全球山崩目錄之時間與空間趨勢分析

技研小組 嚴曉嘉

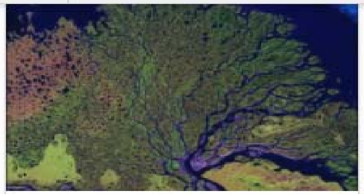
106年9月5日

- NASA黑客松是美國航太總署創新育成活動之一
- 2017年為第六屆，於 4 月29-30日全球同步舉行
- 邀請全球公民使用美國航太總署所提供**開源數據**，解決太空與地球任務相關挑戰

NASA
SPACE APPS
CHALLENGE
TAIWAN

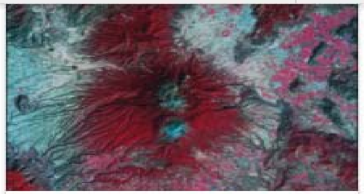
Ideate and Create!

Challenges in this category will ask you to interpret NASA Earth Science data creatively and design new means to experience NASA Earth Science data and technologies.



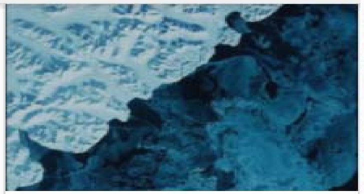
Our Ecological Neighborhood

Challenges in this category will ask you to use NASA Earth Science data to study ecological systems and generate solutions to understand life here on Earth better.



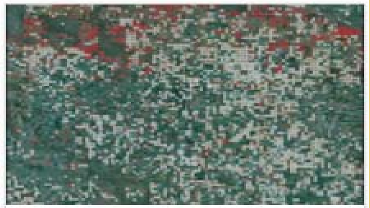
Warning! Danger Ahead!

Challenges in this category will ask you to analyze NASA data to assist in monitoring natural disasters and phenomena associated with health risks, and to assess their impacts on life and property.



Planetary Blues

Challenges in this category will ask you to analyze and visualize NASA's data on the hydrosphere (surface and groundwater, etc.) and the cryosphere (sea ice and ice sheets, etc.).



The Earth and Us

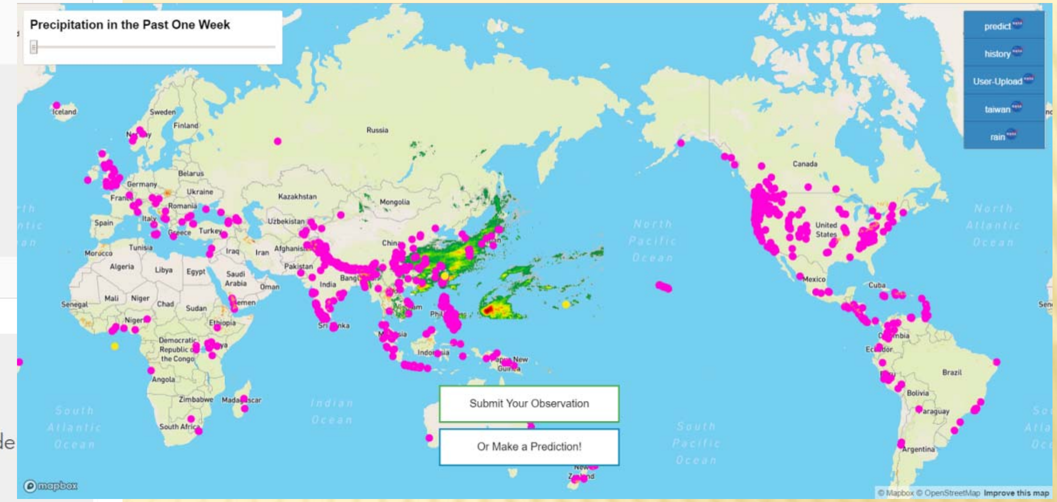
Challenges in this category will ask you to combine NASA Earth Science data with sociological and economic information to generate new understanding and perspectives on human-environment interactions.

Awards & Nominations

Space Bar has received the following awards and nominations. Way to go!

Best Mission Concept

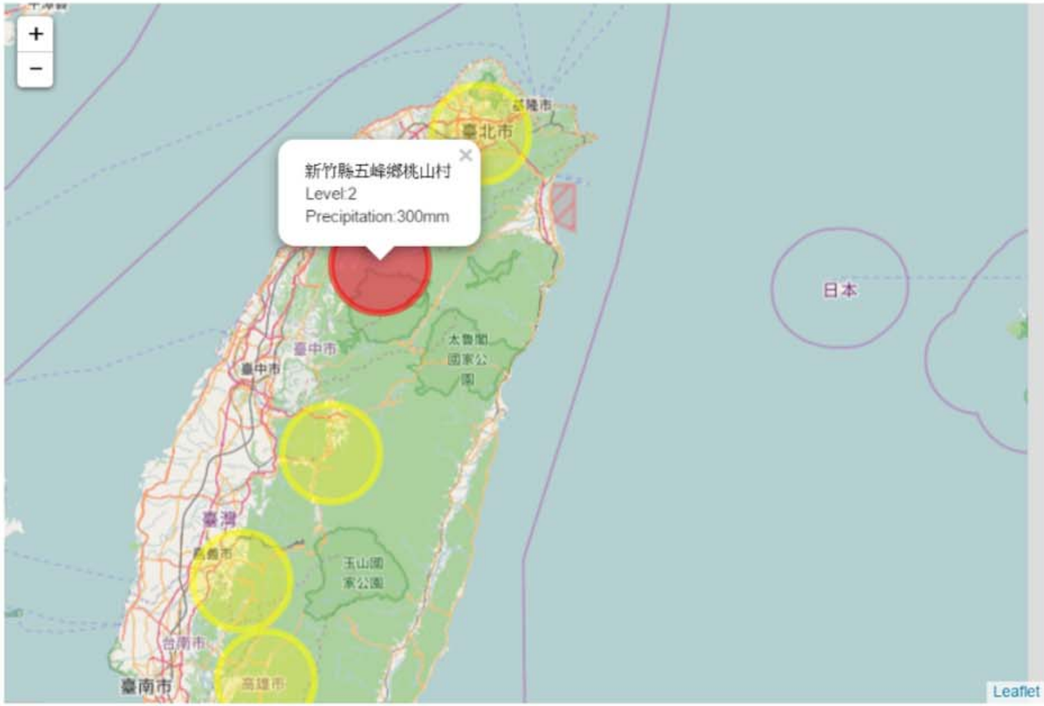
The solution with the most plausible solution concept and design.



THE CHALLENGE | WHEN LANDSLIDES STRIKE

Design an easy-to-use tool to allow the public to discover and understand landslide data, and to contribute their own observations for use by emergency managers.

Landslide Prediction Market



新竹縣五峰鄉桃山村

Do you think a landslide will happen here within 2 months?

Yes | No

To ensure serious predictions, we request you submit an amount to bid. If your prediction is correct, you shall receive additional rewards according to the bidding stakes at that time.

5000

Stakes: 1.0657654366094265

The current bidding stakes are calculated according to parimutuel betting standards

我不是機器人

Outline

- 前言
- 研究方法
- 結果與討論
- 結論與建議

ELSEVIER

Geomorphology

Volume 249, 15 November 2015, Pages 4-15

Spatial and temporal analysis of a global landslide catalog

Dalia Kirschbaum [a], Thomas Stanley [a, b], Yaping Zhou [a, c]

[a] NASA Goddard Space Flight Center, Hydrological Sciences Laboratory, USA

[b] Universities Space Research Association, USA

[c] GESTAR/Morgan State University, USA

前言(1/2)

- 崩塌災害是全球近年來主要自然災害之一。
- 依研究目的，崩塌圖層區分為
  - ✓ 過去一特定時間（Booth et al,2009；Guzzetti等,2012）
  - ✓ 某特殊事件(災難性)後（Bucknam等,2001；Xu等,2013; Murillo-García等,2014）
- 方法介紹-地調所、林務局

經濟部中央地質調查所_航照判釋山崩目錄

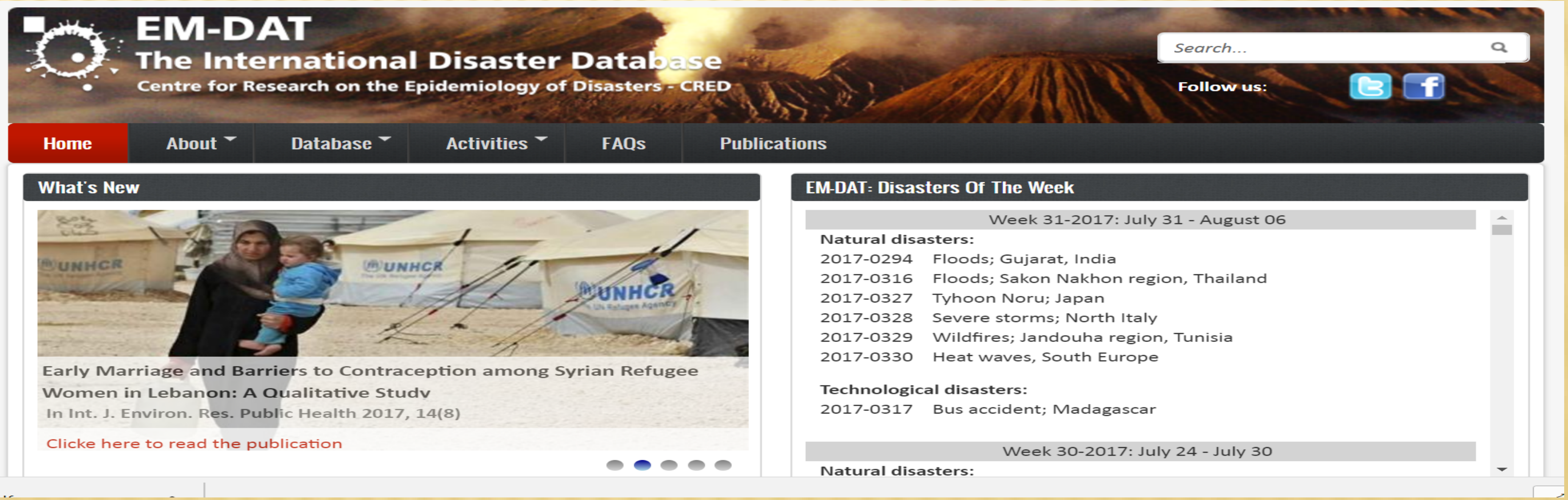
資料集評分: ❤❤❤❤❤ 平均: 4.6 (8 投票)

資料集描述	崩塌裸露地範圍圈繪
主要欄位說明	山崩範圍中心點坐標、山崩類別
資料資源	SHP SHP　檢視資料
資料集類型	原始資料
資料集提供機關名稱	經濟部中央地質調查所
資料量	約187657筆
更新頻率	不定期
授權方式	政府資料開放授權條款-第1版
授權說明網址	http://data.gov.tw/license
計費方式	免費

資料名稱：	衛星判釋全島崩塌地圖
摘要：	由林務局委託成功大學，以當年度1~7 月全島鑲嵌福衛二號衛星影像(93 1 公頃。
父階詮釋資料：	無父階詮釋資料
子階詮釋資料：	檢視
歷史版本：	無歷史版本詮釋資料
WMS：	104年衛星判釋全島崩塌地圖
圖資：	第 1 頁，共2頁　總筆數： 12 筆 97年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱 98年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱 93年度SPOT判釋全島崩塌地圖(shapefile) 下載 訂閱 94年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱 95年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱 96年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱 99年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱 100年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱 101年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱 102年度福衛判釋全島崩塌地圖(shapefile) 下載 訂閱

前言(2/2)

