Observation of the Near-seabed Velocity and Particles Resuspension During Nonlinear Internal Solitary Wave Events near the Dongsha Plateau at the Northern South China Sea

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LONG-TERM GOALS

Nonlinear internal solitary waves (ISWs) are thought to be one of the causes of the formation of some of the largest sediment waves over the northern South China Sea and onset of the sediment resuspension events. The long-term scientific goals are to understand the energy dissipation of large amplitude ISWs at the last stage of the trans-basin propagation and the relationship between the energy dissipation of ISWs and particle resuspension.

OBJECTIVES

When nonlinear ISWs reach the continental slope, their energy is dissipated via the bottom friction or internal breaking and the waveform changes. While the energy cascades down to finer scale, the bottom turbulence interaction and/or the dynamic pressure perturbation induced by ISWs cause the resuspension and redistribution of sediment particles and likely form the continuous sediment waves on the seafloor [*Ma et al., 2008* and *Reeder et al.*, 2011]. To our knowledge, there are no direct observations of near-bottom velocity and sediment resuspension during ISW events. The main objectives are to measure the near bottom velocities and observe the thickness of bottom nepheloid layer through a series of observations.

APPROACH

Previous observation techniques include using the surface and subsurface mooring with Conductivity-Temperature-Depth (CTD) sensors and Acoustic Doppler Current Profiler (ADCP) attached, or via shipboard survey which have induced large error on the vertical velocity measurement due to the moving platform. We adopted a sample scheme using a bottom-lander to host a 300 kHz upward looking ADCP for measuring the ISW events from a fixed point on the seafloor. This is to ensure the quality of the velocity measurement. Two cruises are planned for the observation during the perk period of the ISW events. Each cruise will have ~5 days of shiptime. Surveys will be conducted before, during and after the nonlinear ISW events. This project is a collaboration with colleagues of the National Sun Yat-sen University (NSYSU) and National Taiwan University (NTU). The bottom-lander is designed by the Institute of Undersea Technology (IUT) - NSYSU.

WORK COMPLETED

The first ISWs observation cruise has been completed (09/12 ~09/16, 2015) using the Taiwanese Ocean Researcher III (OR3). The bottom-lander with ADCP, temperature and pressure sensors are shown in Figure 1. The sea state was not ideal during this time of season over the South China Sea. Inclement weather made the deployment and recovery via OR3 difficult. We managed to execute the observations as planned.

RESULTS

OR3 Cruise 9/12 – 9/16, 2015

1. The bottom-lander were deployed for 2.5 days (0300 9/13 ~ 1700 9/15) at the water depth of 340 meters. The 300 kHz ADCP measured ~80 m in range with 2-m in vertical resolution. The first bin of the measurement was ~ 6.2 m above seafloor. Three large ISW events were recorded during this period. Preliminary result shows the maximum horizontal velocity along the ISW propagation path at 6.2 m above seafloor of these three large ISWs were 0.72 m/s, 0.65 m/s and 0.67 m/s respectively. The vertical velocity at the same location is also large. This seems too large to be true since it is comparable to the horizontal velocity along the ISW propagation direction (Fig. 2). I will do further analysis to verify and cross check with other ancillary dataset.

2. Shipboard yo-yo CTD cast were conducted during second and third ISW events. The shipboard radar provided the information of the ISW propagation direction. The direction of propagation on the third ISW event is ~ 300°T (Fig. 3). The CTD cast showed the changes of physical properties before, during and after ISW event (Fig. 4). A nepheloid layer of ~ 30 m in thickness near the bottom is shown on the transmissometer measurement (Fig. 4e). The thickness of nepheloid layer does not change as the ISW passed. Since the nepheloid is related to the availability of sediment particles. Previous observation shown the benthic layer near Dongsha region occurred below the depth ~400 m. The bared seafloor might prevent the thickness increases of the nepheloid layer.

IMPACT/APPLICATION

The near bottom velocity is measured for the first time using a bottom-lander with a 300 kHz upward looking ADCP during the ISW events. The experience will help us to plan the next cruise in the spring of 2016. These results are valuable to our effort to determine if the ISWs caused the onset of sediment resuspension and/or maintained the balance of benthic nepheloid layer.

REFERENCES

Ma, B.B., Reeder, D.B., Yang, Y.J., Lou, J.Y. (2008), Observations of internal solitary waves in the South China Sea. Ocean Sciences 2008, Orlando, FL. March.

Reeder, D. B., B. B. Ma, and Y. J. Yang (2011), Very large subaqueous sand dunes on the upper continental slope in the South China Sea generated by episodic, shoaling deep-water internal solitary waves, *Mar Geol*, *279*(1-4), 12-18.

