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# **STRONG INTERNAL SOLITONS ON THE CONTINENTAL SHELF: A COMPARATIVE THEORETICAL AND OBSERVATIONAL STUDY**

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## **LONG TERM GOALS**

To develop an improved theoretical framework for internal waves that takes into account the strength of forcing, the depth and strength of the pycnocline, the influence of upwelling and current shear, etc. by means of strongly interacting theoretical and observational analyses.

## **SCIENTIFIC OBJECTIVES**

The overall scientific objective of this work is to improve present theory of tidally-forced internal waves and to document and explain their structure and evolution in the coastal zone.

## **APPROACH**

- 1) To test existing and proposed IW theories against the radar data set and in-situ data collected during the Coastal Ocean Probing Experiment (COPE).
- 2) To adjust the theoretical descriptions of IWs so that they are in better agreement with observations.
- 3) To use newly-formulated IW theories to suggest new observational approaches to improve our understanding of IWs in the coastal zone.

## **WORK COMPLETED**

A comprehensive analysis was completed on shore-based radar and in-situ data from FLIP that were collected during COPE. Three separate events were analyzed and the results submitted to JGR - Oceans (Kropfli, et al., 1997). An electronic representation of the temporal evolution of IWs observed by the ETL radars over a tidal cycle was made available to ONR over the Internet.

## **RESULTS**

Simultaneous and coincident observations of radar backscatter cross-section and in-situ observations of ocean current and temperature profiles were made during COPE during the passage of tidally-forced IWs. Exceptionally nonlinear, tidally generated trains on IWs, often in the form of a series of solitary pulses-internal solitons were observed, that sometimes reached the

amplitude of over 25 m in isotherm depressions on the background of 5-7 m deep pycnocline. A commonly used Korteweg-de Vries equation is inapplicable in these situations. We suggested modified evolution equations which include the higher-order nonlinearities and give much better agreement with the observational data. A more detailed modeling of the evolution of a broad initial impulse into a group of solitons based on these modified equations has been started. In all cases of COPE data that were analyzed, maximum radar cross-sections were found not over the region of highest strain rate, as expected, but *between* the thermocline depressions/current maxima caused by the IWs. Minimum radar cross-sections were found directly over the thermocline depressions, which in the strongest cases exceeded 25 m. Observed radar signatures of IWs had characteristics of alternating bands of strongly approaching and weakly approaching (or possibly receding) surface waves having non-Bragg-like and Bragg-like characteristics respectively. Two competing theories were used to explain the observations but the data were insufficient to validate one over the other. Suggestions have been made for future experiments directed toward the initiation of IWs in the coastal zone.

### **IMPACT/APPLICATION**

The COPE data set is probably the only one in existence in which the detailed microwave scattering and emission characteristics were made simultaneously and coincidentally with current and density profiles as IWs propagated through the measurement area. Also, large-scale radar observations over a tidal cycle made during COPE show for the first time the temporal and spatial evolution of tidally-forced IWs. (SAR imagery or images made from aircraft are only for a brief period of time and cannot be used to show the continuous evolution of IWs.) The analysis performed to date and the analyses we expect to complete should go a long way in improving our knowledge of internal waves and the impact they have on the coastal zone.

### **TRANSITIONS**

The first analyses of COPE data have just been submitted for publication in JGR-Oceans (Kropfli, et al., 1997) and thus it is premature to have had an impact on the scientific community. These results will also be presented at the upcoming URSI meeting in Boulder (January, 1998) and at the February '98 Ocean Sciences Meeting.

### **REFERENCES**

1. R. Kropfli, L. Ostrovsky, T. Stanton, E. Skirta, A. Keane, and V. Irisov, 1997: Relationships between strong internal waves in the coastal zone and their radar and radiometric signatures. Submitted to *J. Geophys. Res.*
2. T. Stanton and L. Ostrovsky. Observations of Very Strong Internal Solitons in the Oceanic Shelf: from Inside and from Above. In preparation.