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LINEAR AND WEAKLY NONLINEAR INSTABILITY OF SHALLOW MIXING LAYERS WITH VARIABLE DEPTH AND NON-UNIFORM FRICTION

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Shallow flows in compound and composite channels are characterized by different water depths in the main channel and floodplains. In addition, resistance forces are usually larger in the shallow part of the channel. These two factors play an important role in the mass and momentum exchange for shallow flows with free surface. Similar situation takes place in case of floods where water occupies partially vegetated areas [1].

Linear stability problem for shallow mixing layers with free surface is obtained and solved numerically for the cases of constant and varying depth of the channel. Hyperbolic tangent function is used to model the profile of varying depth. Bottom friction is modeled by means of the Chezy formula. The friction coefficient is also assumed to be a function of the transverse coordinate. Numerical solution of the eigenvalue problem is obtained by a collocation method. The role of the parameters characterizing the problem on the stability characteristics is investigated. In particular, it is shown that the increase of the Froude number and/or friction in the main channel stabilizes the flow.

The evolution of the most unstable mode for the case where the bed friction number is slightly smaller than the critical value is analyzed using the methods of weakly nonlinear theory. The amplitude of the most unstable perturbation in accordance with the linear theory is multiplied by an unknown amplitude function depending on slow longitudinal variable and time. The method of multiple scales is used to derive the amplitude evolution equation [2].

It is shown in [3] that for shallow water flows under the rigid-lid assumption the amplitude evolution equation is the complex Ginzburg-Landau equation. In the present paper we show that the amplitude evolution equation for shallow flows with free surface (when water depth and friction coefficients are not constant) is the complex Schroedinger equation. The coefficients of the equation are obtained in the form of integrals depending on solutions at orders one and two.

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