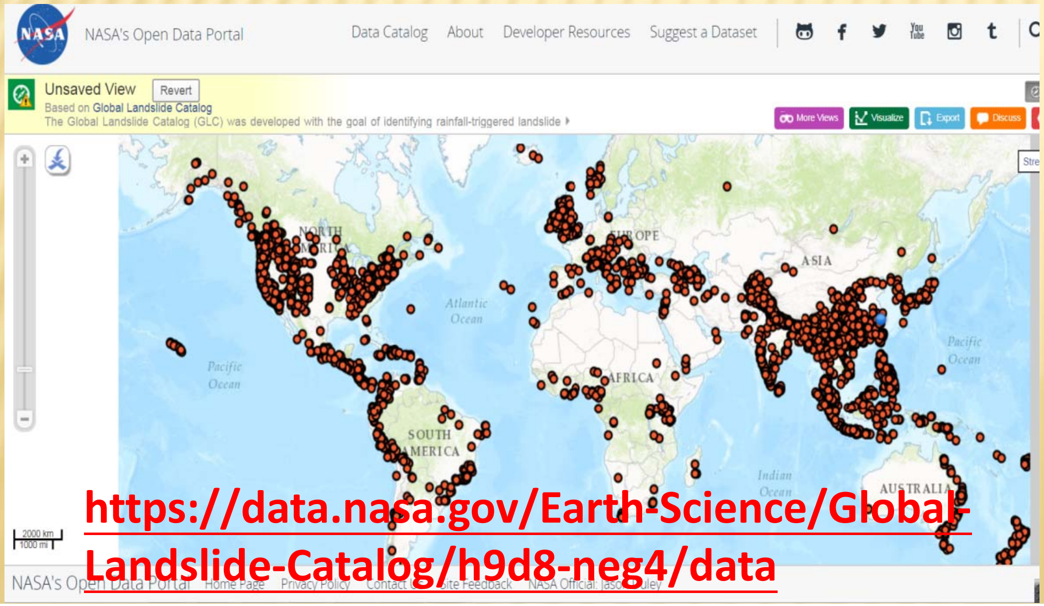
- 報紙報紙，發表文章，航空照片和其他來源；屬**點數據庫**（Guzzetti等,1994； Pradhan,2010）
- 本研究即採用點數據庫針對**全球降雨引發崩塌事件**進行分析探討。
- 研究延續Kirschaum(2010)分析7年之研究方法且運用了TRMM估算崩塌與降雨關係



研究方法

資料蒐集 | 全球山崩目錄不穩定性 | 降雨分析

- GLC集結線上影音內容、歷史災害資料庫、發表報告、社群網路等資訊所彙整而成
- 線上資訊系運用google/alert及相關蒐尋引擎，2007-2013共5741事件



https://data.nasa.gov/Earth-Science/Global-Landslide-Catalog/h9d8-neg4/data

研究方法

資料蒐集 | 全球山崩目錄不穩定性 | 降雨分析

Category	Information on category
ID	Unique ID for each reported landslide event
Date	Reported year, month and day of the landslide event, (not when it was reported). Separate columns for year, month and day.
Time	Reported hour and minute of the failure, recorded as HH:MM (24 clock, local time). This field may also include an approximate time of day if known (e.g. morning, afternoon, evening).
Location	Latitude and longitude of the reported event
Country	Country in which the landslide occurred
Nearest place	Additional location information, including the nearest geographic location (e.g. village, city, region, landmark) if known.
Landslide type	Mass movement types are included if known or specified in the source and includes the most frequently reported types of events*: landslide, mudslide, debris flow, rockfall, earthflow, translational slide, snow avalanche, lahar, complex event, riverbank collapse, creep, other or unknown.
Landslide trigger	Includes the most common triggers of landslide events (more than one trigger can be specified). These include: rain, downpour, continuous rain, tropical cyclone, monsoon, mining or digging, construction, earthquake, flooding, volcanic e[...] freeze/thaw, snowfall/snowmelt, or unknown[...]
Storm name	Includes the name or number of a tropical cyclone if identified (e.g. Hurricane Sandy, Typhoon Etau, Tropical Depression No. 12)
Fatalities	Number of reported fatalities in the event
Other impacts	Number of people injured, affected or houses [...] the event

Information source	Source of report information, includes news source, field observation, disaster database, personal communication, etc.
Information link	URL link to news report or other online source that has a listing of the report.
Comments	Includes event information such as dimensions of the landslide, characteristics, impacts, timing or situation resulting in the slope failure and other relevant information.
Location accuracy	This field assigns a qualitative uncertainty in the landslide location based on the estimated area over which the landslide realistically occurred, described as a radius from the event coordinates to a given radius (in kilometers). • Location known exactly or within 0.1 km • Event location known within 1 km • Event location known within 5 km • Event location known within 10 km • Event location known within 15 km • Event location known within 25 km • Event location known within 50 km • Event > 50 km • Unknown
Landslide size	This category is to identify the relative size of the landslide in an attempt to differentiate small landslides occurring in backyards and along roads from larger landslides that have caused catastrophic damage and cover wide areas. The "Size Classification" values are from Kirschbaum et al. (2010), which describe the landslide cataloging methodology. We have mapped these 1–5 rankings into the following categories: • *Small*: Small landslide affecting one hillslope or small area (Formerly Size Class 1): Minimal impacts to infrastructure and roads, no fatalities. • *Medium*: Moderately sized landslide that could be either a single event or multiple landslides within an area, and involves a large volume of material (Formerly Size Classes 2 and 3): Moderate impact to infrastructure and roads, may result in fatalities. • *Large*: Large landslide or series of landslides that occur in one general area but cover a wide area: Substantial impacts to infrastructure and roads, likely moderate to high number of fatalities • *Very Large*: Very large landslide or multiple events that affect an entire region (often encompassing an entire village or larger area): Catastrophic impacts to infrastructure and roads, high numbers of fatalities.

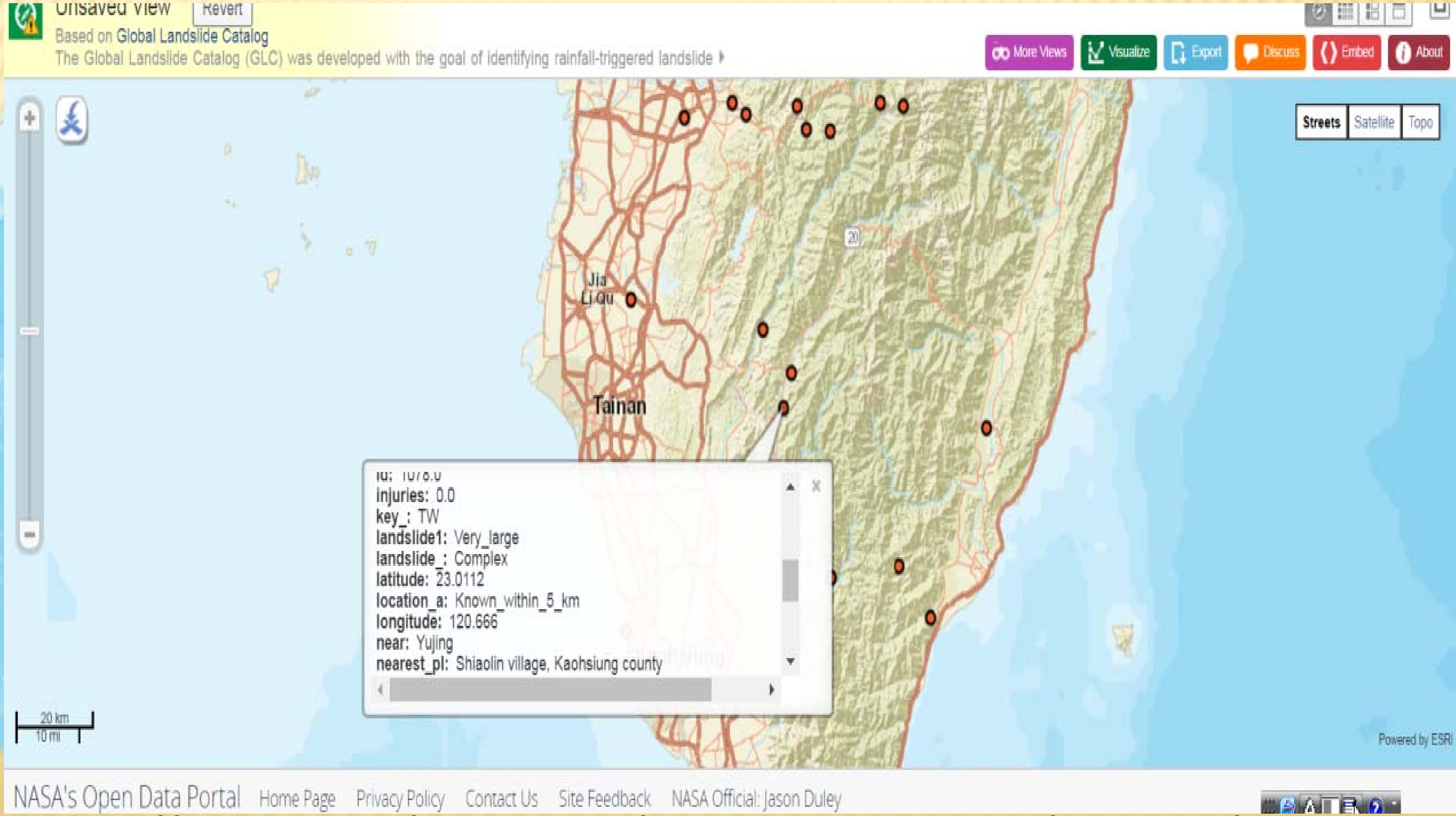
- ✓ 16個參數
- ✓ 規模參照Kirschbaum et al. (2010)分4等級
- ✓ 截至2016年總紀錄9,500多個崩塌事件

研究方法

資料蒐集

全球山崩目錄不穩定性

降雨分析



https://data.nasa.gov/Earth-Science/Global-Landslide-Catalog/h9d8-neg4/data

研究方法

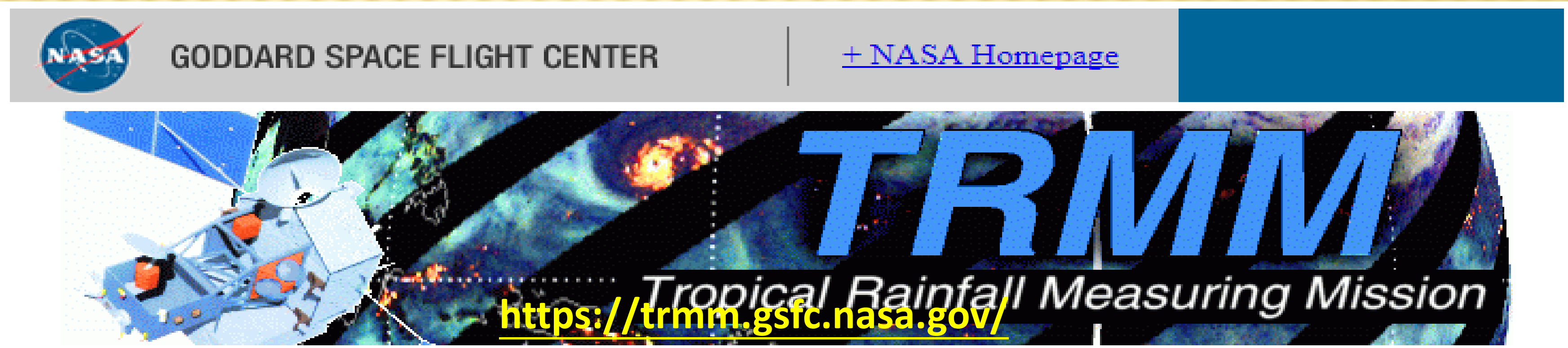
資料蒐集 | **全球山崩目錄不穩定性** | 降雨分析

- 搜尋引擎-以美、英語言為主，忽略非美系語言；加葡萄牙、西班牙語，目前**未納入中文**
- 報導多以**颱風引發複合型災害**災害描述對地區造成傷害 (ex: typhoon Morakot caused flooding and landslides in Taiwan)
- 事件多以對人或財產造成傷害為主，或災害發生影響對象為主-→**發生地、時間不確定性**
- 資料不確定因素，建置**subset(3550個cases)**
  - ✓發生位置據報導25KM內
  - ✓確定降雨誘發
  - ✓位於南北緯度50度內，以利降雨分析
  - ✓尺度為中以上