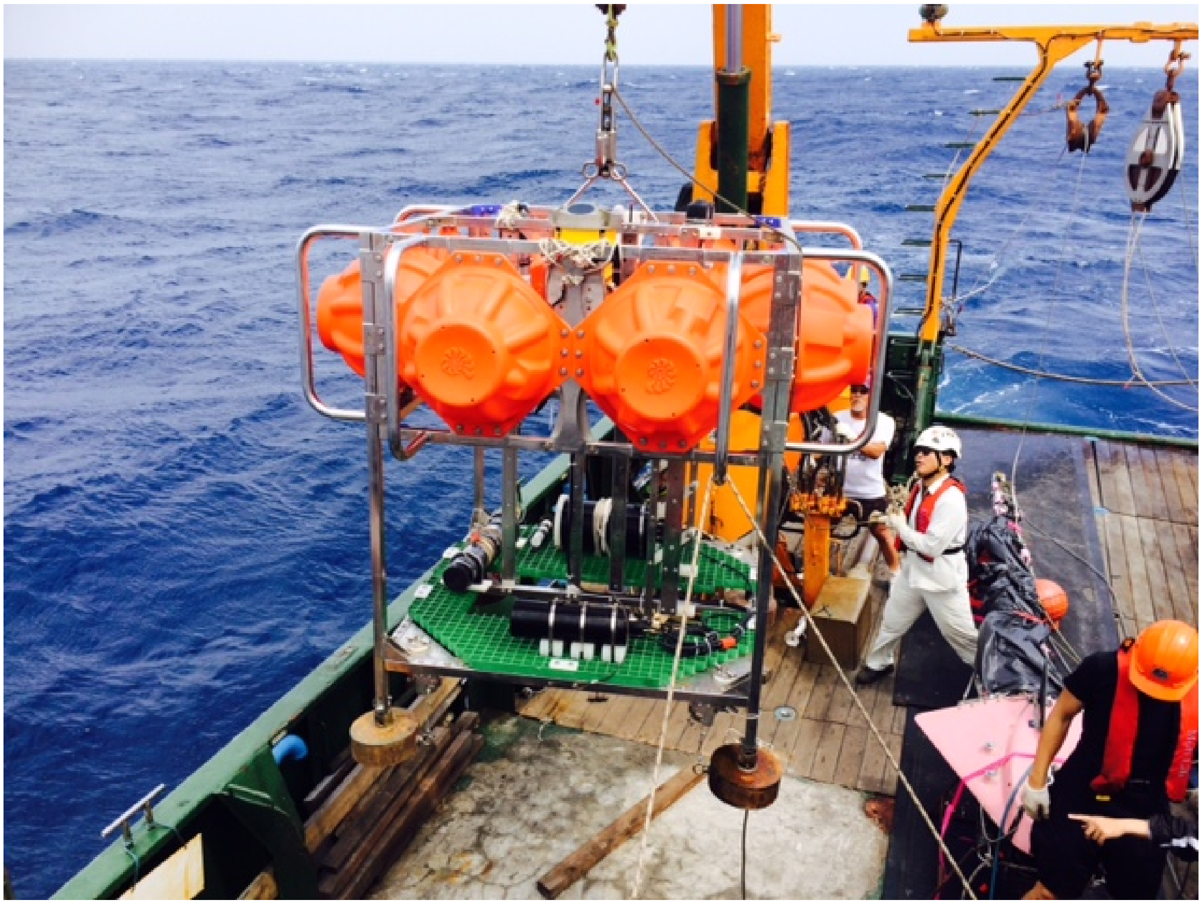

Figure 1. A bottom-lander (BL) platform with a upward looking ADCP attached. The BL is designed by IUT-NSYSU.

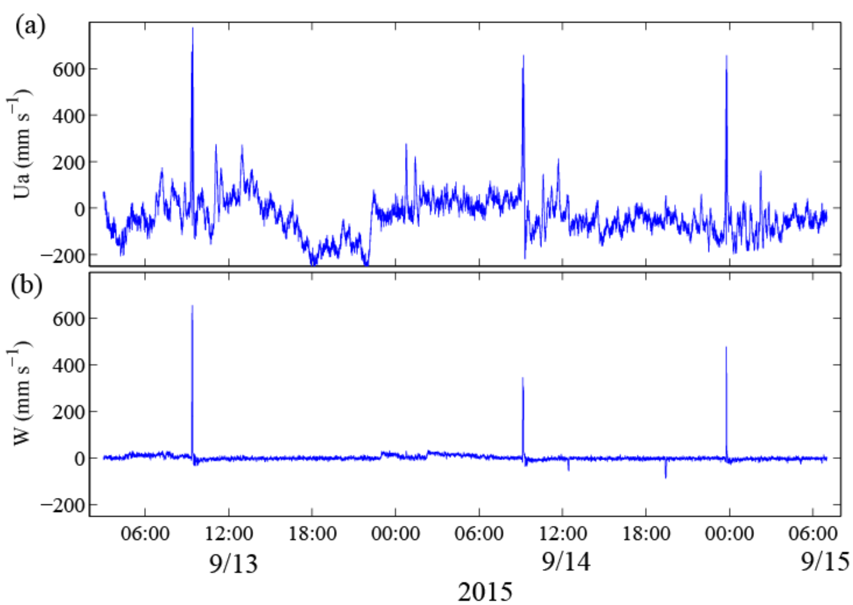

Figure 2. The first bin (6.2 m above seafloor) of 300 kHz ADCP measurement. (a) Horizontal velocity along ISW propagation path (rotated 30 degrees). (b) Vertical velocity.

