Application of High-resolution LiDAR-derived DEM in Landslide Volume Estimation

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- TAIWAN

長榮大學 Chang Jung Christian University

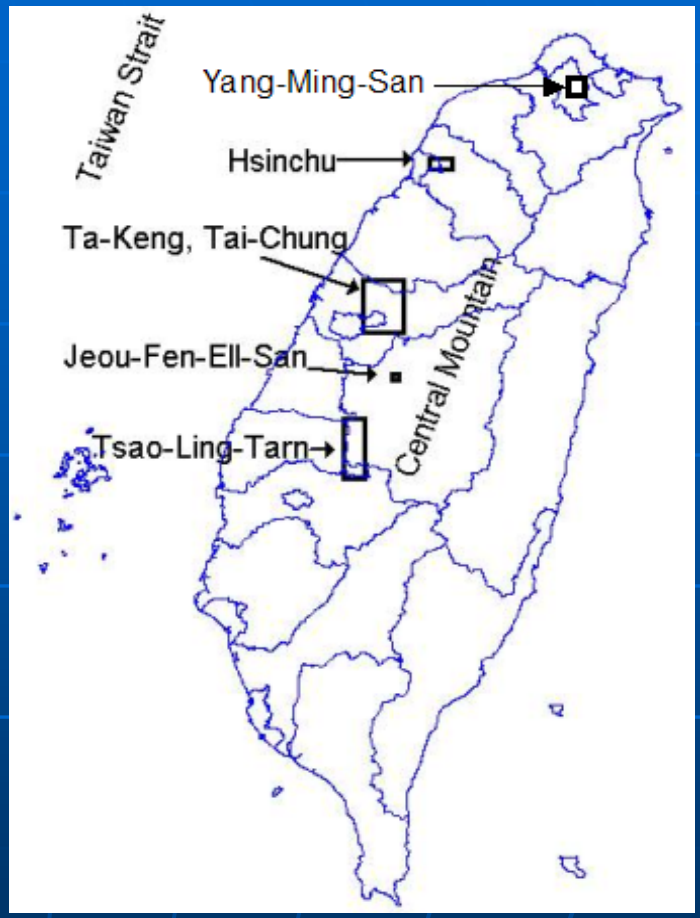
成功大學 National Cheng Kung University

Lidar Application in Taiwan (2002-2004)

GPS installation

LiDAR installation

Control units



Optech and Leica run demo flights

- Optech ALTM 2033
  - March 20~April 03, 2002
  - Beach Super King Air 350
- Leica ALS40
  - April 10~ April 16, 2002
  - Beach Super King Air 200