研究方法

資料蒐集 | 全球山崩目錄不穩定性 | 降雨分析

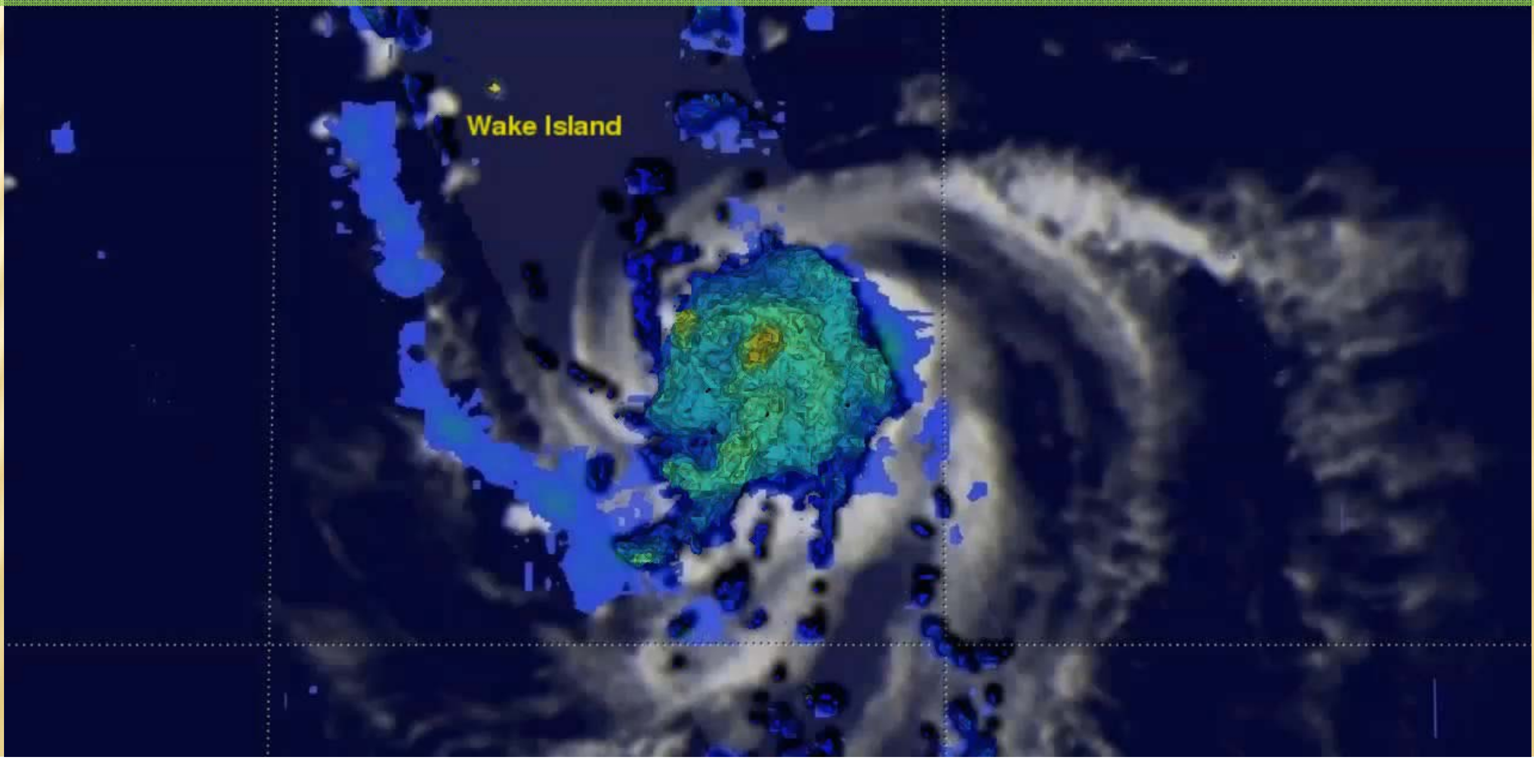
- 過往研究多以ID thresholds相關研究全球性、區域性崩塌問題 (e.g. Larsen and Simon, 1993; Crozier, 1999; Frattini et al.,2009; Meyer et al., 2012;Caine, 1980; Hong et al., 2006; Guzzetti et al.,2008; Kirschbaum et al., 2012)
- 本報告採用NASA TRMM(Tropical Rainfall Measuring Mission-熱帶雨量測量任務)，探討降雨誘發崩塌之相關性研究
  - ✓使用熱帶雨量測量任務（TRMM）**多衛星降水分析**（TMPA）Version 7即時紀錄的衛星記錄降水，可從**50°N到50°S**以0.25° ×0.25°，2000 - 2013年**3小時降雨量**（3B42RT）（Huffman等人，2007年，2010年）



研究方法

資料蒐集 | 全球山崩目錄不穩定性 | 降雨分析

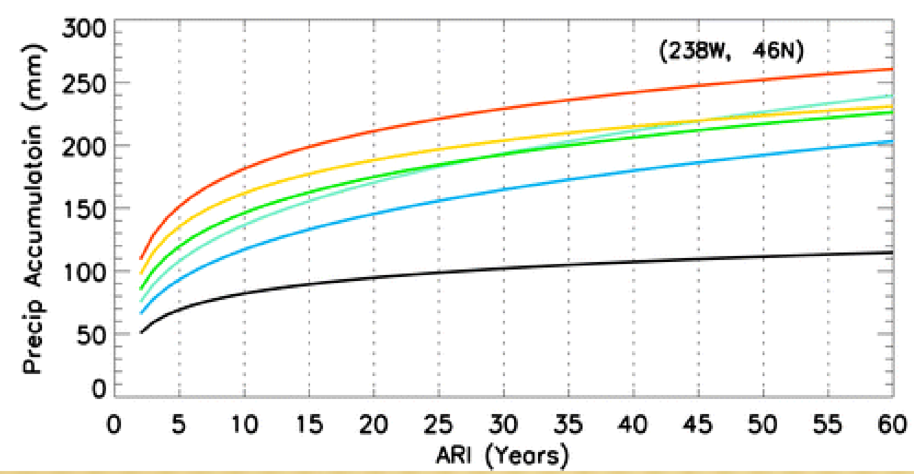
- ✓ 美國和日本的航太總署攜手合作建立衛星氣象網路，其中「全球降雨量測量」專案將耗資11億美元（約台幣357億元）
- ✓ 2011年開始，提供每3小時更新1次的降雨量報告，加強氣象預測精確度及深入了解水循環如何影響氣候變化
- ✓ 美日兩國「熱帶雨量測量任務」的延伸，「核心」衛星將經由雙頻雷達和被動式微波輻射計來測量降雨量，約有6至8個衛星追蹤記錄資料。

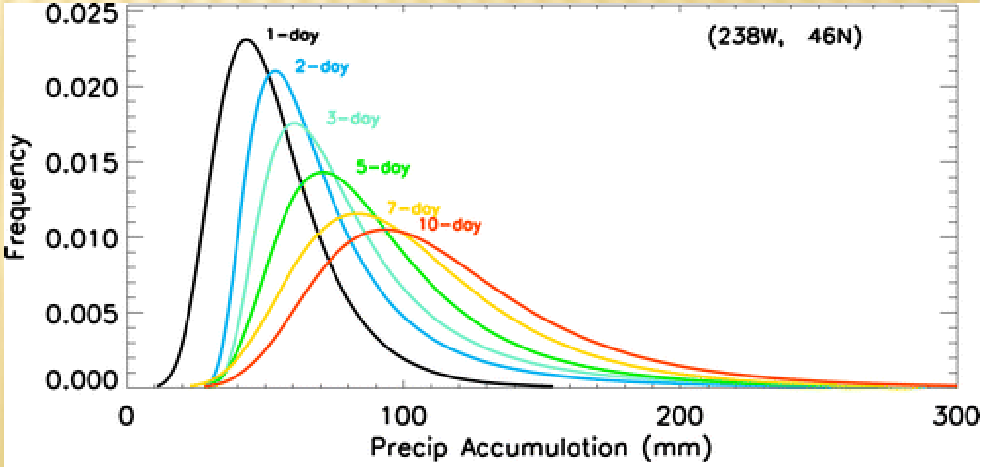


研究方法

資料蒐集 | 全球山崩目錄不穩定性 | **降雨分析**

- 本報告利用TMPA RT降水資訊，並評估每事件降雨量與14年衛星記錄中之降雨分佈關係
- 採用兩種不同方法來定義極端降雨量：
  - ✓ **雨量百分等級**(Percentiles)
  - ✓ **重現期距**（ARI-average recurrence interval ）
- 針對GLC subsets(3550案件)比較extremal rainfall(ARIS及PERCENTIL)與崩塌關係





研究方法

資料蒐集 | 全球山崩目錄不穩定性 | **降雨分析**

降雨百分比

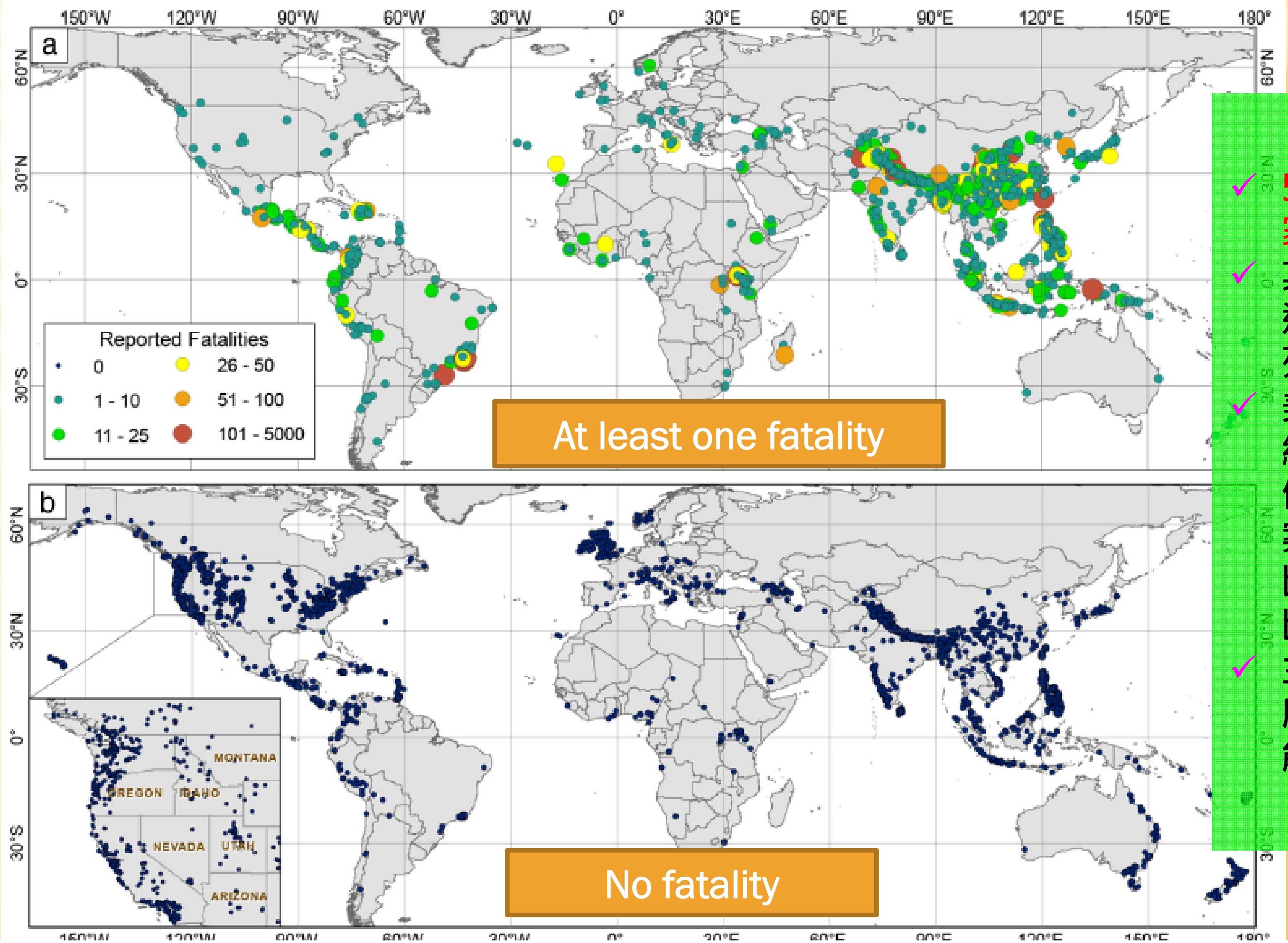
1. 首先計算每個崩塌事件日期（7天累積的3週窗口）兩週內的最大1天，3天和7天累積降雨量
2. 再萃取該崩塌事件之14年間降雨時間序列除去非降雨，計算其降雨序列之第50，第75，第95和第99大降雨量排序
3. 最後，將1,3天和7天累積最大降雨量與降雨百分比進行比較，探討最大降雨量是否超過計算的百分位數值

