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Seismic oceanography study of a mode-2 internal solitary wave in the northeast South China Sea

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The nonlinear internal solitary waves (ISWs) are ubiquitous and recently many mode-1 ISWs have been reported to be detected in the northeast South China Sea by using the seismic oceanography method. However, few mode-2 ISWs are discovered in seismic data in the South China Sea. Thus, waveform characteristics and kinematics parameters of the mode-2 ISWs in this region need further study.

In this paper, one convex mode-2 ISW is presented near Dongsha Plateau on September 20th, 2009, and is analyzed by the combination of reprocessed seismic section and reanalysis hydrographic data. The seismic events of the multi-channel seismic section are extracted to obtain the vertical amplitude distribution and water depth of the mode-2 ISW. The seismic events can be used to analyze the structural characteristics in a snapshot, while different pre-stack common-offset gathers (COGs) can observe the seismic fine structures of the mode-2 ISW in chronological order. Furthermore, we use COGs method to calculate the apparent phase velocities of the peak and trough part of the mode-2 ISW on the seismic section and then correct the phase velocities according to the seismic measurement direction and ISWs propagation direction derived from satellite data. Theoretically, the reanalysis hydrographic data can be used to calculate the vertical structure and propagation speed of ISW based on the KdV model, and the theoretical results can be compared with those from seismic observations.

In total, 10 seismic events are extracted to obtain wave amplitudes and corresponding water depth distribution. Among the seismic events, only 2 events are elevation wave types and the rest 8 events are depression wave types. The maximum amplitude is about 25.5m of a depression wave event at 200m water depth. The dimensionless amplitude is 2.56, this number shows that the mode-2 ISW is of large amplitude. Moreover, the pycnocline is displaced over 20% from the mid-depth of the total seawater depth, illustrating the mode-2 ISW is of asymmetry. The fine structures of the mode-2 ISW observed on COGs also show the asymmetric and complex wave disturbance in different acquisition times. The apparent phase velocity of the crest is 1.59m/s, while the apparent phase velocity of the trough (the maximum amplitude) is 0.8065, the results indicate that the elevation waves of the mode-2 ISW may move faster than the underlying depression waves. Finally, the corrected phase speed of the mode-2 ISW is consistent with the

propagation speed calculated by the KdV equation. More pieces of evidence are needed to explain the generation and to predict further evolution of the asymmetric mode-2 ISW, and seismic oceanography may be one of the key techniques to answer these questions.