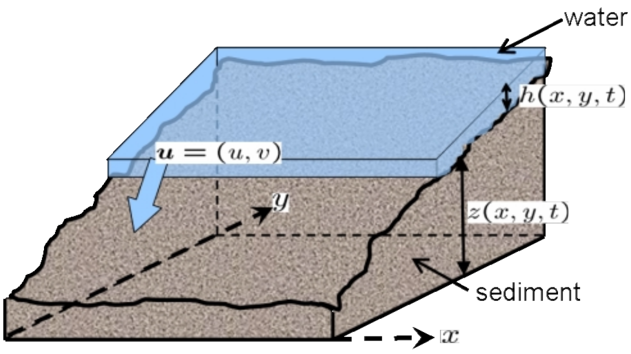

Fig. 1. Definitions of variables in the fluid erosion.

Table 1. Parameters used in the simulation.

Parameter	Value
c_f	0.01
D_f	0.005
k	1.2
α	0.8
β	0.7
h_0	0.0001
Δx	0.1
Δy	0.1
Δt	0.1
N_x	256
N_y	512

For the sake of simplicity, we do not consider the mixed flow dynamics of water and sediment. Evolution of the elevation z is expressed by

$$\frac{\partial z}{\partial t} = -q_s + D_f \nabla^2 z \tag{6}$$

$$q_s = k Q^\alpha S^\beta \tag{7}$$

where q_s is the rate of eroded sediment; D_f is the diffusion coefficient; and k, α, and β are constants. Q and S denote the discharge, i.e. the local flow rate of the fluid phase, and the local slope gradient, respectively, such that

$$Q = h\ |\boldsymbol{u}|/h_0 \tag{8}$$

$$S = \sqrt{(\partial z/\partial x)^2 + (\partial z/\partial y)^2}. \tag{9}$$

The first term on the right-hand side of Eq. (6) is associated with channel erosion, and the second term is associated with diffusion. Eq. (7) is based on a detachment-limited model (Howard, 1994). In a detachment-limited model q_s is propotional to $A^\alpha S^\beta$, where A denotes the drainage area. However, because it is hard to calculate the drainage area A in every numerical step, in our model the discharge Q is used instead of A. Note that the relation between the drainage area and the discharge is $Q \propto A$ (Leopold *et al.*, 1964). The exponents α, β, and the coefficient k are 0.8, 0.7, and 1.2, respectively, based on Howard (1994).

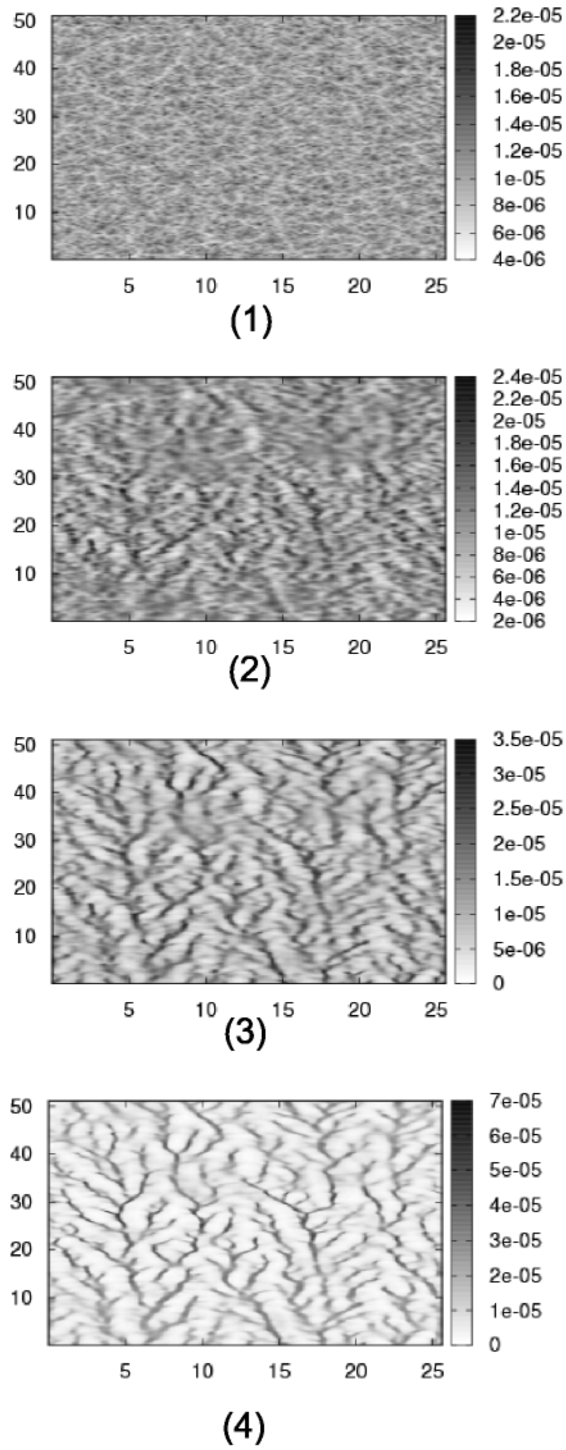

Fig. 2. Visualization of distributions of the water depth for the initial gradient $S_0 = 0.0001$. The darker areas indicate deeper region. (1) $t = 100$, (2) $t = 1100$, (3) $t = 1800$, and (4) $t = 2300$.

3. Numerical Calculation

We apply the CIP (cubic interpolated pseudoparticle) method Ogata and Yabe, 2004) to the advection term in the shallow water equations (2)–(4). We apply the ADI (alternating direction implicit) method and the cyclic reduction algorithm to the diffusion term in Eq. (6), the central difference in space, and the forward difference in time. The grid sizes in the x and y directions are Δx and Δy, and the number of grid points is given by $N_x \times N_y$.