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Tracer Studies of Mixing in Stratified Coastal Waters

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Abstract

This grant was supported by the Physical Oceanography Program in the Processes and Prediction Division of the Ocean, Atmosphere and Space Department of ONR. The objectives were to inject dye plumes in the coastal ocean as part of the multi-PI Coastal Mixing and Optics Experiment (CMO) south of New England and observe the dye dispersal in a quantitative manner, and to measure micro-scale temperature fluctuations from a towed platform for comparison with microstructure expectations developed from the dye behavior.

Three trips offshore on the *R/V Oceanus* were conducted in September 1995, September 1996 and August 1997. Five dye injection and mapping studies were completed and bounds for the cross-isopycnal turbulent diffusivity coefficient were obtained for each. A new towed microstructure system yielded useful data. The project involved a few technical accomplishments which enabled the scientific studies: Two dye-measurement tow vehicles were designed, built and used at sea; power distribution and data acquisition hardware and software systems within the tow vehicle were designed and built; shipboard computer systems were integrated to enable real-time dye mapping.

Results

It was determined that mixing of heat and salt across surfaces of constant density was very small in the summertime on the southern New England continental shelf. Dye was injected five times. Each dye patch was mapped two or three times over a five day period. The vertical and horizontal growth rates of the patch provided direct estimates of the turbulent diffusion rate within the water column. Ancillary measurements of environmental conditions were made during the dye experiments to allow interpretation of the results. These include wind, vertical current structure, and vertical density gradient. The vertical diffusivity of heat, computed directly from observed spreading of the dye particles under the typical assumption that turbulent diffusion rates of heat and dye are equal, ranged from 40 to 100 times the rate of molecular heat diffusivity. Lateral diffusion of dye was a factor of ten or so greater than anticipated by existing theoretical arguments, and possible explanations were developed during the course of this project.

The microstructure data, in conjunction with the established Osborn-Cox heat flux model, provided near-bottom estimates that agreed with the multi-day averaged dye results. The microstructure signals provided vertical structures of diffusion rate, a level of detail which may prove complementary to dye-derived estimates in these and future studies. Microstructure signals above the bottom boundary area gave a higher mean diffusivity than the dye experiments, and suggested a reduction of diffusivity for increased density gradients.

Under this grant the PI's attended Coastal Mixing and Optics Experiment meetings in Cambridge, MA (1995), San Diego, CA (1996), Santa Fe, NM (1997) and Keystone CO (1998) and presented results, as well as 1998 and 2000 AGU Ocean Sciences meetings.

Publications

Rehmann, C. R., and T. F. Duda, Diapycnal diffusivity inferred from scalar microstructure measurements near the New England shelf/slope front, *J. Phys. Oceanogr.,* in press, June 2000.

Sundermeyer, M. A. and J. R. Ledwell, Lateral dispersion over the continental shelf: Analysis of dye-release experiments, *J. Geophys. Res.*, Submitted, 2000.

James R. Ledwell, Timothy F. Duda, Miles A. Sundermeyer, Dye studies of diapycnal diffusivity on the continental shelf, in preparation for submission to *J. Geophys. Res.*, 2000.

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