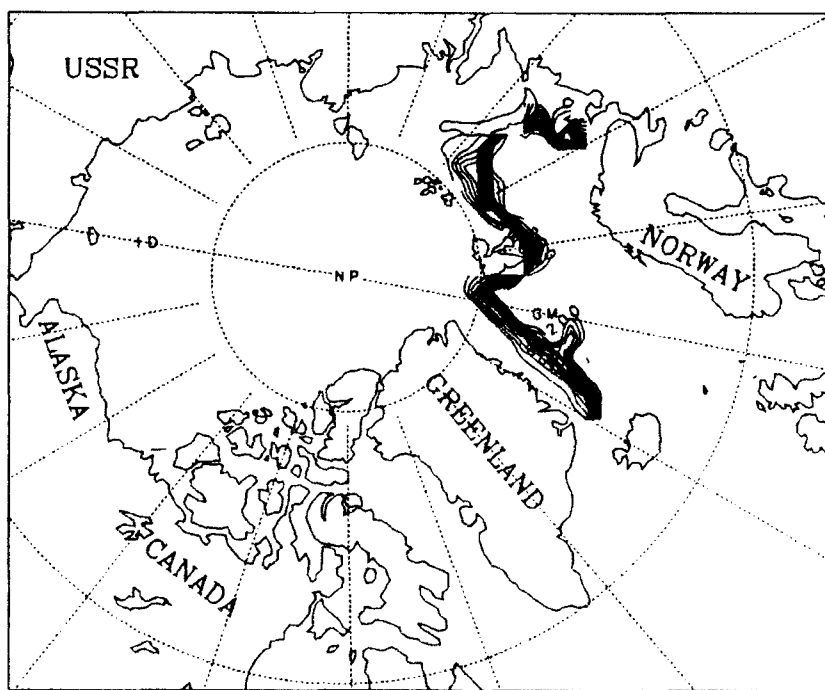
ICE THICKNESS

1992 APRIL



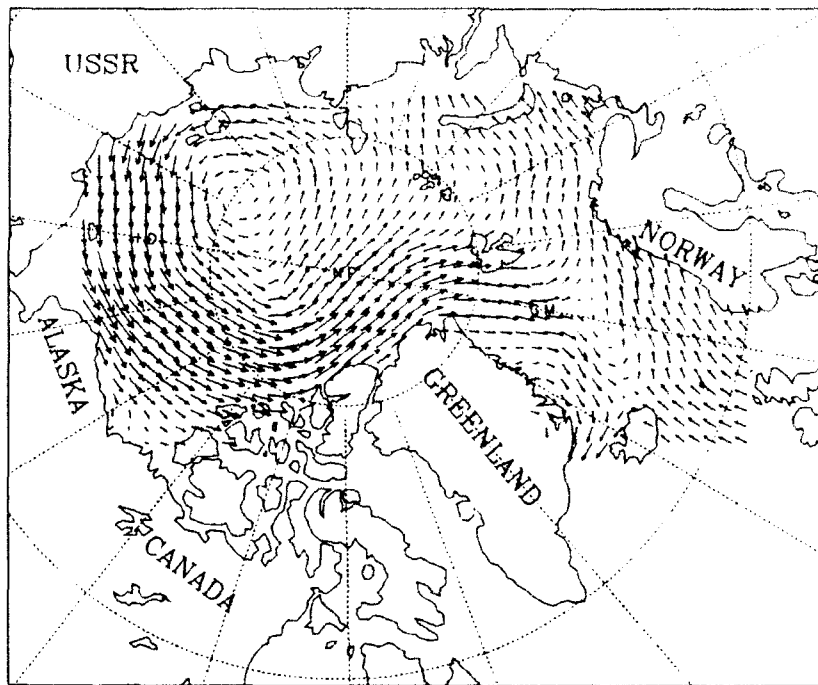
ICE CONCENTRATION

1992 APRIL



WIND VELOCITIES

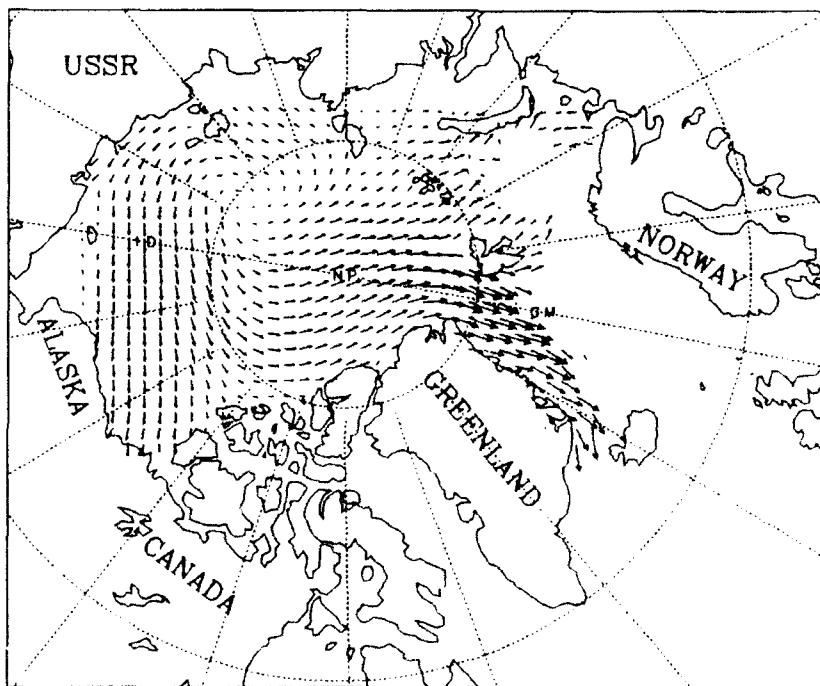
1992 MAY



0.200E-02
MAXIMUM VECTOR

ICE VELOCITIES

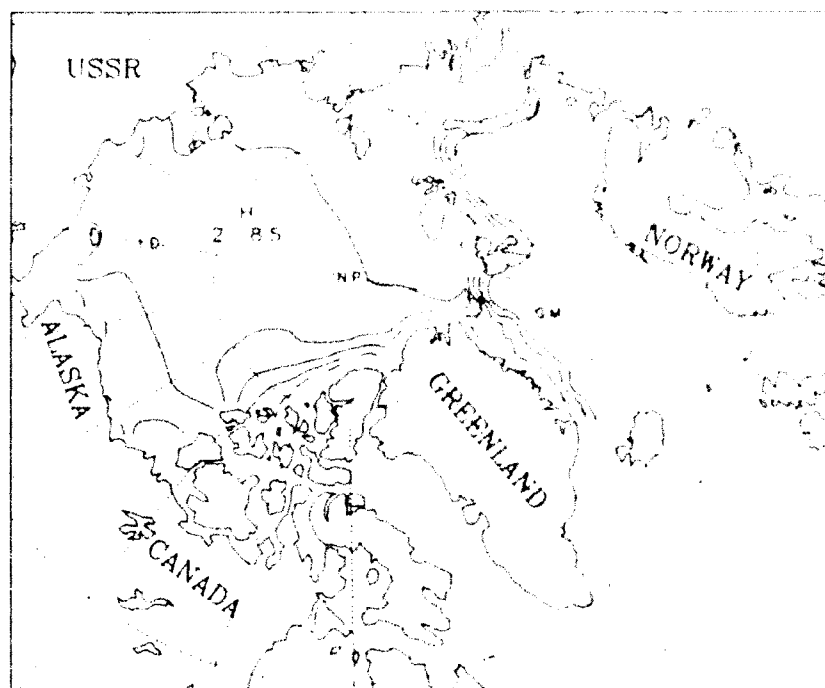
1992 MAY



0.300E-00
MAXIMUM VECTOR

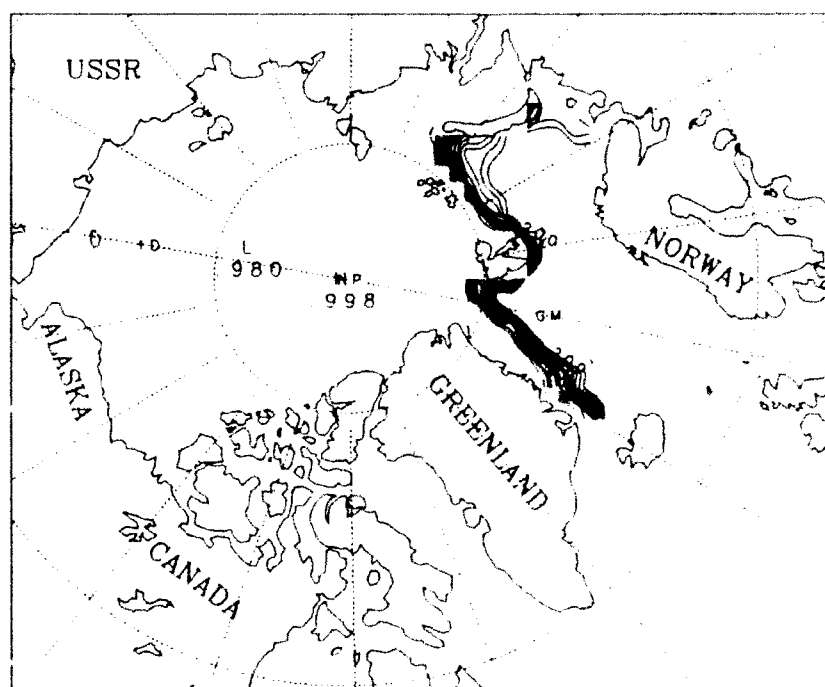
ICE THICKNESS

1992 MAY



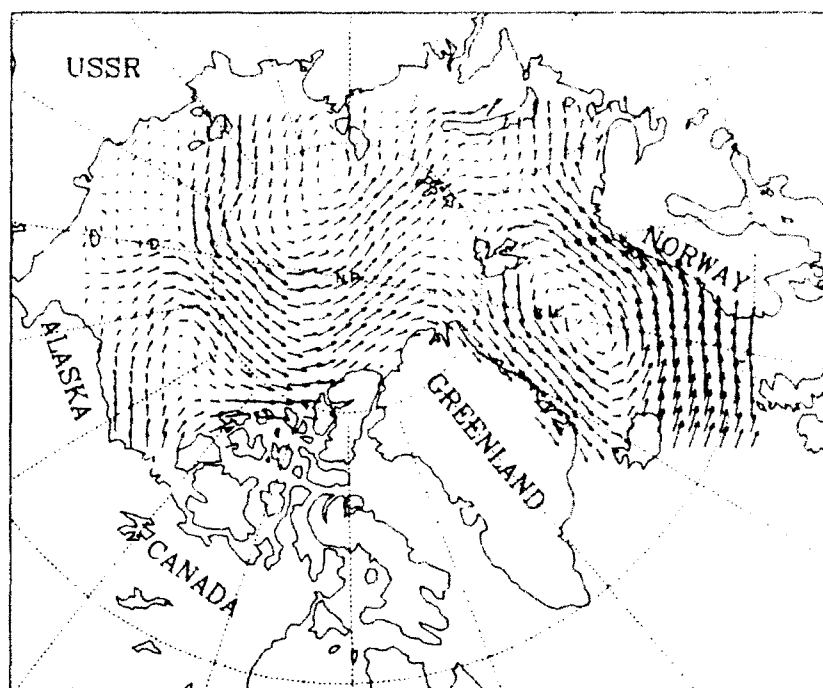
ICE CONCENTRATION

1992 MAY



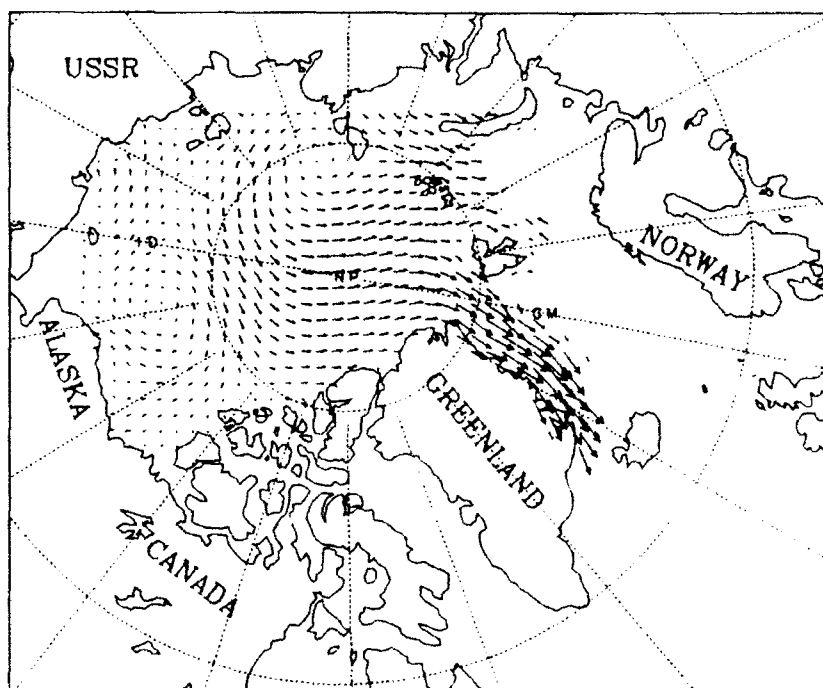
WIND VELOCITIES

1992 JUNE



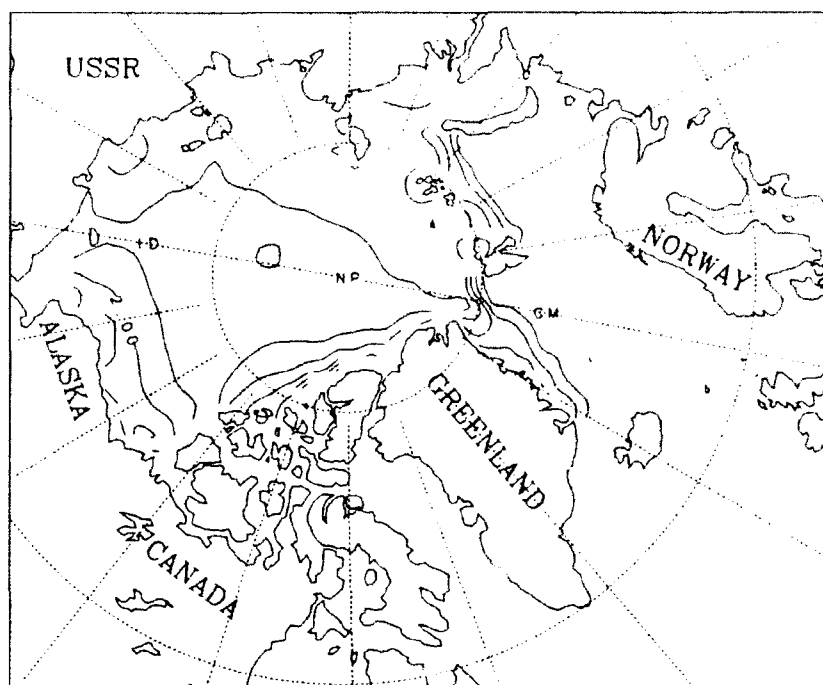
ICE VELOCITIES

1992 JUNE



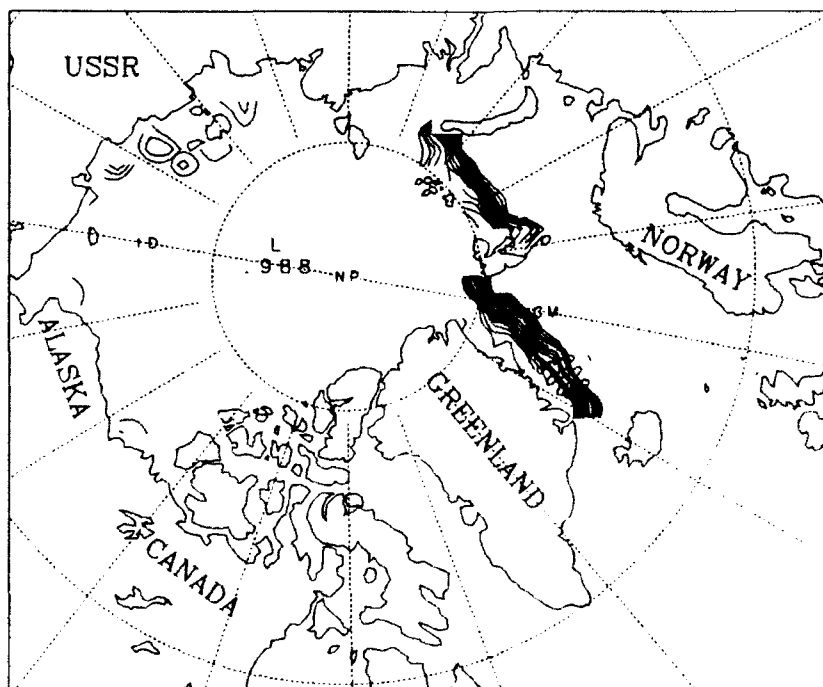
ICE THICKNESS

1992 JUNE



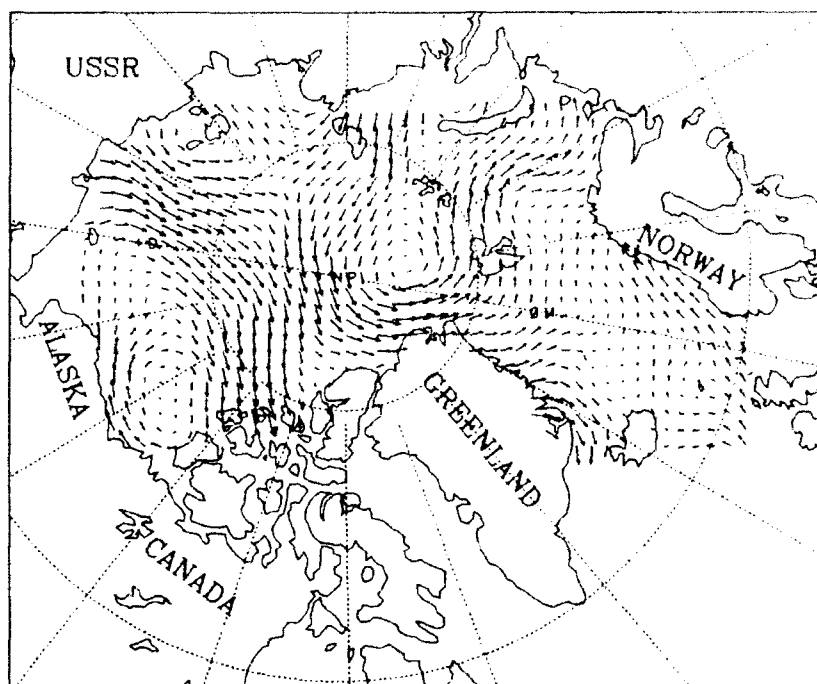
ICE CONCENTRATION

1992 JUNE



WIND VELOCITIES

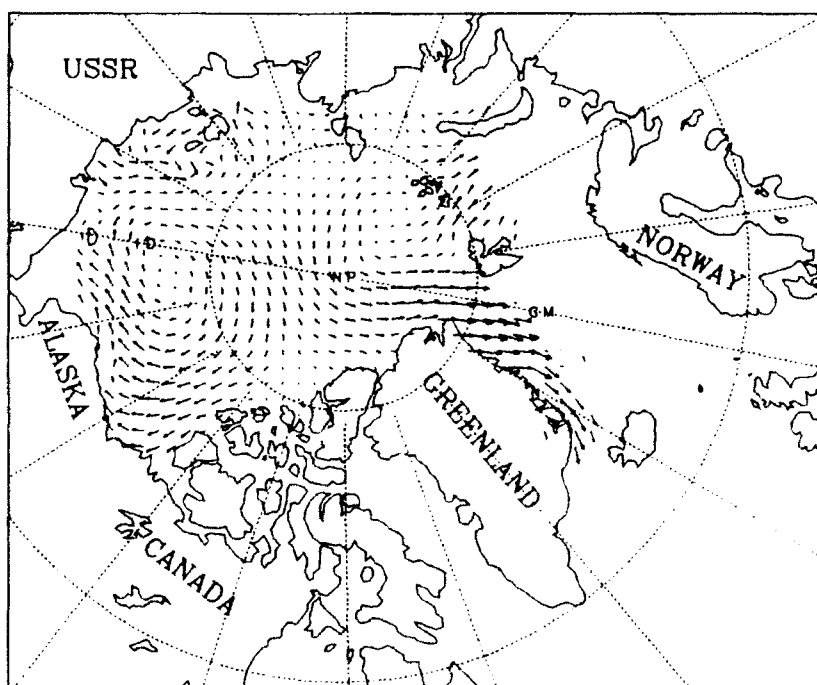
1992 JULY



0.200E+02
MAXIMUM VECTOR

ICE VELOCITIES

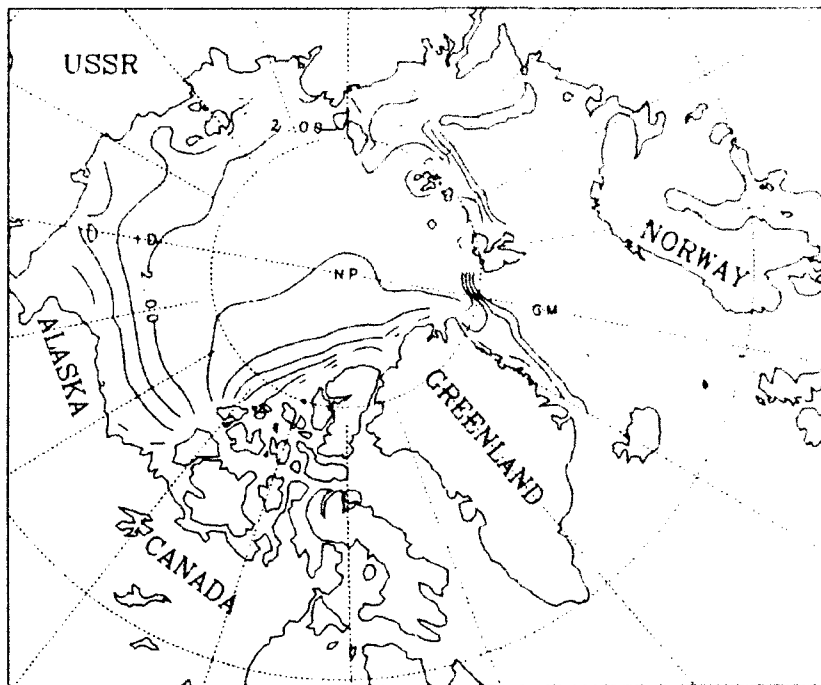
1992 JULY



0.300E+00
MAXIMUM VECTOR

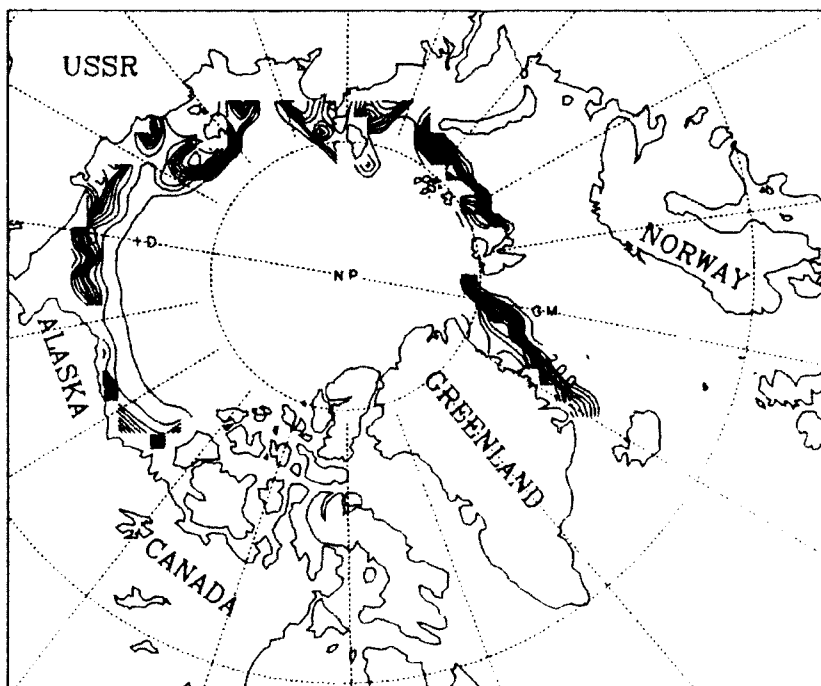
ICE THICKNESS

1992 JULY



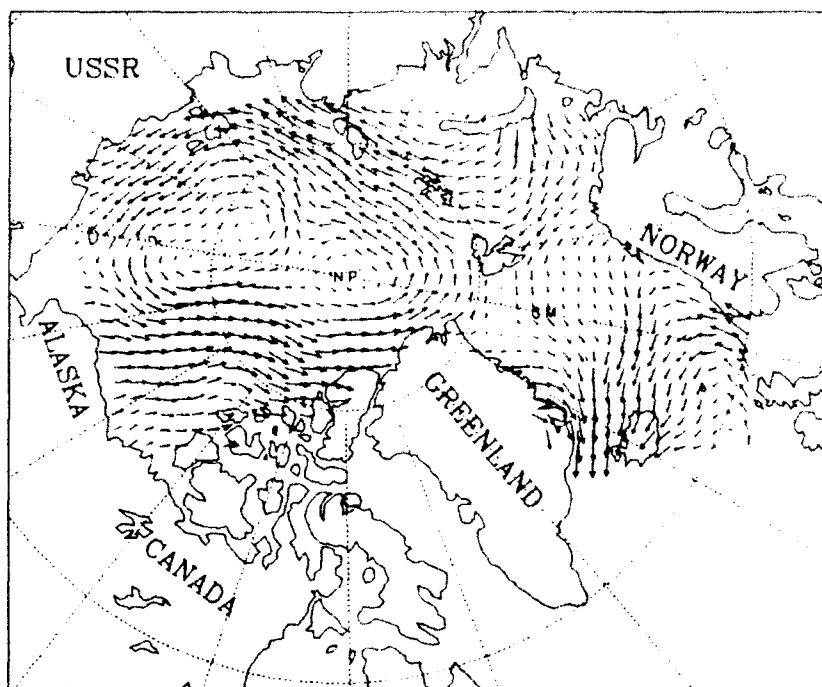
ICE CONCENTRATION

1992 JULY



WIND VELOCITIES

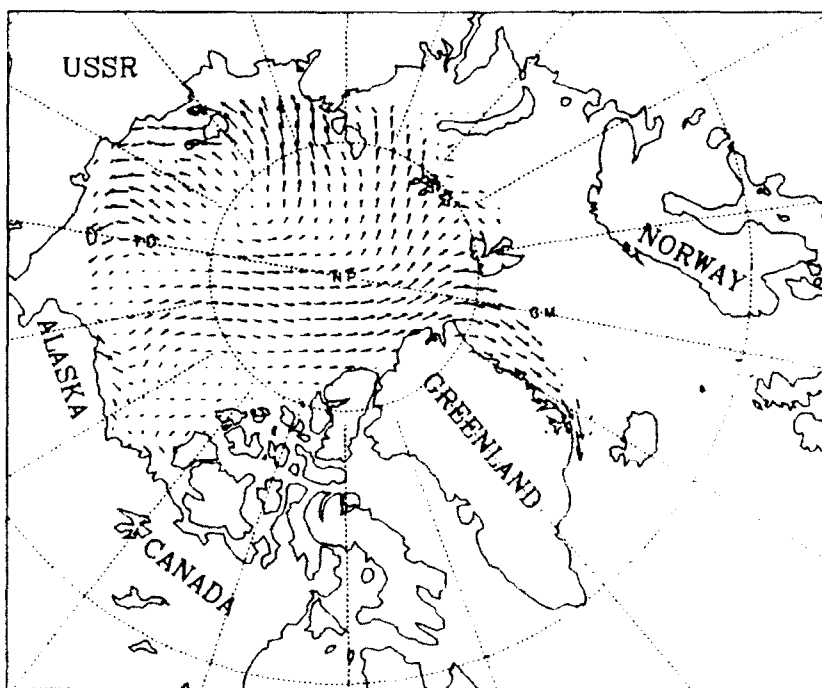
1992 AUGUST



0 2001-02
MAXIMUM VECTOR

ICE VELOCITIES

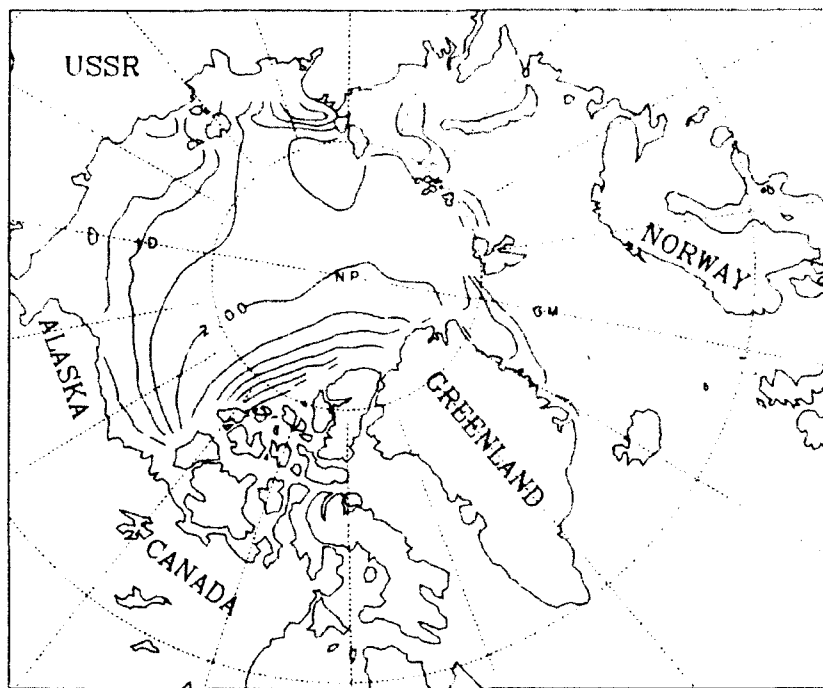
1992 AUGUST



0 3091-00
MAXIMUM VECTOR

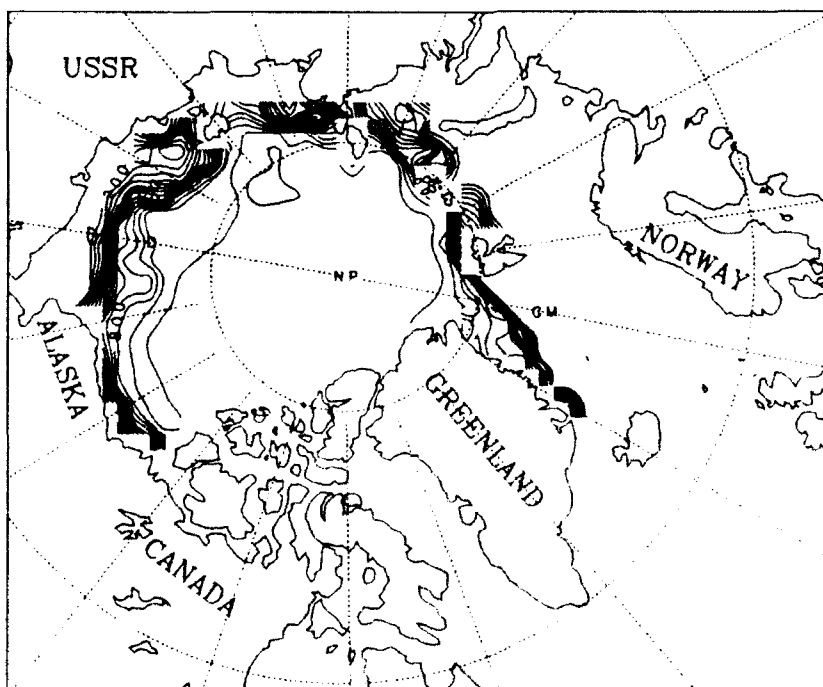
ICE THICKNESS

1992 AUGUST



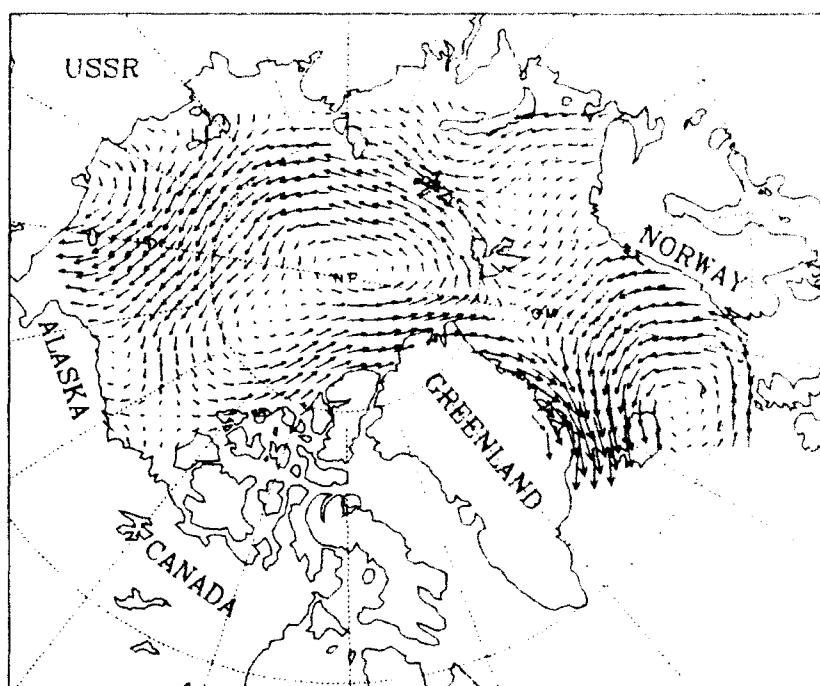
ICE CONCENTRATION

1992 AUGUST



WIND VELOCITIES

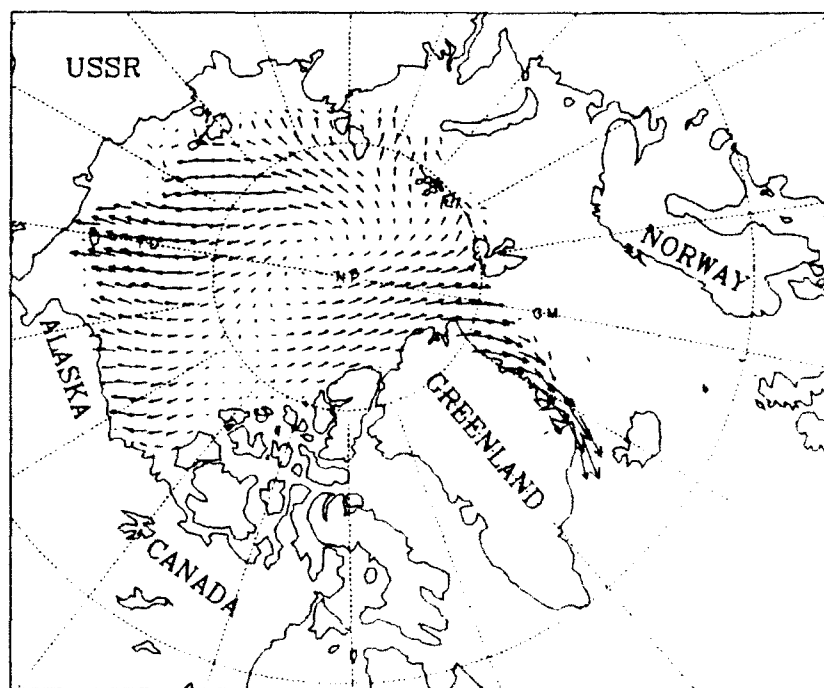
1992 SEPTEMBER



0 300E-02
MAXIMUM VECTOR

ICE VELOCITIES

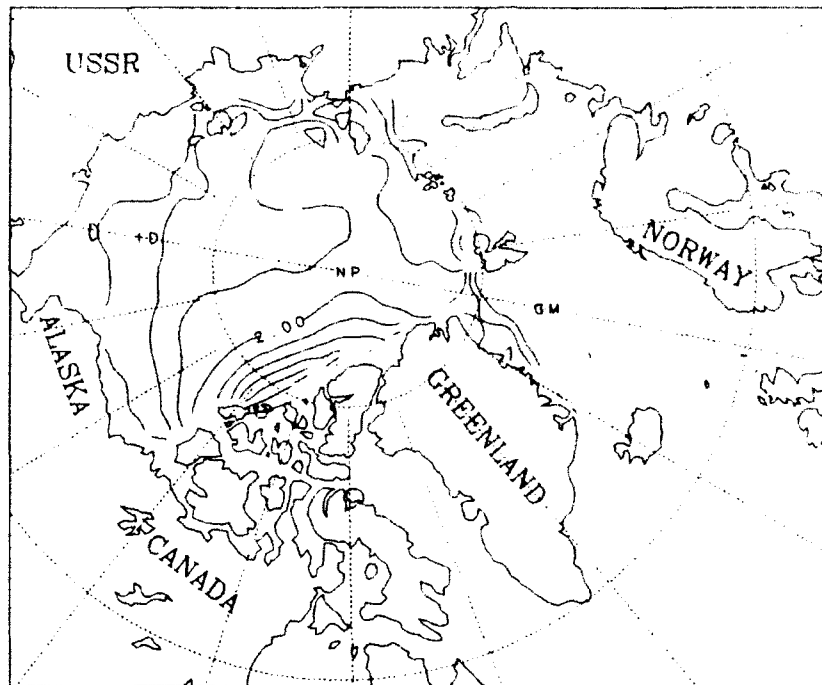
1992 SEPTEMBER



0 300E-02
MAXIMUM VECTOR

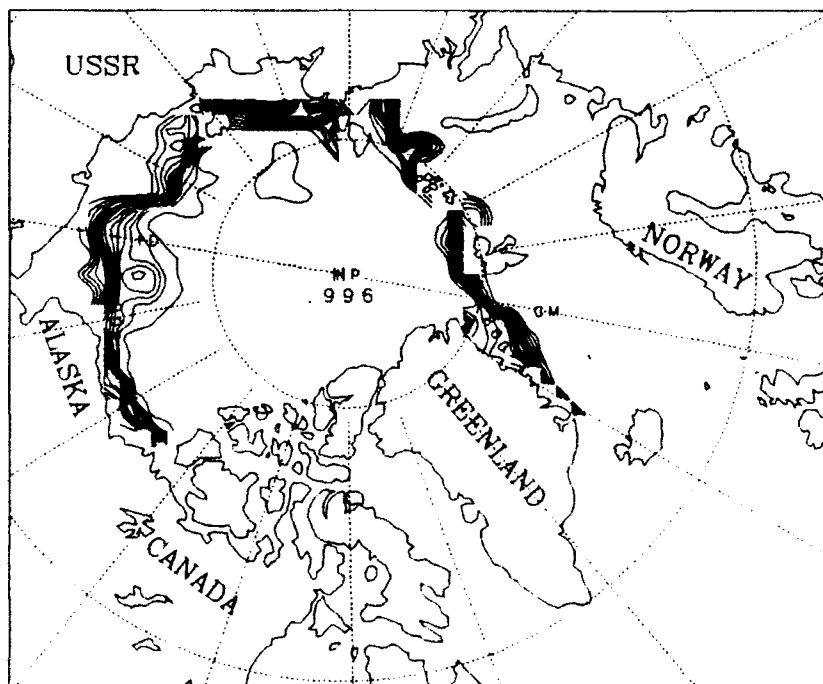
ICE THICKNESS

1992 SEPTEMBER



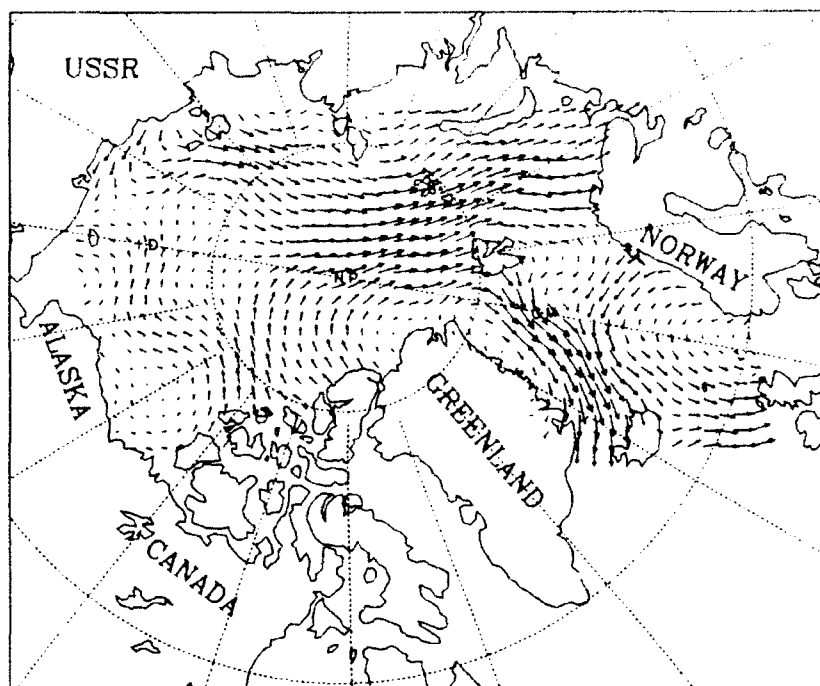
ICE CONCENTRATION

1992 SEPTEMBER



WIND VELOCITIES

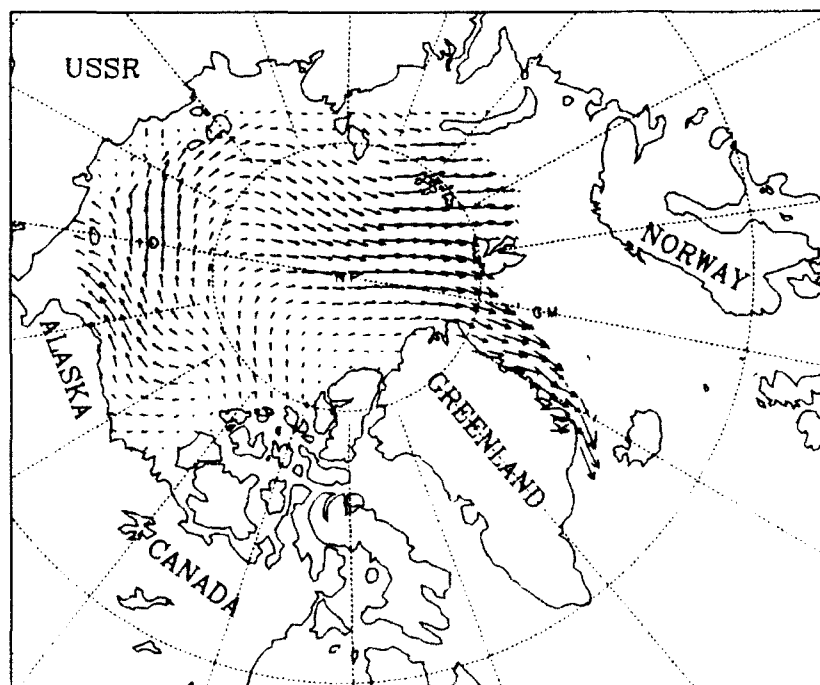
1992 OCTOBER



0.200E+02
MAXIMUM VECTOR

ICE VELOCITIES

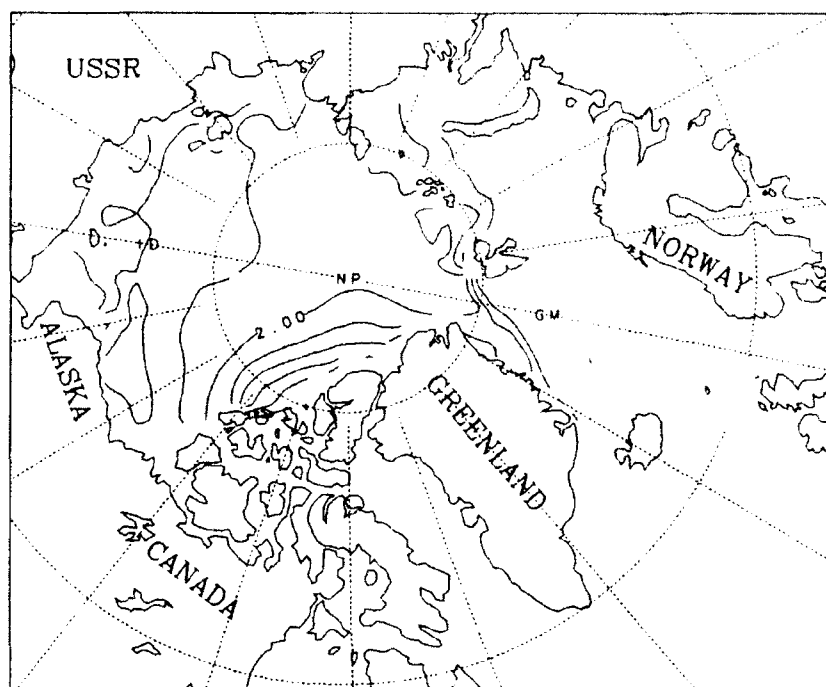
1992 OCTOBER



0.300E+00
MAXIMUM VECTOR

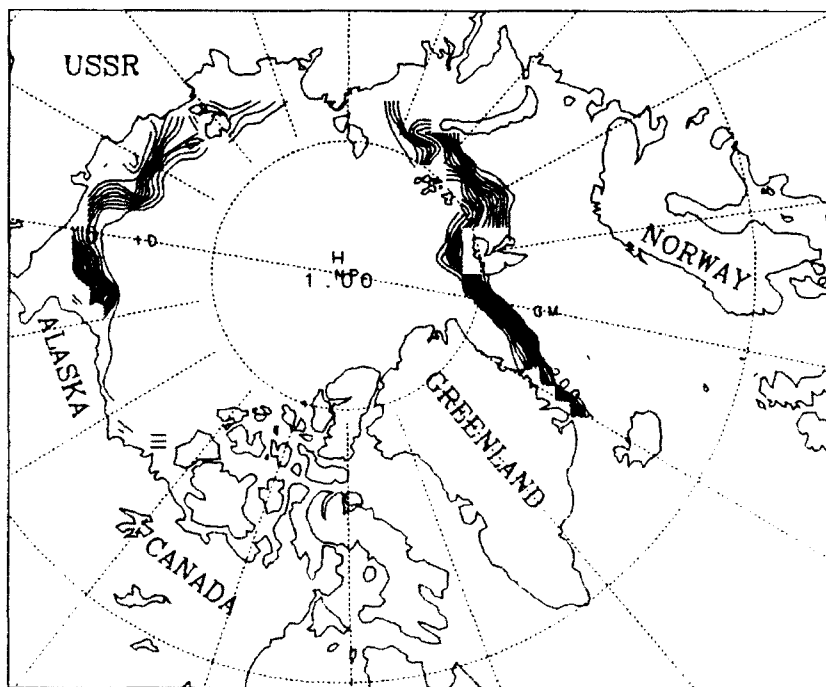
ICE THICKNESS

1992 OCTOBER



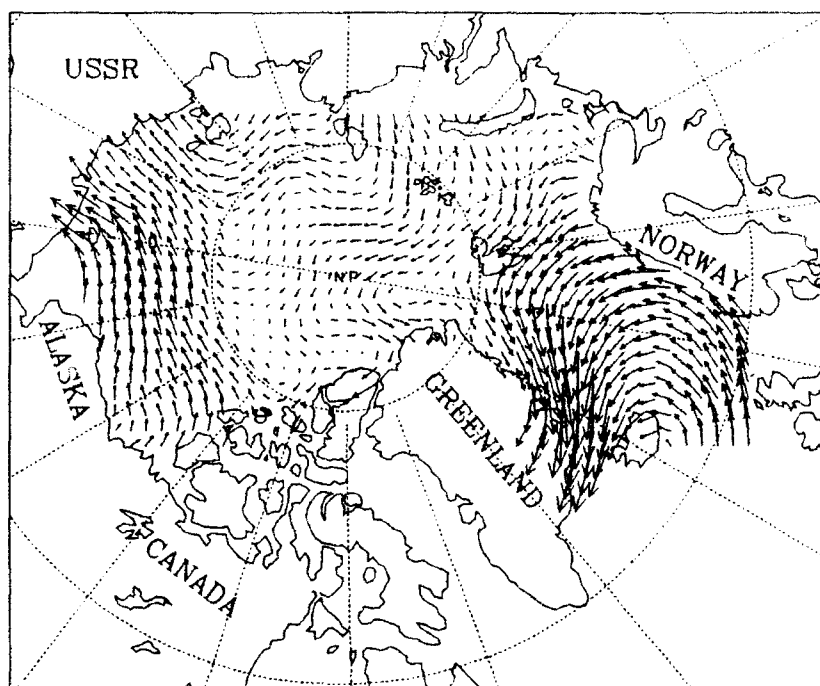
ICE CONCENTRATION

1992 OCTOBER



WIND VELOCITIES

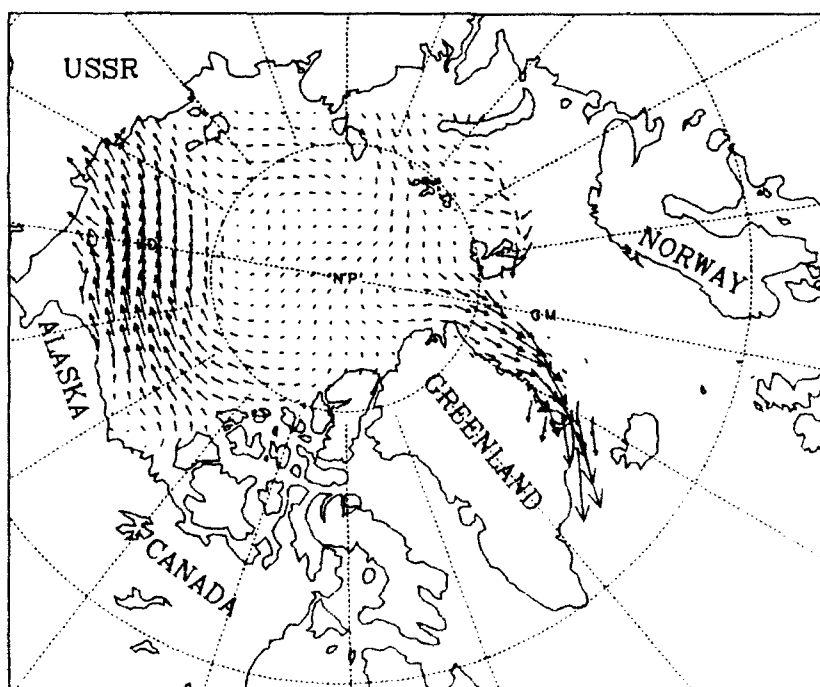
1992 NOVEMBER



0.200E+02
MAXIMUM VECTOR

ICE VELOCITIES

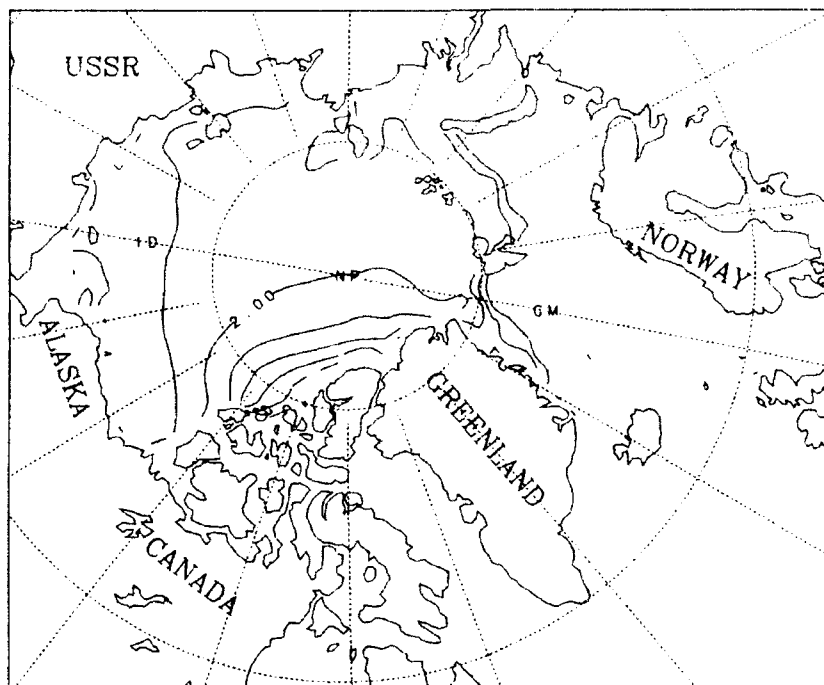
1992 NOVEMBER



0.500E+00
MAXIMUM VECTOR

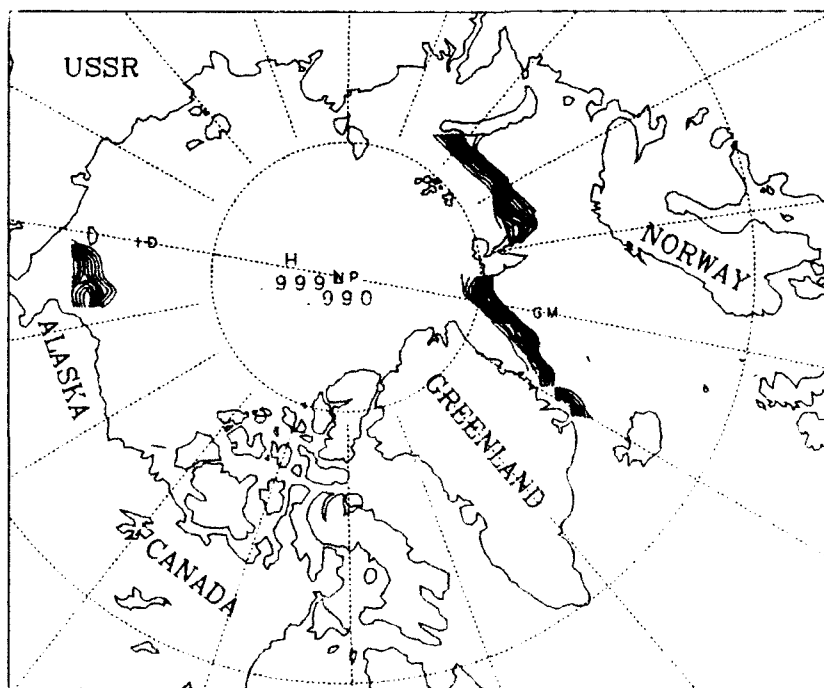
ICE THICKNESS

1992 NOVEMBER



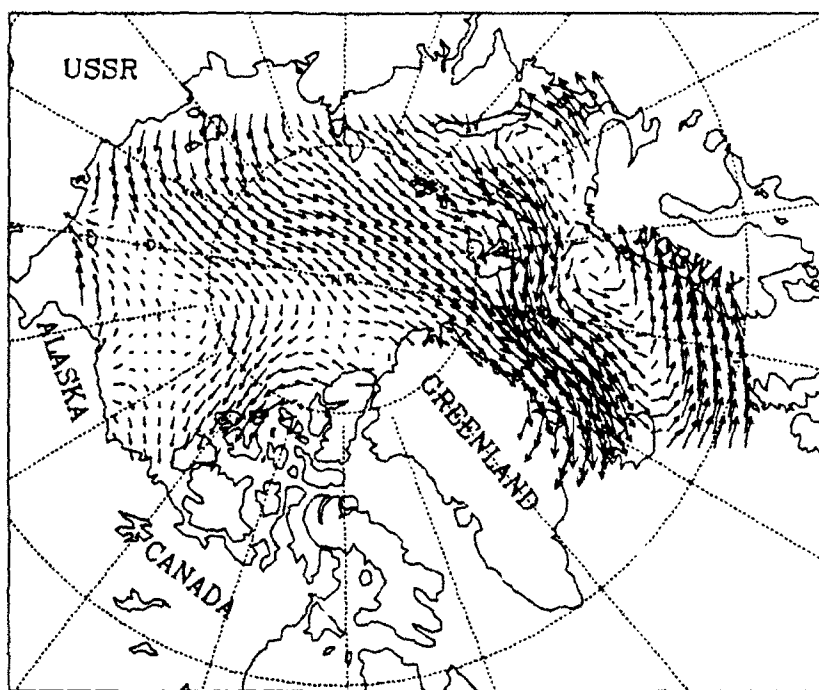
ICE CONCENTRATION

1992 NOVEMBER



WIND VELOCITIES

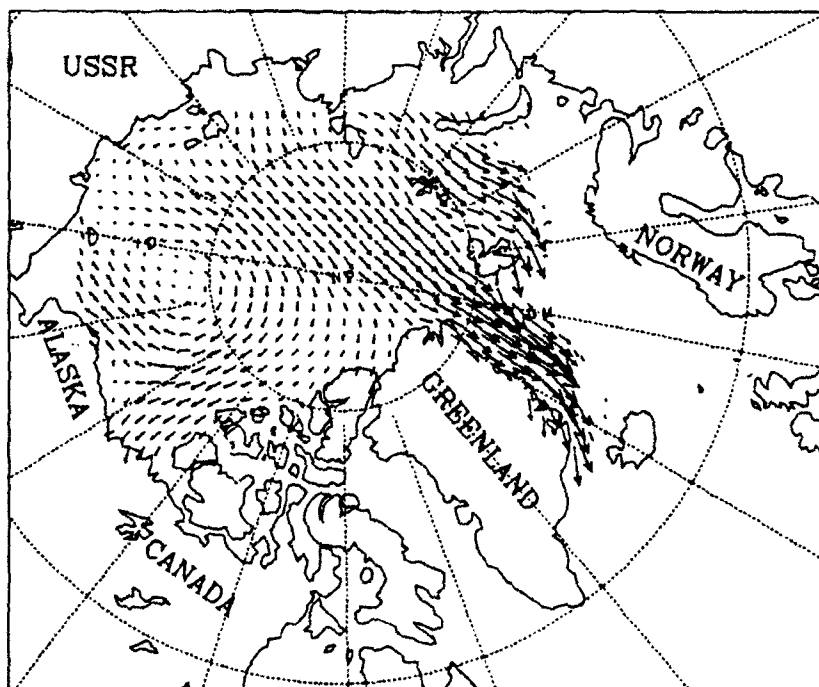
1992 DECEMBER



0.200E-02
MAXIMUM VECTOR

ICE VELOCITIES

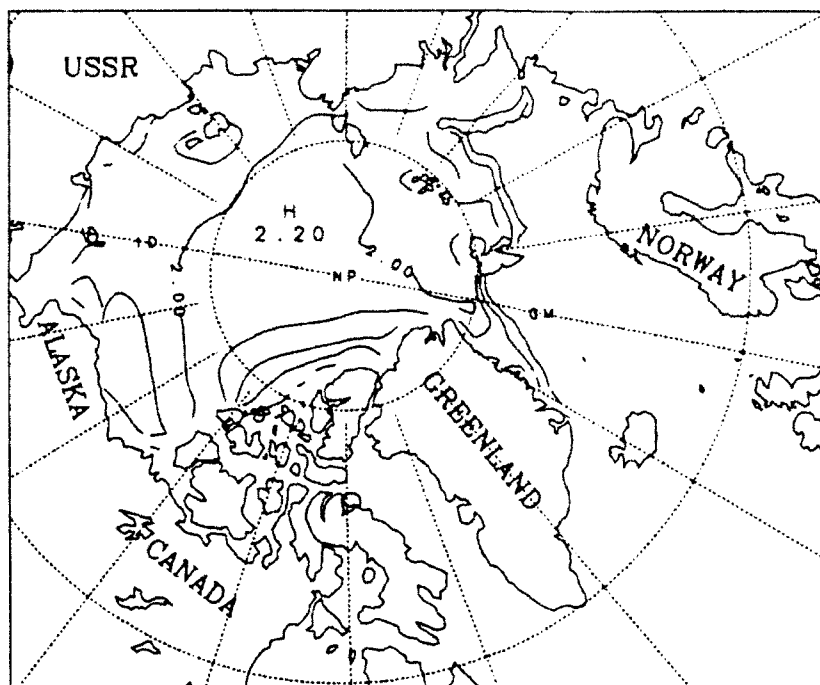
1992 DECEMBER



0.300E-00
MAXIMUM VECTOR

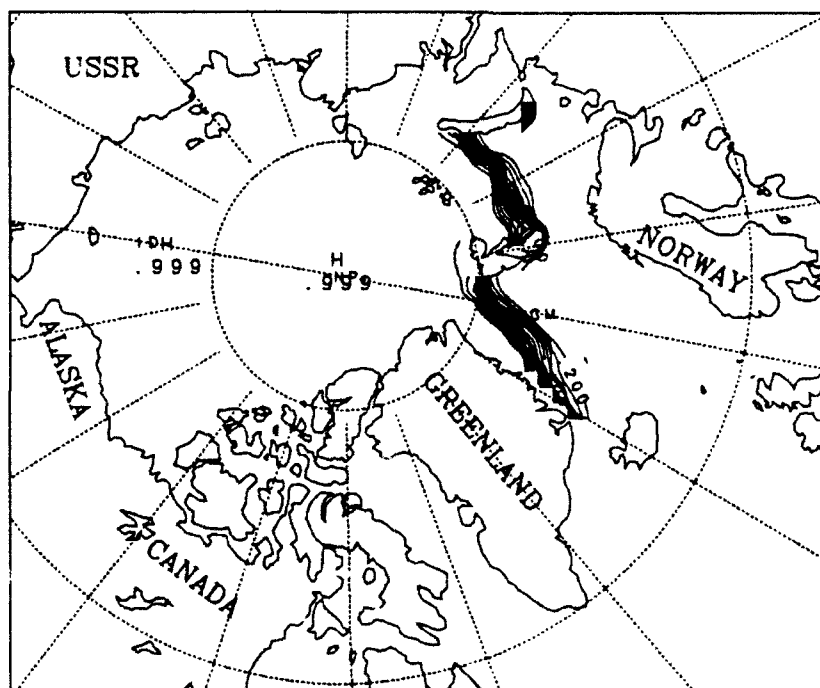
ICE THICKNESS

1992 DECEMBER



ICE CONCENTRATION

1992 DECEMBER



RPIPS-B MODEL GRID

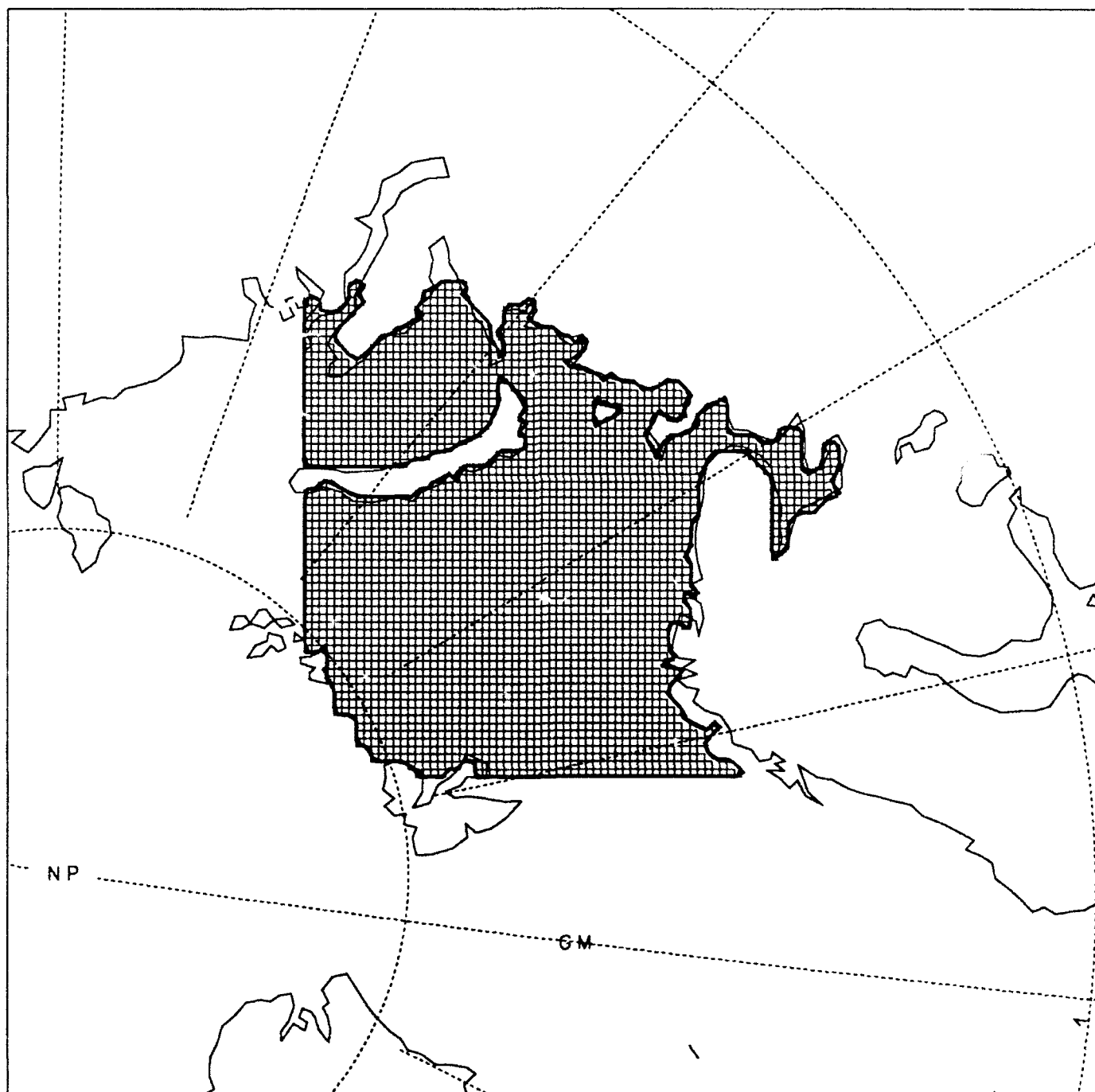


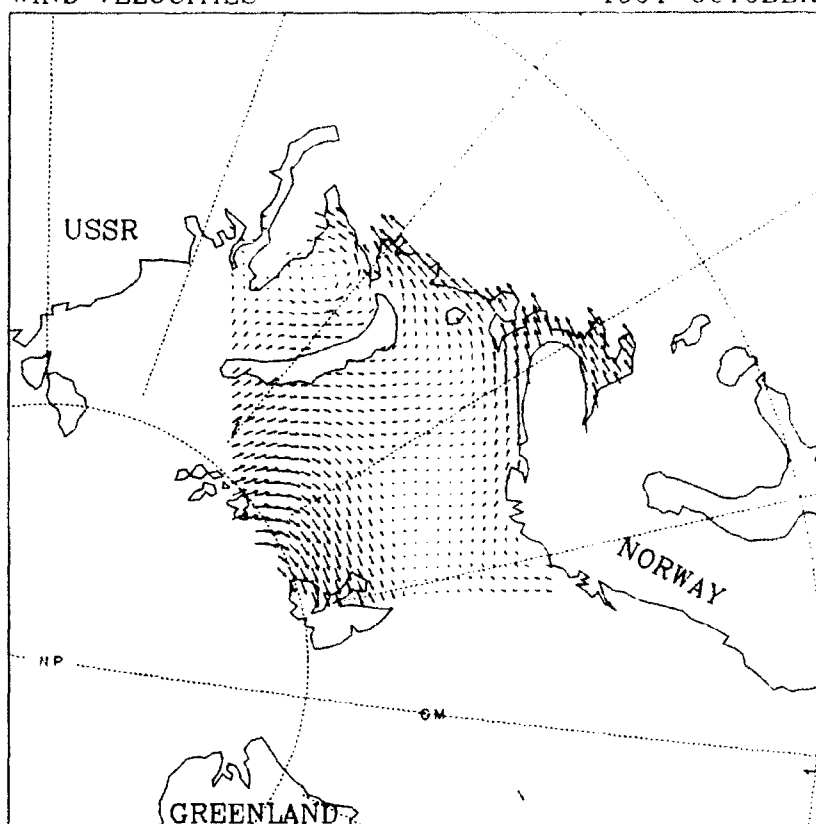
Figure 2. RPIPS-B domain with the 25 km resolution grid overlaid.

