FIG WORKING WEEK 2023
28 May - 1 June 2023 Orlando Florida USA
Protecting Our World, Conquering New Frontiers

Presented at the FIG Working Week 2023,
28 May - 1 June 2023 in Orlando, Florida, USA

The Disaster Management of Large Scale Landslide:

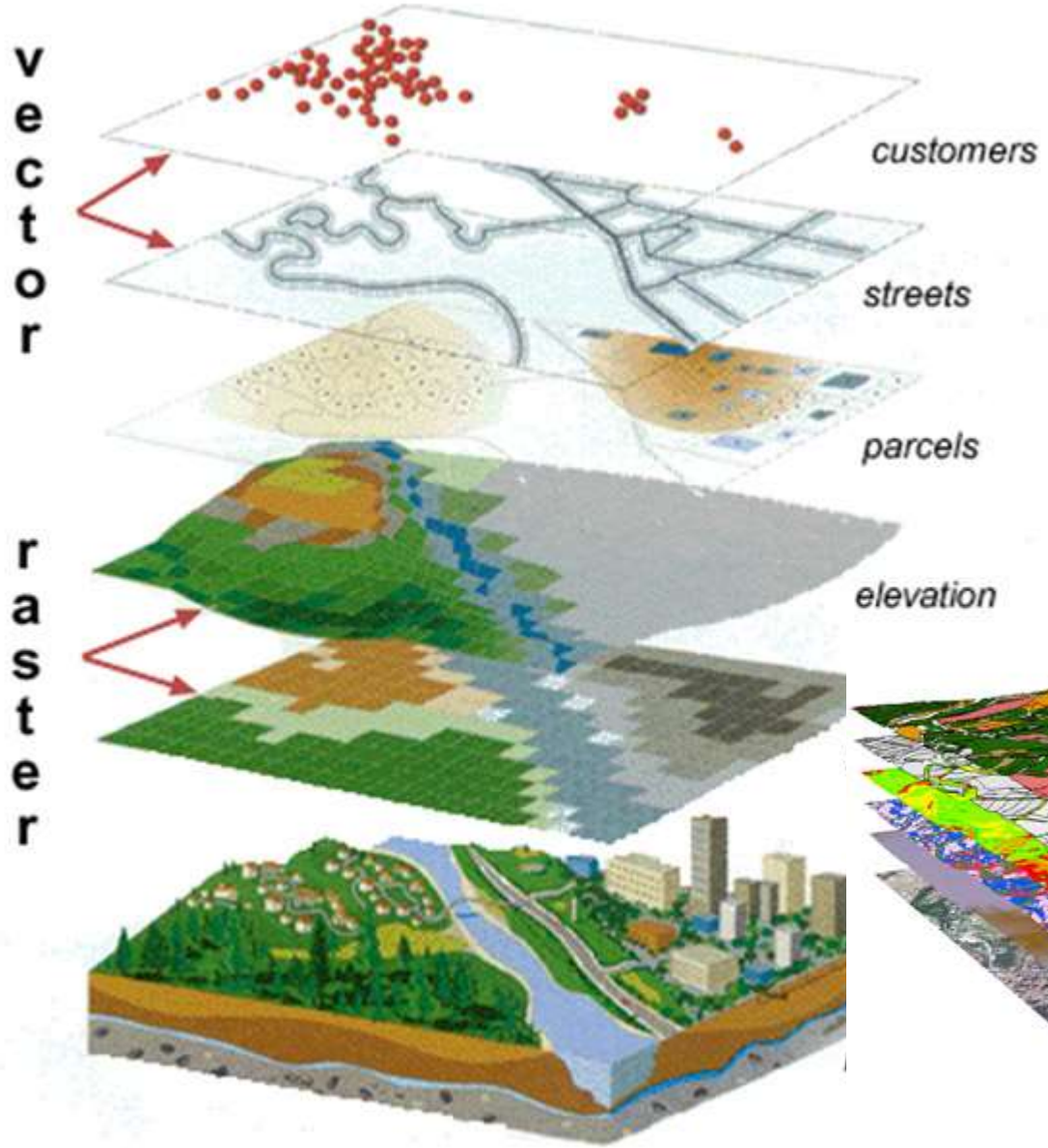
A Case Study of Debris Flow Early Responding Systems

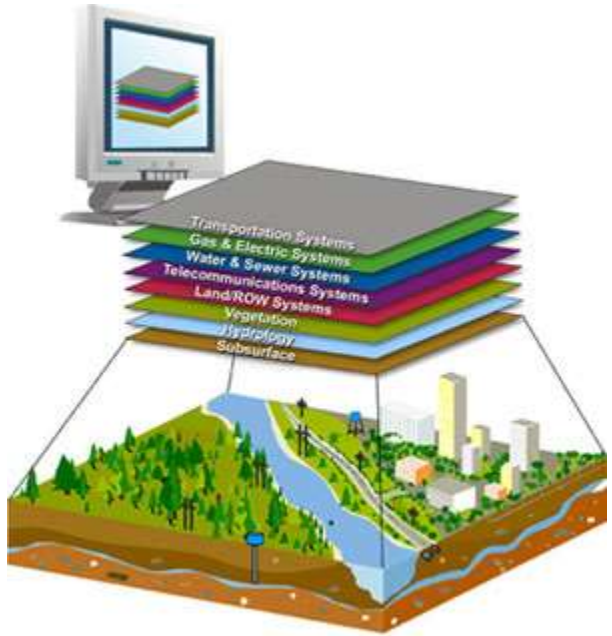
Tien-Yin Chou
Director / Lifetime Distinguished Professor
GIS Research Center, Feng Chia University, Taiwan

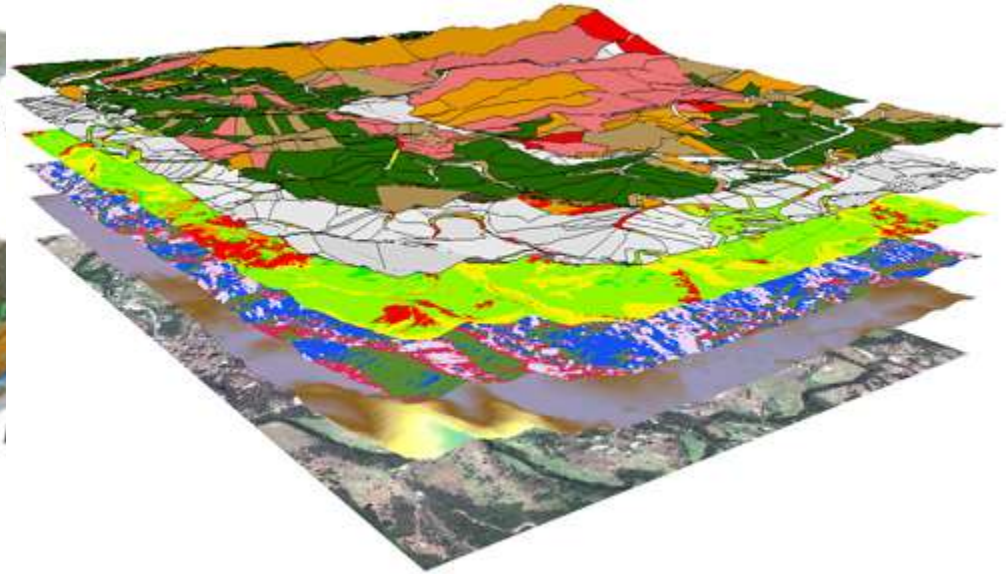
Chen-Yang Lee
Director General, Soil and Water Conservation Bureau, Council of Agriculture, Taiwan

Organized By NSPS FIG INTERNATIONAL FEDERATION OF SURVEYORS
Diamond Sponsors esri THE SCIENCE OF WHERE Trimble

