EGU2020-9365
https://doi.org/10.5194/egusphere-egu2020-9365
EGU General Assembly 2020

Observation of dynamic fine structure in ocean using pre-stack seismic data

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We propose a method for observing the dynamic thermohaline fine structure using pre-stack seismic data, and combine it with PIV(Particle-Image-Velocimetry) technology to obtain a series of vertical two-dimensional flow velocity sections.
Because of the redundancy of the multi-channel reflection seismic data, the reflection seismic structure at the same location can be observed multiple times from pre-stack seismic data. First, we extract the common-midpoint gathers (CMPs) from the multi-channel reflection seismic data. Then extract the common-offset gathers (COGs) from CMPs. Finally, a seismic processing sequence, such as noise attenuation, normal move out (NMO), velocity analysis and migration, is applied for imaging the reflection structure in COG sections. These COG sections with different offsets are the images of the thermohaline fine structure of seawater at different times. We apply this method to study a typical internal solitary wave in the Dongsha plateau of the South China Sea. We find that the waveform of the internal solitary wave(ISW) in shallow water region does not change much during propagation, but the front becomes flatter and the rear becomes steeper in deep water region, so there is a ISW shoaling change vertically.
We apply the PIV technique to the COG pre-stack migrated sections and calculate the flow velocity sections of the internal solitary wave. To verify the correctness of the flow velocity sections, we compare it with the theoretical flow velocity section calculated from the KdV equation. It is found that the two sections are consistent in flow directions, and the PIV result shows the structure of wave induced velocity well. In the PIV calculation results, the average value of the velocity in the horizontal direction is 1.7 m/s, and in the vertical direction is 0.3 m/s. This result is larger than the theory, especially the horizontal velocity. We speculate that the horizontal velocity contains not only the wave induced velocity component of the internal solitary wave but also the phase velocity component.
In summary, we use pre-stack seismic data to observe changes in the thermohaline fine structure during the propagation of internal solitary waves, and find that the waveforms of internal solitary waves vary differently at different depths. We use the PIV technique to calculate the flow velocity section of the internal solitary wave and compare it with the theoretical results. We find that our method is feasible to describe the flow velocity qualitatively, but it needs further improvement in quantitative description. This method has great potential in studying the dynamic evolution of mesoscale or submesoscale ocean processes.