重現期距

1. 以GLC子集中的3550個崩塌位置為中心的5×5度網格，利用TRMM RT data計算其14年間之1日、2日、3日、7日及10日之年最大降雨量
2. 經以頻率分析求得各重現期距之暴雨量，

結果與討論

GLC reports and fatalities | 社會經濟指標 | GLC and extreme rainfall

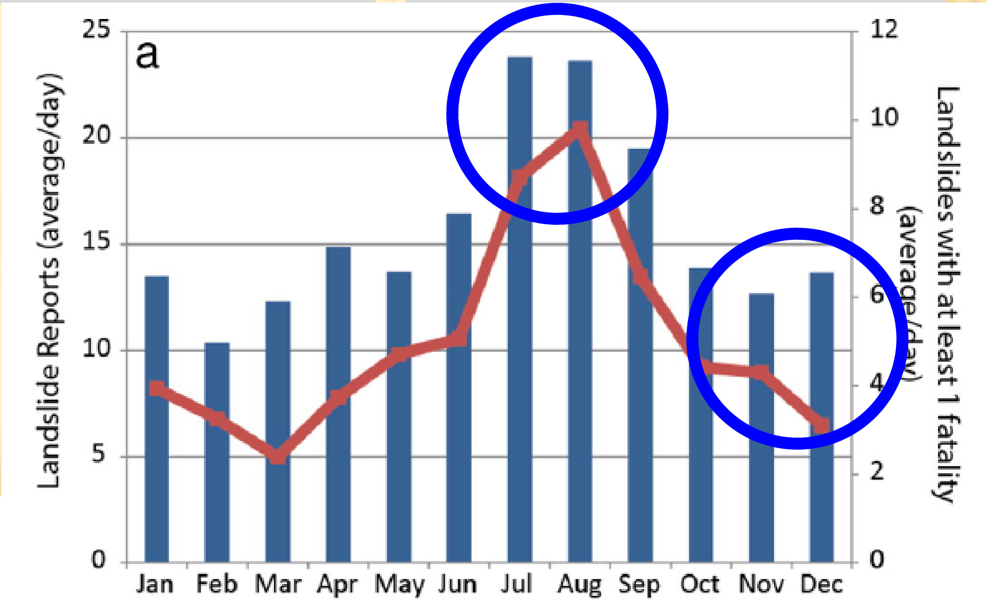


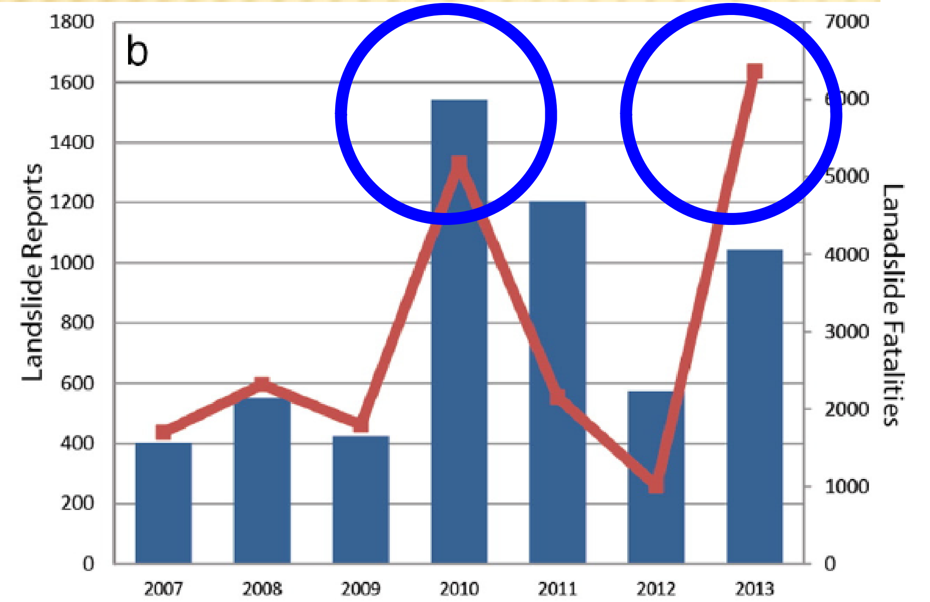
- ✓ 5,741點分布124國家(2007-2013)
- ✓ 其中，1,827事件，造成約20,500傷亡，死亡率約佔30%
- ✓ 美國、英國、澳洲紐西蘭4國有多案例但少災亡(27.5%案例，僅0.7%傷亡比例，且1.6%傷亡比例超過1人
- ✓ 主要由於英文搜尋所以即便小案例也能紀錄