RPIPS-B 1991

MONTHLY MEANS

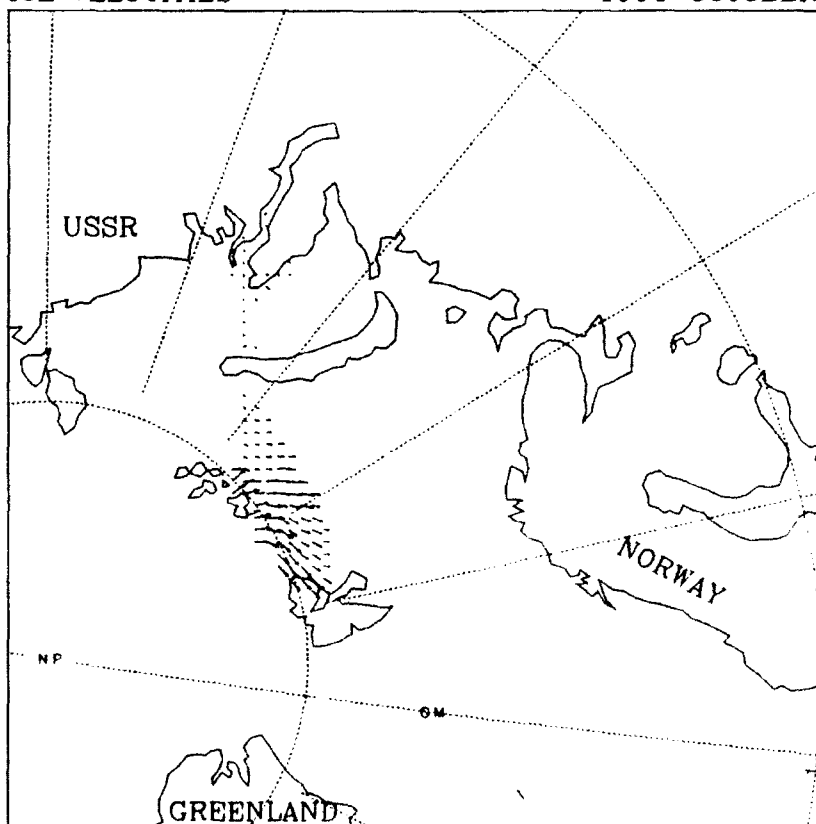
WIND VELOCITIES

1991 OCTOBER



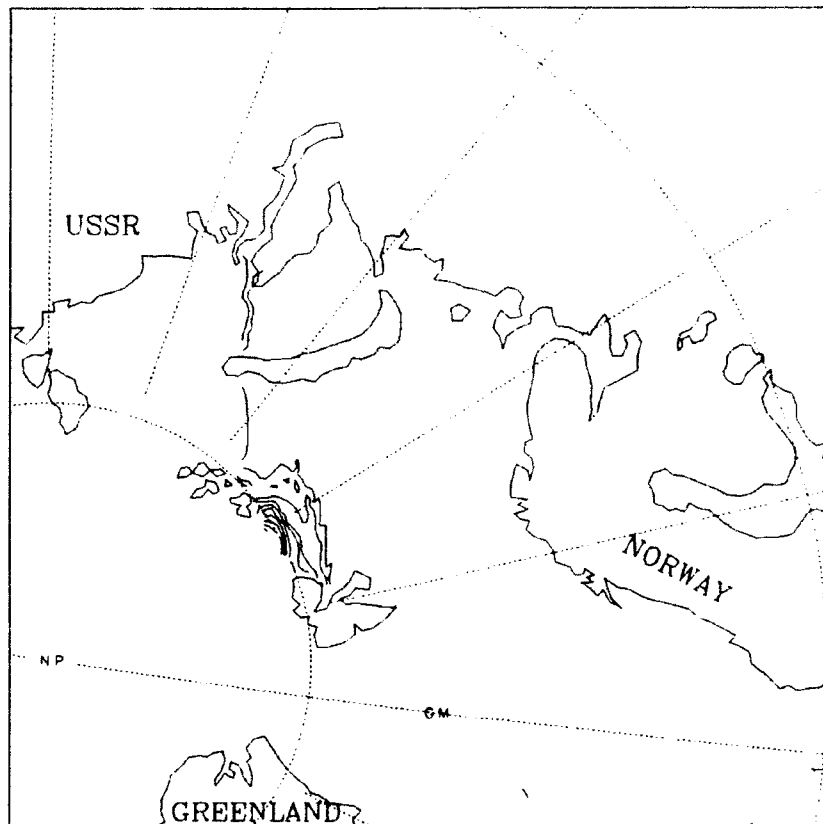
ICE VELOCITIES

1991 OCTOBER



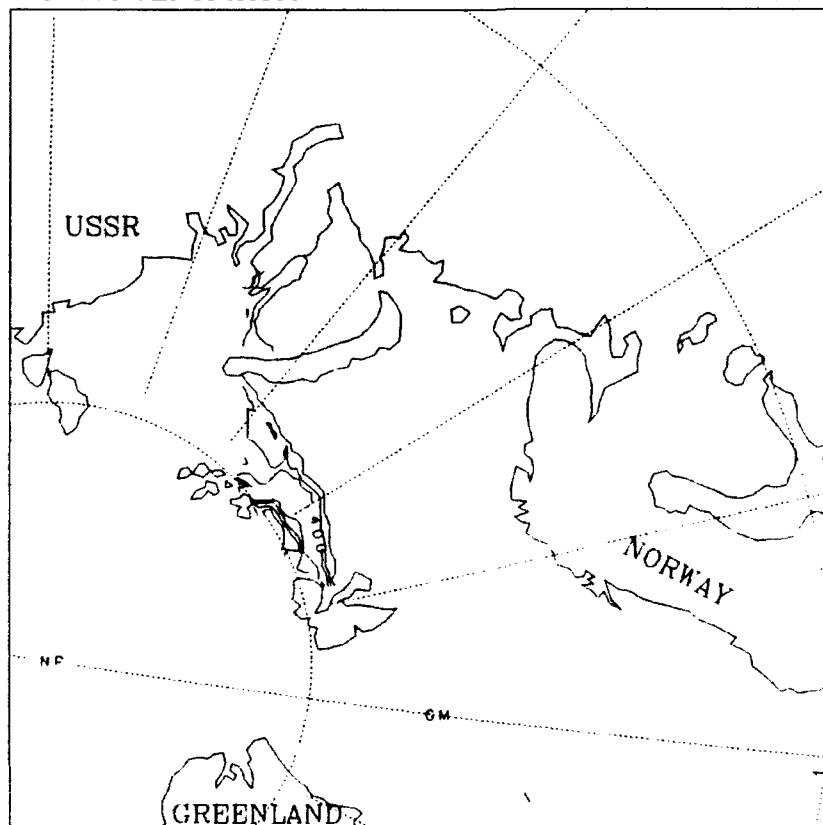
ICE THICKNESS

1991 OCTOBER



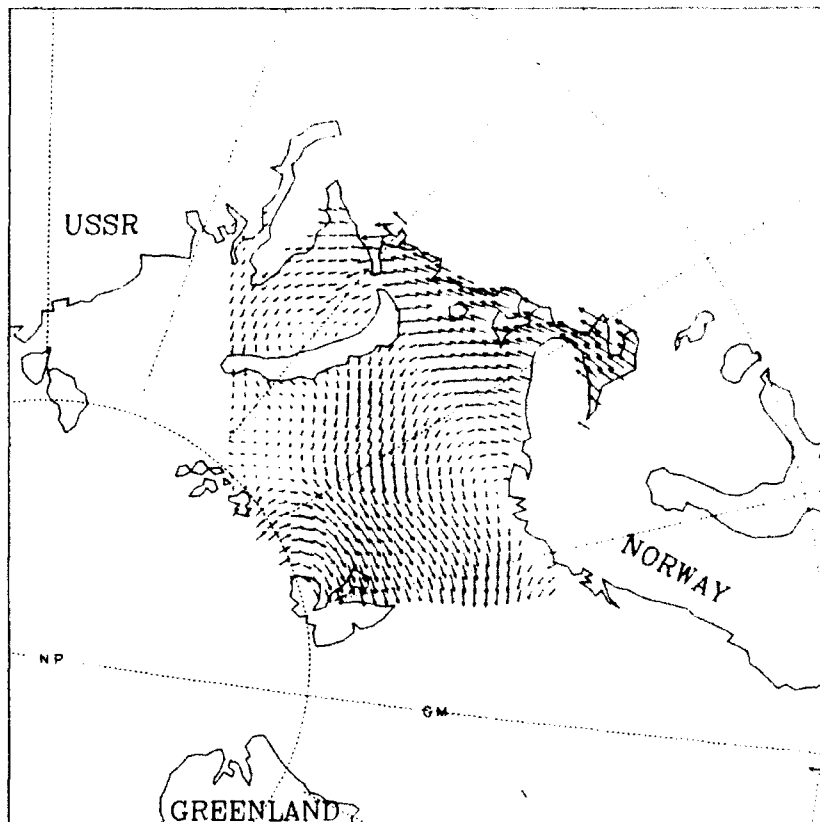
ICE CONCENTRATION

1991 OCTOBER



WIND VELOCITIES

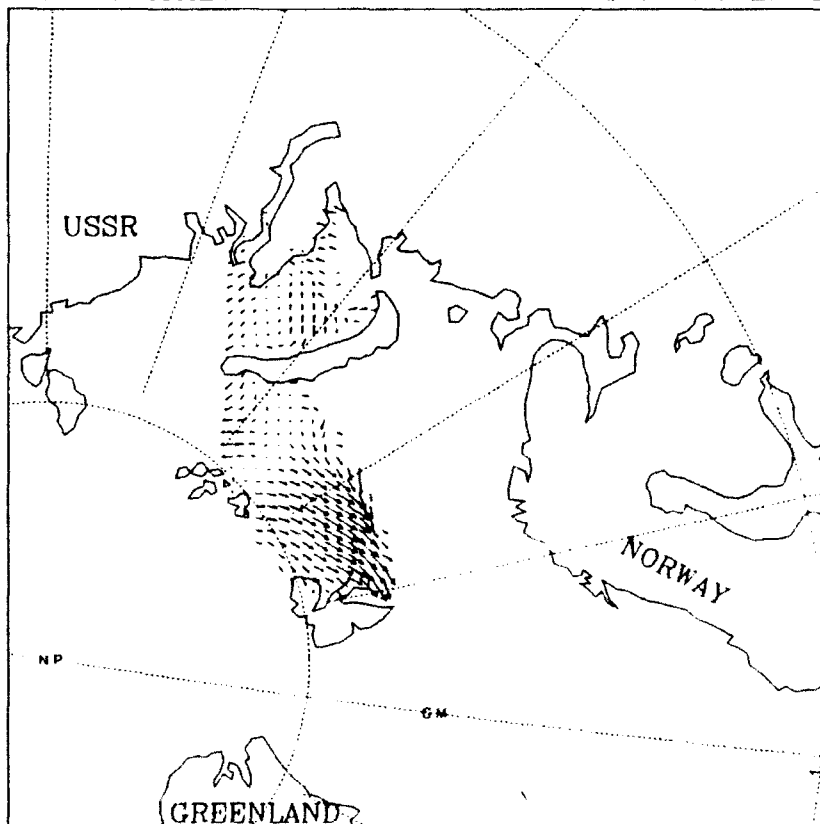
1991 NOVEMBER



0.308E-02
MAXIMUM VECTOR

ICE VELOCITIES

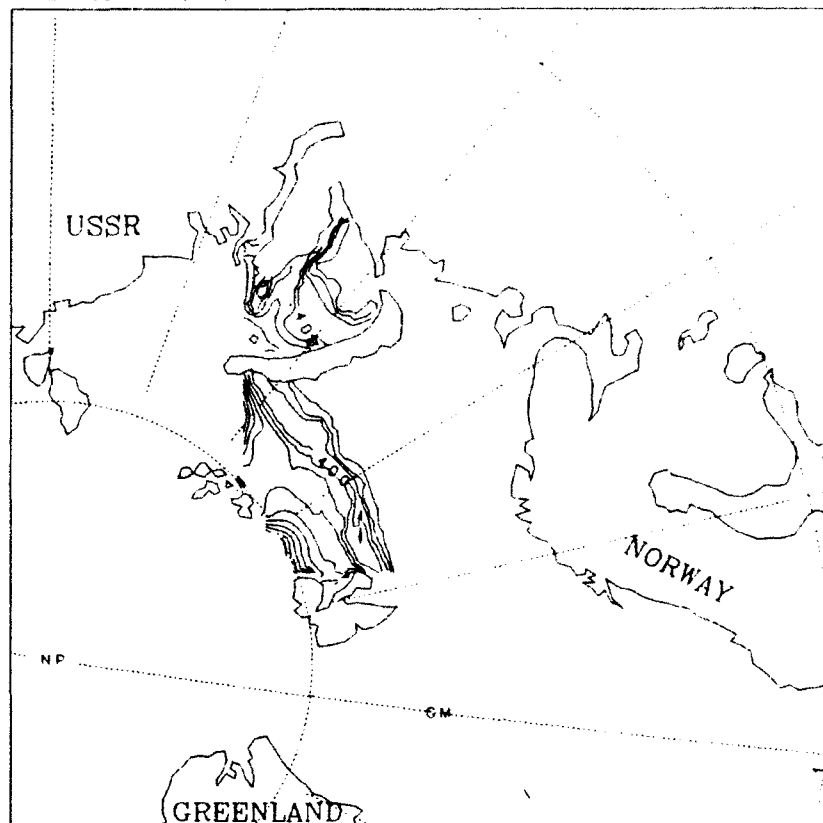
1991 NOVEMBER



0.308E-00
MAXIMUM VECTOR

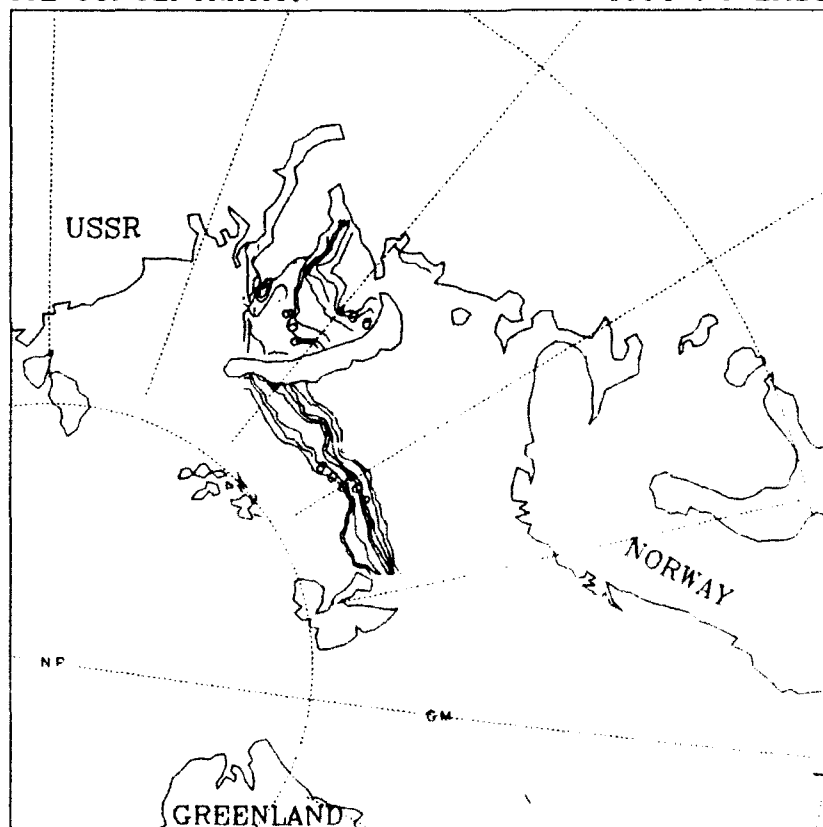
ICE THICKNESS

1991 NOVEMBER



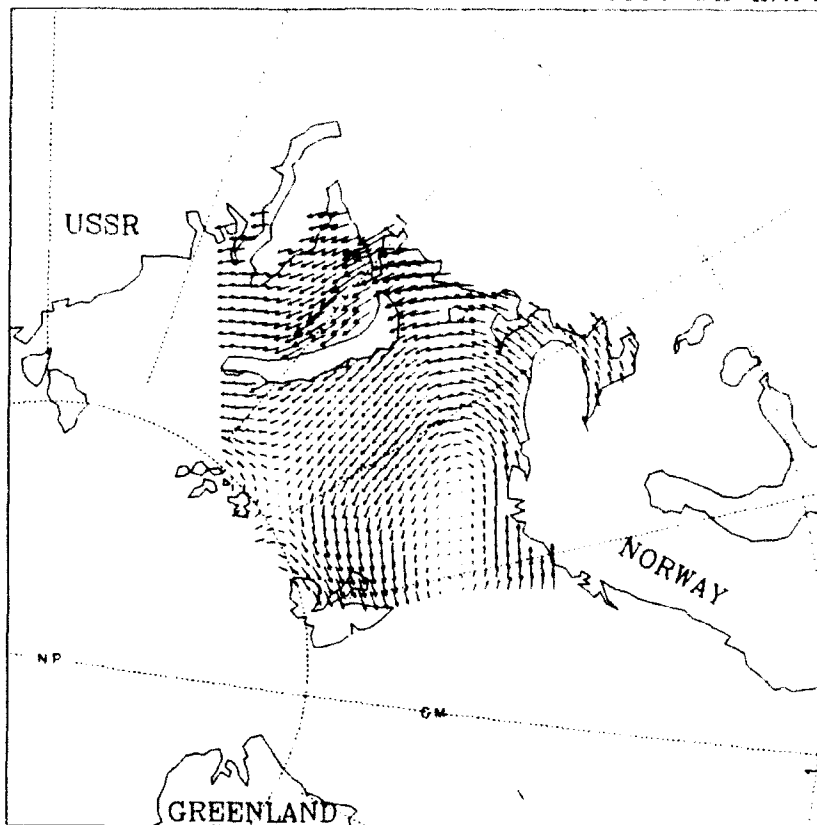
ICE CONCENTRATION

1991 NOVEMBER



WIND VELOCITIES

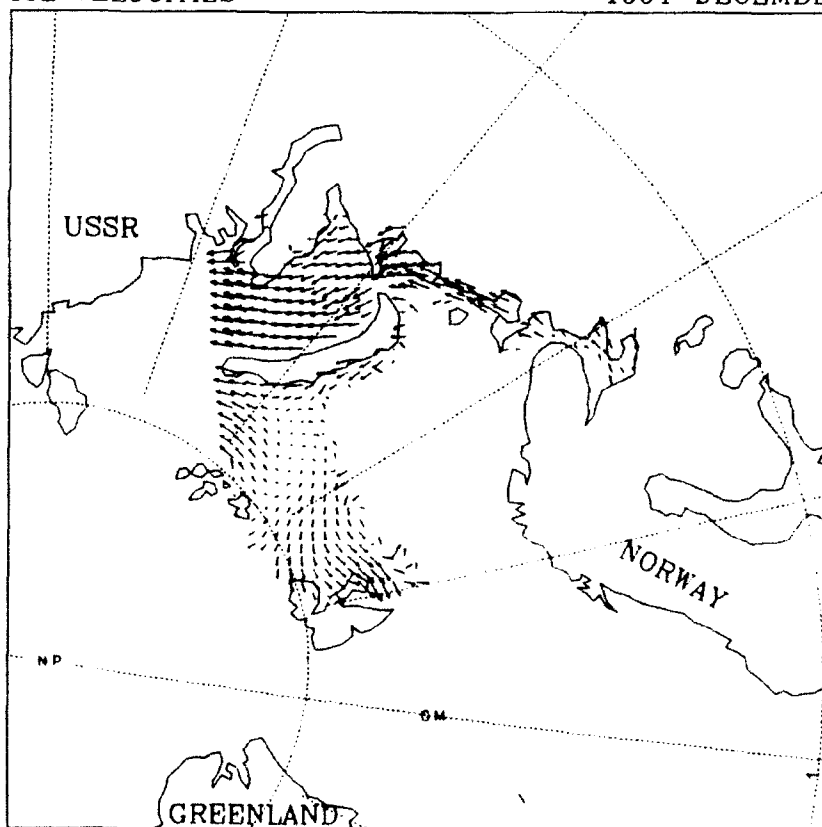
1991 DECEMBER



0 300E-02
MAXIMUM VECTOR

ICE VELOCITIES

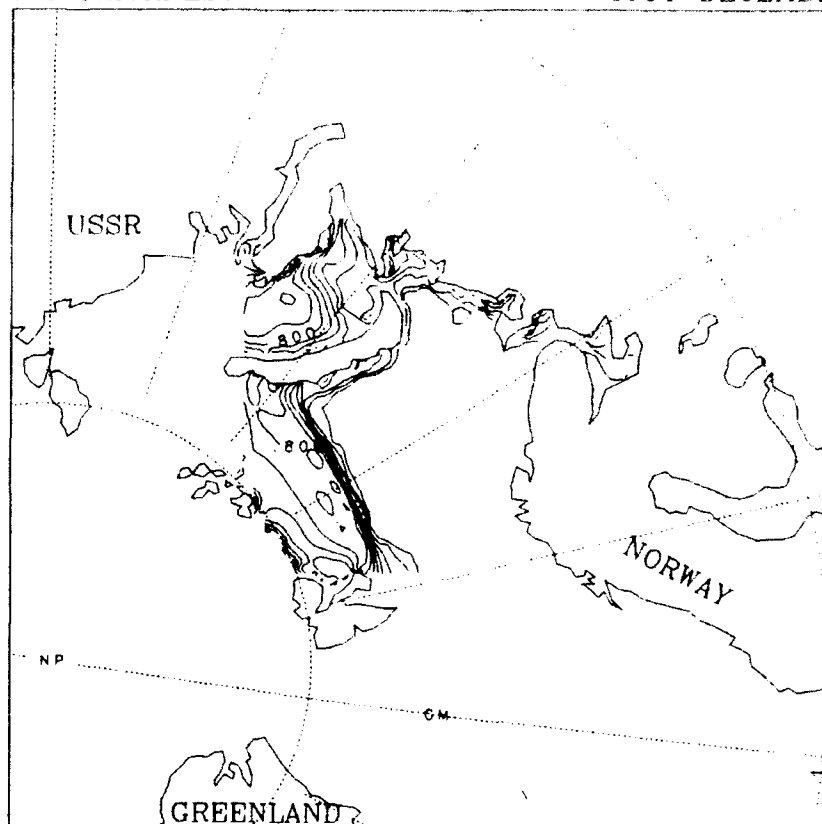
1991 DECEMBER



0 300E-02
MAXIMUM VECTOR

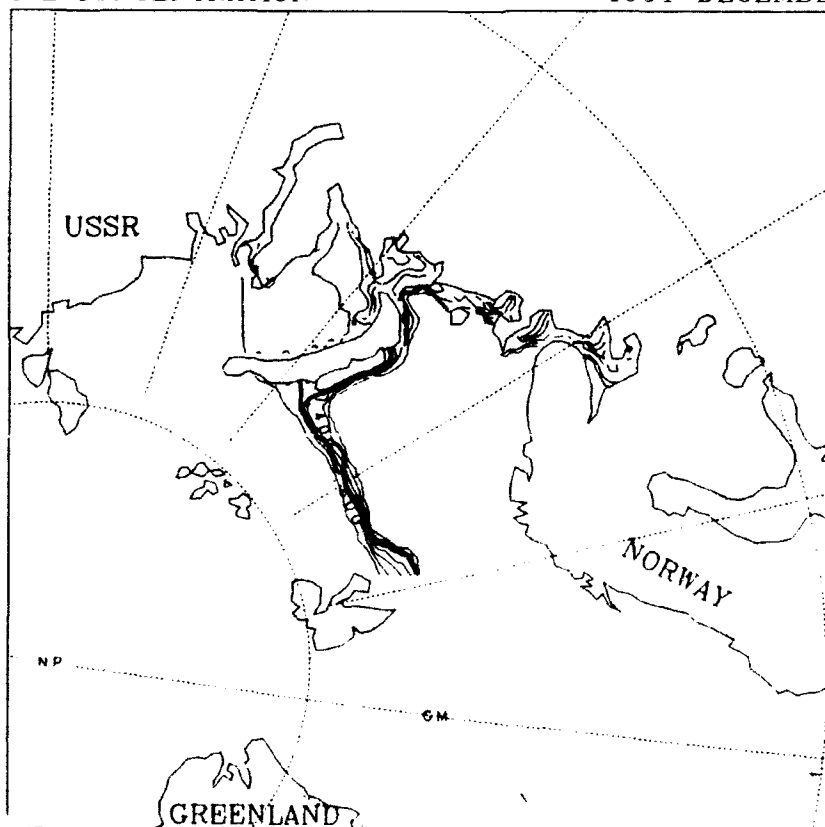
ICE THICKNESS

1991 DECEMBER



ICE CONCENTRATION

1991 DECEMBER

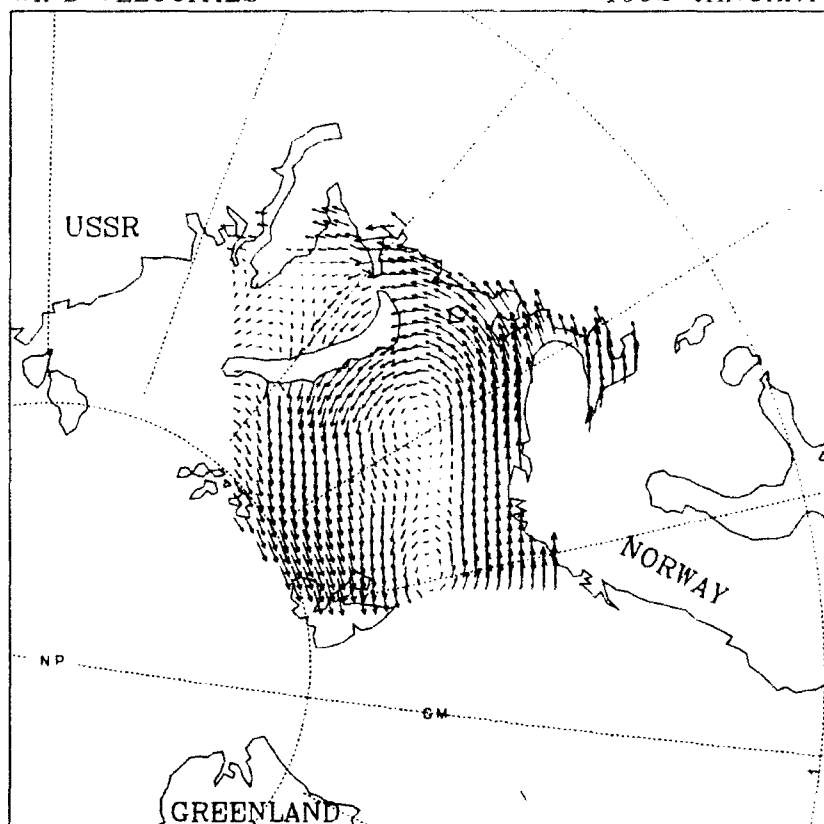


RPIPS-B 1992

MONTHLY MEANS

WIND VELOCITIES

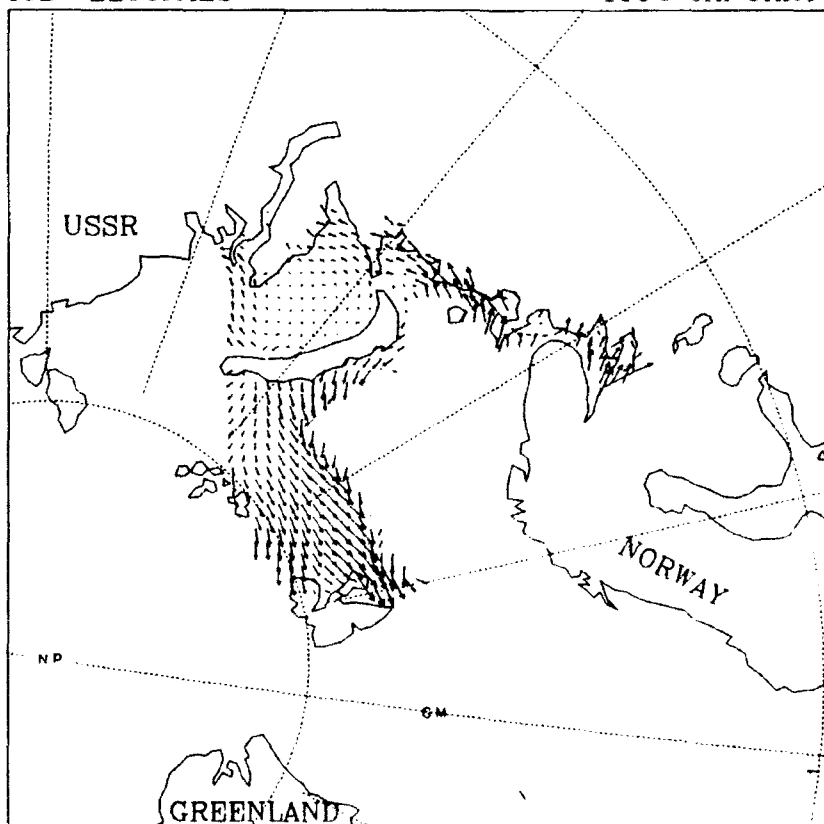
1992 JANUARY



0.300E-02
MAXIMUM VECTOR

ICE VELOCITIES

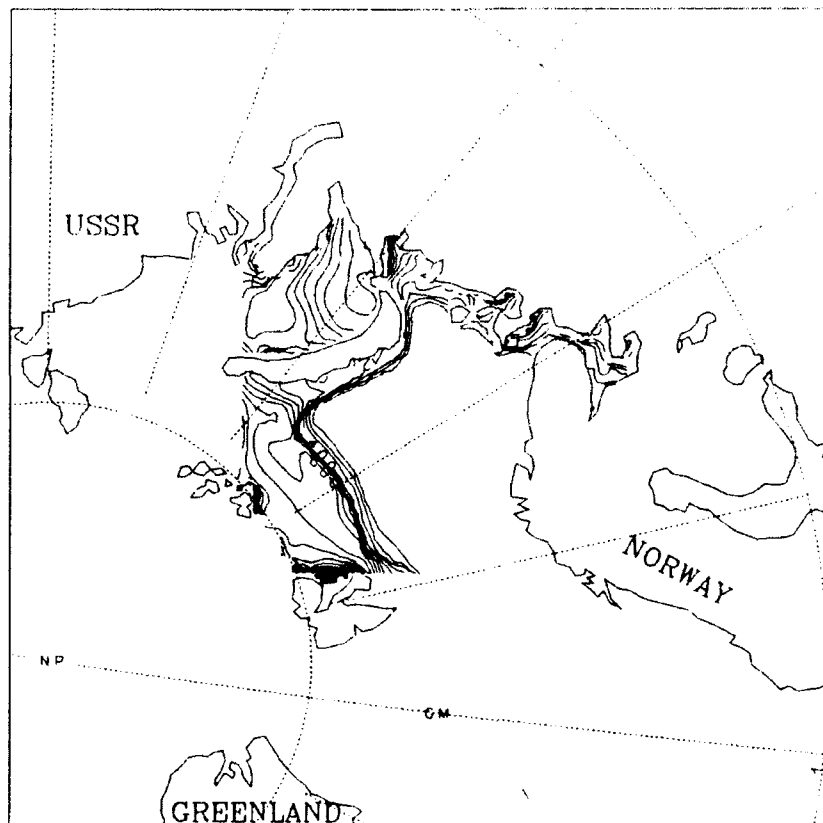
1992 JANUARY



0.300E-00
MAXIMUM VECTOR

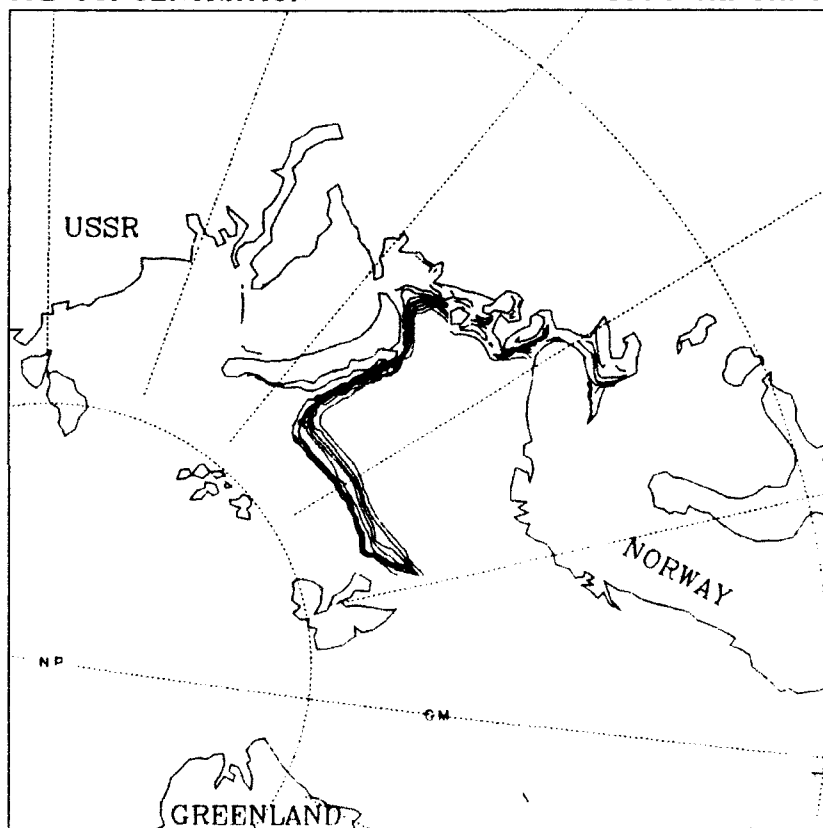
ICE THICKNESS

1992 JANUARY



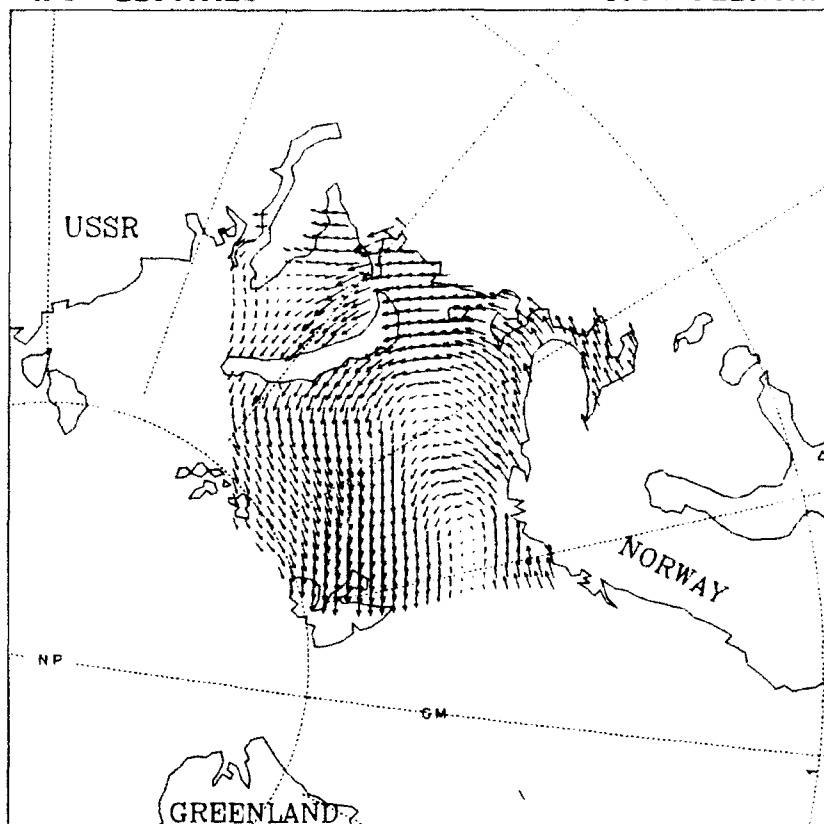
ICE CONCENTRATION

1992 JANUARY



WIND VELOCITIES

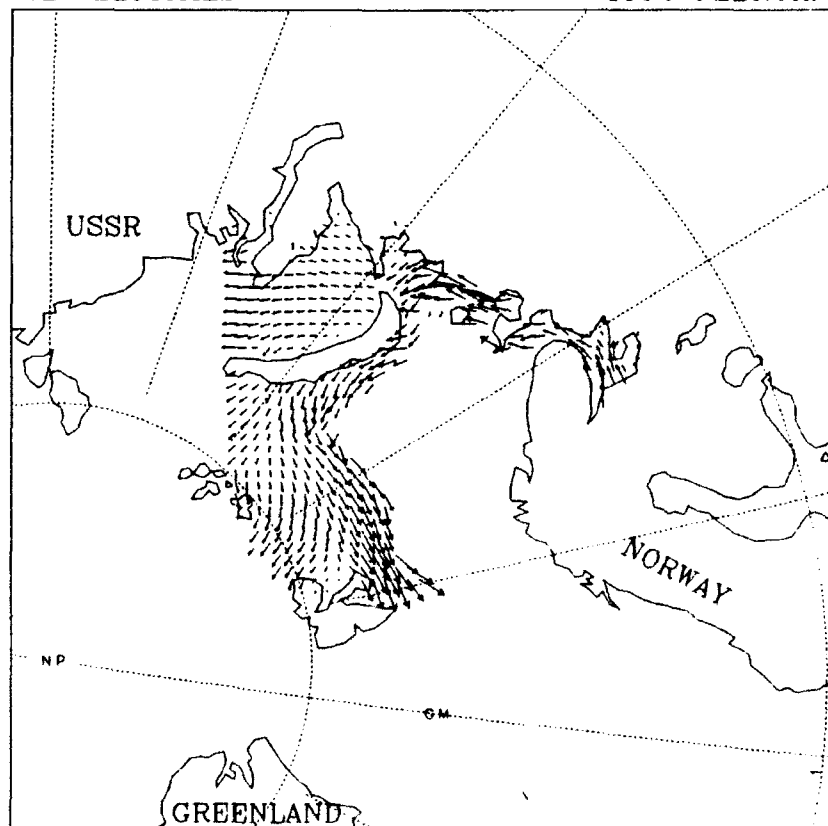
1992 FEBRUARY



0.300E+02
MAXIMUM VECTOR

ICE VELOCITIES

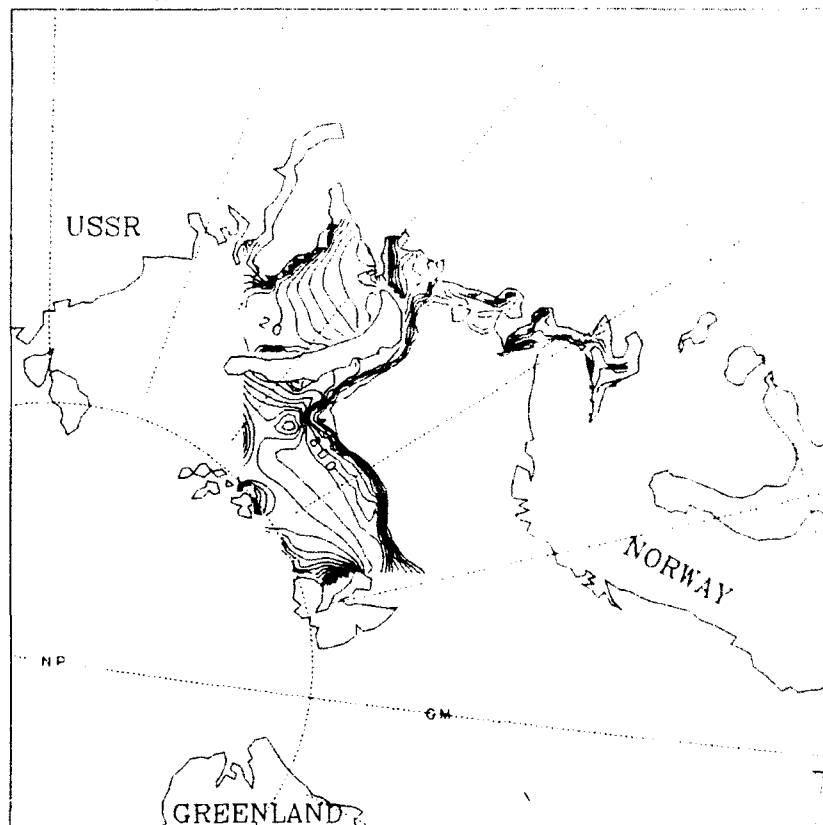
1992 FEBRUARY



0.300E+00
MAXIMUM VECTOR

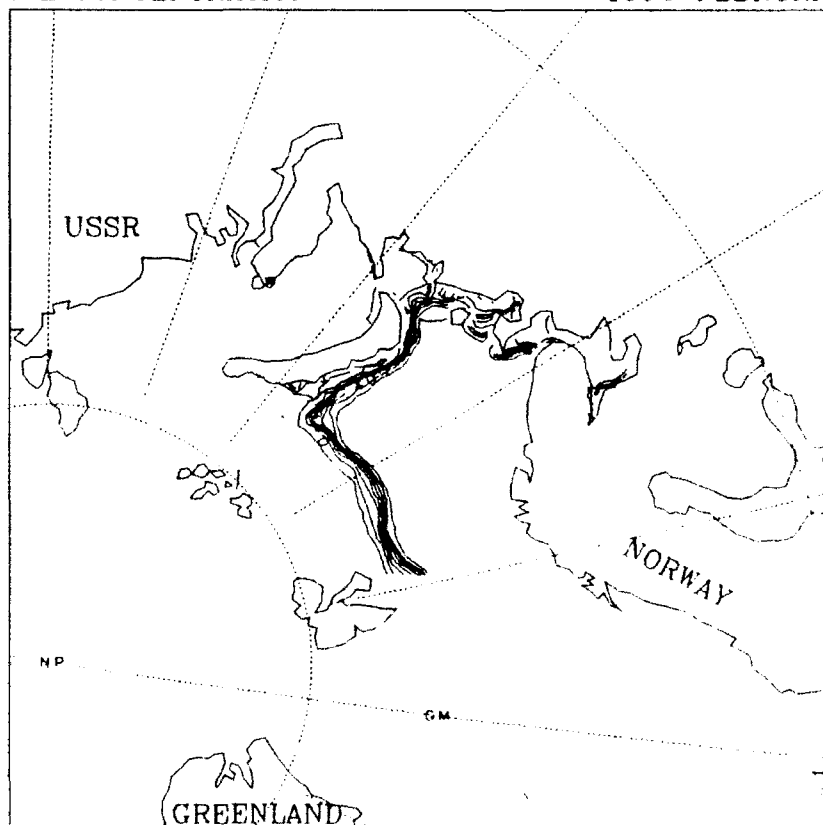
ICE THICKNESS

1992 FEBRUARY



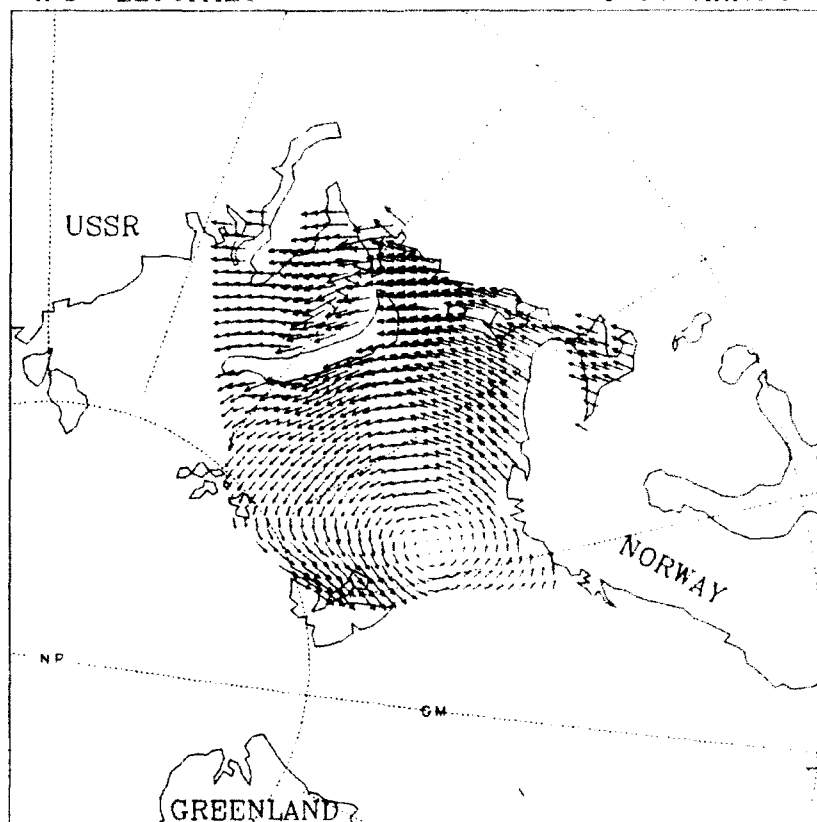
