# 臺北市立萬芳高級中學會議紀錄

名稱： 105-2( 8 )教學研究會

時間： 106 年 06 月 10 日

主題： 台灣前瞻風險再與氣候變遷

主席： 邱怡禎 紀錄： 王瑜敏

簽到：如簽到表

應到人數:

實到人數:

重要會議內容：

如附

# 臺灣的颱風降雨與氣候變遷

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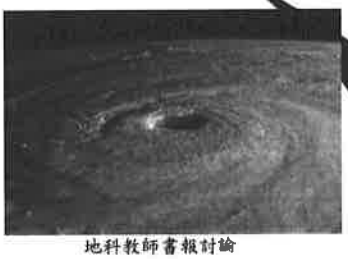


地科教師書報討論
@萬芳高中地科教室 (2017/06/10)

## 研讀文章

* **Chang, C.-P., Y. Lei, C.-H. Sui, X. Lin, and F. Ren, 2012: Tropical cyclone and extreme rainfall trends in East Asian summer monsoon since mid-20th century, *Geophys. Res. Lett.*, 39, L18702.**

* **Chang, C.-P., Y. T. Yang, and H. C. Kuo, 2013: Large Increasing Trend of Tropical Cyclone Rainfall in Taiwan and the Roles of Terrain. *J. Climate*, 26, 4138–4147.**

* Huang, H.-L., M.-J. Yang, and C.-H. Sui, 2014: Water budget and precipitation efficiency of Typhoon Morakot (2009). *J. Atmos. Sci.*, 71, 1129

* Wu, C.-C., T.-H. Yen, Y.-H. Huang, C.-K. Yu, and S.-G. Chen, 2016: Statistical Characteristic of Heavy Rainfall Associated with Typhoons near Taiwan Based on High-Density Automatic Rain Gauge Data. *Bull. Amer. Meteor. Soc.* 97, 1363-1375.

## Introduction

* 全球暖化→ 水氣容量增加 → 降雨強度和強降雨增加。１００年降雨強度應該增加７％，降雨量應該增加２%. 可是：

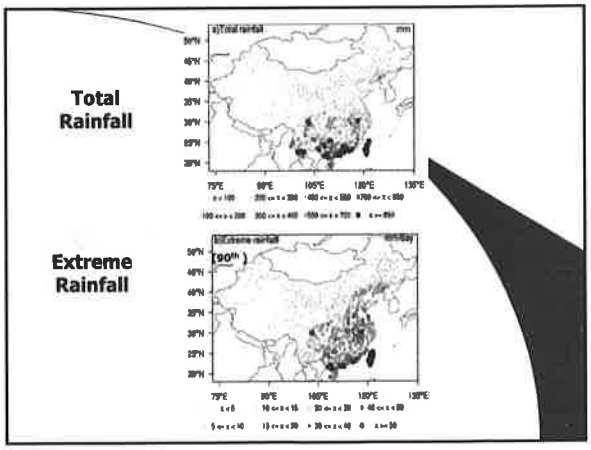
1) 氣候模式模擬的結果是過去數十年北半[illegible]地極端強降雨增加。這和歐洲和北美洲觀測趨勢[illegible]，但亞洲季風區訊號不清楚，增加程度遠少於[illegible]百分比。

2) 1998年以來台灣強降雨趨勢大量增加，主要是[illegible]風降雨增加所致，增加程度遠超過這些百分比。[illegible]因為全球暖化？(水氣增加引起正反饋作用？)

## 1960-2011資料分析

- Chang, C.-P., Y. Lei, C.-H. Sui, X. Lin, and F. Ren, 2012: Tropical cyclone and extreme rainfall trends in East Asian summer monsoon since mid-20th century, *Geophys. Res. Lett.*, 39, L18702.
- Chang, C.-P., Y. T. Yang, and H. C. Kuo, 2013: Large Increasing Trend of Tropical Cyclone Rainfall in Taiwan and the Roles of Terrain. *J. Climate*, 26, 4138–4147.
  - 21世紀侵台颱風降雨破紀錄增加 – 導致極端降水增加。
  - 影響降雨的因素-大範圍水汽影響? 局部影響? 外來影響?
  - 降雨增加趨勢和降雨強[illegible]趨勢的異同? – 颱風頻率和持續時間。
  - 增加的機制? – 路徑變化和[illegible]的交互作用。
  - 多年代際降雨強度變化遭露的[illegible]化還是自然變化?