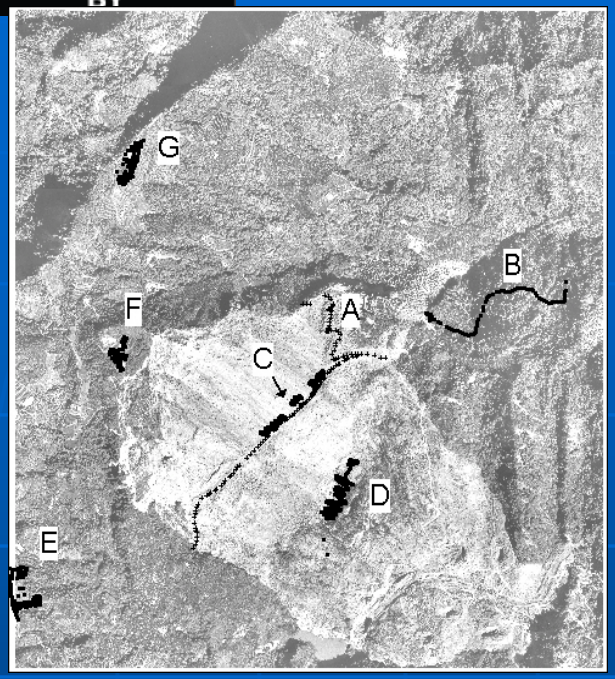
King Air 350

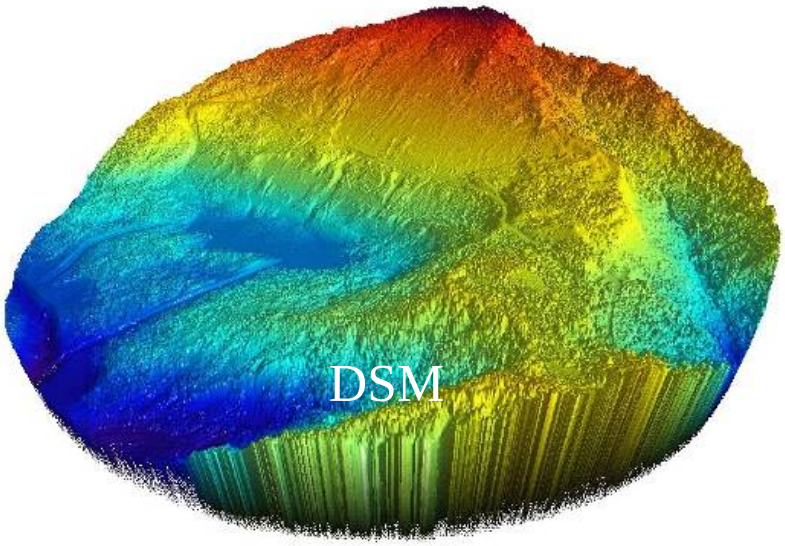
King Air 200

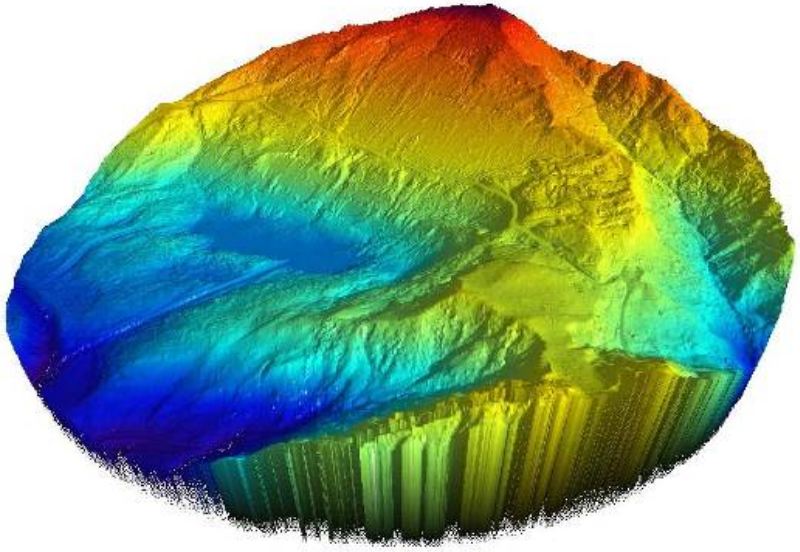
BN2-B 20/26

BK-117 B1

Jeou-Fen- Er-Shan

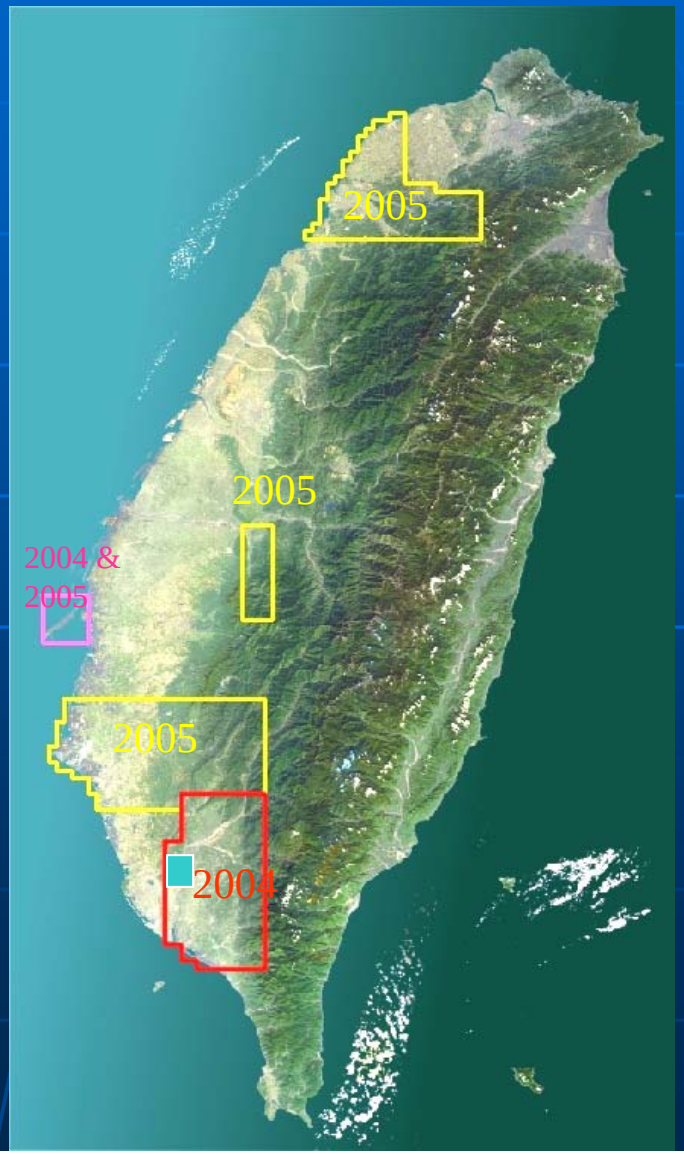






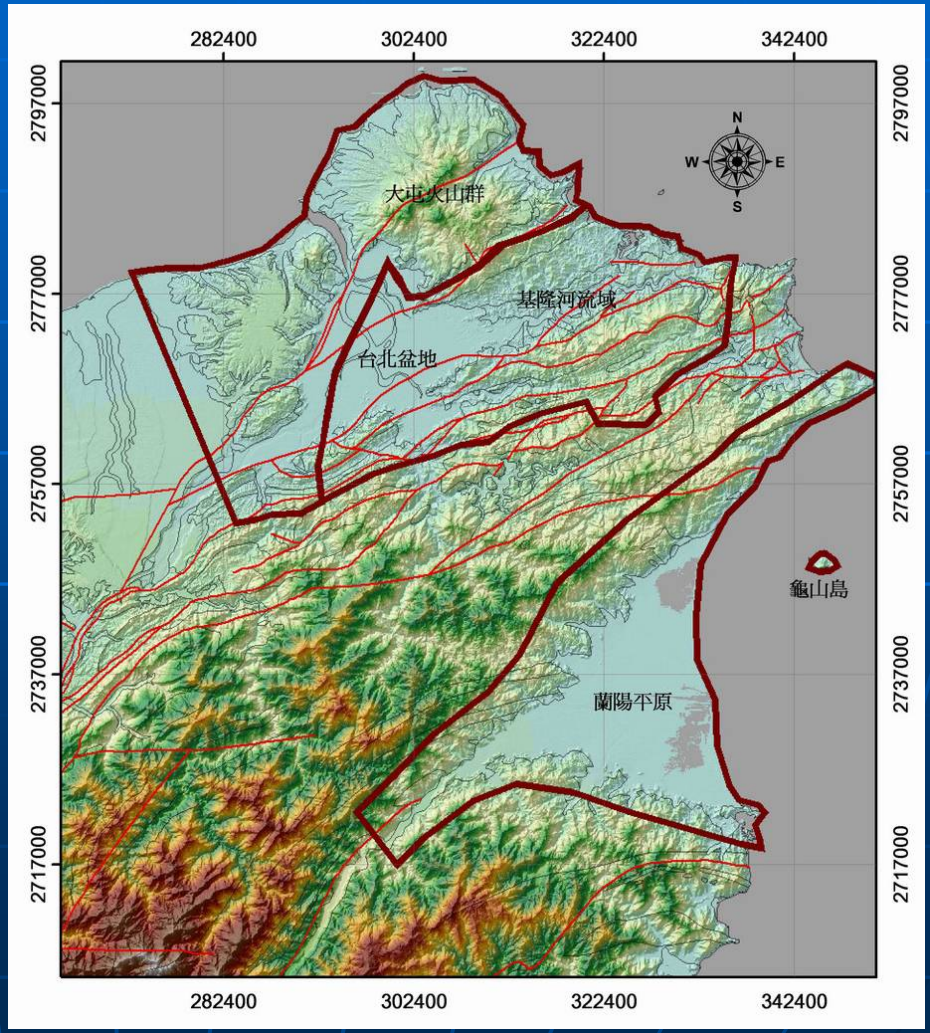
MOI (Ministry of Interior) LiDAR Program in 2004-2005

- Conducted by
  - Industrial Technology Research Institute
- Point density>1 point/m²
- 4000 Km²: DEM and DSM of 1m Grid

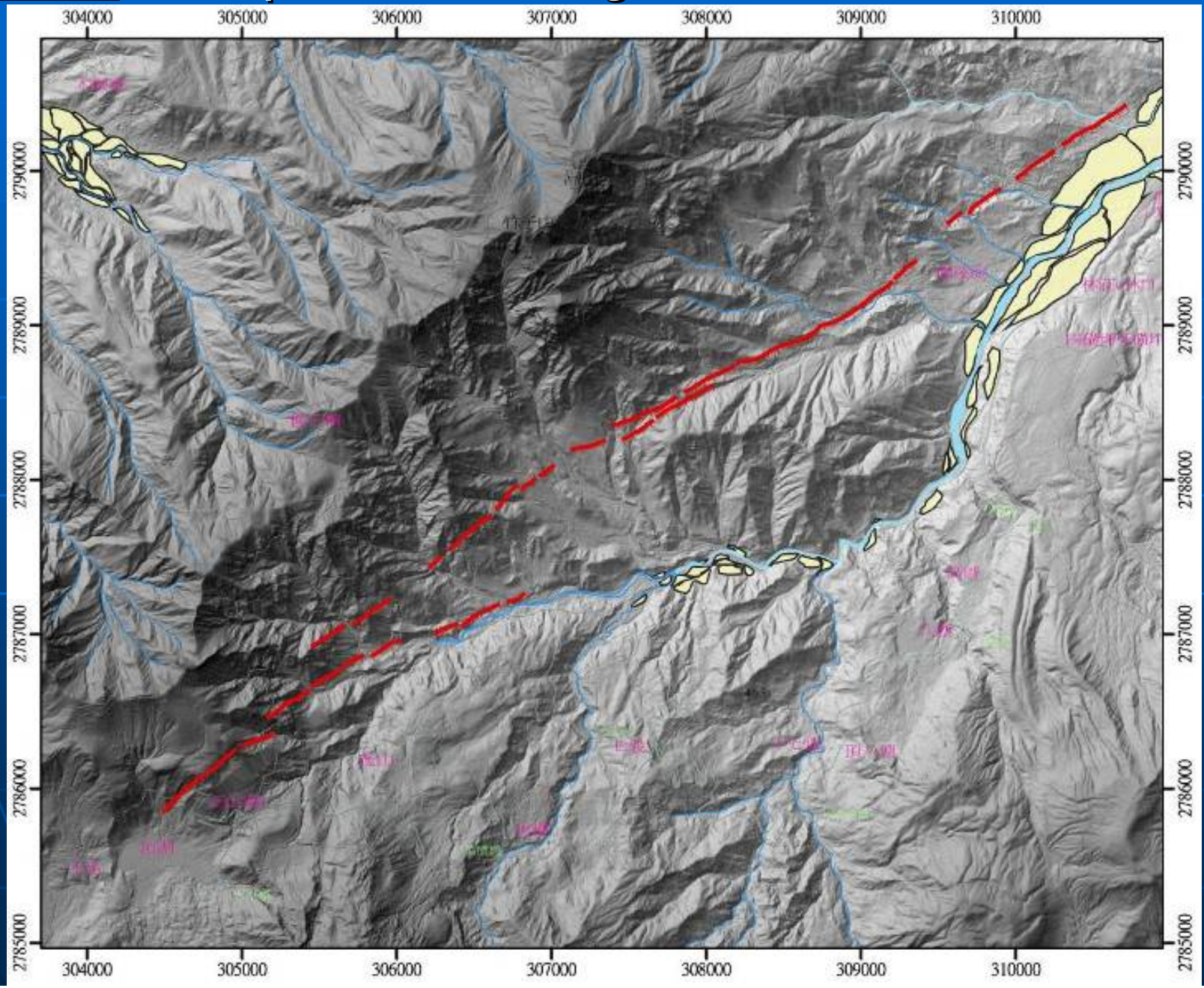


Geological structures and Hazards Survey of Taipei Metropolitan Area (2005-2007)

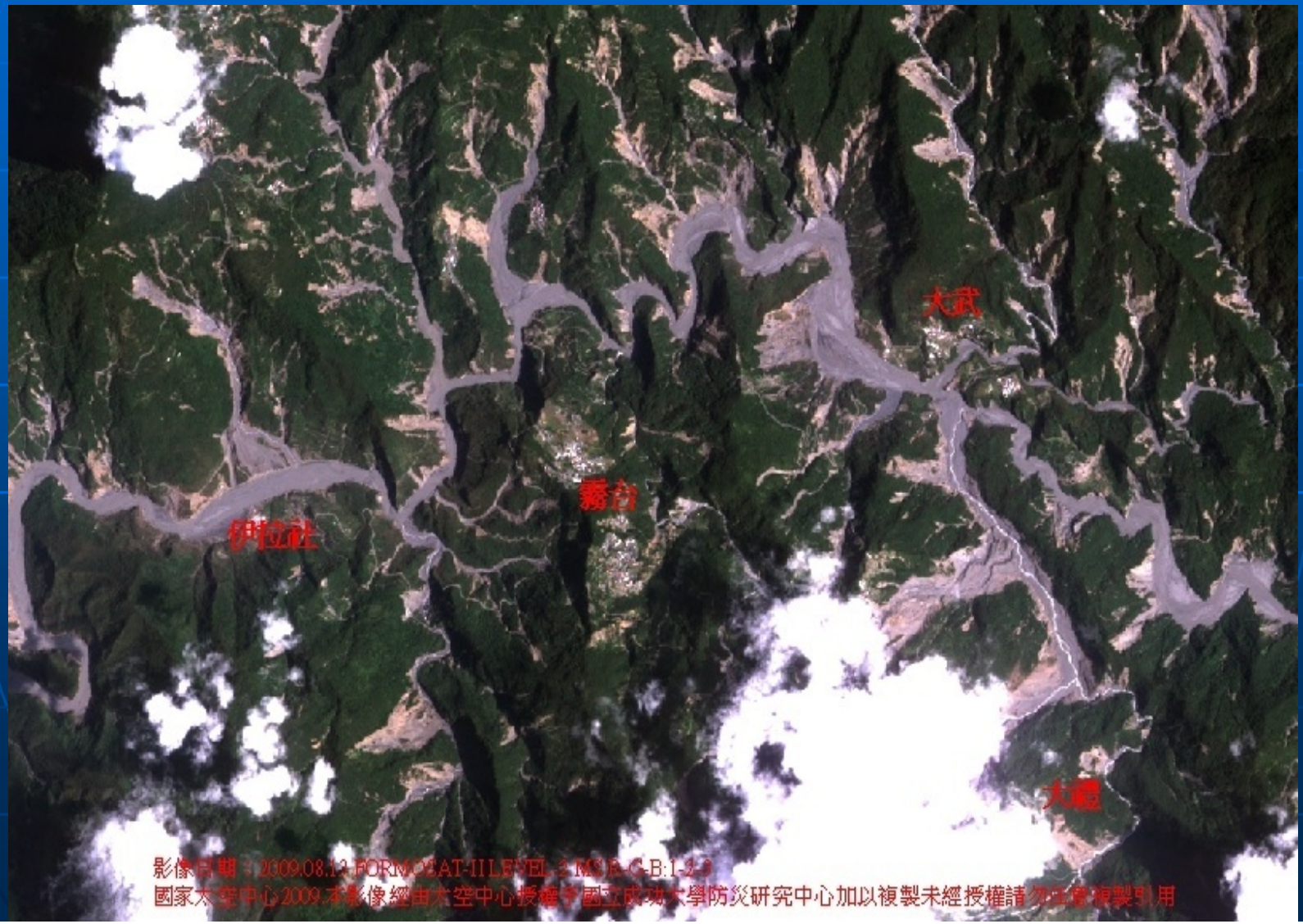
- 2,490 Km^2 : DEM and DSM of 2m Grid
- Point density>1 point/m^2
- Drainage analysis
- Active structure analysis
- Analysis of Volcanic Topography
- Supported by Geological Survey of Taiwan