ICE CONCENTRATION

1992 FEBRUARY



WIND VELOCITIES

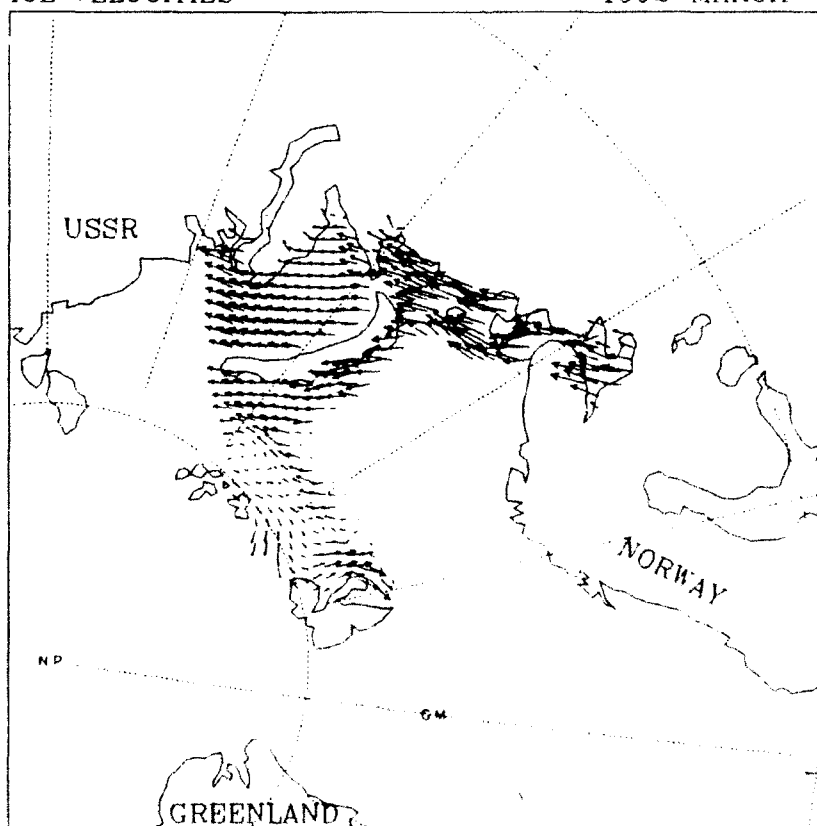
1992 MARCH



10 m/s
MAXIMUM VECTOR

ICE VELOCITIES

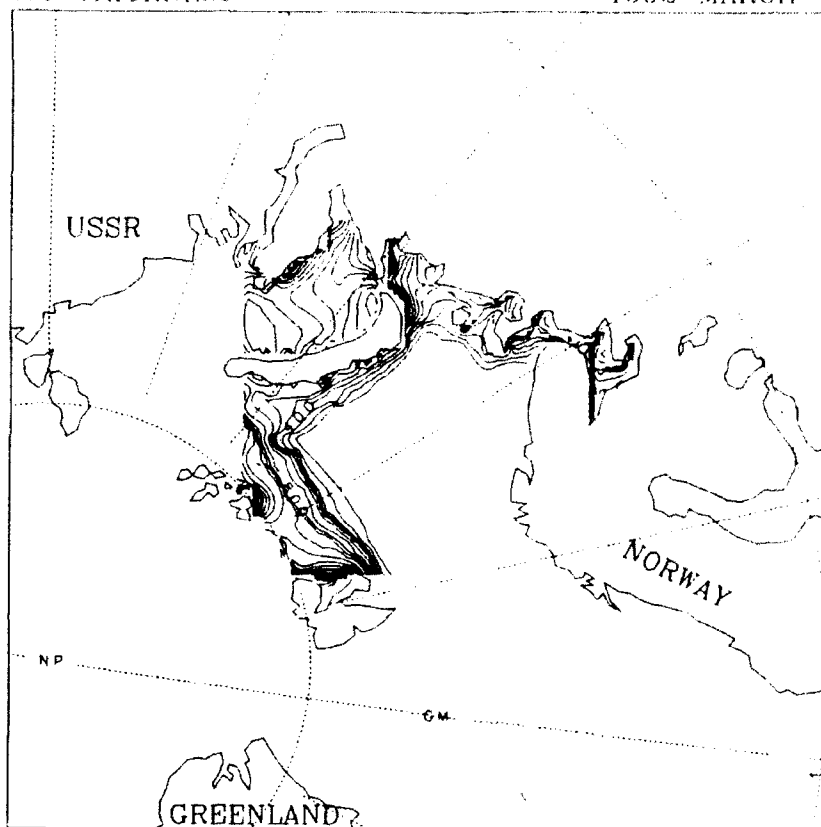
1992 MARCH



10 m/s
MAXIMUM VECTOR

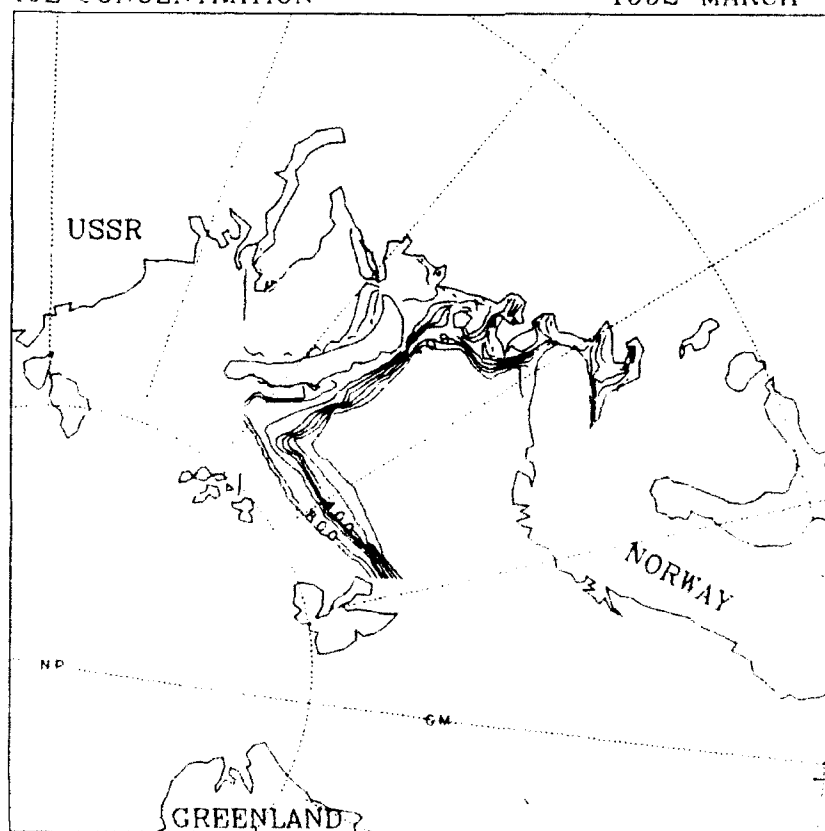
ICE THICKNESS

1992 MARCH



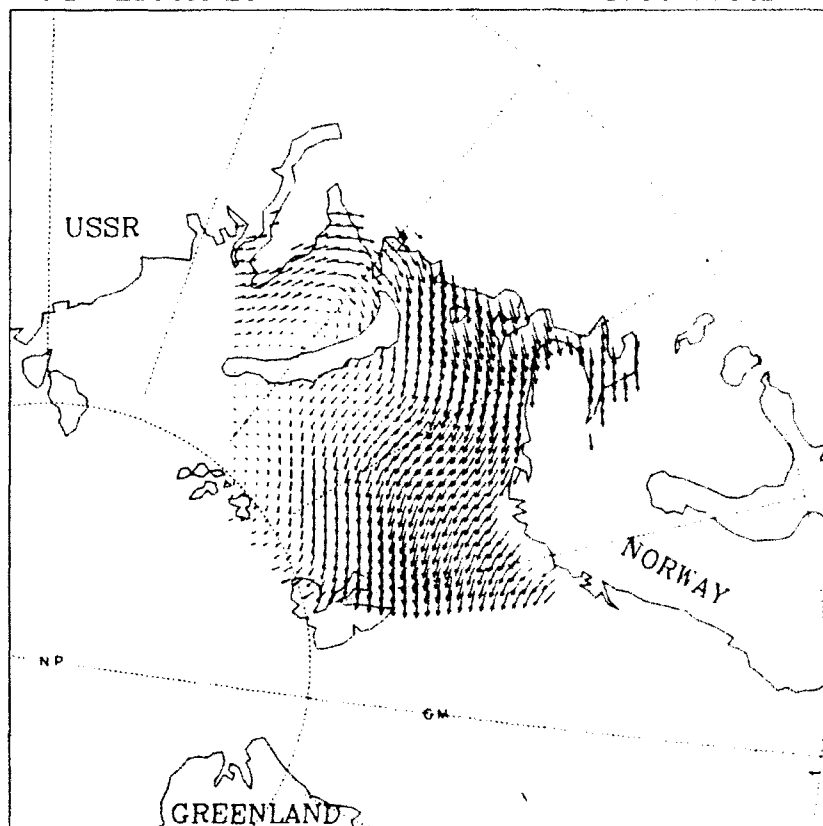
ICE CONCENTRATION

1992 MARCH



WIND VELOCITIES

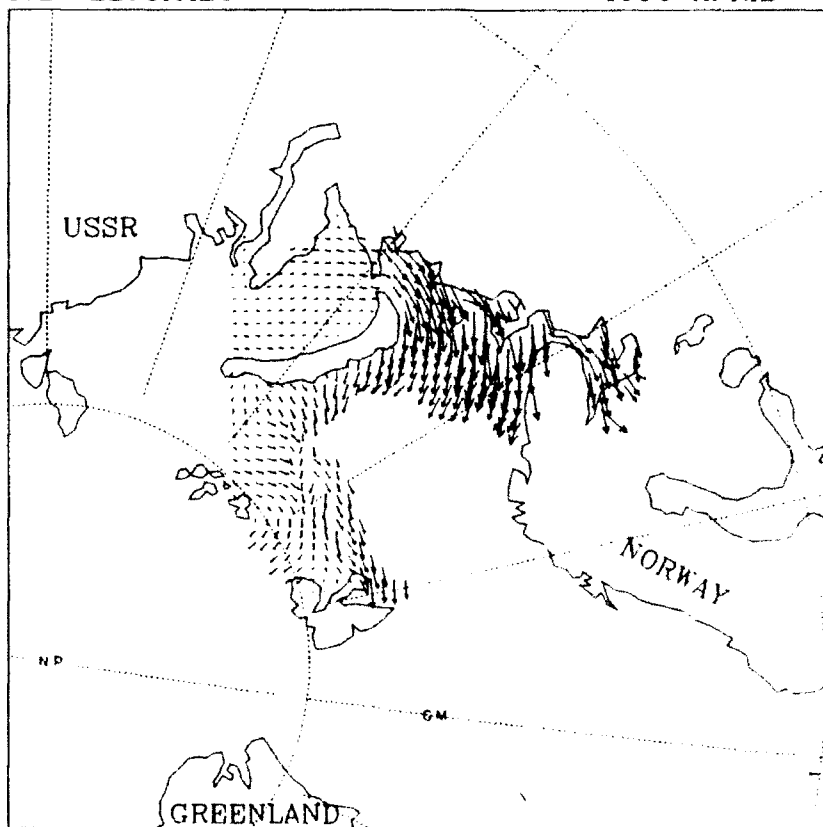
1992 APRIL



0 3000 6000
MAXIMUM VECTOR

ICE VELOCITIES

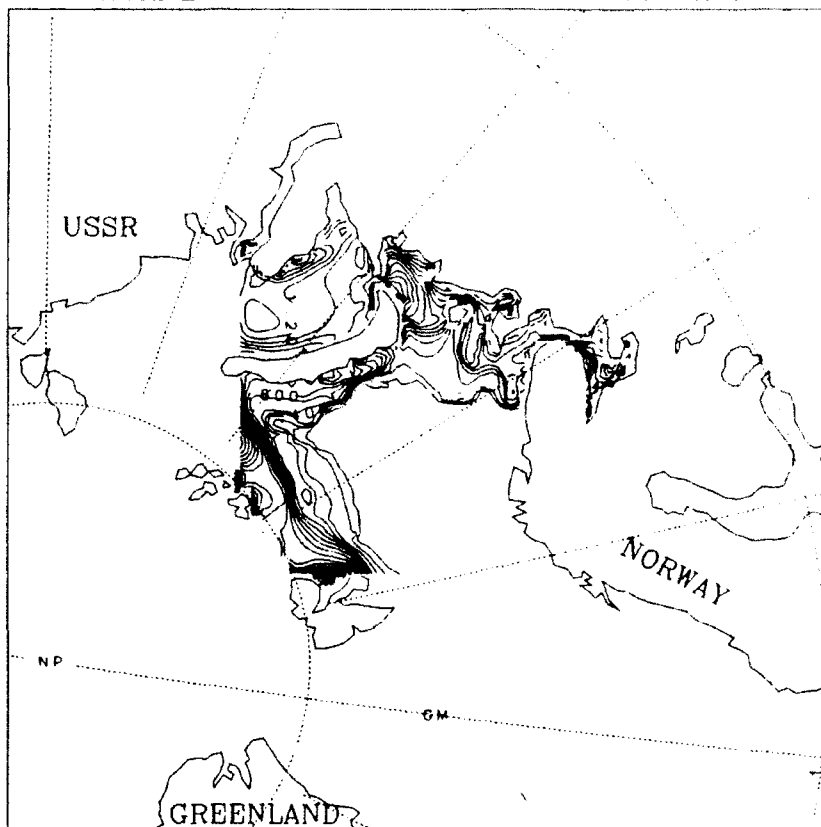
1992 APRIL



0 3000 6000
MAXIMUM VECTOR

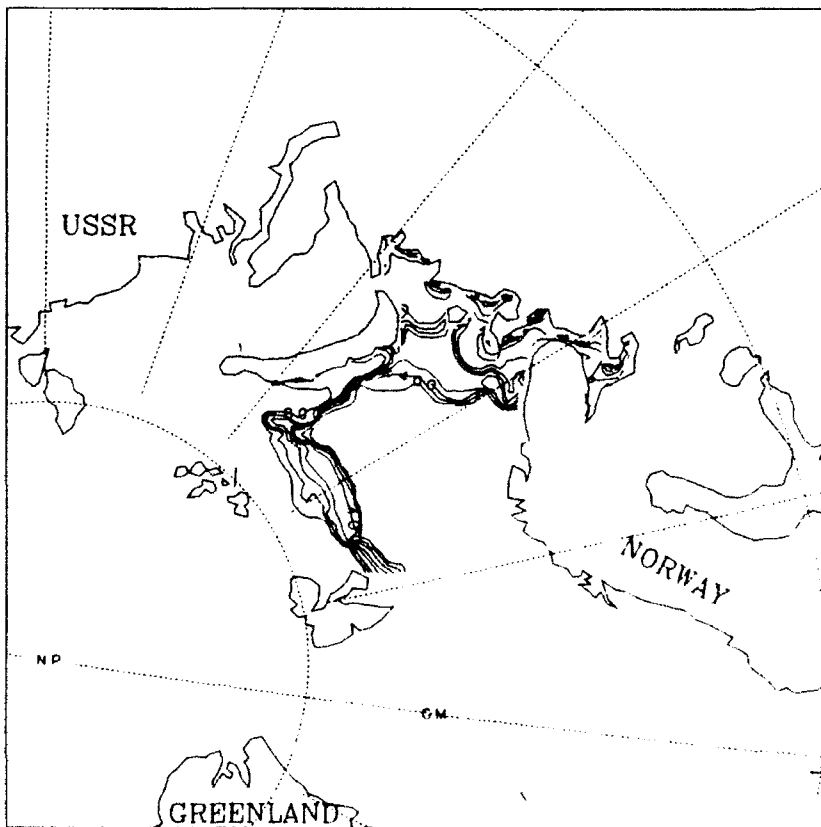
ICE THICKNESS

1992 APRIL



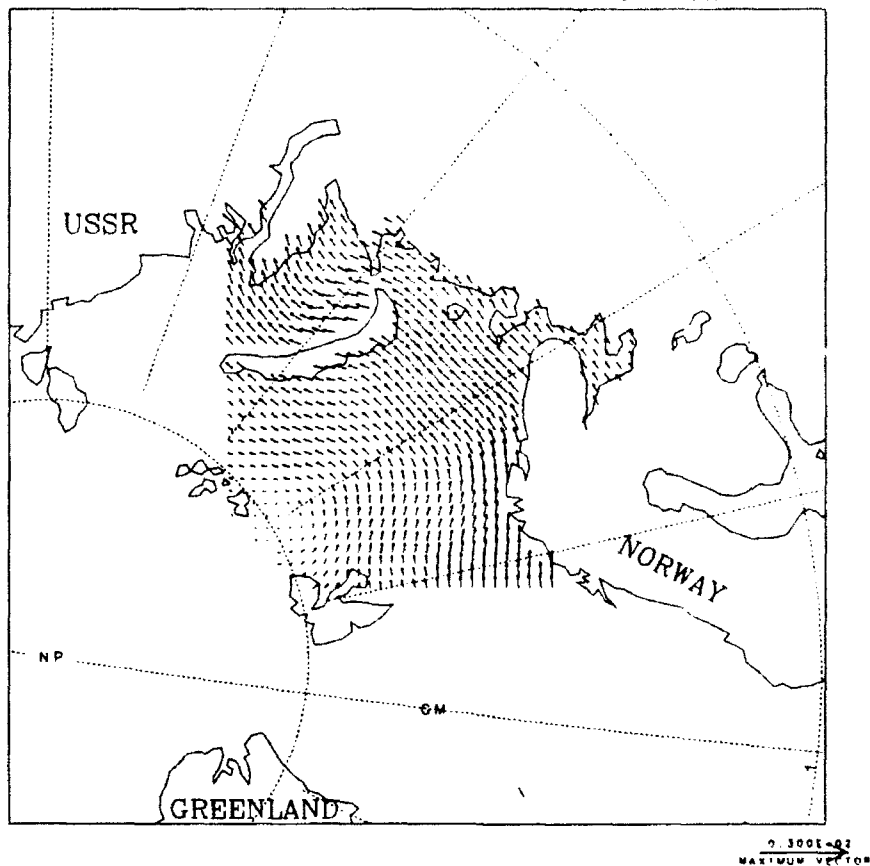
ICE CONCENTRATION

1992 APRIL



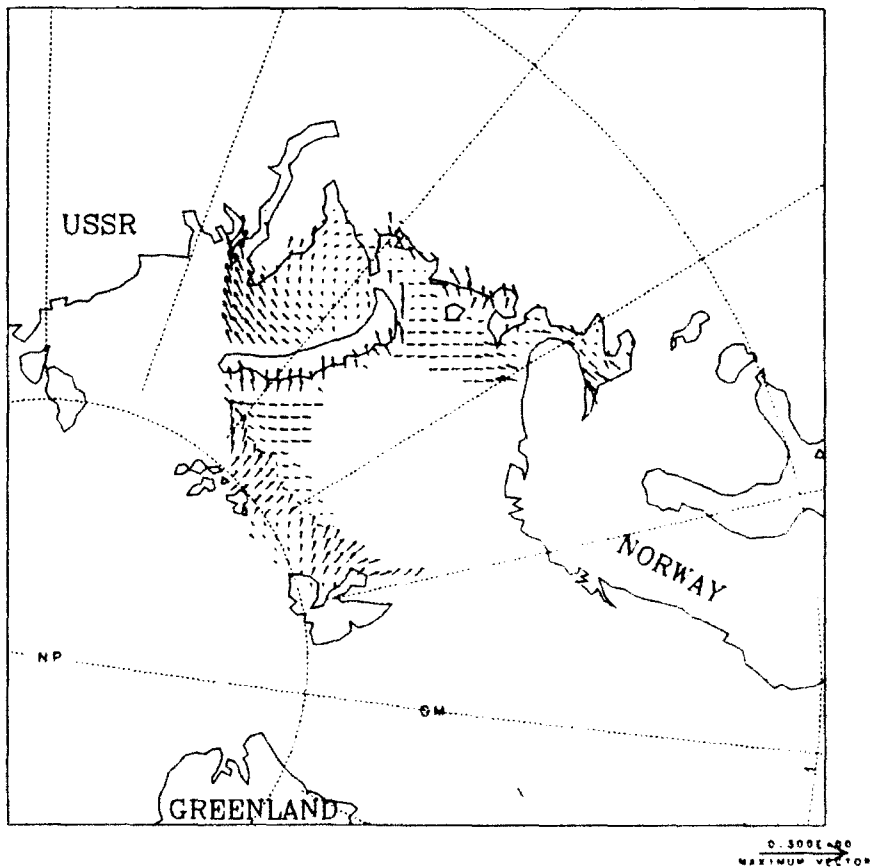
WIND VELOCITIES

1992 MAY



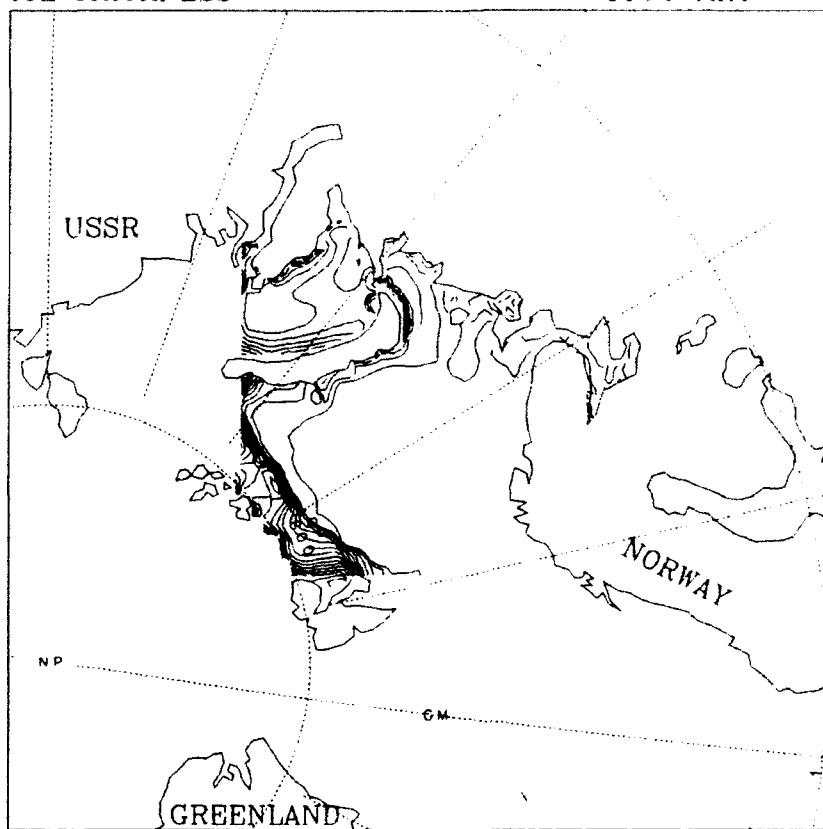
ICE VELOCITIES

1992 MAY



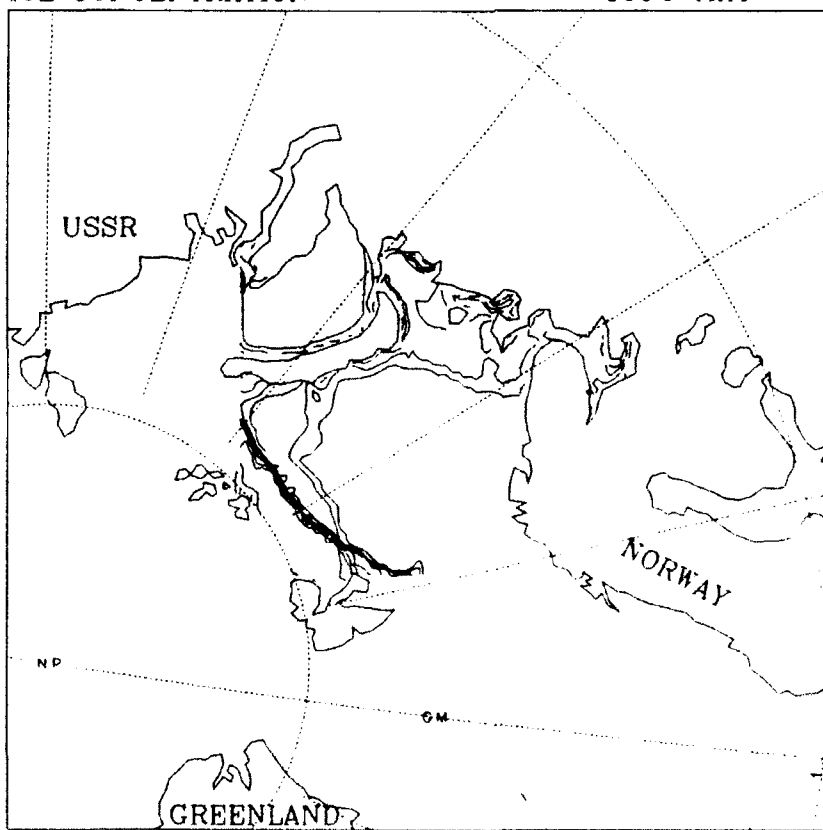
ICE THICKNESS

1992 MAY



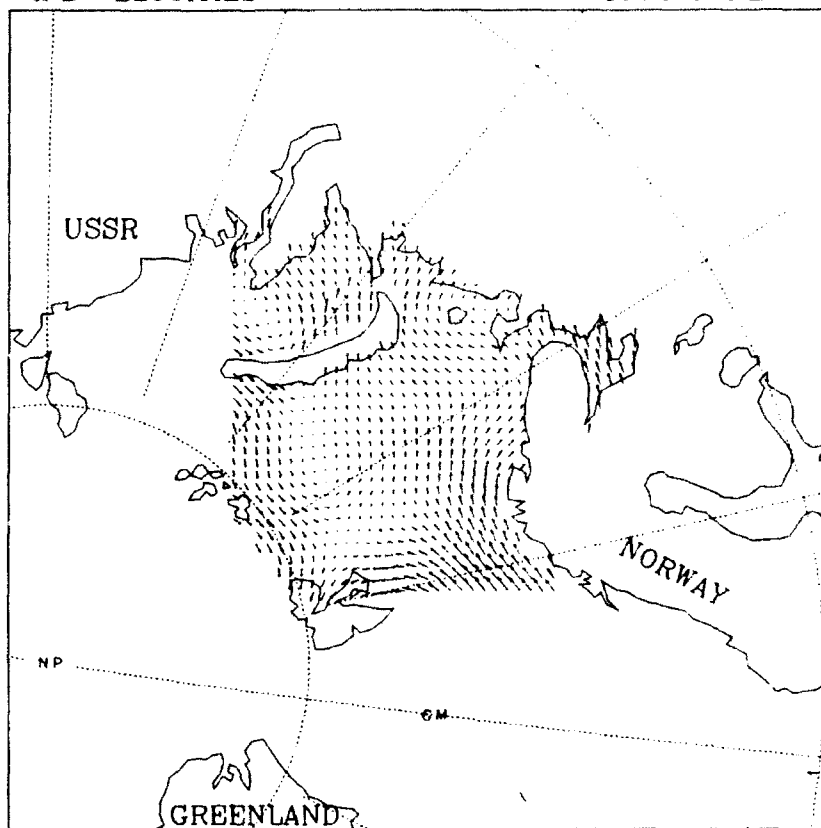
ICE CONCENTRATION

1992 MAY



WIND VELOCITIES

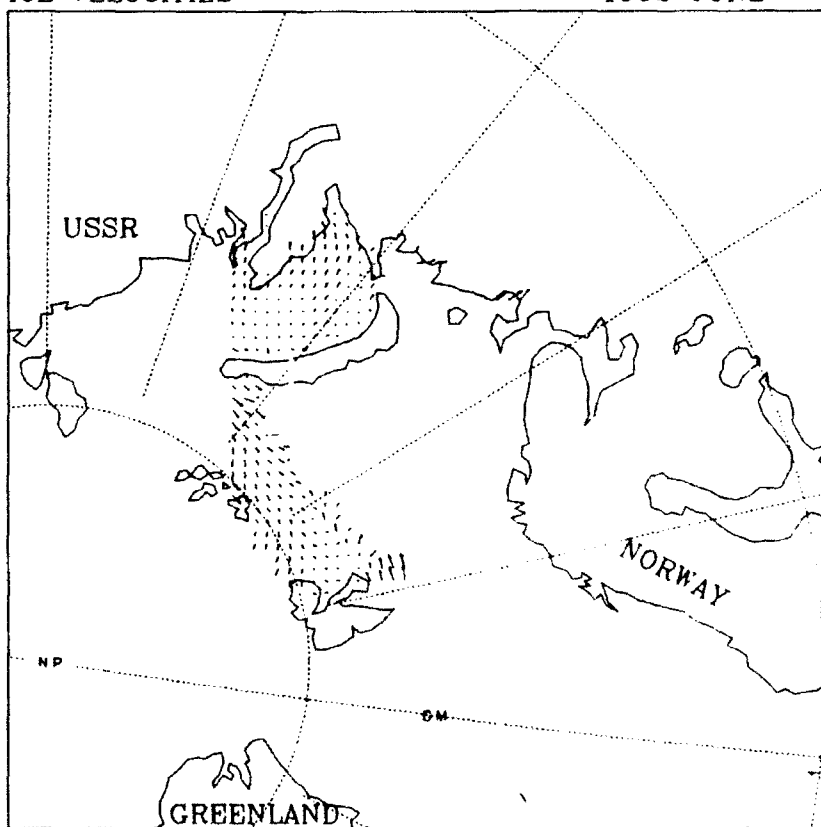
1992 JUNE



0.388482
MAXIMUM VECTOR

ICE VELOCITIES

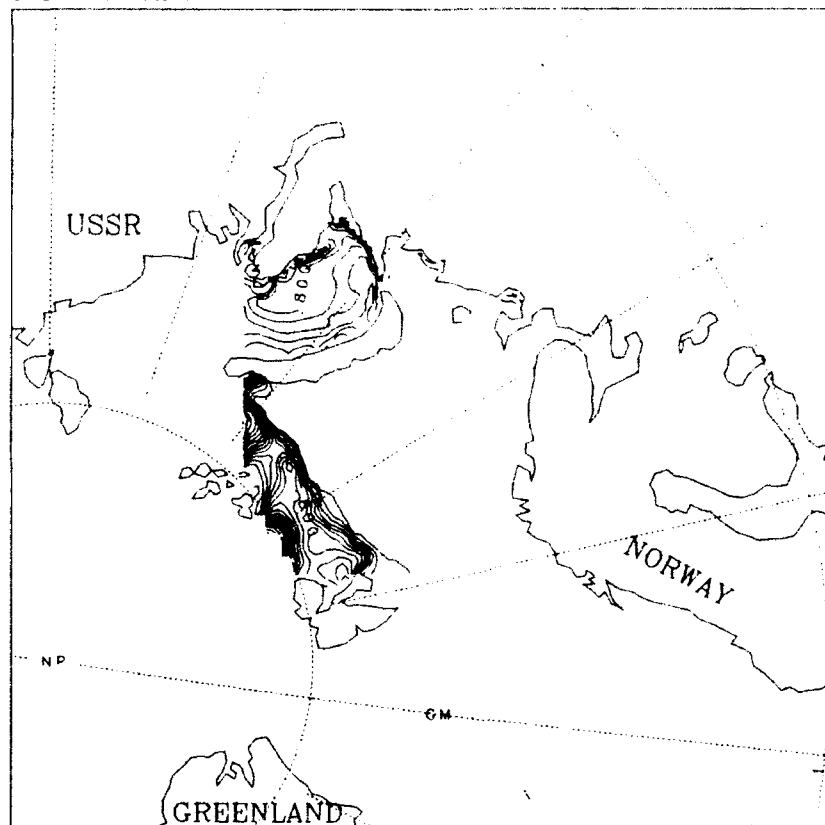
1992 JUNE



0.388482
MAXIMUM VECTOR

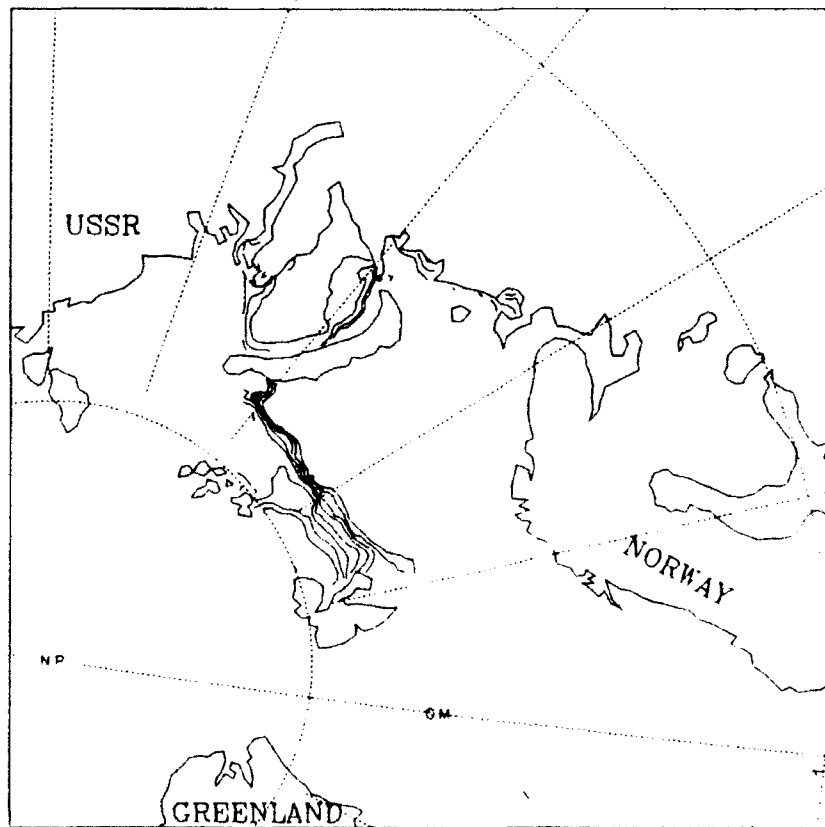
ICE THICKNESS

1992 JUNE



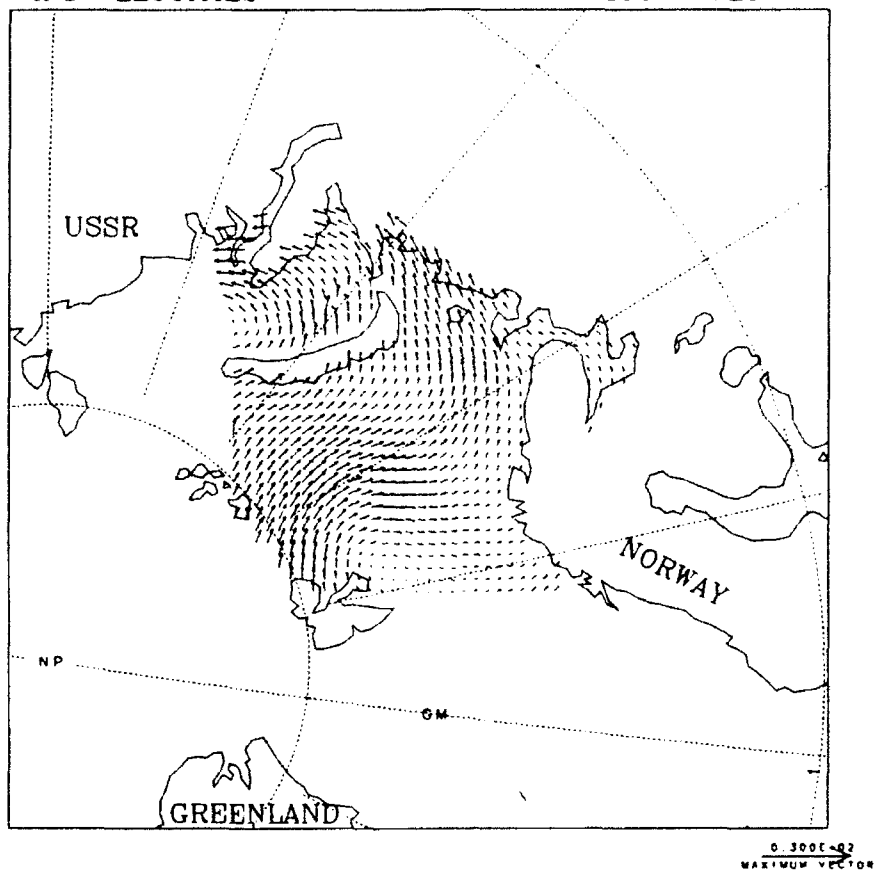
ICE CONCENTRATION

1992 JUNE



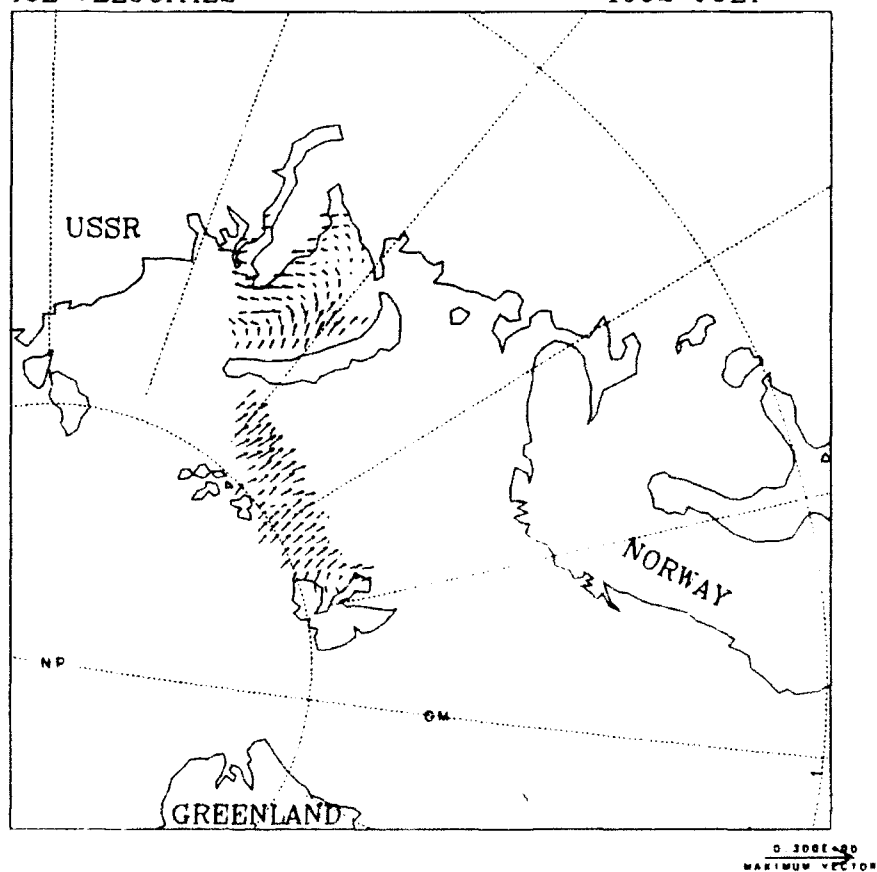
WIND VELOCITIES

1992 JULY



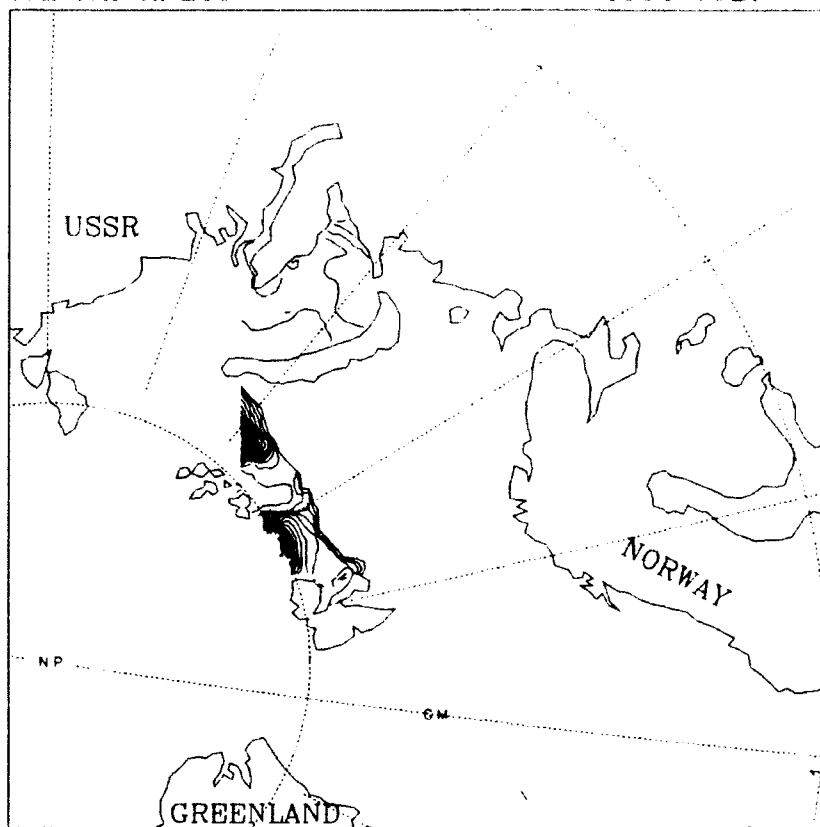
ICE VELOCITIES

1992 JULY



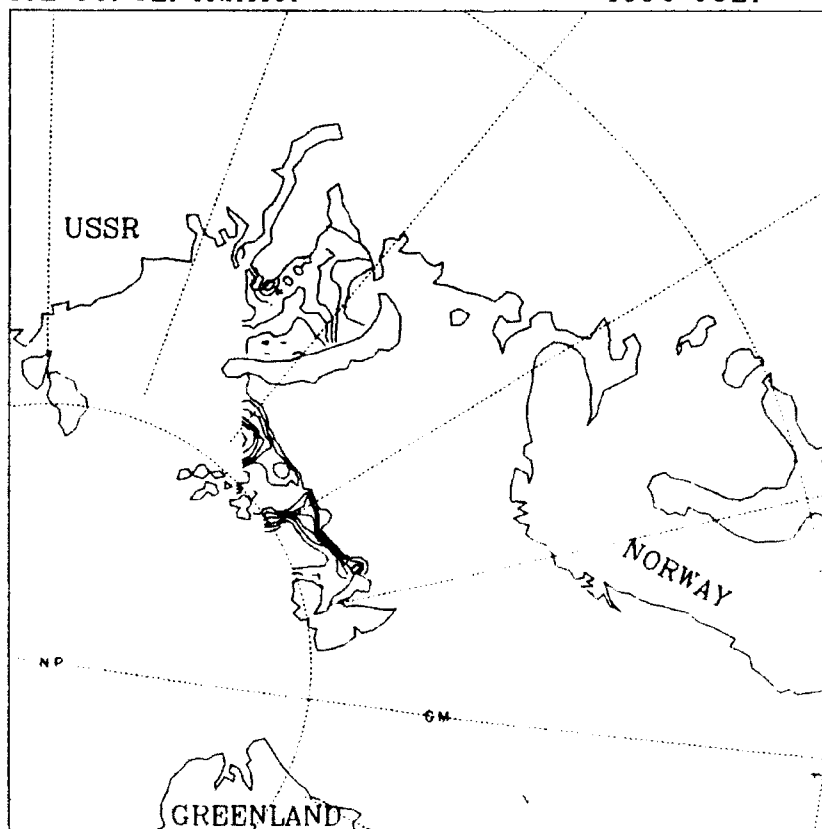
ICE THICKNESS

1992 JULY



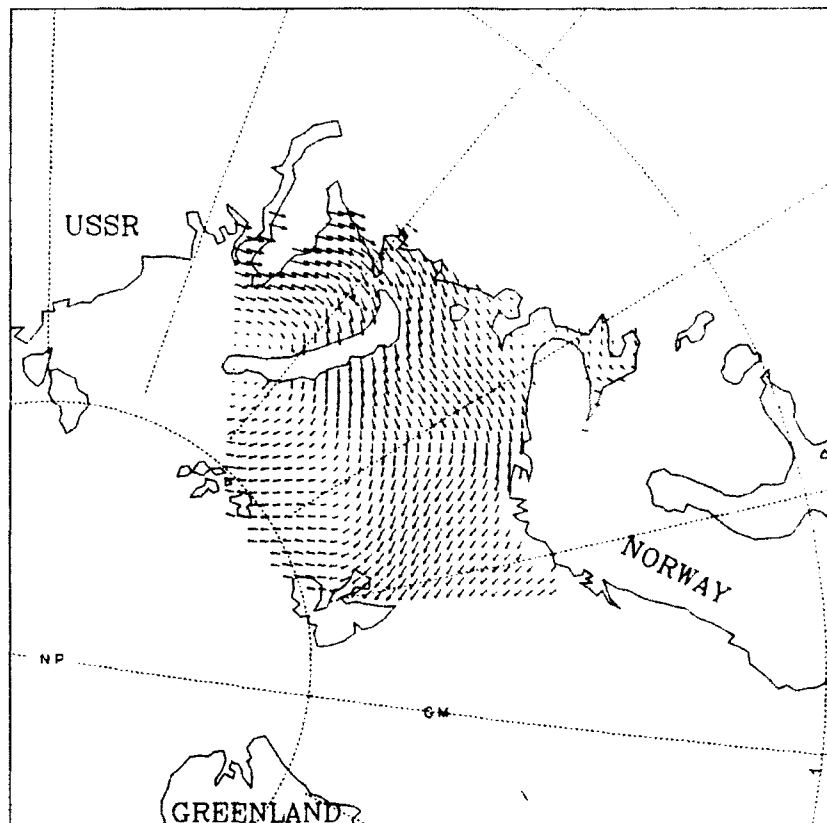
ICE CONCENTRATION

1992 JULY



WIND VELOCITIES

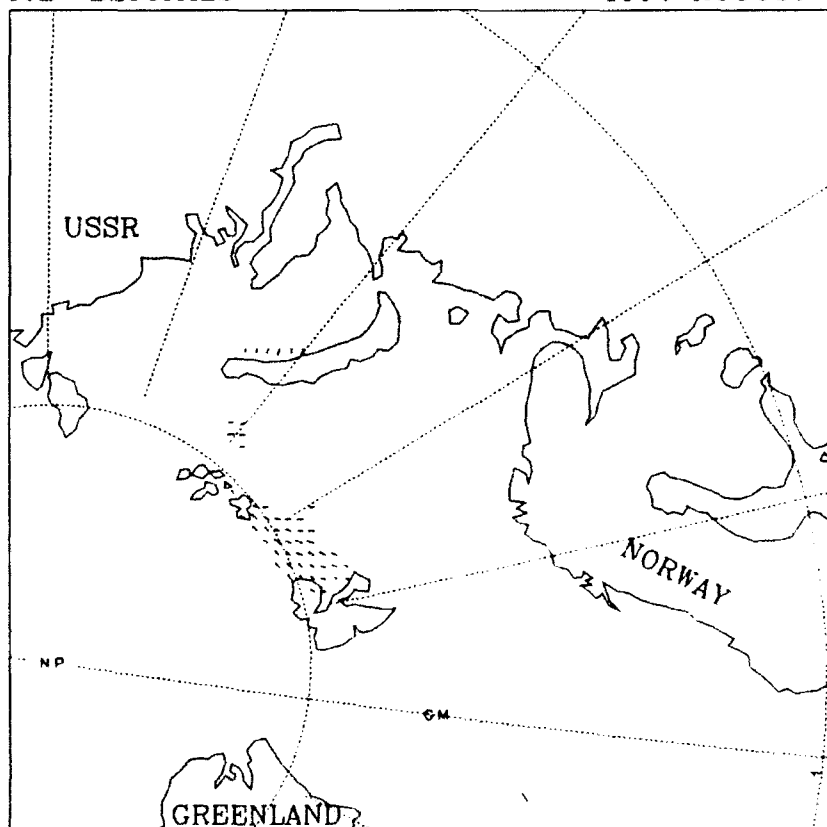
1992 AUGUST



0.308E+02
MAXIMUM VECTOR