**研讀文章1:** Chang, C.-P., Y. Lei, C.-H. Sui, X. Lin, and F. Ren, 2012: Tropical cyclone and extreme rainfall trends in East Asian summer monsoon since mid-20th century, *Geophys. Res. Lett.*, **39**, L18702.

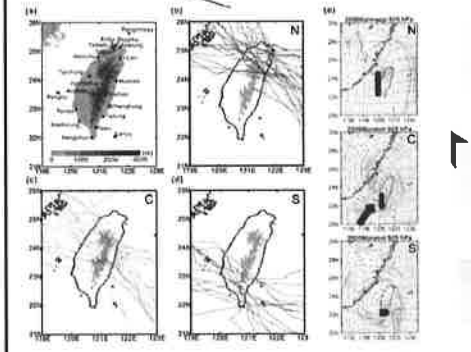


**The 12 typhoons in 1960-2011 with total rainfall over Taiwan exceeding 3500 mm during the three phases. The 9 since 2004 are highlighted.**

| Rank | Year | Typhoon Name | Total (h) | Rainfall (mm) |
|---|---|---|---|---|
| 1 | 2009 | Morakot | 48 | 8996 |
| 2 | 2001 | Nari | 75 | 8108 |
| 3 | 2008 | Sinlaku | 48 | 6196 |
| 4 | 2008 | Haitang | 32 | 5689 |
| 5 | 1996 | Herb | 16 | 4836 |
| 6 | 1969 | Sarah | 38 | 4655 |
| 7 | 1960 | Shirley | 24 | 4637 |
| 8 | 2007 | Krosa | 23 | 3834 |
| 9 | 2004 | Mindulle | 41 | 3856 |
| 10 | 2008 | Jangmi | 25 | 3800 |
| 11 | 2008 | Kalmaegi | 23 | 3783 |
| 12 | 2006 | Talim | 17 | 3526 |

## Taiwan Typhoon Rain Intensity

- 21 hourly stations 1960-2011 (→2014)
- 84 (→89) landfalling typhoons (all seasons)
- Re-analyzed TC tracks by CWB & NTU,
- 三類主要路徑:北(N)、中(C)、南(S),
- 3 Track Phases:
  PRe-landfall(登路前), OverLand(登路後), EXit(離開後)
- Rainfall affected by
  Interaction with Terrain
  Interaction with Monsoon



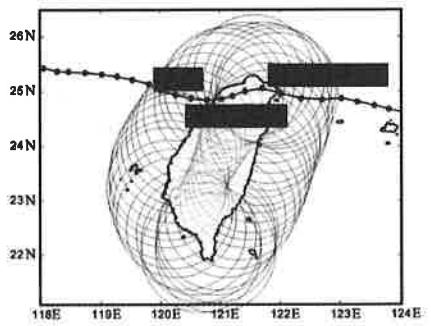

Maximum Terrain Interaction

Maximum SW monsoon Interaction

Minimum Terrain Interaction

**1960-2011: 21 hourly stations , 84 landfalling typhoons**

## Typhoon Track Phases




## PRelandfall
## 登陸前

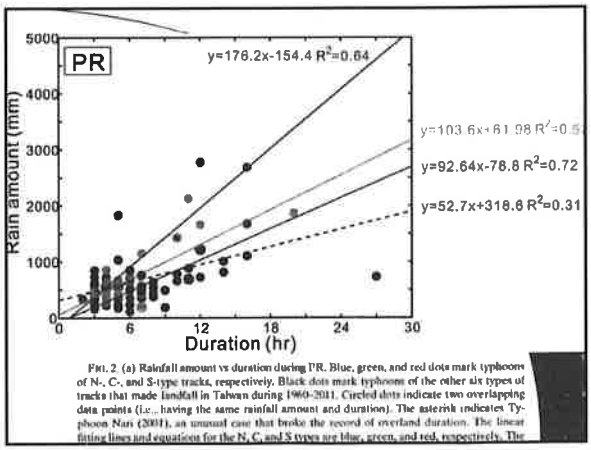
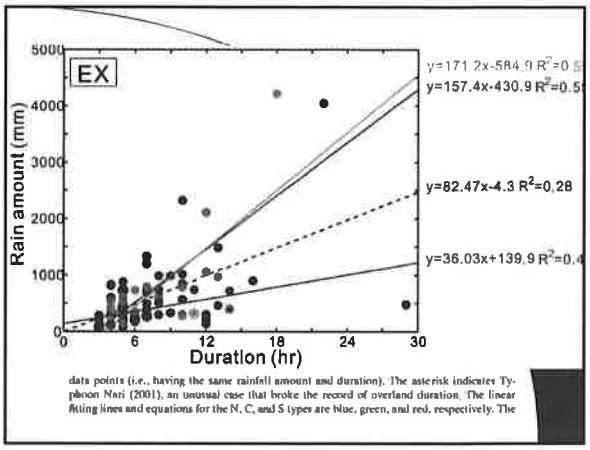