An Example of Geological Research

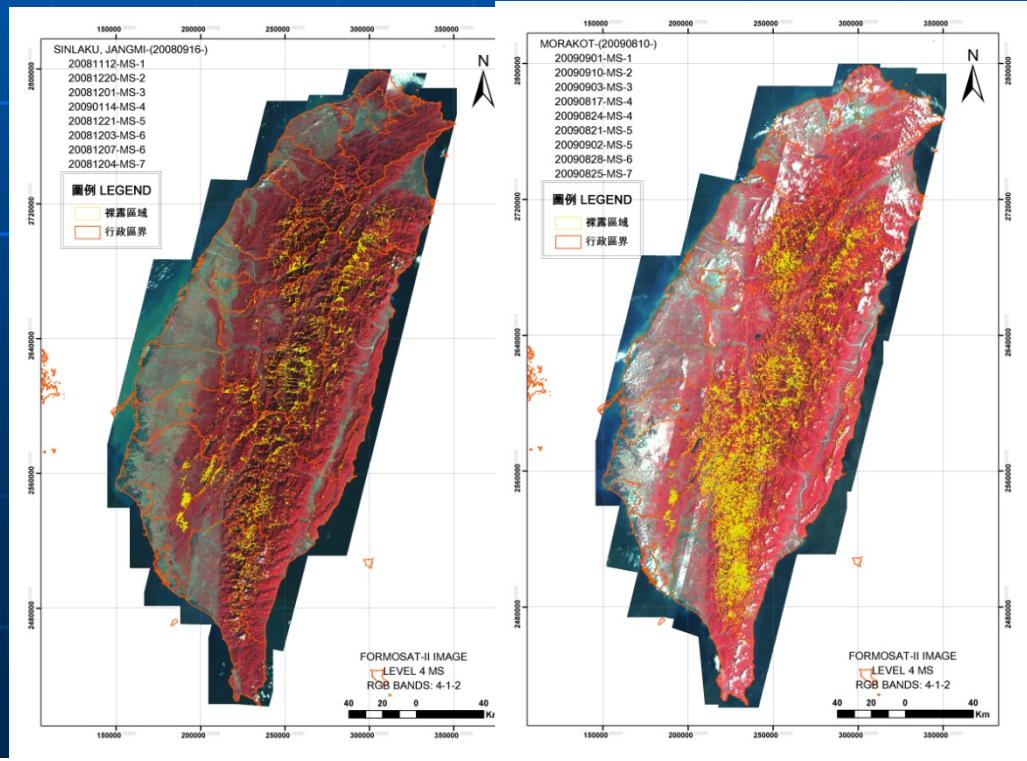


Fomosat-2 image taken after Typhoon Morakot (Aug. , 2009)



National LiDAR Mapping Project (2010-2015)

- Expecting to finish a complete coverage of Taiwan
- **National LiDAR Mapping is launched**
  - **2010-2012 LiDAR Mapping for Morakot hazard area**
  - **2012~2015 The rest of Taiwan will be surveyed**
- Optech ALTM-Orion
  - Optech ALTM-Gemini
  - Optech ALTM-Pegasus
  - Leica ALS60
  - RIEGL_LMS-Q680i
    - 2004 Optech ALTM 3070
    - 2004 Leica ALS50



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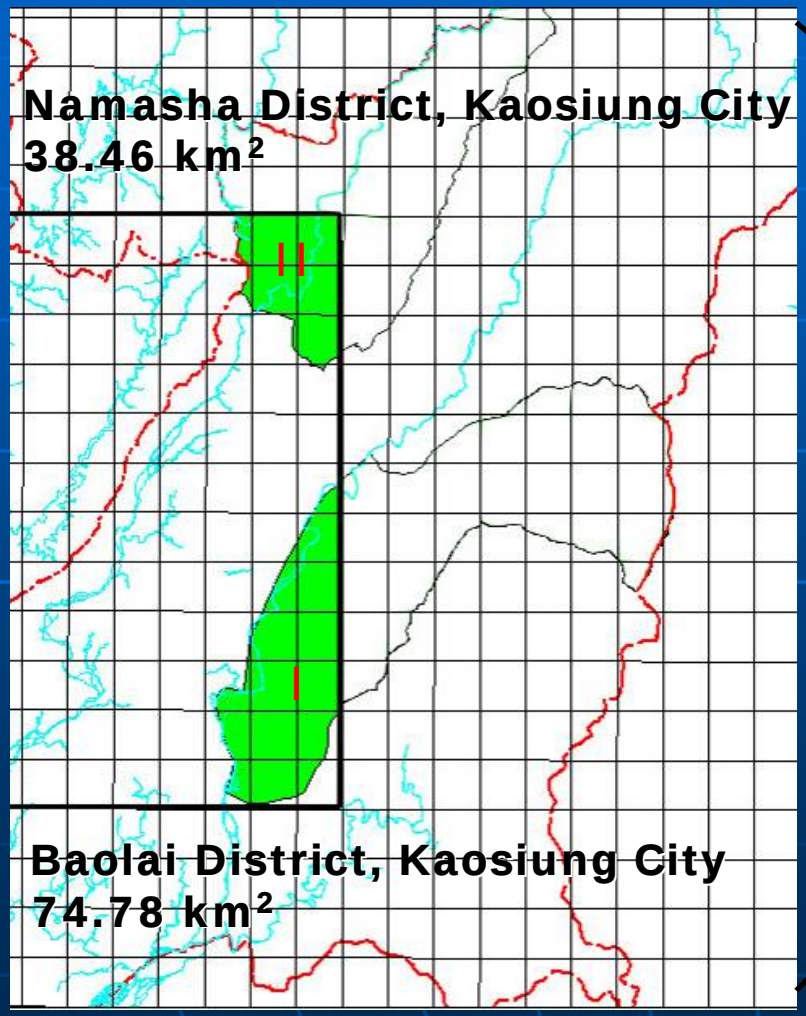
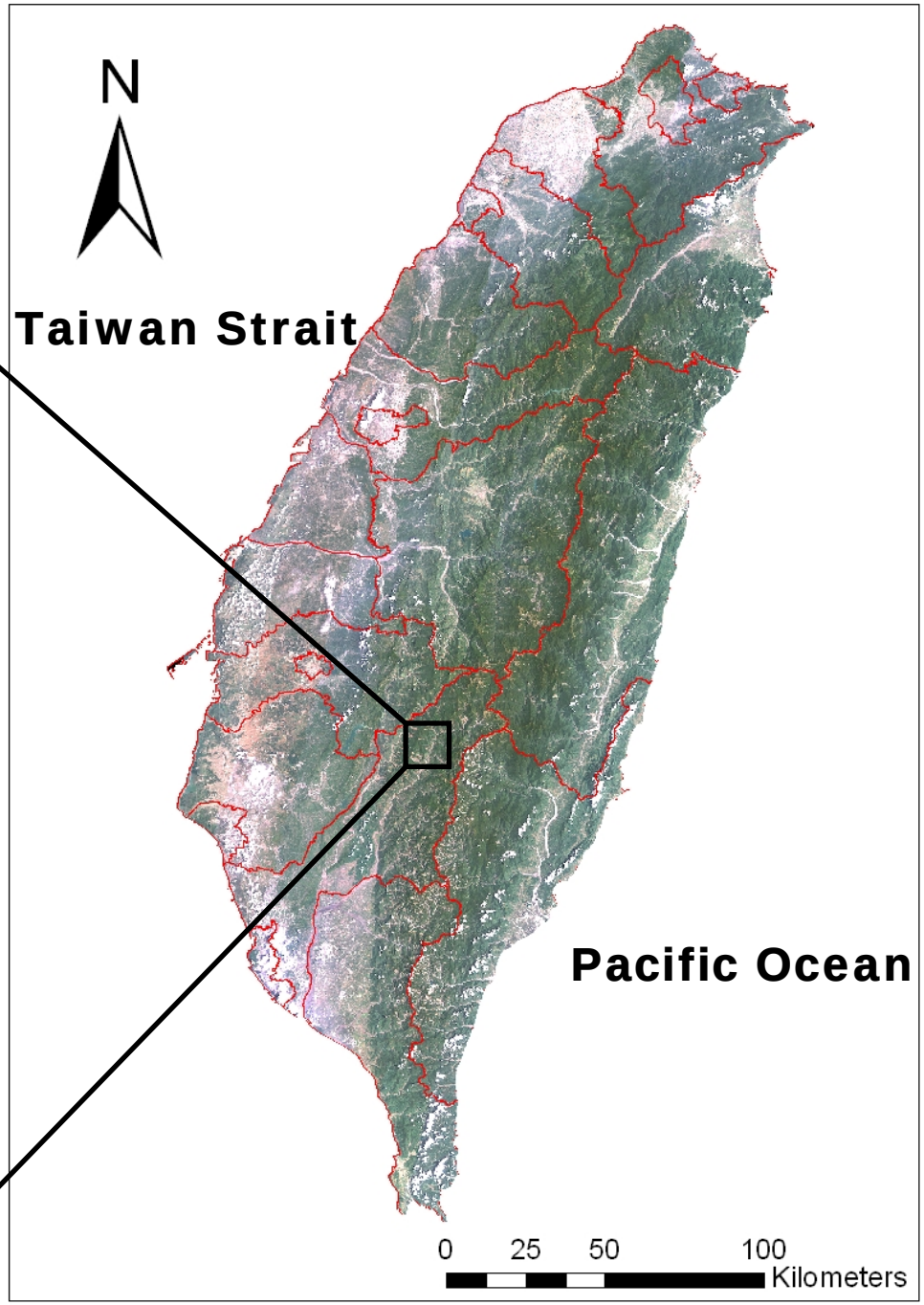
Background