ICE VELOCITIES

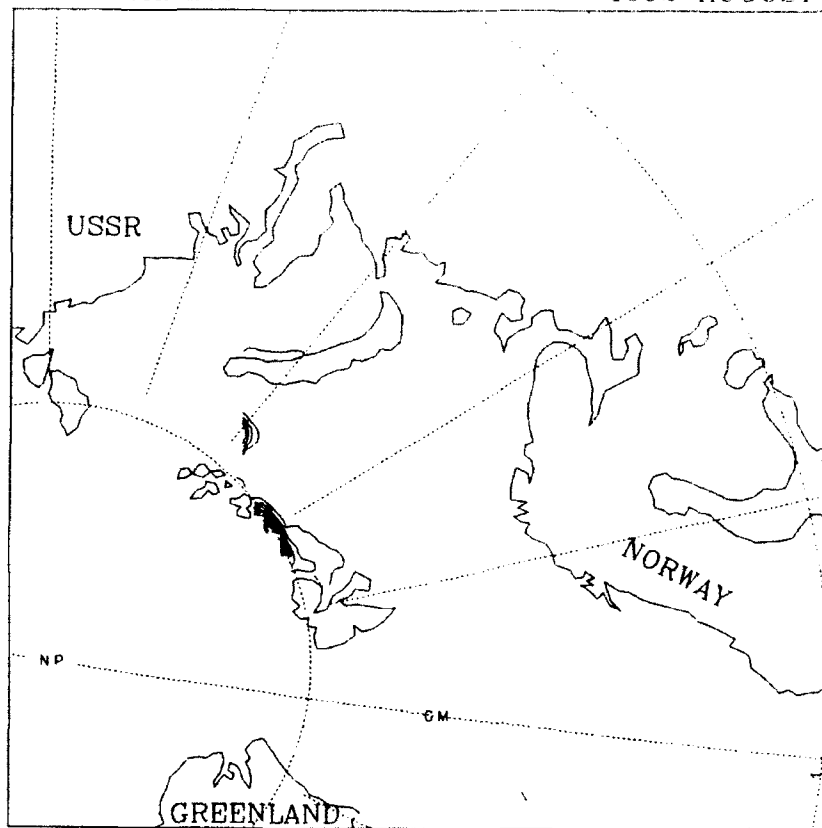
1992 AUGUST



0.308E+00
MAXIMUM VECTOR

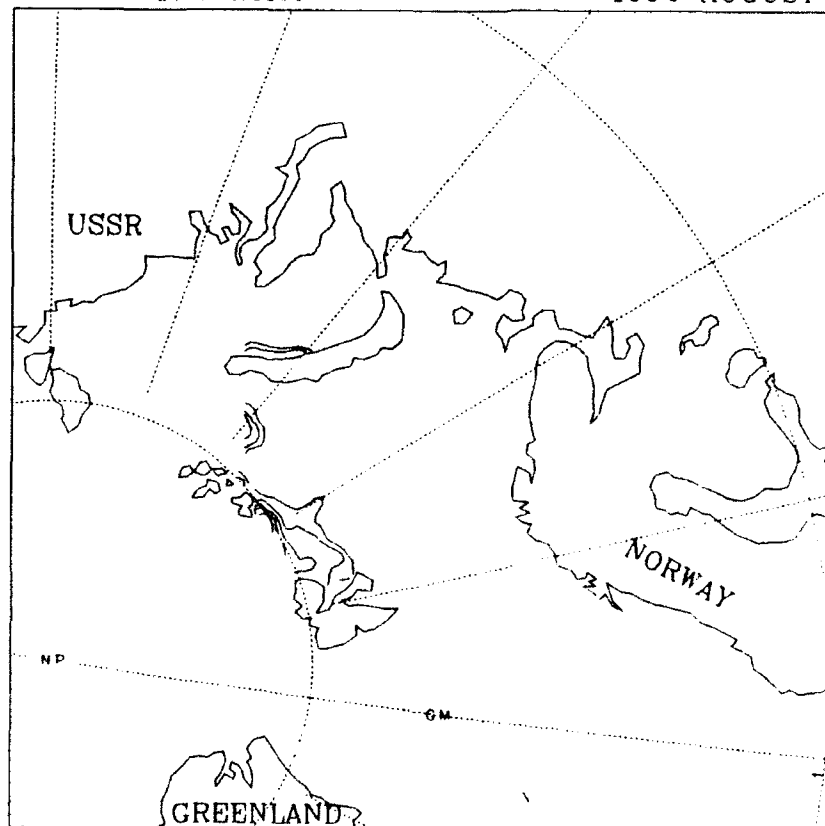
ICE THICKNESS

1992 AUGUST



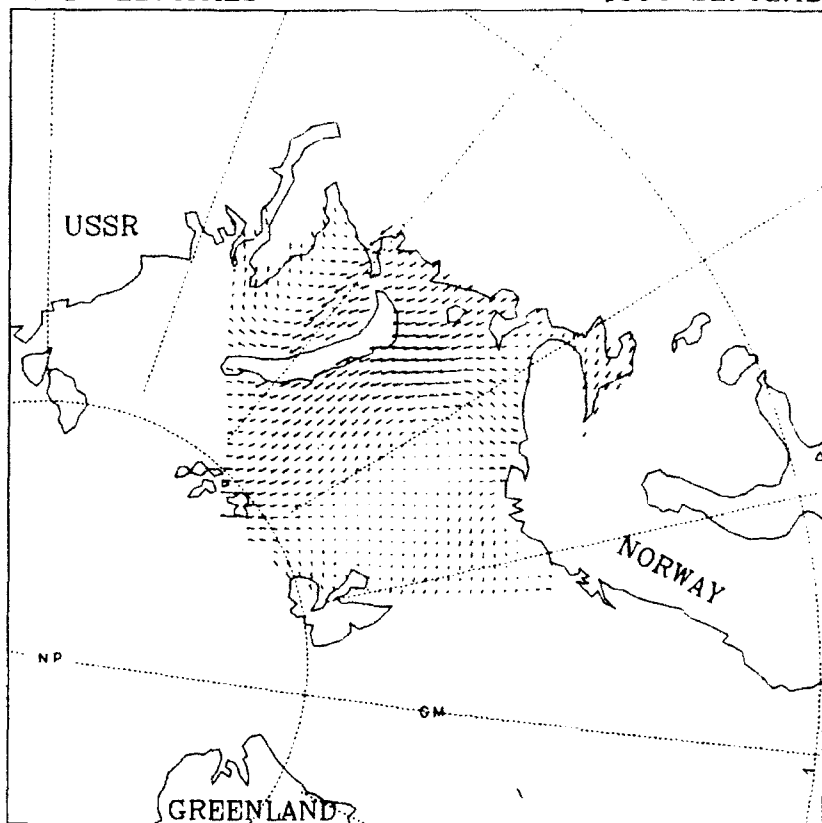
ICE CONCENTRATION

1992 AUGUST



WIND VELOCITIES

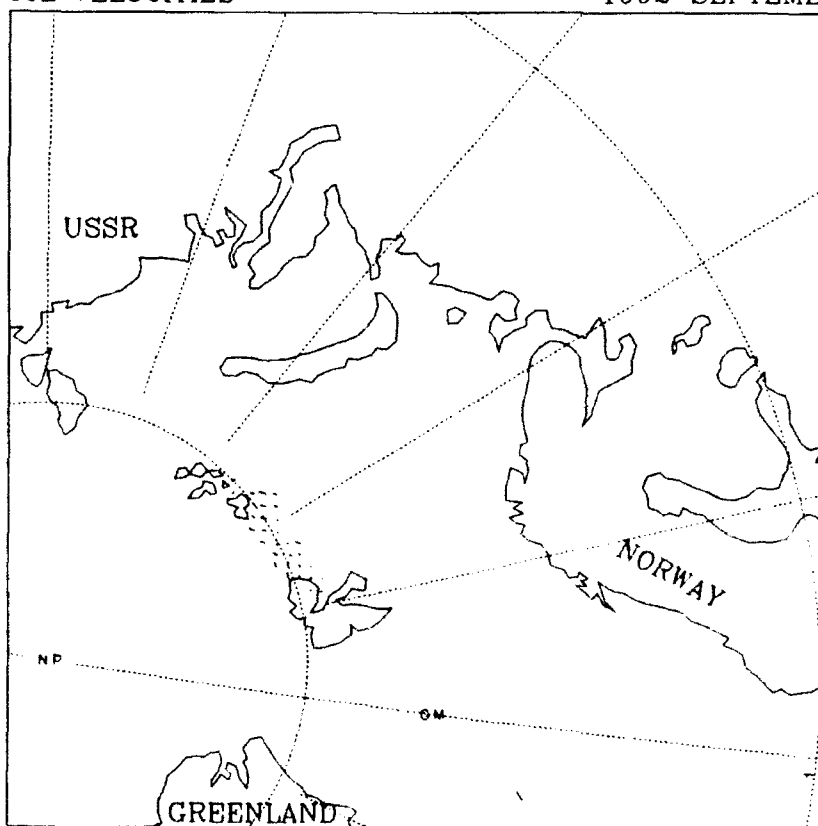
1992 SEPTEMBER



0 3000 m/s
MAXIMUM VECTOR

ICE VELOCITIES

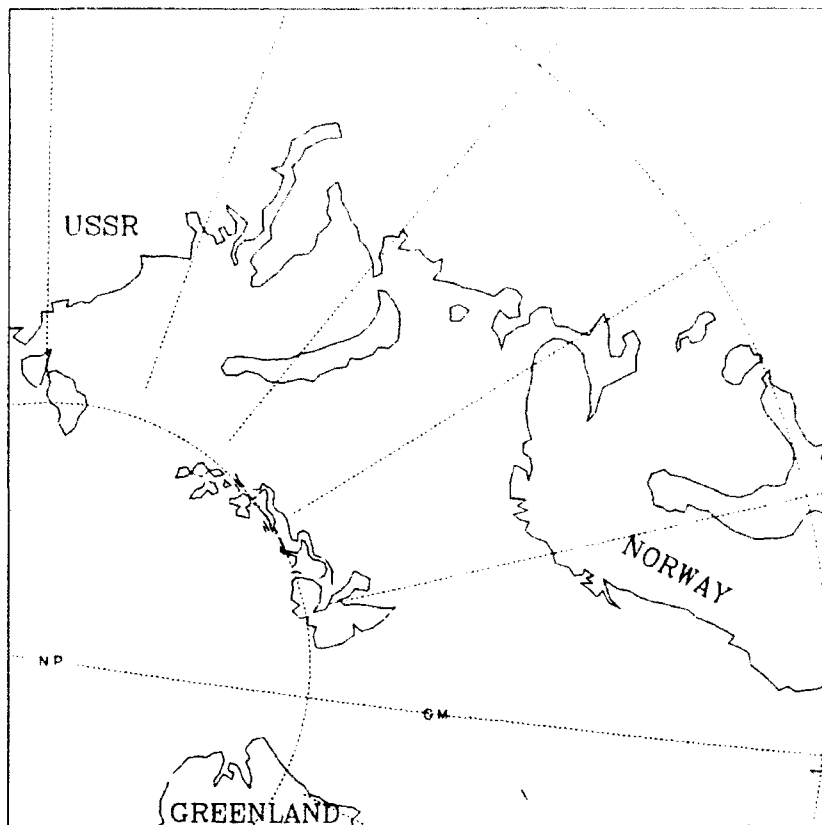
1992 SEPTEMBER



0 3000 m/s
MAXIMUM VECTOR

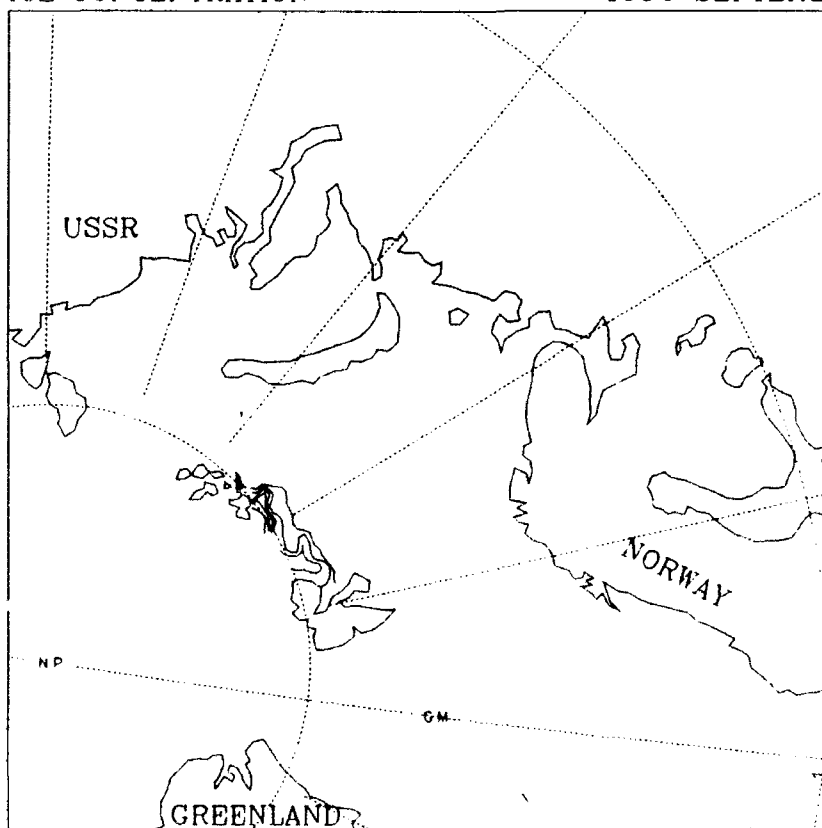
ICE THICKNESS

1992 SEPTEMBER



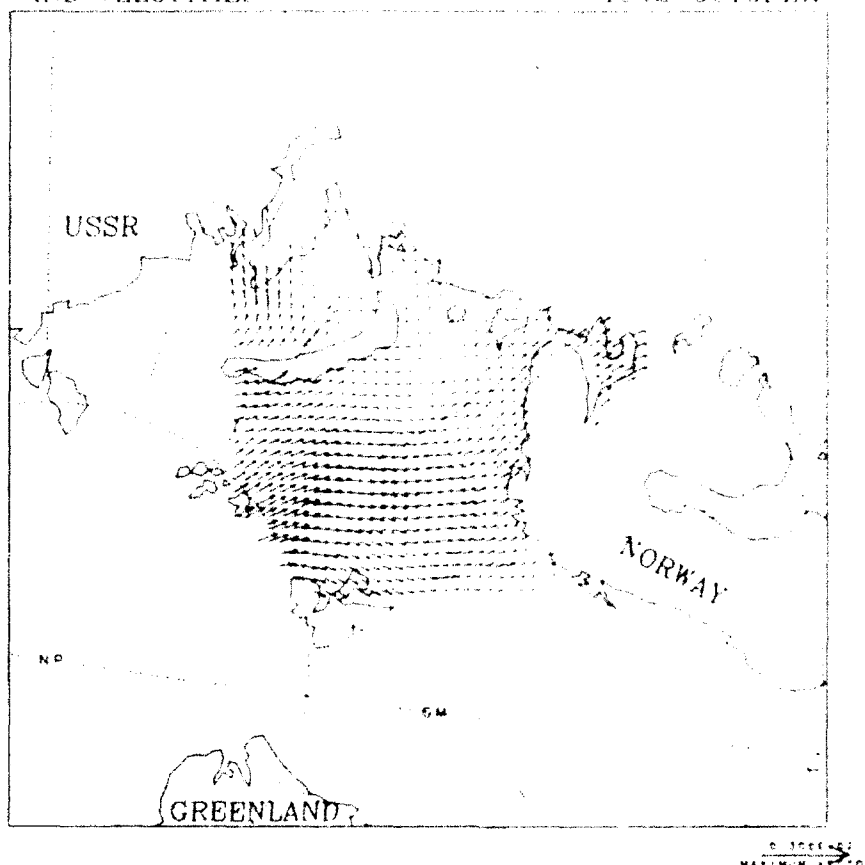
ICE CONCENTRATION

1992 SEPTEMBER



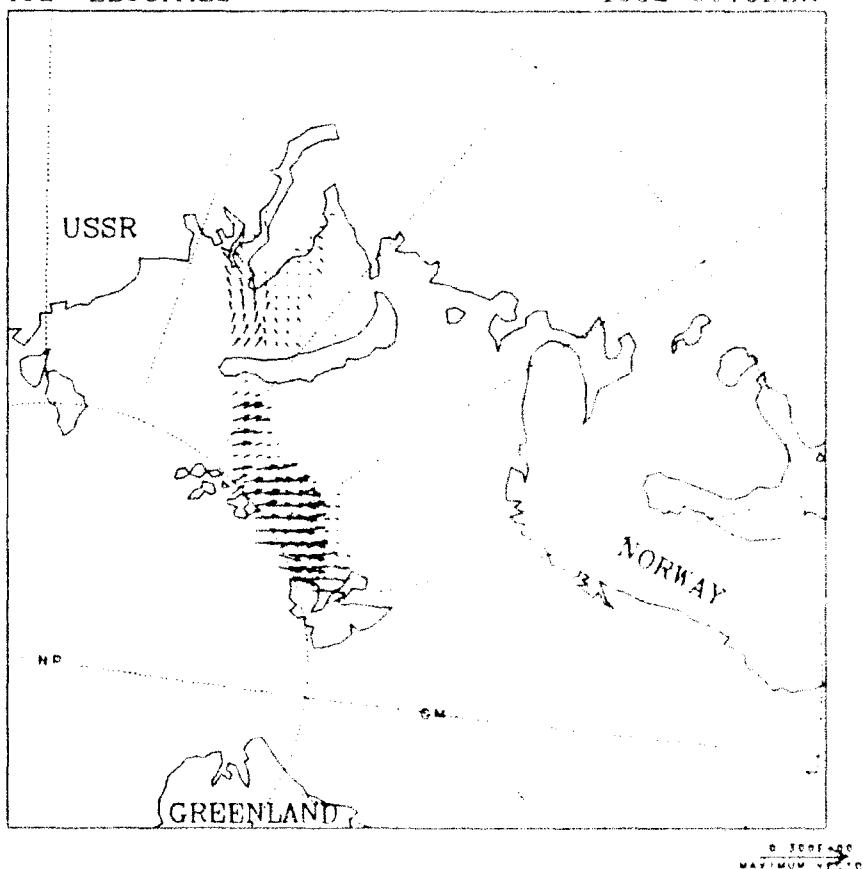
WIND VELOCITIES

1992 OCTOBER



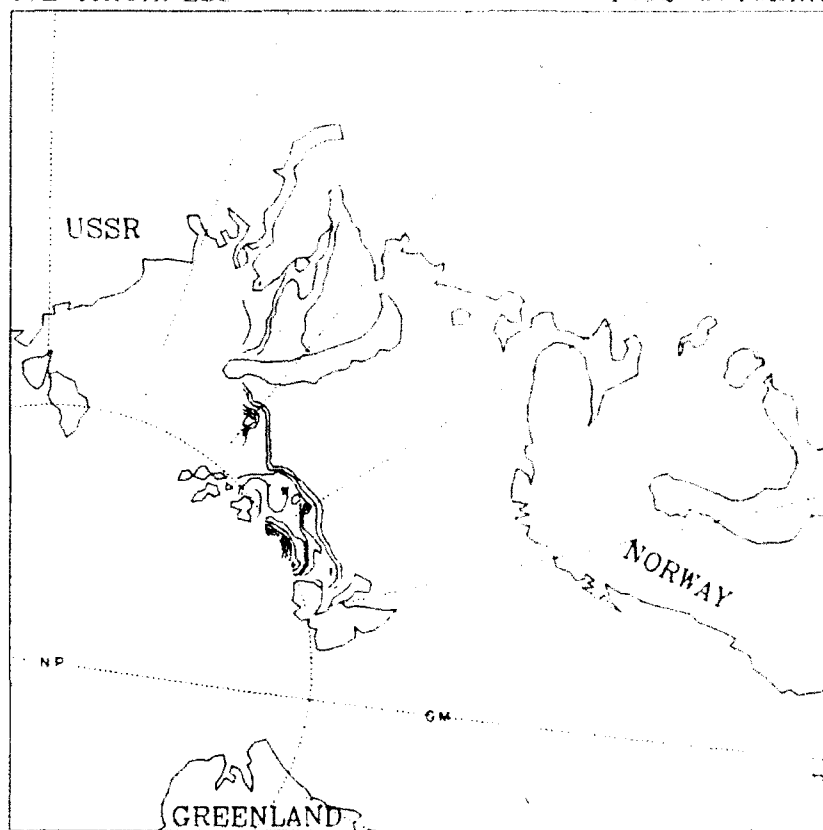
ICE VELOCITIES

1992 OCTOBER



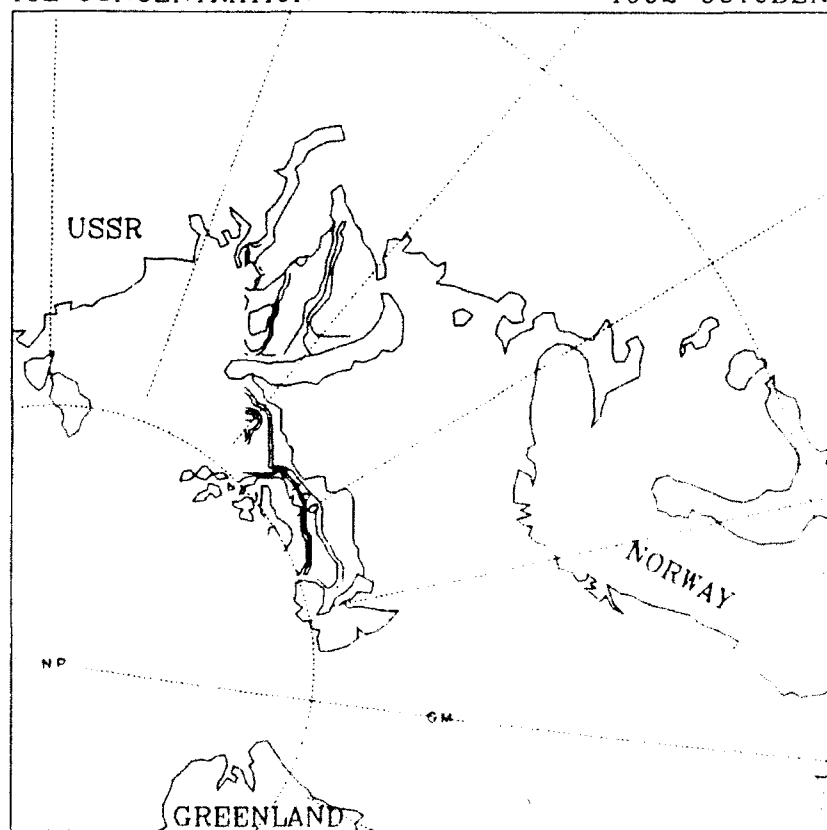
ICE THICKNESS

1992 OCTOBER



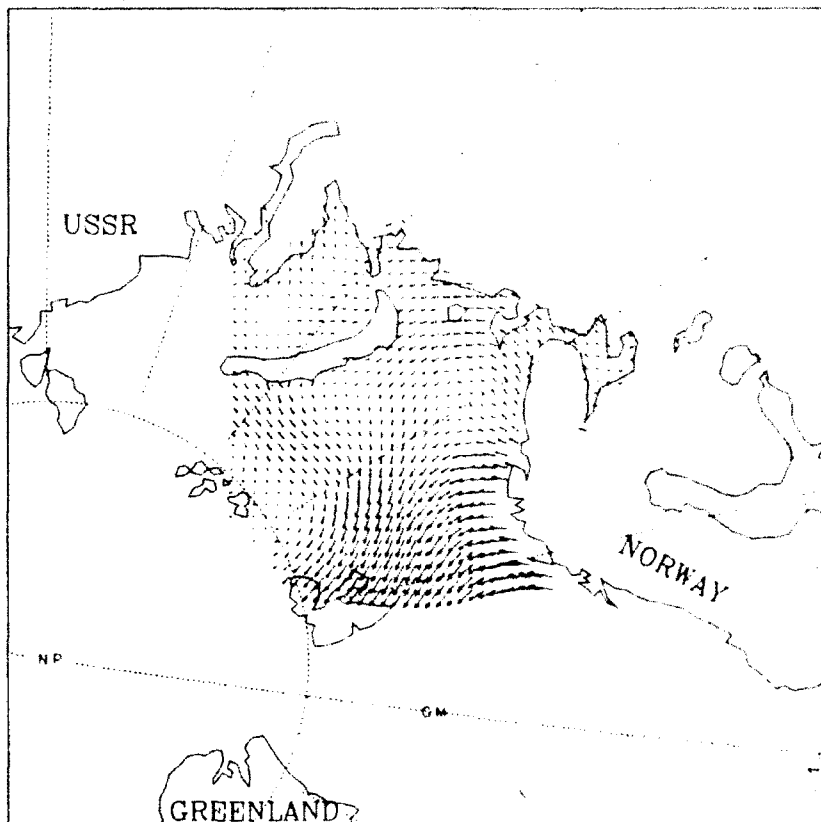
ICE CONCENTRATION

1992 OCTOBER



WIND VELOCITIES

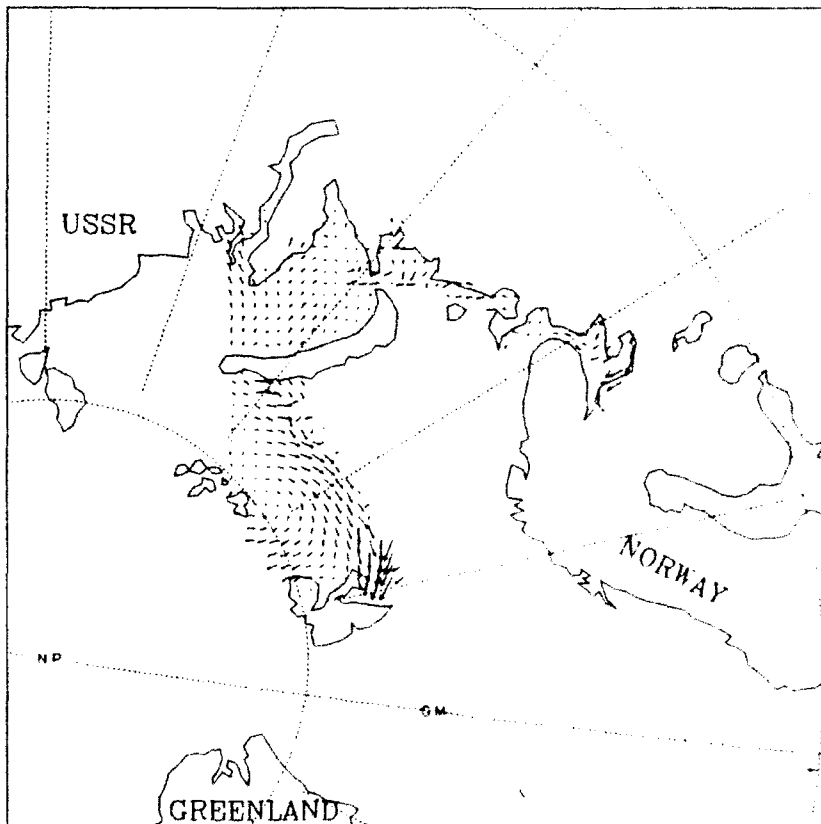
1992 NOVEMBER



0.300E-02
MAXIMUM VECTOR

ICE VELOCITIES

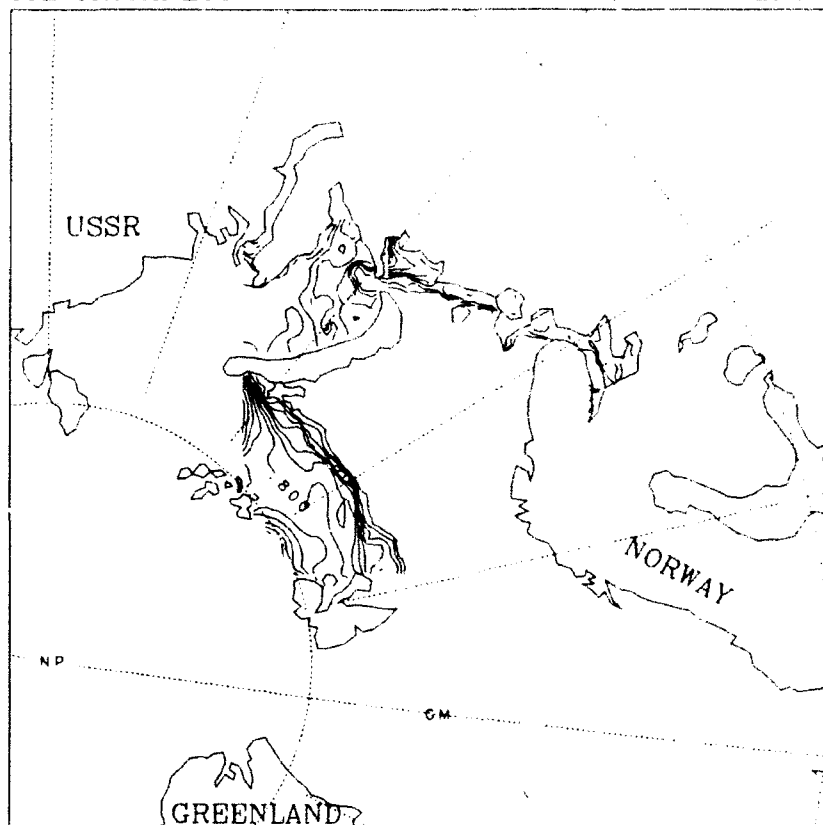
1992 NOVEMBER



0.300E-02
MAXIMUM VECTOR

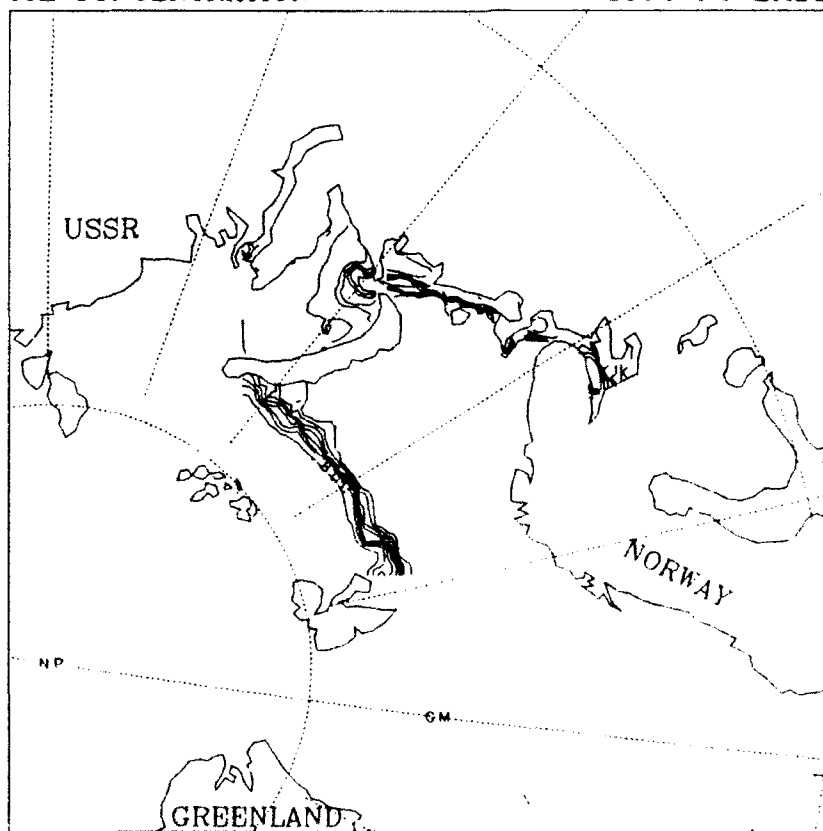
ICE THICKNESS

1992 NOVEMBER



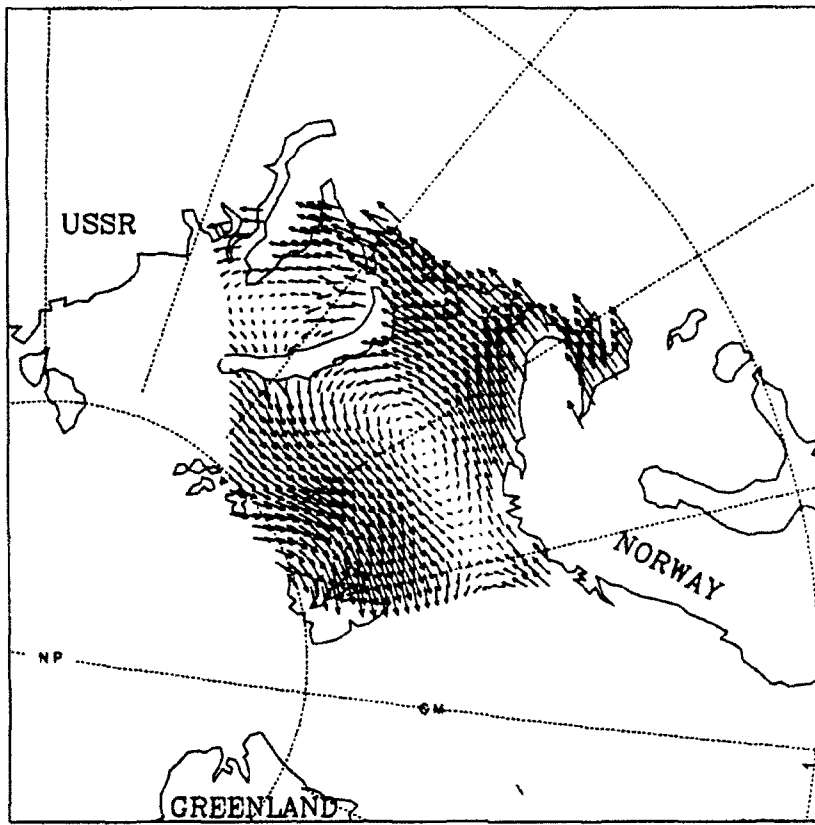
ICE CONCENTRATION

1992 NOVEMBER



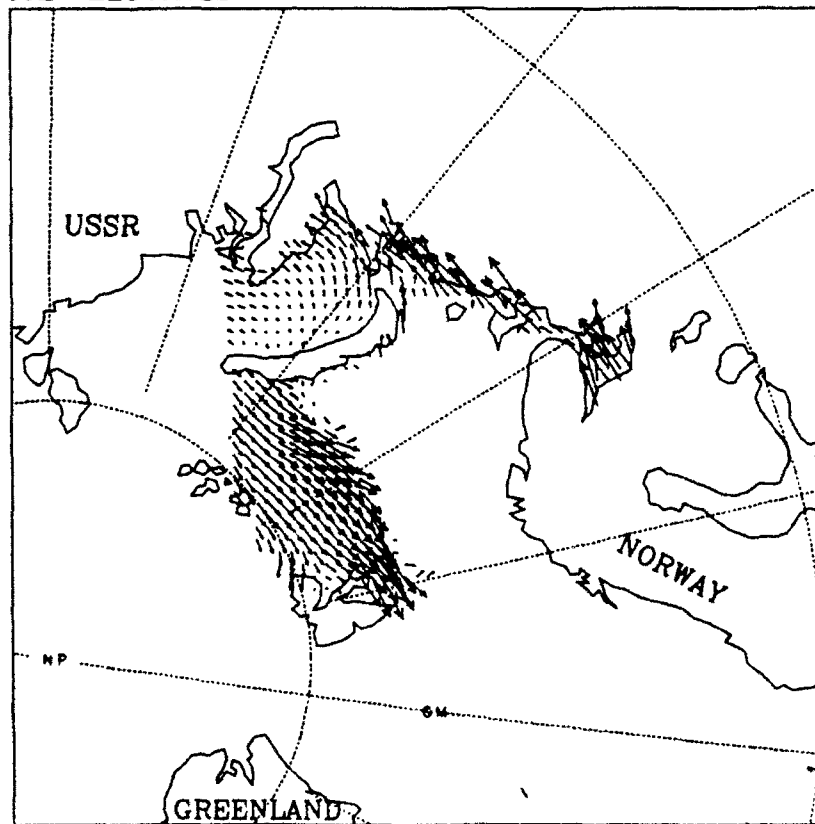
WIND VELOCITIES

1992 DECEMBER



ICE VELOCITIES

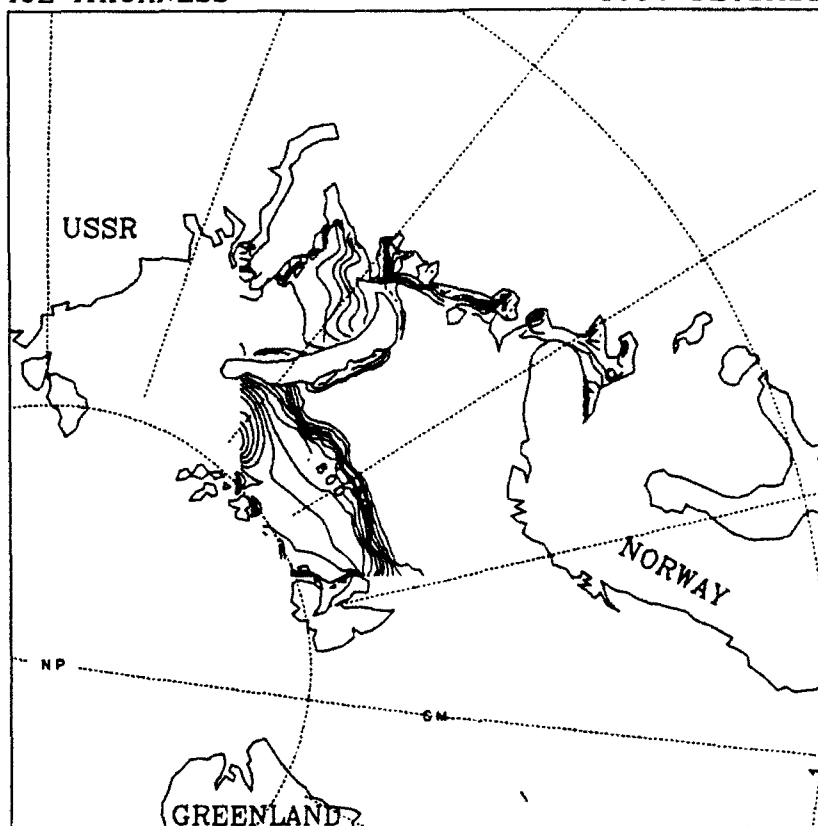
1992 DECEMBER



0.0001-0.0002
MAXIMUM VELOCITY

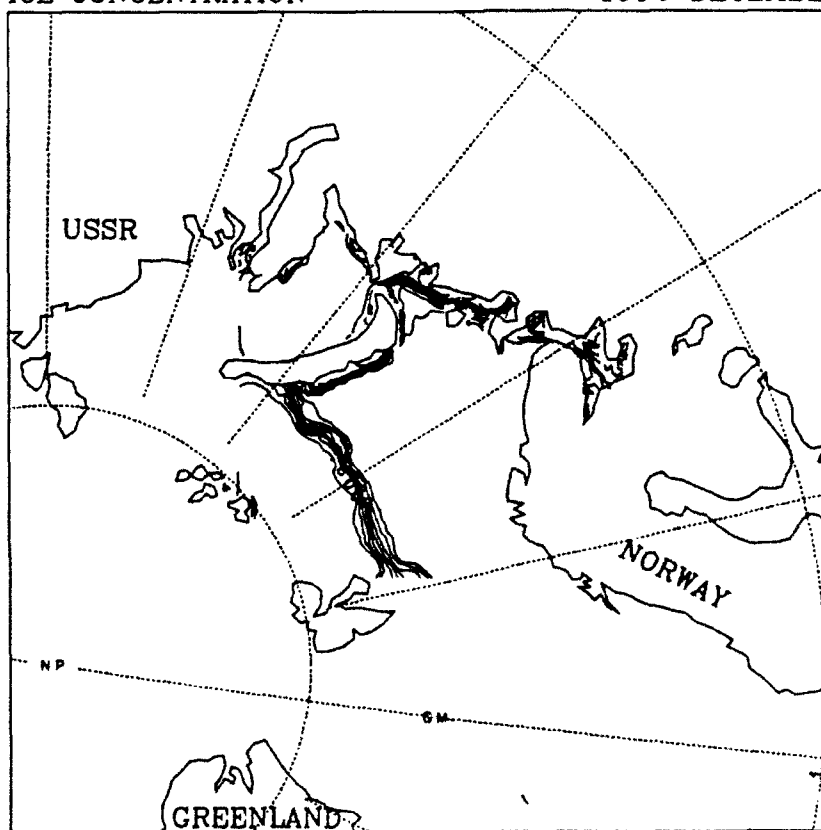
ICE THICKNESS

1992 DECEMBER



ICE CONCENTRATION

1992 DECEMBER



RPIPS-G MODEL GRID

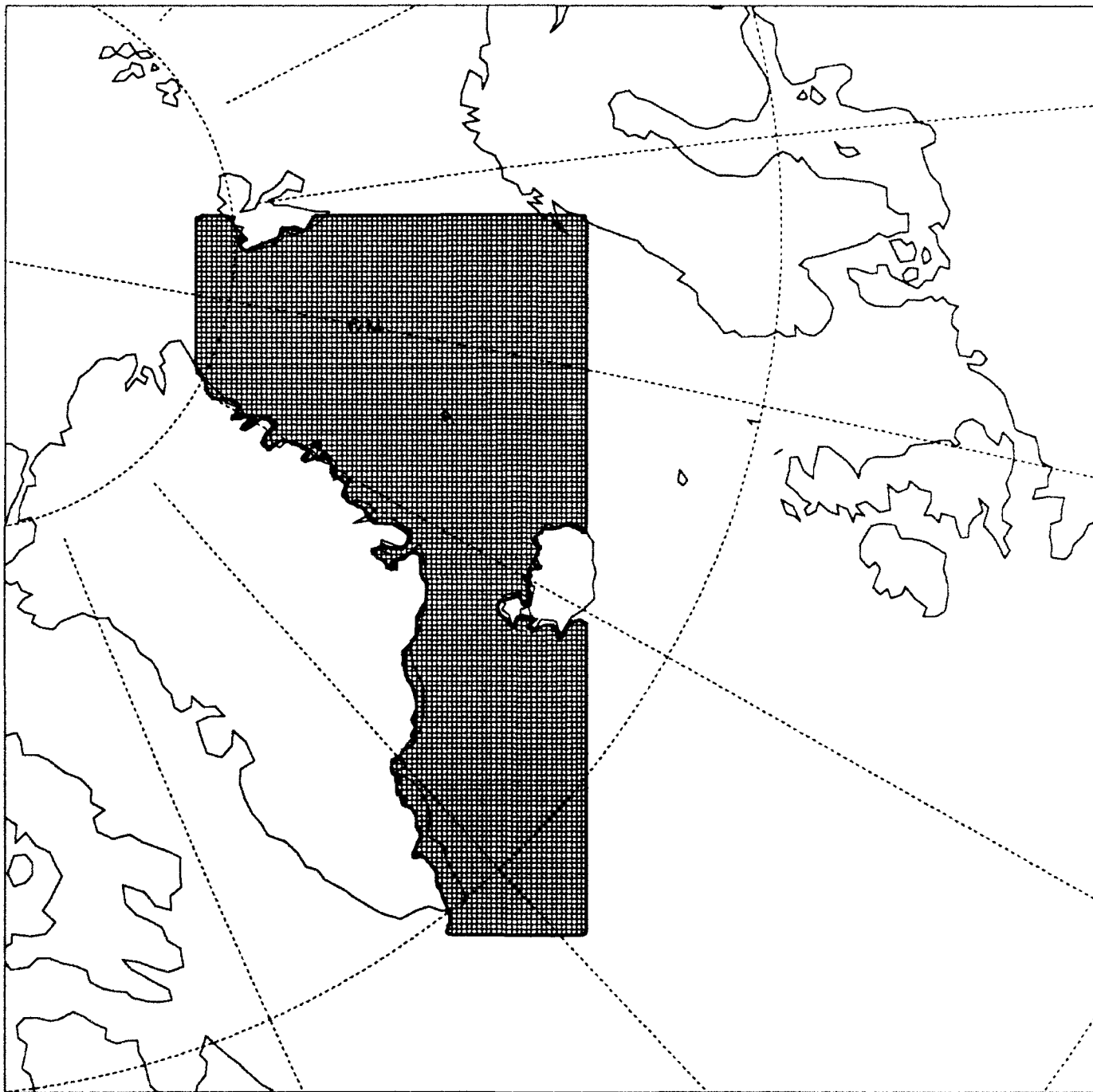


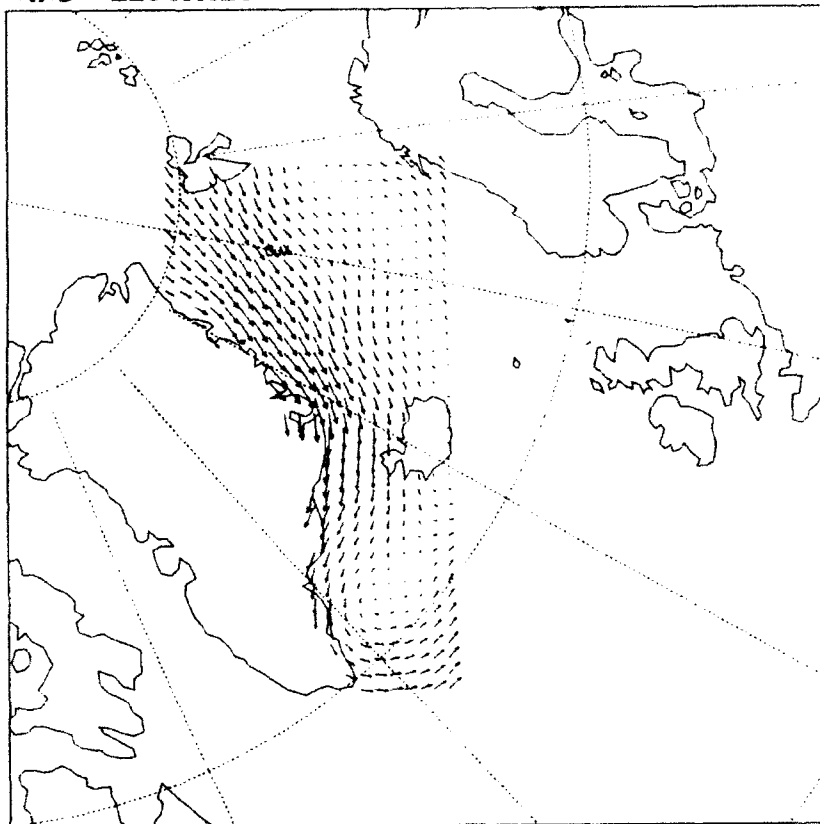
Figure 3. RPIPS-G domain with the 20 km resolution grid overlaid.

