The interactions between wind turbulence and water surface waves is a classic fluid mechanics problem with many important geophysical, environmental, and engineering applications. To obtain improved understanding of the fundamental mechanisms of wave-turbulence interactions, we developed an advanced computational tool called Wave-Ocean-Wind (WOW) and used it to perform wave-phase-resolved simulations for nonlinear wave fields and direct numerical and large eddy simulations for turbulent airflows over waves to study different aspects of the problem. From computer simulations and theoretical analyses, we developed a viscous curvilinear model to explain the dynamics of wind over opposing waves and fast following waves. On the initial generation of waves, we obtained direct numerical evidence that supports Phillips' theory and further extended the analyses of Phillips' resonance mechanics. We also elucidated the role of nonlinear wave-wave interaction in developed wind-wave fields.

BIO

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