A research on initial formation process of intermittent debris flow

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Some debris flows are intermittent surges flows with discontinuous changes in water depth. These phenomena are considered to be a kind of nonlinear wave phenomena based on flow instability.

The authors show a KdV-Burgers equation as an equation representing the change in water depth. When the phase velocity in the equation is long wave velocity, the equation becomes a Burgers equation.

The characteristic of the roll wave is that it has a discontinuous change in water depth and flows down intermittently as many surges.

Roll wave experiments were performed using a straight channel with a length of 56m, a width of 10cm, a depth of 15cm and a channel gradient of &theta;=2.5 deg.

The experimental conditions are by a plane water and a flow containing 42% (C=0.42) solid particles.

The particles are cylindrical particles with a typical particle size of d = 3 mm and a density of &sigma;=1.04 g/cm$^3$ made of polystyrene.

The flow conditions of the plane water are as follows: mean discharge Q = 1112cm$^3$/s, mean depth h = 1.23cm at the downstream end of the channel, mean flow velocity u = 90.2cm/s,

and the flow conditions with solid particles Q=1193cm$^3$/s, h = 1.35cm, u = 88.4cm/s.

To supply water to the flume, a water tank storing 0.5m$^3$ is placed on the upstream side of the flume, and water or a mixture of water and particles is supplied from the upstream end of the flume. The water tank is closed and the inside is kept at a constant pressure according to the Marriott
bottle principle. As a result, the water supply is constant.

In the case of plane water, the period is \( T = 1.12 \text{sec} \) at \( x = 14 \text{m} \) from the upstream end of the flume, and at the downstream end \( x = 56 \text{m} \) \( T = 2.25 \text{sec} \).

In the flow including solid particles, \( T = 1.78 \text{sec} \) and \( T = 3.06 \text{sec} \) at the same position. In each case, the surge period becomes longer as the flow goes down. The wave velocity of the surge here in the experimental results is different.

Looking at the details of the waveform, the subsequent surge may catch up. Therefore, it is considered that the period of the surge becomes longer as it flows down and combines with other surges.

In the Burgers equation, the initial condition waveform is integrated into a waveform with wave number \( k = 1 \) by the initial condition of a non-integer multiple waveform and non-fixed boundary conditions at both ends.

From the above, it is considered that the initial waveform formation of the roll wave is contributed by the weak shock wave equation such as the Burgers equation.

In this Burgers equation, when the waveform is integrated into a waveform with wavenumber \( k = 1 \), the analytical solution shows that the phase velocity \( v_{p0} \) is no longer \( c_{0} \).

Therefore, the governing equation returns to the KdV-Burgers equation.