Real World – Complex Information…







Sustainable Environment Monitoring and Management

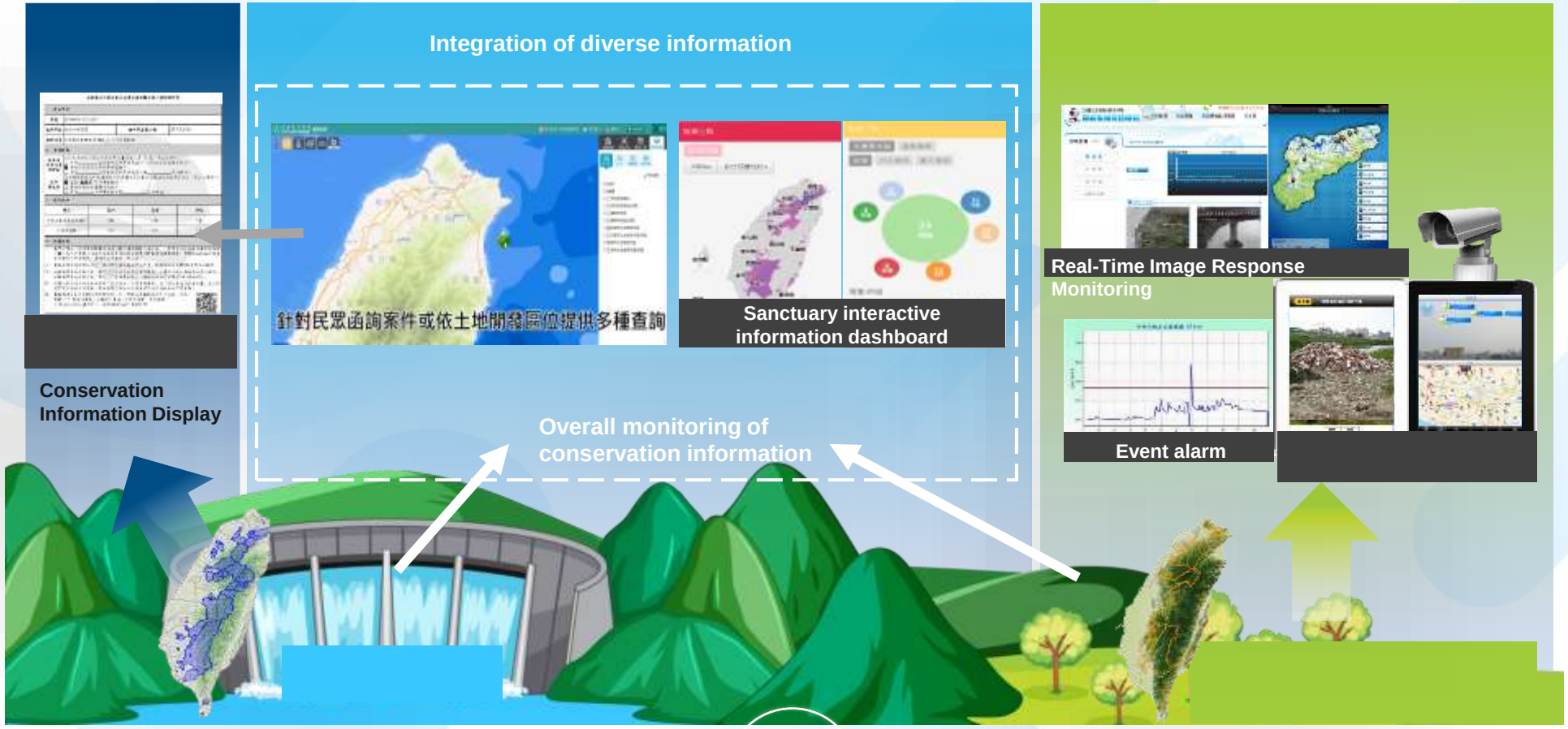
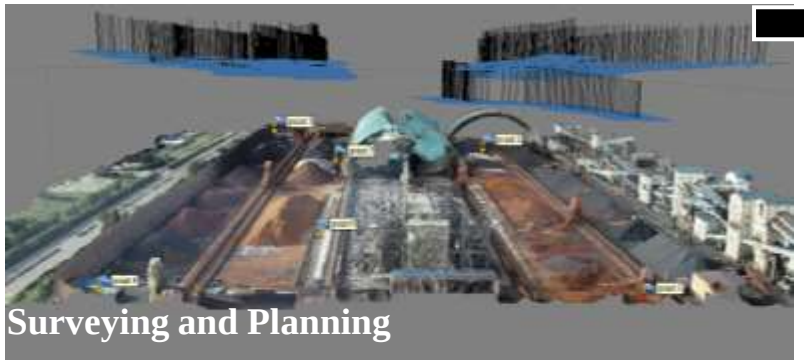
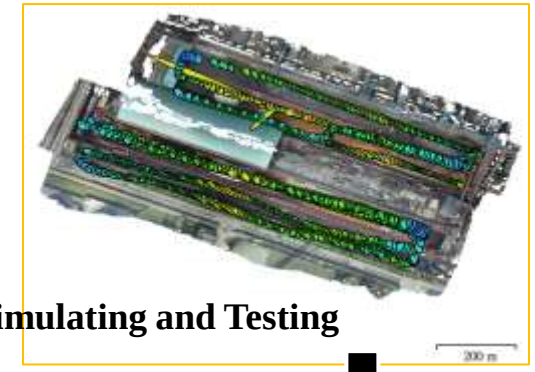
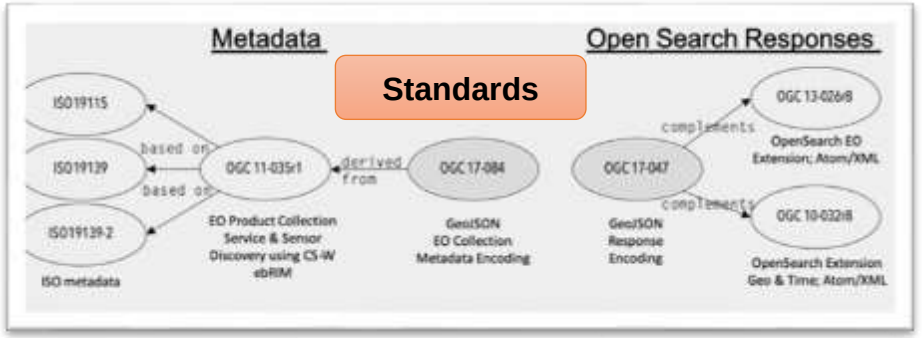


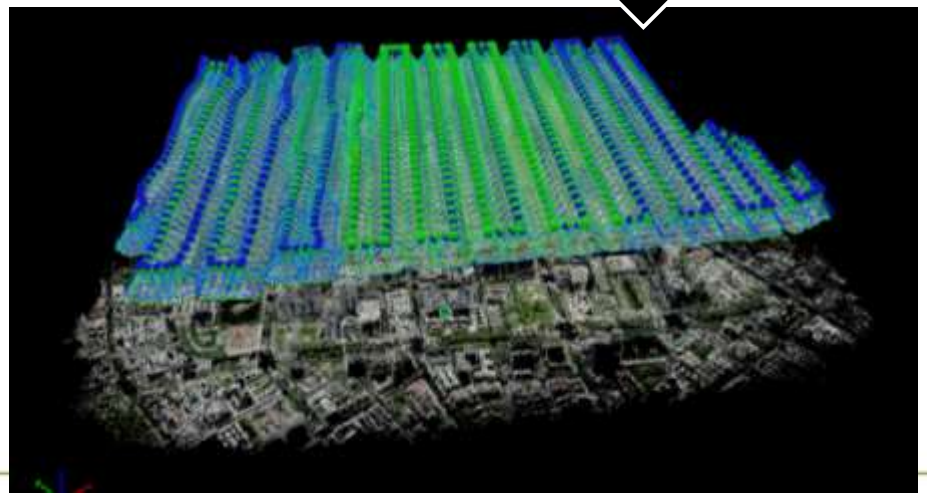
FIG Working Week 2023
28 May - 1 June 2023 Orlando Florida USA
Protecting Our World, Conquering New Frontiers

