Real Time Predictions of the Convective Activity in the Labrador Sea

Martin Visbeck
LDEO, Columbia University
Palisades, NY 10964
phone: (914) 365-8531
email: visbeck@ldeo.columbia.edu
Award # N00014-98-1-0302
http://www.ldeo.columbia.edu/~visbeck/labsea

LONG-TERM GOALS

This effort contributes to a better understanding of the deep convective process in the ocean. In particular we are interested to evaluate the skills of a prediction system based on real time data in combination with ocean models to forecast the deep convective activity in a given region from a few weeks up to a few month in advance.

OBJECTIVES

- Apply and evaluate and improve, in real time, a minimum prediction system to forecast the convective activity several weeks in advance.
- Assess the relative importance of one-dimensional mixing physics versus lateral effects due to mesoscale eddies or other variable flows.

APPROACH

We build on our analysis of the historical data for the Labrador Sea region, which include climatologies of oceanic and atmospheric data as well as individual ocean station data and results from pilot experiments during the winter 1994/95. We have separated the typical mean seasonal cycle from interannual variability for the region. These data sets are used to determine a regional buoyancy budget.

The main task was to run our one dimensional prediction system in real time using climatological surface forcing and real time temperature and salinity profiles from profiling ALACE floats (provided by R. Davis and B. Owens)

Finally, we started to use a more complete ocean general circulation model to try to simulate the situation in the Labrador Sea during the convective seasons of 1996-1998. The model is run a two different resolution, coarse (100-200 km) and intermediate resolution (~25 km) and forced by monthly or daily atmospheric fields. The initial conditions were either the climatology of a longer model run, or the objectively analyzed observations from October 1996.

WORK COMPLETED

From October 1997 until early March of 1998 we have made real time predictions for the expected maximum convective activity of the central Labrador Sea. So far we have only used the one dimensional system because it performed much better compared to the dynamical ocean models. The predictions

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were used in combination with historical data to double check the float deployment strategy during the winter cruise Jan-Feb 1998.

We are also integrating two dynamical ocean model for the North Atlantic and preforming sensitivity studies using different parameter choices, initial conditions and surface forcing data sets. The results are very preliminary at this points and we are trying to improve the boundary and initial conditions.

RESULTS

We were able to run our one dimensional prediction system in real time and made the results available on the WWW. We typically updated the predictions every 2-3 weeks. We show two examples of the 1-D prediction system one from a forecast made in mid November 1997 (Fig. 1a) and a second one from late February 1998 (Fig. 1b). The colors show the expected mixed layer depth at the end of the convective season. One can clearly see that the early estimate was deeper than what the later one showed.

