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THE PRODUCTION AND MIXING EFFECTS OF LANGMUIR CIRCULATIONS

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Abstract

In oceans and lakes, the interaction of surface waves with a wind-driven current produces a field of counter-rotating, longitudinal vortices aligned in the direction of the wind which are known as Langmuir circulations. This thesis covers a laboratory study of the production mechanism for this circulation and the effect it has on the mean flow. Waves of various amplitude and frequency were added to a pumped current in a labortatory flume. Longitudinal vortices formed in wavy flow conditions for which $\frac{(ak)^2C}{u_*} > 5.4$; where a, k, C are the wave amplitude, wave number and phase speed, respectively, and u_* is the friction velocity. The vortical motion was observed with flow visualization techniques that involved dye and positively buoyant beads. Indirect evidence for the presence of longitudinal vortices was gained through a study of changes in the vertical profile of streamwise velocity. By placing screens upstream of the wavemaker, a linear shear was imposed on the mean flow. When vortices formed, this shear was rapidly erased demonstrating that Langmuir circulations enhance the mixing of momentum. Dye studies revealed that the mixing of scalars is also enhanced. Finally, when longitudinal vortices were produced the rate of dissipation of turbulent kinetic energy was increased by as much as a factor of 40 above that measured in the absence of vortices with and without waves. The enhanced dissipation was strongly dependent on $\frac{(ak)^2C}{u_*}$.

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