National Geospatial Strategy and Digital Twin Application



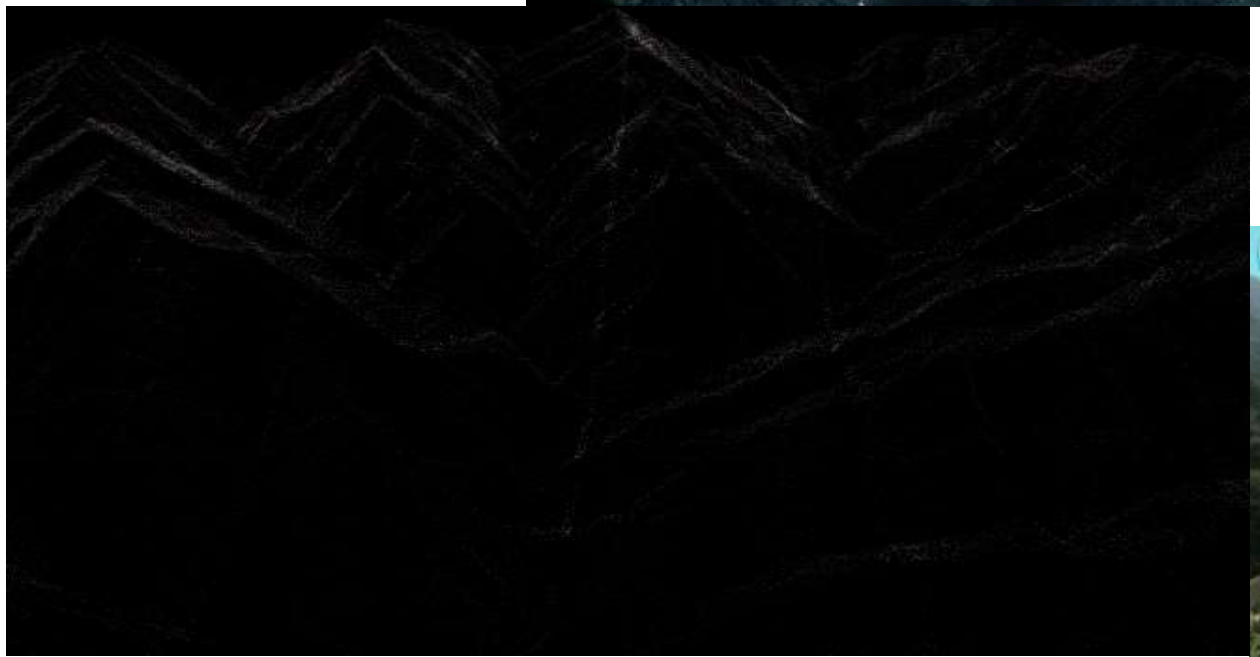


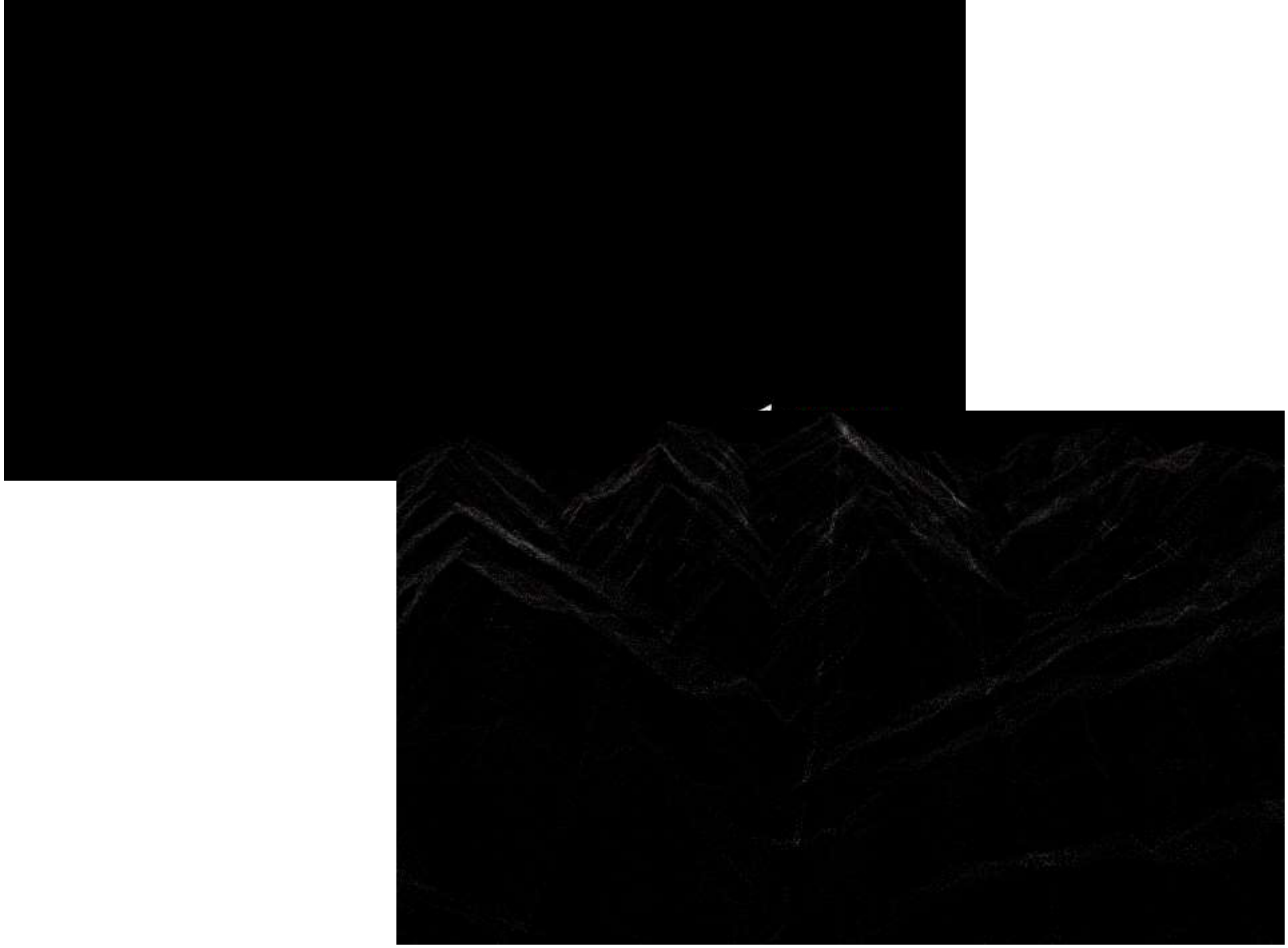




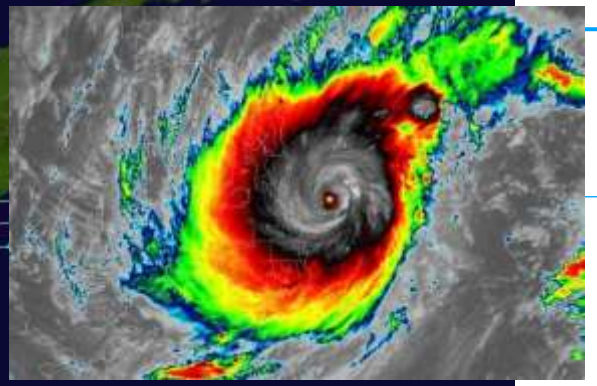
Path planning → Build navi-points → Convert points to GeoJson