RPIPS-G 1991

MONTHLY MEANS

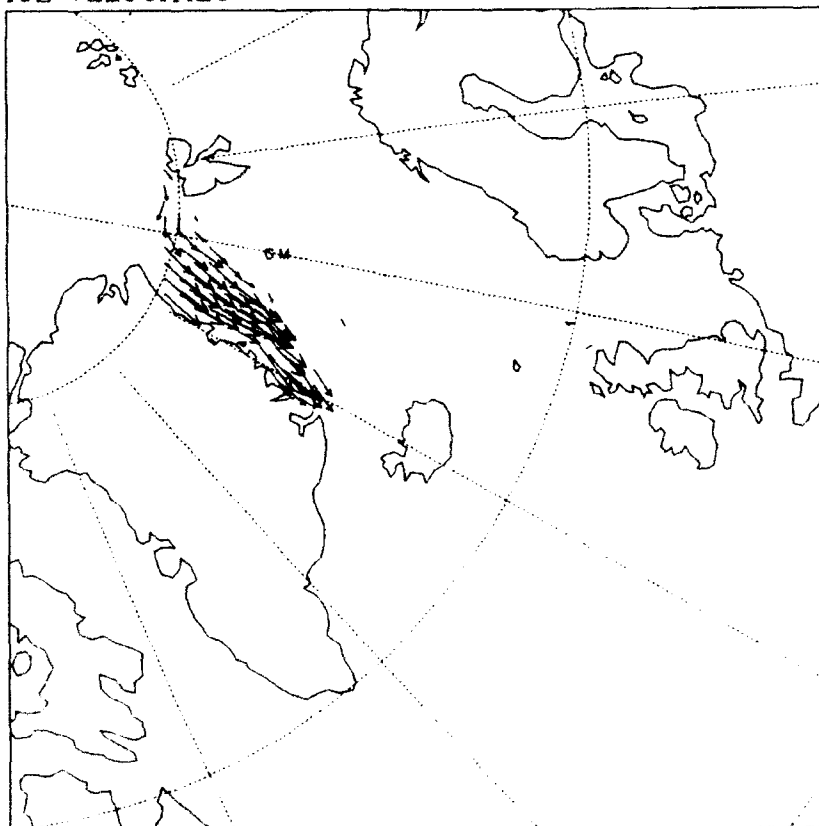
WIND VELOCITIES

1991 OCTOBER



ICE VELOCITIES

1991 OCTOBER

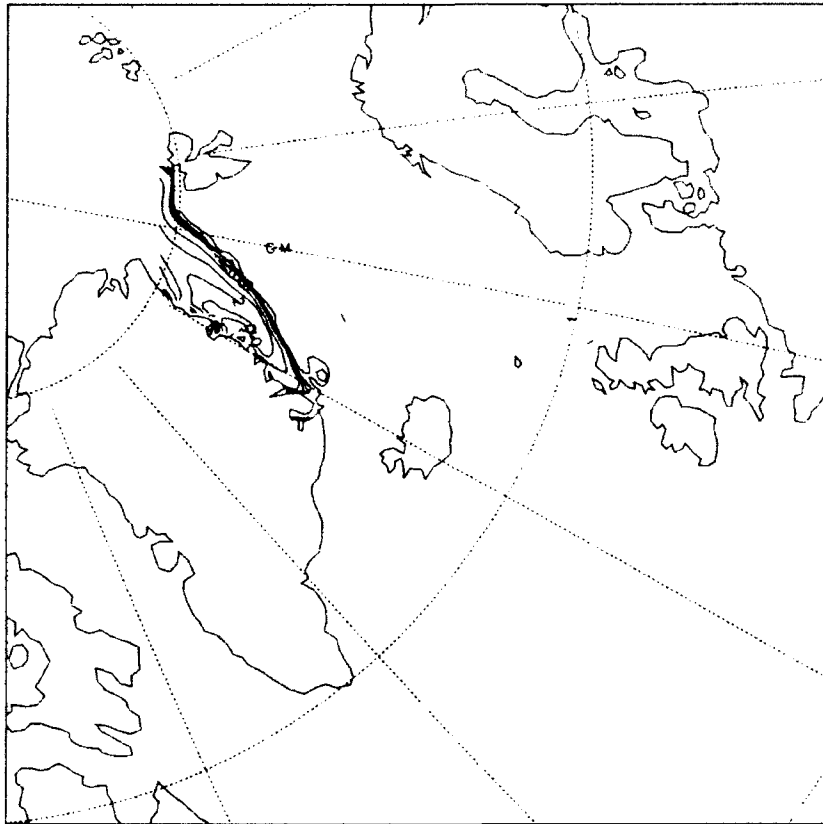


0.300E+02
MAXIMUM VECTOR

0.300E+02
MAXIMUM VECTOR

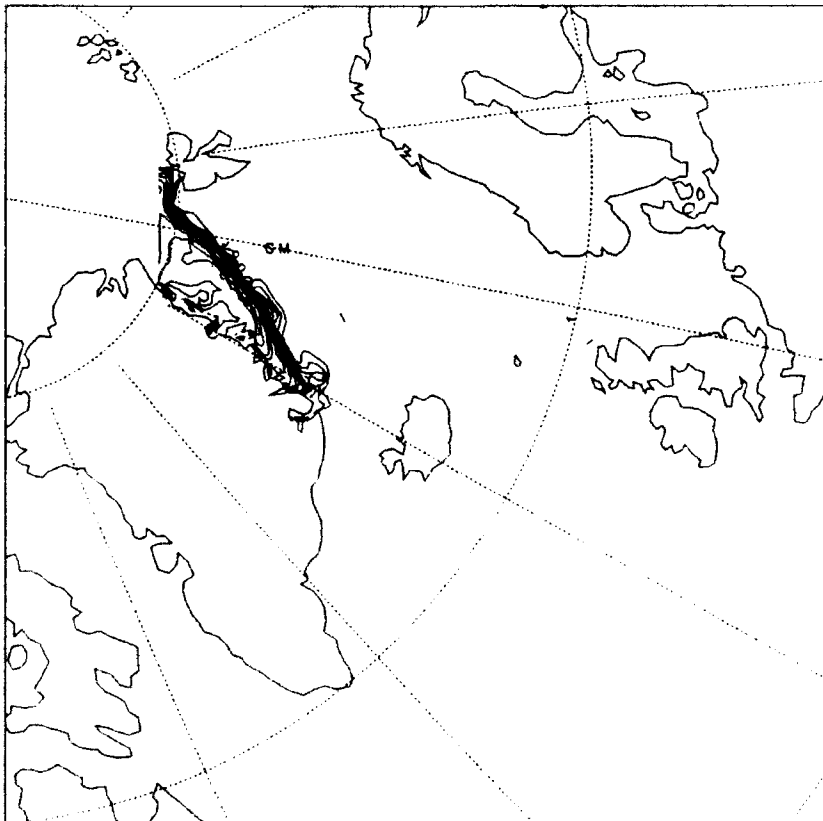
ICE THICKNESS

1991 OCTOBER



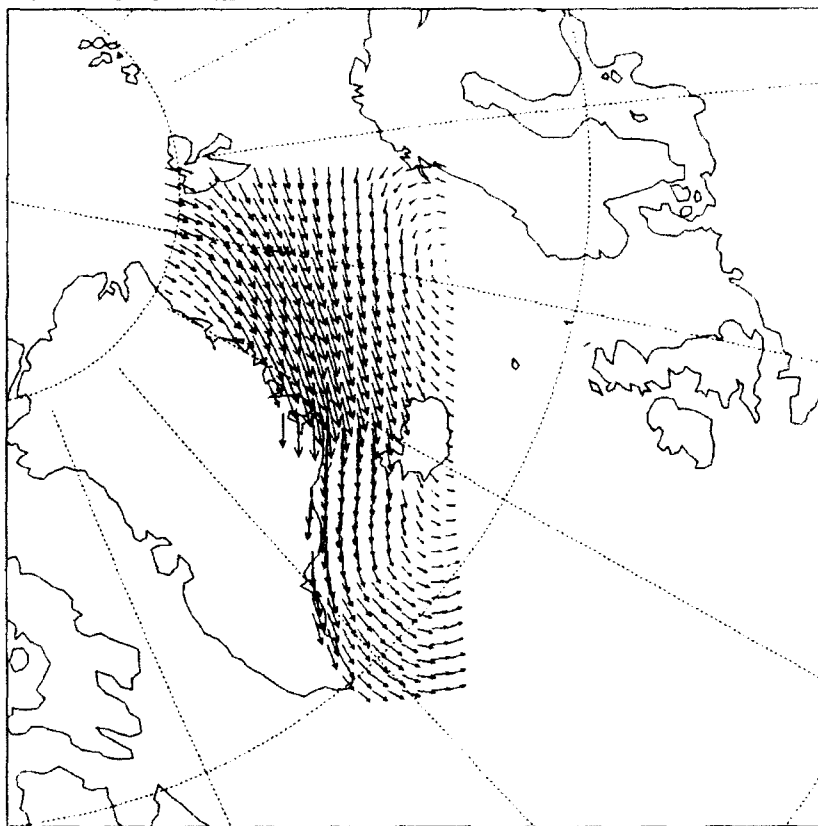
ICE CONCENTRATION

1991 OCTOBER



WIND VELOCITIES

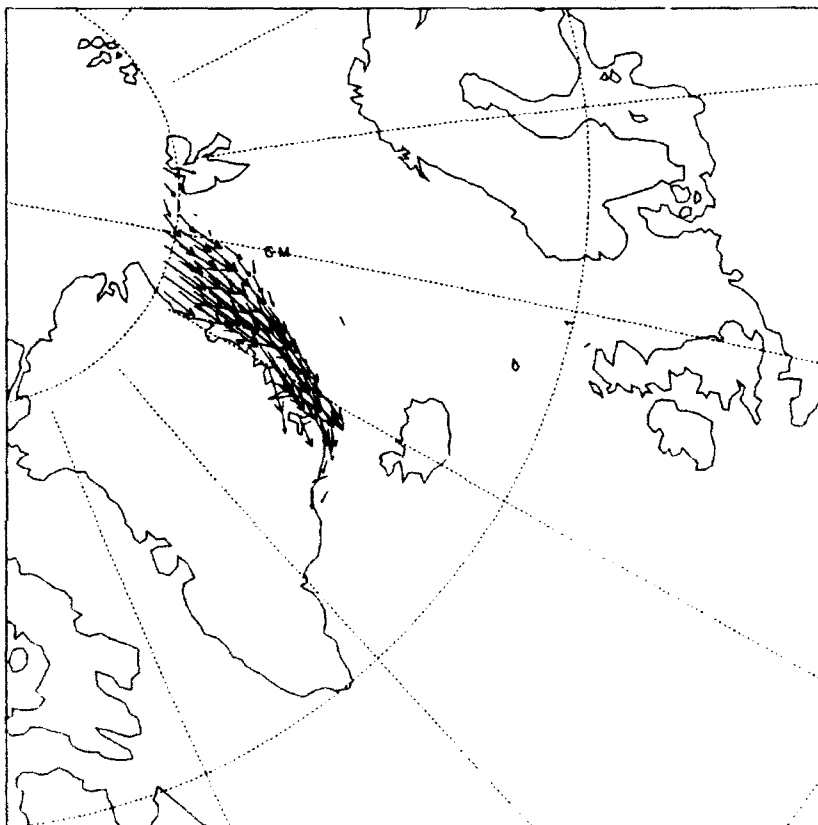
1991 NOVEMBER



0.300E-02
MAXIMUM VECTOR

ICE VELOCITIES

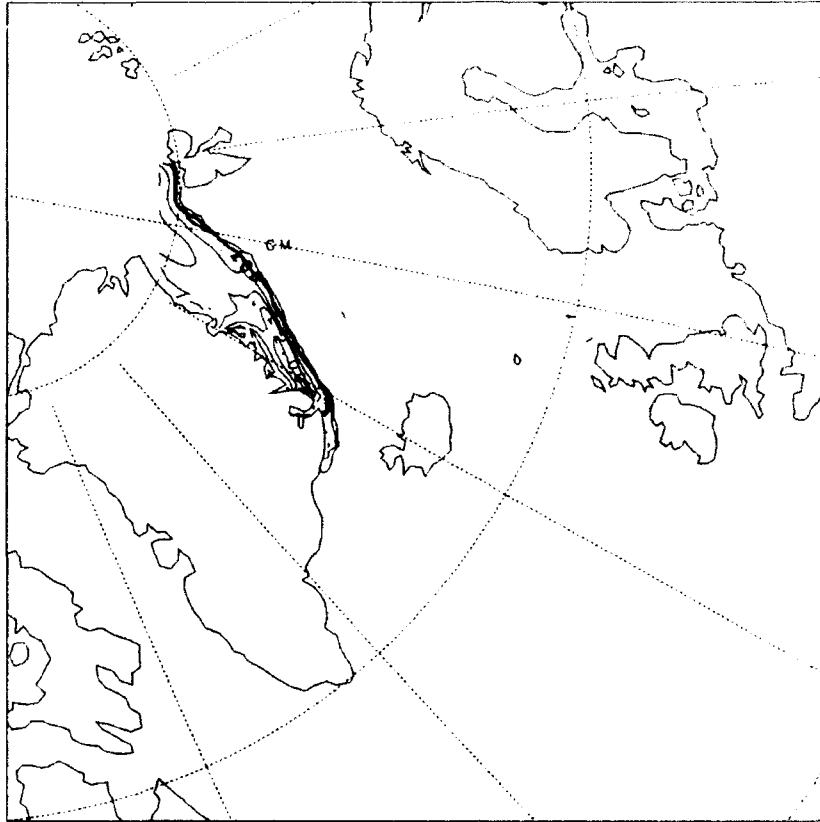
1991 NOVEMBER



0.300E-02
MAXIMUM VECTOR

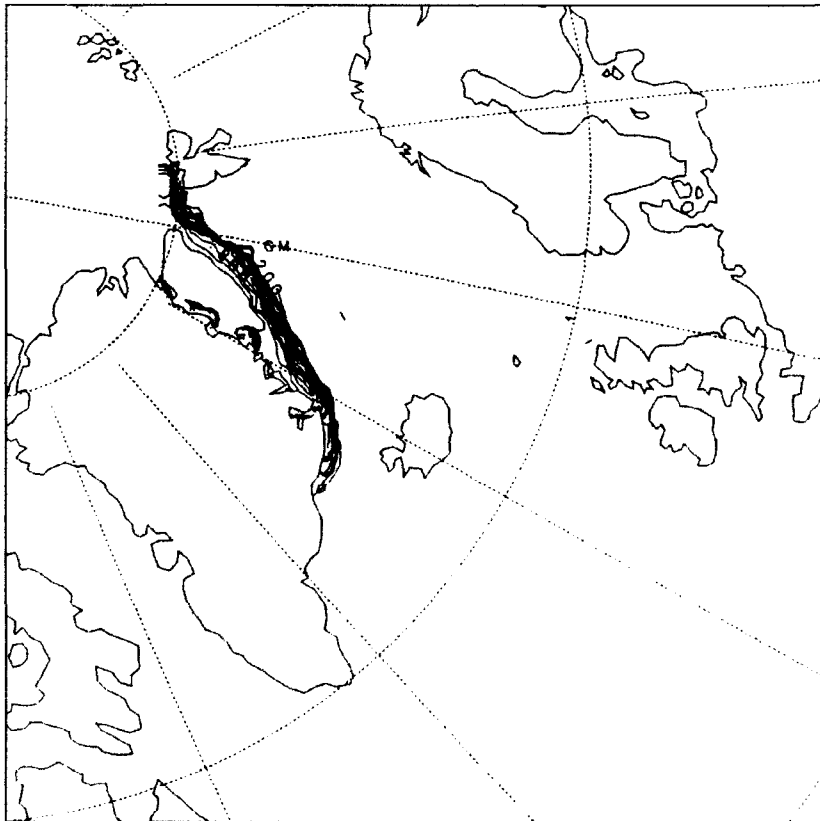
ICE THICKNESS

1991 NOVEMBER



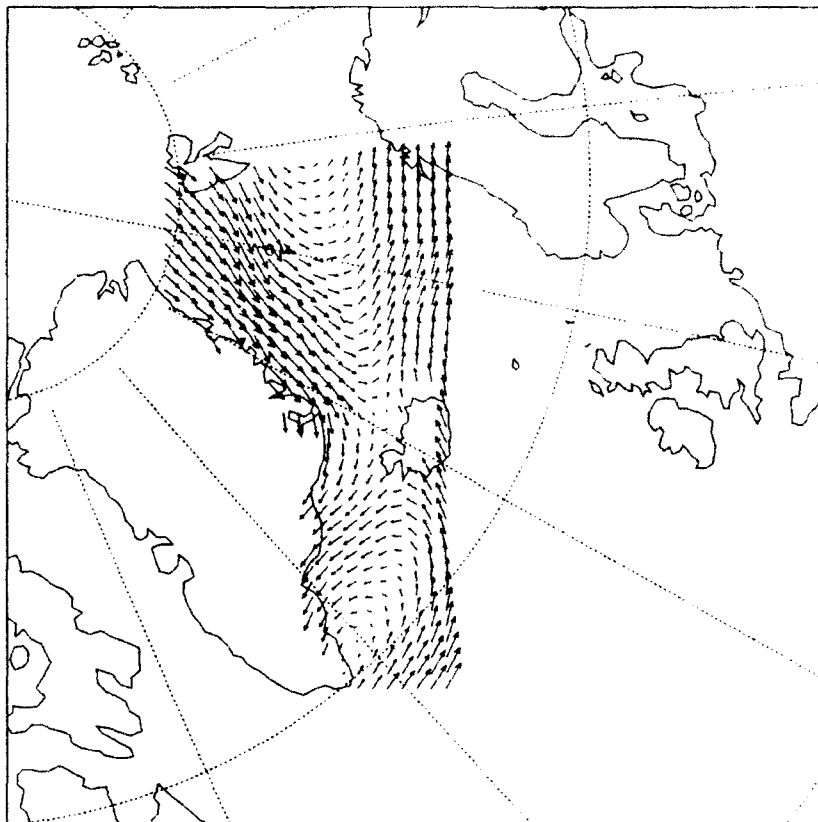
ICE CONCENTRATION

1991 NOVEMBER



WIND VELOCITIES

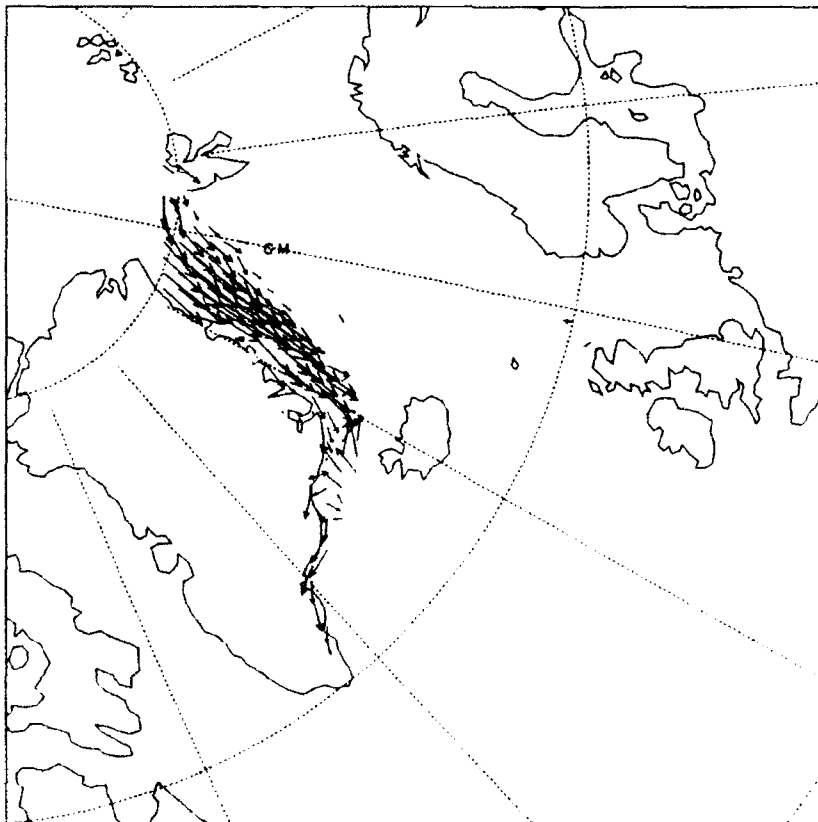
1991 DECEMBER



0.300E+02
MAXIMUM VECTOR

ICE VELOCITIES

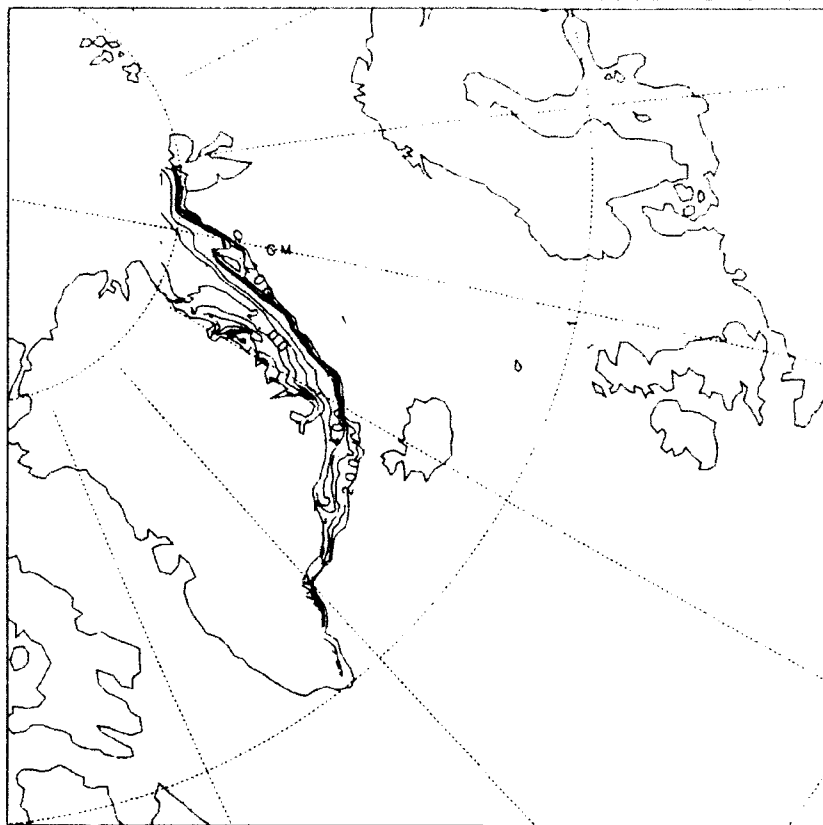
1991 DECEMBER



0.300E+00
MAXIMUM VECTOR

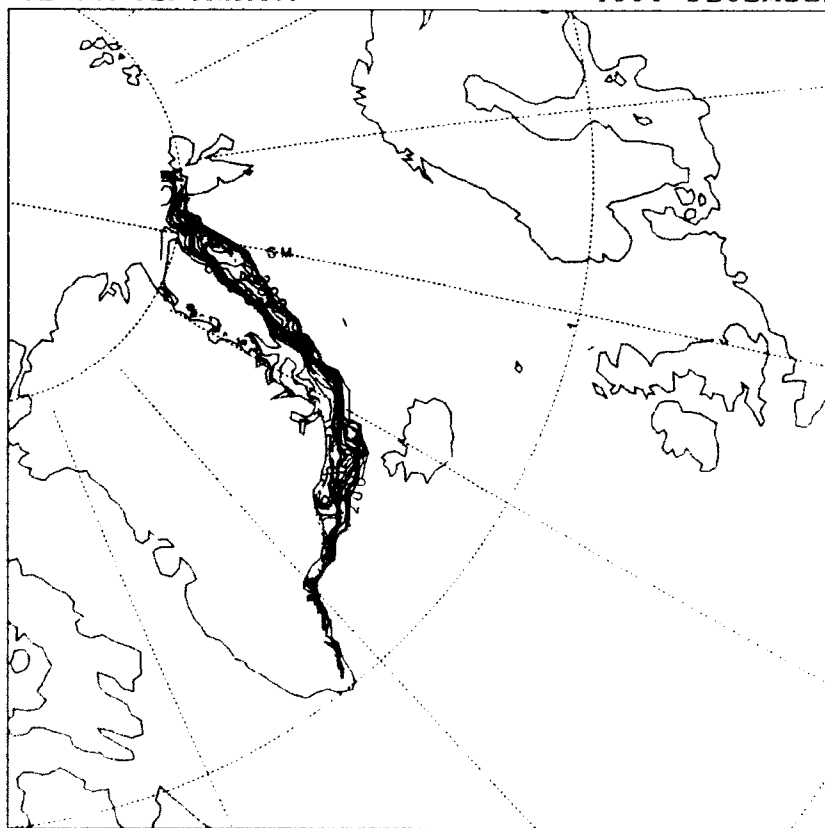
ICE THICKNESS

1991 DECEMBER



ICE CONCENTRATION

1991 DECEMBER

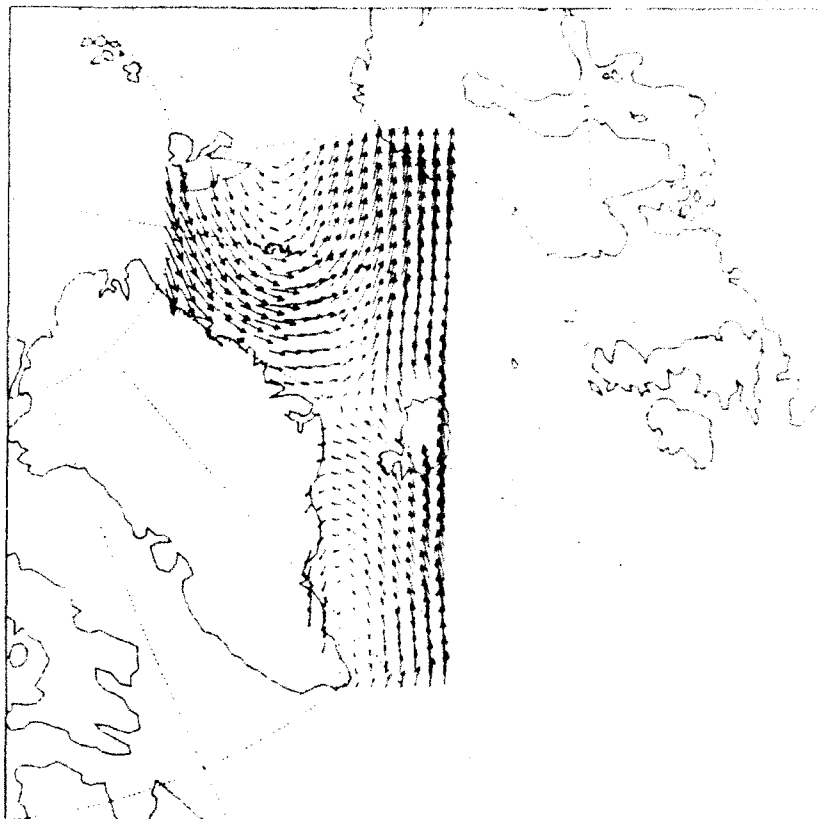


RPIPS-G 1992

MONTHLY MEANS

WIND VELOCITIES

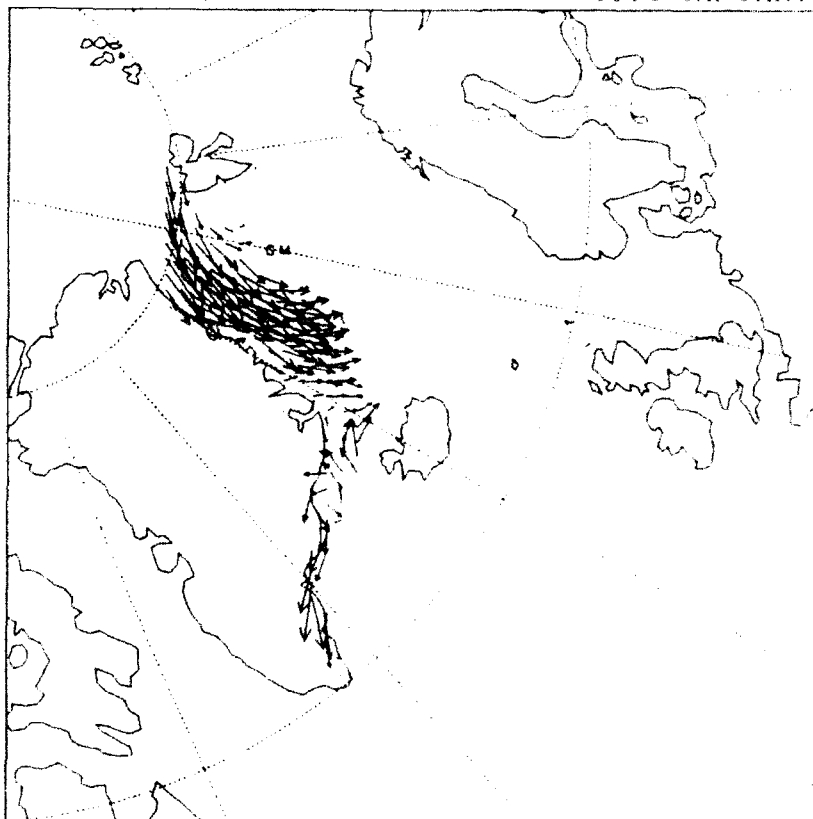
19 2 JANUARY



10 3000 60
MAXIMUM VECTOR

ICE VELOCITIES

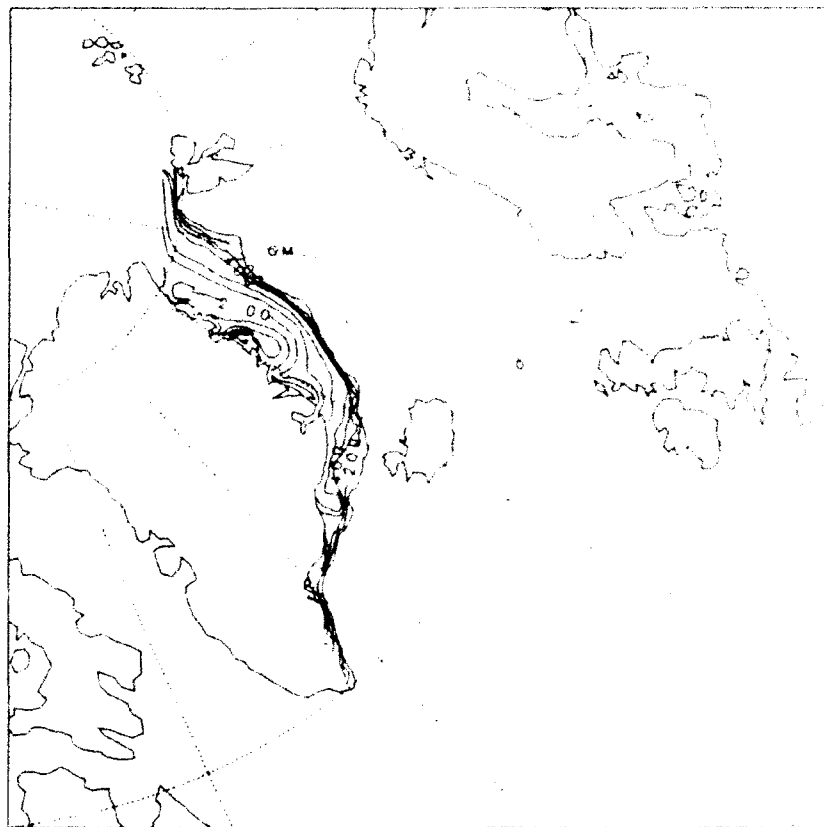
1992 JANUARY



10 3000 60
MAXIMUM VECTOR

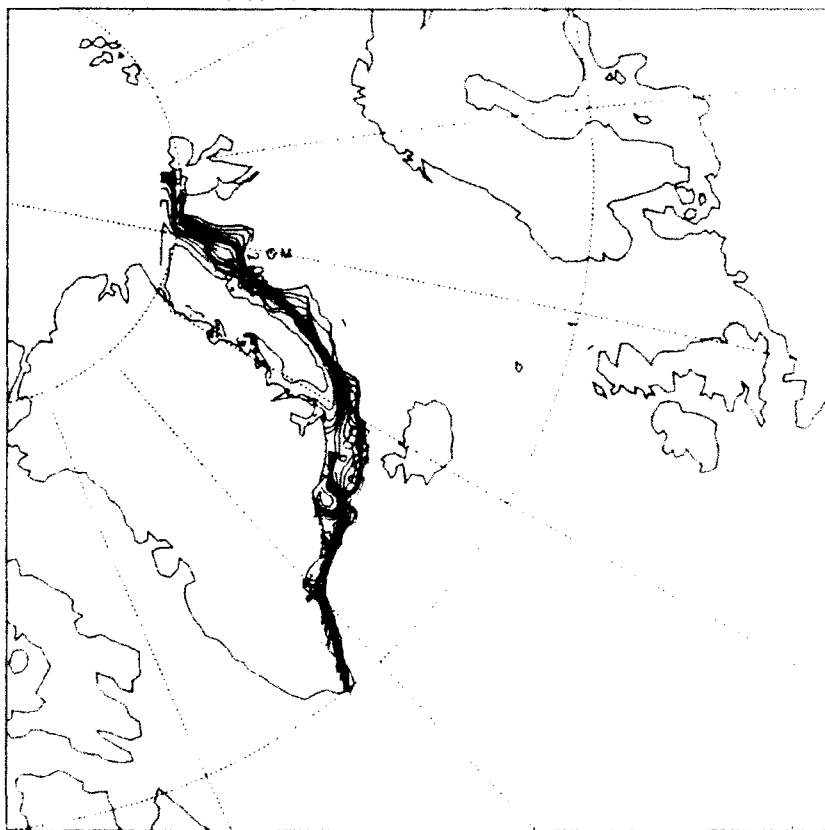
ICE THICKNESS

1992 JANUARY



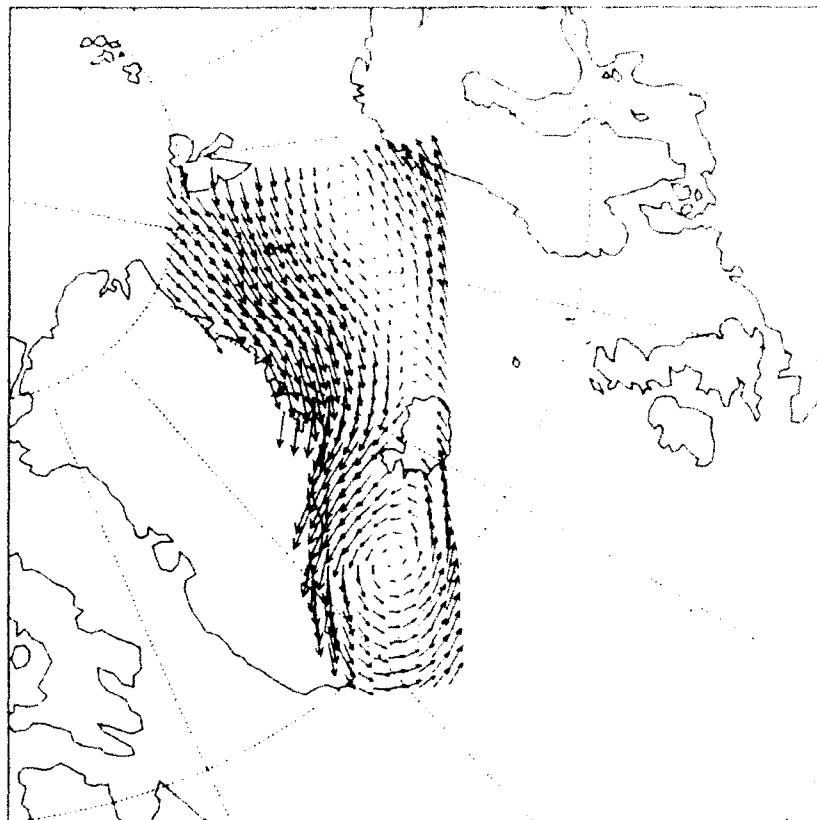
ICE CONCENTRATION

1992 JANUARY



WIND VELOCITIES

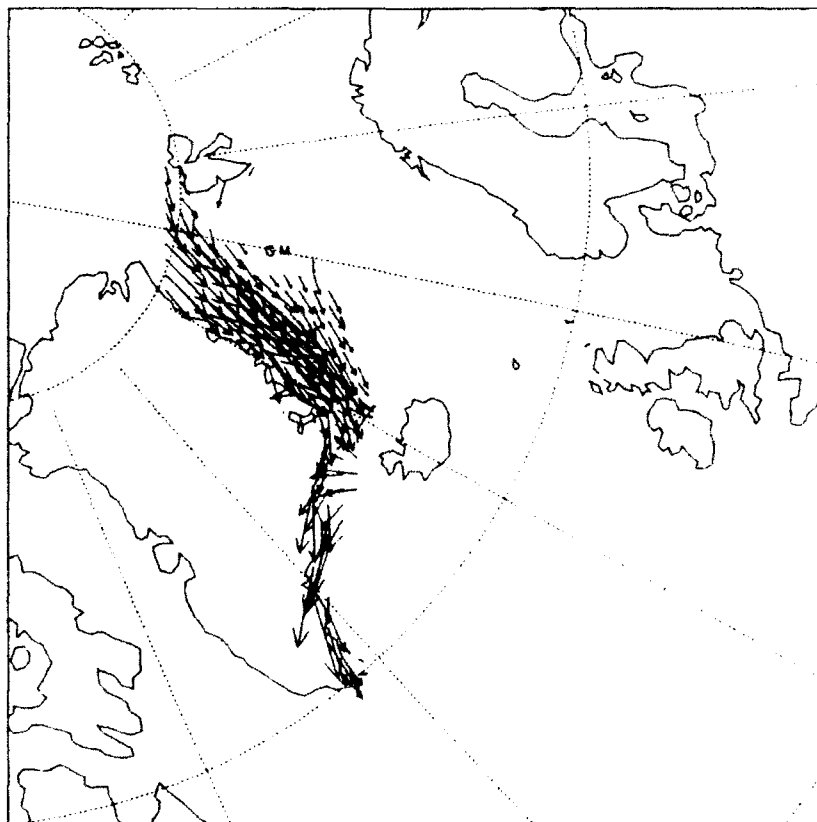
1992 FEBRUARY



0 3000-400
MAXIMUM VECTOR

ICE VELOCITIES

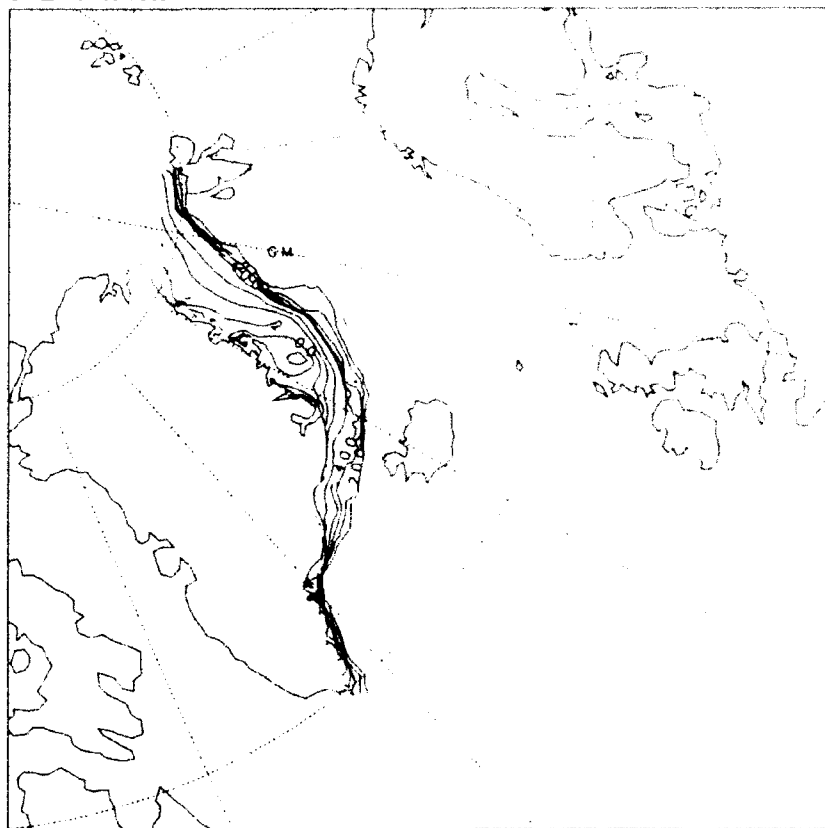
1992 FEBRUARY



0 3000-400
MAXIMUM VECTOR

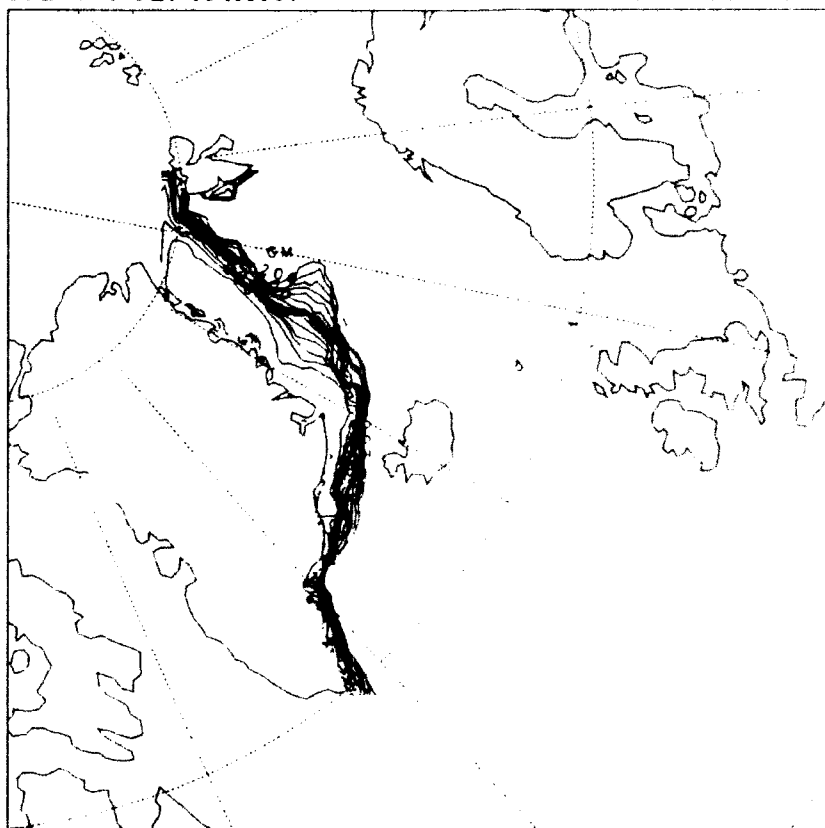
ICE THICKNESS

1992 FEBRUARY



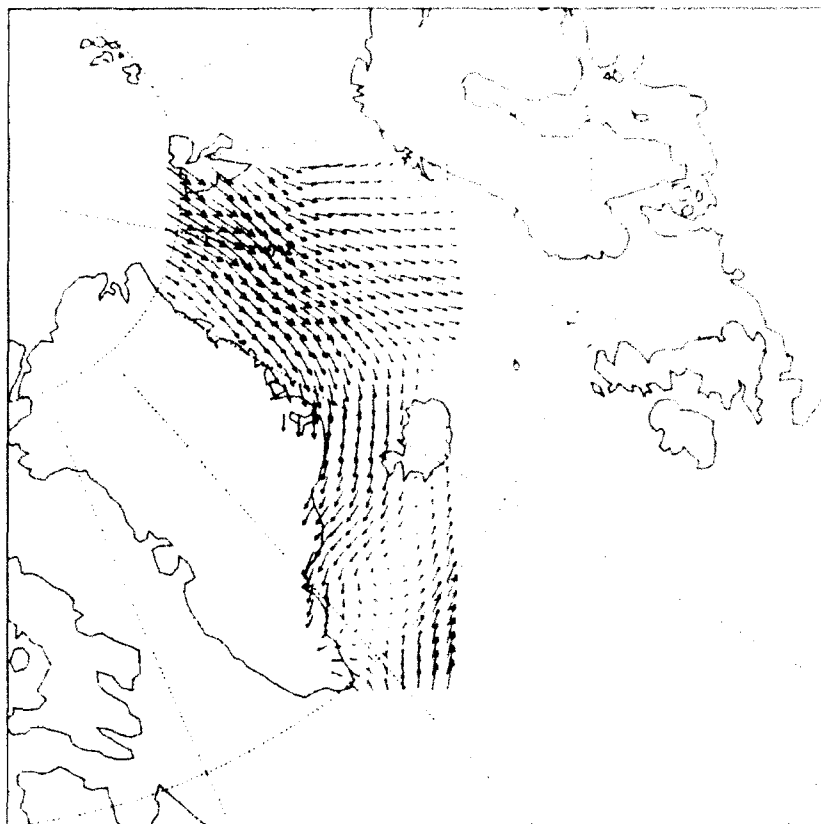
ICE CONCENTRATION

1992 FEBRUARY