結果與討論

GLC reports and fatalities | 社會經濟指標 | GLC and extreme rainfall

- ✓ 以北半球之東亞、南亞、西南亞7-9月為極值(雨季及颱風好發期)
- ✓ 第二高峰落於南半球之12-1月之南美、巴西、秘魯哥倫比亞、印度尼西亞及馬來西亞

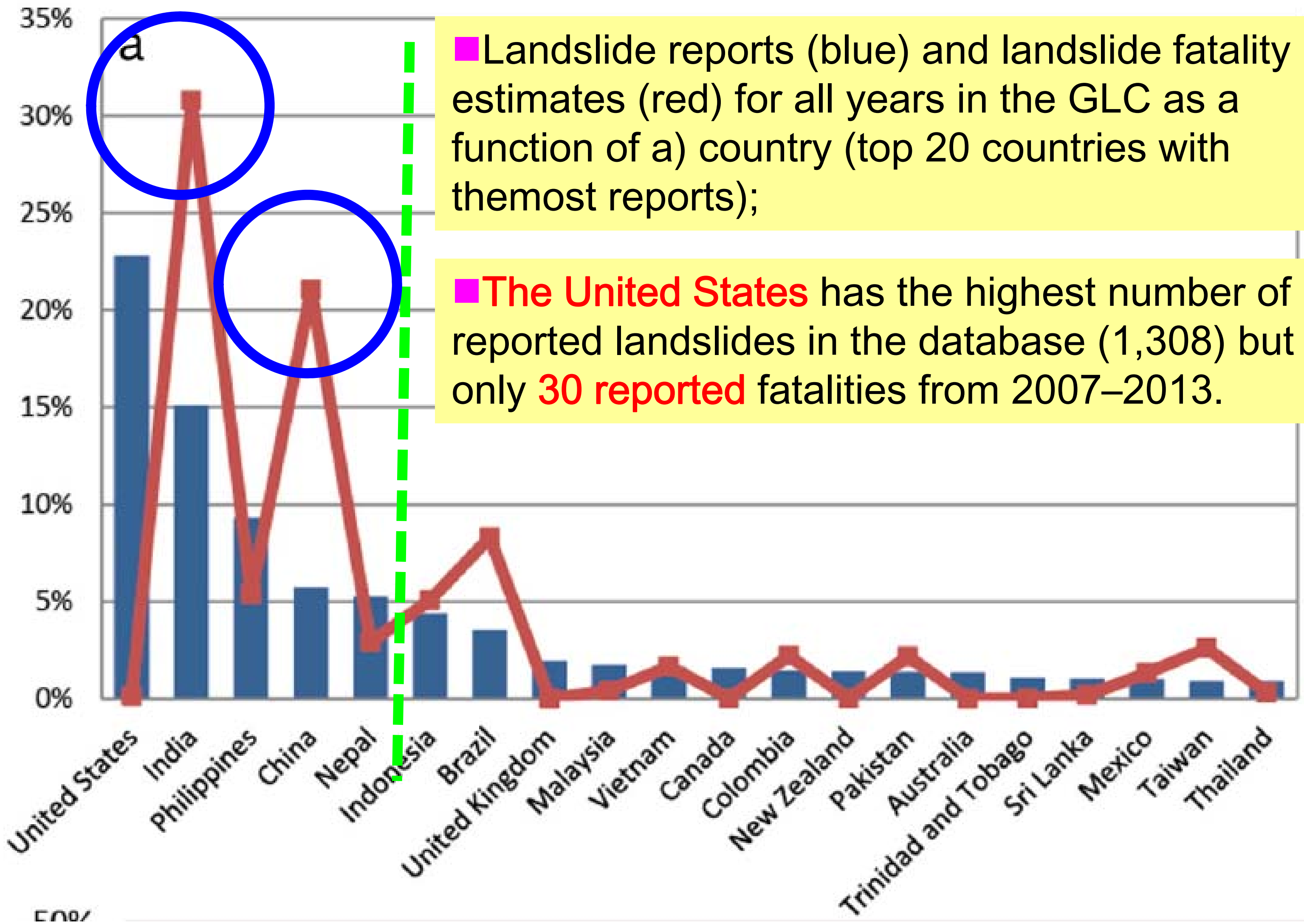




- ✓ 高峰為2010年(聖嬰現象)、2011及2013年；主要傷亡則為2013年造成之5,000人死傷
- ✓ 從統計崩塌事件與死傷並無決定關聯性

結果與討論

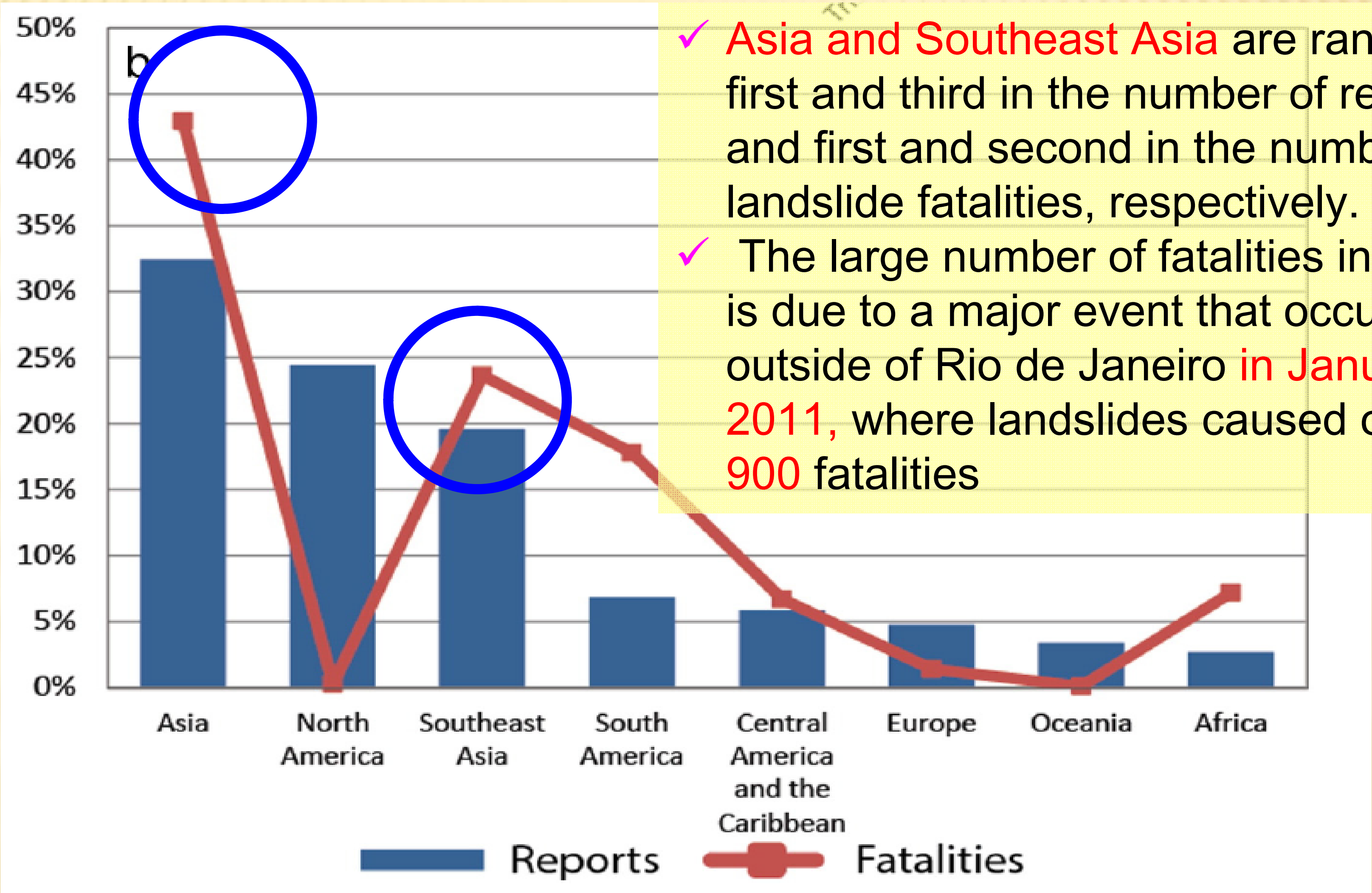
GLC reports and fatalities | 社會經濟指標 | GLC and extreme rainfall



- Landslide reports (blue) and landslide fatality estimates (red) for all years in the GLC as a function of a) country (top 20 countries with themost reports);
- The United States has the highest number of reported landslides in the database (1,308) but only 30 reported fatalities from 2007–2013.

結果與討論

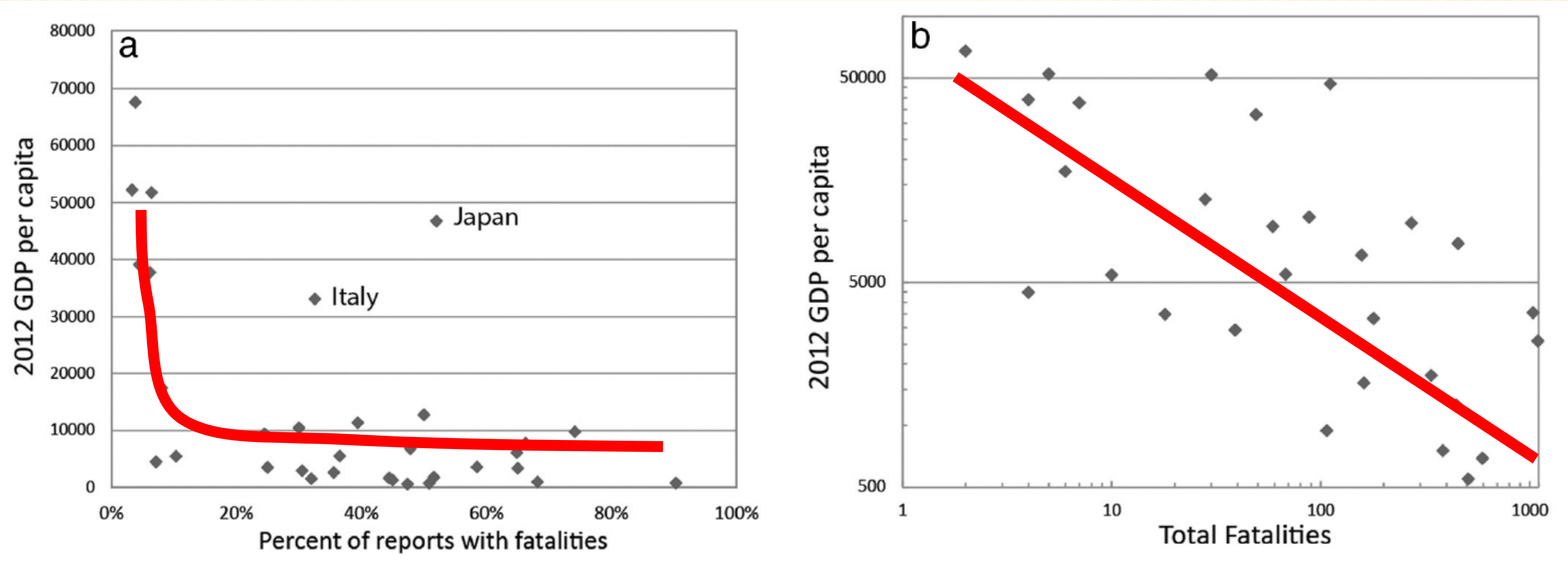
GLC reports and fatalities | 社會經濟指標 | GLC and extreme rainfall



- ✓ Asia and Southeast Asia are ranked first and third in the number of reports and first and second in the number of landslide fatalities, respectively.
- ✓ The large number of fatalities in Brazil is due to a major event that occurred outside of Rio de Janeiro in January 2011, where landslides caused over 900 fatalities

結果與討論

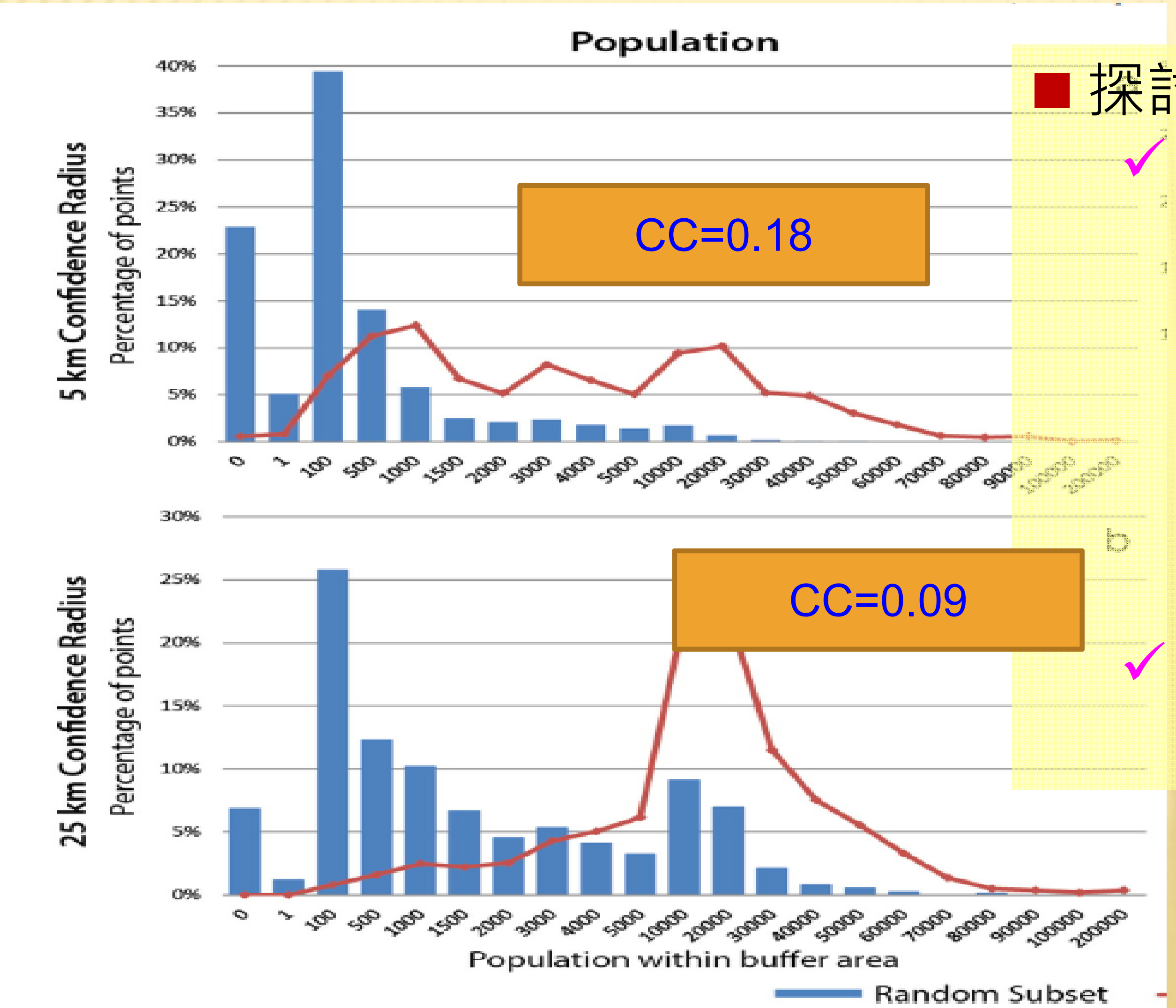
GLC reports and fatalities | **社會經濟指標** | GLC and extreme rainfall