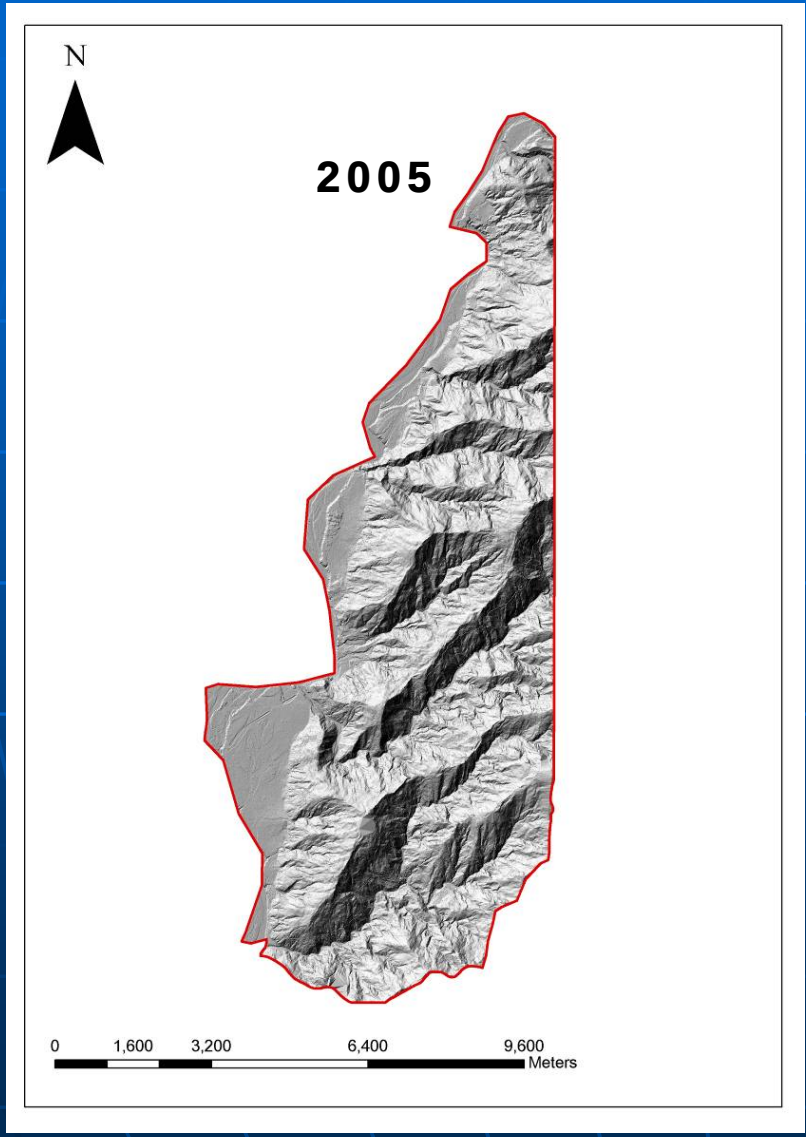
- On a regional scale, it is difficult and time consuming to measure the sediments induced by landslides for an extremely rainfall or catastrophic earthquake event.
- How much sediments induced by landslides is crucial in sediments yielding of a catchment, debris flow forecasting, and related hazards' assessment.
- Using multi-temporal LiDAR derived high-resolution DEM to examine the area-volume relation of landslides become possible.

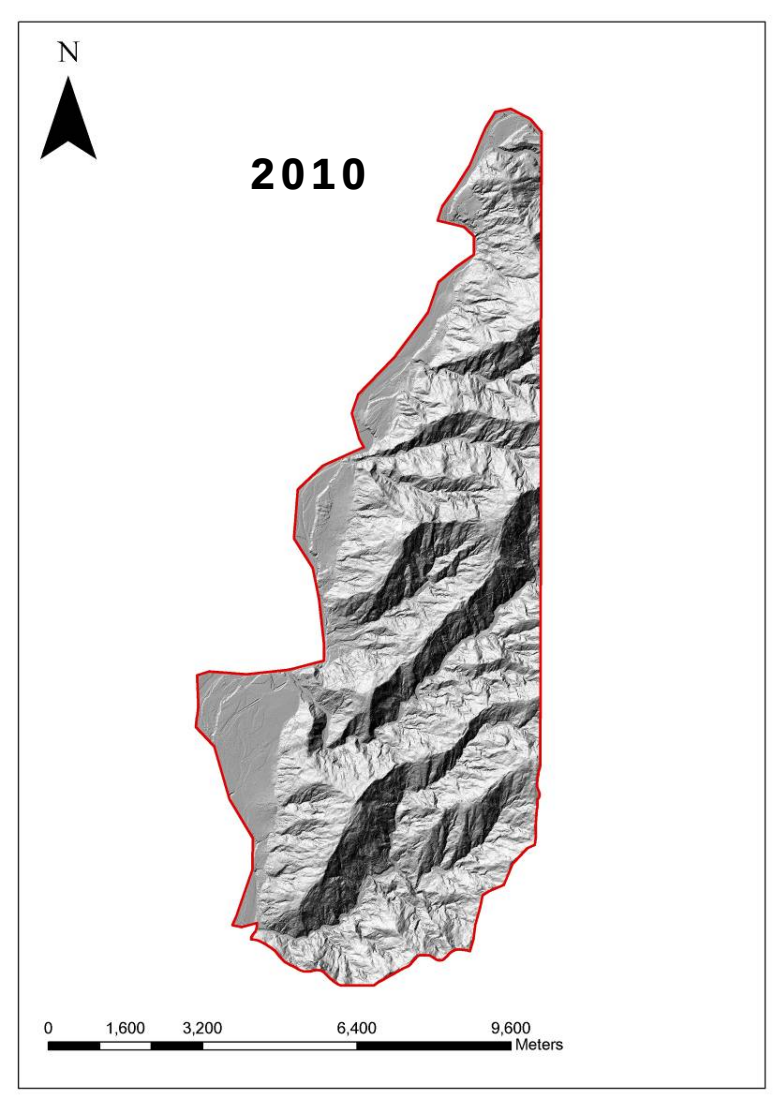
Study area





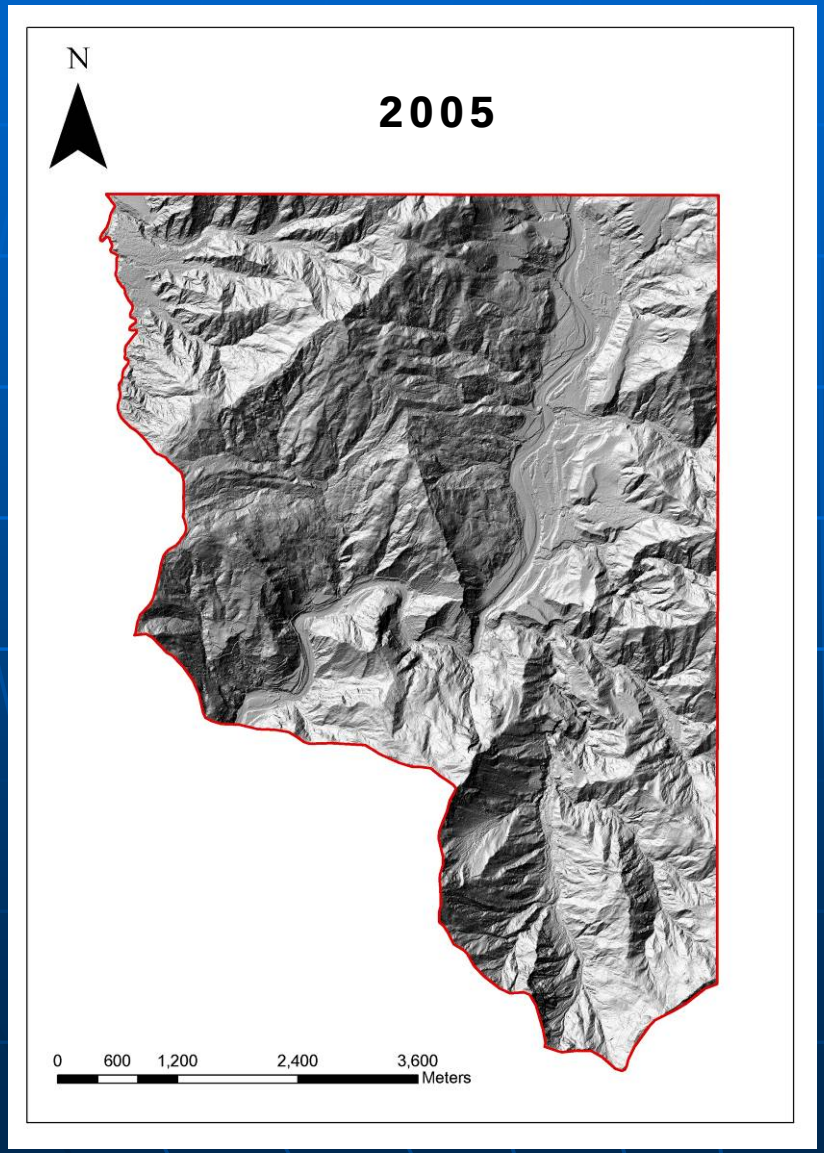
LiDAR-derived 2m DEM of the study area I

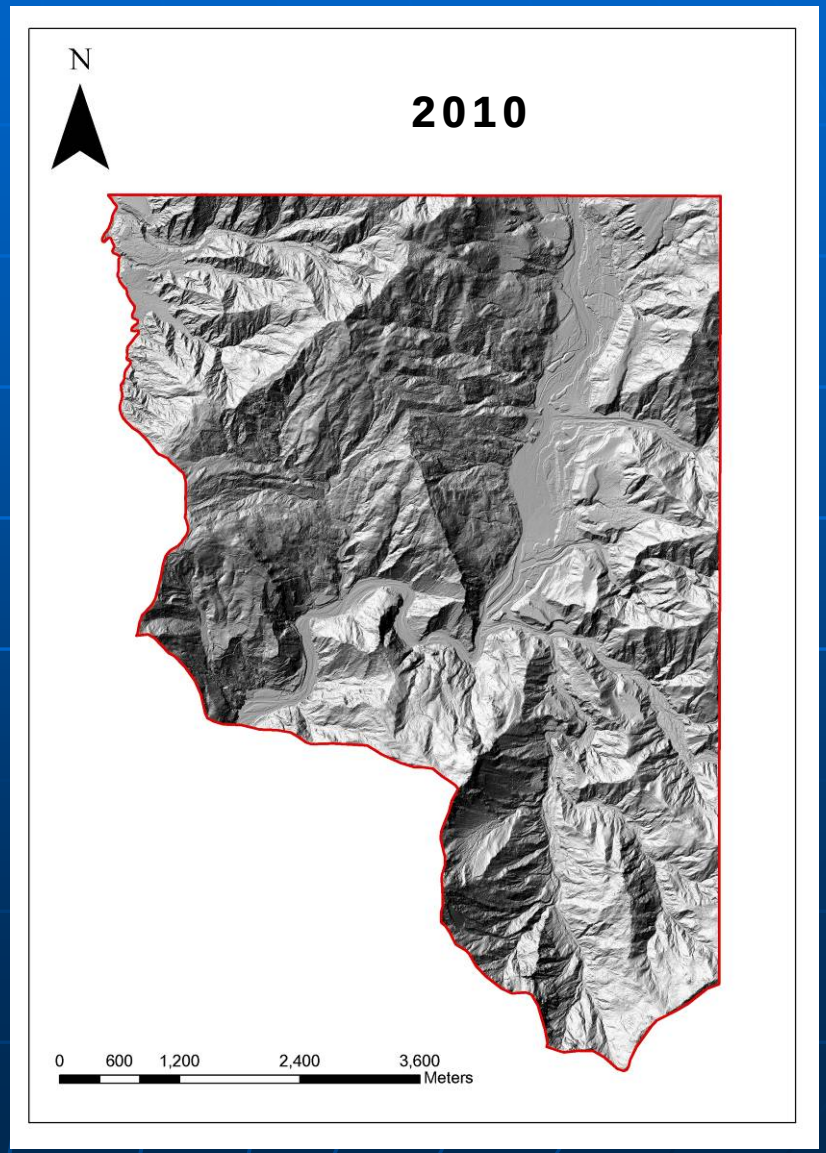




The error bar of elevation is within 20-30 cm.

