Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**
4. TITLE AND SUBTITLE **Langrangian Floats for Deep Convection**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Washington,Applied Physics Laboratory,Seattle,WA,98105**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADM002252.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**2**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Lagrangian Floats for Deep Convection

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LONG TERM GOALS

I aim to understand the process of deep convection in the ocean.

OBJECTIVES

Near surface water is mixed to great depth at a few high latitude locations, thereby forming the deep and bottom masses of the ocean. This proposal has supported the development and deployment of neutrally buoyant floats in the Labrador Sea in the winters of 1997 and 1998 and the analysis of the resulting data. These floats provide detailed information on the processes and rates of deep convection.

APPROACH

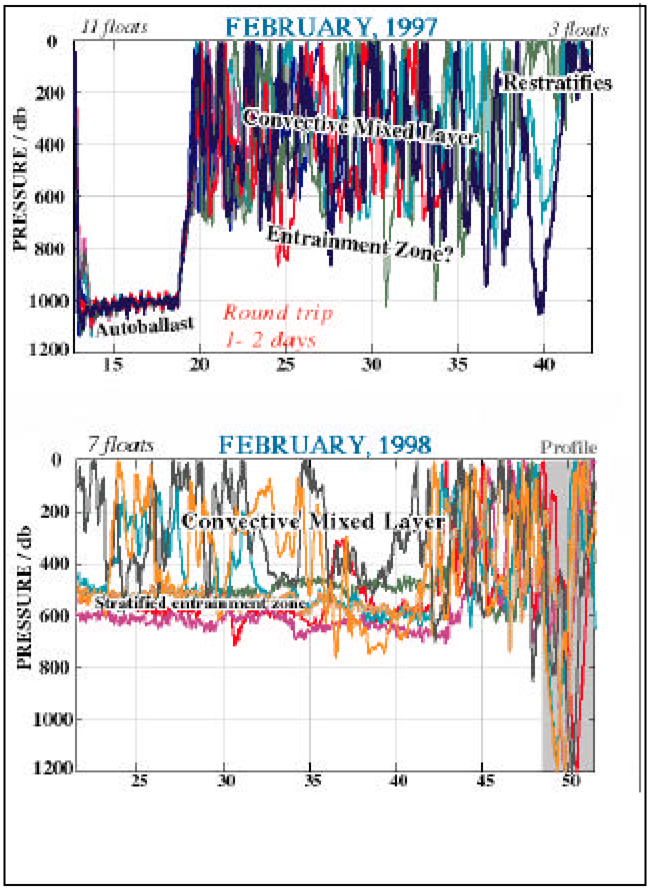
The Lagrangian floats (see figure) accurately follow water motions through a combination of a density which matches that of seawater and a high drag. The density is matched to that of the ambient water by actively changing the float's volume and will stay matched, despite changes in pressure and temperature, though a combination of active control and a hull compressibility which is close to that of seawater. High drag is achieved through a large circular cloth drogue attached to the float. The horizontal motion of the float is determined by acoustic tracking (RAFOS) and its vertical motion is determined from pressure. Data is relayed at the end of the 2-month mission via satellite (ARGOS). These data are supplemented by meteorological and oceanographic data from other investigators involved in the Labrador Sea Deep Convection experiment. Data analysis is partially supported by the AASERT grant, which supports a graduate student, Elizabeth Steffen.

WORK COMPLETED

A total of 20 float records were returned: 13 from the winter of 1997, 7 from the winter of 1998. Overall, the floats worked very well, although there is room for improvement. The PI, supported by the main grant, and a graduate student, Elizabeth Steffen, supported by the associated AASERT grant, participated in the 1998 float deployment cruise in the Labrador Sea. Nearly 70 floats were launched, for 3 different ONR PI's and a cross-basin CTD section completed.

RESULTS

The figure shows depth/time data from the 1997 (top) and 1998 (bottom) floats. A convectively mixed layer extending from the surface to about 700m in 1997 and 600m in 1998 is evident. The floats cycle across this layer, with speeds often exceeding 10 cm/s. Occasionally, floats penetrate well below the layer, some reaching depths exceeding 1 km. In 1998, some of the floats were seeded below the convective layer. These are eventually entrained into the convective layer as it deepens.



A number of quantitative statistics can be extracted. The mixing time, equal to the time for a float to traverse the layer, is about a day. The rms vertical velocity is 2-3 cm/s and varies with the surface heat flux. Vertical velocity is well correlated with temperature, resulting in a vertical heat flux. The patterns of temperature and depth variation show strong downward velocities, “Convective Plumes”, which play an important role in entrainment and weak, less active upward velocities.

IMPACT/APPLICATIONS

These direct measurement of the vertical velocity and temperature fluctuations associated with deep convection will allow direct comparisons with theory and numerical models. The long-lived, autonomous Lagrangian floats can be used in many other environments; measurements in the equatorial undercurrent and under hurricanes will be made soon.

RELATED PROJECTS

These floats are close relatives of those used to study mixing in the Littoral zone and upper ocean mixed layer funded by ONR 322PO. Mixing processes in these various environments are similar in many ways and we learn the most by comparing and contrasting them.

PUBLICATIONS

The Lab Sea Group, 1998, The Labrador Sea Deep Convection Experiment, *Bulletin of the American Meteorological Society*, in press