- ✓ GLC崩塌目錄大於20案例且至少1傷亡之國家與其2012人口GDP比較
- ✓ 崩塌死傷與國家GDP呈現指數遞減情形

結果與討論

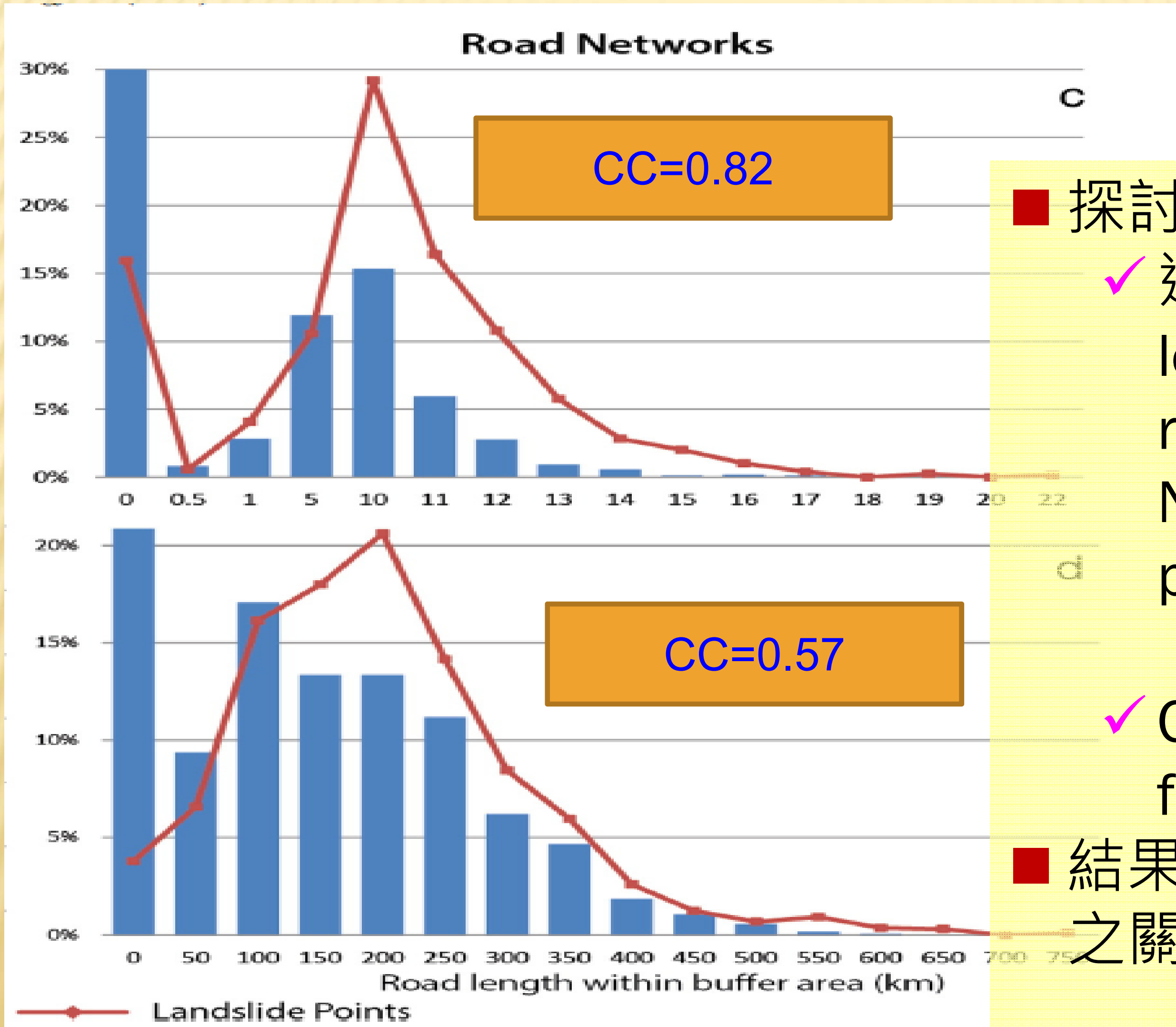
GLC reports and fatalities | **社會經濟指標** | GLC and extreme rainfall



- 探討崩塌與人口分佈關係
  - ✓ 運用land scan(1km解析)之人口分布資料庫進行每崩塌事件 其周遭5及25公里之分析 (arc gis buffer geoprocessing)
  - ✓ Create random points for landsacn datas

結果與討論

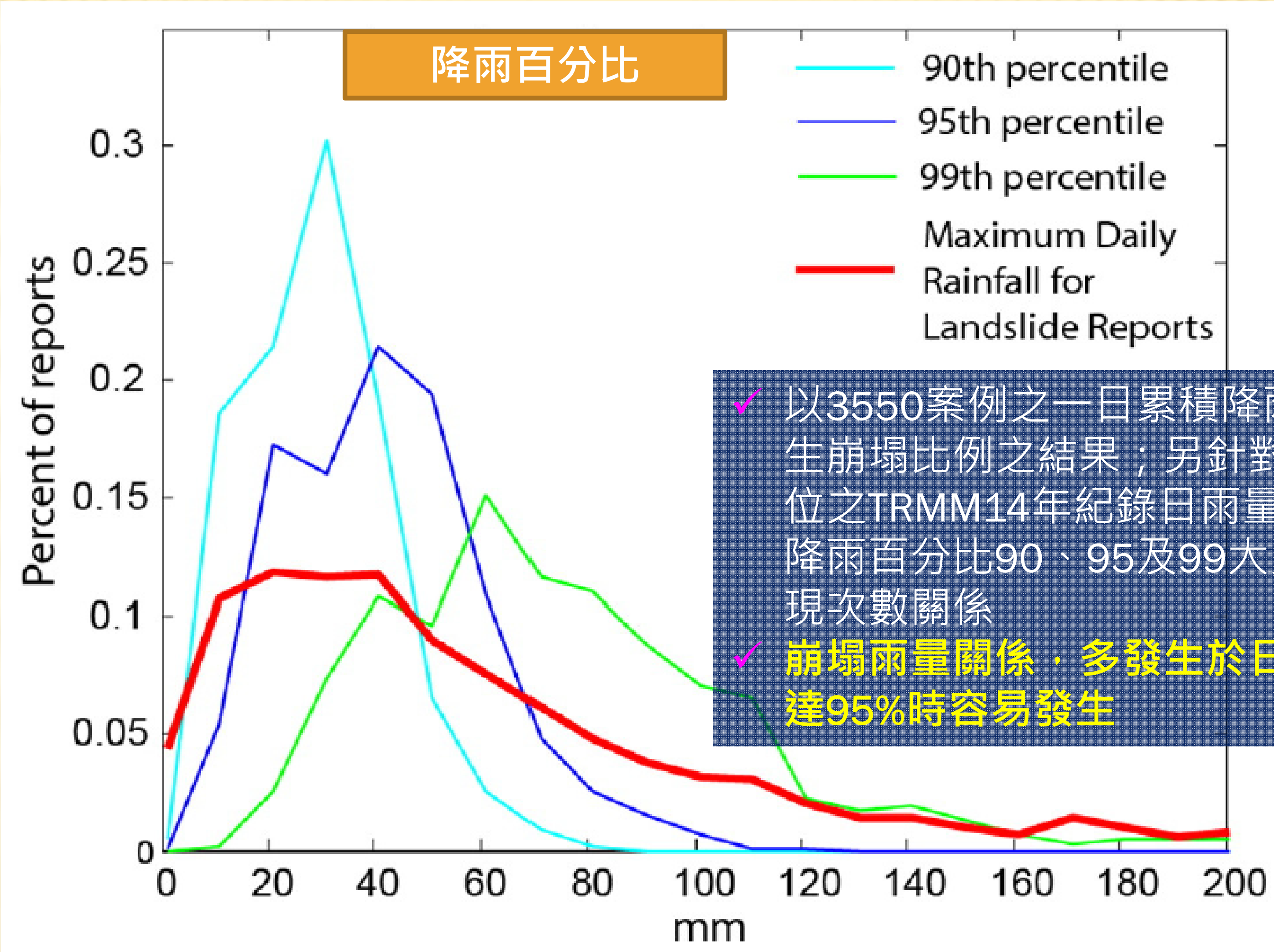
GLC reports and fatalities | **社會經濟指標** | GLC and extreme rainfall



- 探討道路開發與崩塌關係
  - ✓ 運用2009 vector map level 0 road database，random point 取50 N~S間再用GIS geo processing
  - ✓ Create random points for landsacn datas
- 結果顯示道路與崩塌發生之關係性高於人口分佈

結果與討論

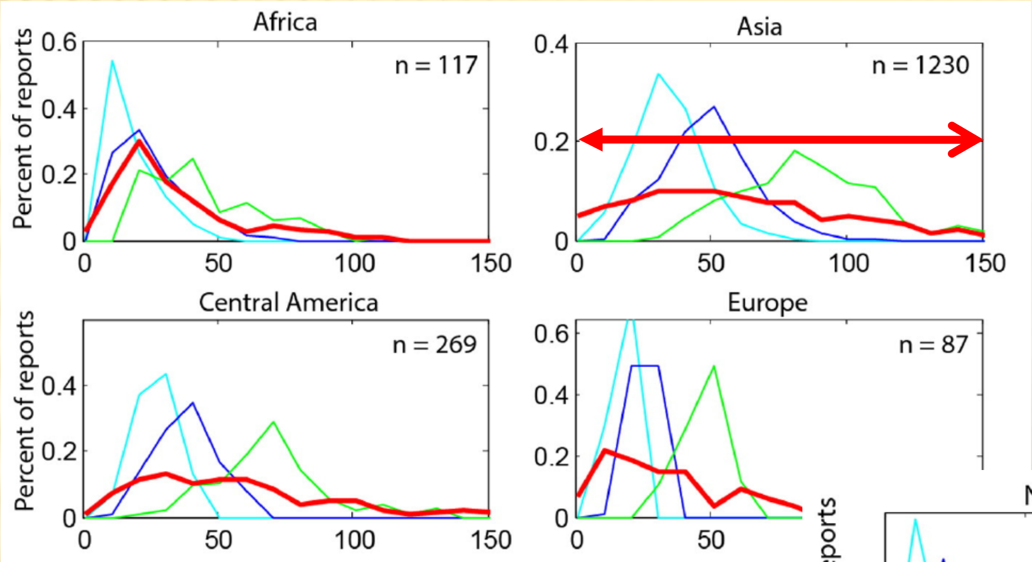
GLC reports and fatalities | 社會經濟指標 | GLC and extreme rainfall



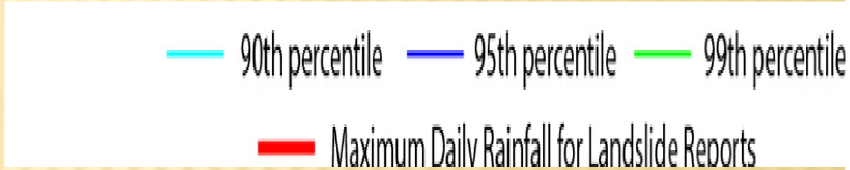
- 以3550案例之一日累積降雨量與其發生崩塌比例之結果；另針對每崩塌點位之TRMM14年紀錄日雨量結果，其降雨百分比90、95及99大之雨量與出現次數關係
- **崩塌雨量關係，多發生於日累積雨量達95%時容易發生**

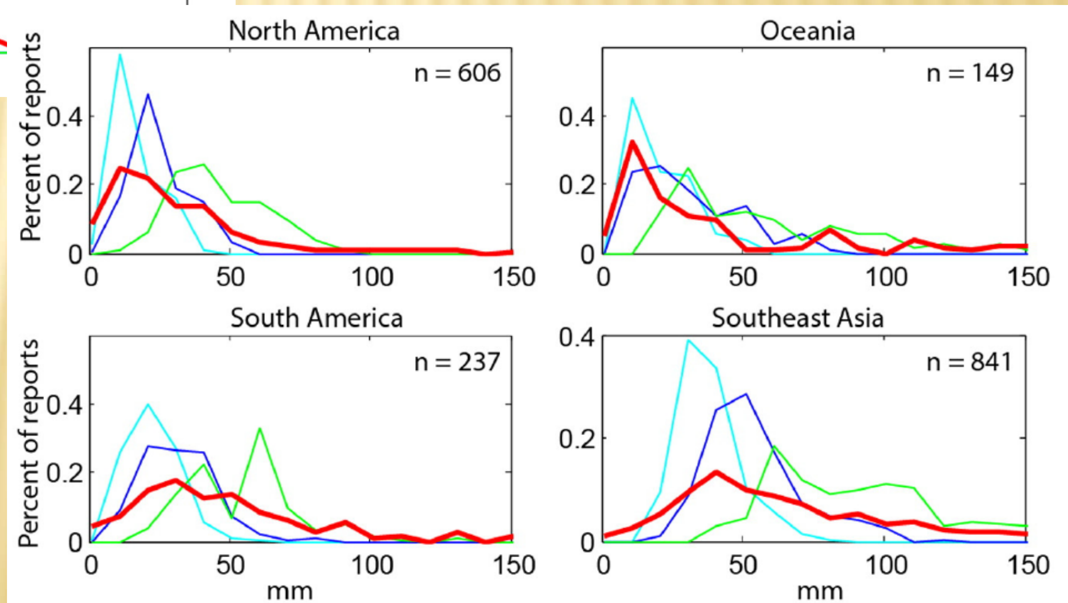
結果與討論

GLC reports and fatalities | 社會經濟指標 | **GLC and extreme rainfall**



比對8大區域之崩塌事件與雨量之關係。





- ✓ 亞洲、東南亞及中美之降雨誘發崩塌之**降雨值區間**較大，然而均滿足降雨百分比95時誘發崩塌之關係
- ✓ OCEANIA之關係則以90誘發，可能是樣本數較少
- ✓ 歐洲樣本數少，關性性低

