Hydrography of the Labrador Sea During Active Convection

Robert S. Pickart
Department of Physical Oceanography, MS #21
Woods Hole Oceanographic Institution, Woods Hole, MA 02543
phone: (508) 289-2858 fax: (508) 457-2181 email: rpickart@whoi.edu

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http://www.whoi.edu/science/PO/people/pickartgroup/index.html

LONG-TERM GOALS

To improve our understanding of the dynamics of open-ocean convection and its parameterization in large-scale numerical models.

OBJECTIVES

The main objectives are (1) to describe the large-scale context within which convection occurs, including the water masses involved and the general circulation, and (2) to characterize the mixed-layer structure and variability, both laterally and vertically, and hence shed light on the nature of the overturning.

APPROACH

A hydrographic data set was collected in winter 1997 as part of the "Deep Convection" Accelerated Research Initiative (ARI). These data — together with atmospheric forcing fields (K. Moore, University of Toronto) and hydrography collected the previous fall and following spring (A. Clarke, Bedford Institute of Oceanography) — are being analyzed together to investigate overturning in the Labrador Sea. To elucidate various larger-scale aspects of convection in the subpolar North Atlantic, a hydrographic/direct-velocity data set from the Irminger and Labrador Seas during the time period 1990–97 was assembled.

WORK COMPLETED

We are now in the final analysis stage of this project. To date there have been two papers accepted and one submitted. The latter is a study describing the overall hydrographic conditions of the Labrador Sea during active convection (Pickart *et al.*, 2000). An additional study using the historical Labrador/Irminger Sea hydrographic data has also recently been finished, and was presented at the 2000 American Geophysical Union meeting and European Geophysical Society meeting. This work is presently being written up for publication. Finally, a WHOI post-doctoral scholar (F. Straneo) is working with Pickart to address Labrador Sea Water spreading pathways and timescales using an advective-diffusive numerical model, based on the absolute mid-depth flow field of Lavender *et al.* (2000).

RESULTS

As discussed in Pickart *et al.* (2000), overturning was observed in winter 1997 both in the interior of the Labrador Sea as well as in the western rim current. These two geographical regions, separated by roughly the 3000-m isobath, produced different vintages of Labrador Sea Water (LSW). The offshore

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water mass is the familiar cold/fresh/dense LSW. The boundary current water mass is somewhat warmer, saltier, and lighter (though in the far field it would be difficult to distinguish these products). The springtime hydrographic survey, conducted two months after the winter cruise, suggests that the boundary current product was quickly flushed out of the Labrador Sea. By contrast, the offshore water mass was apparently formed within the cyclonic recirculating gyre measured by Lavender *et al.* (2000), hence it is more constrained to remain in the Labrador Sea (Figure 1). Interestingly, LSW was not formed in the eastern and northern parts of the basin. We argue that this is due to a continual release of buoyant coastal water from the West Greenland Current into basin via eddy shedding.

Using the historical hydrography we have shown that deep convection likely occurs in the Irminger Sea as well as the Labrador Sea. This idea contradicts the modern-day notion that newly formed LSW found in the Irminger basin was advected from the Labrador Sea. We have demonstrated that the oceanographic preconditioning, circulation pattern, and atmospheric forcing are all conducive for overturning in the western Irminger Sea. Furthermore, an advective–diffusive model shows that both the spatial distribution and timescale of newly-convected water leaving the Labrador Sea is inconsistent with the properties measured in the Irminger Sea. This adds further credence to the local formation hypothesis.

IMPACT / APPLICATIONS

Our studies have highlighted the importance of the boundary current system in impacting deep convection. It was shown for the first time that deep convection occurs directly into a boundary current, enabling newly-formed water to exit the region quickly. The release of fresh water from the coastal boundary current apparently dictates where the overturning can occur within the interior basin. Finally, if a second area of overturning exists (the Irminger Sea), this will change our thinking with regard to ventilation of the mid-depth North Atlantic, and provide an important benchmark for modeling studies.

TRANSITIONS

None.

RELATED PROJECTS

This study is part of the Deep Convection ARI. Related projects include drifter studies, air–sea flux and atmospheric circulation studies, and analyses of moored data.