FIG. 2. (a) Rainfall amount vs duration during PR. Blue, green, and red dots mark typhoons of N-, C-, and S-type tracks, respectively. Black dots mark typhoons of the other six types of tracks that made landfall in Taiwan during 1960-2011. Circled dots indicate two overlapping data points (i.e., having the same rainfall amount and duration). The asterisk indicates Typhoon Nari (2001), an unusual case that broke the record of overland duration. The linear fitting lines and equations for the N, C, and S types are blue, green, and red, respectively. The

**EXit**
**離陸期間**




data points (i.e., having the same rainfall amount and duration). The asterisk indicates Typhoon Nari (2001), an unusual case that broke the record of overland duration. The linear fitting lines and equations for the N, C, and S types are blue, green, and red, respectively. The

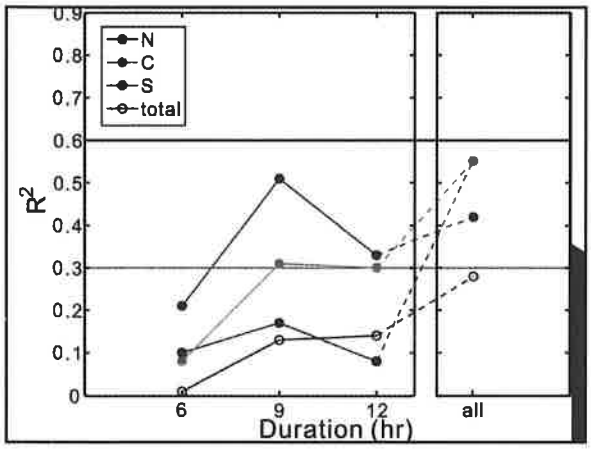



**Table 2: The 12-hour rainfall intensity (mm) for the three track types during the three phases.**

| Track Type \ Phase | PR | OL | EX |
|---|---|---|---|
| N | 1960 | 2132 | 1458 |
| C | 1305 | 1558 | |
| S | 1033 | 812 | 57 |

**Table 3: The frequency and duration of the N, C, and S typhoons before and after 2004.**

TABLE 3. The frequency (number of typhoons with the percentage of the total in parentheses) and duration (h) of the three types of tracks before and after 2004.

| | 1960–2003 | 2004–11 |
|---|---|---|
| Frequency | | |
| N | 21 (44.6%) | 5 (31.3%) |
| C | 15 (31.9%) | 8 (50.0%) |
| S | 11 (23.4%) | 3 (18.8%) |
| Duration | | |
| N | 15.9 | 24.0 |
| C | 23.9 | 23.3 |
| S | 21.7 | 20.0 |

=> the large increase of typhoon rainfall intensity on Taiwan since 2004 is related to changes in both track frequency and duration.