結果與討論

GLC reports and fatalities | 社會經濟指標 | **GLC and extreme rainfall**

- 將 subsetted GLC內紀載崩塌事件，最大1天，3天(兩週內)和7天(三周內)累積降雨量，與該崩塌事件之14年間降雨時間序列除去非降雨，計算其降雨序列之（第50，第75，第95和第99）。
- 78%最大1日降雨大於90%降雨百分比之機率為78%
- 最大三日與七日降雨大於90%降雨百分比之機率則為75及73%
- 95%降雨百分比之1-7日則較少range(61-56%)
- 99%降雨百分比則僅26-27%
- 扣除日降雨小於10mm之事件，則崩塌發生大於99%降雨百分比約30%

Percentage of landslides exceeding the 50th, 90th, 95th and 99th percentiles based on 1, 3 and 7-day rainfall accumulations within the several weeks surrounding the reported event.

降雨百分比

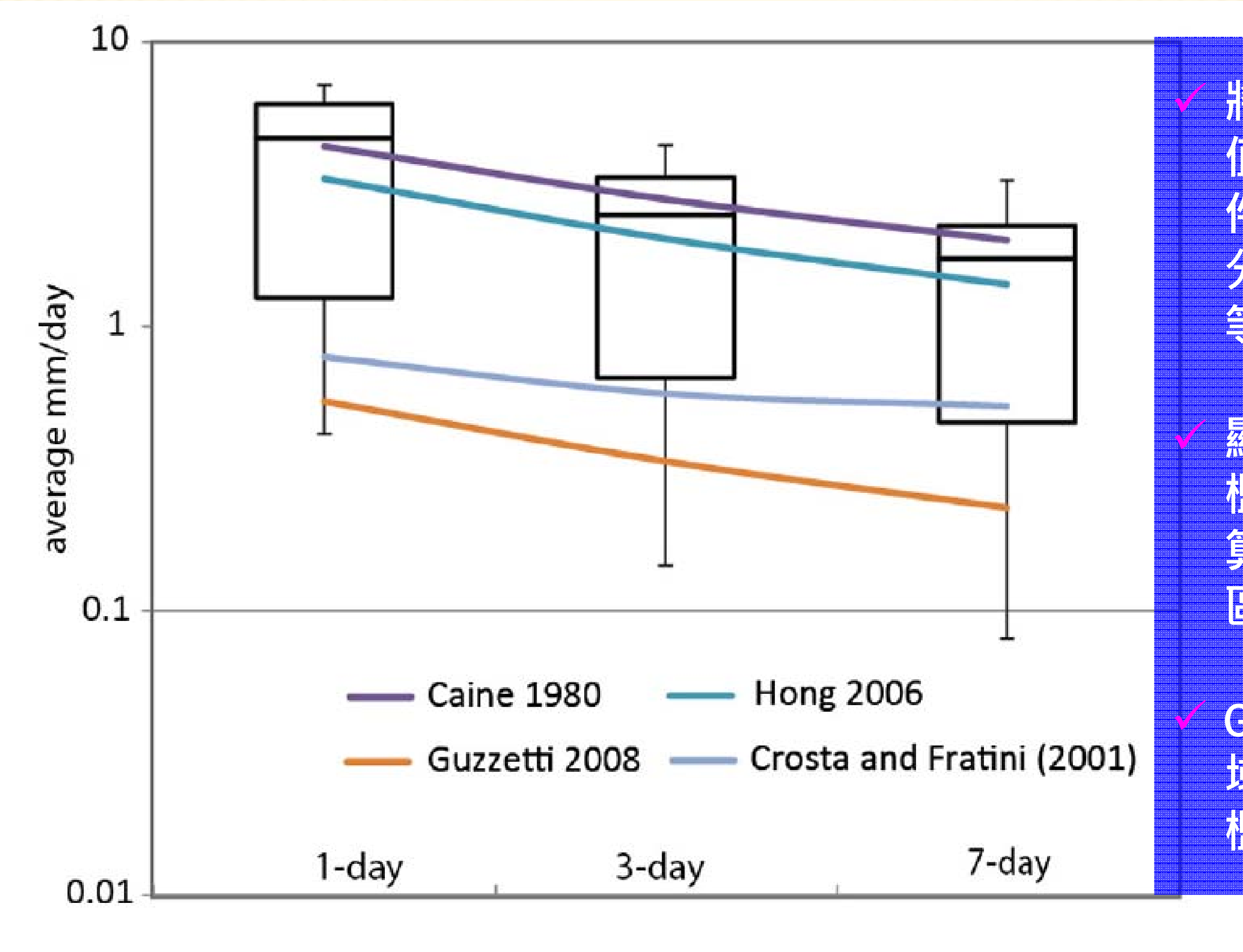
	50th	90th	95th	99th
1-day	97.4%	78.1%	61.3%	27.3%
3-day	96.5%	74.7%	59.5%	27.5%
7-day	96.9%	72.5%	56.3%	25.9%

結果與討論

GLC reports and fatalities

社會經濟指標

GLC and extreme rainfall



- ✓ 將各家學者之ID門檻值與本研究各崩塌事件之降雨資料，採四分位法及最大最小值等加以比較
- ✓ 顯示3位學者之ID門檻值均落在GLC所演算之四分位法降雨量區間內
- ✓ GLC資料用以推估區域性或全球性之ID門檻值有其可信度

結果與討論

GLC reports and fatalities

社會經濟指標

GLC and extreme rainfall

- 利用TRMM針對崩塌點位中心，計算5度經緯度範圍內之各重現期距降雨量與崩塌點位1、2、3-10日累積降雨量之關係。
- 崩塌地位置之各日累積降雨量大於重現期距1年之日雨量，分別為54-82%；
- 隨著重現期距越大，超過百分比愈小。
- 崩塌地日降雨量重現期距10年之降雨量Range僅從22至31%。

重現期距

Percentage of landslide points w... currence interval (in years) greater than or equal to 1, 2, 5 or 10 years based on rainfall accumulations from 1 to 10 days within a 5° × 5° area surrounding the reported landslide event.

		Average recurrence interval			
		>=1	>=2	>=5	>=10
Rainfall accumulation window	1-day	53.8	43.5	29.8	22.0
	2-day	63.2	53.5	33.6	24.6
	3-day	67.7	57.6	37.2	25.4
	5-day	75.1	61.7	38.6	26.7
	7-day	77.7	66.0	40.6	28.6
	10-day	81.6	69.0	44.2	31.3

結果與討論

GLC reports and fatalities | 社會經濟指標 | **GLC and extreme rainfall**

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- ✓ 比較兩種方式估算結果
  - a) 較低重現期與百分比小之雨量超過百分比較大
  - b) 重現期距分析結果係隨累積日雨量增大而變大，雨量百分比法則相反
  - c) 每種方法有其互補性
- ✓ 重現期距法系採崩塌地為中心，5度經緯內雨量分析結果，可能最大降雨量距崩塌地甚遠，250公里非同一個暴雨系統。
- ✓ ARI法係以記錄崩塌事件往前回朔之雨量，若崩塌事件描述錯誤恐造成分析數據錯誤，亦或無法反應降雨誘發崩塌情勢。
- ✓ 相較下，降雨百分比較能反映**短延時(1 day)**誘發崩塌情形

結果與討論

GLC reports and fatalities | 社會經濟指標 | **GLC and extreme rainfall**

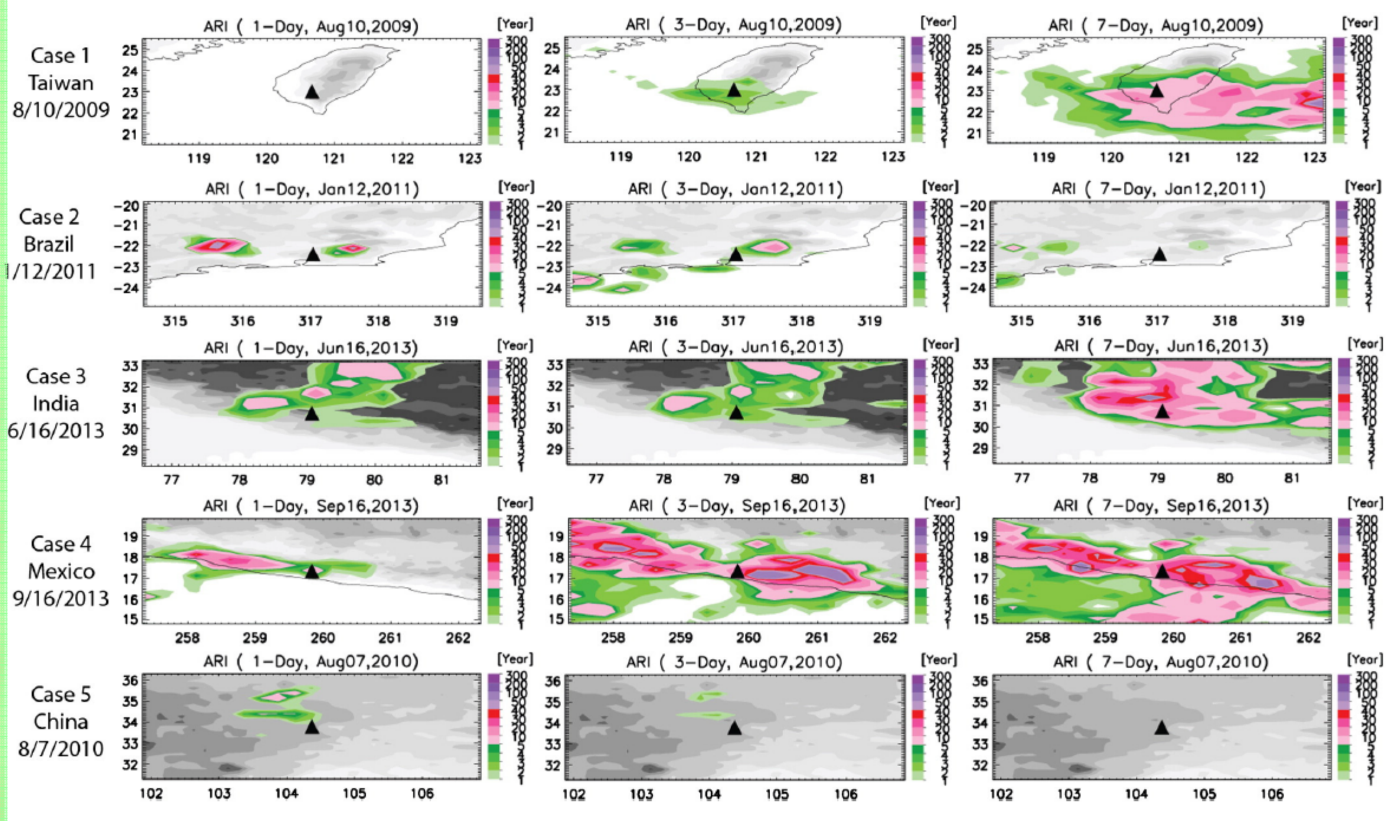
- 從2007-2013年間選五個災難性崩塌事件分析，評估極端降雨誘發崩塌影響
- 顯示五個地區之基本資料與分析結果
- 換算崩塌區內最大之重現期距降雨
- 兩種降雨方式估算之1、3、7天累積降雨量

