

Demonstration Of A Relocatable Regional Ocean Atmosphere Modeling System with Coastal Autonomous Sampling Networks: Turbulence Characterization from an AUV

Edward R. Levine
Naval Undersea Warfare Center, Division Newport
Code 8211
Newport, RI 02841-1708
phone: (401) 832-4772 fax: (401) 832-2146 email: levineer@tech.npt.nuwc.navy.mil
Award #: N0001499WX30276, N0001499WX30275, N0001499WX30429
<http://marine.rutgers.edu/MAS>

LONG-TERM GOAL

My long term goal is to utilize turbulence measurements obtained from small Autonomous Underwater Vehicle (AUV) based sensors as the subgrid characterization tool in combined coastal ocean observation/prediction networks.

OBJECTIVES

I wish to use AUV-based turbulence measurements to quantify mixing in shallow water physical process studies (upwelling regions, fronts, boundary layers) within the context of the LEO-15 based National Ocean Partnership Program (NOPP) coupled ocean observation/modeling system. This includes estimating mixing levels, identifying regions of enhanced mixing, determining the horizontal spatial scale of mixing events, defining the role of boundary layers, and parameterizing results for coastal predictive model testing studies of subgrid scale processes.

APPROACH

My approach is to integrate an optimum turbulence sensor suite into a small, logistically simple, AUV, and establish this small AUV as a viable platform for coastal turbulence research. Towards this end, I obtain horizontal profiles of dissipation rate, temperature microstructure, 3-dimensional small scale velocity, finescale vertical shear of horizontal current, and stratification in the coastal environment. The sensors provided data for estimates of eddy diffusivity profile (Gargett and Moum (1995), eddy viscosity profile (using the truncated TKE equation), Richardson numbers, and fluxes [using the correlation technique].

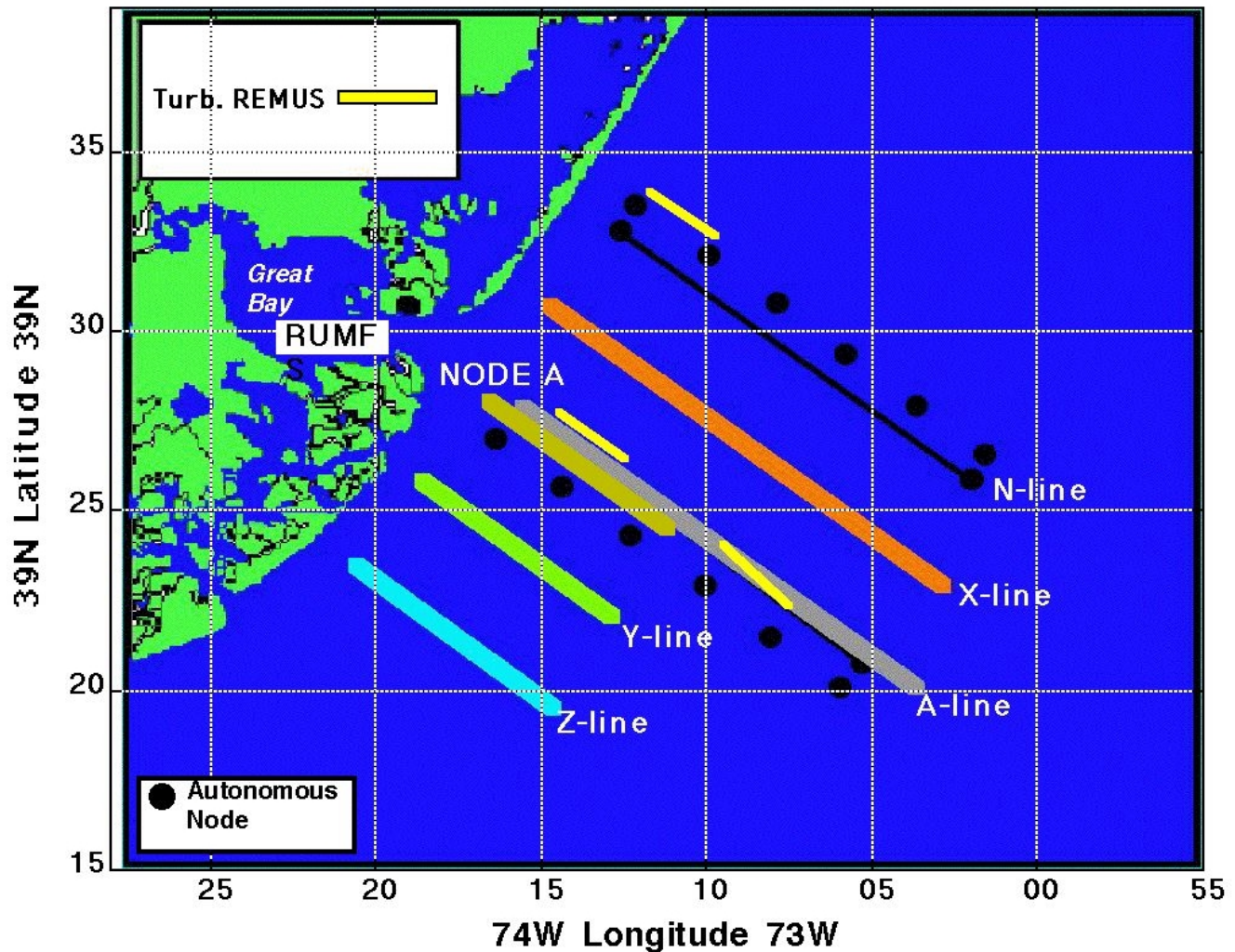
Subsequently, I studied mixing in the context of the multi-scale measurements surrounding the NOPP LEO-15 node site in the Mid-Atlantic Bight. I sampled adaptively using the Rutgers University continental shelf model SCRUM (Song and Haidvogel, 1994). These data enable us to evaluate turbulence closure schemes associated with subgrid mixing processes as parameterized by different boundary layer submodels in SCRUM, the coastal circulation model

