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A Theory for Steady and Variable Wind-and Wave-Induced Currents

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ABSTRACT

A theory is presented for time-dependent currents induced by a variable wind stress and wave field in deep water away from coastal boundaries. It is based on a second-order perturbation expansion of the Navier-Stokes equations in Lagrangian coordinates. The effects of rotation and of a constant eddy viscosity are included. Partial differential equations are derived for the vertical and time variation of the mass transport velocity, together with boundary conditions at the sea surface.

Some simple analytical solutions are presented. For small viscosities, a near-zero mean mass transport is obtained, in agreement with Ursell. Inertial oscillation are superimposed on the above mean solution, in agreement with Hasselmann and Pollard. In the case of a constant wind stress and a constant, horizontally homogeneous wave field, the steady-state results of Weber are reproduced (a surface drift current of about 3% of the wind speed, 23–30 deg to the right of the wind direction).

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