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On the vertical structure of internal solitary waves in the northeastern South China Sea

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Internal solitary waves (ISWs) make important contributions to energy cascade, ocean mixing and material transport in the ocean. However, there are few observational studies on the vertical structure of ISWs. The high-spatial resolution of seismic data enables us to obtain clear internal structure image of ISWs, so we can conduct a detailed research on their vertical structure. In this article, we report 11 ISWs near Dongsha Atoll in the South China Sea using two-dimensional seismic data.

We first extracted the amplitudes of ISW from seismic section, and obtained a series of discrete amplitude points. Then, the least-squares spline fitting was used to fit these amplitude points into a vertical structure curve. We calculated vertical structures by linear theory and first-order nonlinear theory, respectively, and compared the observed vertical structure with the two theories. We found that three ISWs conform to the linear vertical structure function, four ISWs conform to the first-order nonlinear vertical structure function, and four ISWs do not conform to the two theories. In order to figure out the reason why the observation did not conform to the theories, we decomposed the fitted vertical structures of these four ISWs by the empirical mode decomposition (EMD) algorithm, and compare the residuals of decomposition with the two theories. The results showed that the residuals of two ISWs are in agreement with the linear vertical structure function, the residual of one ISW conforms to the first-order nonlinear vertical structure function, and one residual of ISW still cannot conform to the two theories. We calculated key parameters of these ISWs to analyze the reasons for difference between observation and theory.

In summary, we found that the shape of vertical structure is mainly determined by nonlinearity. The vertical structure with low degree nonlinearity can be described by linear theory, while ISW with high degree nonlinearity conform to the first-order nonlinear theory. Besides, for an ISW with large amplitude propagating in shallow water, its vertical structure is more susceptible to be affected by the topography. Moreover, the background flow can also affect the vertical structure. We found an ISW was passing through an eddy which was trapped near seafloor, and resulted in the bottom of vertical structure decayed rapidly.