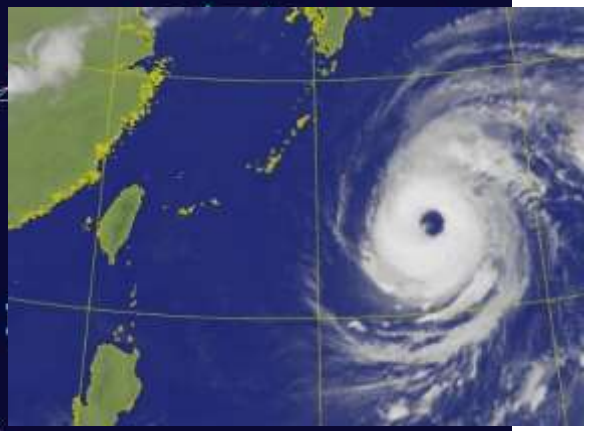
Multi-Scale & Multi-Dimensional

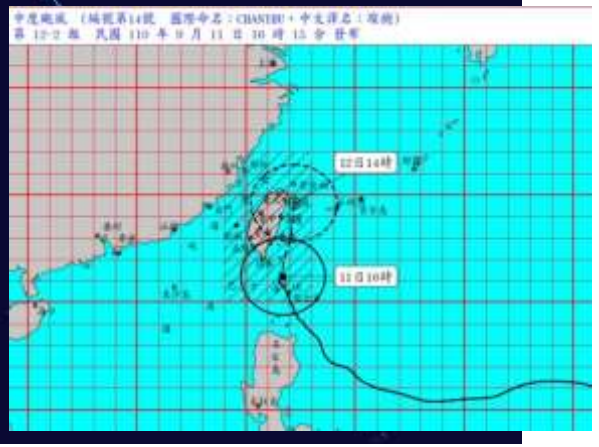




Typhoons

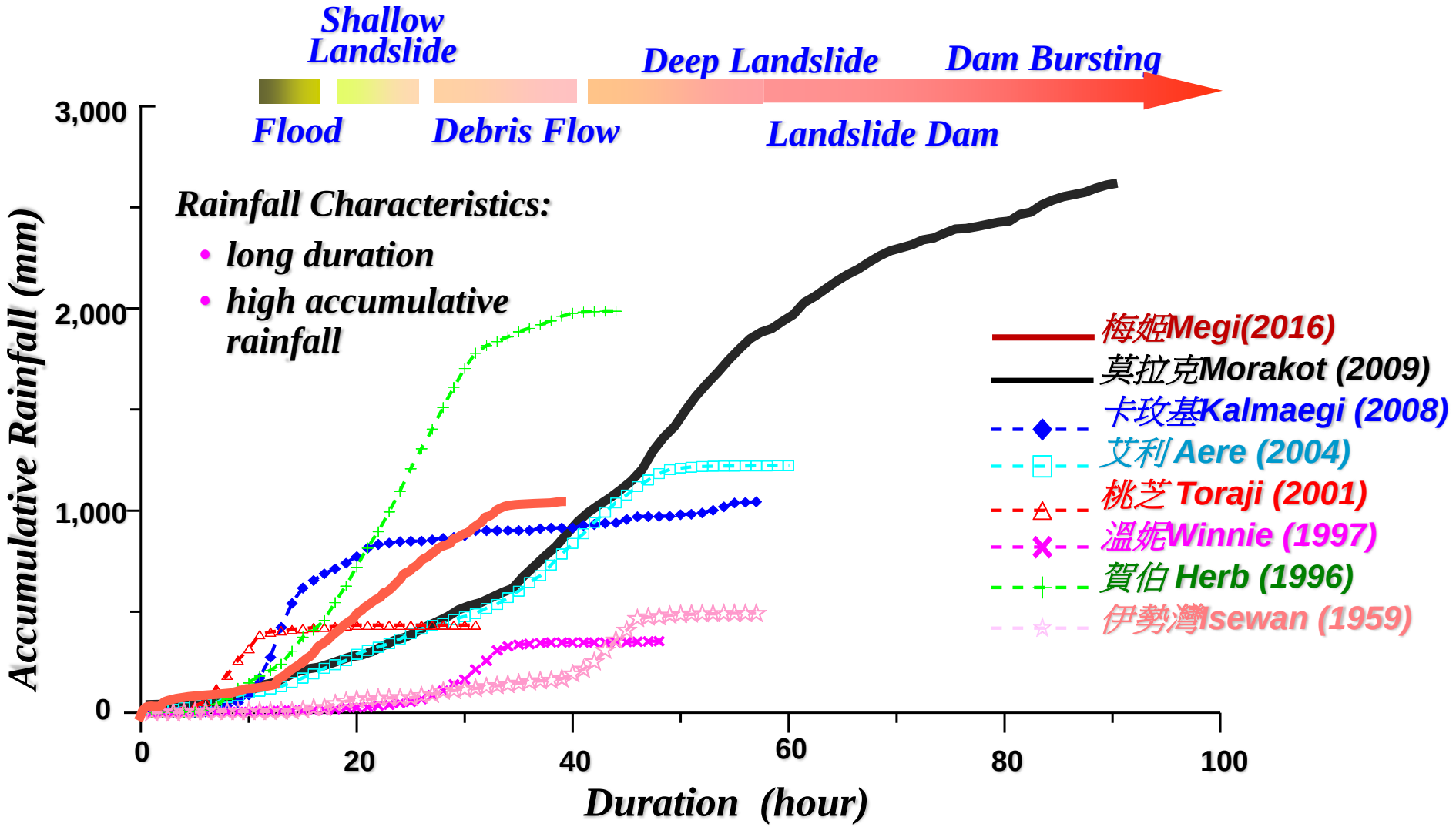






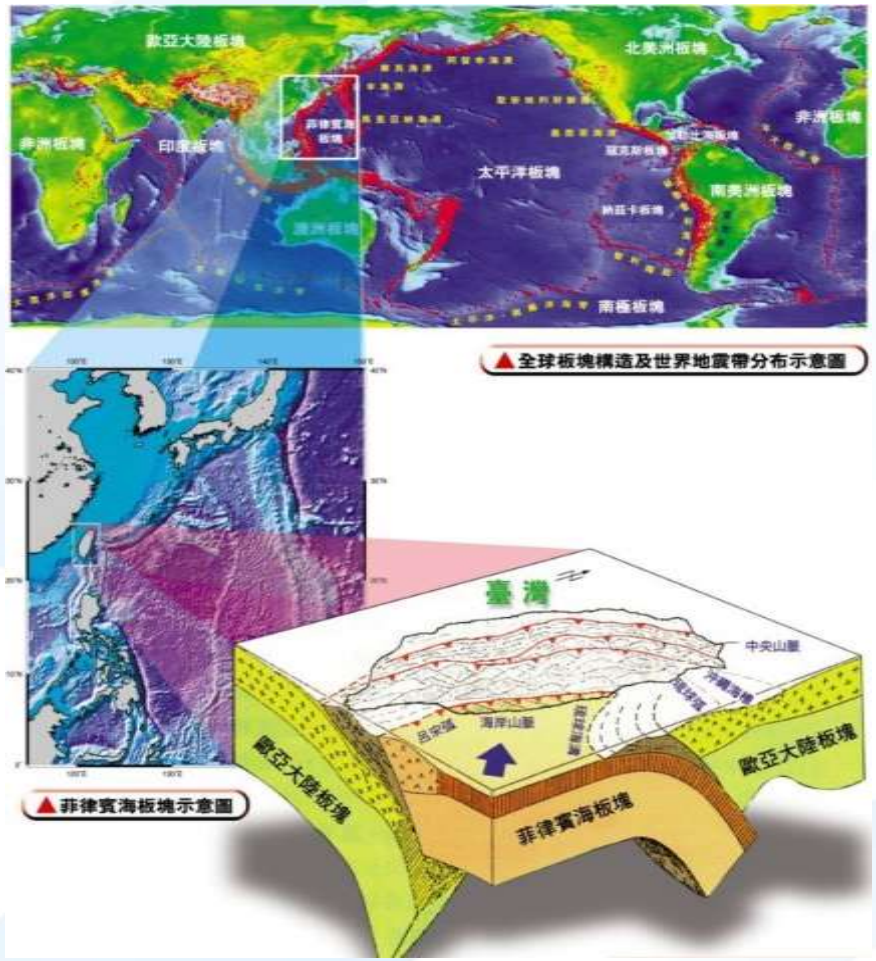
Rainfall-Duration Curve of Typhoons

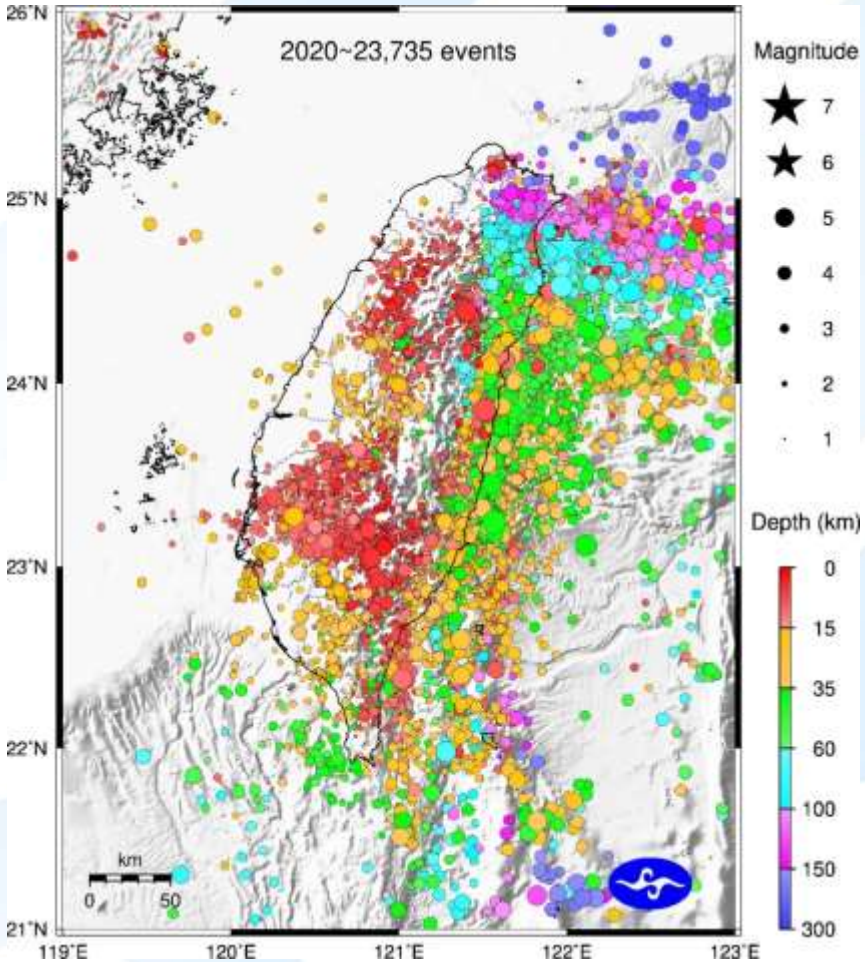
Compound Hazards



Seismicity in Taiwan

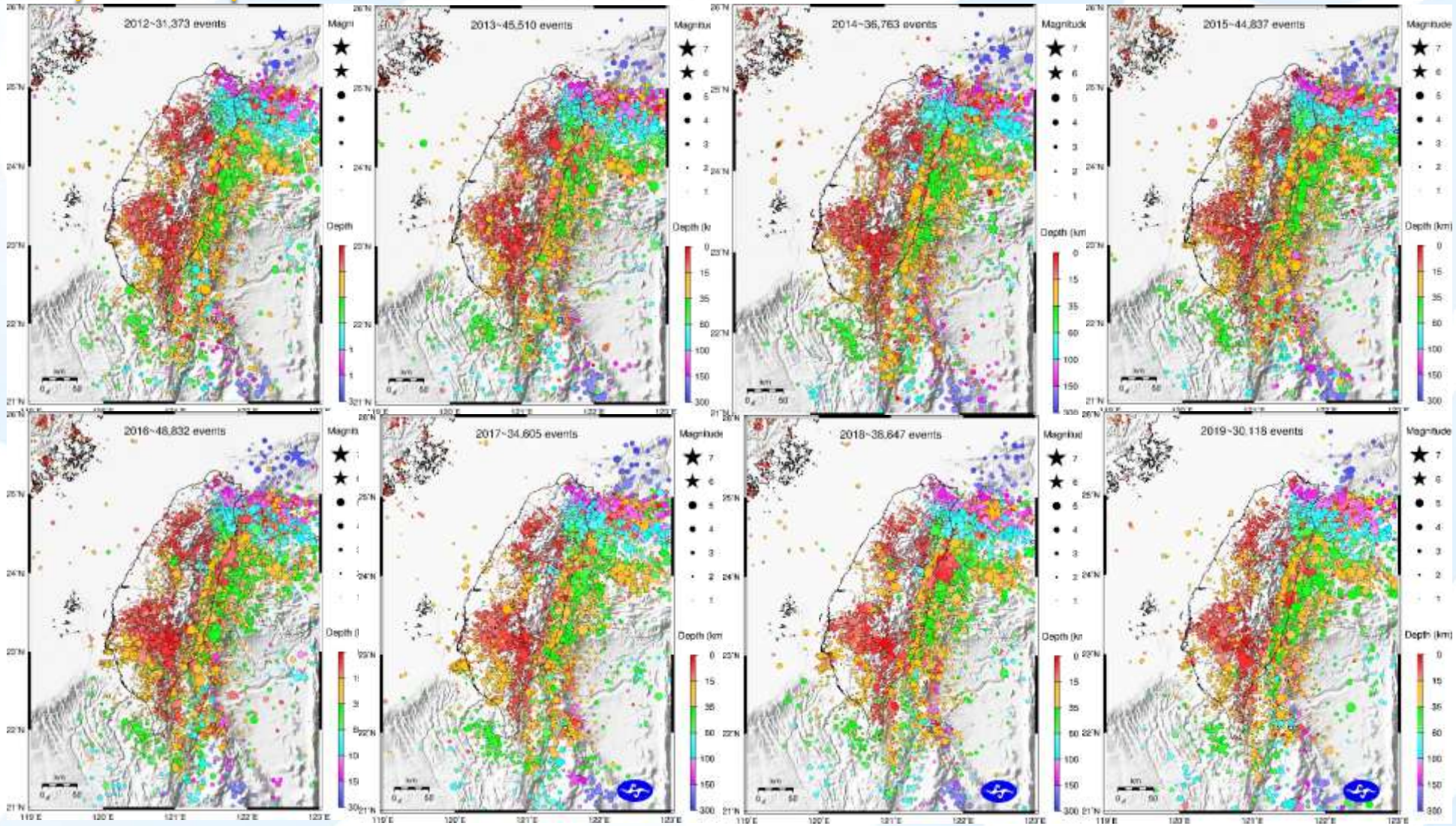
Tectonic plates and faults





Seismicity in Taiwan

How many earthquakes occurred in Taiwan ?



