Atmospheric Forcing of Ocean Convection in the Labrador Sea

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LONG-TERM GOAL

My long-term goal is to improve our ability to model and predict dynamic and thermodynamic ocean processes in high-latitude regions. Specifically, I seek to understand and predict how atmospheric forcing such as surface momentum, heat and salinity fluxes affects the ocean.

OBJECTIVES

The ultimate objective of this study is to understand the relation between atmospheric forcing and deep convection in high-latitude seas, in particular, the Labrador Sea. The atmosphere provides the crucial input into the upper ocean, which results in destabilization and convection in the ocean. A necessary component of this objective is to verify and improve the parameterizations which numerical models use to specify surface fluxes over high-latitude marine regions. Another objective is to enhance our understanding of how these surface fluxes are related to upper-level and large scale atmospheric features. Finally, I seek to quantify the various feedbacks that occur between the ocean and atmosphere in the Labrador Sea and other high-latitude oceans.

APPROACH

My approach is to directly measure *in situ* surface and upper-level meteorological parameters during the 1997 and 1998 Labrador Sea Deep Convection Experiments. During the 1997 cruise of the *R/V Knorr* I performed the radiation and upper-air measurements; groups from the Bedford Institute of Technology (Fred Dobson), University of Kiel (Karl Bumke) and the NOAA Environmental Laboratory (Ola Persson) also provided equipment and personnel to measure turbulent fluxes directly. These measurements are being compared with numerical model and aircraft results, in collaboration with the University of Toronto (Kent Moore, Ian Renfrew). I also used data collected during the 1998 Knorr cruise to estimate the total surface heat and momentum budgets. The numerical models provide detailed spatial estimates of the heat and momentum fluxes, while the *in situ* measurements provide verification (or lack of) of the numerical models and also fluxes concurrent to oceanographic measurements.

WORK COMPLETED

The measurement program was highly successful with all instruments functioning well, despite the extremely harsh environment. I obtained the first and only rawinsonde data set that exists for the Labrador Sea. My student, LTC Laura Bramson, completed a study of the response of the ocean to

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various forcing scenarios using a mixed layer model developed by Roland Garwood. I have constructed a World Wide Web site (address above) with detailed descriptions of the surface (1997 and 1998) and upper-air (1997) data sets. I presented results at several meetings and conferences. I used a small amount of the ONR support to complete work on two papers that were published in refereed journals on topics that were similar, but not directly related to the Labrador Sea Deep Convection Experiment.

RESULTS

The 1997 cruise period was characterized by extremely high heat fluxes. The upper-level measurements revealed some systematic changes in the atmosphere as cold air was advected out over the relatively warm water, but much of the variations in atmospheric structure appeared to be controlled by synoptic features, i.e. storms. An unusual aspect of this period was the consistency of the wind directions from the north and west. This brought in cold continental air and caused the high fluxes. The values of total heat flux from the *in situ* measurements, although very large, were not as large as the operational numerical models results.

During the 1998 cruise wind directions were more variable and the surface heat flux was not as great as 1997. The sensible and latent fluxes were highly correlated with wind direction (Figure).

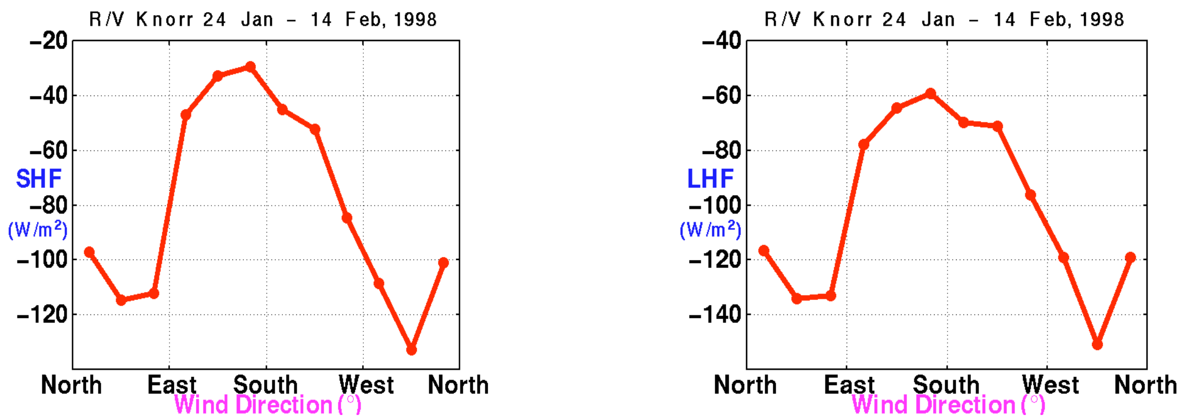

Figure. The bulk sensible (left) and latent (right) surface heat fluxes during the 1998 Knorr cruise as a function of wind direction. Negative indicates surface cooling, i.e. upward fluxes. Note the enhanced flux magnitudes during northerly winds and decreased fluxes during southerly winds.

IMPACT/APPLICATIONS

The discrepancy between the *in situ* measurements and the operational numerical models is an important finding because these numerical models typically provide all the information we have concerning atmospheric forcing of the ocean. A bias in these models would mean that incorrect heat fluxes are being specified throughout the World Ocean.

The correlation between wind direction and sensible heat flux observed during 1998 suggests that it is possible to roughly estimate heat fluxes in the Labrador Sea with only information on wind speed and direction.

TRANSITIONS

I have provided the surface and upper-air data sets to anyone who asked; there were over 12 requests.

RELATED PROJECTS

I have worked on quantifying surface heat fluxes in the central Arctic (SHEBA) and in the Weddell Sea (ANZFLUX). I teach a course on Polar Meteorology to US Navy officers every year and plan to write the first textbook on this topic.

PUBLICATIONS

Bramson, L.S., 1997: Air-sea interactions and deep convection in the Labrador Sea, M.S. Thesis, Naval Postgraduate School, Monterey, CA, 76 pp.

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