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Breaking waves, turbulence and bubbles

Johannes Gemmrich (1), Svein Vagle (2), and Jim Thomson (3)

(1) University of Victoria, Physics & Astronomy, Victoria, Canada (gemmrich@uvic.ca), (2) Fisheries & Oceans Canada, (3) Applied Physics Laboratory, Seattle

The air-sea fluxes of heat, momentum, and gases are to a large extent affected by wave-induced turbulence in the near-surface ocean layer, and are generally increased over the fluxes in a law-of-the-wall type boundary layer. However, air-bubbles generated during the wave breaking process may affect the density stratification and in turn reduce turbulence intensity in the near-surface layer.
The turbulence field beneath surface waves is rather complex and provides great challenges for detailed observations. We obtained high resolution near-surface velocity profiles, bubble cloud measurements and video recordings of the breaking activity in a coastal strait. Conditions ranged from moderate to strong wind forcing with wind speed ranging from 5 m/s to 20 m/s.
Estimates of the dissipation rates of turbulence kinetic energy are calculated from the in-situ velocity measurements. We find dissipation rates, fluctuating by more than two orders of magnitude, are closely linked to the air-fraction associated with micro-bubbles. Combining these turbulence estimates and the bubble cloud characteristics we infer differences in the strength of wave breaking and its effect on wave-induced mixing and air-sea exchange processes.