Geophysical Research Abstracts
Vol. 12, EGU2010-8661, 2010
EGU General Assembly 2010

Convex and concave types of mode-2 internal solitary wave

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Two types of second baroclinic mode (mode-2) internal solitary waves (ISWs) were found in the continental slope of the northern South China Sea. One has waveform with upward/downward and downward/upward displacement of isotherm in the upper and lower water columns, respectively. It is a typical type of mode-2 ISW and named as convex wave. Another, named as concave wave, has waveform with reverse vertical displacement of isotherm. Few concave waves observed in the South China Sea. It is the first time documented here.

Based on the K-dV equation, an analytical three-layer ocean model is used to study the characters of two types of mode-2 ISW. The analytical solution is primarily a function of the thickness of each layer and the density difference between the layers. The thickness of middle layer plays a significant role on the resulted mode-2 ISW. The convex wave could be generated as the thickness of middle layer is relatively thinner than the upper and lower layers. Whereas the thickness of middle layer is larger than half of the water depth, only the concave wave could be produced. In accordance with K-dV equation, the positive and negative quadratic nonlinear coefficient, alpha2, which is also primarily dominated by the thickness of middle layer, leads the convex and concave waves, respectively. The analytical solution shows that the wave propagation of the convex (concave) wave has the same direction of current velocity in middle (upper or lower) layer.

The analysis three-layer model properly reproduces the characteristics of observed mode-2 ISW in the South China Sea. It also provides a criterion for the existence of convex and concave wave. Since a stratified ocean with a thick middle layer is rare, the concave wave was seldom seen. This inference agrees with our observation.