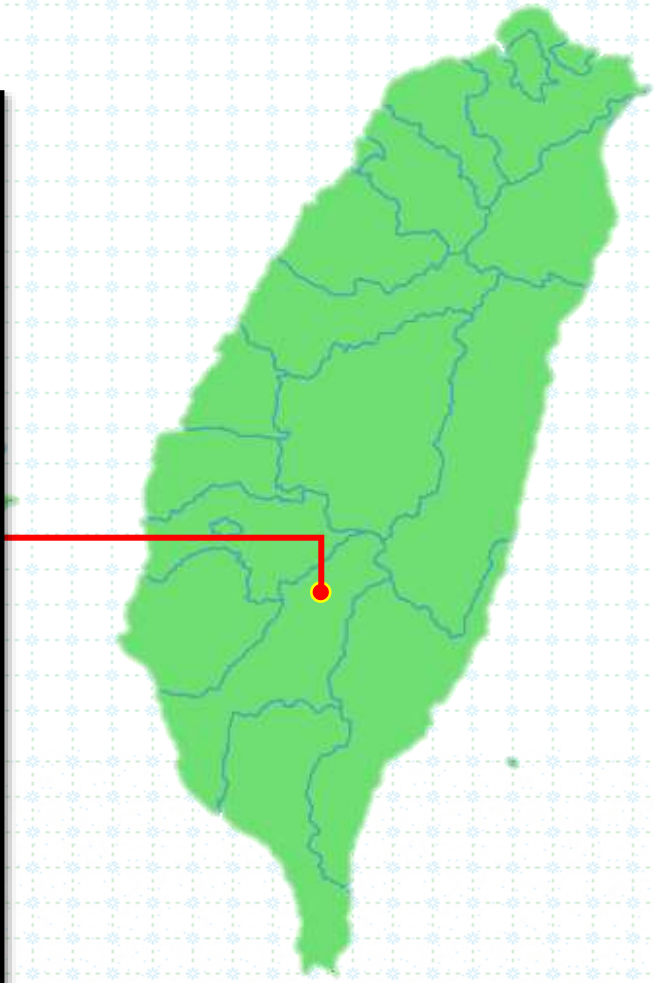
ELEVEN

全家 FamilyMart

Landslide and Debris Flow Disasters in Taiwan

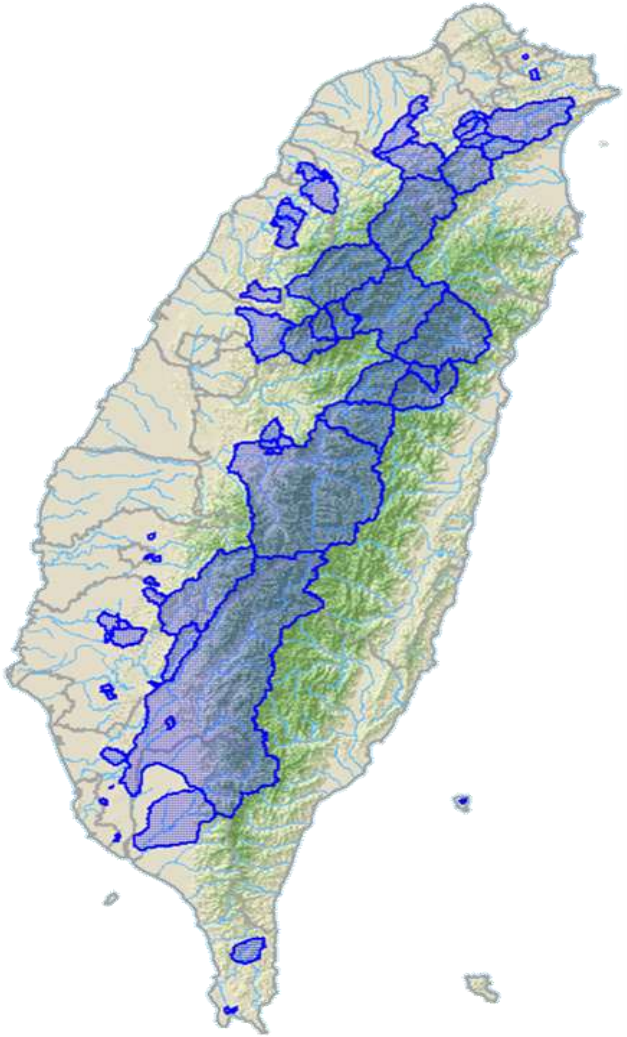
2021 Mingbakelu Bridge Disruption Incident in Kaohsiung

2021.08.07 Tropical Storm Lupit



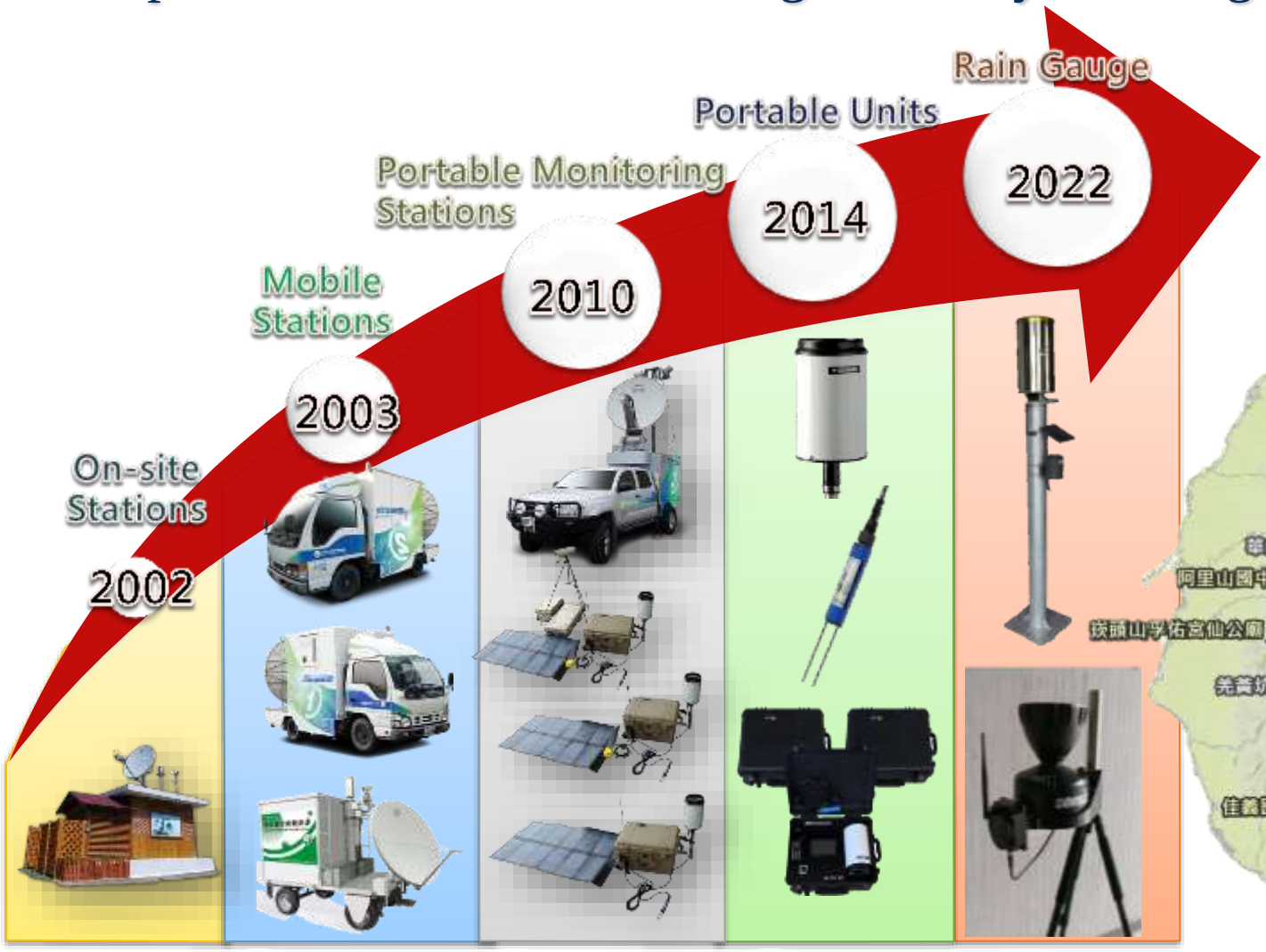
影片來源：公視/我們的島

What we've concerned



- Environmental monitoring
  - Most area in Taiwan is fragile and sensitive.
  - Various equipment used to detect and monitor all kinds of environmental characteristics