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WORK COMPLETED

A turbulence sensor package was electrically and mechanically integrated into the REMUS AUV (Levine and Lueck, 1999). Sensors include two shear probes, an ultra-fast thermistor, an upward and downward looking ADCP, two CTDs, and an ADV-O.

Utilizing these techniques, scientific studies of the Ocean Boundary Layer (OBL) during an upwelling event were conducted near the Rutgers University LEO-15 site on the inner continental shelf off New Jersey during July 1999 (Fig. 1). In the field experiment, high quality data were obtained from all sensors, and data analysis is proceeding well.



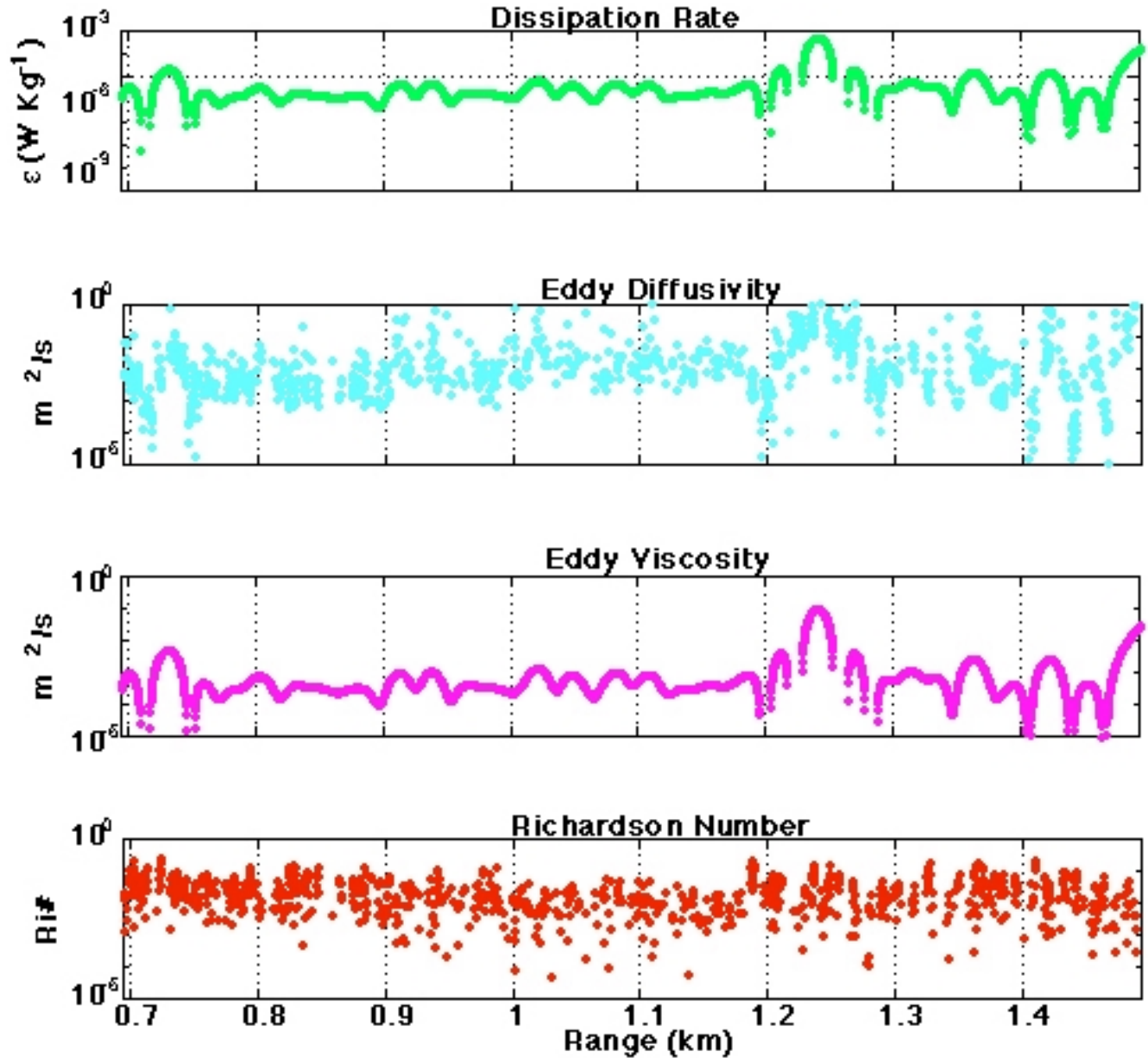
1. AUV trajectories in upwelling region

RESULTS

Using SCRUM model-based adaptive sampling, the AUV was deployed, during July 1999, along a trajectory through components of the Leo-15 upwelling region, including the upstream “pipe” and detached jet. These measurements were made synoptically with those from other platforms which

characterize larger scale structures on the nearby continental shelf. Model predictions which include assimilated data from the wide variety of sampling platforms is also available for comparison.

We ran a total of eleven missions in the upstream pipe (N line, inshore), the downstream pipe (A line, inshore) and the detached jet (A line offshore), at a variety of depths in the core of the features, and in the top and bottom layers. During the course of the experiment, approximately 400 megapoints of high quality turbulence data were obtained. An example of the upstream “pipe” turbulence estimation is shown in Fig 2. For a 7 m depth transit, time series of mixing parameter estimates primarily show dissipation rates of 10^{-7} to $10^{-5} \text{ W kg}^{-1}$, eddy diffusivities of 10^{-4} to $10^{-1} \text{ m}^2 \text{ s}^{-1}$, eddy viscosities of 10^{-5} to $10^{-2} \text{ m}^2 \text{ s}^{-1}$, and Richardson numbers of 10^{-3} to 10^{-1} .