WIND VELOCITIES

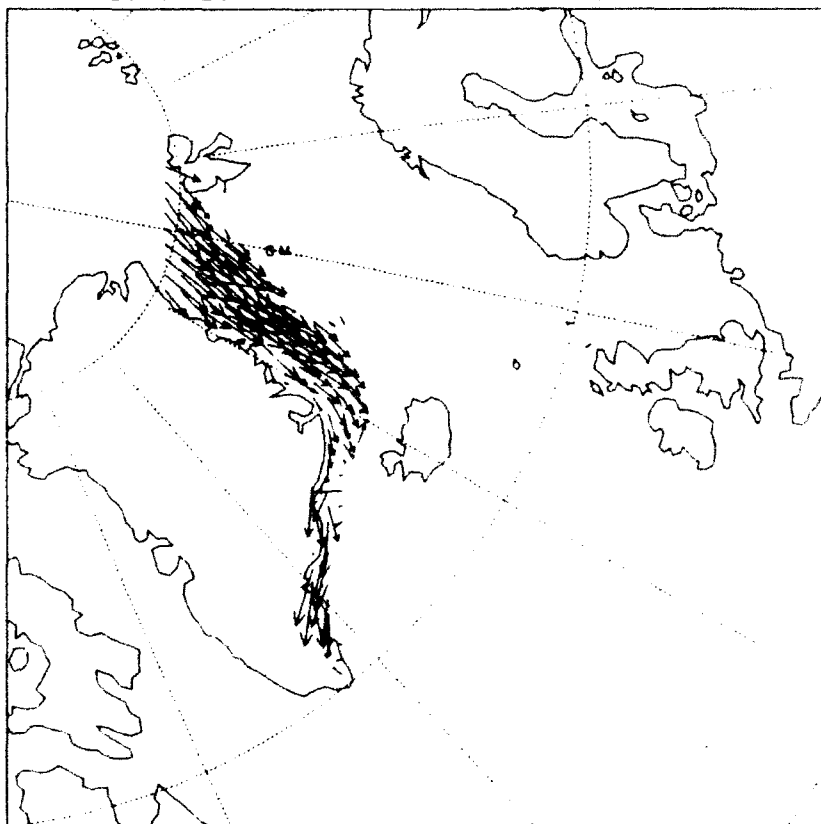
1992 MARCH



0 300E-02
MAXIMUM VECTOR

ICE VELOCITIES

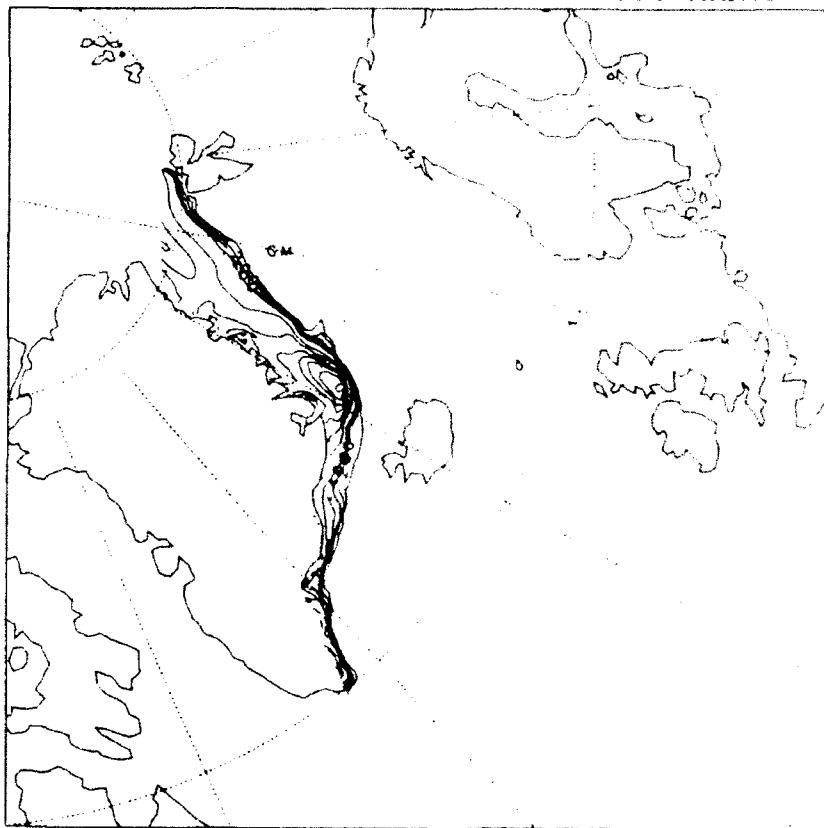
1992 MARCH



0 300E-02
MAXIMUM VECTOR

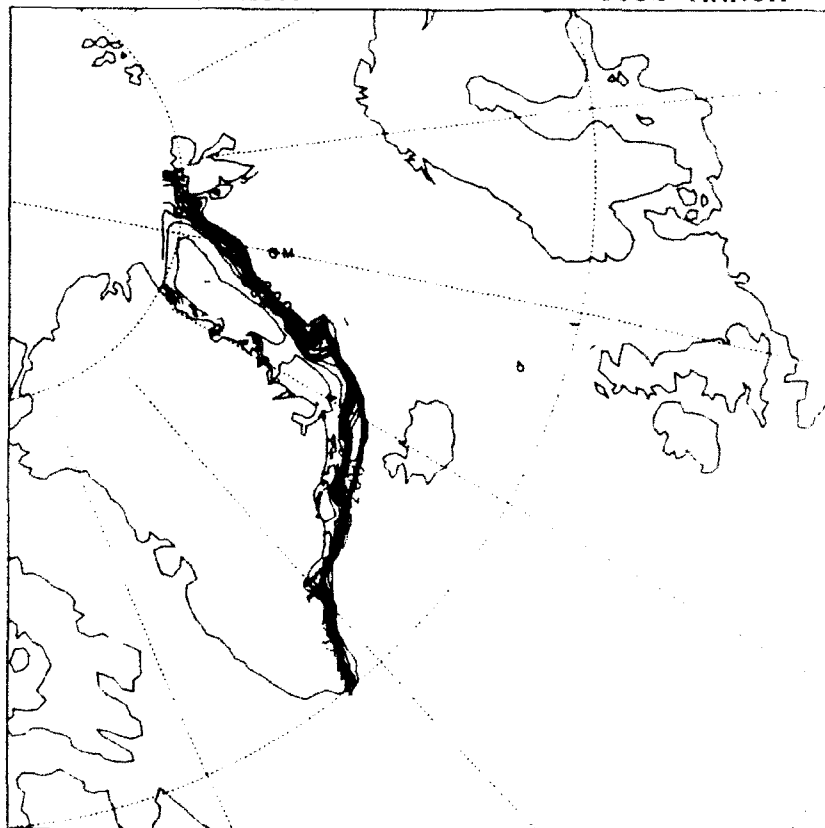
ICE THICKNESS

1992 MARCH



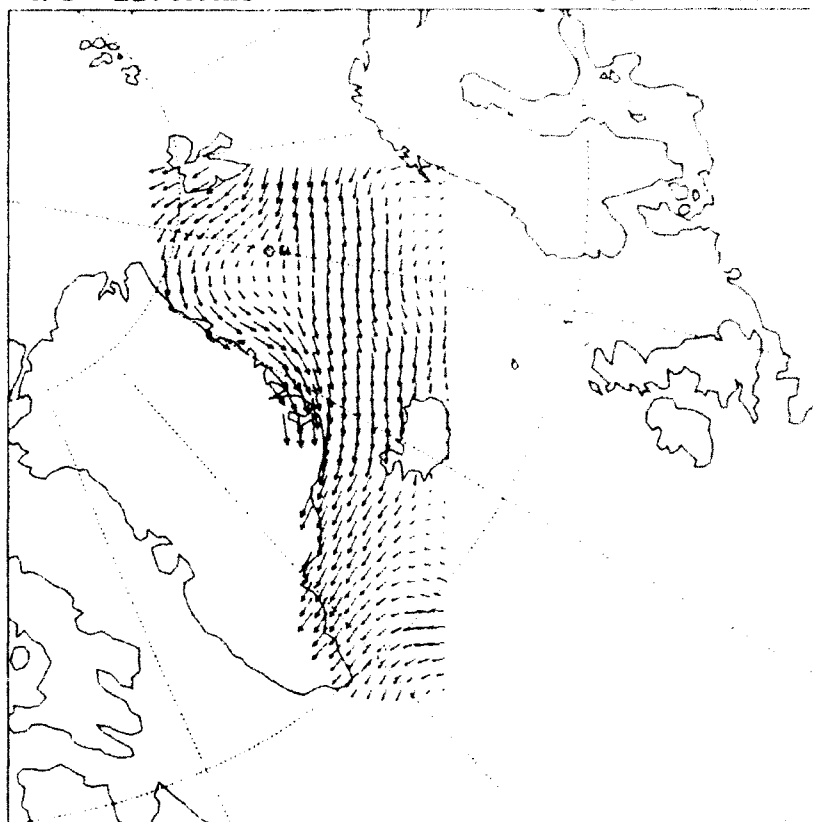
ICE CONCENTRATION

1992 MARCH



WIND VELOCITIES

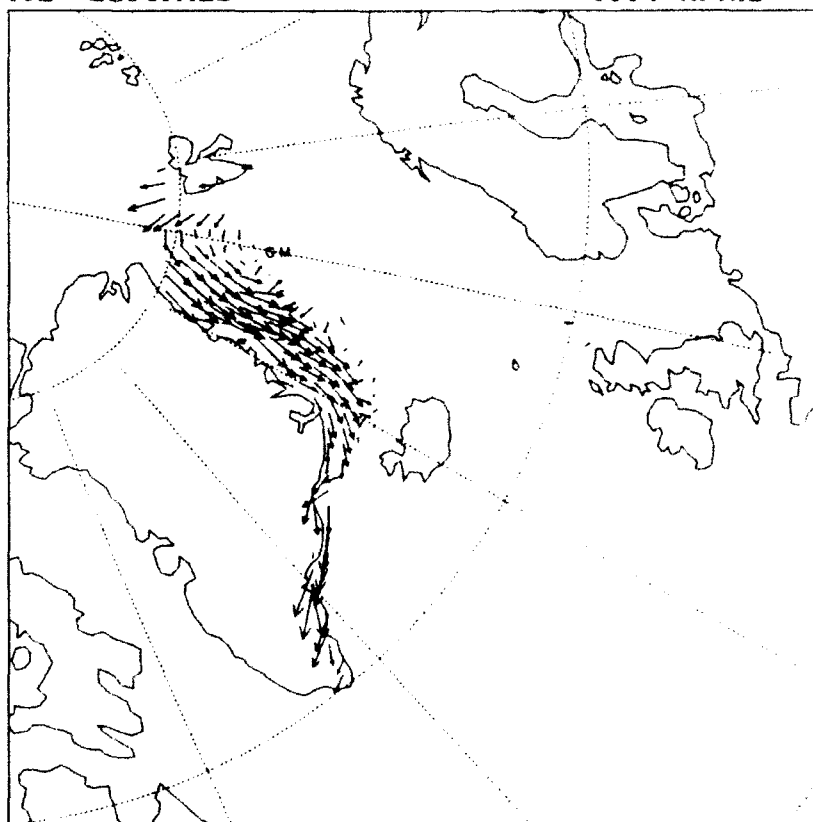
1992 APRIL



0 300E-82
MAXIMUM VECTOR

ICE VELOCITIES

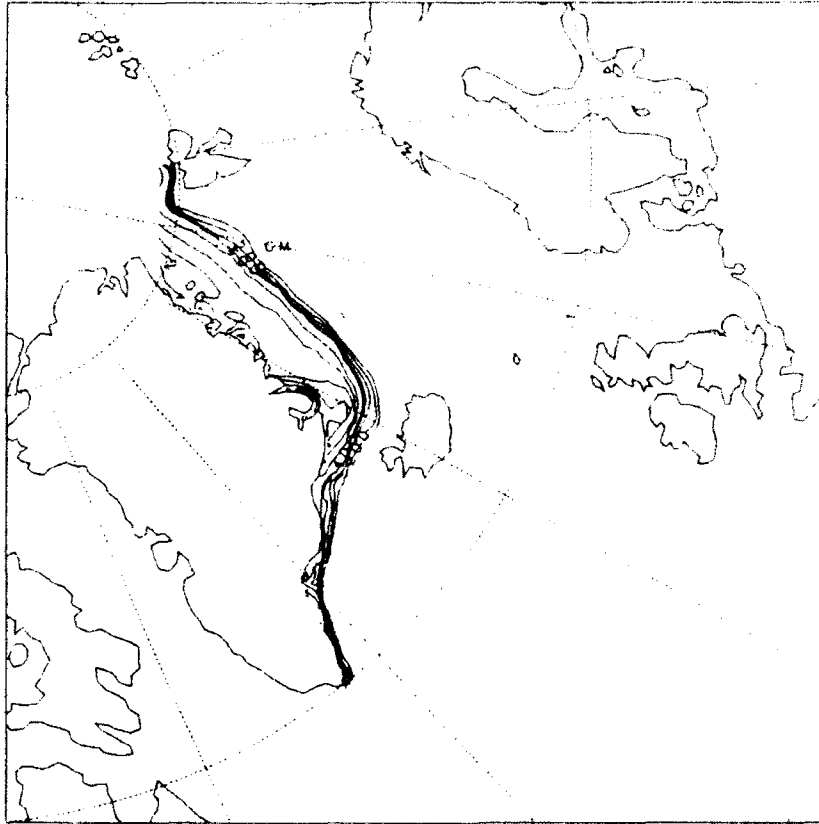
1992 APRIL



0 300E-80
MAXIMUM VECTOR

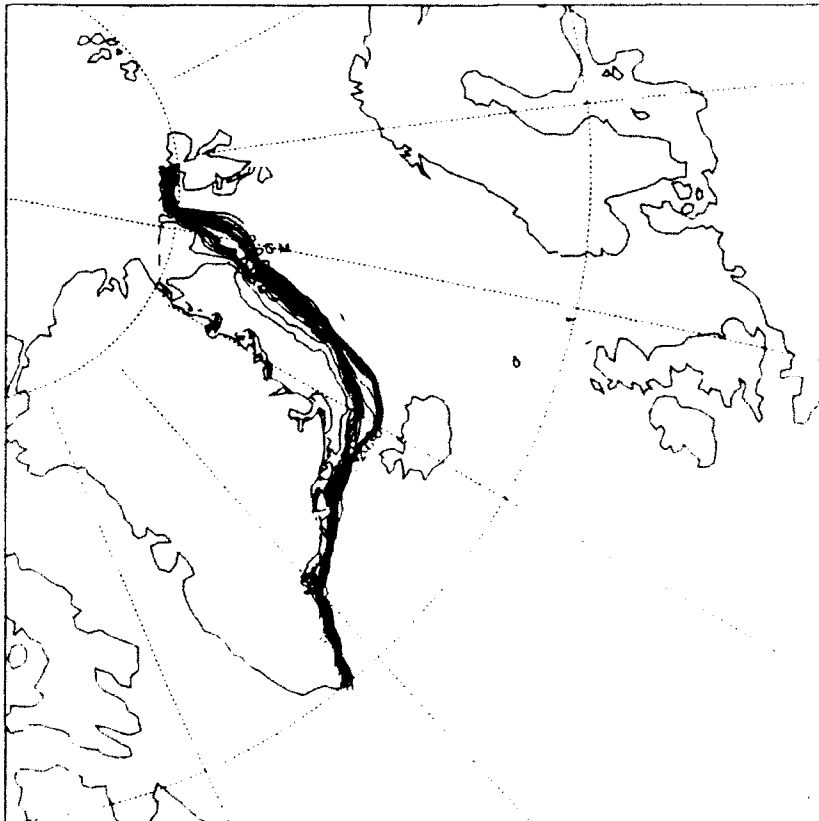
ICE THICKNESS

1992 APRIL



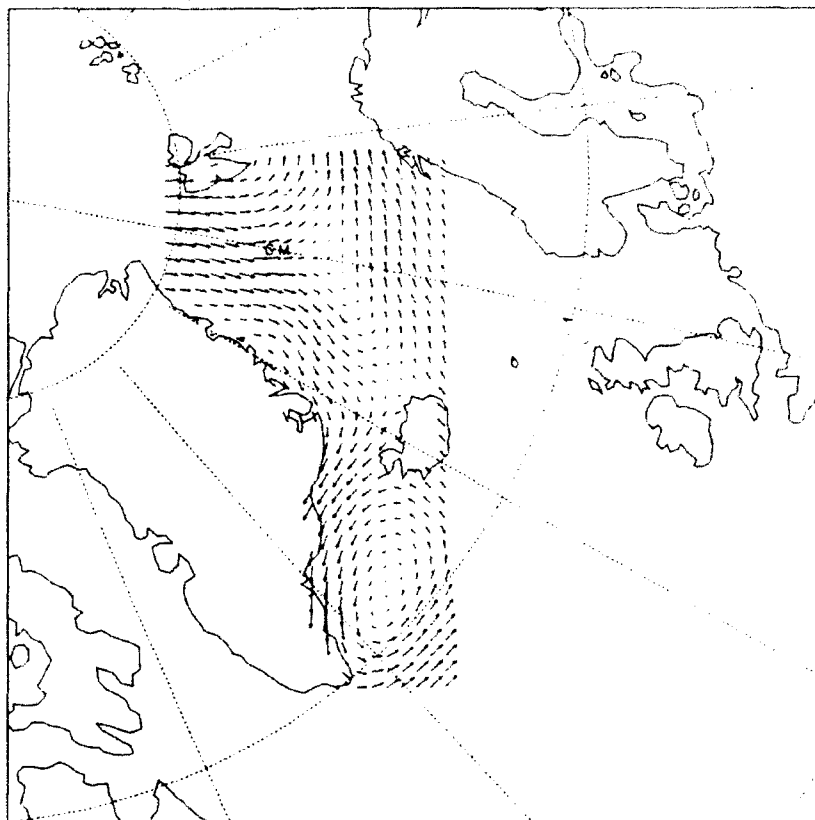
ICE CONCENTRATION

1992 APRIL



WIND VELOCITIES

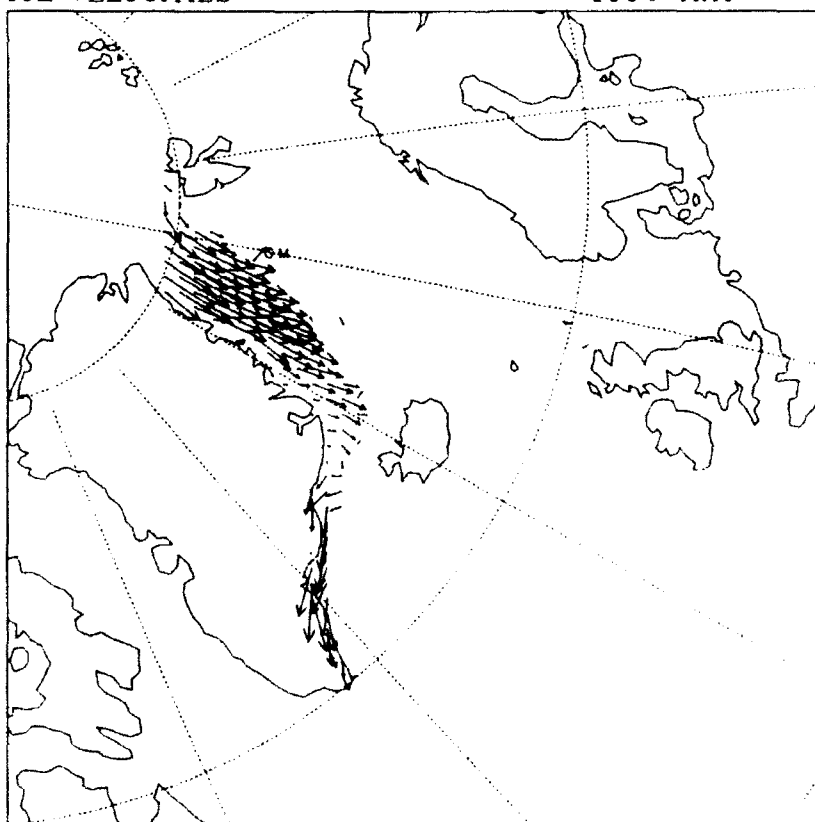
1992 MAY



0.300E+02
MAXIMUM VECTOR

ICE VELOCITIES

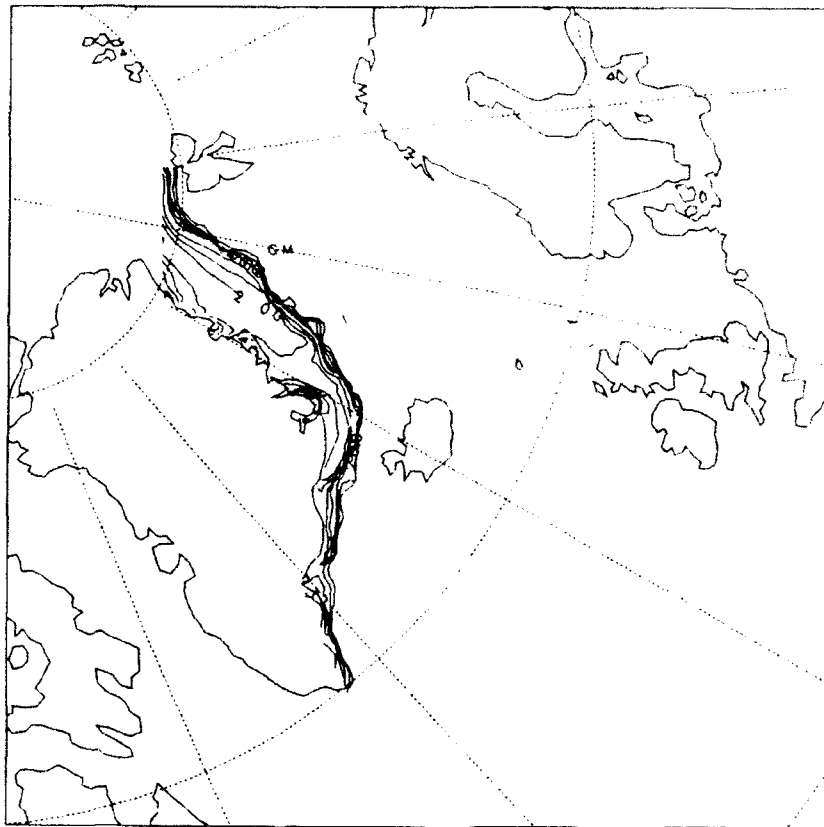
1992 MAY



0.300E+02
MAXIMUM VECTOR

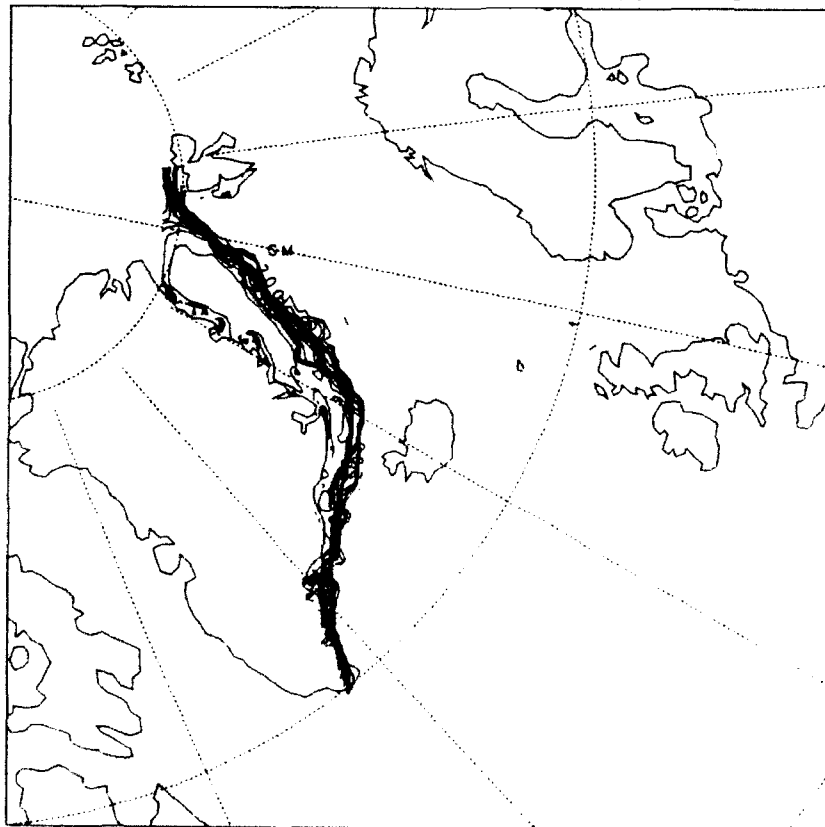
ICE THICKNESS

1992 MAY



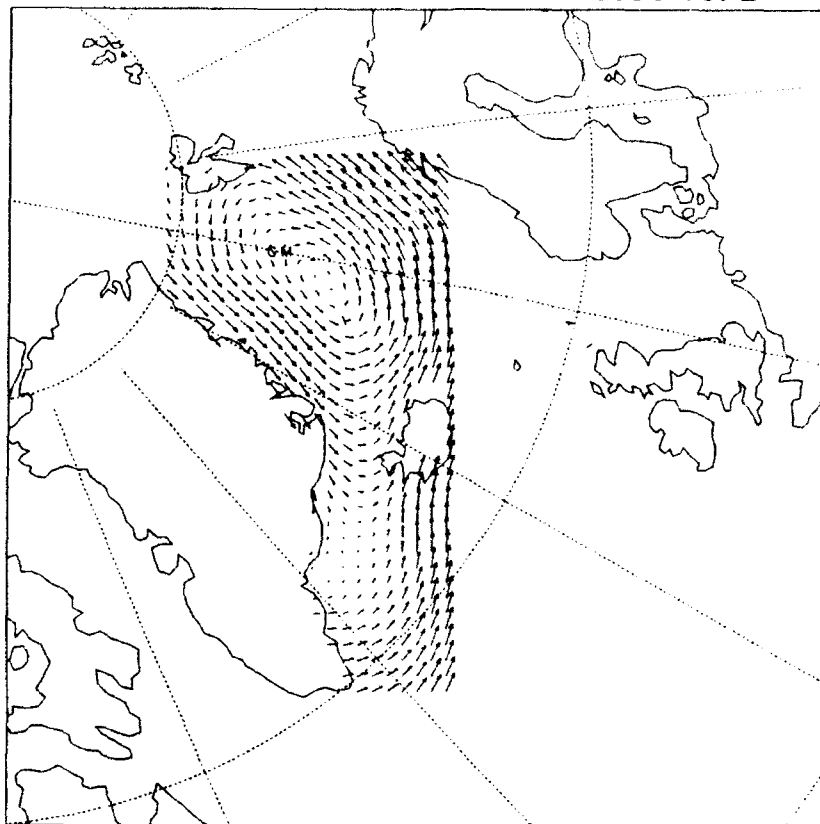
ICE CONCENTRATION

1992 MAY



WIND VELOCITIES

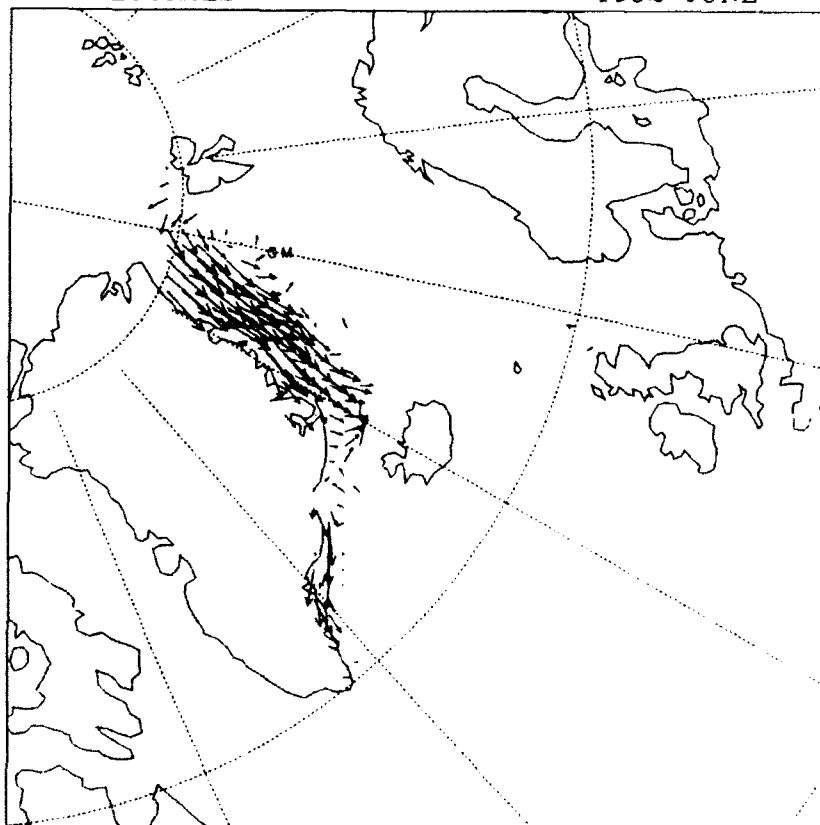
1992 JUNE



0.300E+02
MAXIMUM VECTOR

ICE VELOCITIES

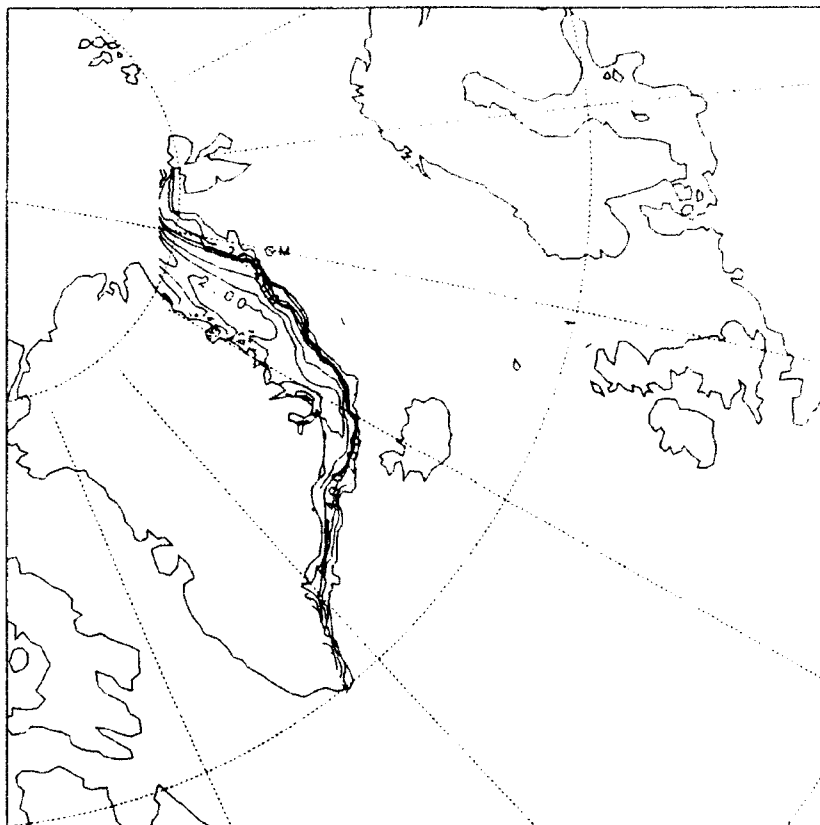
1992 JUNE



0.300E+02
MAXIMUM VECTOR

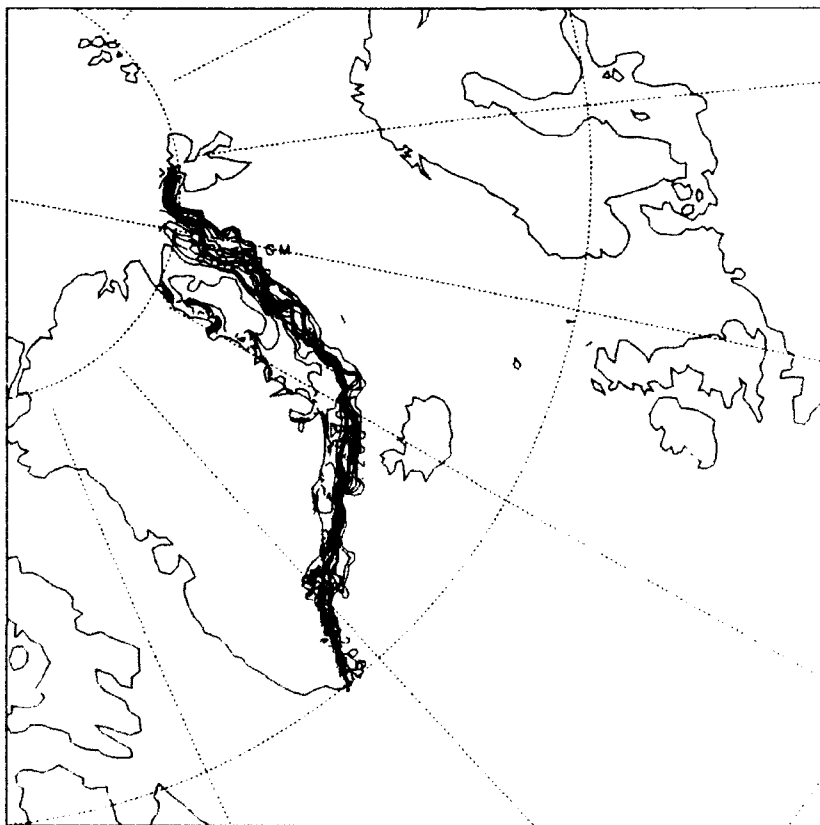
ICE THICKNESS

1992 JUNE



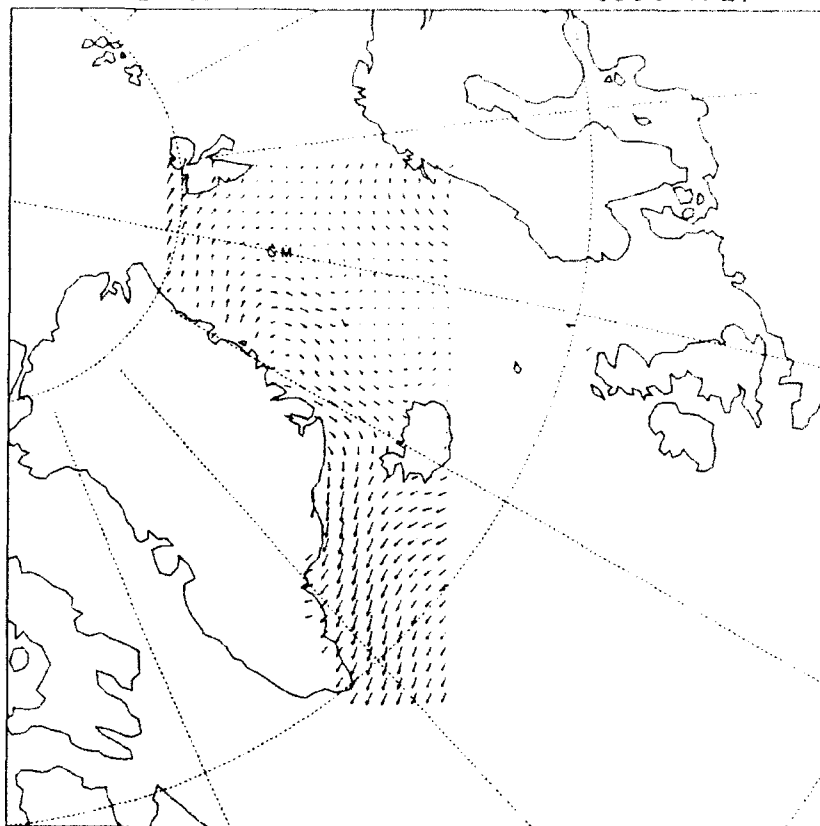
ICE CONCENTRATION

1992 JUNE



WIND VELOCITIES

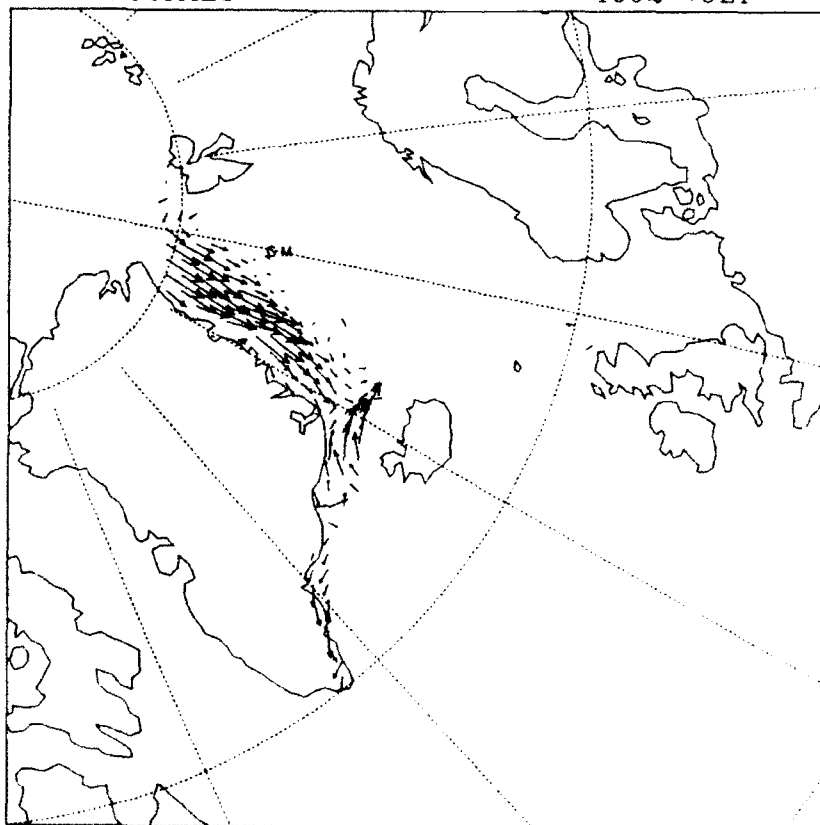
1992 JULY



0 300E-02
MAXIMUM VECTOR

ICE VELOCITIES

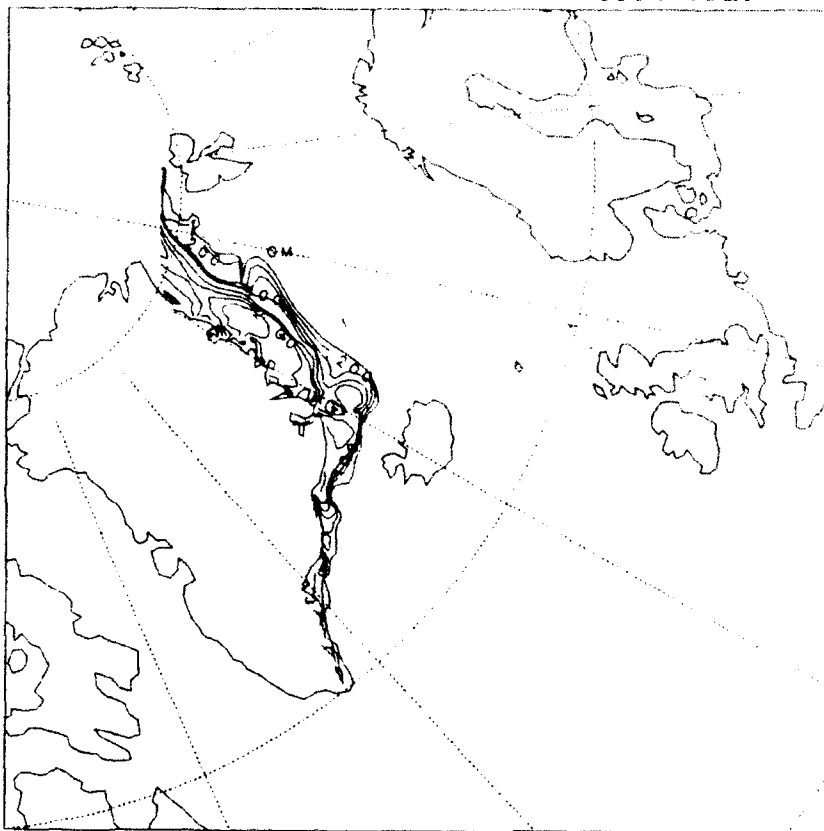
1992 JULY



0 300E-02
MAXIMUM VECTOR

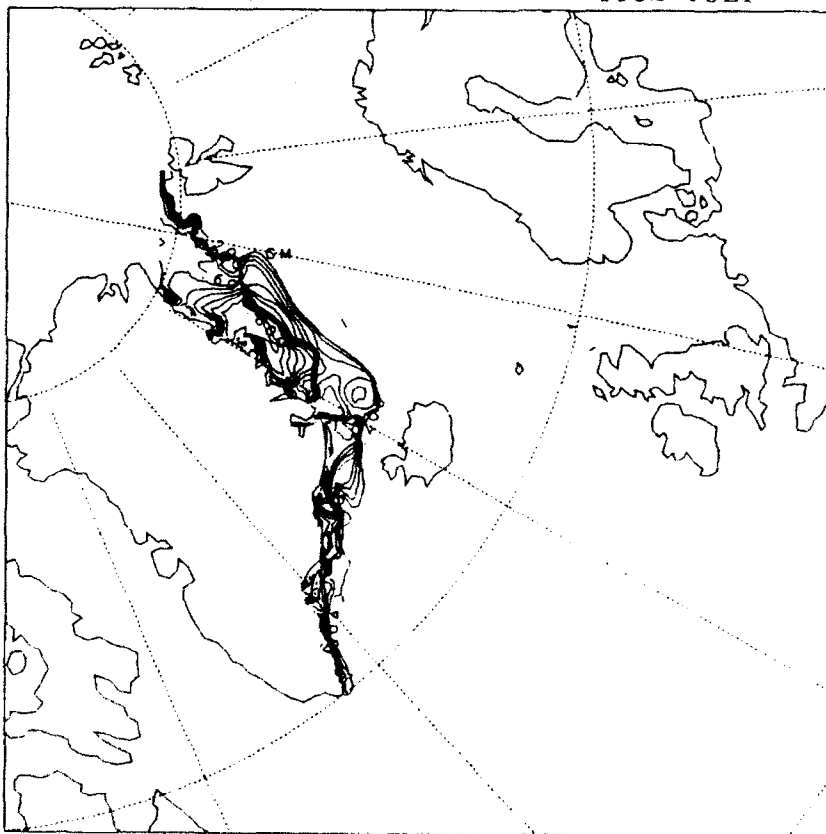
ICE THICKNESS

1992 JULY



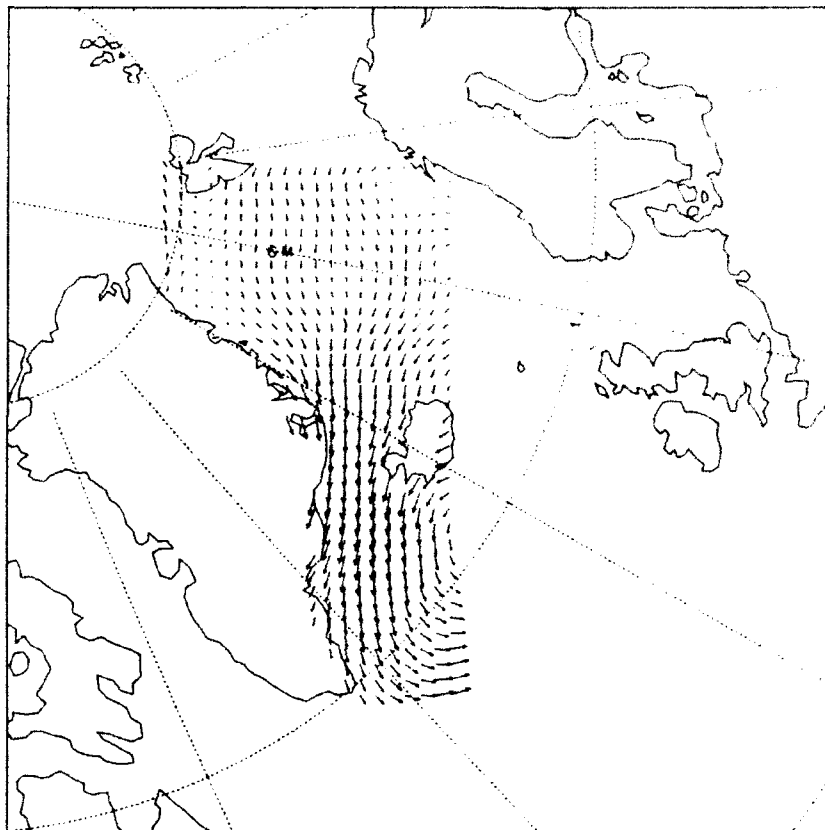
ICE CONCENTRATION

1992 JULY



WIND VELOCITIES

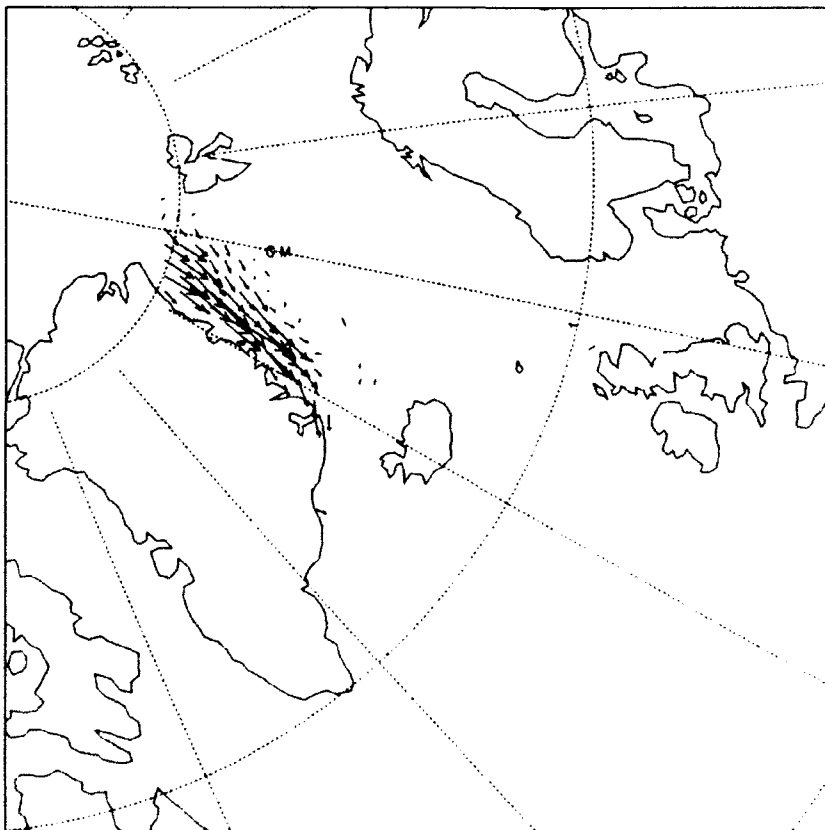
1992 AUGUST



0.300E-02
MAXIMUM VECTOR

ICE VELOCITIES

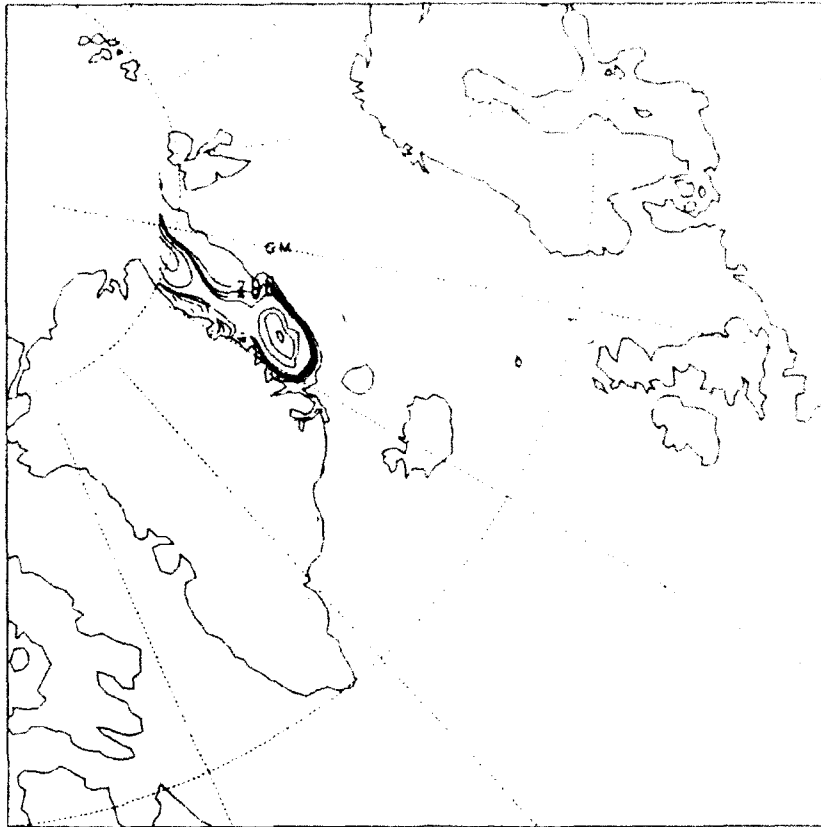