Slope Land Disaster Monitoring and Early Warning



On-site Sta. x24 → Mobile Sta. x 4 → Portable Unit x17 → Rain. Sta. x120

Slope Land Disaster Monitoring Systems in Taiwan

Real-time Monitoring

CCD

soil moisture sensor

geophone

wire sensor

rain gauge

Monitoring station

Mobile Station

Portable Unit

Communication

Satellite

ADSL/Fiber

LoRa

NB-IoT

4G/5G

Management

Emergency Operation Center

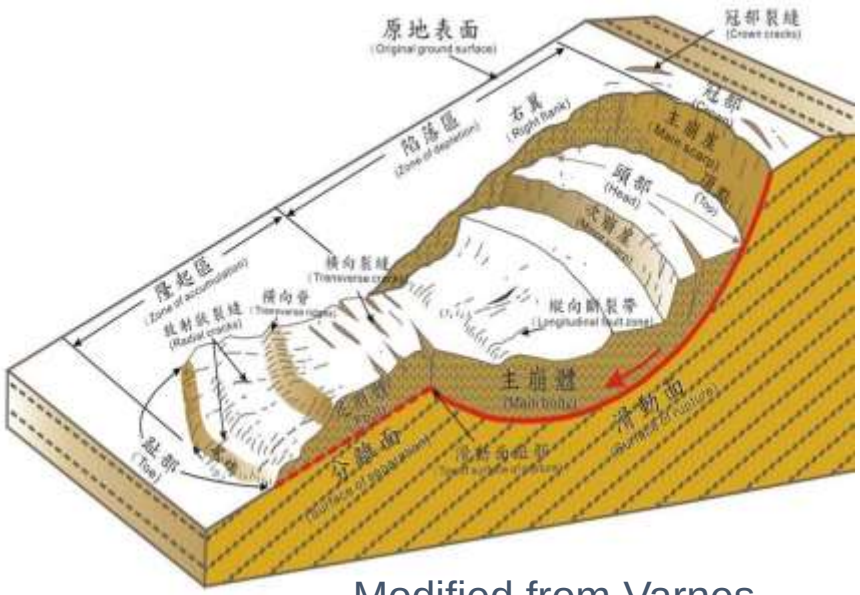
Display Platform and app

Identification of Potential Areas Prone to Large Scale Landslide

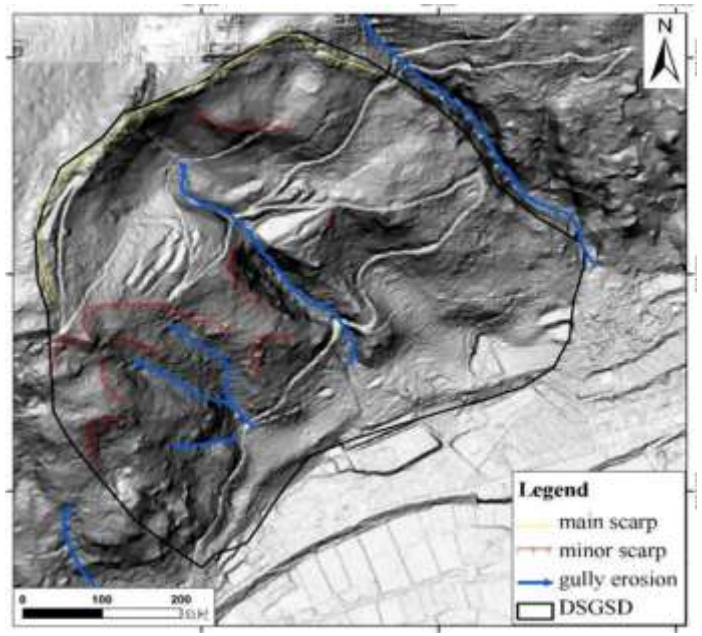
- **9,848 potential areas are located by CGS, Forestry Bureau, and SWBC using *Airborne Lidar Techniques*.**
- **34 priorities are chosen for special treatments including on-site monitoring and engineering.**

Light Detection & Ranging (LiDAR)

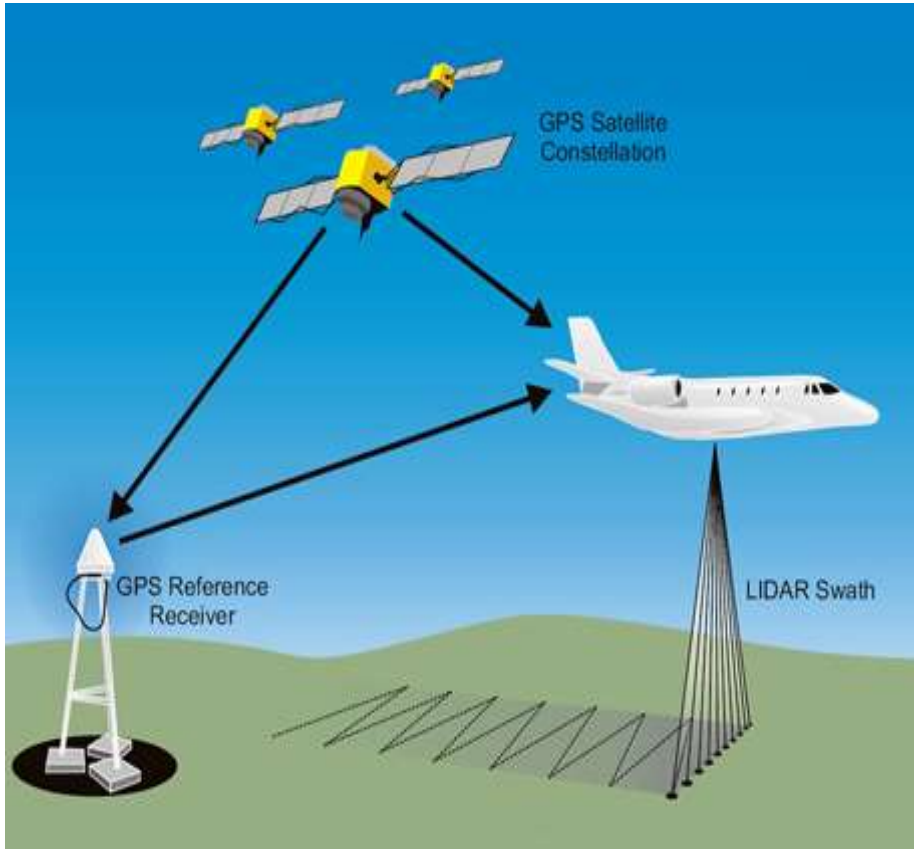
Lidar is commonly used to produce high-resolution DEM (digital elevation model)



Modified from Varnes, 1978



1-m DEM



http://www.arcland.eu/capture/lidar/1514-airborne-lidar-technology

Large-scale Landslide Hazard Mitigation Program

Definition: Area 10 ha; Depth 10 meters ; Volume 100,000 m3

1st Stage : 2017-2020(4 years), --34 sites

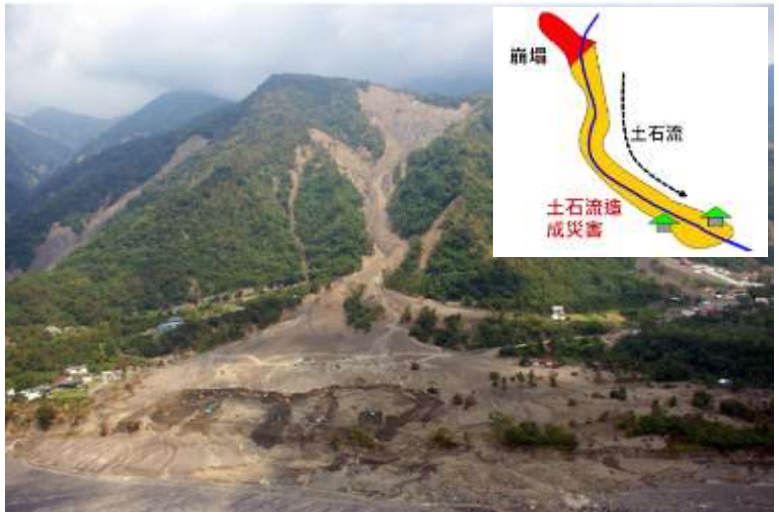
2nd Stage : 2021-2026(6 years), --64 sites

Target : 98 potential sites

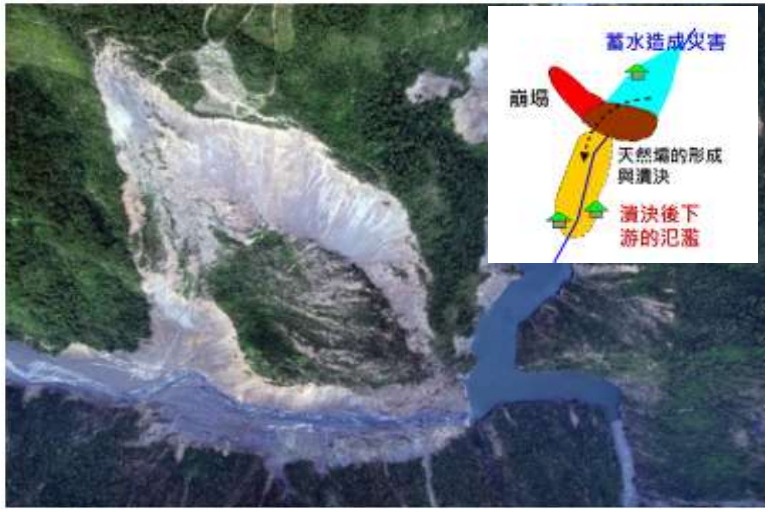
****The event, Large scale landslide, has been contained in the law "Disaster Prevention and Response Act" in 2022 after debris flow in 2000.***

