FINAL REPORT

GRANT/CONTRACT NUMBER: N00014-92-J-1262

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PROJECT TITLE:
A Process Oriented Study of Shallow Convection in Polar Oceans
PRINCIPAL INVESTIGATOR(S): David C Smith IV
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GRANT/CONTRACT NUMBER: N00014-92-J-1262
GRANT/CONTRACT START, END DATES:10/1/93-9/30/94

OBJECTIVES

The objectives of this study are to obtain a better understanding of shallow ocean circulations beneath leads in sea ice associated with ice formation and brine rejection. We would also like to access the role of under ice boundary layer turbulence in mixing away the signature of haline convection beneath leads.

APPROACH

During the period of support, hydrostatic and nonhydrostatic high resolution convection models have been developed for the study of ocean flow beneath leads in sea ice. The results obtained thus far have been for two dimensional flow fields. A three dimensional version of the model has now been developed for future studies of shallow convection in leads and polynyas.

ACCOMPLISHMENTS

We have developed hydrostatic and nonhydrostatic convection models for the study of shallow haline convection beneath leads in sea ice. The models are forced with salt fluxes approriate to typical leads. The models have been used to understand lead circulations under a number of different forcing conditions. Sensitivity of the circulations to lead width, magnitude of the salt flux and speed of the ice relative to the upper ocean have been examined.

Initial results were obtained using a hydrostatic model. This model indicated that lead convection occurs as a transient pulsing phenomena (figure1) which occurs predominantly at lead edges. These events occur for low ice speeds (<10 cm/s) and have time scales of 1-3 hours. At higher ice-water relative speed, near surface mixing associated with under-ice turbulence and mixing rapidly erodes the signature of convection and salt is mixed into the turbulent boundary layer. This finding confirmed an earlier scaling which predicted the existence of free vs. forced convection regimes as a function of salt flux and ice-water relative velocity. The results of these experiments were available during the planning of the LEADEX field program and many participants in that field program saw computer animations of the predicted flow fields before the field program. The results were published in the Journal of Geophysical Research (Smith and Morison,1993).

A subsequent study involved the development of a nonhydrostatic numerical of haline convection. The experiments reported in Smith and Morison(1993) were repeated with identical forcings. The main finding in this second portion of the study is that the hydrostatic model captures the main

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2. The Defense Technical Information Center received the enclosed report (referenced below) which is not marked in accordance with the above reference.

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N00014-92-J-1262
TITLE: A PROCESS ORIENTED STUDY OF SHALLOW CONVECTION IN POLAR OCEANS

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features of lead convection. Nonhydrostatic convection is neither qualitatively nor quantitatively different from hydrostatic simulations. This is true because of the shallow nature of the convective motions, being limited to the upper 40 m of the water column by the presence of the Arctic halocline.

The models have proven useful in the interpretation of the LEADEX field results. Transient events seen in the field data are interpretted as convective events which tend to occur near lead edges as the model predicts. In this model/data intercomparison phase, the model was forced with conditions observed at the LEADEX field sites. The results of this intercomparison are published in Journal of Geophysical Research (Muench, Smith and Paulson,1995).
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1994 GRANT/CONTRACT STATISTICS AND CITATIONS

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PROJECT TITLE:
A Process Oriented Study of Shallow Convection in Polar Oceans
PRINCIPAL INVESTIGATOR(S):David C Smith IV

STATISTICS

a) Papers published (refereed journals) __2__
b) Papers submitted (refereed journals) __2__
c) Books or chapters published _____
d) Books or chapters submitted _____
e) Technical reports/papers (non-refereed) _____
f) Patents filed _____
g) Patents granted _____
h) Invited presentations at conferences __1__
i) Contributed presentations at conferences __1__
j) Undergraduate students* _____
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t) Instrumentation purchased (description, cost):
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CITATIONS

a) Papers published (refereed journals) __2__

1994 Muench, R. D., D. C. Smith, IV and C.A. Paulson: Convection beneath freezing leads: new observations compared with numerical model results J. Geophys. Res. 100,4681-4692.

1993 Smith, D. C., IV and J. H. Morison: A numerical study of haline convection beneath leads in sea ice. J. Geophys. Res., 98, 10,069-10,083.

b) Papers submitted (refereed journals) __2__

1994 Smith, D. C., IV and J. H. Morison:

Nonhydrostatic effects in haline convection beneath leads in sea ice. J. Geophys. Res. (submitted).