1992 AUGUST



0.300E-00
MAXIMUM VECTOR

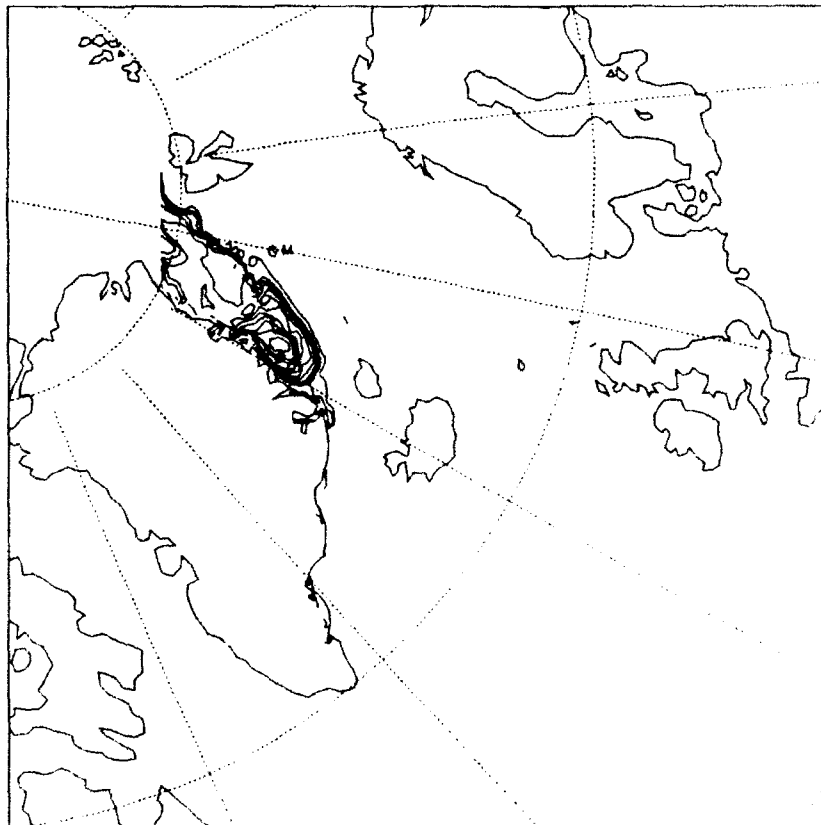
ICE THICKNESS

1992 AUGUST



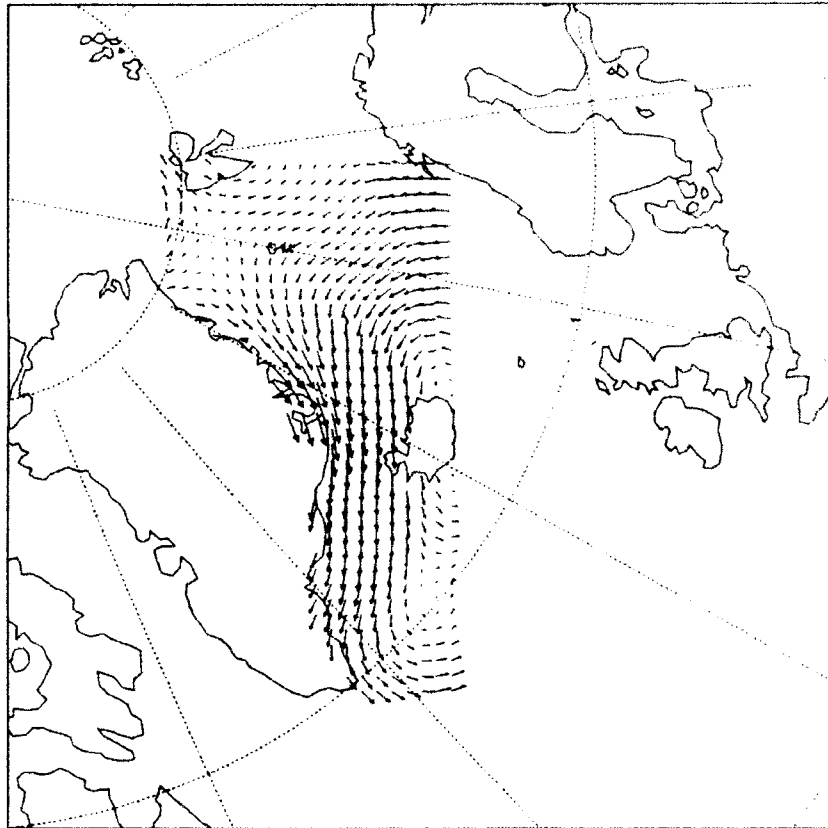
ICE CONCENTRATION

1992 AUGUST



WIND VELOCITIES

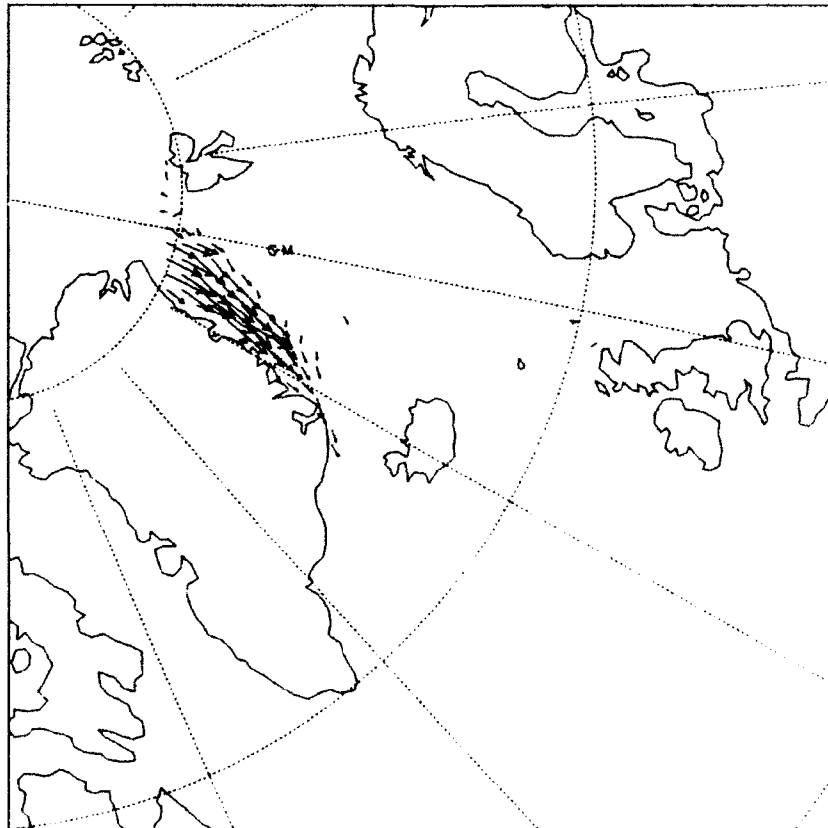
1992 SEPTEMBER



0 300E60
MAXIMUM VECTOR

ICE VELOCITIES

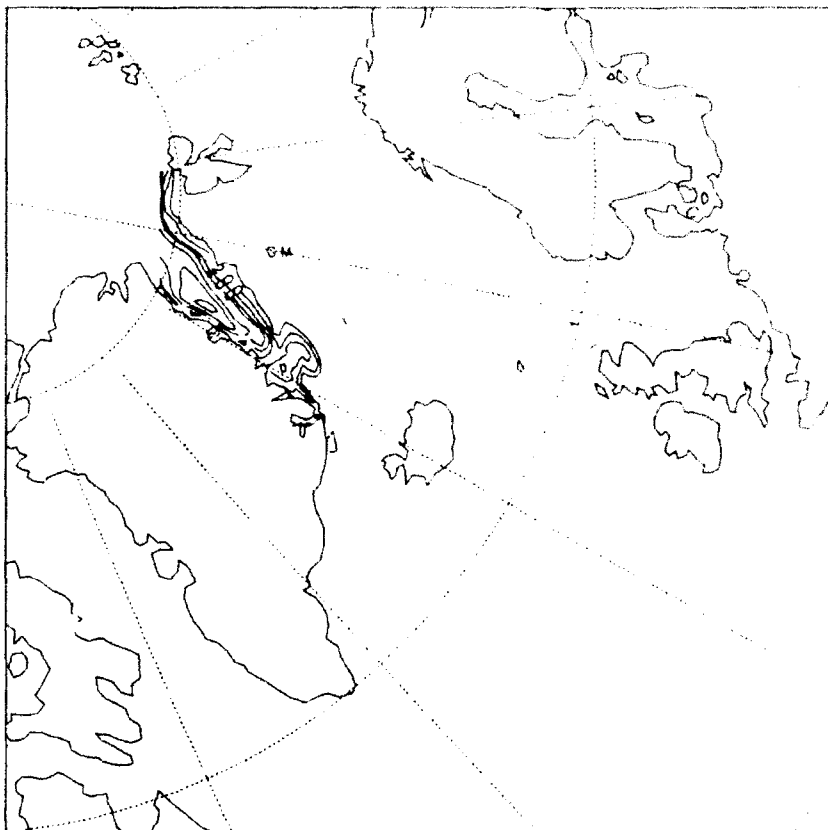
1992 SEPTEMBER



0 300E60
MAXIMUM VECTOR

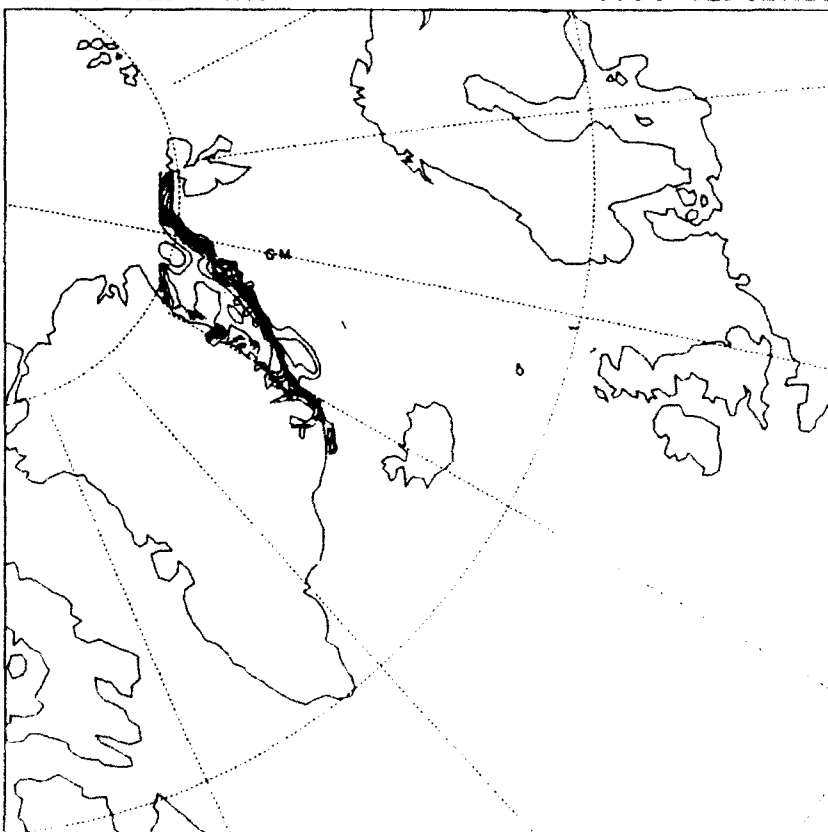
ICE THICKNESS

1992 SEPTEMBER



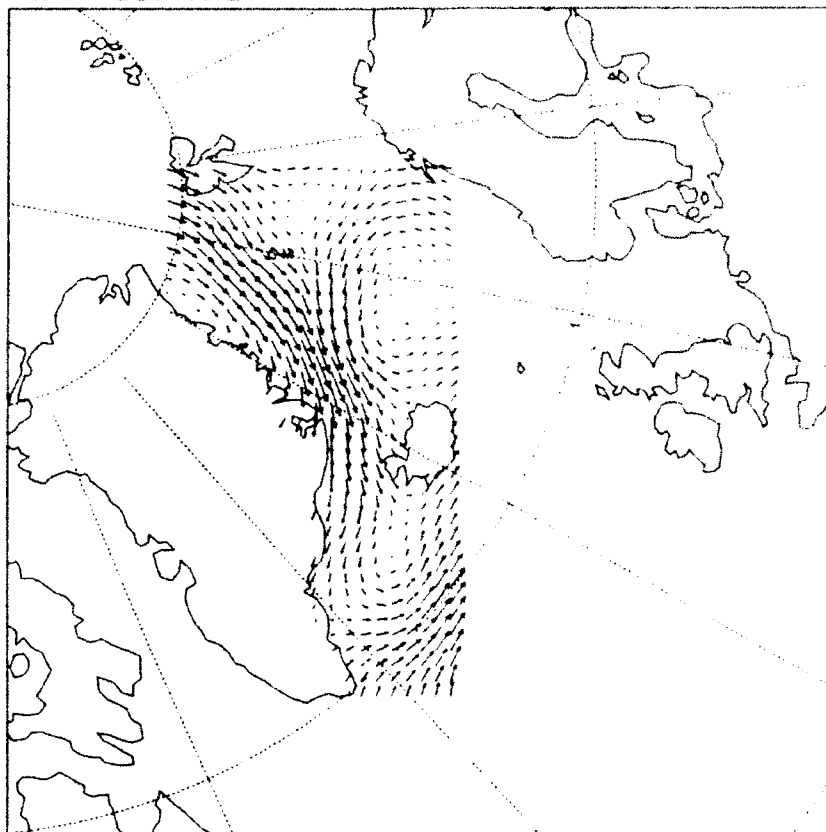
ICE CONCENTRATION

1992 SEPTEMBER



WIND VELOCITIES

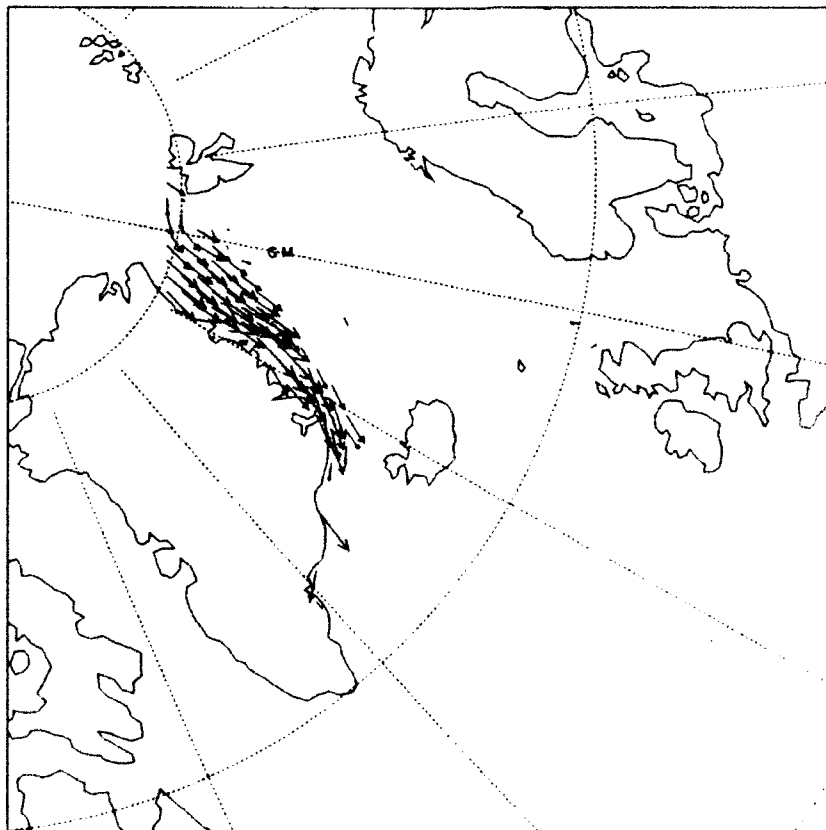
1992 OCTOBER



0.500E+02
MAXIMUM VECTOR

ICE VELOCITIES

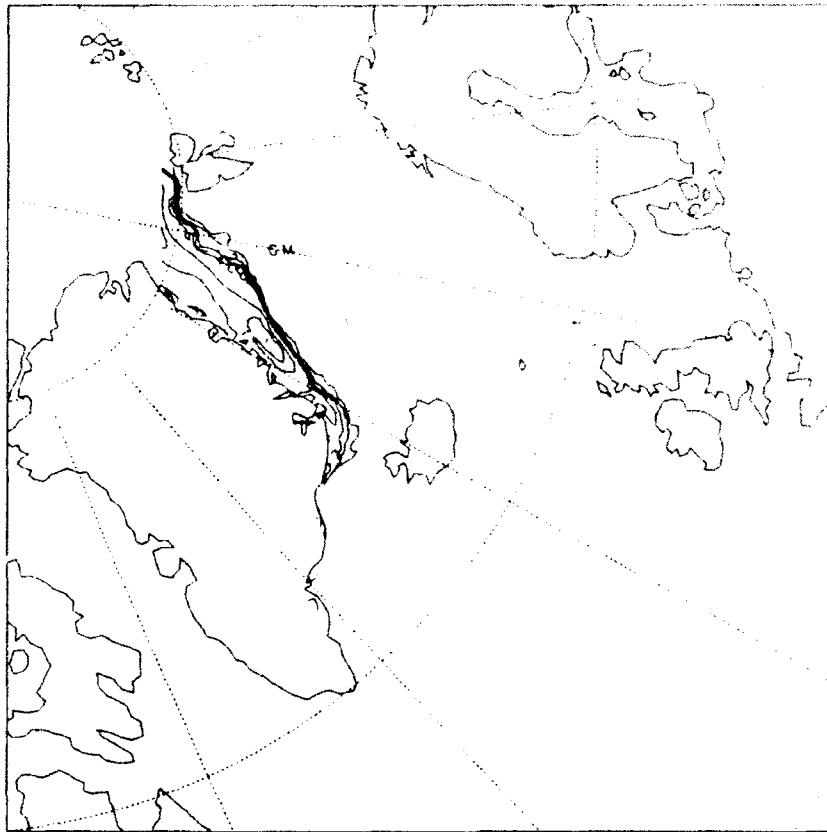
1992 OCTOBER



0.500E+02
MAXIMUM VECTOR

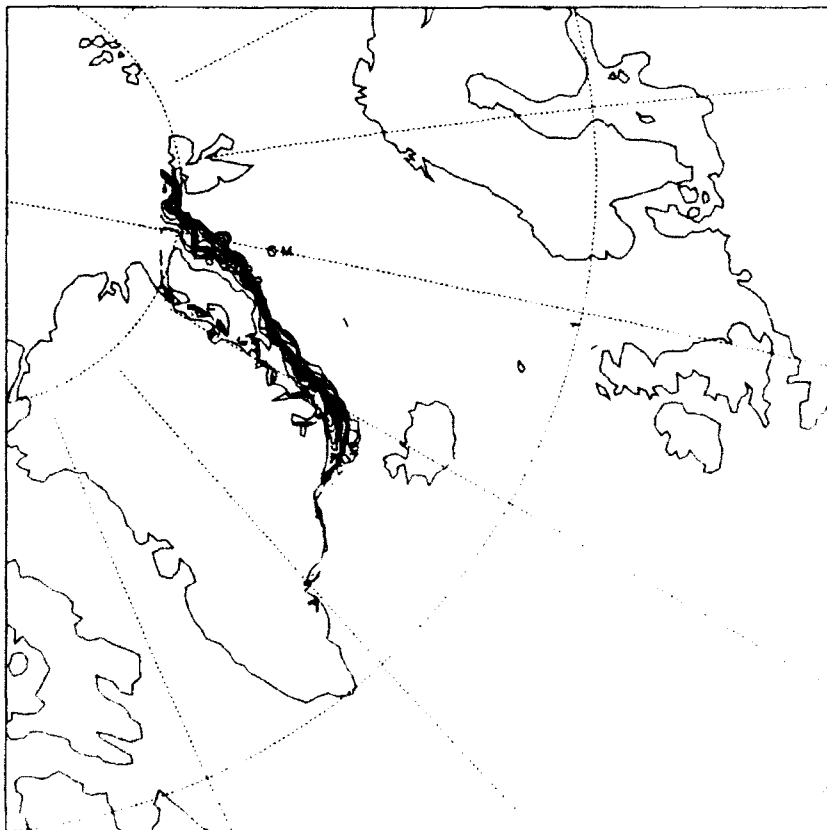
ICE THICKNESS

1992 OCTOBER



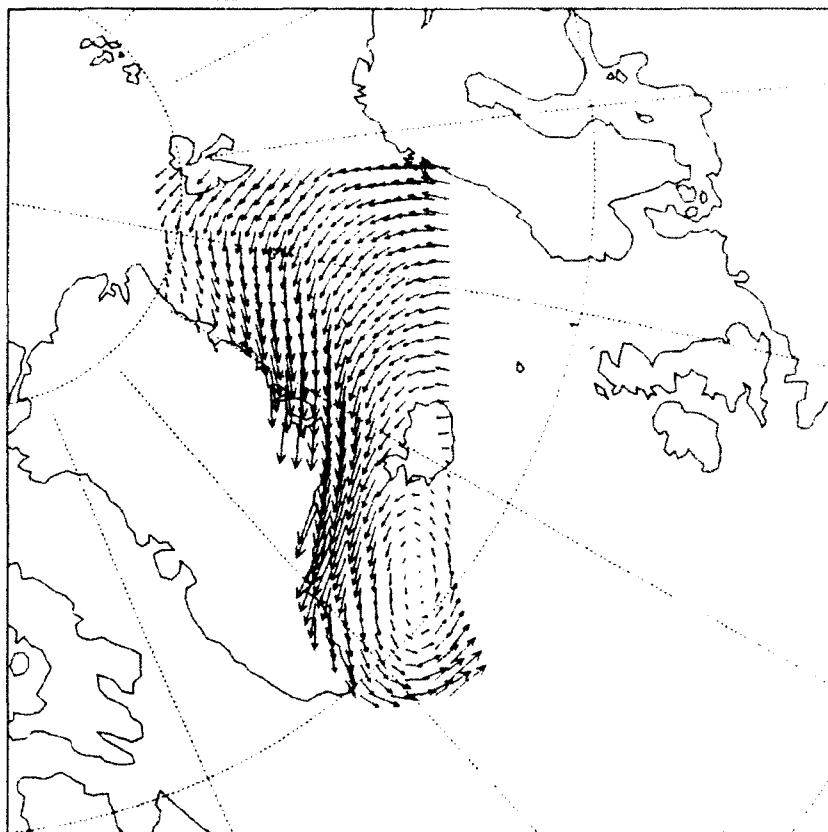
ICE CONCENTRATION

1992 OCTOBER



WIND VELOCITIES

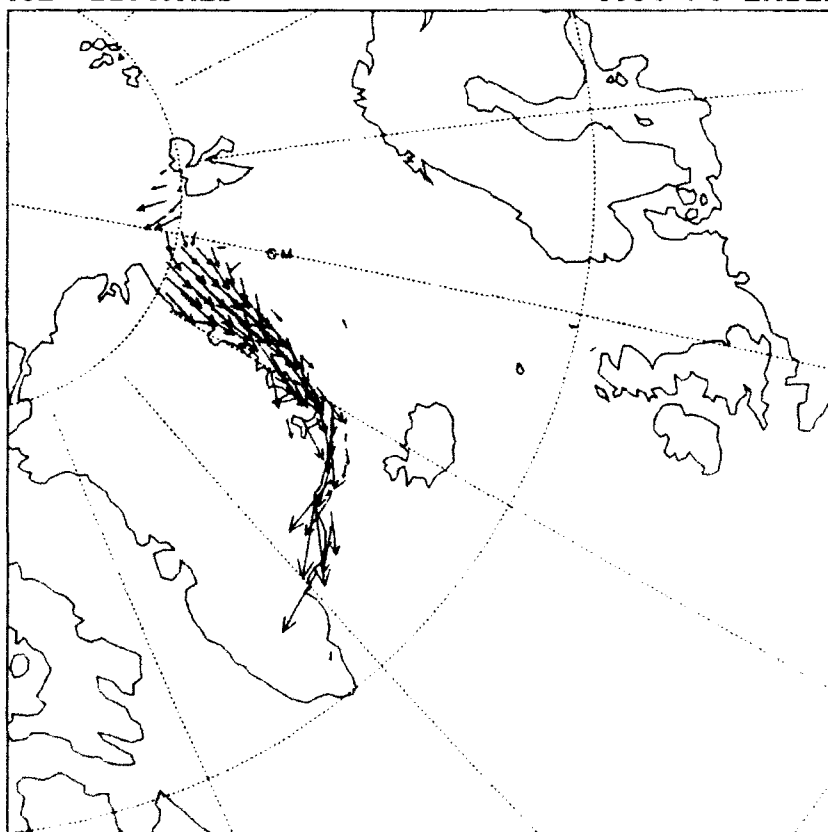
1992 NOVEMBER



0.300E+02
MAXIMUM VECTOR

ICE VELOCITIES

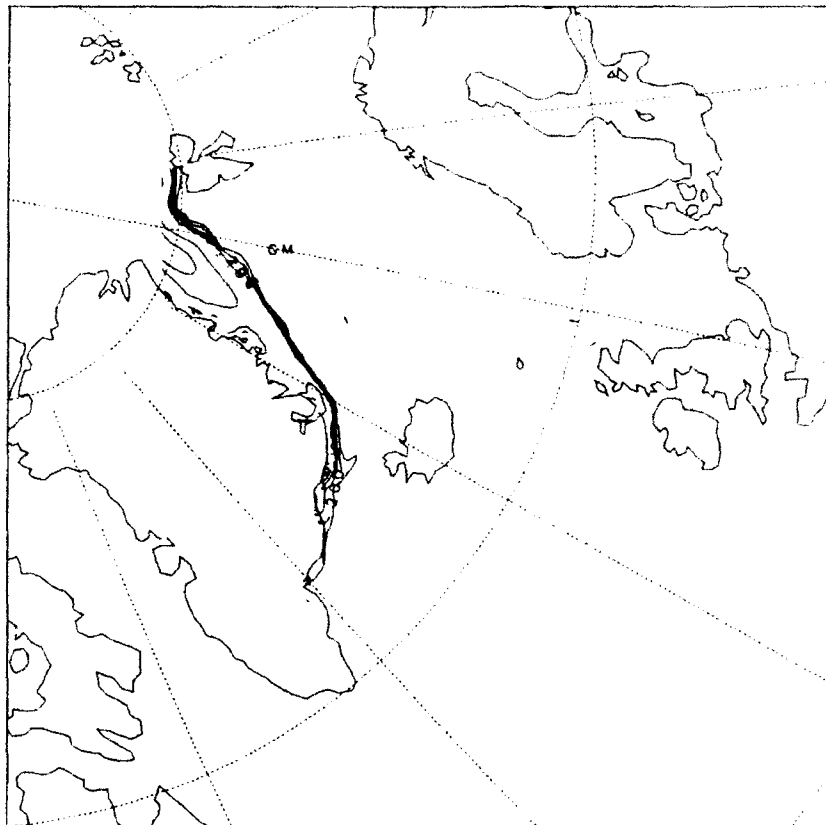
1992 NOVEMBER



0.300E+00
MAXIMUM VECTOR

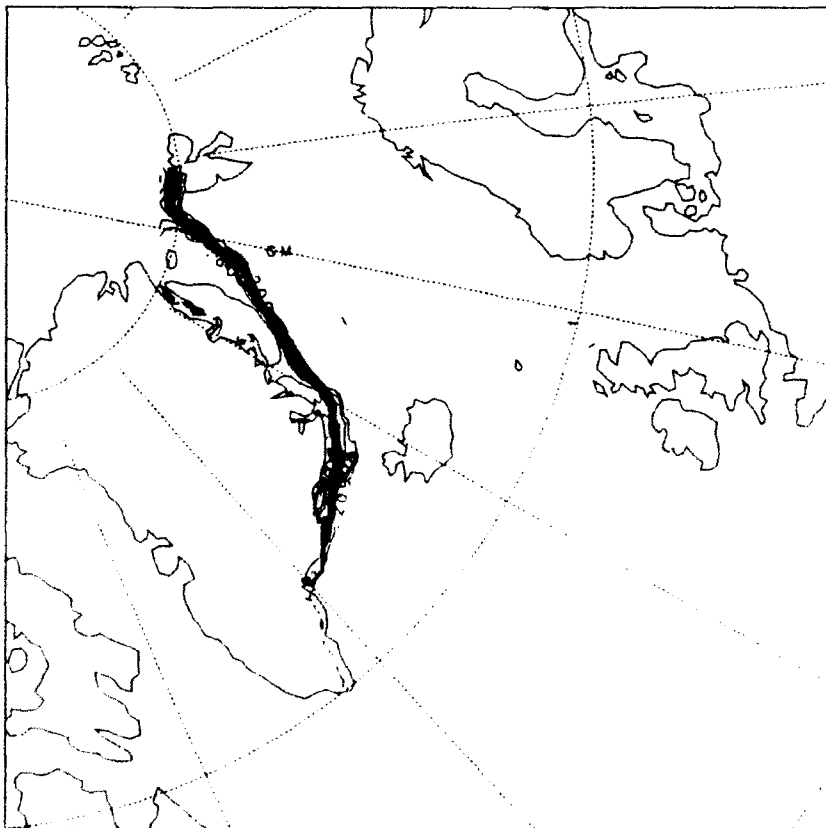
ICE THICKNESS

1992 NOVEMBER



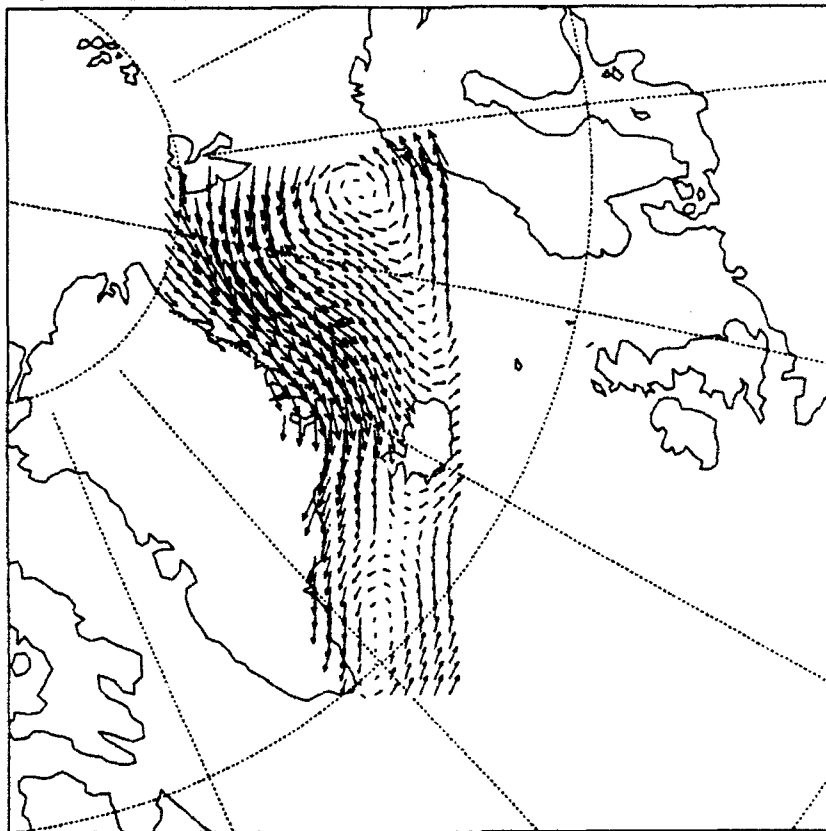
ICE CONCENTRATION

1992 NOVEMBER



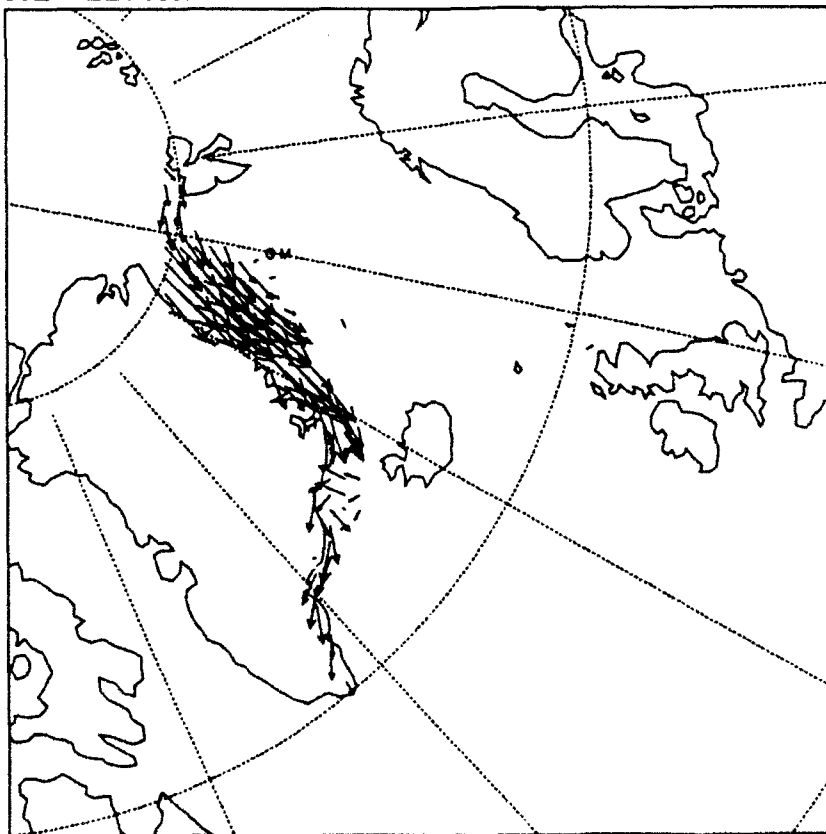
WIND VELOCITIES

1992 DECEMBER



ICE VELOCITIES

1992 DECEMBER

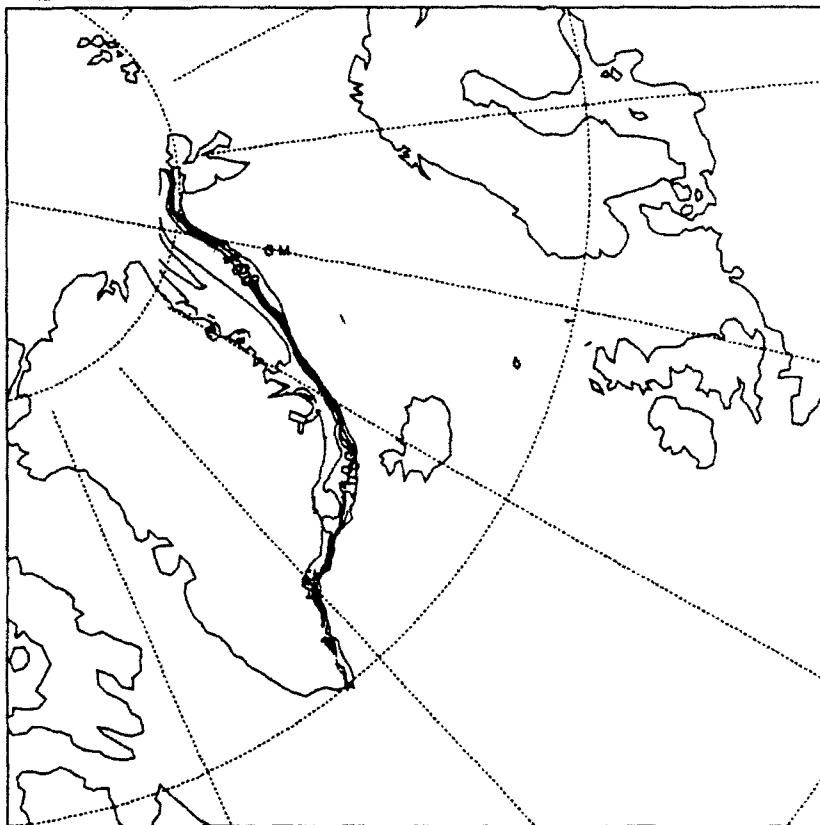


0.300E-02
MAXIMUM VECTOR

0.300E-02
MAXIMUM VECTOR

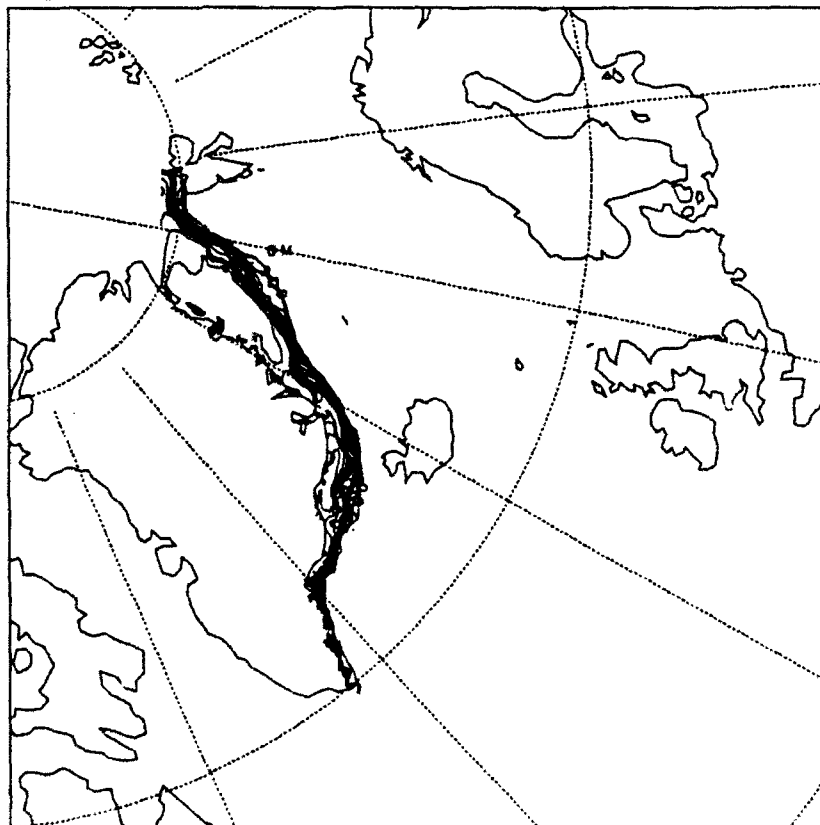
ICE THICKNESS

1992 DECEMBER



ICE CONCENTRATION

1992 DECEMBER



PIPS2.0 MODEL GRID

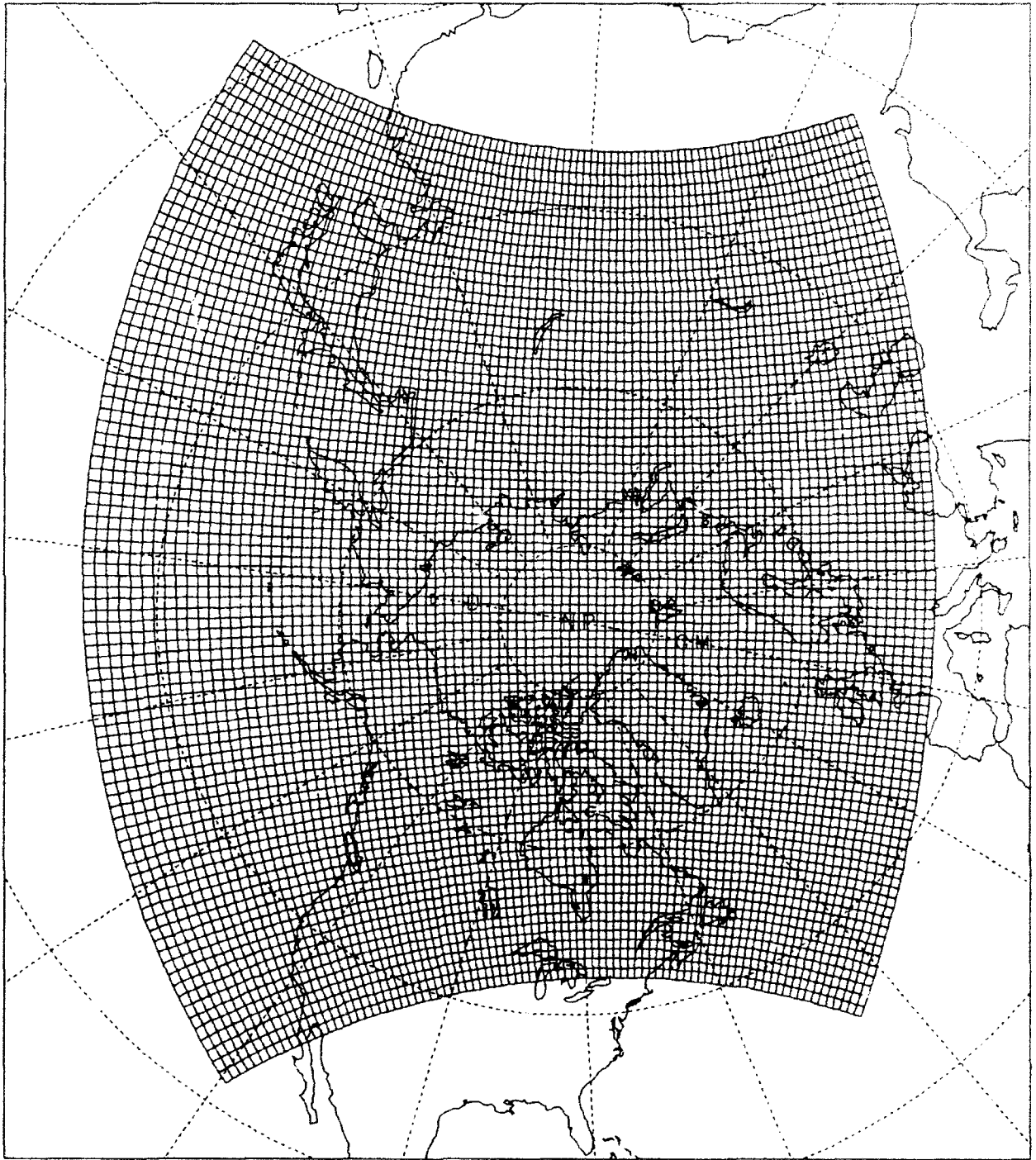


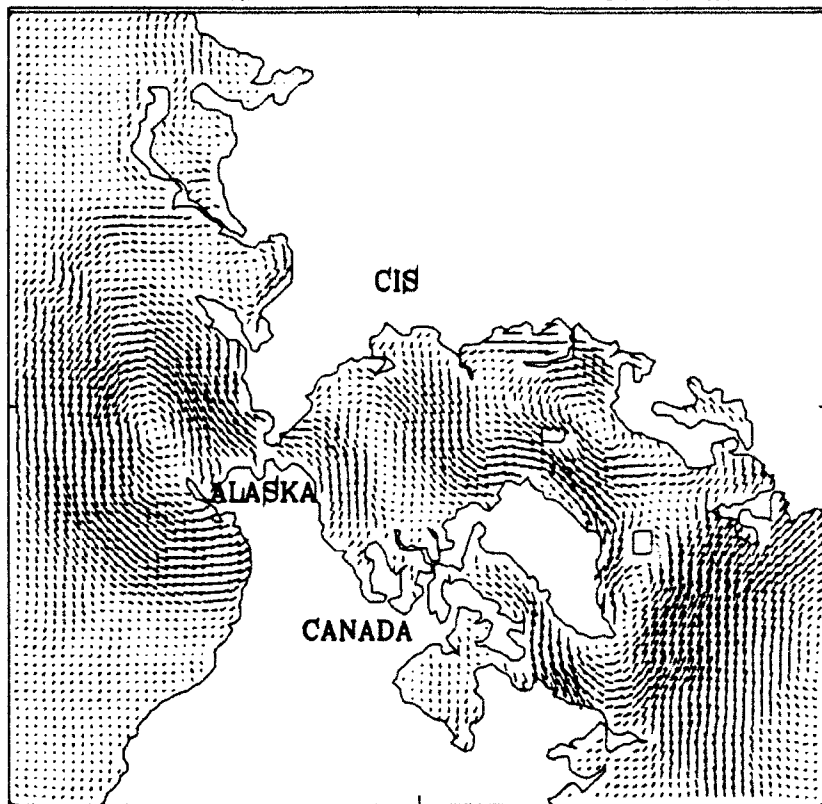
Figure 4. PIPS2.0 domain with the variable resolution grid overlaid. The hatched lines are drawn at every other grid point including land points.

