Instabilities in the Labrador Current

Master-Thesis in Physical Oceanography

Sören Thomsen

supervised by Prof. Dr. Carsten Eden

August 6th, 2012

Universität Hamburg

Institut für Meereskunde

Abstract

The water mass transformation process in the Labrador Sea during winter plays an important role for the Atlantic meridional overturning circulation and the global climate system. The newly formed Labrador Sea Water is exported within the deep Labrador Current (LC) after the convection process. Enhanced eddy kinetic energy (EKE) along the Labrador Current (LC) shows up in different model simulations, in-situ measurements and satellite altimetry data during the transformation and export process. The objective of this study is to investigate the frontal instability processes, which lead to enhanced EKE along the LC during late winter. 1/12° ocean model simulations from the Family of Linked Atlantic Ocean Model Experiments and the Massachusetts Institute of Technology General Circulation Model are evaluated. Linear stability analysis is applied to predict growth rates, wavelengths and EKE values along the LC.

A combination of weak stratification and enhanced vertical shear during winter results in small Richardson numbers within the baroclinic shelf break LC. Consequently, the growth rates of baroclinic waves increase significantly during winter. The balanced mode of baroclinic instability seems to be the dominant instability type responsible for the break up of the LC in the model simulations. The instability process starts when the deep mixed layer patch reaches the boundary current system. These dense and weakly stratified water masses lead to weaker stratification and a strengthening of the lateral density gradients within the shelf break LC. In both model simulations, first baroclinic waves with wavelengths of about $30-40\ km$ develop at the offshore edge of the shelf break LC. Rapidly frontogenesis along the whole LC sets in leading to enhanced EKE. During the rest of the year strong stratification and weak vertical shear leads to larger Richardson numbers and smaller growth rates. Linear stability analysis predicts an interior mode, which has similar wavelengths as the first wavelike disturbances showing up in the model simulations and a shallow mode, which can be associated with mixed layer instabilities. This mode has lateral scales of $O(1\ km)$ and is consequently not resolved in the model simulations. It is suspected that this mode might play an important role for the instability process in the real ocean.