HIGH RESOLUTION SIMULATIONS OF OCEAN BOUNDARY LAYERS WITH STOCHASTIC WAVE BREAKING

Peter P. Sullivan
National Center for Atmospheric Research

Surface waves are visual signatures of the coupling between winds and currents in the atmospheric and oceanic boundary layers. In this presentation we consider the ocean boundary layer (OBL) where surface waves play important and surprising roles in ocean mixing. We simulate turbulent OBLs in the presence of a specified broad wavenumber wave spectrum typical of measured conditions. The simulation model includes the conservative dynamical effects of waves on the wave-averaged currents (vortex forces) and a stochastic representation of the impulses and energy fluxes in a field of breaking waves. The wave influences are shown to be profound in both the mean current profile and turbulent statistics compared to a simulation without these wave influences. As expected from previous studies with partial combinations of these wave influences, Langmuir circulations due to the wave-averaged vortex force make vertical eddy fluxes of momentum and material concentration much more efficient, and they combine with the breakers to increase the turbulent energy and dissipation rate. They also combine in an unexpected positive feedback in which breaker-generated vorticity seeds the creation of a new Langmuir circulation and instigates a deep, strong, intermittent downwelling jet. In order to extend these simulations to high winds with time varying winds over the period of days, typical of a hurricane passage, requires several hundred thousand time steps. To carry out these simulations we have developed a highly parallel mixed pseudospectral finite difference large eddy simulation code. The parallelization uses MPI and a novel 2D domain decomposition that requires only local matrix transposes for the evaluation of the pressure Poisson equation and FFT derivatives. The algorithm has shown good scaling using as many as 16,000 processors on a Cray XT4.