LiDAR-derived 2m DEM of the study area II





LiDAR-derived DEM & DSM

2010: LiDAR DEM 2m

2010: LiDAR DSM 2m

Flow chart of data processing

Interpretated Typhoon Morakot-induced landslides in aerial photos

↓

Define individual landslide boundary in DEM

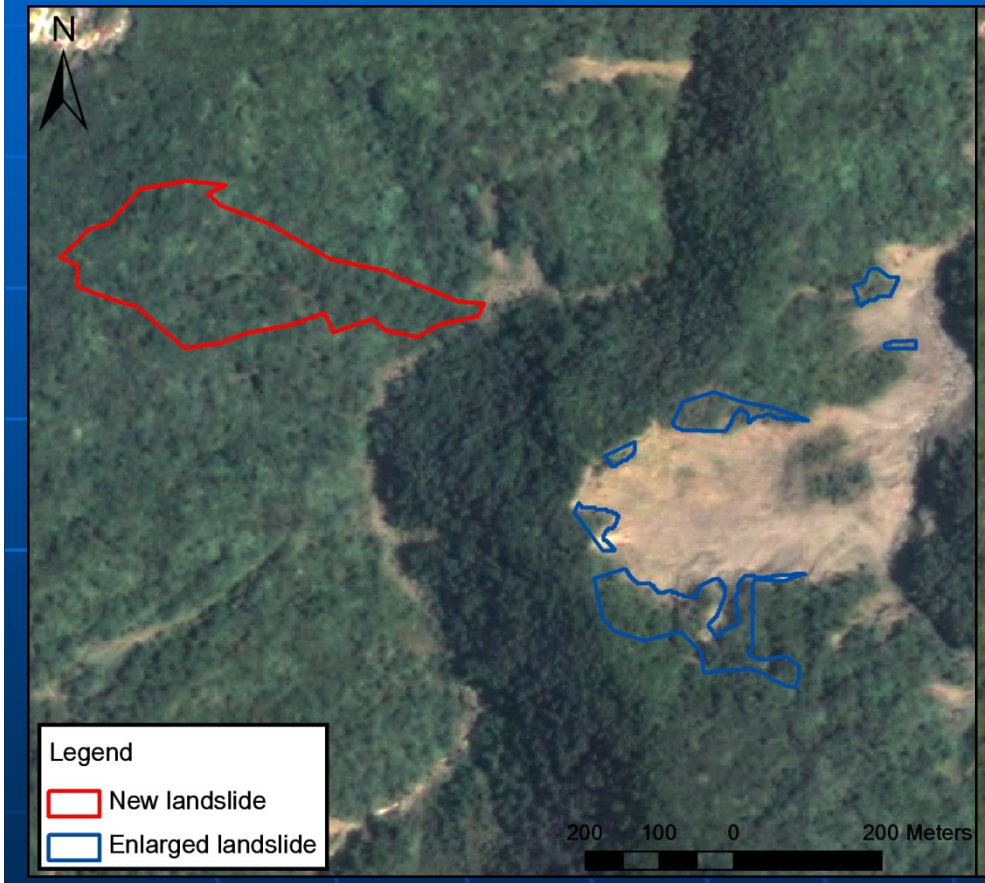
↓

Co-registration of two DEM and calculate volume of individual landslide

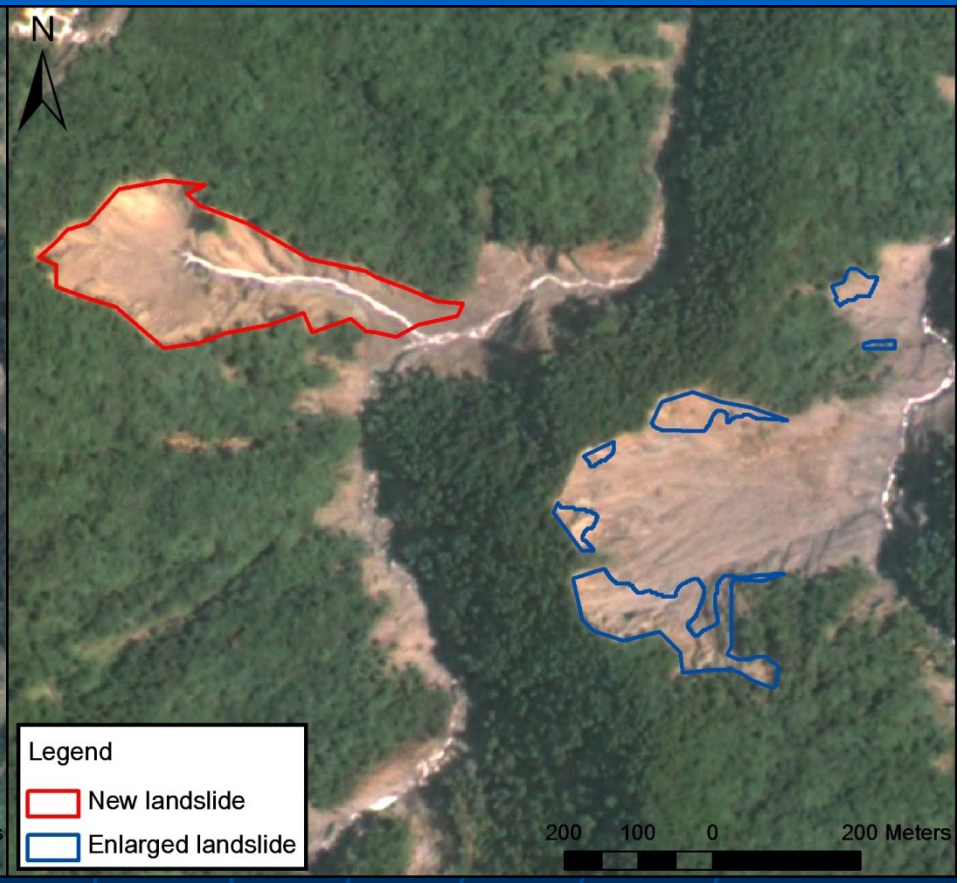
↓

Regression of landslide volume and landslide area $V = aA^b$

