FM9S_11294

XXI International Congress of Theoretical and Applied Mechanics
Warsaw, Poland, August 15–21, 2004

Modified Shallow Water Equations for Inviscid Gravity Currents

Falin Chen, A.C. Ruo

Institute of Applied Mechanics, National Taiwan University, Taipei, Taiwan

To analyze the motion of gravity currents, a common approach is to solve the hyperbolic shallow water equation together with the boundary conditions at both the current source at upstream and the current front at downstream. The use of the front condition is to account for the resistance from the ambient fluid, which, nevertheless, is missed in the shallow water equation. The present study starts from the continuity and inviscid momentum equations and applies the shallow water approximation to derive the so-called modified shallow water equation, in which the ambient resistance is accounted for by a nonlinear term so that the use of the front condition becomes non-necessary. This equation is highly nonlinear, which, under the assumption that the gravity current moves with a constant speed, can be solved by a similarity transformation. Qualitatively, the similarity solution ends up with a gravity current of a profile being close to those observed in experiments and being in a much better shape than those obtained by solving the traditional shallow water equation. Quantitatively, the similarity solution can be converted into a relation in terms of a parameter used in the front condition, which turns out to be exactly the same with that obtained by previous studies using both theoretical as well as experimental approaches. These comparisons support that the present modified shallow water equation can properly govern the motion of inviscid gravity current when the ambient resistance is concerned.

View the extended summary