*C frequency +*
*N duration +*

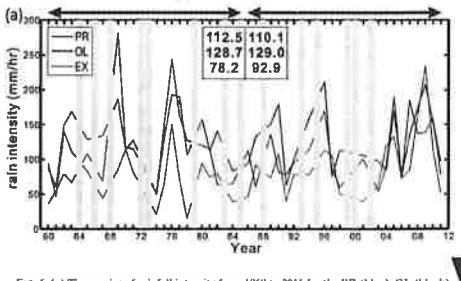



FIG. 6. (a) Time series of rainfall intensity from 1960 to 2011 for the PR (blue), OL (black), and EX (red) phases for weak- and medium-intensity (category 1–3) typhoons. Gray vertical columns indicate years with no typhoons of the three leading types of tracks. The table inside the panel lists the average yearly rainfall intensities of the three phases during the (left) first (1960–85) and (right) second half (1986–2011) of the 52-yr period. The two subperiods are indicated by double ended arrows above the panel. (b) As in (a), but for strong-type (categories

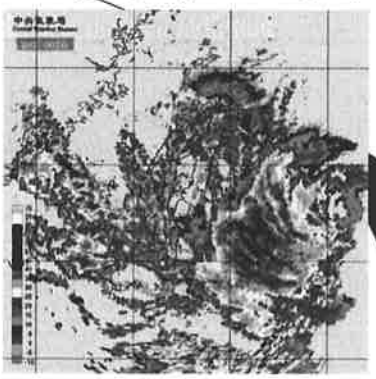
## 小結

- 地形是控制台灣颱風降雨量最重要的因素。
- 登陸前和登陸後，雨量的增加主因為北行路徑颱風經過時間變長和中行路徑颱風變多。
- 登陸前的颱風降雨強度沒有增加。登陸後降雨強度有增加的趨勢，尤其是颱風出海後，降雨強度增加趨勢明顯，導源於季風交互作用增強的趨勢。
  - 這個趨勢並非因為颱風強度正反饋（颱風強度五十年來趨勢是減弱而非增強。）
  - 熱帶季風增強和人類影響導致全球暖化的理論衝突
  - 熱帶季風變化和Mega ENSO及PDO和AMO自然年代變化成正相關。(Wang et al. 2013)

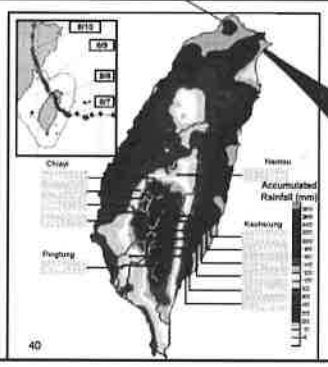
→也和缺引氣流減慢，登陸前後颱風經過時間變長一致。

## Topographic locking effect

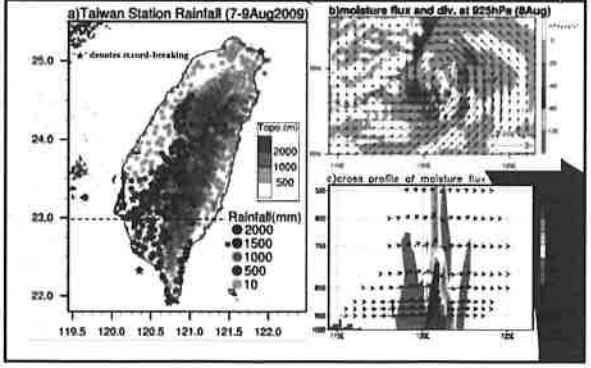
## Radar Reflectivity Loop of Morakot (2009)

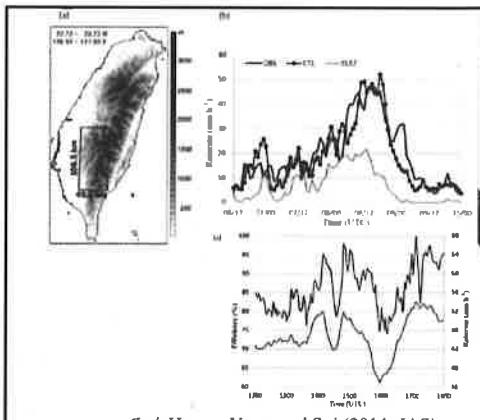


## 破紀錄超大豪雨
## 長延時的持續性降雨




## 地形鎖定降水分佈：莫拉克颱風



取自Huang, Yang, and Sui (2014; JAS)