Landslides recognized from aerial photos took before and after Typhoon Morakot

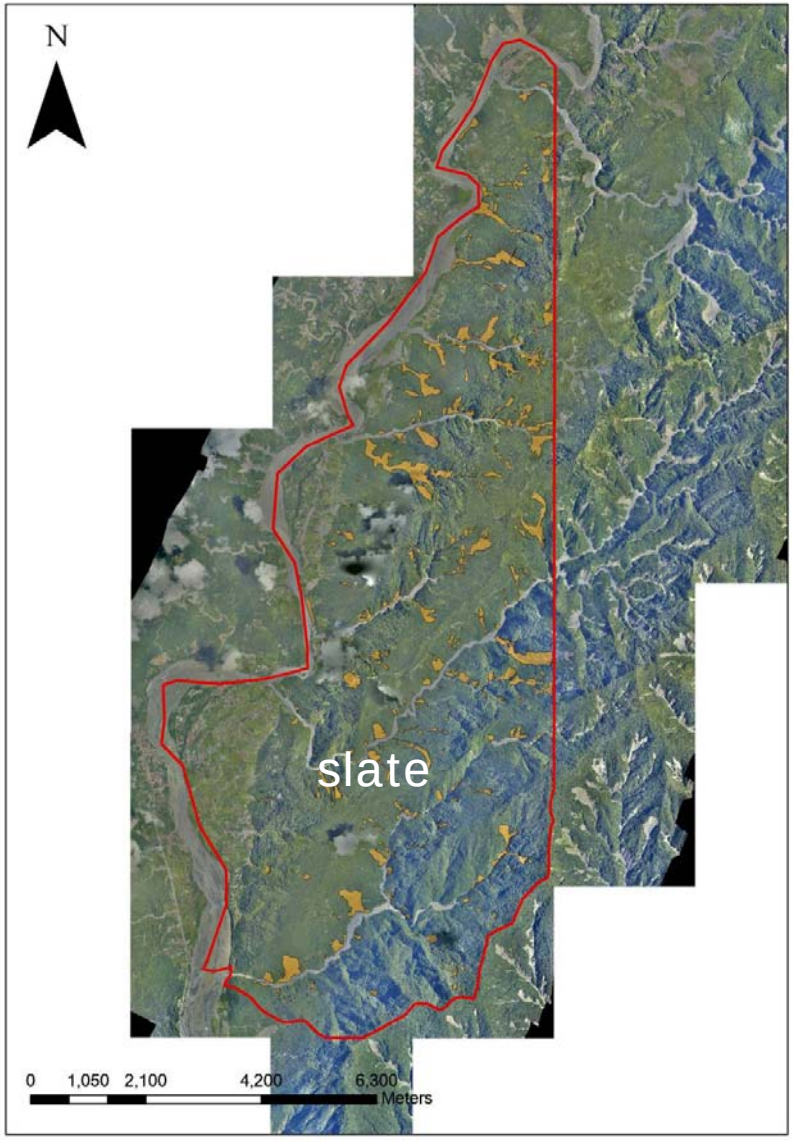


Aerial photo took
before Typhoon Morakot

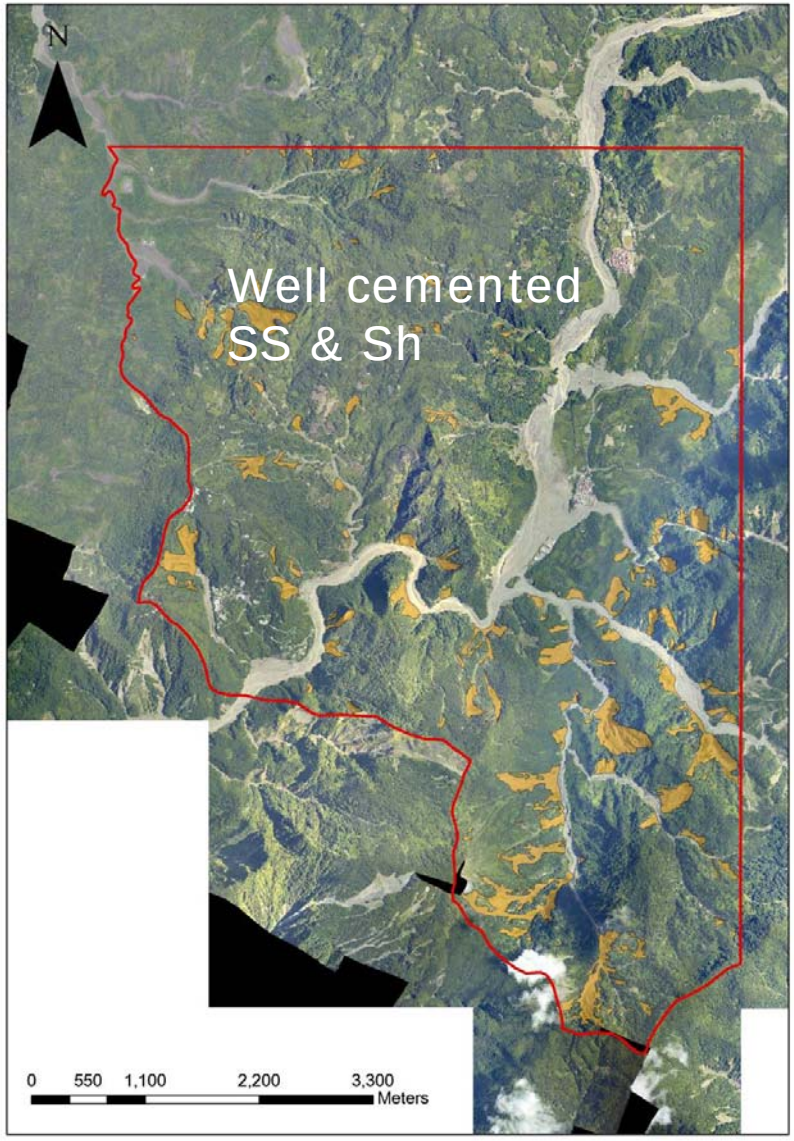


Aerial photo took
after Typhoon Morakot

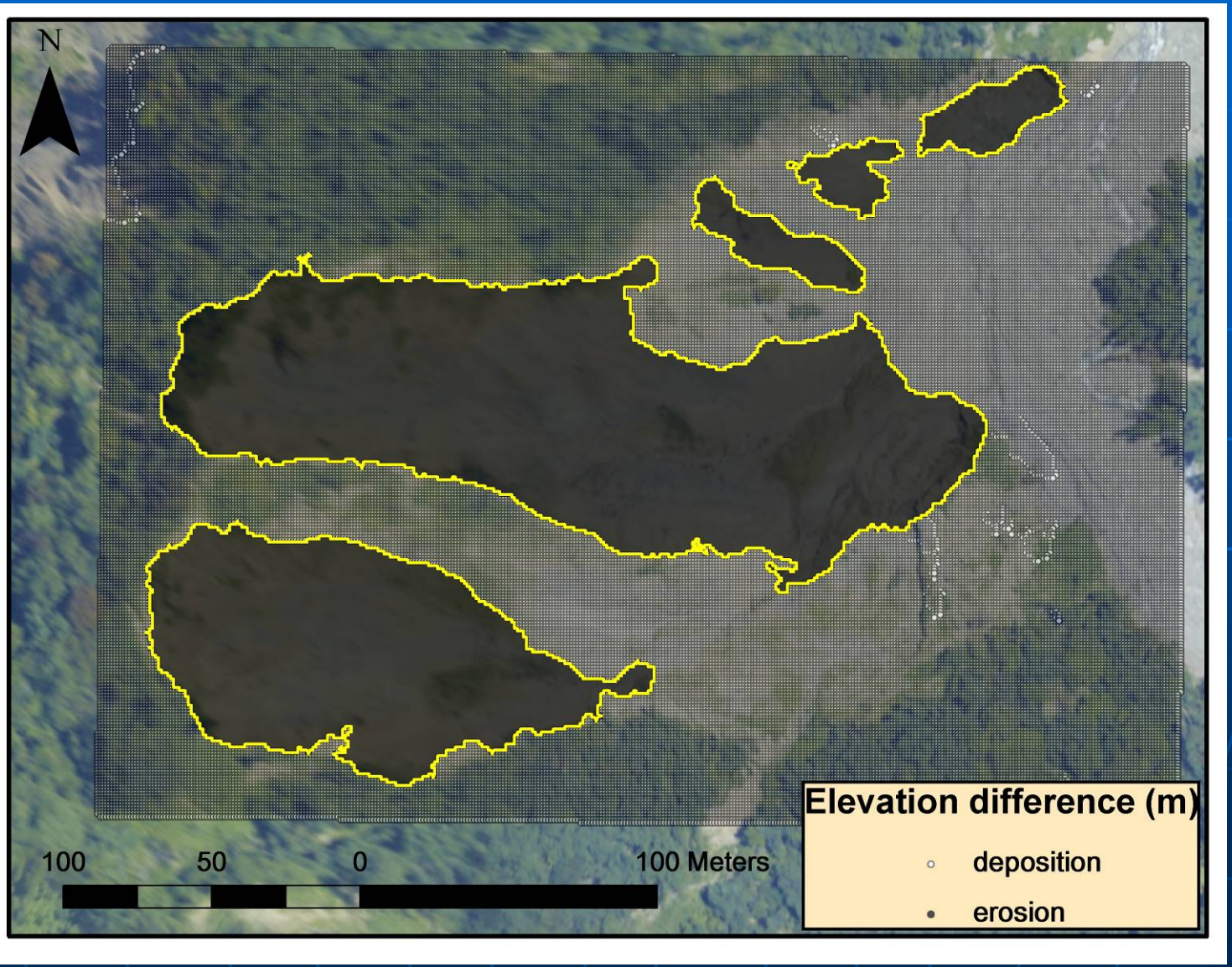
Landslide interpreted in study area I : 286 landslides



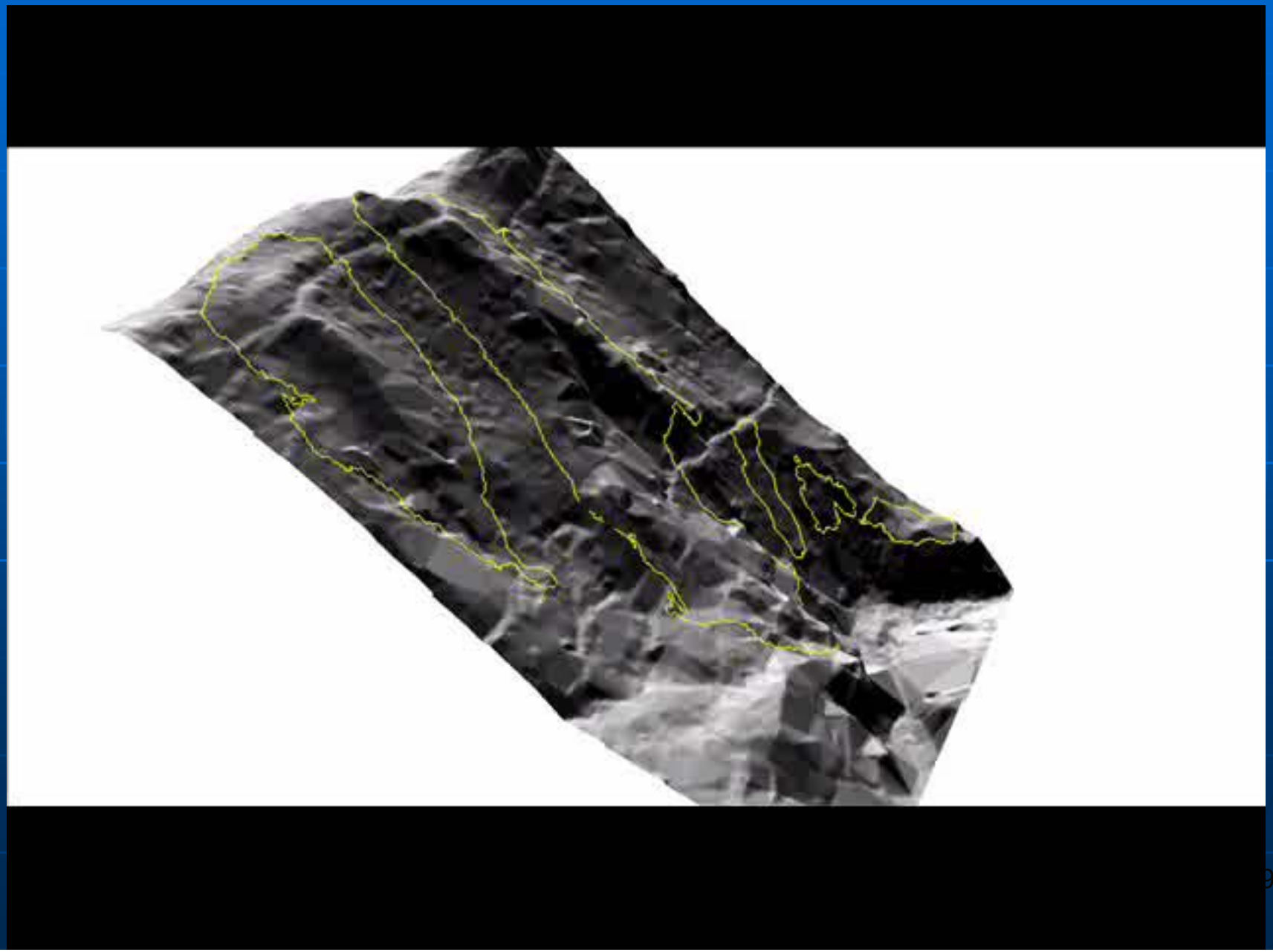
Landslide interpreted in study area II: 127 landslides



