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Extended Abstract
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Simulation of the Debris Flow Due to the Potential Large-scale Landslide Area (T002) in Fuxing, Taoyuan Using iRIC Morpho2DH

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Keywords: iRIC Morpho2DH; Large-scale Landslide; T002

1. Introduction

The heavy rainfall will trigger landslides or debris flow in the slope land, which pose a great threat to the protected targets in the downstream due to the short response time. In order to study and reproduce the features of disasters, the numerical simulation is a common method.

Takebayashi et al. (2020) applied iRIC (International River Interface Cooperative) Morpho2DH (Nelson et al. 2016) to simulate a rainfall-induced the debris flow event in Hiroshima, Japan on August 20, 2014. The research results show that the program can effectively simulate the characteristics of debris flow, such as depth, velocity, influence range, and the required time for the debris flow to travel from the upstream to the downstream protected targets.

The potential large-scale landslides (Slope number T002) located in the north of Taiwan has started to displace since 2012. According to the long-term monitory results, the displacement rate has accelerated at the beginning of 2021. To evaluate the impact and influence area if the landslide forms debris flow during rainfall, this study tries to use the iRIC Morpho2DH model to demonstrate the situation simulation.

2. Materials and Methods

(1) The study area:

The potential large-scale landslide area located in Fuxing Taoyuan (Slope number T002) (N24.658414, E121.392633) started to displace in 2012 (**Figure 1**). The slope of the area is up gentle (30 - 40 degrees) and down steep (40 - 55 degrees and some about 60 degrees), and the slope is 290 meters high. According to the long-term monitory results, the displacement rate has accelerated at the beginning of 2021 and retarded in July, but the activates and expands are still continuing toward the slope toe.

(2) iRIC Morpho2DH

iRIC is a program jointly developed by the United States Geological Survey, Kyoto University, and other units for analyzing river and terrain dynamics (morphodynamics). iRIC Morpho2DH can simulate the migration and accumulation process of debris flow caused by landslides of slope land. iRIC Morpho2DH divides the fluid into laminar and turbulent layers to calculate energy dissipation and uses

the drag coefficient in the Chezy formula to calculate bed friction. Therefore, this program can calculate debris flow and debris flow/mud flow mixtures. The program can also consider the influence of structures (such as buildings, sabo dams, etc.), and can accurately simulate the behavior of soil and rock flow even in complex areas.

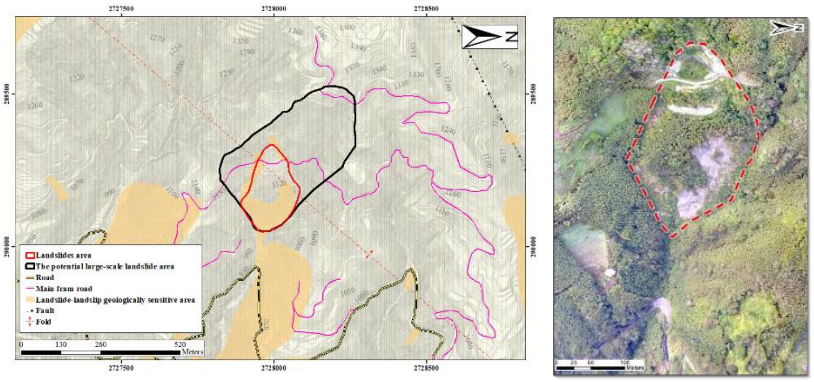

Figure 1. The study area (2021.08.05).

Table 1. The setting of this study.

Material/Parameter	Setting
DEM	2021/08/31 DEM by SWCB (By UAV-LiDAR, resample to 20 cm resolution)
Depth of Landslide	20m (Outside), 30 m (Center)
Simulation Grids	52×31=1,612 (10 m × 10 m)
MaxErosionDepth	0.5 m
Laminar Flow Depth Ratio	0.1 (0.1-0.4)*
Minimum Flow Depth	0.01 m*
Liquid Behavior Sediment Ratio	0.02
Resistance Coefficient	140*

*Refer to iRIC Morpho2DH manual

3. Results and Discussion

The simulation results show the iRIC Morpho2DH program can conduct the depth, maximum depth, and main deposition area of debris flow effectively. They also indicate that the road will be buried by the sediment around 10 to 15 sec after the debris flow occurring, and the depth over 5 m (**Figures 2 and 3**). These results can predict the possible impact range after the potential large-scale landslide collapse preliminarily, and help the government official to make the decision for evacuation of inhabitants and take response actions effectively.

