A Numerical Study on the Source of Nonlinear Internal Wave (NLIW) in the Luzon Strait

Guan-Yu Chen*, Rei-Jon Wu, Ko-Sien Fu , Ro-Sheng Tseng, Yu-Hwui Wang
Institute of Physical Oceanography, National Sun Yat-Sen University,

Cho-Teng Liu

Institute of Physical Oceanography, National Taiwan University

Abstract

This research discusses the internal wave source, through the Princeton Ocean Model (POM) and a two-dimensional model developed by Lynett and Liu(2002) and modified by Cheng *et al.*(2005). There are two POM simulations, one has bigger grid size of 3.6km for the whole Luzon Strait in the region 118°E ~123°E and 18°N ~22°N, the other has a smaller grid of 1.6km, for 118.5°E ~123°E and 19.5°N ~21.5°N. The total simulation period is 25 days and the east side is driven by tidal calculated from WXTide32 model. Three dimensional flow field during May, 2005, is simulated for temperature, baroclinic velocity distribution, and baroclinic energy flux.

In the field experiment of May 2005, large amplitude NLIWs were observed three times by R/V Ocean Researcher 3 (OR3) at (120.5˚E, 20˚N) during May 9~11. The NLIW on May 9 evolved into a series of solitary wave forms which were observed by Fishery Boat 1 and 2 (FB1&2) at (118.4 ◦ E, 20.5 ◦ N) and (119.5 ◦ E, 20.5 ◦ N), respectively. In this numerical simulation, when the baroclinic velocity of the layer near pycnocline is high, NLIWs are observed. At the same time, no NLIWs were observed by R/V Fishery Researcher 1 (FR1). Both the numerical simulations and the EOF analysis of the temperature profile show that the corresponding baroclinic modes are quite diverse at FR1 while in the west of Heng-Chun Ridge only the first baroclinic mode is significant. Changes in stratification do not affect the results. We concluded that in spring tide period, tidal motion dominates the generation of NLIW and Kuroshio is unimportant.

The POM simulation suggests there are more than one source for NLIW in the Luzon Strait. We want to describe how different wave arcs merge into a long wave crest based on a two-dimensional model developed by Lynett and Liu(2002) and modified by Cheng *et al.*(2005). Laterally, internal waves can become very wide when it is far away from its origin. The extra energy can be explained by nonlinear wave-wave interaction because the energy of large amplitude internal wave increases after interacting with smaller internal waves. The present study show how two wave

fronts of separate origin interact with each other. When one is significantly larger than the other, the energy is transfered from the smaller wave to the larger wave. This explains why a wave from a small region does not attenuate after propagating for a long distance.

For simplicity, Lynett and Liu's original code uses a fixed upper (mixed) layer thickness and the incident wave profile is set to be of hyperbolic-secant-square profile. These simplifications, however, limit the applicability of the numerical model. Some researchers suggested that this model cannot predict the propagation of internal wave correctly (e.g. Ramp et al. 2004); this problem can be partly attributed to the simplification of constant mixed layer thickness. In order to improve the accuracy of simulation, mixed-layer thickness is allowed to change from place to place. Initial conditions are also modified so that wave forms of non-hyperbolic -secant functions and wave fronts taken by satellite can be used.

References

Chao S-Y, D-S Ko, R-C Lien, P-T Shaw (2006), Assessing the West Ridge of Luzon Strait as an Internal Wave Mediator, submitted to J. Oceanogr.

Chao Shenn-Yu, Ping-Tung Shaw, Ming-Kuang Hsu, and Ying-Jang Yang (2006), Reflection and Diffraction of Internal Solitary Waves by a Circular Island, submitted to J. Oceanogr.

Cheng, M.H., J.R.C. Hsu and C.Y. Chen, 2005: Numerical model for internal solitary wave evolution on impermeable variable seabed, Proc. 27th Ocean Eng. Conf. in Taiwan, pp. 355-359.

LIU C.-T., R. PINKEL, M.-K. HSU, J. M. KLYMAK, H.-W. CHEN, C. VILLANOY, Nonlinear Internal Waves From the Luzon Strait, Eos, Vol. 87, No. 42, 17 October 2006, PAGES 449-451

Lynett, P. J. and P. L.-F. Liu, 2002, A two-dimensional, depth-integrated model for internal wave propagation over variable bathymetry, Wave Motion, vol. 36(3), 221-240.

Munroe JR, Lamb KG (2005): Topographic amplitude dependence of internal wave generation by tidal forcing over idealized three-dimensional topography, J. Geophys. Res.-Oceans 110 (C2): Art. No. C02001.

Ramp, S.R., T. Y. Tang, T. F. Duda, J.F. Lynch (2004): Internal Solitons in the Northeastern South China Sea, IEEE J. Ocean Eng., 29, 1157-1181.

Yang Y.-J., T. Y. Tang, M. H. Chang, A. K. Liu, M.-K. Hsu, and S. R. Ramp (2004): Solitons Northeast of Tung-Sha Island During the ASIAEX Pilot Studies, IEEE J. Ocean Eng., 29, 1182-1199.