

Velcro Measurements of Turbulence in Coastal Oceans

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LONG-TERM GOAL:

Significant turbulent transports within coastal oceans have been shown to be highly sporadic in both time and space, challenging present ship-based, labour-intensive turbulence measurement techniques. My long-term goal is to lower the cost and effort required to find those locations which dominate coastal mixing, to describe their time evolution, and to quantify their effects. The ultimate objective is an automated system, operating without ship support and returning data via local radio (cell-phone) networks.

SCIENTIFIC OBJECTIVES:

The goal of this project is to develop survey tools - instrumentation and analysis techniques - which will produce 2-dimensional fields of important turbulent quantities simultaneously with the mean shear and density fields which generate them. Such survey tools will be essential if we are first to find the 'hot spots' of coastal ocean turbulence (allowing more expensive techniques to be concentrated in the most important areas) and then to provide an adequate description of turbulent flow evolution over the enormous range of temporal scales which are relevant to coastal oceans, from the semi-diurnal tidal period through annual and interannual variations in buoyancy forcing.

APPROACH:

My approach has been to modify a standard acoustic Doppler current profiler (rotating one beam to vertical) to measure directly the field of vertical velocity (w) in highly energetic coastal mixing flows. An unambiguous measure of w then allows estimation of turbulence properties from measurement of the largest energy-containing eddies (rather than the smallest microscales), an approach which offers the potential of 2-dimensional mapping of turbulence properties.

WORK COMPLETED:

A 'Velcro' estimate of turbulent kinetic energy dissipation rate M has been refined and calibrated against more standard measures. A manuscript (Gargett 1997) has been submitted for publication as part of the forthcoming special issue of JTech which originated in the fall 1996 ONR-sponsored meeting on ocean turbulence sensors and techniques.

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Results:

I have developed an algorithm for estimating turbulent kinetic energy dissipation rate M from data obtained in coastal tidal fronts using DOT, a specialized acoustic Doppler profiler (Gargett 1994). This algorithm has been successfully ‘ground-truthed’ against standard microprofiler measurements of M , and used to provide unparalleled resolution of the dissipative structure of tidal fronts. Figure 1 illustrates both a sample DOT-derived field of $\log M$ (colour-coded), and the enormous degree by which standard microprofilers undersample such strong and complex flows.

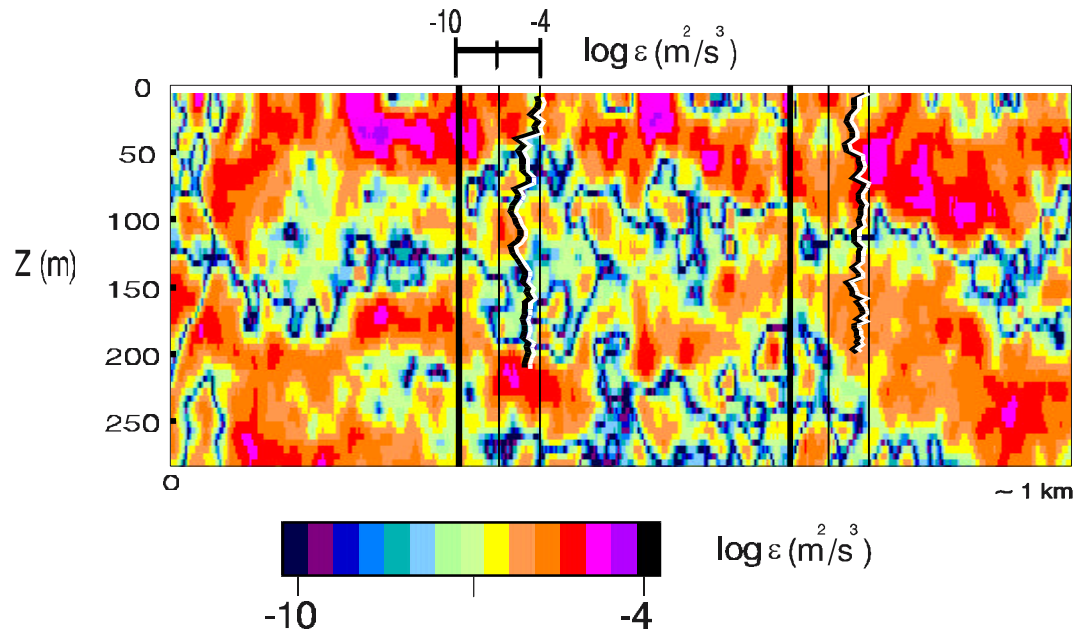


Figure 1: This color-coded two-dimensional field of (the logarithm of) turbulent kinetic energy dissipation rate M is obtained from measurement of the vertical velocity associated with the large eddies of a turbulent tidal front (Gargett 1997). It is clear that microprofiler measurements of $\log M$ (taken as fast as possible, at the locations of the heavy vertical lines) are totally inadequate to describe the dissipative structure in flows of such strength and complexity.

IMPACT/APPLICATIONS:

This research has demonstrated that microscale profilers cannot be operated fast/frequently enough to do an adequate job of sampling strong coastal mixing flows, much less survey for the location/timing of such flows. These inadequacies are addressed by the system developed in this research. Such a survey tool has an essential part to play in the measurement of turbulence in coastal regimes, although further platform development is necessary to transition this tool to exposed coastal environments. The robust nature of the sensors and the low (relative to microprofilers) data rate make this a very promising technique for AUV applications.

TRANSITIONS:

not yet

RELATED PROJECTS:

1. The DOT system will be used in Sept/Oct 1998 as part of a joint project (with M. Gregg of APL U Wash) to study the generation and evolution of density-driven intrusions entering Puget Sound over its seaward sill. Results will allow examination of the Velcro approach to estimation of M in a very different turbulent flow, moreover one of great relevance to the deep ocean as well as coastal silled inlets.
2. I am working with J. Moum of OSU to investigate the relationships among various vertical length scales associated with stratified turbulence. During a past cruise, the OSU microprofiler was used to measure Thorpe (overturning) scale LT and Ozmidov scale LO , while the DOT system determined the large-eddy vertical length scale LV - we will attempt to discover whether and how these scales are related across the variety of Reynolds and Richardson numbers encountered in the field.

REFERENCES:

- Gargett, A.E. 1994: Observing turbulence with a modified acoustic Doppler current profiler. *J. Atmosph. Oceanic Tech.*, **11**(6), 1592-1610.
- Gargett, A. E. 1997. Velcro measurement of ocean turbulence. Submitted to *J. Atmosph. Oceanic Tech.*