Numerical Simulation for Landform Evolution with a Stream Erosion Model: Dependence on Area Partition

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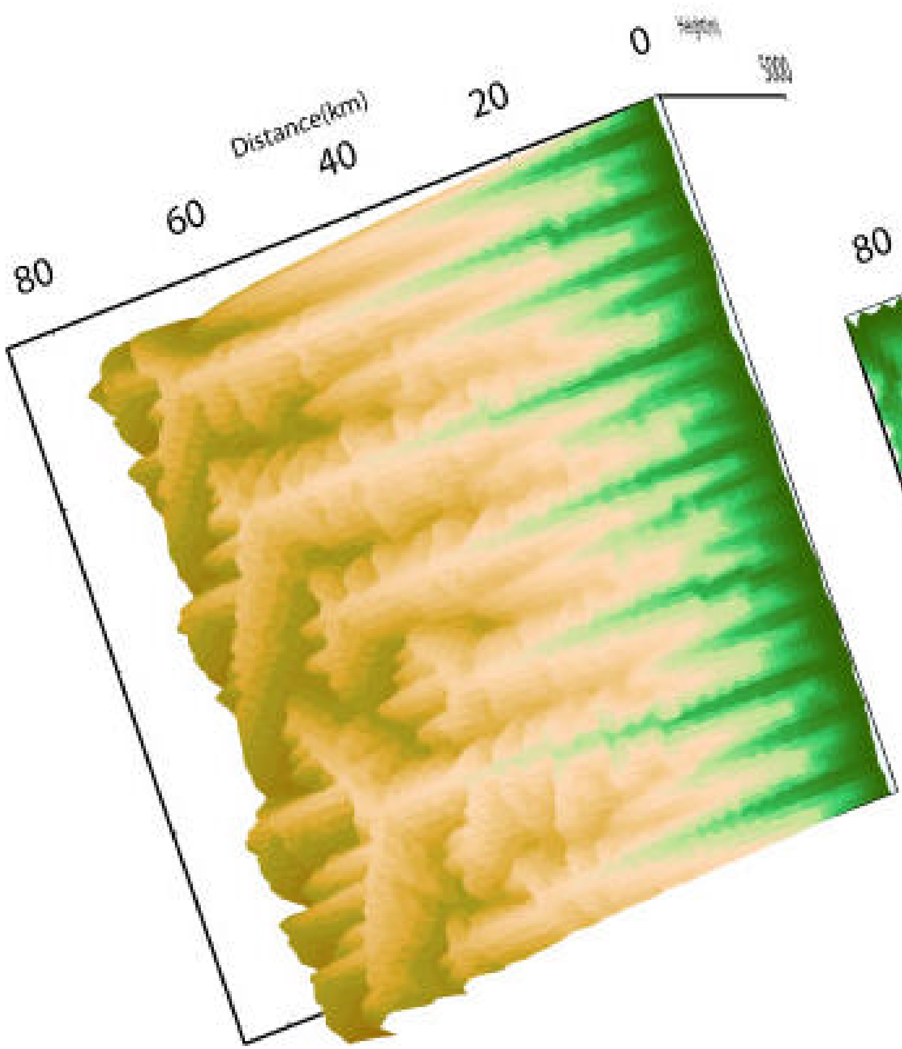
Geomorphic processes are roughly classified into two groups; internal and external processes. The internal processes cause crustal uplift and subsidence, while the external processes cause erosion and sedimentation. In general, landform evolves toward a dynamic stable state in which these two opposite processes are balancing with each other. Thus, combining a quantitative model describing internal processes with that describing external processes, we can obtain a coupled nonlinear equation system governing the landform evolution process. As for the quantitative model describing external processes, we use a stream erosion model proposed by Howard and Kerby (1983). In this model the rate of surface erosion at a point is proportional to the product of a power of drainage area A and a power of local slope S at the point. Incorporating a crustal uplift model into the stream erosion model, and discretizing it in time and space, we can construct a 3D numerical simulation model for landform evolution. Given a height distribution at a certain time, we can evaluate the drainage area A and the slope S at every point of the model region, and compute the amount of erosion at the time step by the stream erosion model. Then, adding the difference between the amount of uplift and the amount of erosion at the time step to the initial height, we obtain the height distribution at the next time step. Iterating this process, we can numerically simulate the landform evolution process.

In 2004 EPS Joint Meeting, with this simulation model, we have examined the relationship between the location of maximum uplift axis and that of mountain range axis, and found that the mountain range axis gradually migrates from the maximum uplift axis toward the center of the crustal uplift region. The balanced height of the mountain range is in proportion to the crustal uplift rate. Taking these simulation results into consideration, we have simulated the landform evolution process in Taiwan for the last 5 Myr, and succeeded in reproducing the present height distribution.