4. Conclusions

Compared to simulation programs that require significant time and expense, iRIC Morpho2DH is a free and simplified debris flow simulation program that can replicate landslide disaster processes. While more detail parameters or simulation conditions such as the moving bed are helpful to obtain more precise results, The iRIC Morpho2DH model still plays an important role in providing disaster reduction and prevention information at the first time of a disaster occurrence.

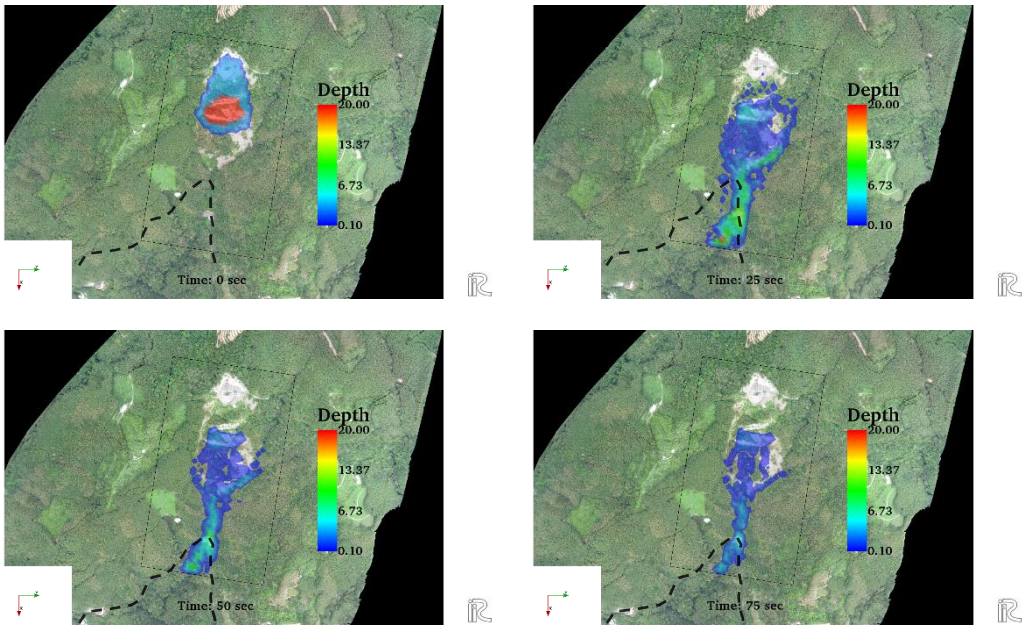

Figure 2. The simulation depth results of iRIC. a) t = 0 s; b) t =25 s; c) t =50 s; and d) t =75 s

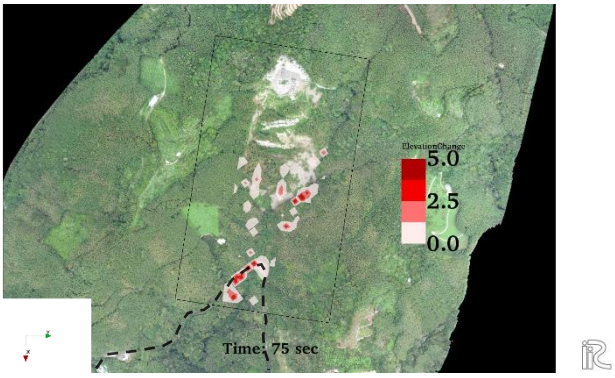

Figure 3. The results of debris flow accumulation by iRIC (t =75 s).