2. Mixing parameters in upstream “pipe”

For the final model prediction cycle, our estimated eddy viscosity in the upstream pipe was utilized as the inshore maximum value for the SCRUM sub-grid scale parameterization. Subsequent to the experiment, 2-D diagnostic runs of the model (S. Durski, personal communication) show that the data-derived eddy viscosity, and variation around its value can significantly affect the onset and character of the upwelling.

IMPACT/APPLICATION

The AUV-based turbulence measurements provide a unique horizontal profiling view of the variability of the mixing environment that cannot be obtained by more conventionally sampling measurements, and this approach can be further exploited in yo-yoed horizontal sections. These techniques will be invaluable in upwelling process studies in which competing turbulence closure model alternatives are testing in SCRUM to parameterize subgrid processes. Competing OBL alternatives include those of Mellor-Yamada (1974) Large et al. (1994), and Price et al. (1986). Features such as the evolution of the upwelling front can be tested.

TRANSITIONS

Our AUV sensor technologies, hardware and software, are being considered for inclusion as tactical oceanography payloads for the Manta UUV Initiative.

RELATED PROJECTS

Previous studies with the Rutgers group were conducted in 1998-99 under separate NOPP support. My AUV-based turbulence measurement system has been utilized in NOPP studies with the Harvard led LOOPS project, in Cape Cod Bay in September 1998. The system is also being utilized in NOPP FRONT studies on the New England continental shelf during 1999-2001.

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