Geophysical Research Abstracts,
Vol. 11, EGU2009-10987, 2009
EGU General Assembly 2009

Near-bed Turbulence in the Bottom Boundary Layer of the Coastal Ocean

E. E. Hackett (1), L. Luznik (2), A. Nayak (3), J. Katz (3), and T. R. Osborn (1)

(1) Johns Hopkins University, Department of Earth and Planetary Sciences, Baltimore, MD, USA, (2) United States Naval Academy, Department of Mechanical Engineering, Annapolis, MD, USA, (3) Johns Hopkins University, Department of Mechanical Engineering, Baltimore, MD, USA

A submersible Particle Image Velocimetry (PIV) system, along with a series of other sensors, such as an Acoustic Doppler Velocimeter (ADV), CTD, and pressure transducers, are used to perform measurements in the combined surface wave-current bottom boundary layer of the coastal ocean. Recent experiments were conducted on the Atlantic continental shelf near the LEO-15 research site located offshore of New Jersey in August 2008. Data was acquired at the seabed up to 27 cm above it in 20 m deep water. PIV data consists of time series of two-dimensional, streamwise and bed-normal, spatial distributions of two components of velocity. Data analysis focuses on two hour-long data sets that were acquired consecutively, over which period the tidal current reached its maximum value. In the first set, the amplitude of wave orbital velocity is approximately twice the tidal current, and in the second, they are approximately equal in magnitude. These unique high-resolution measurements enable investigation of the turbulence characteristics in the sub-log region of the boundary layer. The complex dynamics in this region include the wave boundary layer, wave-bottom interactions, roughness effects due to ripples and bioturbation, and the transitional region (buffer region) just below the log law region of the boundary layer. Velocity profiles show a log region in the upper part of the two-dimensional cross-section and evidence of a wave boundary layer at the lowest elevations resolved. Energetic wave-induced motions prevent direct calculation of stresses. Since the wave orbital velocities are much larger than turbulence fluctuations, even a small coordinate system misalignment results in wave contaminated covariance estimates. Consequently, an adaptive filtering technique is applied, which minimizes the impact of wave-induced motion (Shaw and Trowbridge, 2001, J. Atmos. Oceanic Technol., 18, 1540-1557). The technique requires use of two sensors spatially separated such that the wave motion is coherent between the two locations and the turbulence is not. In addition, the technique assumes that cross-correlations between the turbulence and waves are zero. Using the ADV and PIV data, Reynolds stress profiles are calculated. Reynolds shear stresses reach maximum values in the buffer region. Stress estimates within the wave boundary layer are not possible with this technique due to strong interactions between the waves and turbulence; at least part of the turbulence generated in this region is a result of wave interaction with bottom topography. Furthermore, additional complications arise from phase lags between data acquired within and outside the wave boundary layer. PIV data enables the direct calculation of spatial gradients in the two-dimensional cross section. The continuity equation is used to obtain direct estimates of the cross-stream gradients of cross-stream velocity. Dissipation rate estimates are computed as a function of elevation, where remaining out-of-plane gradients are assumed to be averages of measured in-plane gradients. Dissipation rates are approximately constant in the log region, and increase rapidly below it. Shear production of turbulent kinetic energy is computed as a function of elevation and compared with the dissipation rate estimates. Hilbert transforms of spatially averaged PIV data, to reduce effects of turbulence, are used to compute wave phase, and phase-averaged turbulence statistics are computed. At the lowest elevations, variability of the dissipation rate with phase is observed.