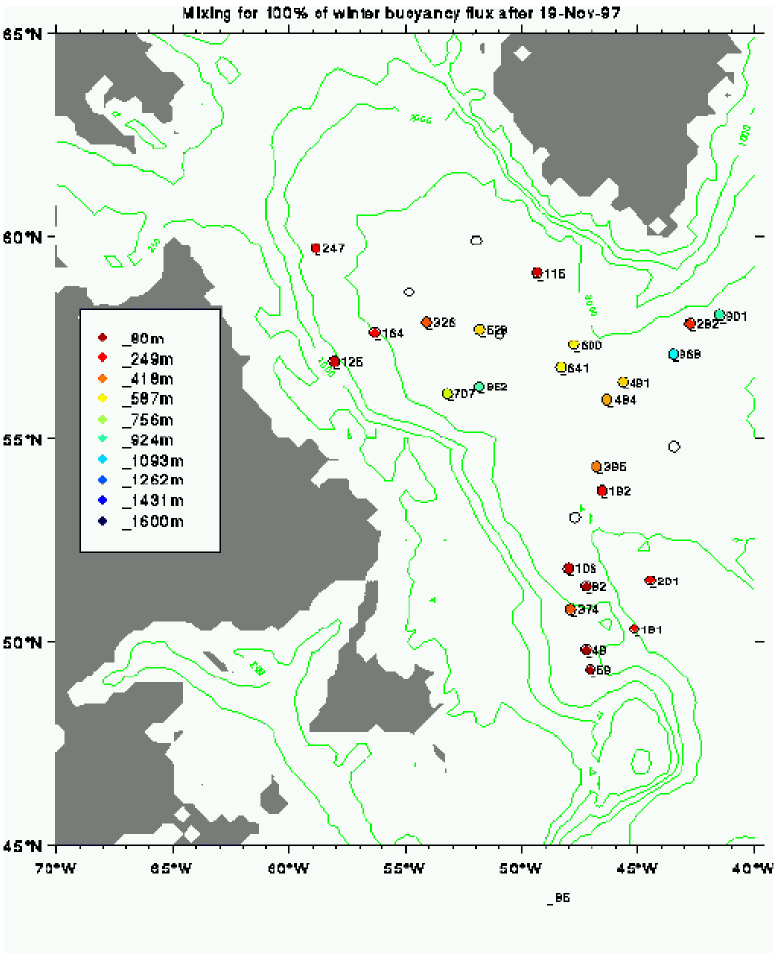

Figure 1a

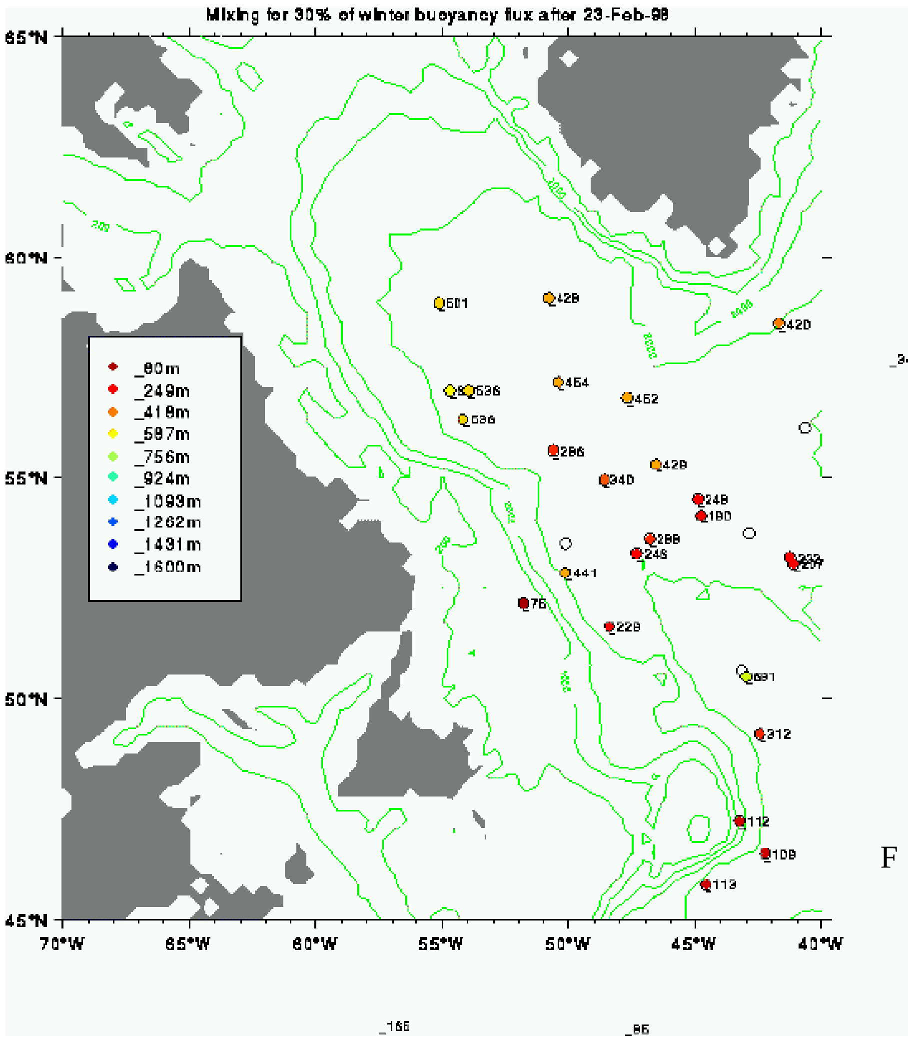

Figure 1b

Results from the one dimensional prediction system which uses the real time PALACE float temperature and salinity profiles to initialize a mixed layer model. The climatological heat fluxes are applied to compute the expected depth of the mixed layers at the end of winter. Two cases are shown for the 1997-1998 season with two different lead times.

It became clear that these large uncertainty stems from the unknown atmospheric conditions. A correlation analysis showed that much of the monthly and interannual heat flux variability in the central Labrador Sea is linked to the North Atlantic Oscillation (NAO). Therefore, some time was spent to better understand the response of the North Atlantic Ocean to NAO forcing (Visbeck et al. 1998). We are currently quantifying the skill of the prediction system for different hindcast scenarios. The question we would like to answer is:

What is the relative contribution to the convective activity due to interannual variability in the preconditioning (as observed by the float network in late fall) compared to the interannual variability in the surface forcing?

The outcome of this study will tell us what the prospects are for good skills in convection forecasts. If most of the uncertainty is in the atmospheric forcing we will have little chance to obtain good high predictions, since there is no skillful predictive system for the NAO. However, if the oceanic density field in early winter contributes significantly we have a much better chance to improve our skills.

Preliminary analysis of more complete coarse resolution three-dimensional dynamical models has shown that it is difficult to overcome model shortcomings such as to much diffusion and to weak advection within the boundary currents. However, the higher resolution model produced somewhat better results. What remains a problem is the adequate initialization of the models and we are currently trying a number of different strategies.

IMPACT/APPLICATIONS

This study will help to identify potential problems of dynamical forecast systems in regions of deep mixing activity. It will also give an assessment of state of the art ocean circulation models in regions where deep convection is expected.

TRANSITIONS

We have developed a research mode prediction systems which was not designed to be directly transferred to operational centers. However, the concept can readily be adopted and the identification of major shortcomings as well a potential solution should be beneficial for operational ocean forecast efforts.

RELATED PROJECTS

This project is well connected to many other components of the Accelerated Research Initiative "Deep Convection". We have work with sea going PIs to guide their observational strategies, disseminate information relevant to the group and also provide some generic information about the ARI on the web. We collaborate with the modelling effort at MIT (J. Marshall) and started to compare their high resolution results to our coarse resolution simulations. We have provided objectively analyzed temperature and salinity fields as initial conditions for their simulations. A crucial part of our project depended on the real time PALACE data provided by R. Davis.

We have also spent some time working with J. Bellingham (MIT) to advise him on strategies for the AUV experiment in the Labrador Sea. His efforts are funded under ONR's MURI program.

REFERENCES

The findings from most of our work can be found on the web under http://www.ldeo.columbia.edu/~visbeck/labsea

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