Figure 3. OR3 shipboard radar recorded the ISW on 09-14-2015 08:23 GMT. The ISW propagation direction is ~300°T.

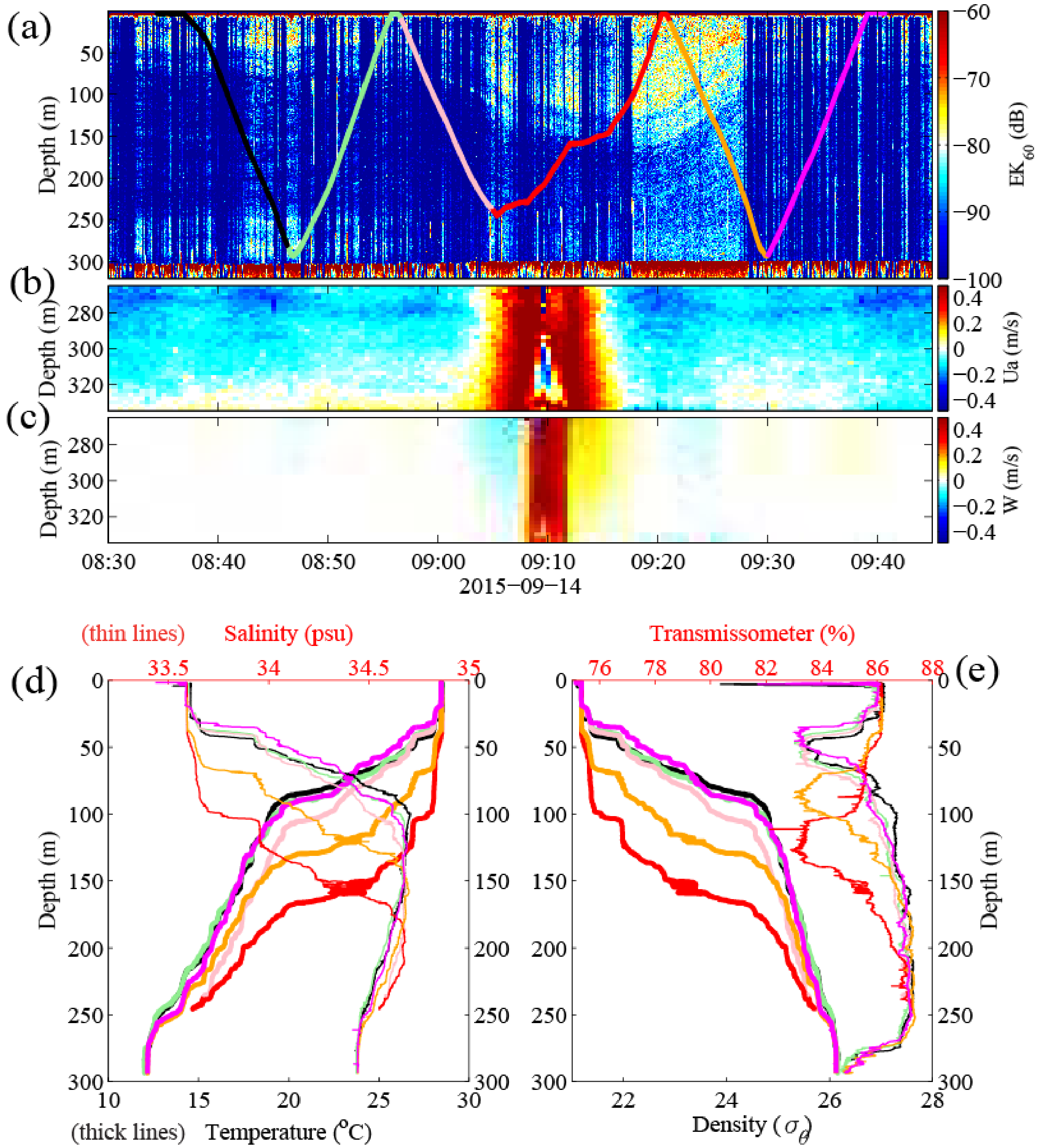

Figure 4. The 09/14, 2015 ISW (same ISW as shown on Fig.3) observed using ADCP on the bottom-lander and shipboard equipment. (a) Shipboard Yo-Yo CTDs cast over the Ek-60 echosounder image. The vertical stripes are due to that the CTD cage was in the water at the same time. (b) Horizontal velocity along ISW propagation path. (c) Vertical velocity. (d) Temperature (think lines) and salinity (thin lines) profiles (color coded as in (a)). (e) Density (think lines) and transmissometer (thin lines) profiles.