Stream Morphological Analysis By Airborne Laser Altimetry And Fractal Dimension

Mon-Shieh Yang¹, Ming-Chee Wu², and Jin-King Liu³

¹ PhD Candidate, Department of Earth Sciences, National Cheng Kung University (NCKU), Taiwan, R.O.C
Email: MSYang@IEEE.org
² Associate Professor, Department of Earth Sciences, National Cheng Kung University (NCKU), Taiwan, R.O.C
³ Taiwan Group on Earth Observations (T GEO), Taiwan, R.O.C

ABSTRACT
In this study, fractal dimension are employed to evaluate the stream morphology. The results showed that the upper-reaches demonstrate higher roughness values than the lower-reaches; the materials from debris flow and landslides also influence the incoming flow and sediment carrying capacities.

A-1. Introduction
(1) Stream morphology may present different stages of fluvial characteristics.
(2) The stream morphology is being adjusted by the incoming stream flows as well as the sediments been carried.
(3) Streams are showing a very complicate topography due to the high eroding capability caused by secondary disasters such as landslides and debris flows after heavy rain or typhoon.
(4) To understand the balancing characteristics between incoming flow and sediment regime.

A-2. Scopes of Work
● Quantifying the morphology along a river channel.
● Data of the pre-disaster and the post-disaster were compared to determine the variability of stream morphology.
● Using Fractal dimension to understand the topographic roughness.
● The degree of complexity of a polygon is characterized by the fractal dimension.

A-3. Study Area and Materials
➢ The study area, with 5.5x7 km², is located at the northeast portion of Kaohsiung City, Taiwan.

Landslide events
➢ Hsiaolin village-located at the northeast part of Kaohsiung City, sustained heavy damage during a catastrophic landslide event by Typhoon Morakot.

Regional geological setting
➢ The river-bed geological setting of Hsiaolin village reach was primarily consisted with alternation of sandstone and shale.

Topographic data
➢ Airborne LiDAR DEM
➢ LiDAR data: Collected both before and after the disaster caused by Typhoon Morakot in 2005 and 2010.

B. Fractal Dimension
(1) The degree of complexity of a polygon is characterized by the fractal dimension (D)

\[ D = \frac{2 \ln(A)}{\ln(P)} \]
where

\[ A = \text{total patch area} \]
\[ P = \text{total patch perimeter} \]

(2) To equals 2 times the logarithm of patch perimeter (m) on DEM which divided by the logarithm of patch area (m²)

\[ P = 4 \times A^{D/2} \]
\[ D = \frac{2 \ln(0.25 P)}{\ln A} \]

C. Results and Discussion
➢ The variety of river bed roughness

Shape complexity

Table 1. Typhoon events induced flooding fractal dimension change

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1.14</td>
<td>1</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.71</td>
<td>2</td>
</tr>
<tr>
<td>Mean</td>
<td>1.33</td>
<td>1.37</td>
</tr>
</tbody>
</table>

➢ The spatial variety of the river-bed roughness

Figure 2. The spatial variety of the river-bed roughness

D. Conclusion
● The results has shown the relationship between river morphology and disaster events.
● LiDAR derived data and morphology analysis technique can be treated as a disaster prevented and management tool.
● Integrated field observation data for hydrological and engineering applications in the further works.