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Langmuir turbulence and nonlocal fluxes in closure models.

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This presentation is about including the physics of Langmuir circulations in models of upper-ocean turbulence.

Modifications made previously to fully include the Craik-Leibovich (CL) vortex force due to surface waves in quasi-equilibrium 'q2-q2l' second moment closures (SMC), such as 'Mellor-Yamada 2.5', are extended here to the much broader class of weak-equilibrium turbulence models (i.e. 'k-ε', 'k-l', 'k-ω' models) used to parameterize upper-ocean mixing. Including CL vortex production terms in the algebraic Reynolds stress model (ARSM) leads to straightforward algebraic solutions for the stability functions, determining the eddy viscosities and diffusivities in a purely local closure for Langmuir turbulence. However, including a representation of the near-surface pressure-strain closure term, an essentially nonlocal approximation for dynamics of convergence towards and downwelling along Langmuir jets, is more problematic for the weak-equilibrium case than it was for quasi-equilibrium ARSMs. This circumstance motivates construction of a more general approach to incorporating nonlocal terms within the ARSM of SMCs, and invites the inclusion of additional nonlocal transport of second moments within that framework.

Large eddy simulations (LES) of neutral and buoyant tracers are analyzed to develop nonlocal closures within the new framework, in order to improve prediction of the dispersion of pollutants, bubbles or biota in the upper ocean below surface waves. Transport of Reynolds stress and flux components are evaluated in LES results for improving their prediction in the lower mixed layer and transition zones, and of the impact of Langmuir turbulence on entrainment. A unified approach to nonlocal fluxes in both Langmuir turbulence and buoyant convection, both associated with coherent patterns of surface convergence and unbalanced budgets of bulk vertical kinetic energy, provides insight not only to their addition to SMC's but also to their extension beyond only buoyantly driven convective fluxes currently addressed in nonlocal first moment closures (i.e. 'KPP').