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Final Report for Dr. Russ E. Davis: Convection in the Labrador Sea
Grant N00014-95-10686

The long-term goal of this grant was to describe the process of deep oceanic convection well enough to provide critical tests of, and guidance to, models used to predict subsurface ocean conditions.

The observational objective of this project was to define the statistics of plume processes (typical vertical velocities, temperature fluctuations and the vertical heat flux) and to develop a resolved picture of how the chimney scale evolves over two complete cooling seasons. This observational picture was to be compared with model predictions that relate the plume properties to physical parameters (surface buoyancy flux, earth's rotation and the initial oceanic density stratification) and predict how chimney scale structures evolve.

The initial operational plan was to deploy 20 Profiling Autonomous Lagrangian Circulation Explorer (PALACE) floats to observe deep convection in the Labrador Sea over the winter of 1996/97. During the cooling season these floats would measure temperature and salinity profiles every 4 days and between these profiles they would measure time series of vertical velocity and temperature fluctuations near 400 m depth. Lateral motion of the floats would define circulation on the chimney and basin scales. During the warming season the profiling interval will be doubled to extend life.

In preparation for this, a design for adding Vertical Current Meter (VCM) capability to the PALACE float was designed, two prototype floats were constructed and calibrated, and deployed locally for a field test. This test showed that the measured VCM response to vertical flow is linear down to 1 mm/s, where ocean variability confused the test, and shows no hint of the asymmetric response implicated in older designs. Comparison shows that vertical velocities down to 0.1 mm/s (10 meter/day) are easily measured. Twenty floats, 10 obtained from a DURIP award, were then constructed.

As plans for the Convection ARI developed a second observational year (winter of 1997/98) was added and it was decided, at the suggestion of program manager Micael van Woert, to withold 5 of these floats for the second year and deploy 15 in February 1997. Five were placed in a cluster near the vertical-current measuring floats deployed by Prater of URI and the other ten were deployed within 200 km of that spot in the northwestern Labrador Sea. All floats report temperature profiles to 1500 m, and nine report salinity profiles as well. Two were damaged in deployment and do not descend to their parking depth and one failed for unknown causes in March 1997. The remainder were operational at the end of June.

The horizontal motion of the floats deployed in 1997 shows that there is weak cyclonic flow in the gyre interior in winter; this is less clear in other times of the year. The trajectories also show how floats placed outside the boundary current along the Canadian coast can escape to the southwest in weak chaotic motion in the interior. Sequential temperature and salinity profiles show that convection penetrated to 1400 m in March of 1997. Even during the period that convection was occurring the T and S profiles show considerable fine structure; the convecting layer is certainly more complicated than a deep mixed layer. These results suggest that lateral motion and potentially double diffusive turbulence play roles in Labrador Sea deep convection.

Time series of temperature and velocity near 400 m confirm that convection was active during February-April. Downwelling jets up to 10 cm/s, and somewhat weaker upwelling bursts, were observed during this period. Temperature fluctuations of 0.05\(deC are common after the convective layer has extended below the float depth but these fluctuations show a complex and varied connection with vertical velocity.

A follow-on grant has been approved and the remaining 5 are ready for deployment in January 1998.