		Case 1	Case 2	Case 3	Case 4	Case 5
Event information	Location	Shiaolin, Taiwan	Teresópolis, Brazil	Kedarnath, India	La Pintada, Mexico	Zhouqu, China
	Date	8/10/2009	1/12/2011	6/16/2013	9/16/2013	8/7/2010
	Trigger	Typhoon Morakot	Heavy rainfall	Heavy rainfall	Tropical Cyclone Manuel	Heavy rainfall
	Fatalities	491	424	5000	68	1765
ARI over 5 × 5° grid	Maximum ARI	190 years (5-day)	188 years (2-day)	77 years (7-day)	99 years (3-day)	8.5 years (1-day)
	1-day	Null	52.8	18.5	42.1	8.5
	3-day	4.1	18.3	9.8	99.1	2.6
	7-day	65.9	10.2	77.4	80.9	0.8
Rain accum. at GLC point	1-day	232.6	60.9	119.9	85.5	35.9
	3-day	454.1	128.1	300.6	180.9	35.9
	7-day	549.3	196.4	515.0	268.2	130.7

結果與討論

GLC reports and fatalities | 社會經濟指標 | **GLC and extreme rainfall**

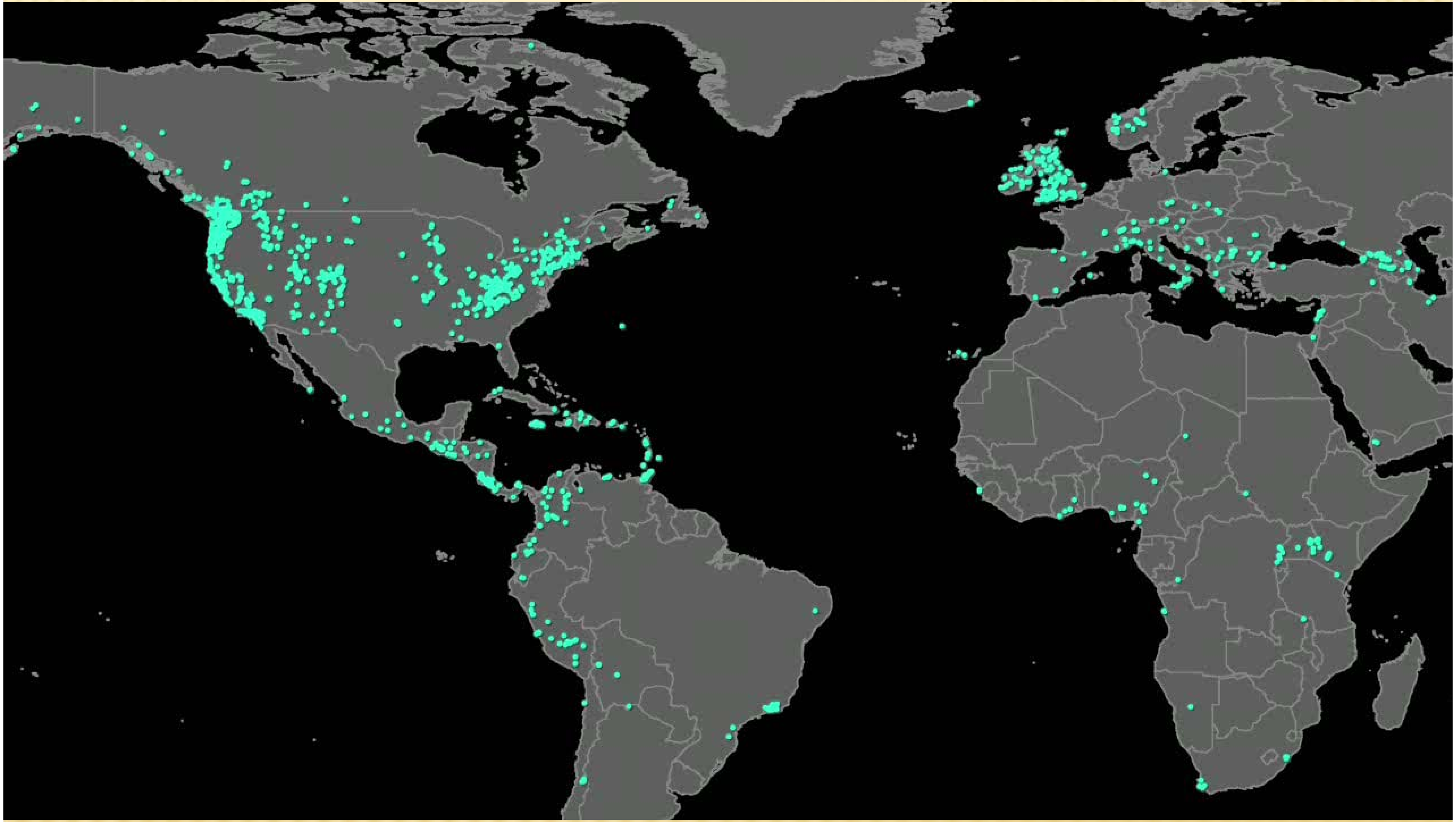
- ✓ 崩塌地顯示黑色三角形
- ✓ ARI在每個CASE內計算最強烈降水的結果，以紅色至紫色陰影顯示。
- ✓ 對於某些事件，累積窗口中的最大ARI重合山體滑坡報告;該地區其他地方觀測到了高峰降雨。
- ✓ 4/5至少有一個累積窗口估計大約50年以上的ARI超過滑坡位置附近
- ✓ 強調必須使用**多個積累窗口**來捕獲不同持續時間降雨

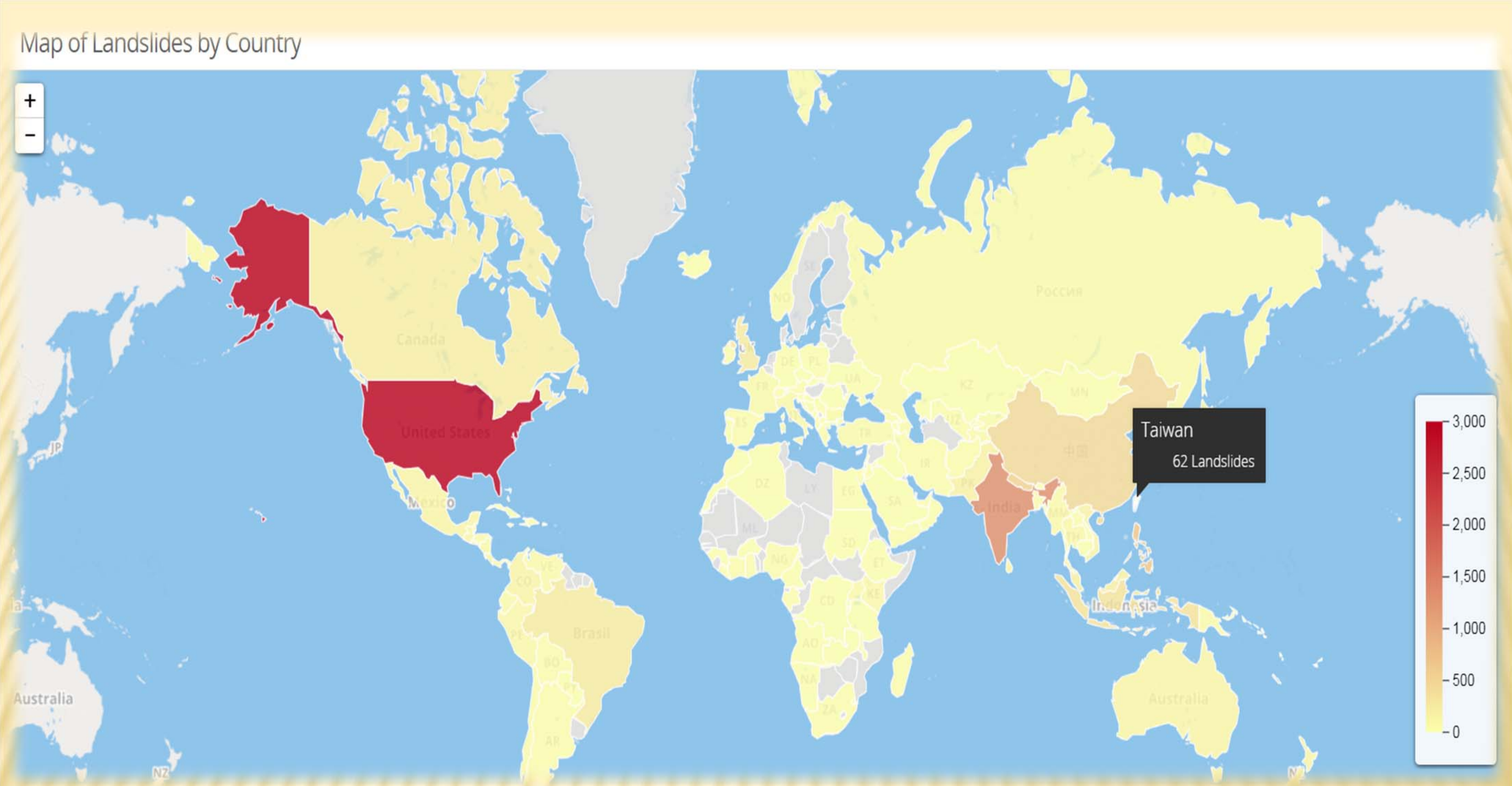


g. 9. Results of average recurrence interval (ARI) results for five extreme landslides in the GLC. Plots show the landslide location (black triangle) centered in a 5 × 5° box. ARI is calculated r 1, 3 and 7-day (left, center and right columns, respectively) rain accumulations prior to the landslide event for each of the 5 cases.

結論與建議

- 經統計，全球崩塌發生時間於7-9月最常發生。
- 記錄以亞洲、北美、東南亞之崩塌最為常見；相較下北美所記錄崩塌事件造成之傷亡僅佔5%以下
- 記錄到的崩塌事件與其衛星降雨估算(TRMM)去推估極端降雨與崩塌發生之相關性
  - 在所統計的3550崩塌點位事件中，經以14年之TRMM分析其每日降雨，結果顯示60%以上之崩塌事件其發生時之日降雨大於該點位之95%日均降雨量
- 本研究調查極端降雨事件重現年距與致災性崩塌事件關係
  - 結果顯示即便崩塌目錄之各項分析均有差異擺盪情況，但對於全球尺度一或區域性之崩塌與降雨關係，能提供了特徵參數及崩塌研究之相關資料庫。
- 本文章提醒了基本資料建置之重要、並提供幾項分析方式供吾人思考，資料建置後運用加值性
- 本文所提出之結論雖可預見想像、惟數據會說話之概念運用在行政部門、研究成果之重要性功不可沒




Map of Landslides by Country
Taiwan
62 Landslides
3,000
2,500
2,000
1,500
1,000
500
0
Canada
United States
Mexico
Brasil
India
Indonesia
Australia
Россия

謝謝聆聽
敬請指教