Large-scale Landslide types

By gravity

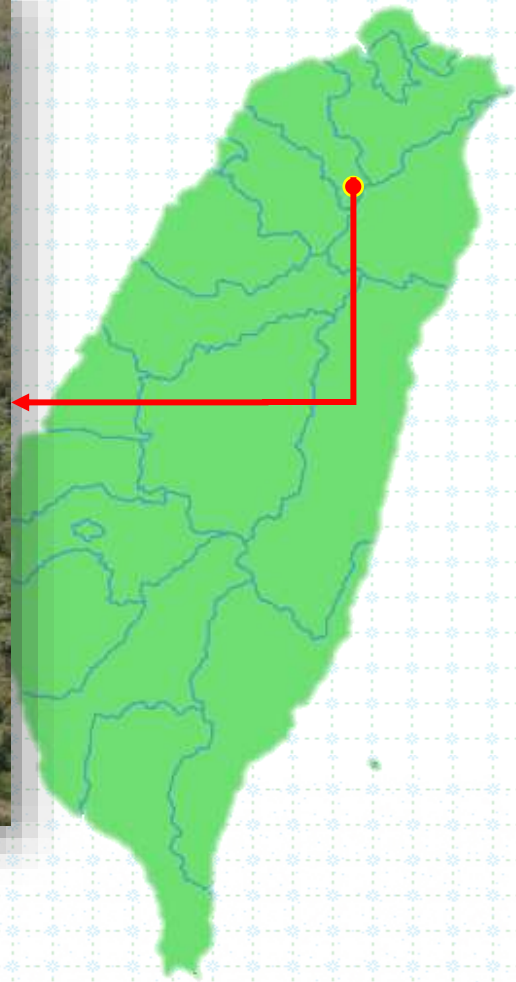


By debris flow



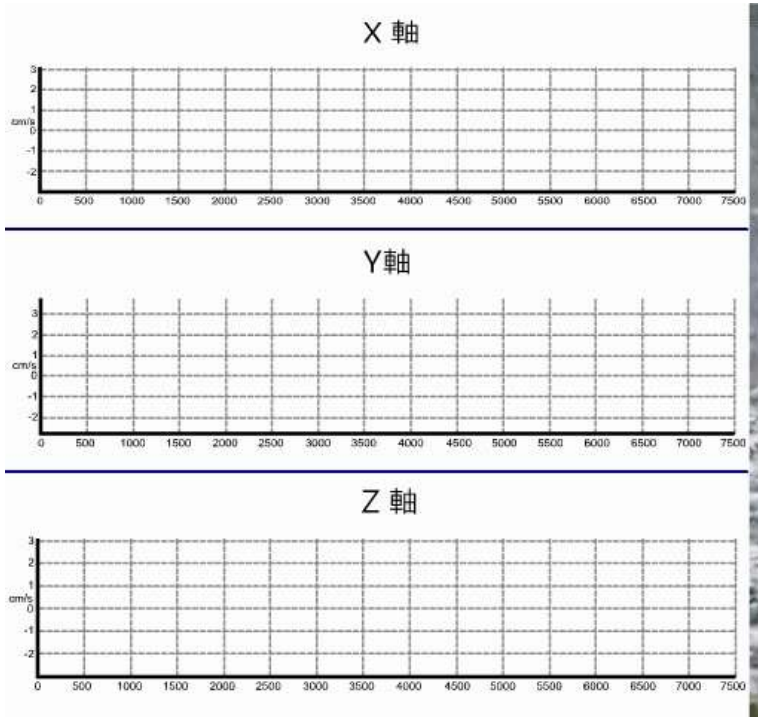
By barrier lake

Large-Scale Landslide Disaster



- **Long-term slope sliding from 2002**
- Displacement expanded from 2021 Jan.
- **Potential landslide volume 92,000**m^3

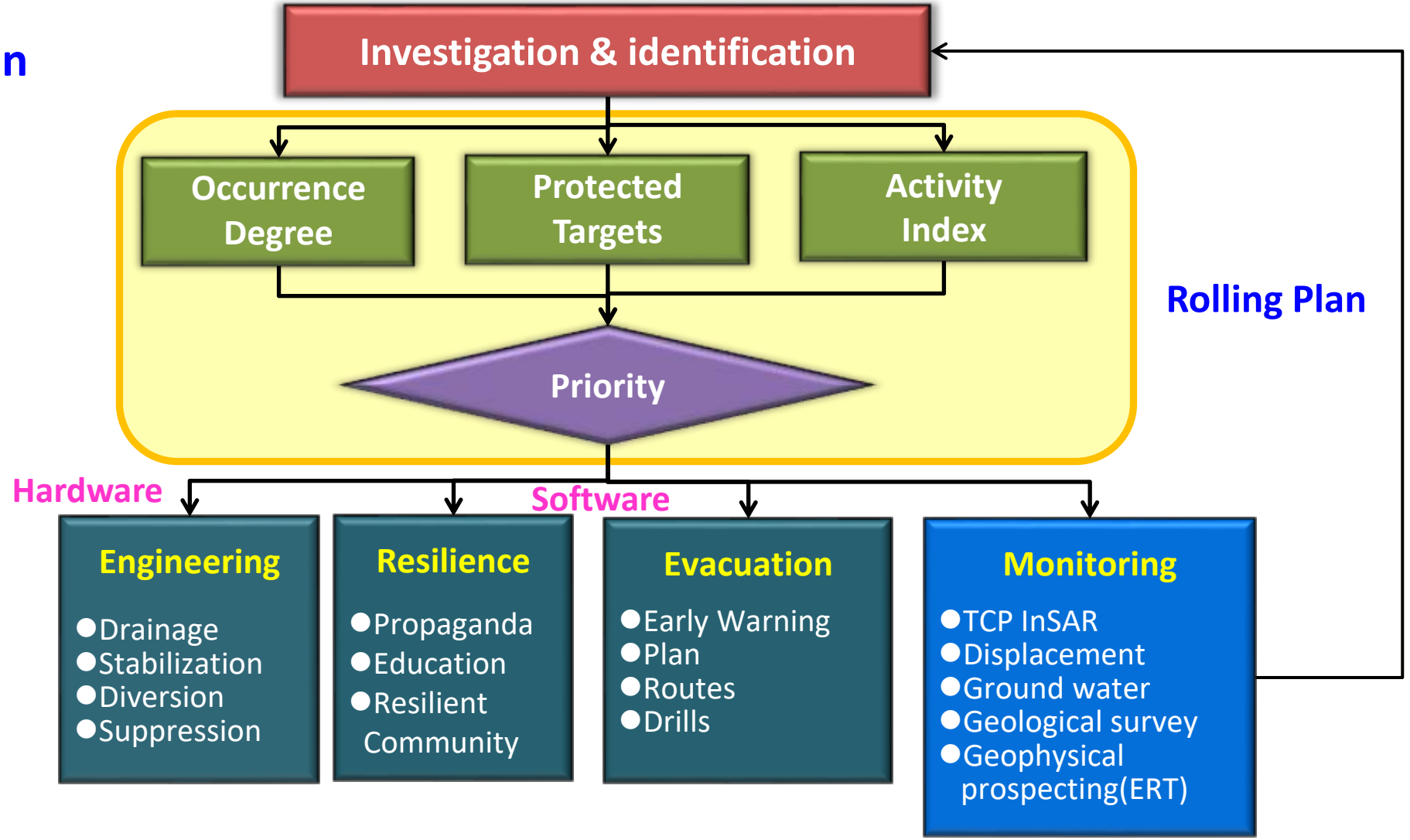
影片來源：youtube/華視新聞雜誌


X 軸
Y軸
Z 軸
cm/s
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500

AM 06:56:00
水土保持局

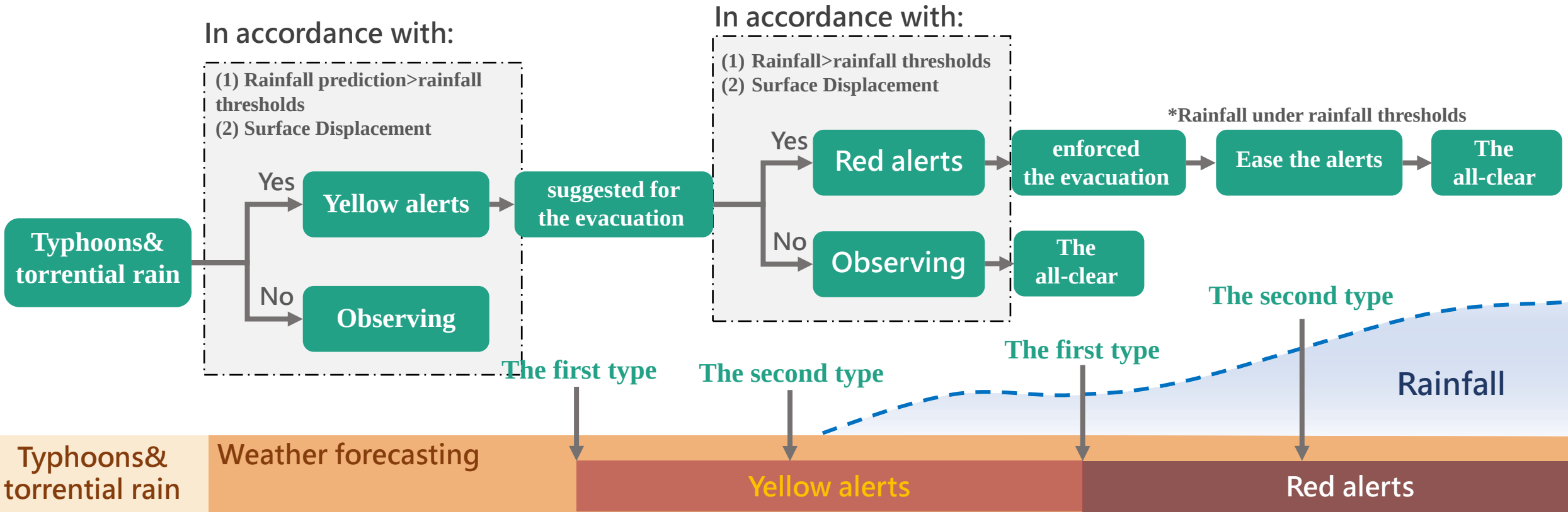
CCD camera
Soil moisture sensor
Water level meter
Wire sensor
Rain gauge
Geophone
Instrumental cabin

Framework of Large Scale Landslide Hazard Mitigation



The procedure of early responding systems

The first type landslide & The second type landslide



- The first type landslide(Rainfall:300-500mm)

*The source areas overlapped by debris flow and large scale landslide

- The second type landslide(Rainfall:300-900mm)

*The source areas only for large scale landslide

The emergency measures(releasing messages):
1.Local agencies issue warns for the public
2. Underprivileged Groups are suggested for the evacuation

The emergency measures(releasing messages and implements):
Local agencies enforce the evacuation

Slope land Disaster Monitoring Technology for Decision-Making

Sensing equipment

>Sensor Web Enablement

>Wireless Sensor Network

>OGC SensorThings API

Debris flow / Sediment / Ecosystem
Landslide / Bridge

Satellite
Fiber optic
Microwave
5G/4G
LoRa
NB-IoT

Emergency Operation Center

Alert

Monitoring website / Smart stations

warnings

Images analysis process

1

2

3

CAUSE OF FLOODSE ANALYSIS

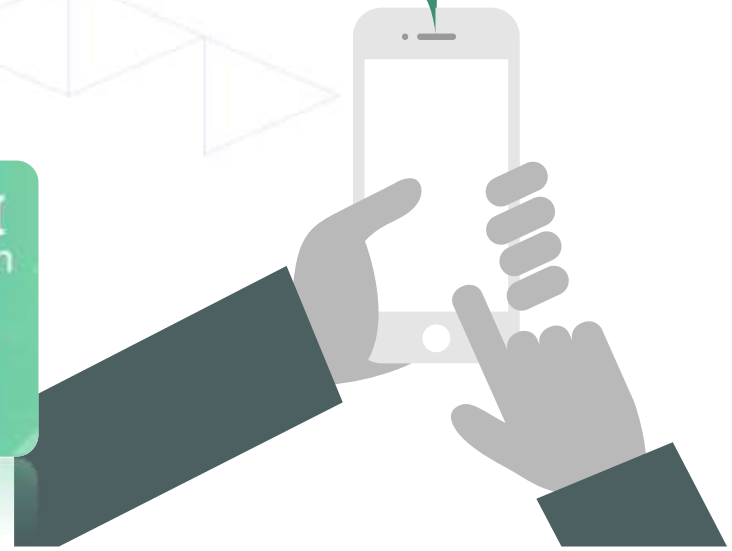
INCREASE TRAINING SMAPLES BY COLLECTING IMAGE FEEDBACKS.