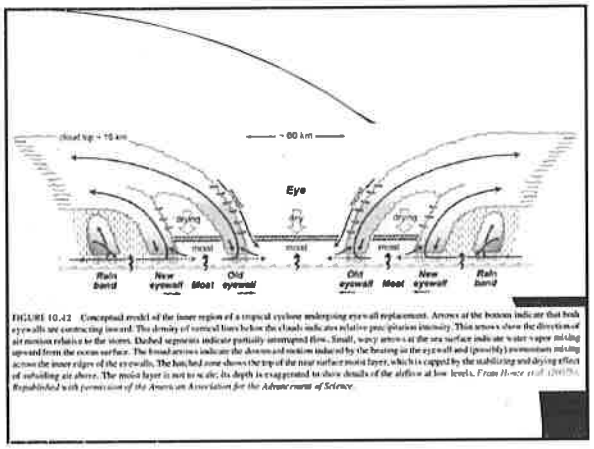



FIGURE 10.42 Conceptual model of the inner region of a tropical cyclone undergoing eyewall replacement. Arrows at the bottom indicate that both eyewalls are contracting inward. The density of vertical lines below the clouds indicates relative precipitation intensity. Thin arrows show the direction of air motion relative to the storm. Dashed segments indicate partially interrupted flow. Small, wavy arrows at the sea surface indicate water vapor mixing upward from the ocean surface. The broad arrows indicate the descent motion induced by the heating in the eyewall and (possibly) momentum mixing across the inner edges of the eyewalls. The hatched zone shows the top of the near-surface moist layer, which is capped by the stabilizing and drying effect of subsiding air above. The moist layer is not to scale; its depth is exaggerated to show details of the airflow at low levels. *From Houze et al. (2007a). Republished with permission of the American Association for the Advancement of Science.*

## 總結

* 颱風現象為大氣科學領域中多重尺度交互作用的複雜議題，颱風路徑及伴隨風雨預報為科學上極為困難，但於作業上極為重要的任務。

* 全球暖化造成極端氣候，異常降水現象如[illegible]及乾旱發生頻率增加。

* 人不可能勝天，應該愛護自然環境，永續台灣

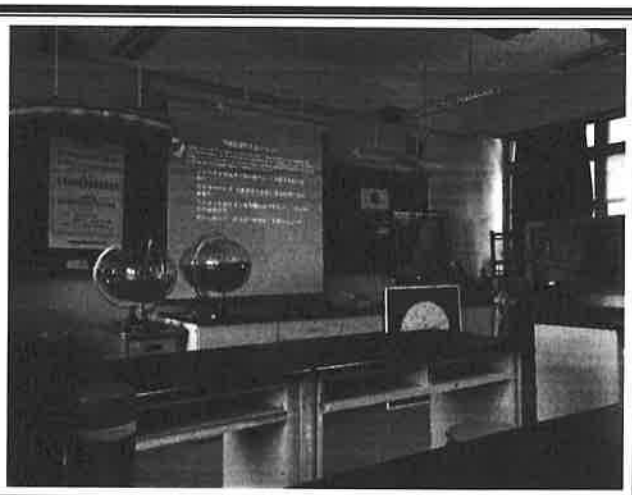
附件

# 臺北市立萬芳高級中學105學年度第2學期
## 活動照片

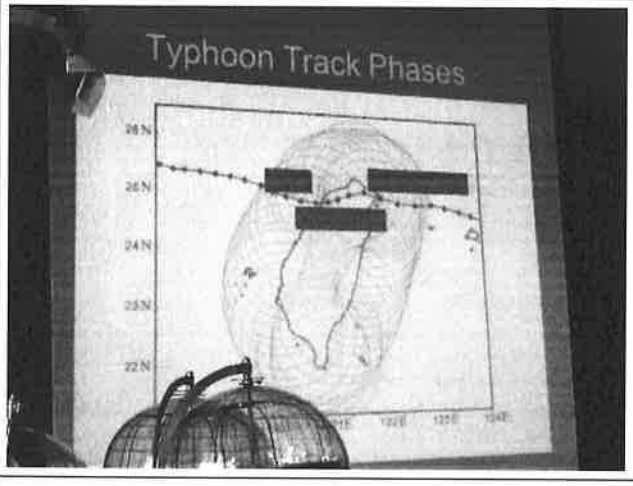
活動：台灣的颱風降雨與氣候變遷

日期：106.06.10　　地點：萬芳高中- 生科教室

圖說： 楊明仁教授介紹議題



圖說：楊明仁教授介紹議題




圖說：台灣颱風

圖說：參與的老師們認真聽講

成果特色與檢討簡述

如附