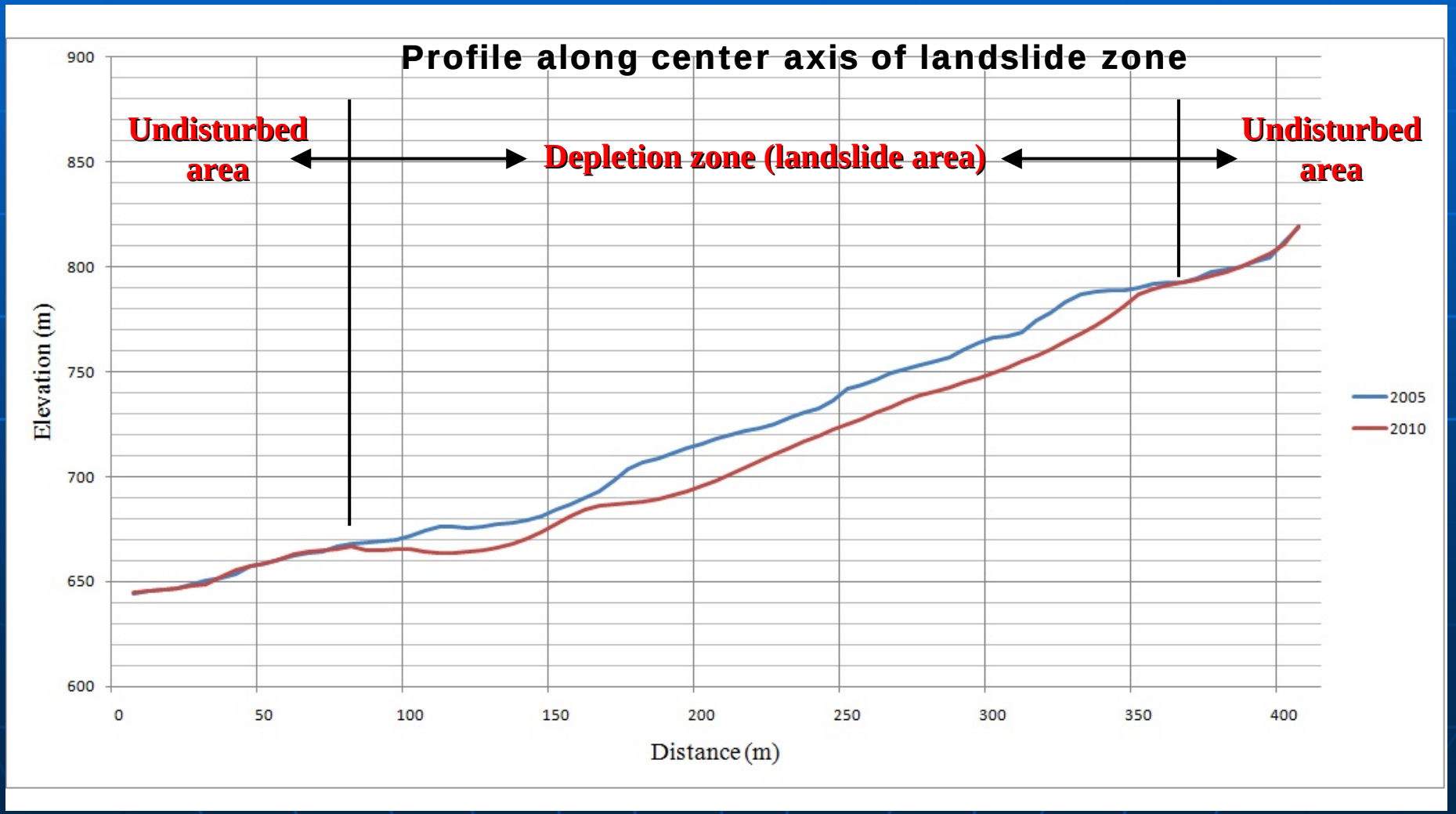
Defined individual Landslide boundary



3D DEM Variation_ with landslide boundary



Defined individual Landslide boundary



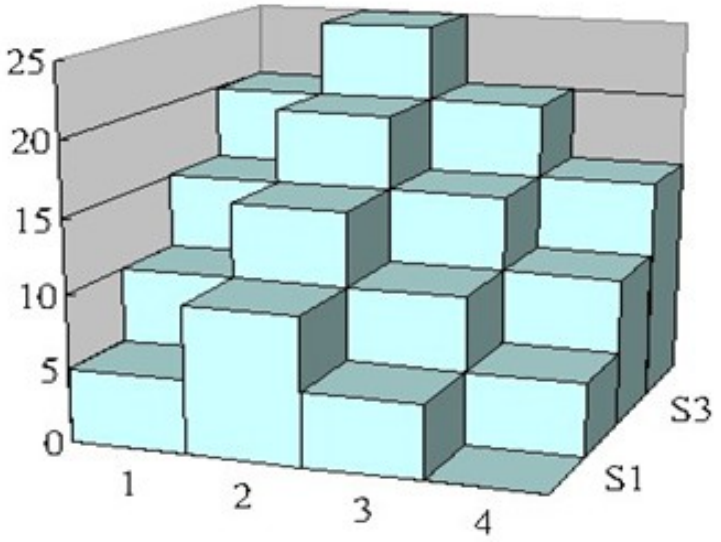
Estimation of individual landslide volume

$$V = A\left(\sum_{i=1}^{n} h_i\right)$$

$$A = cell\ area\ (m^2)$$

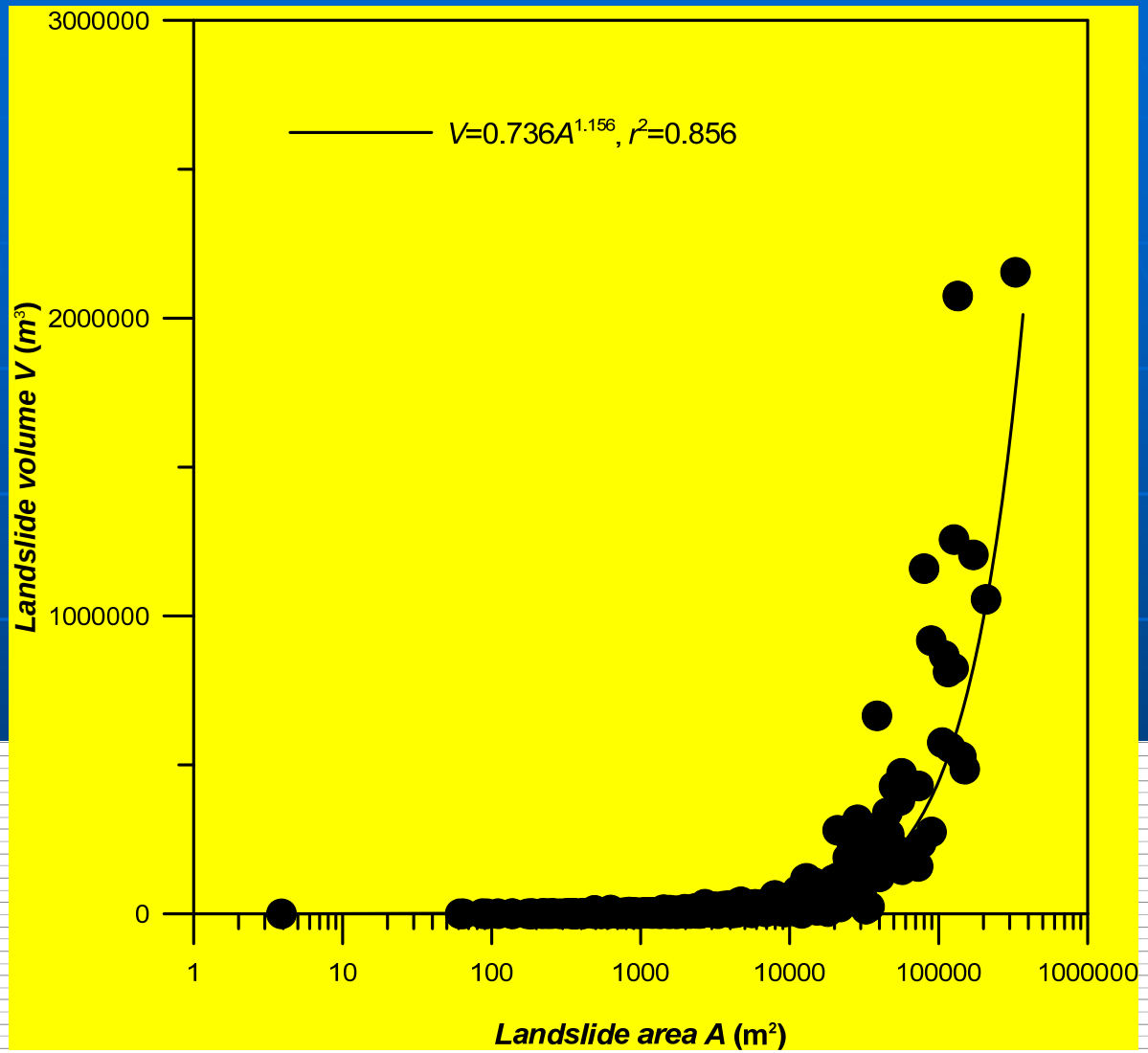
$$h_i = elevation\ \ difference\ (m)$$

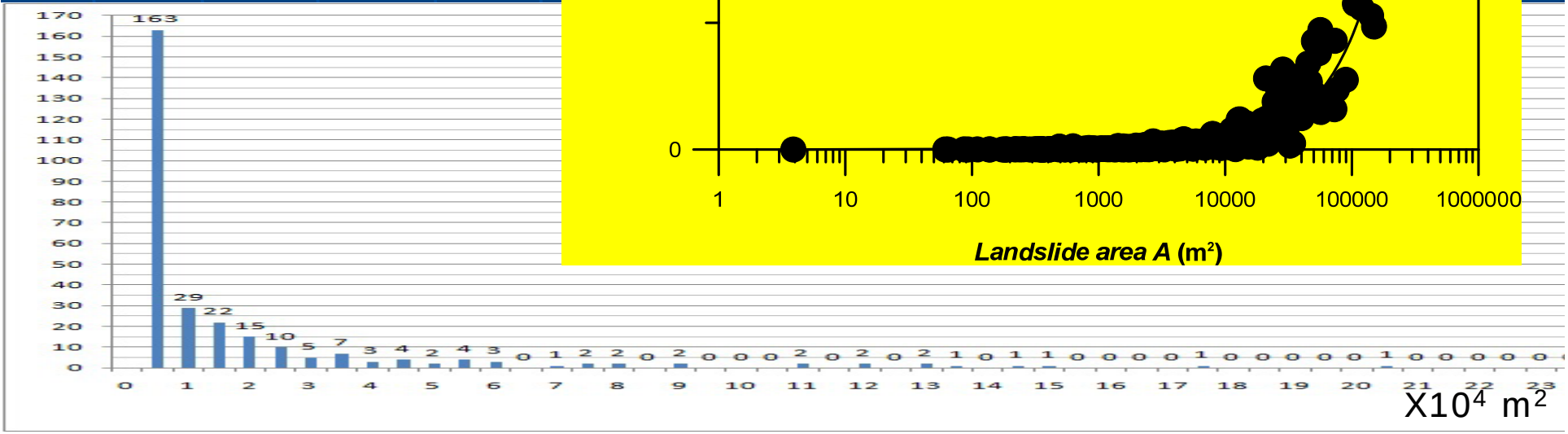
20	25	20	15
15	20	15	10
10	15	10	5
5	10	5	0



