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Time-depth variability of turbulence in the tidal bottom layer

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Current structure and turbulent quantities within a tidal bottom boundary layer (BBL) have been examined using an upward-looking acoustic Doppler current profiler (ADCP). The instrument was deployed on the seafloor, off the north-eastern French coast in the eastern English Channel over 12 tidal cycles and covered the period of the transition from mean spring to neap tide. Forcing regimes varied from calm to moderate storm conditions during the deployment. For the study of turbulent quantities in the BBL, we have chosen a calm period, when an effect of surface wave on the velocity structure was negligible. During this period, the stresses were found to vary regularly with the predominantly semidiurnal tidal flow, with the along-shore stress being generally greater during the flood flow ($\approx$ 3.0 Pa) than during the ebb flow ($\approx$ -1.5 Pa). The turbulent kinetic energy (TKE) production rate, P, TKE density, Q, and its dissipation rate, ϵ, followed a nearly regular cycle with close to quarter-diurnal period.

Near the seabed, peak values of P, Q and ϵ were found to be $0.5\,Wm^{-3}, 0.5\,m^2s^{-2}$ and, $0.04\,Wm^{-3}$, respectively, during the flood while, during the ebb, these quantities reached smaller values: $0.1\,Wm^{-3}$, $0.1\,m^2s^{-2}$ and $0.03\,Wm^{-3}$, respectively. Near the bottom, eddy viscosity, A_z, peak ranged from about $0.1\,m^2s^{-1}$ during the flood to $0.03\,m^2s^{-1}$ during ebb flow. Away from the bottom, A_z increased to reach a maximum near the mid-depth. Time-depth variation of the P/ϵ ratio indicated that the turbulence in the BBL, most of the time, was at a non-equilibrium state ($P/\epsilon \neq 1$). The largest deviation from the equilibrium occurred during the flood, when P/ϵ exceeded about one decade near the bottom. During the ebb, P/ϵ was close to the equilibrium state, slightly decreasing with height above the bottom. Varying between 0.0012 and 0.0025, the drag coefficient was found to depend on the phase of tide that presumably associated with a dissimilarity of bottom roughness on ebb and flood. The mixing length derived from the measurements showed a good agreement with mixing length theory. Turbulent quantities are found to be close to those of other researches working on direct measurements of turbulence in tidal flows.