References

1. Takebayashi, H. Morpho2DH Tutorial - Bed Material Load, *An iRIC Project document*, 2016
2. Nelson, J. M.; Shimizu, Y.; Abe, T.; Asahi, K.; Gamou, M.; Inoue, T.; Iwasaki, T.; Kakinuma, T.; Kawamura, S.; Kimura, I.; Kyuka, T.; McDonald, R. R.; Nabi, M.; Nakatsugawa, M.; Simões, F. R.; Takebayashi, H.; Watanabe, Y. The international river interface cooperative: public domain flow and morphodynamics software for education and applications. *Advances in Water Resources*, 2016, Volume 93, pp. 62–74.
3. Takebaya, H.; Fujita, M. Numerical Simulation of a Debris Flow on the Basis of a Two-Dimensional Continuum Body Model. *Geosciences*, 2020, Volume 10, pp. 45.
4. The information link of BigGIS for T002: https://gis.swcb.gov.tw/map/?left-menu_PID=Landslide_P6

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The information link of T002 on DATA and BigGIS (SWCB)

Introduction

- The heavy rainfall will trigger landslides or debris flow in the slope land, which pose a great threat to the protected targets in the downstream due to the short response time. In order to study and reproduce the features of disasters, the numerical simulation is a common method.
- Takebayashi et al. (2020) applied **iRIC (International River Interface Cooperative) Morpho2DH** (Nelson et al. 2016) to simulate a rainfall-induced the debris flow event in Hiroshima, Japan on August 20, 2014. The research results showed that the program can effectively simulate the characteristics of debris flow for the debris flow to travel from the upstream to the downstream protected targets.
- The **Potential Large-scale Landslides** (Taoyuan City-Fuxing District-T002) located in the north of Taiwan has been displacing since 2012. According to the long-term monitory results, the displacement rate accelerated at the beginning of 2021. To evaluate the impact and influence area if the landslide forms debris flow during rainfall, this study uses the iRIC Morpho2DH model to demonstrate the situation simulation.

Materials and Methods

The study area

The Potential Large-scale Landslide area located in Fuxing Taoyuan (Taoyuan City-Fuxing District-T002) (N24.658414, E121.392633) started to displace in 2012 (**Figure 1**). The slope of the area is up gentle (30 - 40 degrees) and down steep (40 - 60 degrees), and the slope is 290 meters high.