In the simulation of landform evolution, we should pay more attention to the way of area partition, because the pattern formation of drainage network significantly depends on area partition. In the present study, we examine how the balanced height distribution depends on area partition to find the most appropriate way of area partition. First, we numerically simulated the formation process of drainage network, starting from the initial height distribution with small random variations. As surface erosion proceeds with time, small hollow areas are connected with each other, and a drainage network is gradually developed. We have done this kind of simulation in the area partition with three different types of cells (regular triangle, square, and regular hexagon), and found the following two characteristics. First, there exists a preferred orientation of drainage corresponding to the geometric shape of cells. Second, the drainage network density significantly depends on the cell size. These two characteristics for drainage network development lead to the difference in balanced height distribution.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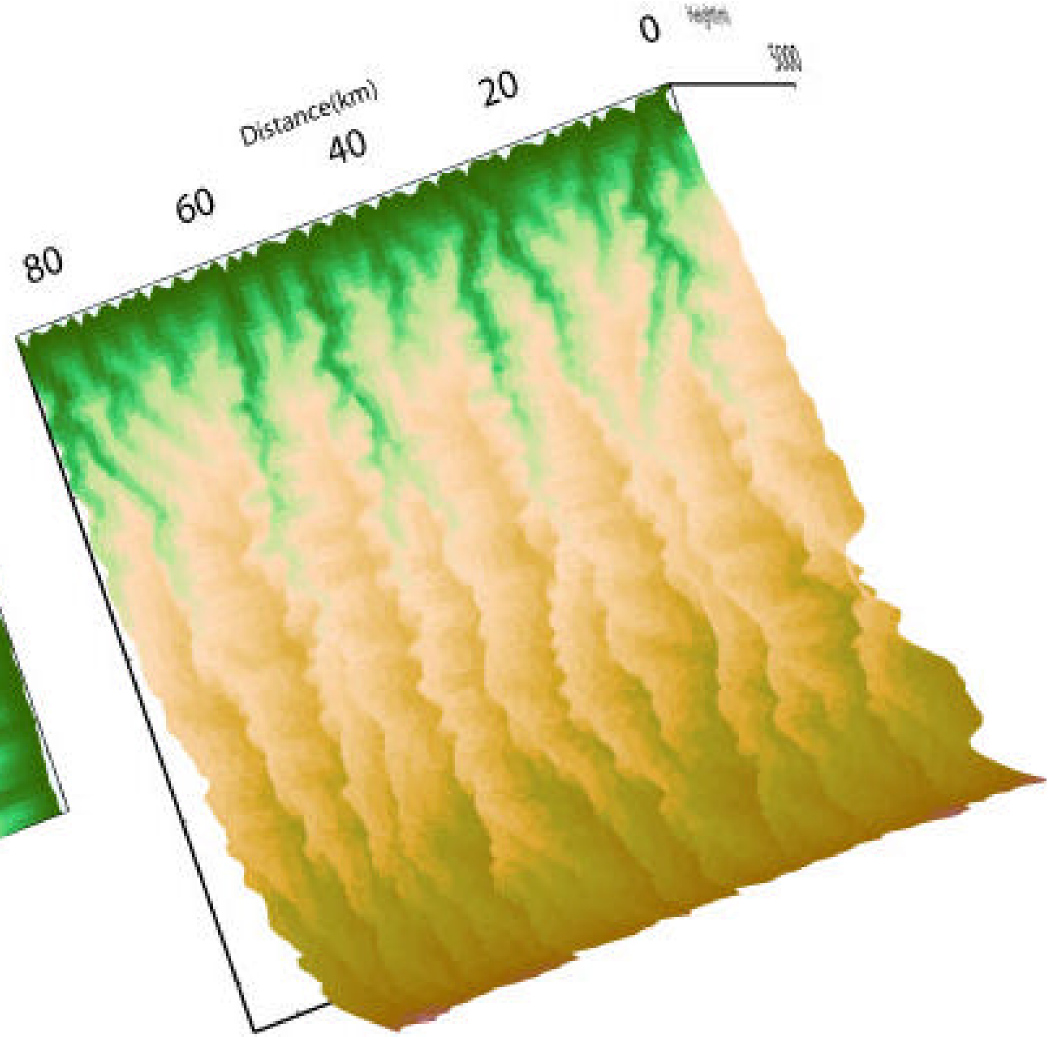
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