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Review

Observational and numerical modeling methods for quantifying coastal ocean turbulence and mixing

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Abstract

In this review paper, state-of-the-art observational and numerical modeling methods for small scale turbulence and mixing with applications to coastal oceans are presented in one context. Unresolved dynamics and remaining problems of field observations and numerical simulations are reviewed on the basis of the approach that modern process-oriented studies should be based on both observations and models. First of all, the basic dynamics of surface and bottom boundary layers as well as intermediate stratified regimes including the interaction of turbulence and internal waves are briefly discussed. Then, an overview is given on just established or recently emerging mechanical, acoustic and optical observational techniques. Microstructure shear probes although developed already in the 1970s have only recently become reliable commercial products. Specifically under surface waves turbulence measurements are difficult due to the necessary decomposition of waves and turbulence. The methods to apply Acoustic Doppler Current Profilers (ADCPs) for estimations of Reynolds stresses, turbulence kinetic energy and dissipation rates are under further development. Finally, applications of well-established turbulence resolving particle image velocimetry (PIV) to the dynamics of the bottom boundary layer are presented. As counterpart to the field methods the state-of-the-art in numerical modeling in coastal seas is presented. This includes the

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application of the Large Eddy Simulation (LES) method to shallow water Langmuir Circulation (LC) and to stratified flow over a topographic obstacle. Furthermore, statistical turbulence closure methods as well as empirical turbulence parameterizations and their applicability to coastal ocean turbulence and mixing are discussed. Specific problems related to the combined wave–current bottom boundary layer are discussed. Finally, two coastal modeling sensitivity studies are presented as applications, a two-dimensional study of upwelling and downwelling and a three-dimensional study for a marginal sea scenario (Baltic Sea). It is concluded that the discussed methods need further refinements specifically to account for the complex dynamics associated with the presence of surface and internal waves.

Keywords: Coastal oceanography; Turbulent fluxes; Micro-structure measurements; Acoustic turbulence measurements; Turbulence modeling; Shelf sea modeling

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