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Formation mechanism of the baroclinic jet structure of the Soya Warm Current during summer

by

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Submitted to Hokkaido University

Abstract

The Soya Warm Current (SWC), which is the coastal current along the northeastern part of Hokkaido, Japan, has a notable baroclinic jet structure during summer. This thesis addresses the formation mechanism of the baroclinic jet by analyzing a realistic numerical model and conducting its sensitivity experiment. The key process is the interaction between the seasonal thermocline and the bottom Ekman layer on the slope off the northeastern coast of Hokkaido; the bottom Ekman transport causes subduction of the warm seasonal-thermocline water below the cold lower-layer water, so the bottom mixed layer develops with a remarkable cross-isobath density gradient. Consequently, the buoyancy transport vanishes as a result of the thermal-wind balance in the mixed layer. The SWC area is divided into two regions during summer: upstream, the adjustment toward the buoyancy shutdown is in progress; and downstream, the buoyancy shutdown occurs. The buoyancy shutdown theory assesses the bottom-mixed-layer thickness to be 50 m, which is consistent with observations and our numerical results. The seasonal thermocline from June to September is strong enough to establish the dominance of the buoyancy shutdown process over the frictional spindown.

In the downstream region, however, the conventional buoyancy shutdown theory is not directly applicable to the SWC because the SWC is not at rest near the bottom. To address the bottom flow formation in the downstream region, an idealized numerical model experiment is conducted. Analysis shows that momentum is produced in the vicinity of the bottom slope owing to eddy generation accompanied by internal instabilities of a baroclinic jet flow. That is, eddy kinetic energy released from mean available potential energy as a result of baroclinic instability is transferred from upper-layer down to bottom surface through the form stress on density interfaces, driving the bottom flow in the downstream region. Bottom drag in the along-isobath direction then increases approximately to the same strength as the form stress. The surface pressure gradient cannot account for the bottom flow formation since the along-isobath SSH gradient almost vanishes in the downstream region.

This study shows that the baroclinic jet structure of the SWC during summer is formed as a result of the buoyancy shutdown process and the resultant baroclinic instability.