Improvement of a Nonlinear Internal Wave Tactical Decision Aid

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LONG-TERM GOALS

The long term goal of the project is to develop a prediction methodology for the geographic location of nonlinear internal waves that can be used as the basis for a future Tactical Decision Aid.

OBJECTIVES

The principal objective is to identify the inputs and establish a procedure that can serve as the basis for the prediction of nonlinear internal wave occurrences.

APPROACH

The effort makes use of the internal wave signatures recorded in satellite imagery and a parameterized model function, to estimate a two dimensional phase speed field over the geographic region of interest. The phase speeds are in turn used to calculate the internal wave propagation times, where contours of propagation time represent the internal wave locations for a particular time since generation. The parameters of the model function are found by minimizing the difference between the calculated propagation times and the observed propagation times for the waves in the georeferenced satellite imagery. The current effort is focused on improving the model by examining fortnightly and seasonal variations as well as the effects of the barotropic tidal currents. The initial work is dedicated to the northern portion of the South China Sea between the Luzon Strait and the Chinese coast near Honk Kong, but the approach has been used in other regions including the Sulu Sea, Celebes Sea and Andaman Sea.

WORK COMPLETED

An empirical prediction methodology has been developed and has been applied to the solitons originating in the Luzon Strait and propagating across South China Sea as well as the solitons in the Sulu and Celebes Seas. The prediction tool was used to support cruises in the South China Sea in April/May 2007 and again in August 2008. A prediction capability (based on the same methodology) was developed for the Sulu Sea and used to support the March 2009 PhilEx cruise that traversed the central Sulu Sea. For the Sulu Sea, the pre-cruise prediction parameters were updated with information from near real time SAR imagery to improve the prediction times.

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Analysis has continued on both in situ and remote sensing imagery from 2006 and 2007 to get a better understanding of the generation trigger in the South China Sea. Work continues on improving the performance of the prediction capability, focusing on the fortnightly cycle which appears to have the largest variance in the results. One area being investigated is how to incorporate the effects of the barotropic tidal currents on the internal wavefront velocity.

RESULTS

The method was applied to the internal solitary waves in the northern portion of the South China Sea west of the Luzon Strait. The model wavefronts locations have been found to be in good agreement with the shape, orientation, location and spacing of the wave signatures observed in the satellite imagery (Figure 1). Propagation time estimates based on the model have errors of ± 1.32 hours (1σ) for depths greater than 1000 meters and ± 2.55 hours (1σ) for all depths over which the waves are observed (Figure 2). For internal waves in the Sulu Sea observed during the during the PhilEx cruise in March 2009, the revised predictions were with in 1 hour of the observed wave arrival times.