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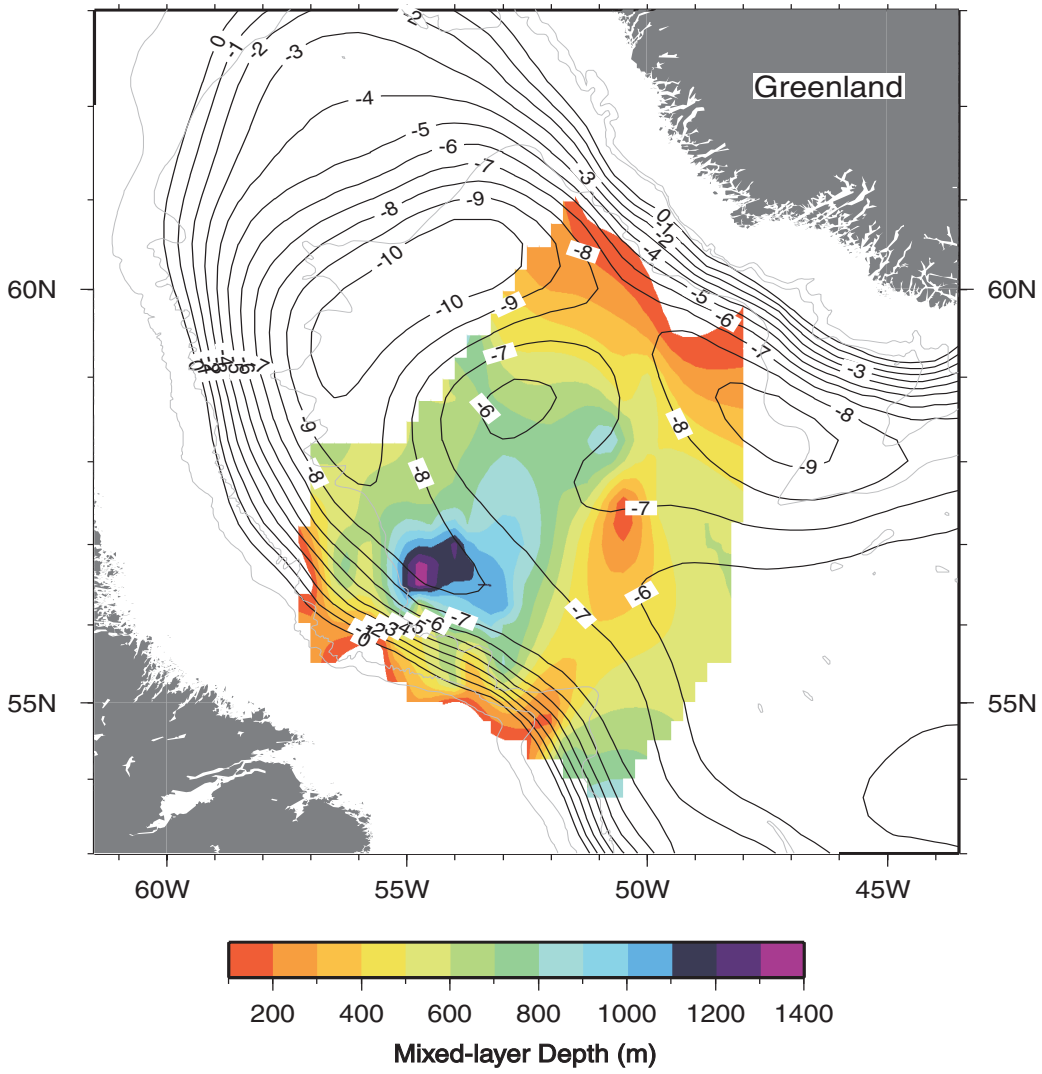

Figure 1. Depth of convection measured in the Labrador Sea during winter 1997, overlayed on the mean absolute geostrophic pressure at 700 m calculated from PALACE floats (Lavender et al., 2000). Note that the deepest mixed-layers are found within the "trough" of the cyclonic recirculation in the western Labrador Sea.