PIPS2.0 1992

MONTHLY MEANS

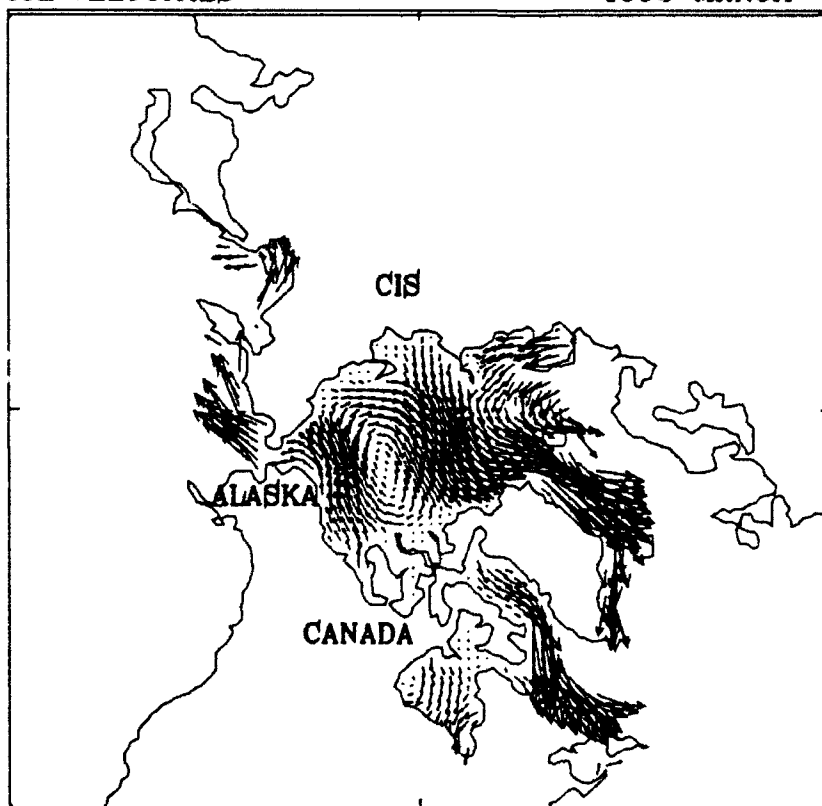
WIND VELOCITIES

1992 MARCH



ICE VELOCITIES

1992 MARCH

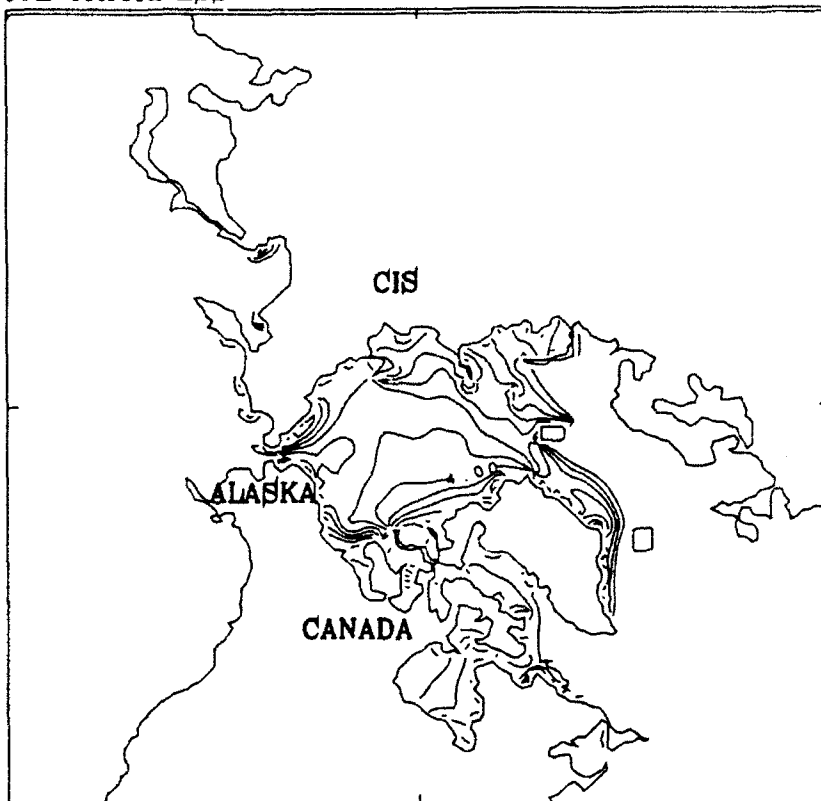


0.0001-02
MAXIMUM VECTOR

0.0001-02
MAXIMUM VECTOR

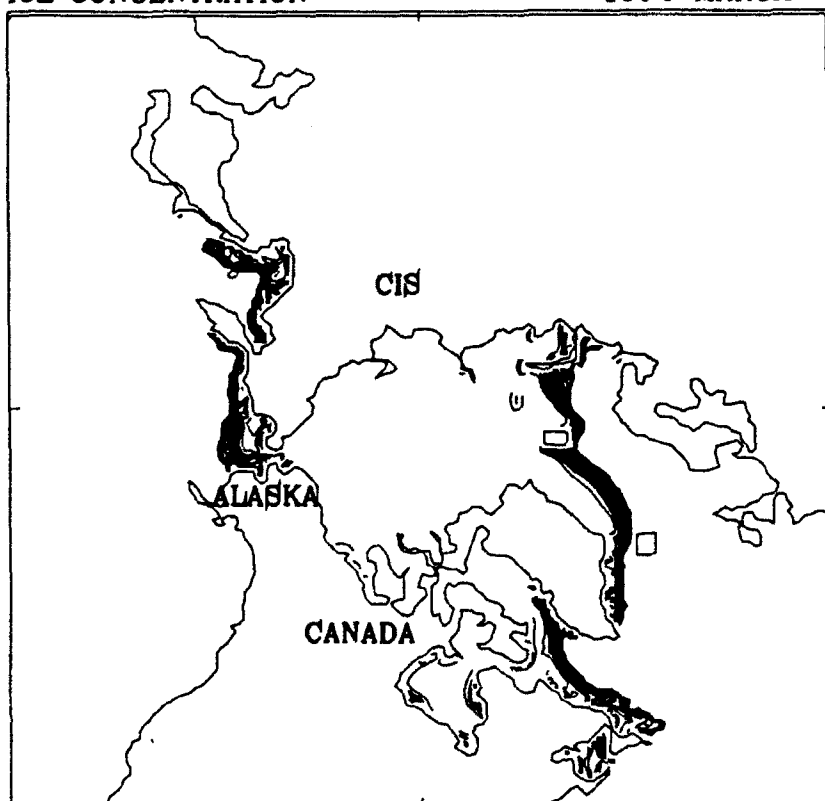
ICE THICKNESS

1992 MARCH



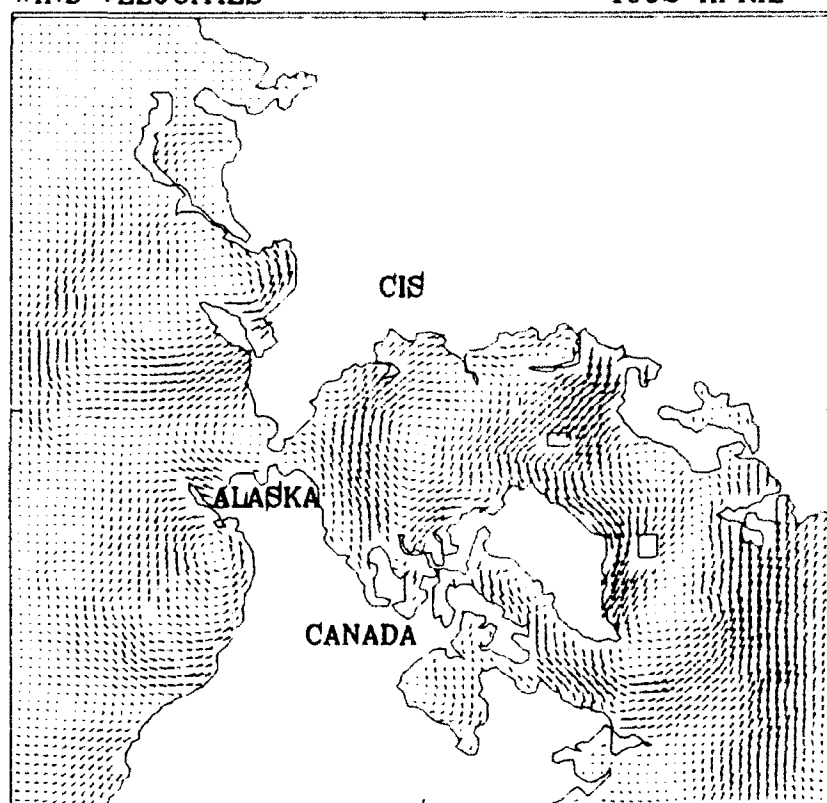
ICE CONCENTRATION

1992 MARCH



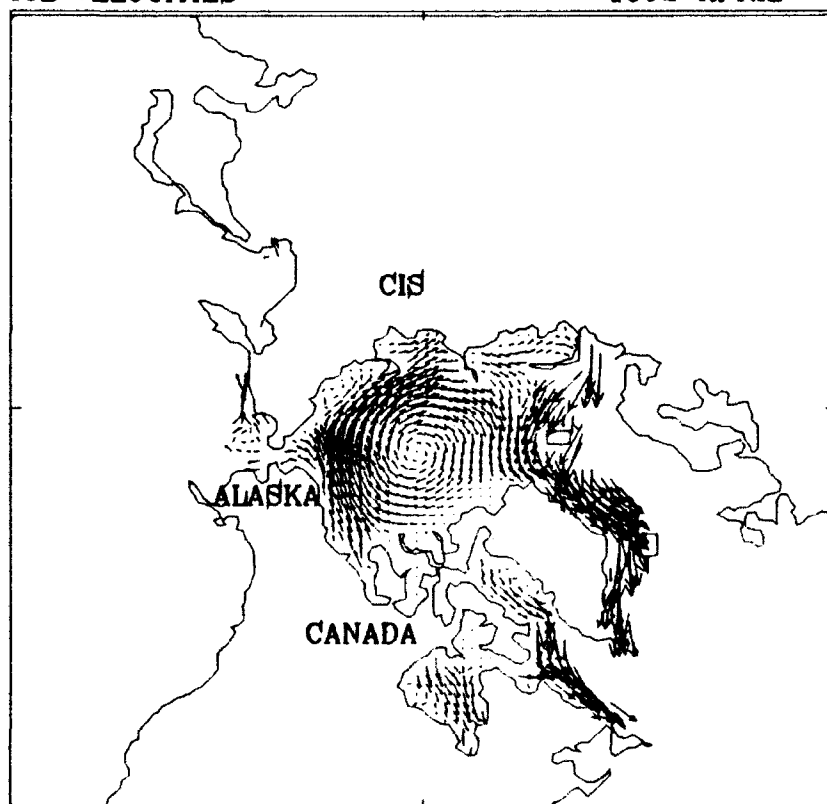
WIND VELOCITIES

1992 APRIL



ICE VELOCITIES

1992 APRIL

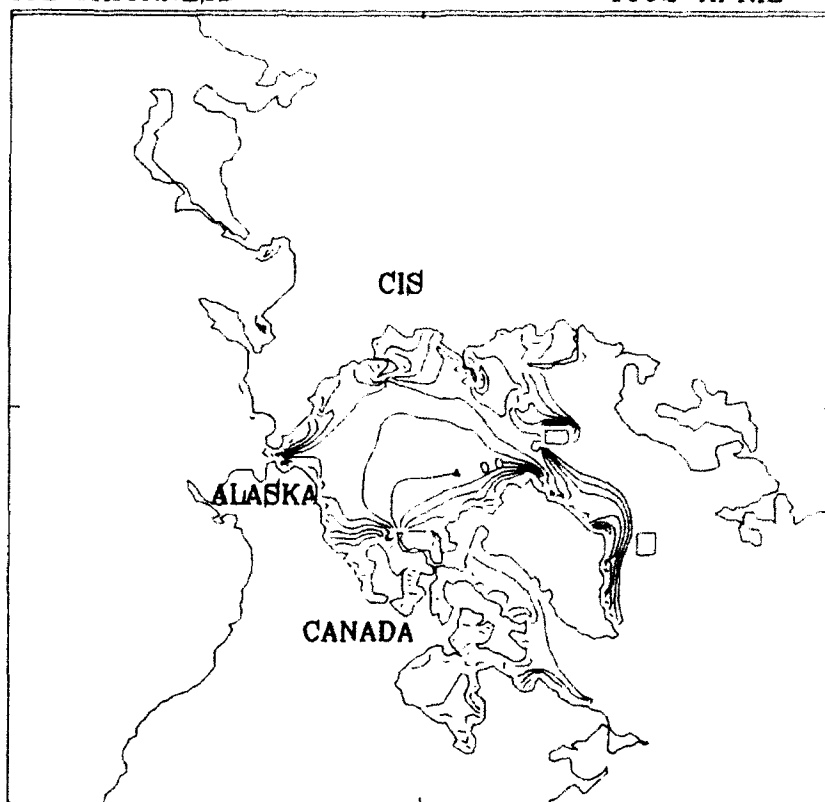


0.500E-02
MAXIMUM VECTOR

0.300E-02
MAXIMUM VECTOR

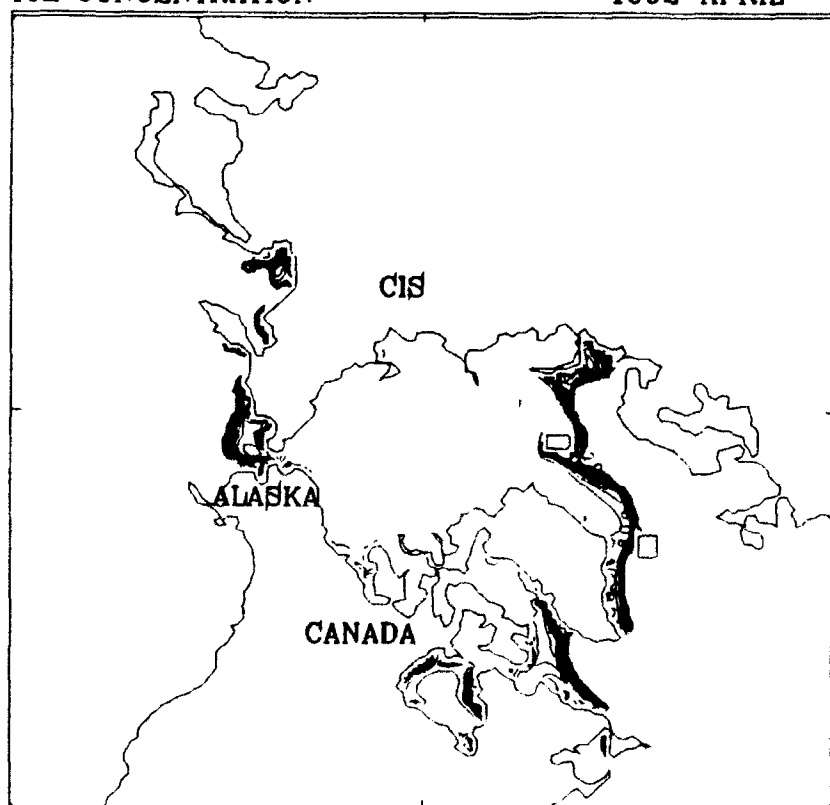
ICE THICKNESS

1992 APRIL



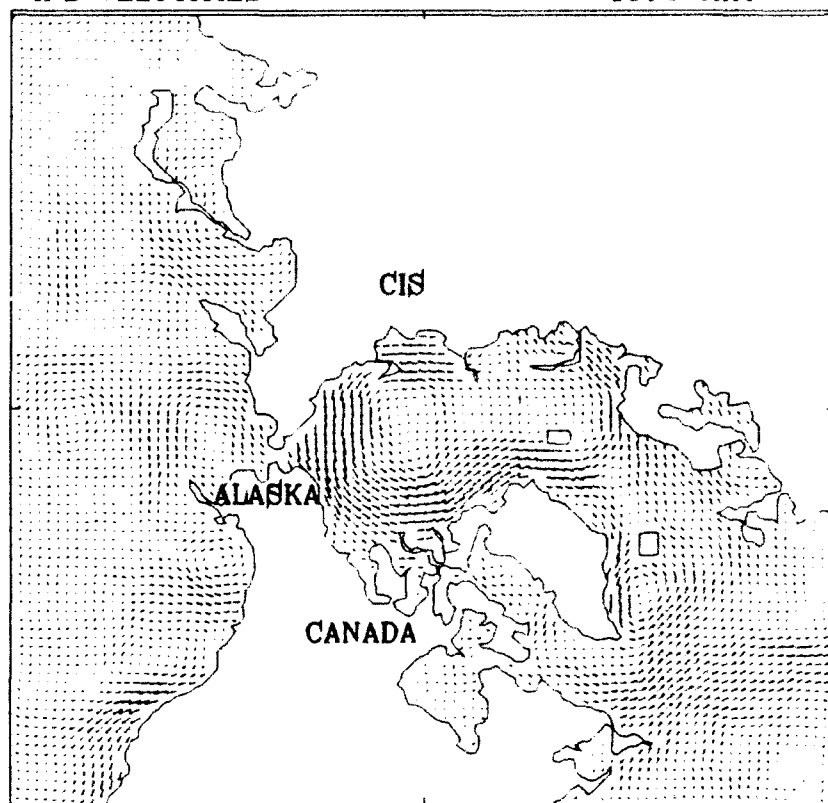
ICE CONCENTRATION

1992 APRIL



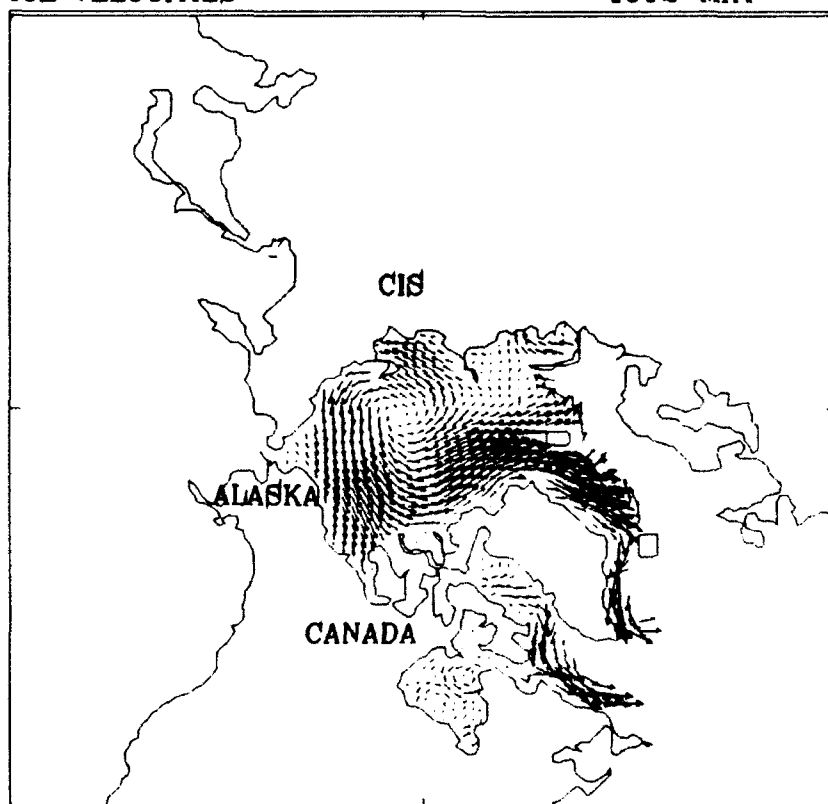
WIND VELOCITIES

1992 MAY



ICE VELOCITIES

1992 MAY

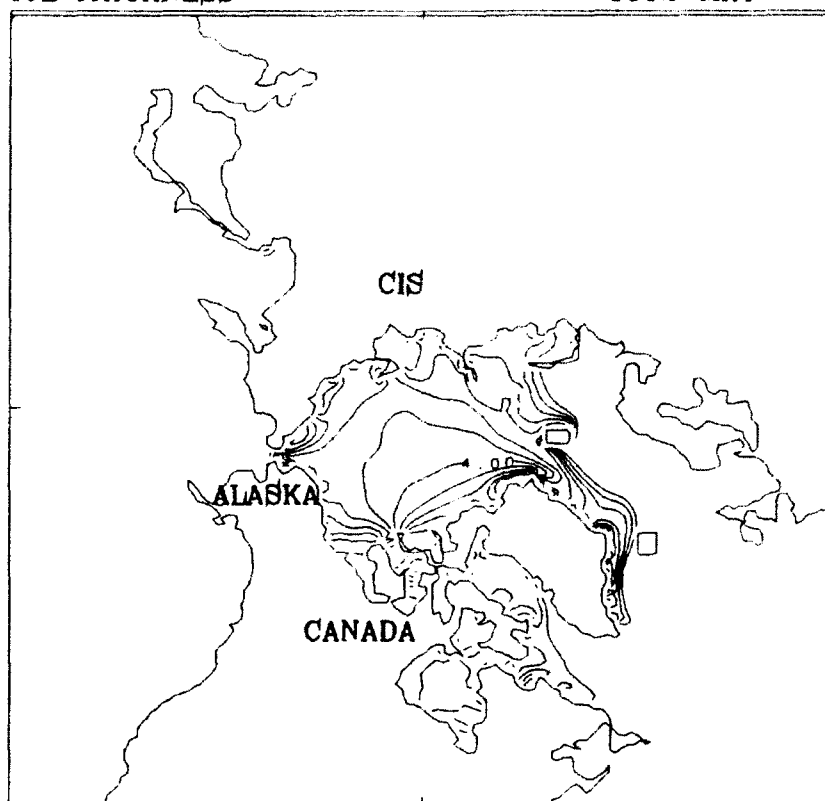


0.500E+02
MAXIMUM VECTOR

0.500E+02
MAXIMUM VECTOR

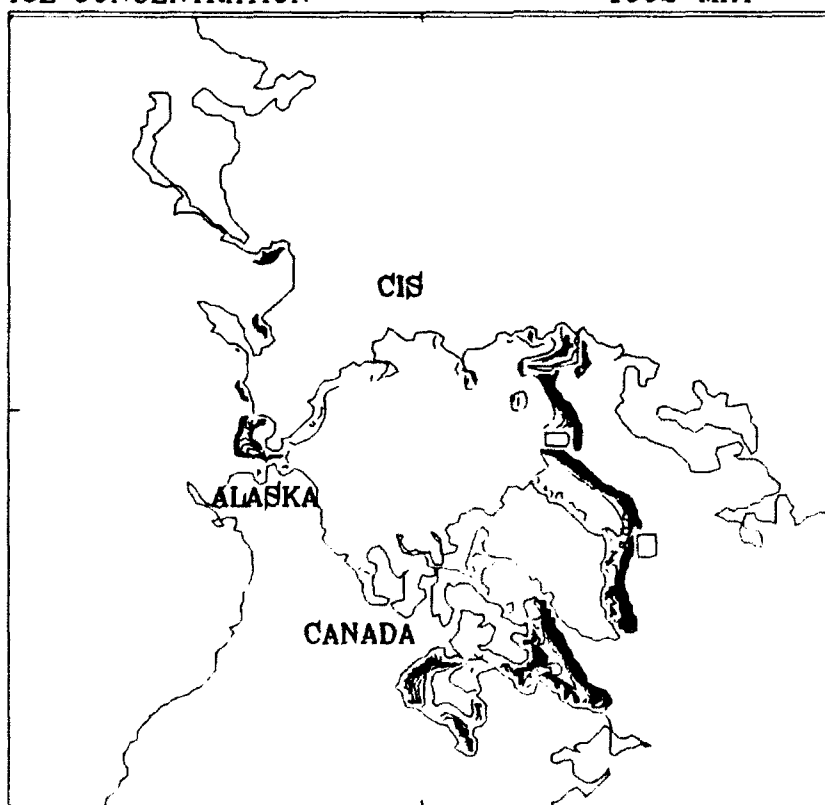
ICE THICKNESS

1992 MAY



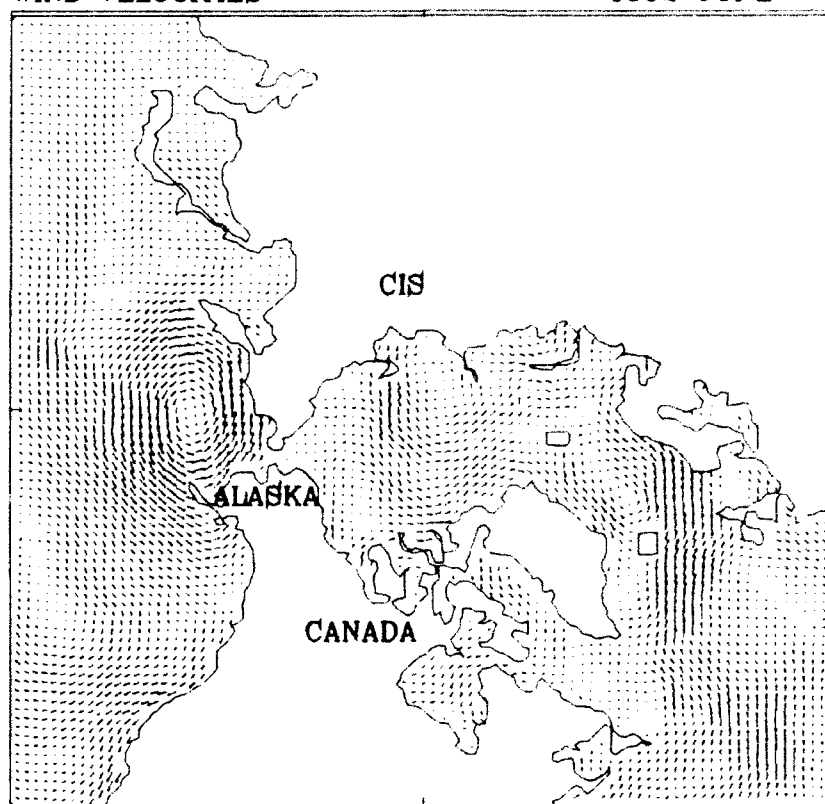
ICE CONCENTRATION

1992 MAY



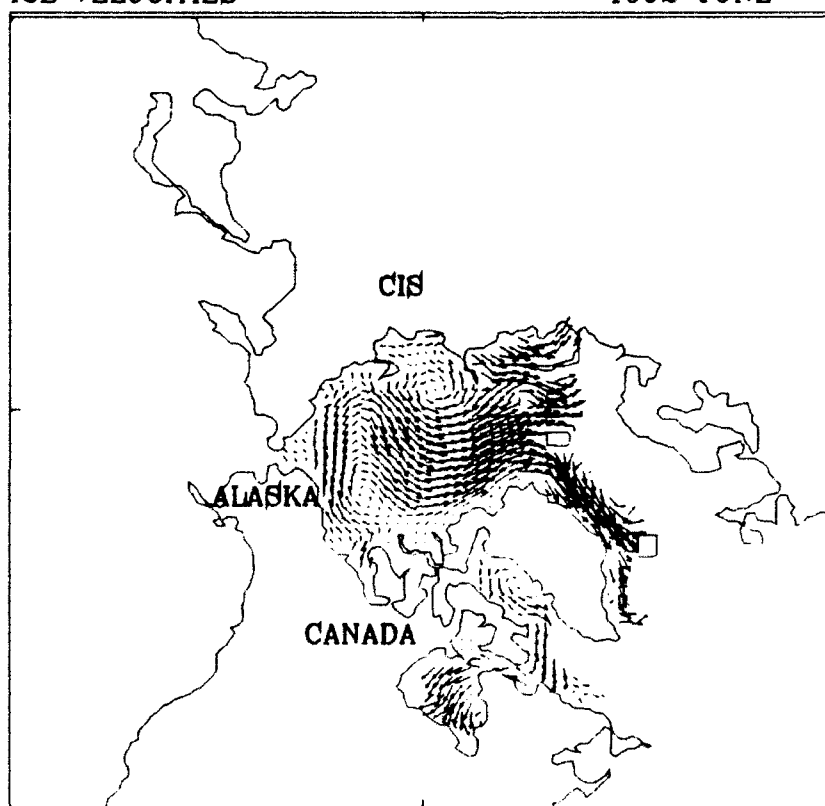
WIND VELOCITIES

1992 JUNE



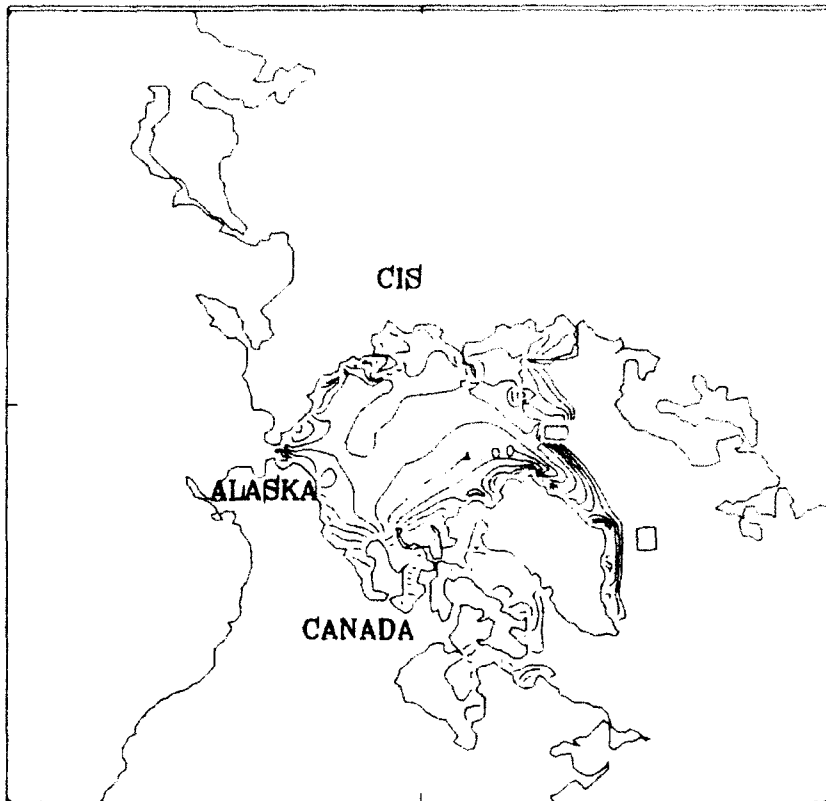
ICE VELOCITIES

1992 JUNE



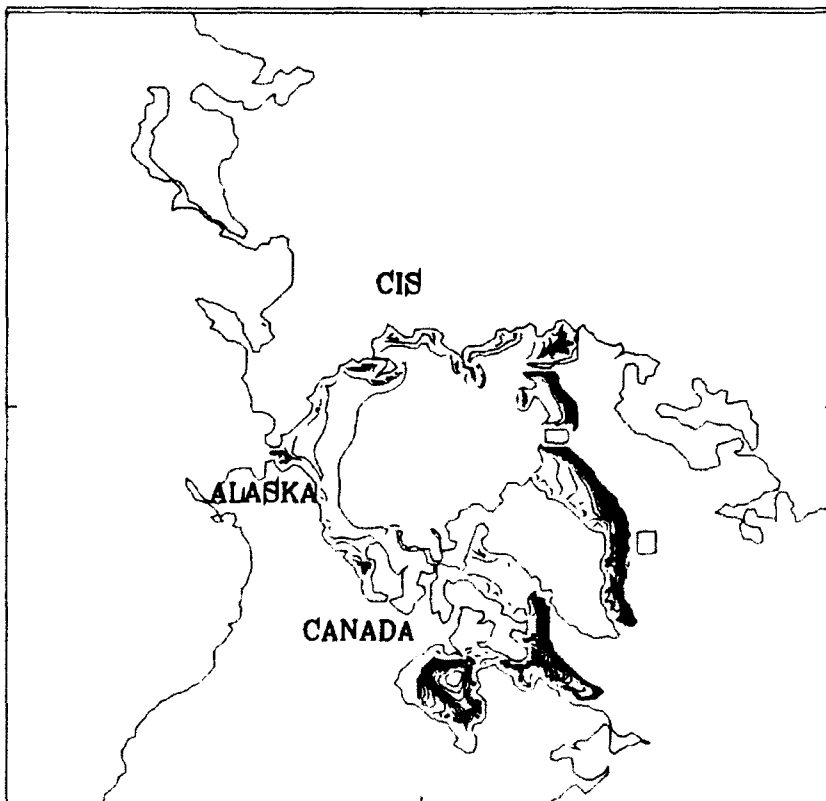
ICE THICKNESS

1992 JUNE



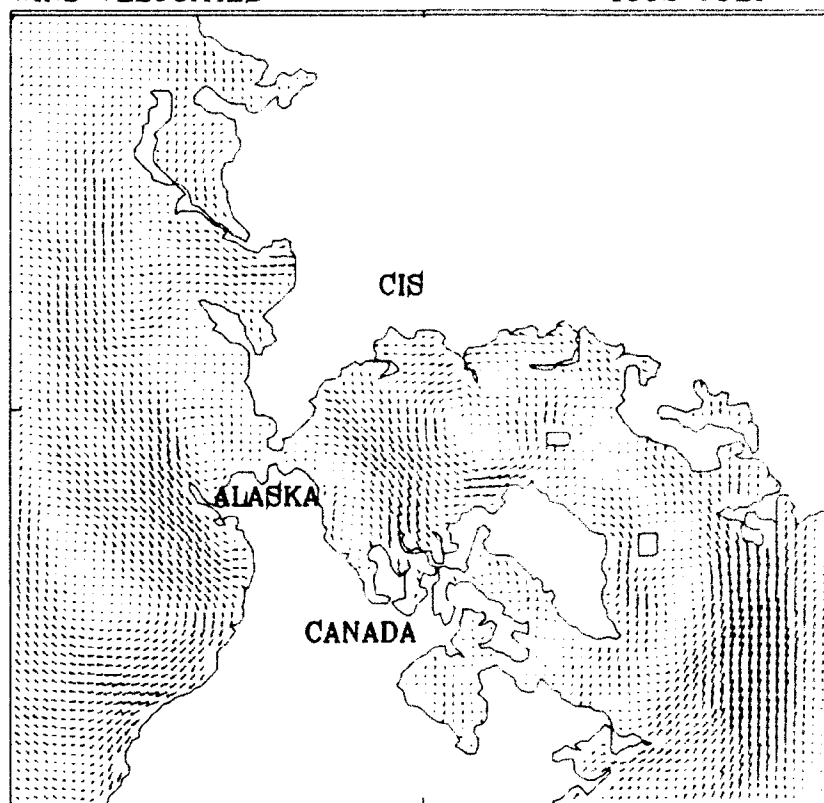
ICE CONCENTRATION

1992 JUNE



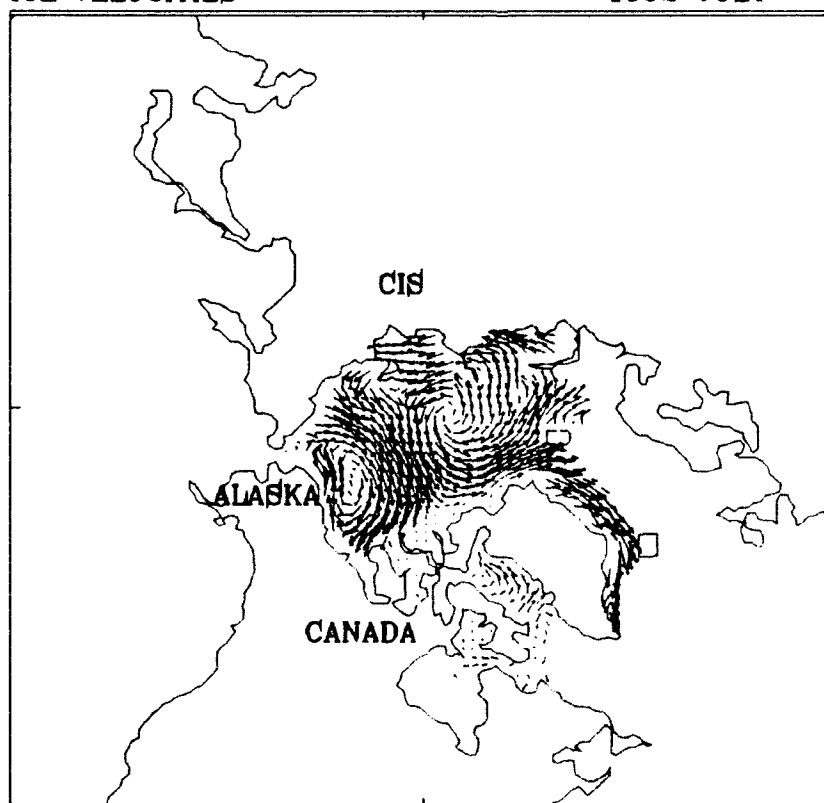
WIND VELOCITIES

1992 JULY



ICE VELOCITIES

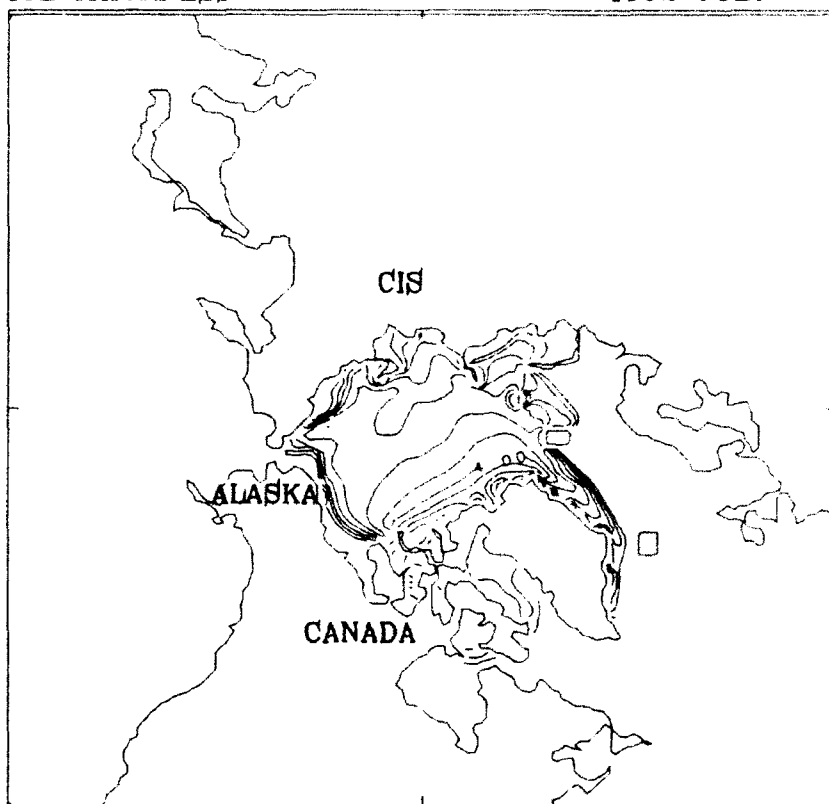
1992 JULY



0.300E-02
MAXIMUM VECTOR

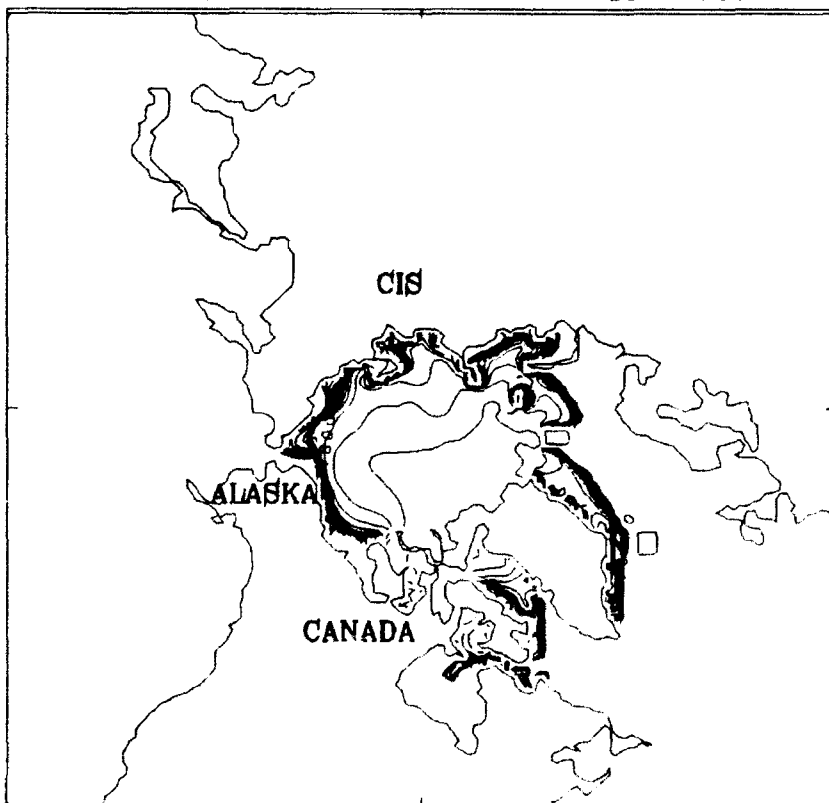
ICE THICKNESS

1992 JULY



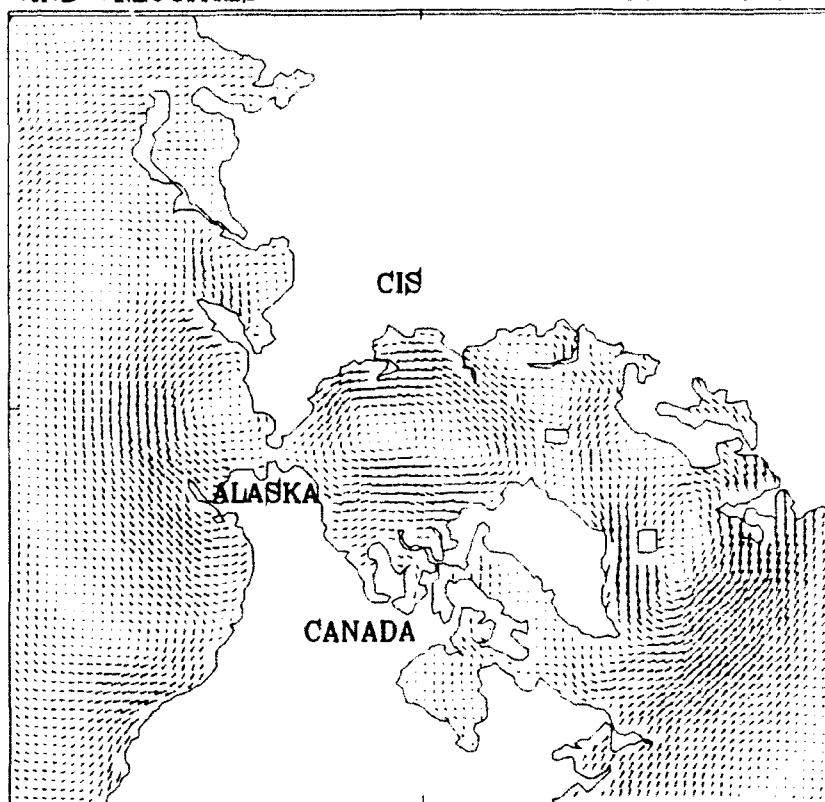
ICE CONCENTRATION

1992 JULY



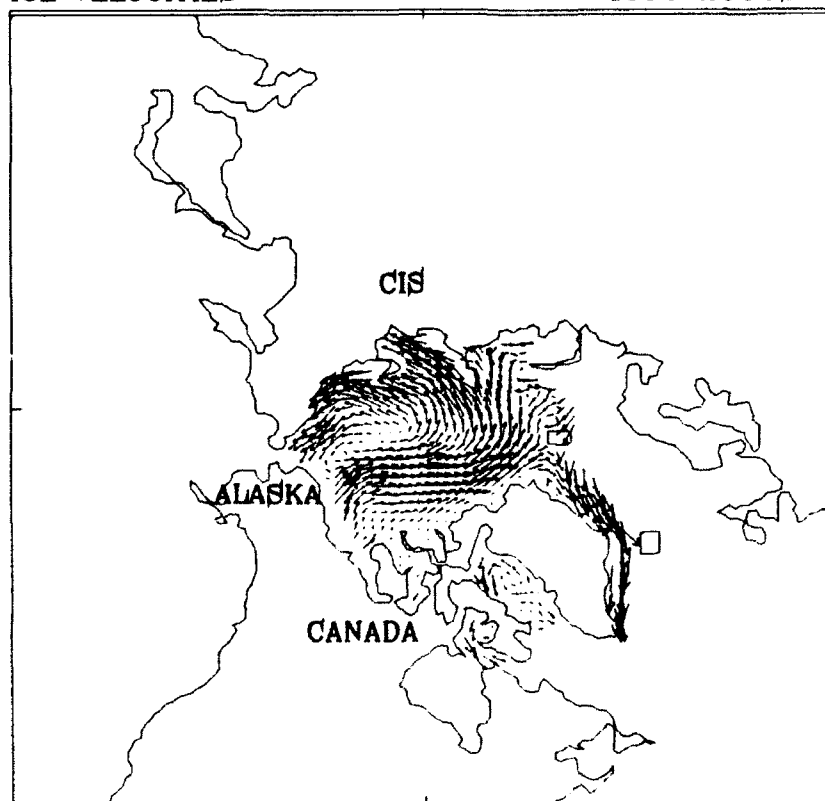
WIND VELOCITIES

1992 AUGUST



ICE VELOCITIES

1992 AUGUST

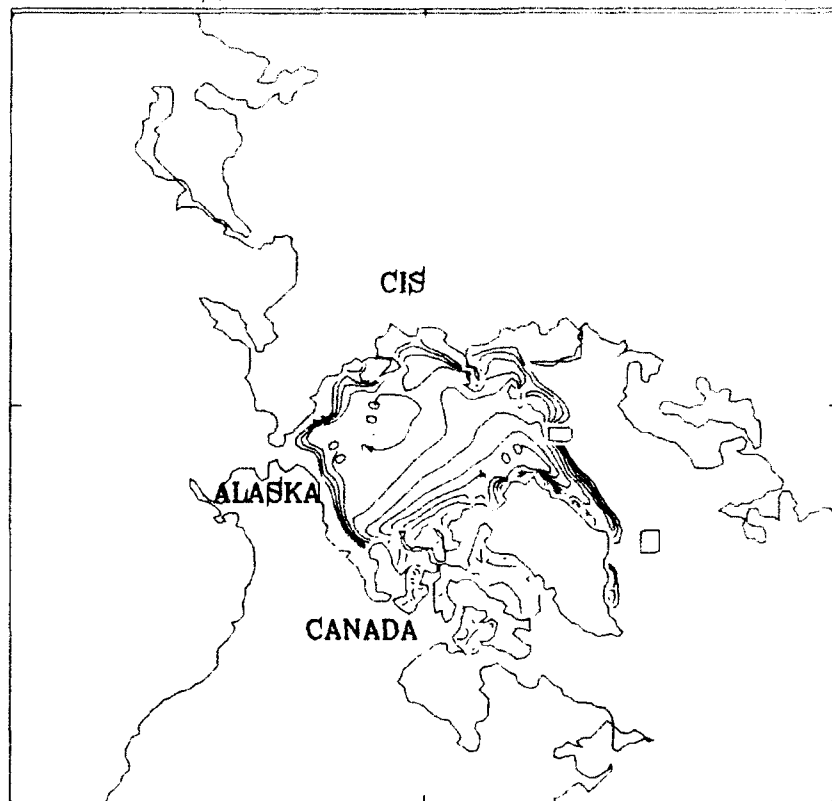


0.500E+02
MAXIMUM VECTOR

0.300E+02
MAXIMUM VECTOR

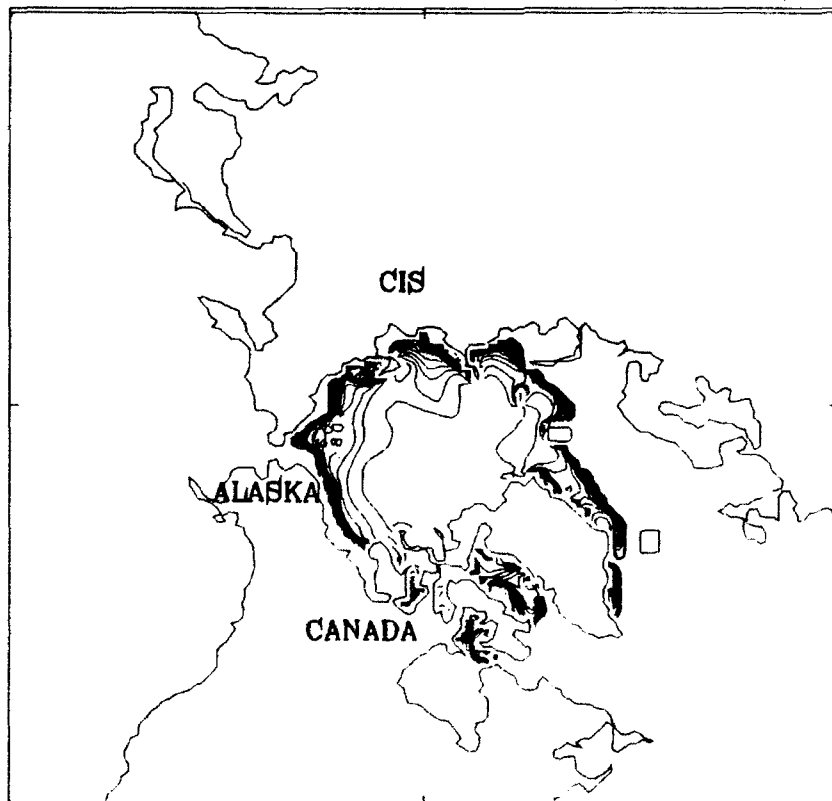
ICE THICKNESS

1992 AUGUST



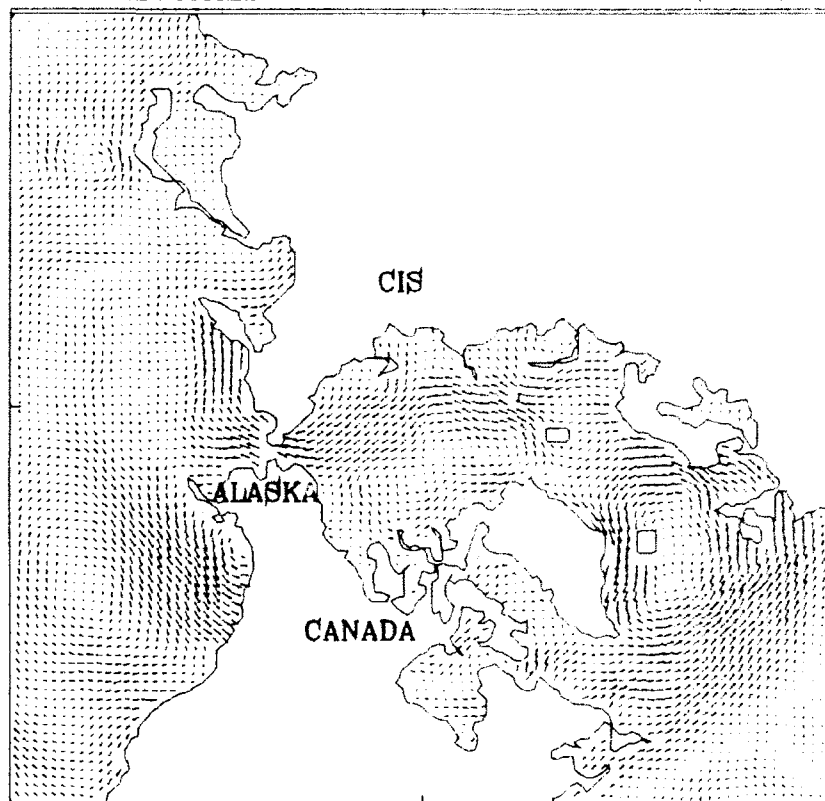
ICE CONCENTRATION

1992 AUGUST



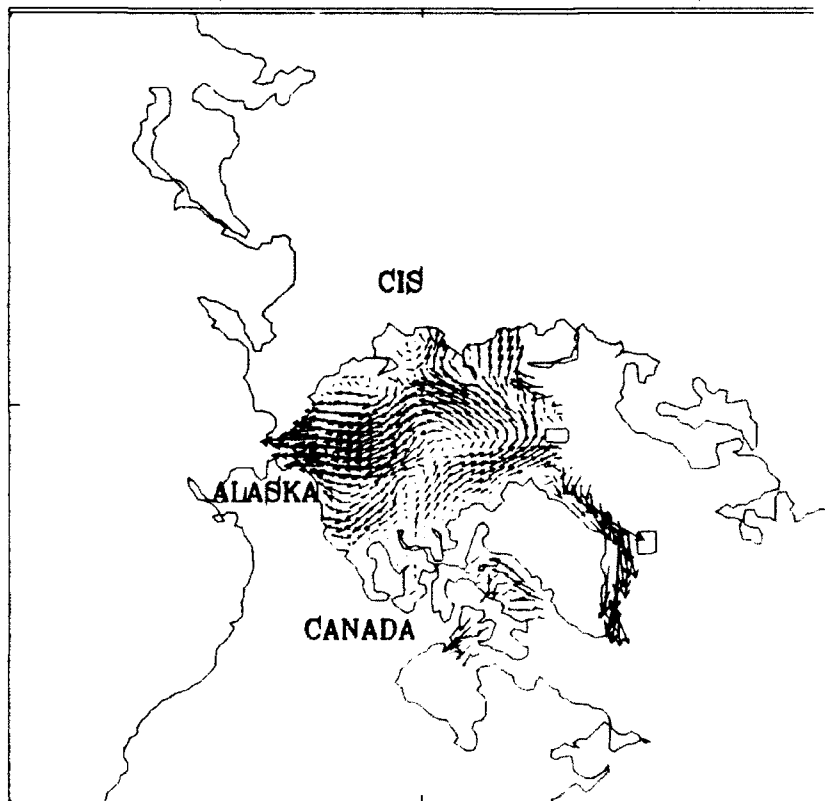
WIND VELOCITIES

1992 SEPTEMBER



ICE VELOCITIES

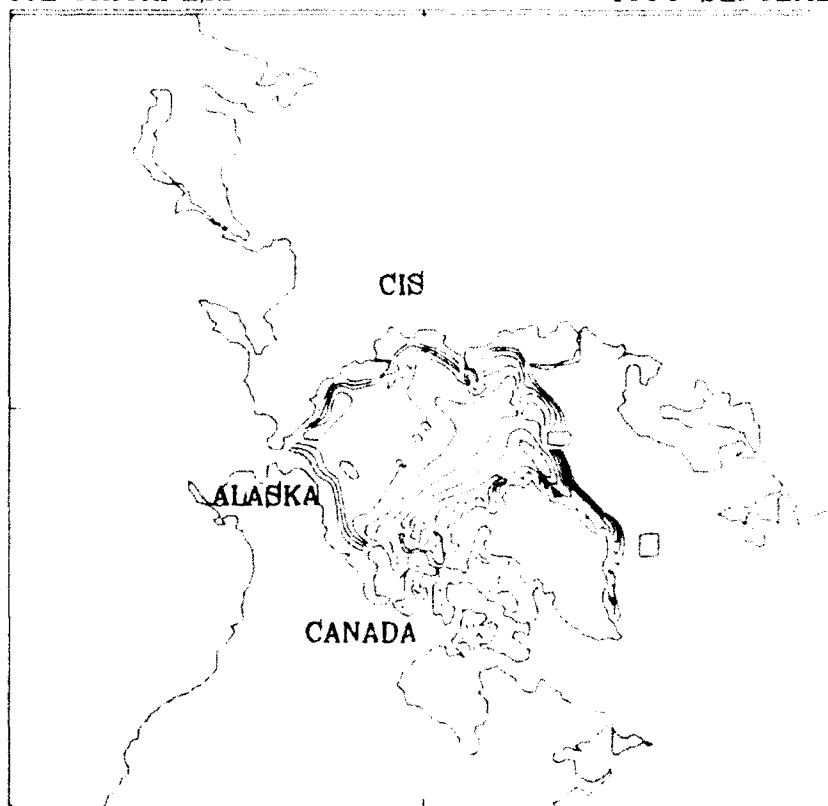
1992 SEPTEMBER



0 300E-02
MAXIMUM VECTOR

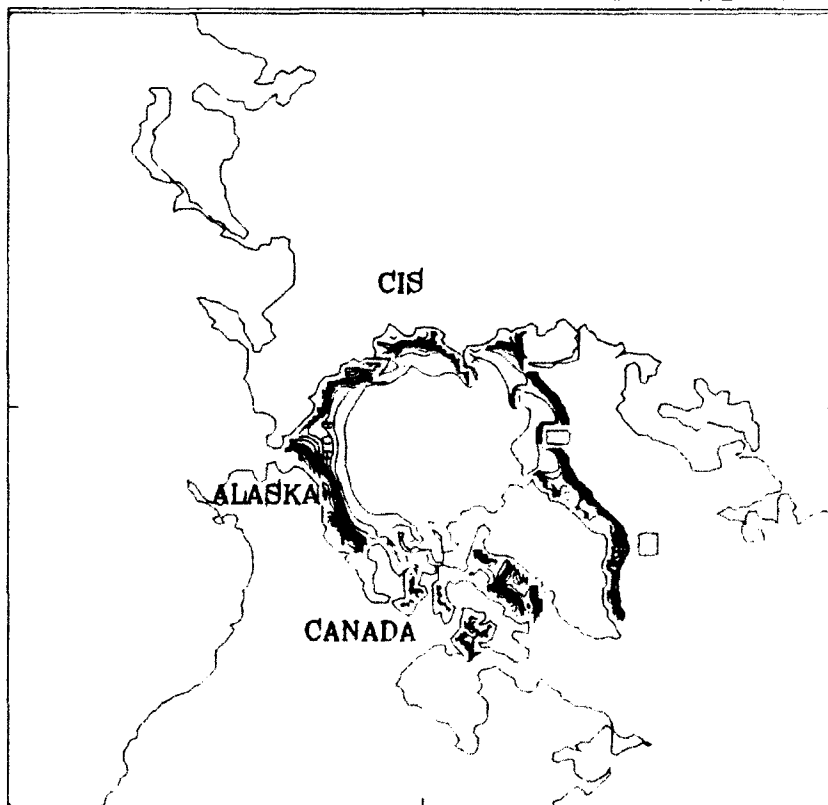
ICE THICKNESS

1992 SEPTEMBER



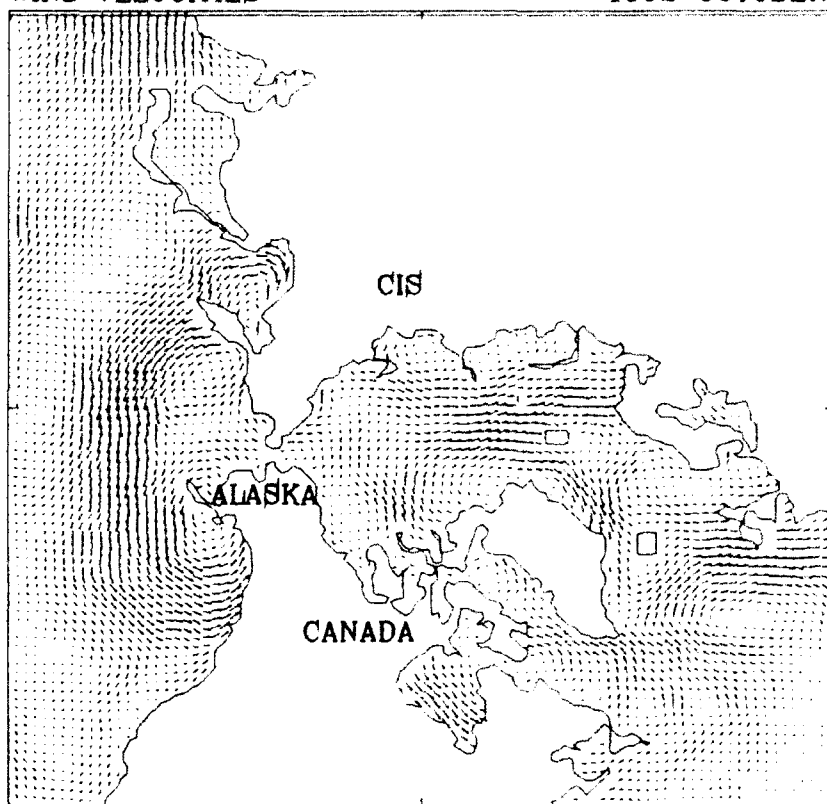
ICE CONCENTRATION

1992 SEPTEMBER



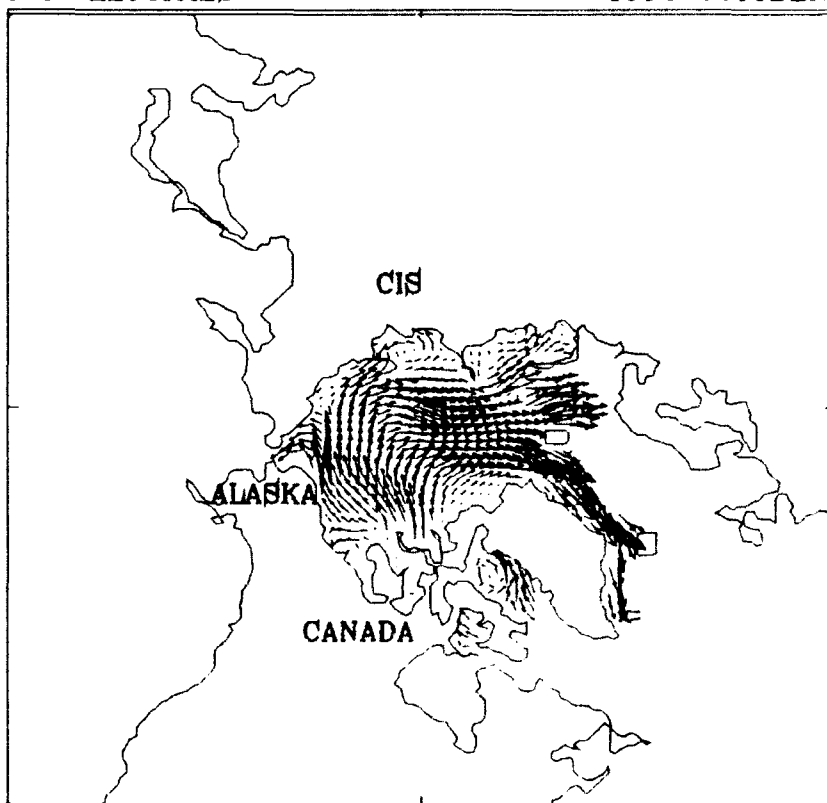
WIND VELOCITIES

1992 OCTOBER



ICE VELOCITIES

1992 OCTOBER

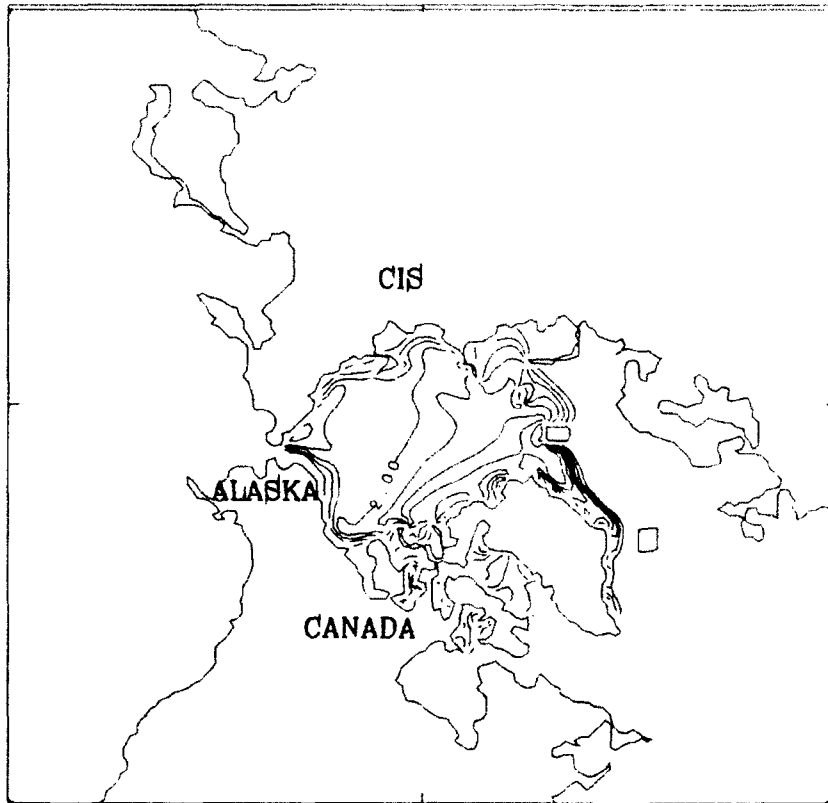


0 300 600
MAXIMUM VELOCITY

0 300 600
MAXIMUM VELOCITY

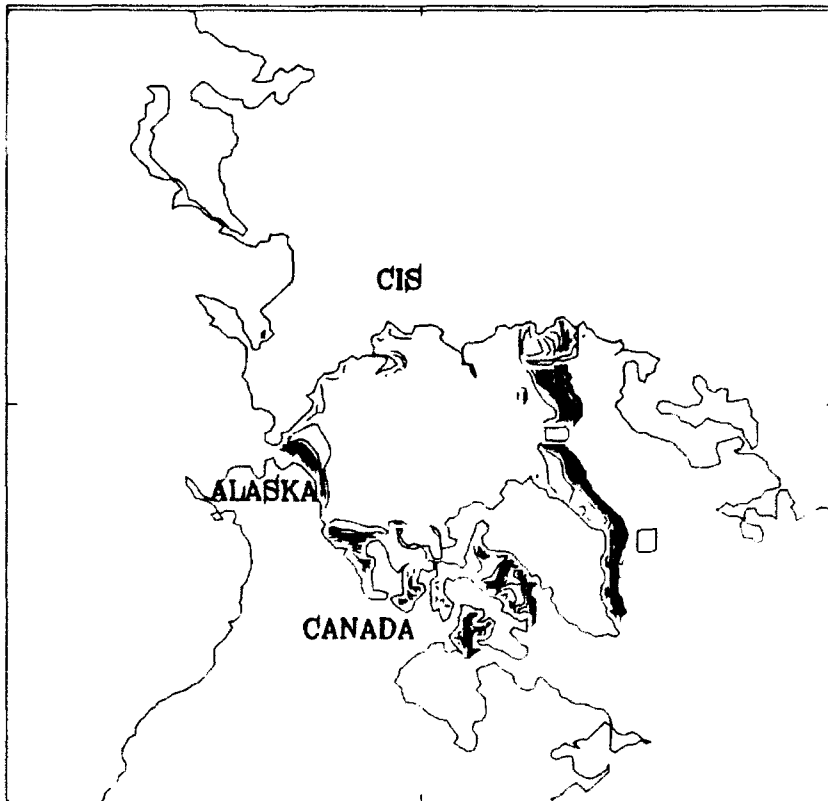
ICE THICKNESS

1992 OCTOBER



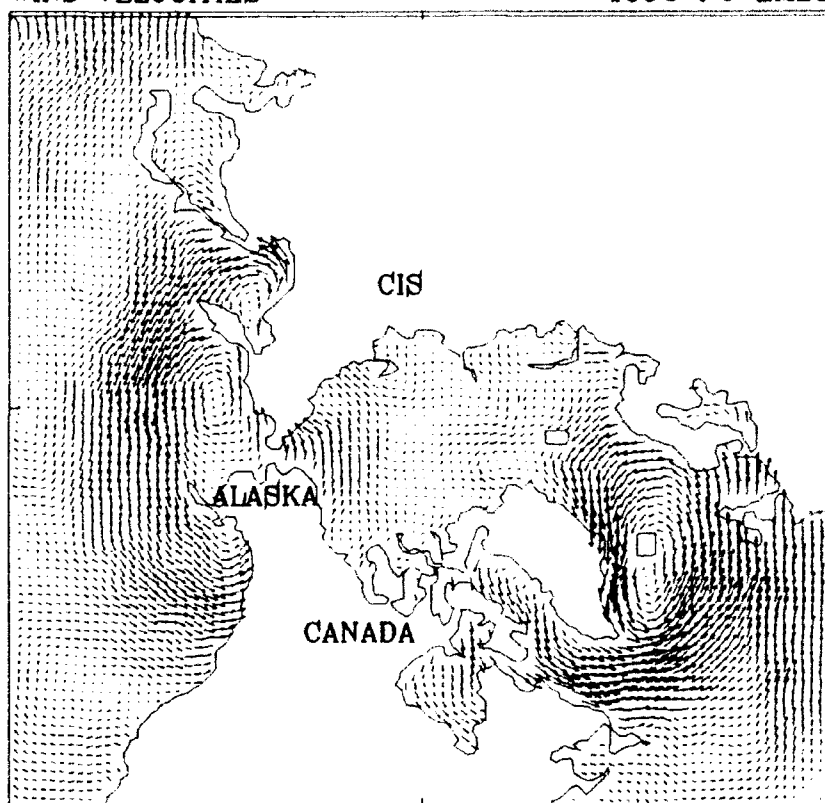
ICE CONCENTRATION

1992 OCTOBER



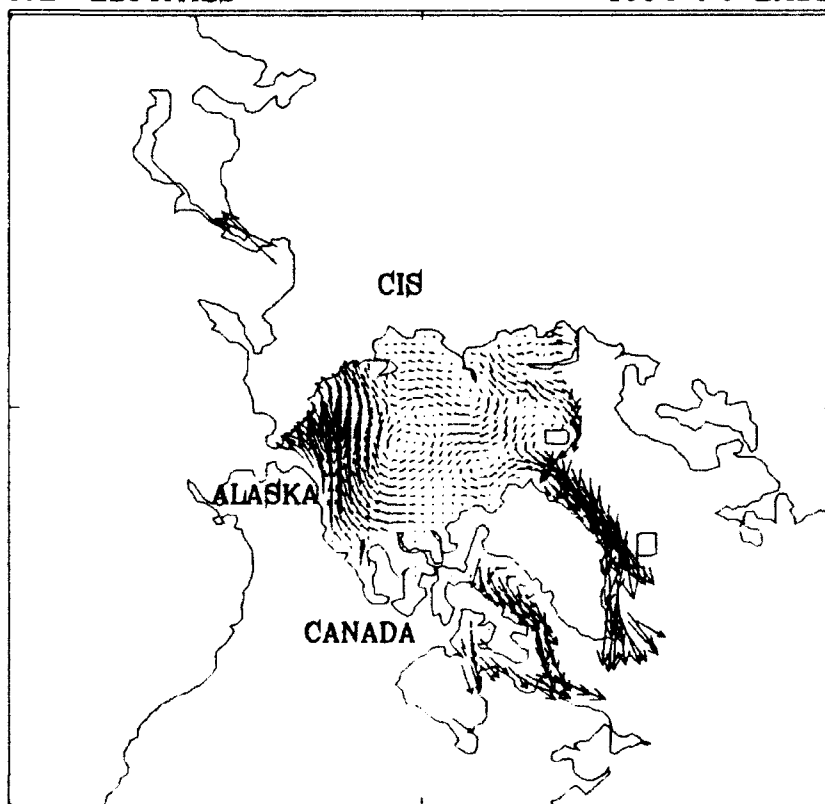
WIND VELOCITIES

1992 NOVEMBER



ICE VELOCITIES

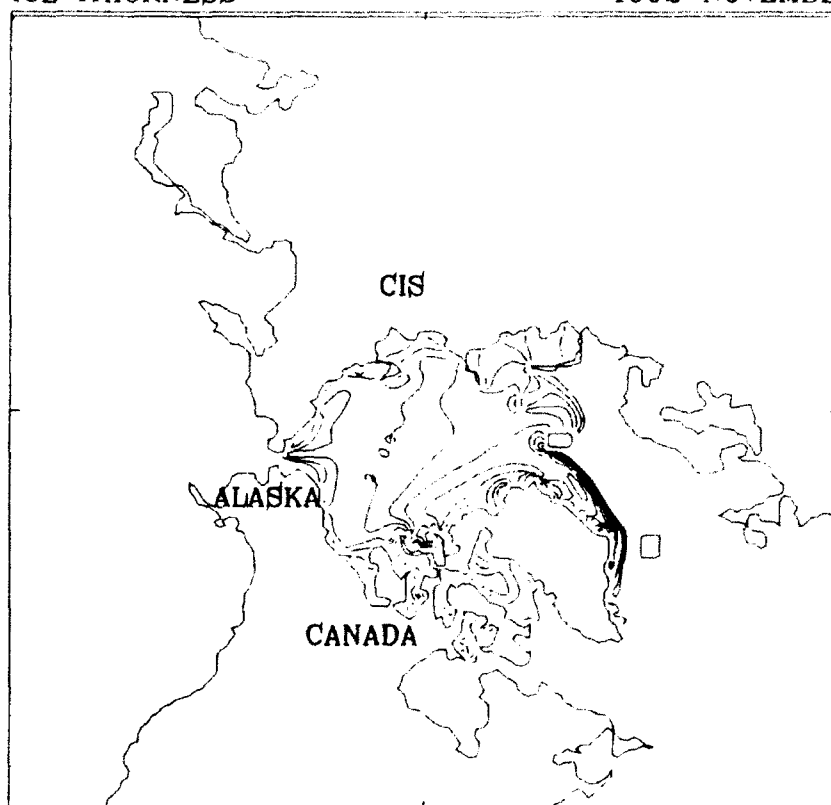
1992 NOVEMBER



0.30E+02
MAXIMUM VECTOR

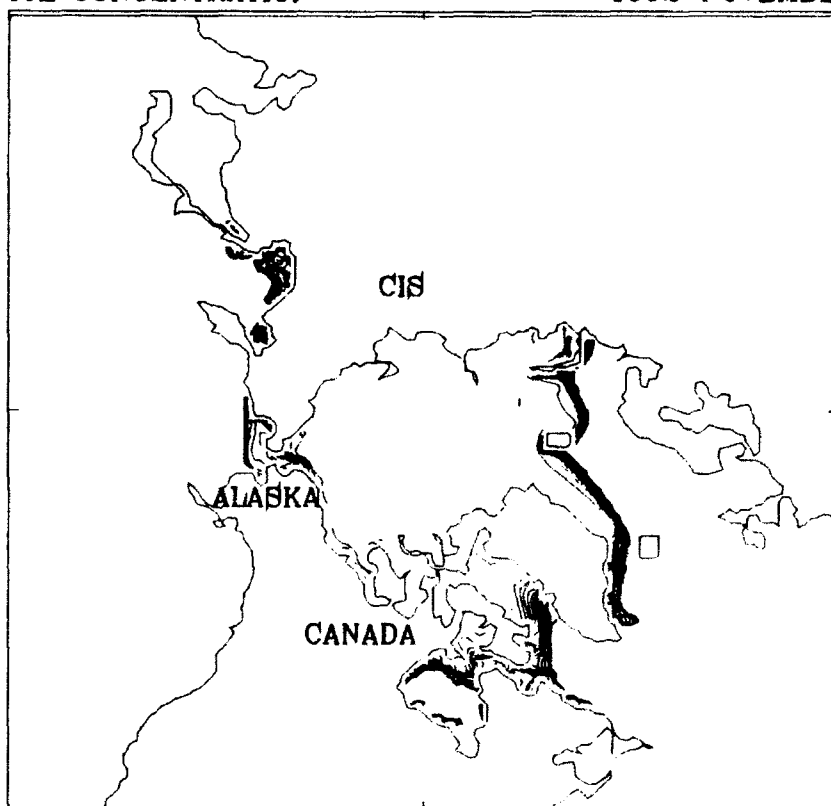
ICE THICKNESS

1992 NOVEMBER



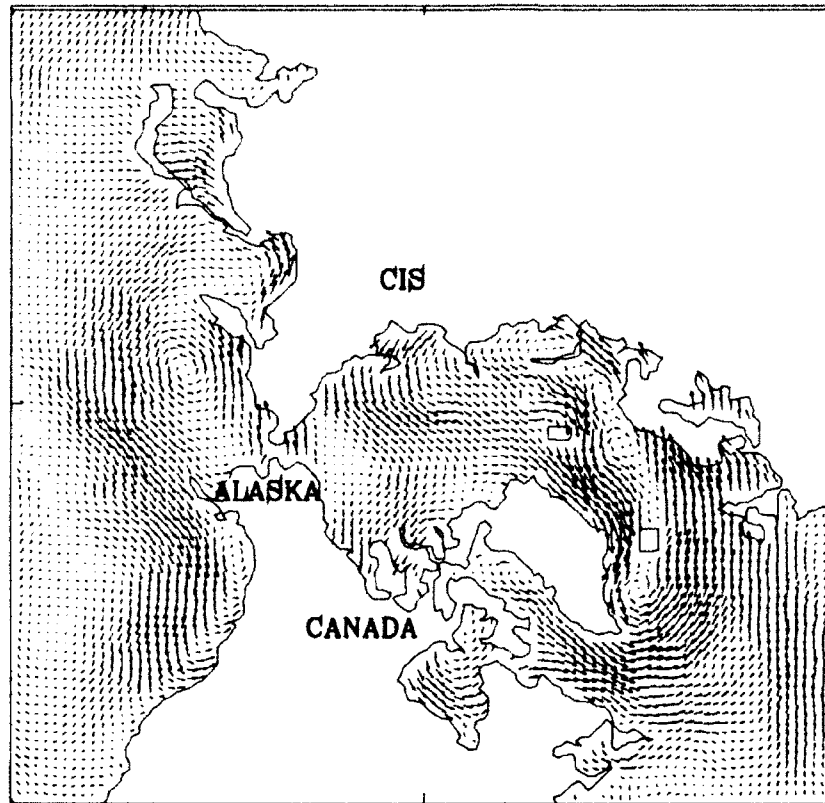
ICE CONCENTRATION

1992 NOVEMBER



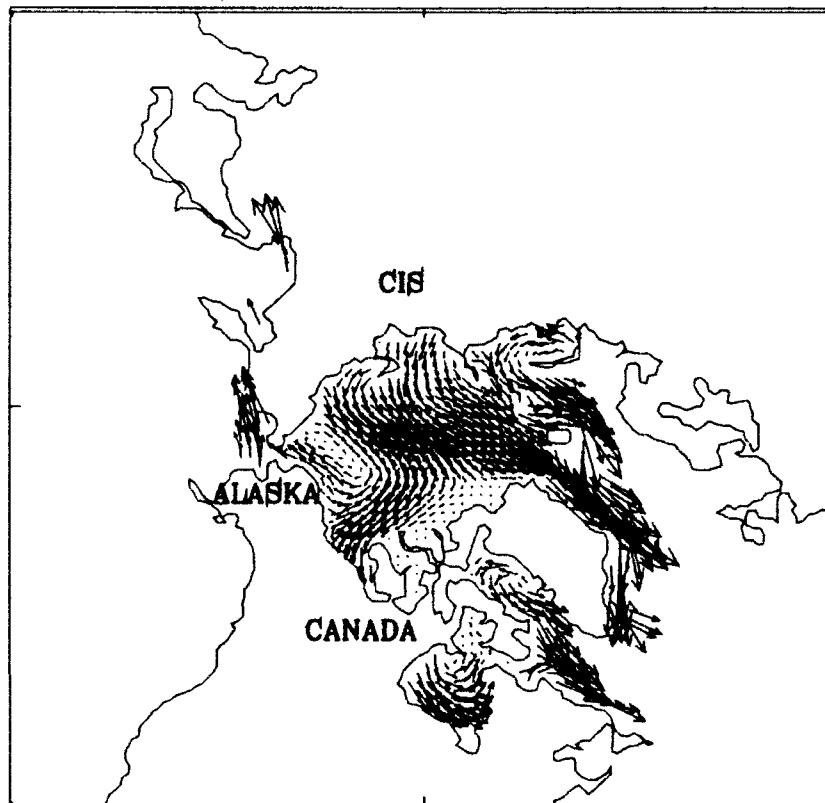
WIND VELOCITIES

1992 DECEMBER



ICE VELOCITIES

1992 DECEMBER

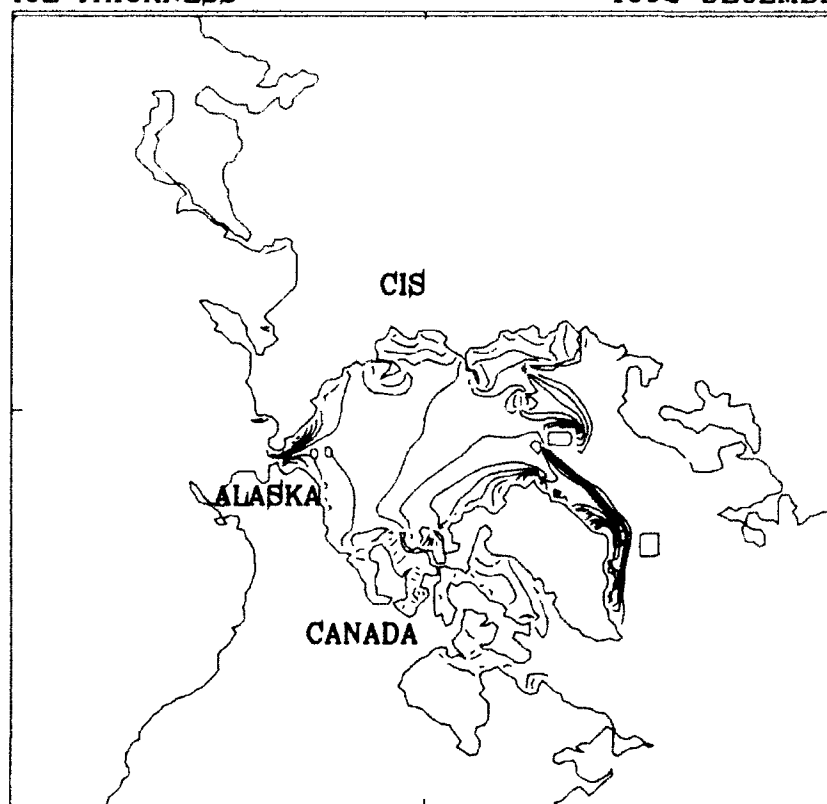


0.500E-02
MAXIMUM VECTOR

0.500E-02
MAXIMUM VECTOR

ICE THICKNESS

1992 DECEMBER



ICE CONCENTRATION

1992 DECEMBER