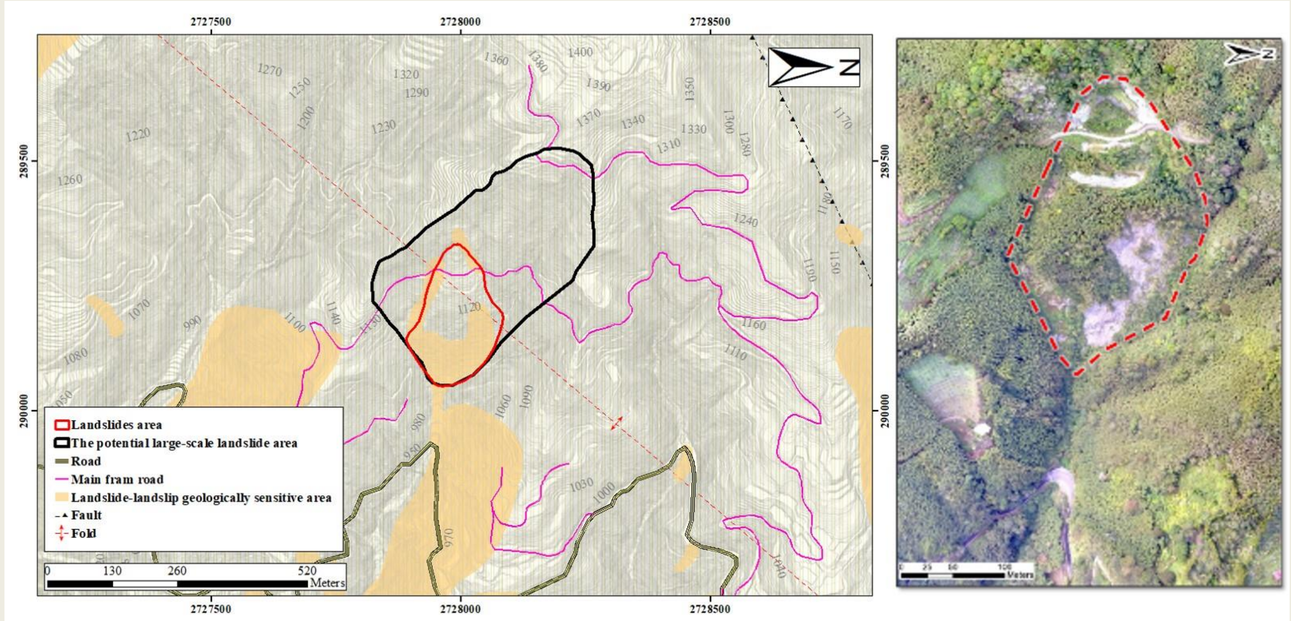

Figure 1. The study area (2021.08.05)

According to the long-term monitory results, the displacement rate has accelerated at the beginning of 2021 and retarded in July (**Figure 2**).

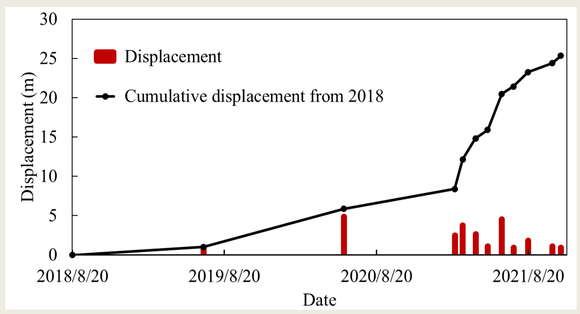

Figure 2. Cumulated Displacement (2018/8 - 2021/11)

iRIC Morpho2DH

- iRIC is a program jointly developed by the United States Geological Survey, Kyoto University, and other units for analyzing river and terrain dynamics (morphodynamics).
- iRIC Morpho2DH divides the fluid into laminar and turbulent layers to calculate energy dissipation and uses the Chezy formula to calculate bed friction. Which can simulate the migration and accumulation process of debris flow caused by landslides.
- Therefore, this program can calculate debris flow and debris flow/mud flow mixtures, and also consider the influence of structures (such as sabo dams, etc.), and can accurately simulate the behavior of soil and rock flow even in complex areas.

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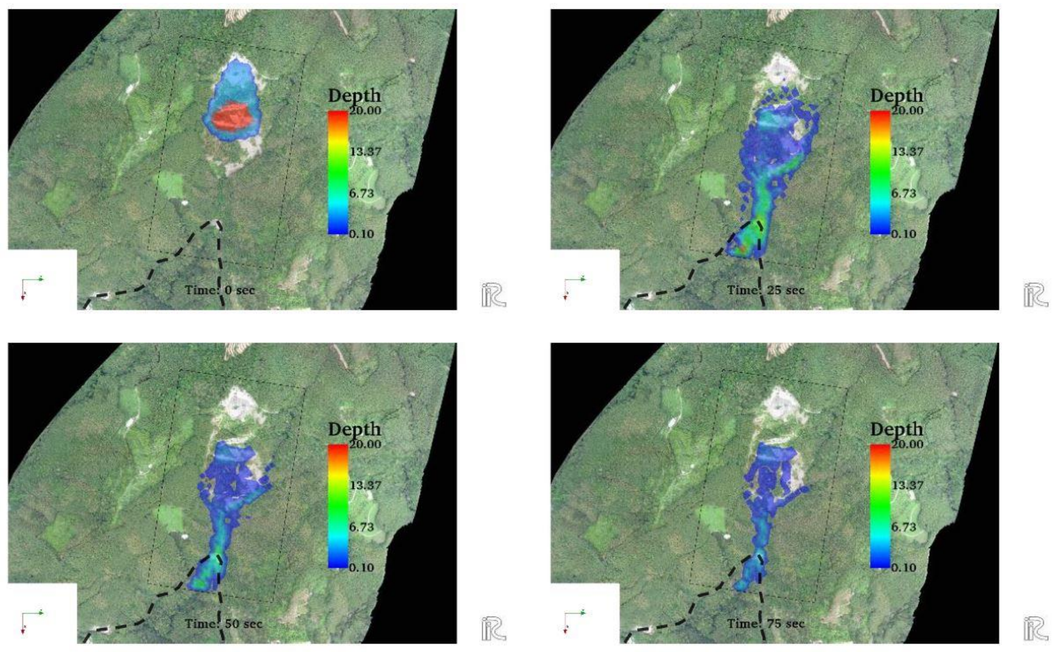
Results and Discussion