J.W.Lavelle and D. C. Smith, IV: The onset of thermal convection from line segment sources. J. Phys. Oceanogr. (submitted).

h) Invited presentations at conferences __1__

Smith, D.C., IV: Nonhydrostatic models of lead convection
High Latitude Ocean-Atmosphere-Ice Interactions Workshop
University of Alaska Fairbanks, July 1994.

i) Contributed presentations at conferences __1__

1994 J.W.Lavelle and D. C. Smith, IV: The onset of thermal convection from line segment sources.
Fall meeting, AGU, San Francisco

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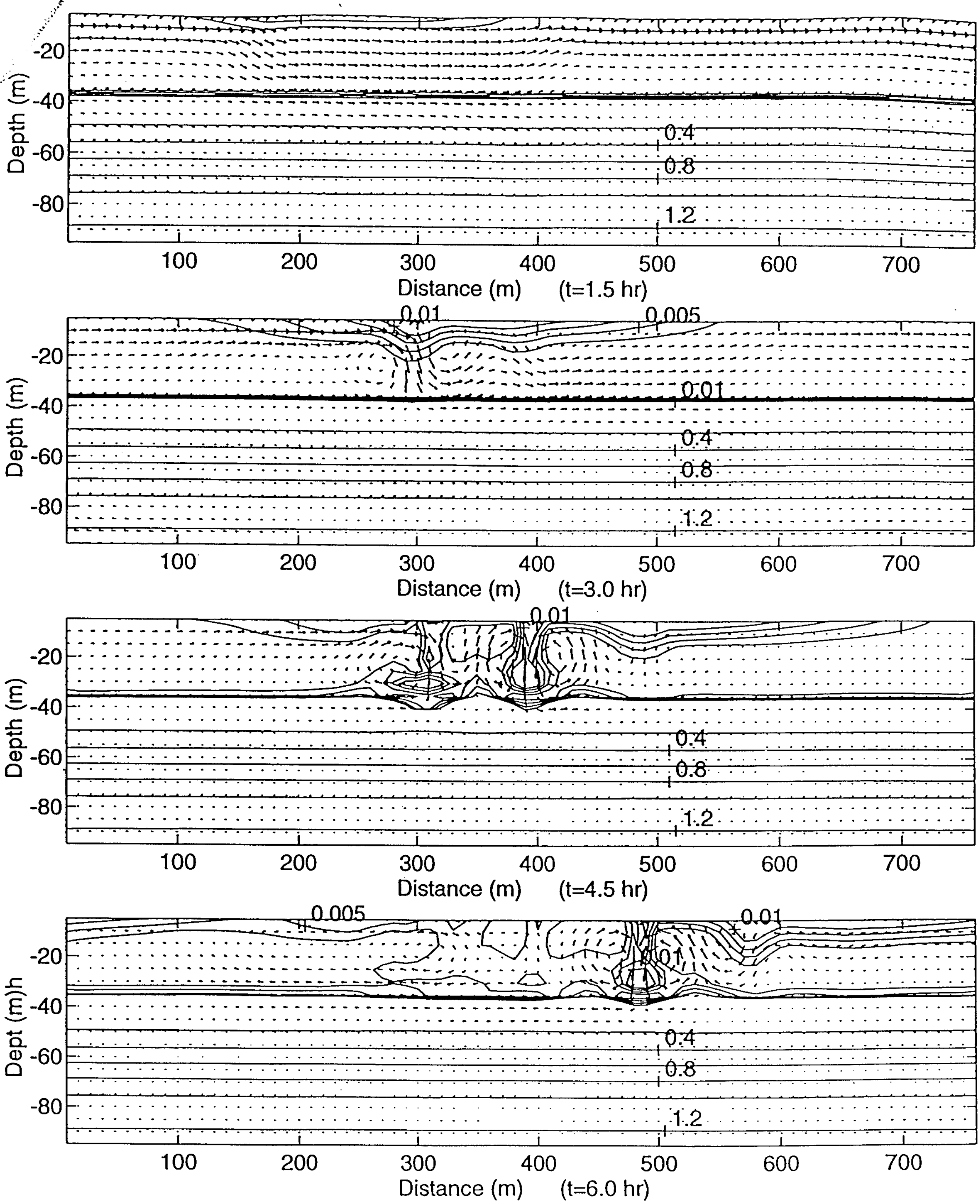

Figure 1. Nonhydrostatic convective circulation beneath a lead in sea ice. The lead occurs as a surface salt flux condition. In this case the lead is moving from left to right at 5 cm/s relative to the upper ocean. The convection occurs as transient sinking events which occur predominantly at lead edges.