Experiment on turbulence developing under surface waves

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When a surface wave – even a gentle, non-breaking one – passes over a turbulent flow, wave energy is transferred to turbulent kinetic energy. The effect has been predicted theoretically and observed in simulation and experiment[c], but the dependence on the properties of the ambient turbulence has not been studied. Despite the direct importance to the energy budget of the ocean, upper-ocean mixing and the flux of gas and heat between ocean and atmosphere, ocean and climate models, systematic studies are scarce.

We study wave-turbulence interactions experimentally. The measurements were performed in two different wave-current-turbulence water channels at NTNU Trondheim[d] , where the turbulence in a background mean flow could be tailored. An active grid at the inlet allowed the turbulence intensity and length scale to be varied for the same mean flow. The flow field was measured in the spanwise-vertical plane by stereo particle image velocimetry (SPIV) and laser-Doppler anemometry (LDA) for various background turbulence cases with waves propagating against the current.

A strong increase in streamwise enstrophy (mean-square streamwise vorticity) is observed after vs before the passage of group of waves with Gaussian envelope. The depth dependence of the enstrophy increase closely follows that observed in direct numerical calculations[e]. Enstrophy is periodically intensified under troughs and reduced under crests as the waves stretch and compress streamwise vortices. Wave-turbulece kinematics are reported both in the cross-flow and spanwise-linear planes. Interactions between waves and turbulence over a large range of scales is responsible for mixing surface water into the deep and controlling the rate of mass and heat transfer between ocean and atmosphere.

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[c] e.g. Teixeira and Belcher *J. Fluid Mech.* **458** 229 (2002); McWilliams, Sullivan and Moeng *J. Fluid Mech.* **334** 1 (1997); Thais and Magnaudet *J. Fluid Mech.* **328** 313 (1996).

[d] Jooss et al *J. Fluid Mech.* **911** A4 (2021); Smeltzer, Æsøy and Ellingsen *J. Fluid Mech.* **873** 508 (2019).

[e] Guo and Shen *J. Fluid Mech.* **733** 538 (2013)