- The simulation results show the iRIC Morpho2DH can conduct the depth, maximum depth, and main deposition area of debris flow effectively. They indicate that the road will be buried by the sediment around **10 to 15 sec** after the occurrence of the debris flow occurring, with depths **over 5 m** (**Figures 3 and 4**).
- These results can predict the possible impact range after the Potential Large-scale Landslide collapse preliminarily, and help SWCB to make the decision about evacuation of inhabitants and take response actions effectively.



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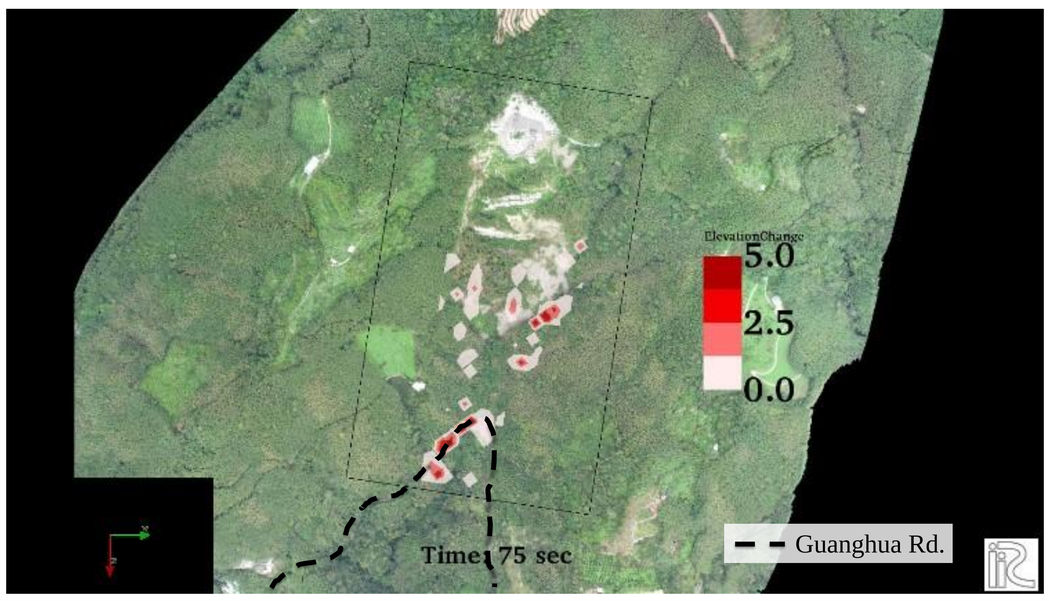

Figure 4. The results of debris flow accumulation by iRIC (t =75 s)

Conclusions

1. Compared to simulation programs that require significant time and expense, iRIC Morpho2DH is a **free and simplified** debris flow simulation program that can replicate landslide disaster processes.
2. While more detail parameters or simulation conditions such as the moving bed are helpful to obtain more precise results.
3. iRIC Morpho2DH plays an important role in providing disaster reduction and prevention strategies at the first time of disaster occurrence.

References

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2. Nelson, J. M.; Shimizu, Y.; Abe, T.; Asahi, K.; Gamou, M.; Inoue, T.; Iwasaki, T.; Kakinuma, T.; Kawamura, S.; Kimura, I.; Kyuka, T.; McDonald, R. R.; Nabi, M.; Nakatsugawa, M.; Simões, F. R.; Takebayashi, H.; Watanabe, Y. The international river interface cooperative: public domain flow and morphodynamics software for education and applications. *Advances in Water Resources*, 2016, Volume 93, pp. 62–74.
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