Landslide volume analysis

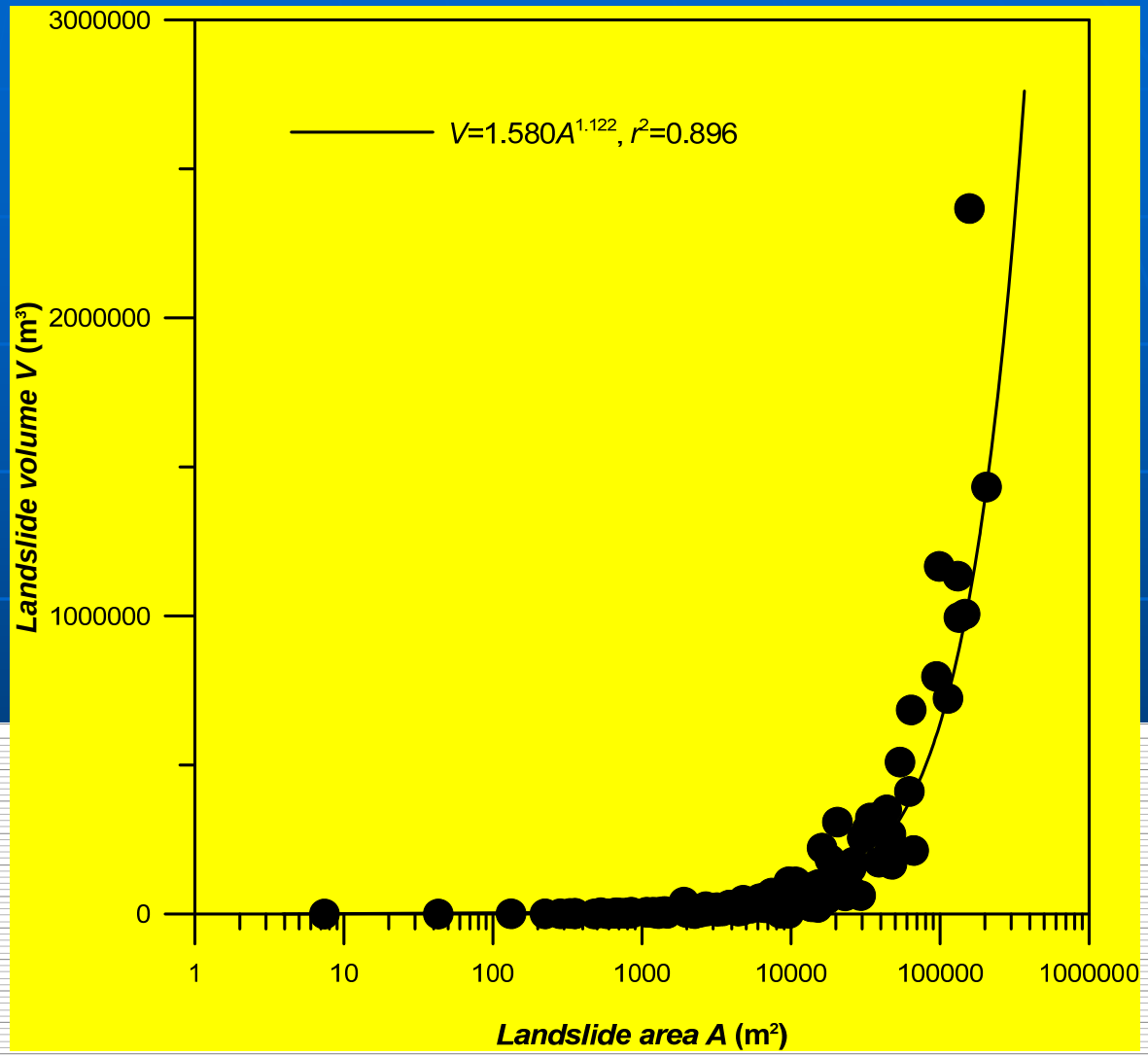
Baolai District (Study area I: slate) : 286 landslides

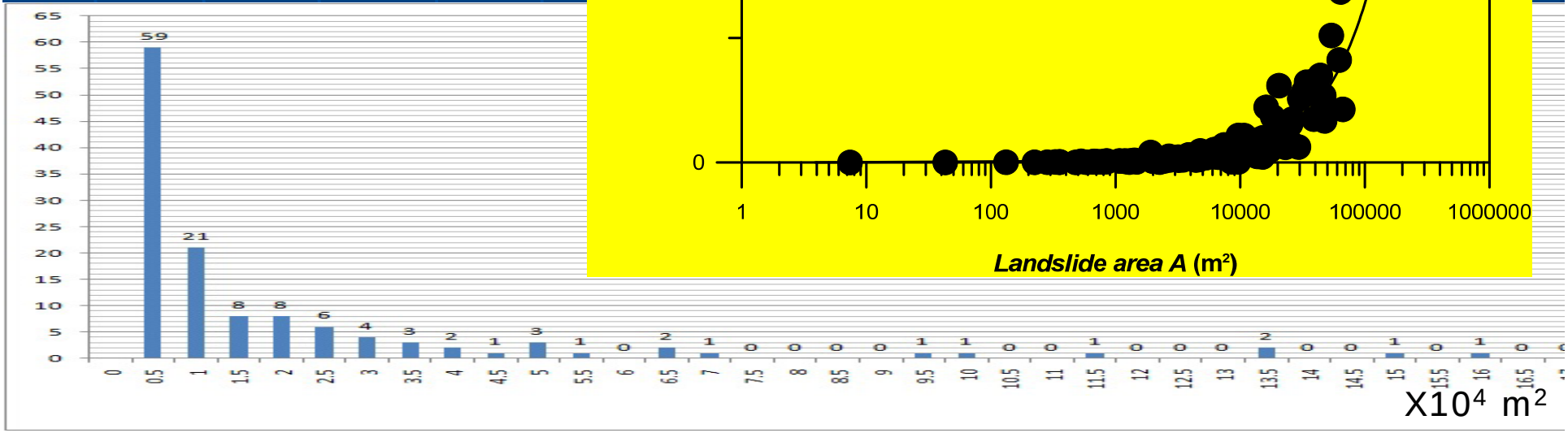




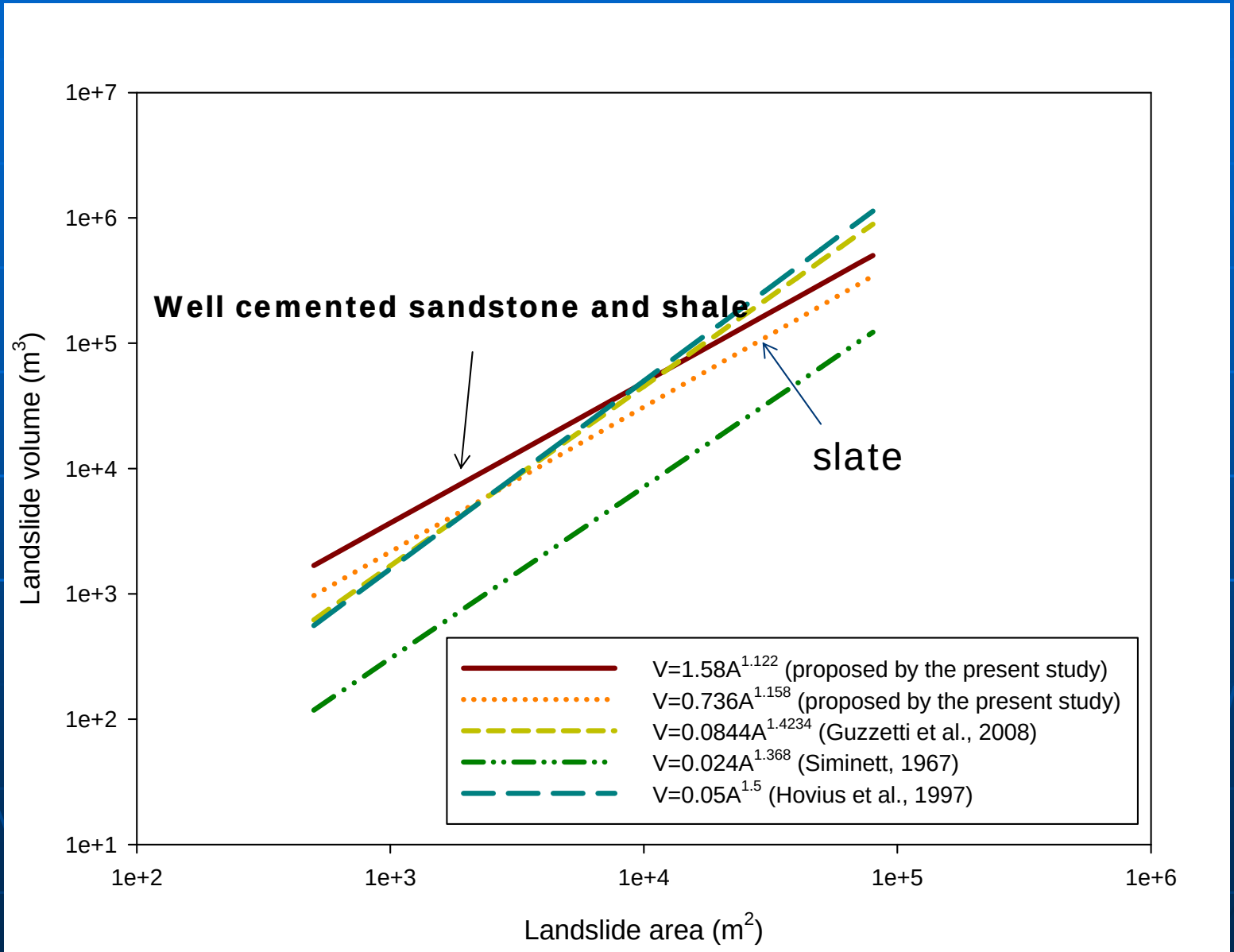
Landslide volume analysis

Namasha District (Study area II, well cemented SS and Sh): 127 landslides





Comparison of different empirical formulas



Conclusions

- Using two-temporal LiDAR-derived DEM can accurately obtain the debris volume induced by landslides.
- Empirical formula links failure area and debris volume for well cemented sandstone and shale, and slate are obtained in this study.
- Emperical formular for different lithology will be obtained in our National LiDAR Mapping Project.

Thanks for your attention