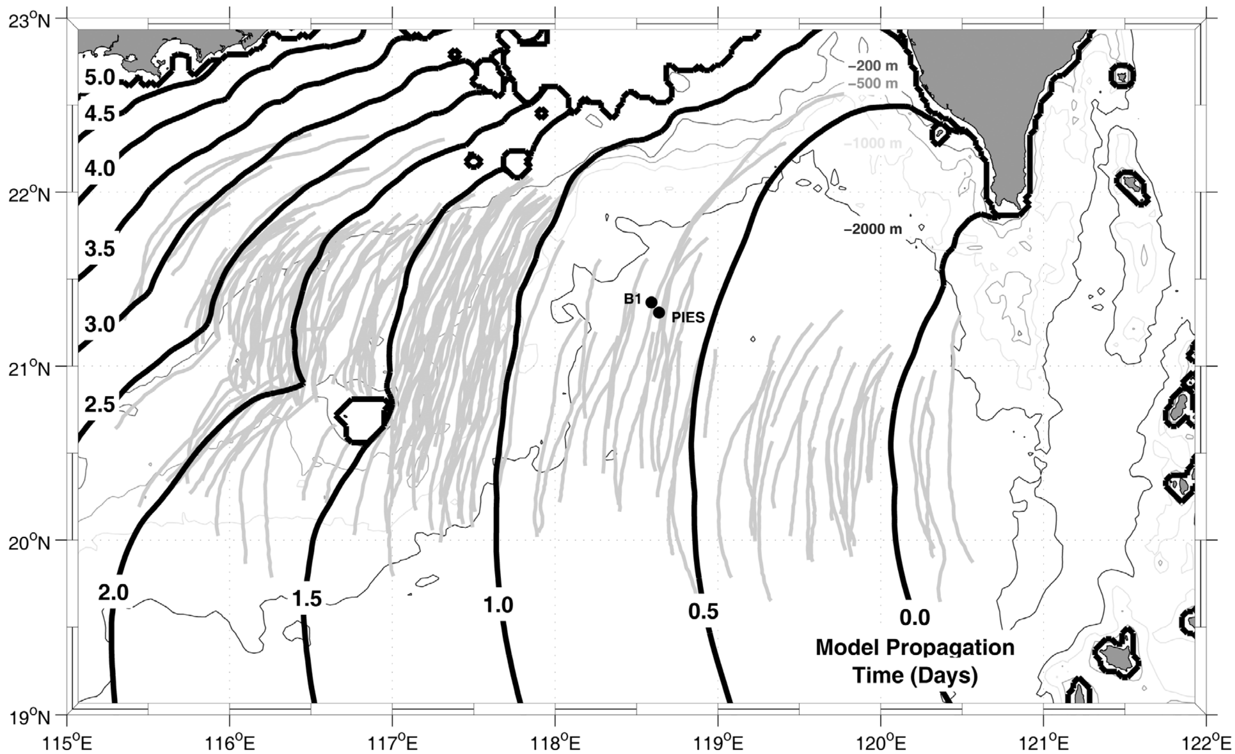

Figure 1. Internal wave signatures in the South China Sea from satellite imagery (gray) with the wavefront locations from the empirical model (black). The figure shows 141 internal wave signatures from 73 satellite images acquired on 61 days between April 2003 through December 2006. B1 and PIES are mooring locations from 2005.

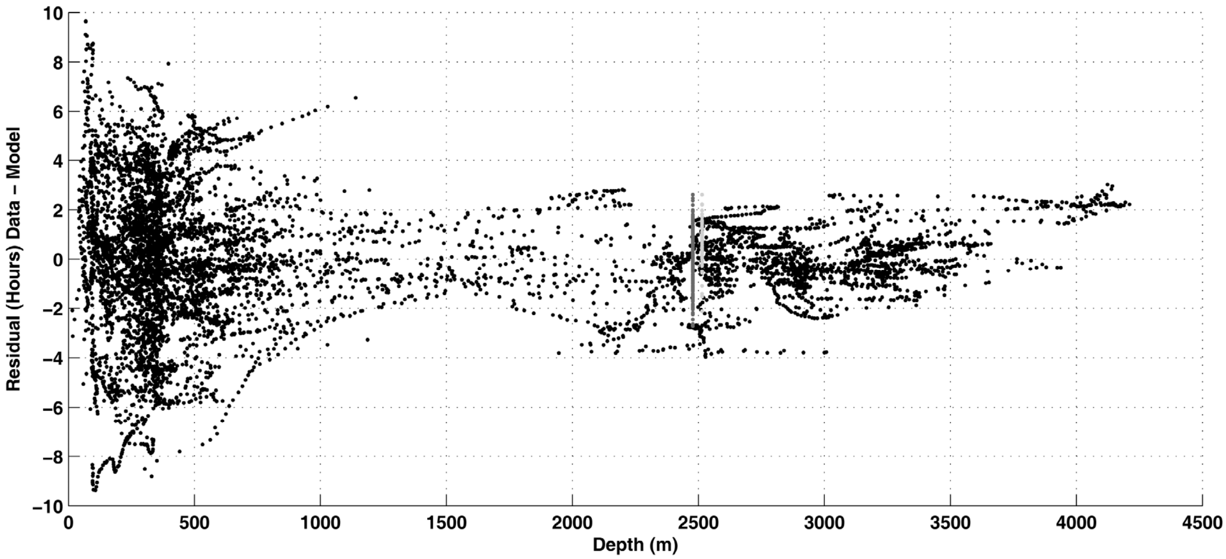

Figure 2. Propagation time residuals (observations minus model) as a function of depth for the internal waves signatures presented in Figure 1. Vertical gray lines are wave observations from moorings B1 (dark) and P1 (light)

IMPACT/APPLICATIONS

An empirical model for estimating the geographic location of nonlinear internal wavefronts from remote sensing imagery has been developed. The model has been generally conceived and can be readily adapted to other regions, requiring only the latitude and longitude positions of internal waves, some understanding of when wave generation occurs and a parameterized function relating geographic location to internal wave velocity. The parameters can be solved for globally (as for the South China Sea) or for specific time period that represent a particular set of conditions. By knowing the time and location of internal wave generation along with a time travel map for a region, it is then possible to establish a predictive capability and serve as the basis of an internal wave tactical decision aid.

RELATED PROJECTS

The PI is the author of the 2nd Edition of the *Atlas of Internal Solitary like Waves and Their Properties* (March 2004). The purpose of the Atlas is to document the various locations and manifestations of internal waves around the world. The Atlas contains 54 case studies of wave occurrences (approximately 550 pages). A copy of the Atlas is maintained on the web at www.internalwaveatlas.com and CD copies are also readily available.

PUBLICATIONS

Jackson, C. R. 2009 "An Empirical Model for Estimating the Geographic Location of Nonlinear Internal Solitary Waves". Journal of Atmospheric and Oceanic Technology, Vol. 26, No. 10. pages 2243–2255