INFORM RELEVANT PERSONNEL

INTEGRATION OF AI RECOGNITION AND WATER INFORMATION SYSTEM.

ISSUE FLOOD WARNING BY TEXTING MESSAGES.

CONFIRM STREAMING IMAGES



AI Technologies

Deep Learning Ecosystem

Application	AI, Classification, etc	Domain Experts, Production/Solution
Framework	*Caffe, TensorFlow*, etc	Open Source Applying, Implementation
Library Language	*cuDNN, OpenCL*, etc	Model Developing, Academic Research
Hardware	GPU, CPU	Cooperate with National High Performance Center

Organized By NSPS
INTERNATIONAL FEDERATION OF SURVEYORS
ors esri THE SCIENCE OF WHERE Trimble

FIG WORKING WEEK 2023
28 May - 1 June 2023 Orlando Florida USA
Protecting Our World, Conquering New Frontiers

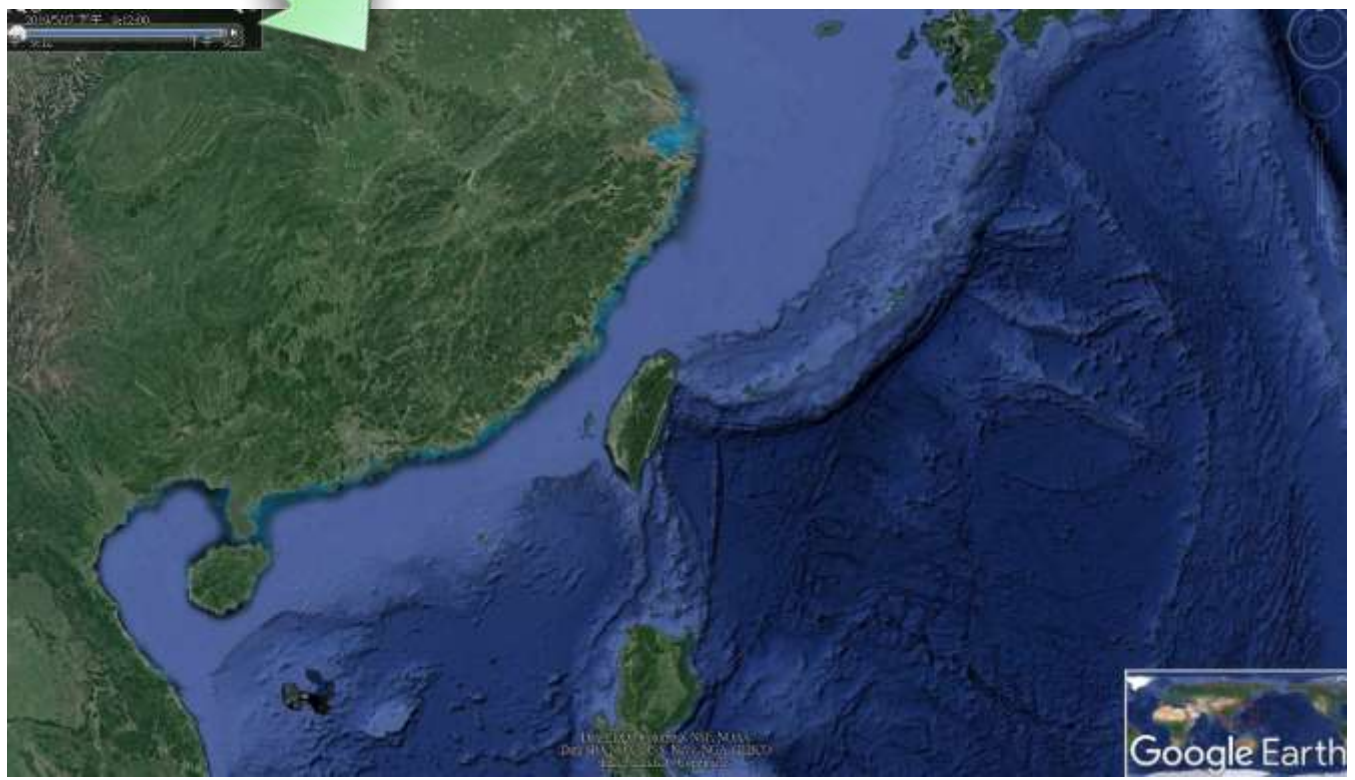
Group on Earth Observation (GEO) - Landslide Scenario in Disaster Pilot

www.gis.tw

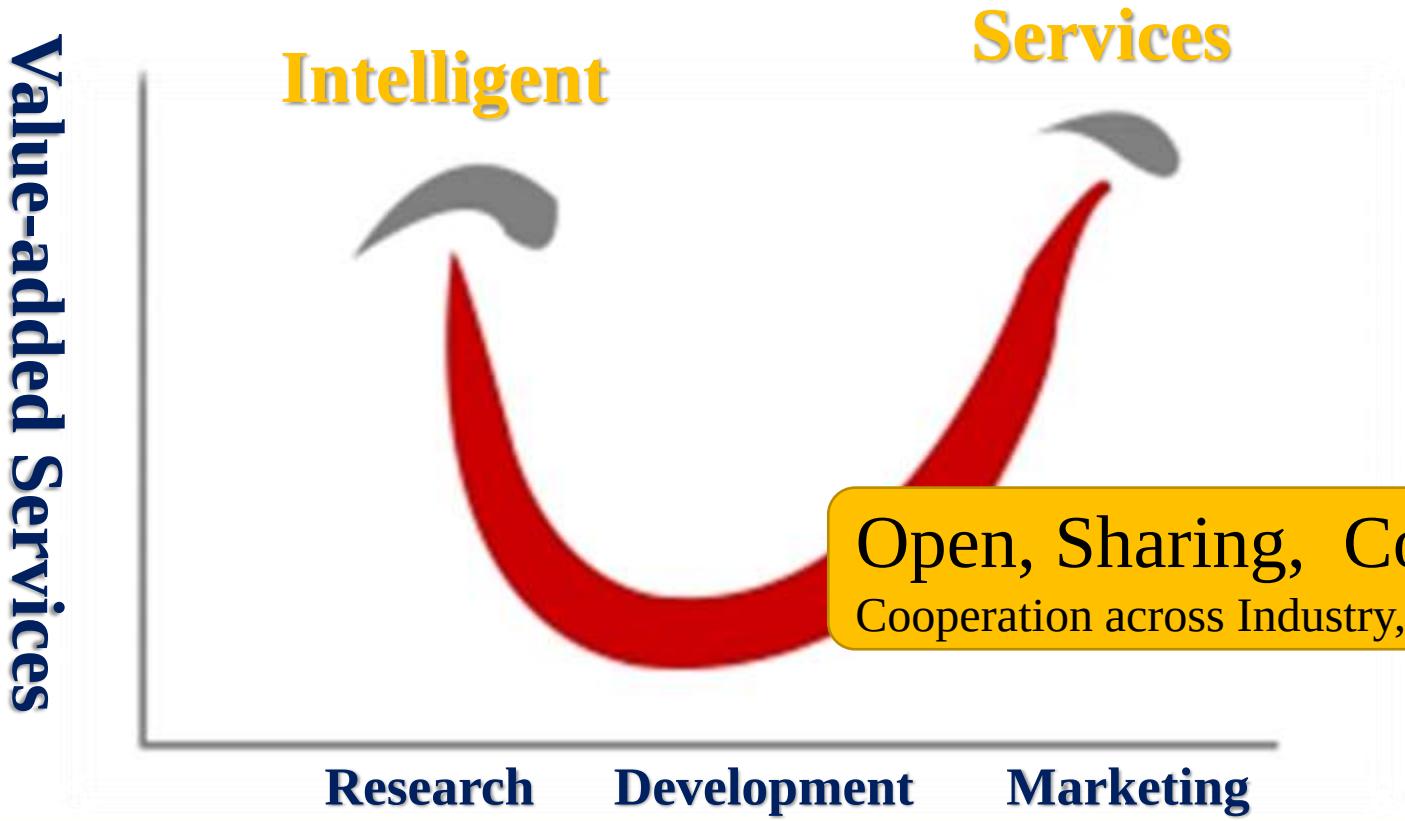
GROUP ON EARTH OBSERVATIONS

Copyright © 2018 Open Geospatial Consortium

AI image recognition to 3D map platform



Smiling curve



Open, Sharing, Communication

Cooperation across Industry, Academy, and Government