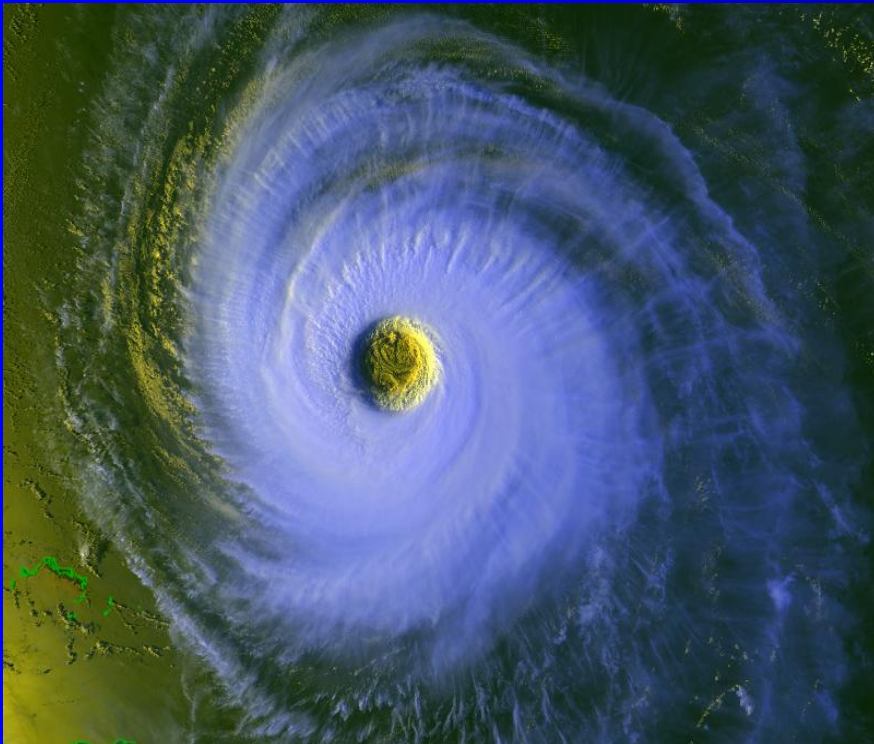


# 臺灣的劇烈天氣

楊明仁 (Ming-Jen Yang)

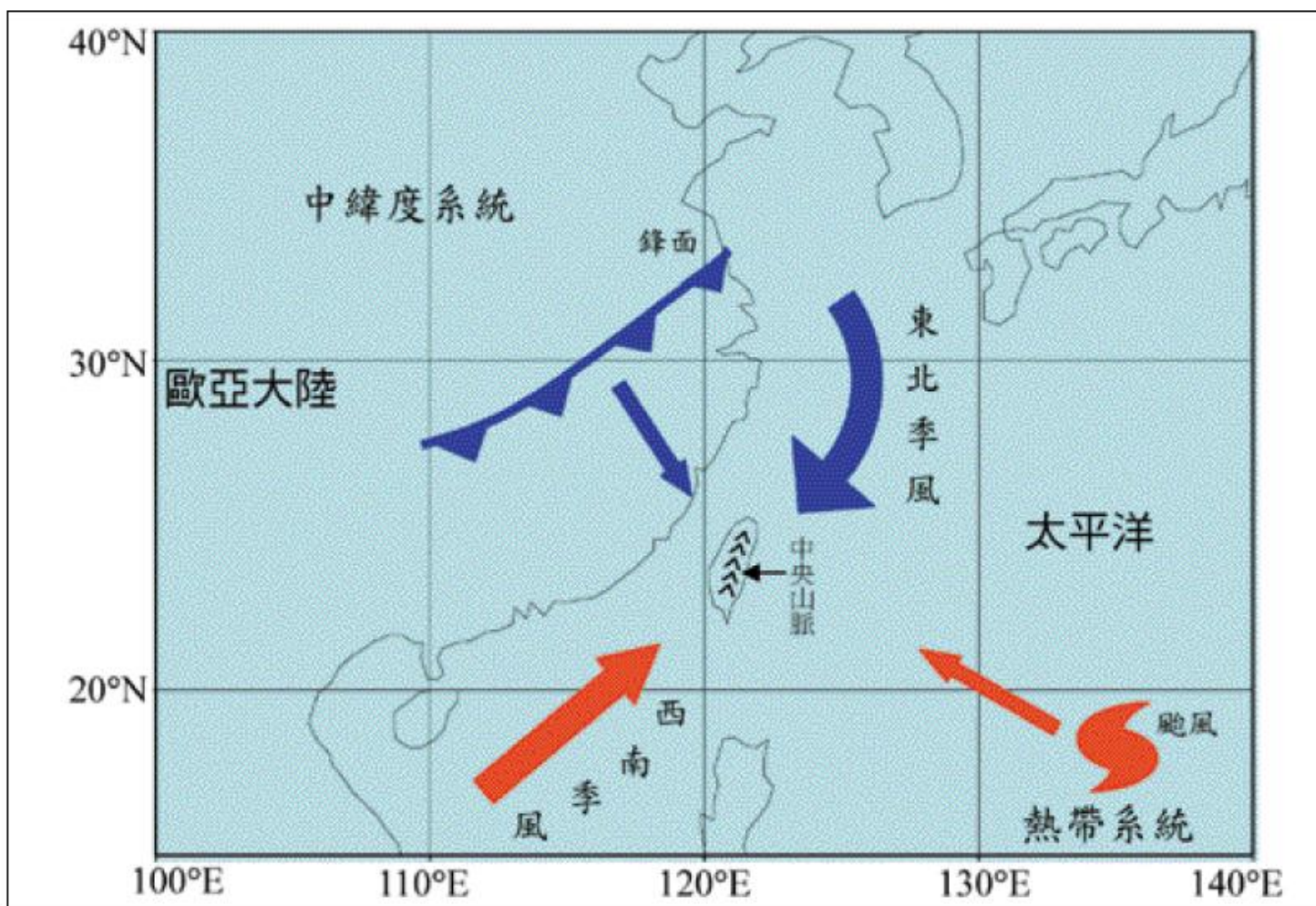
國立臺灣大學大氣科學系



104年度全國地球科學教師研習營

@ 國立臺灣大學思亮館國際會議廳 (2015/10/16)

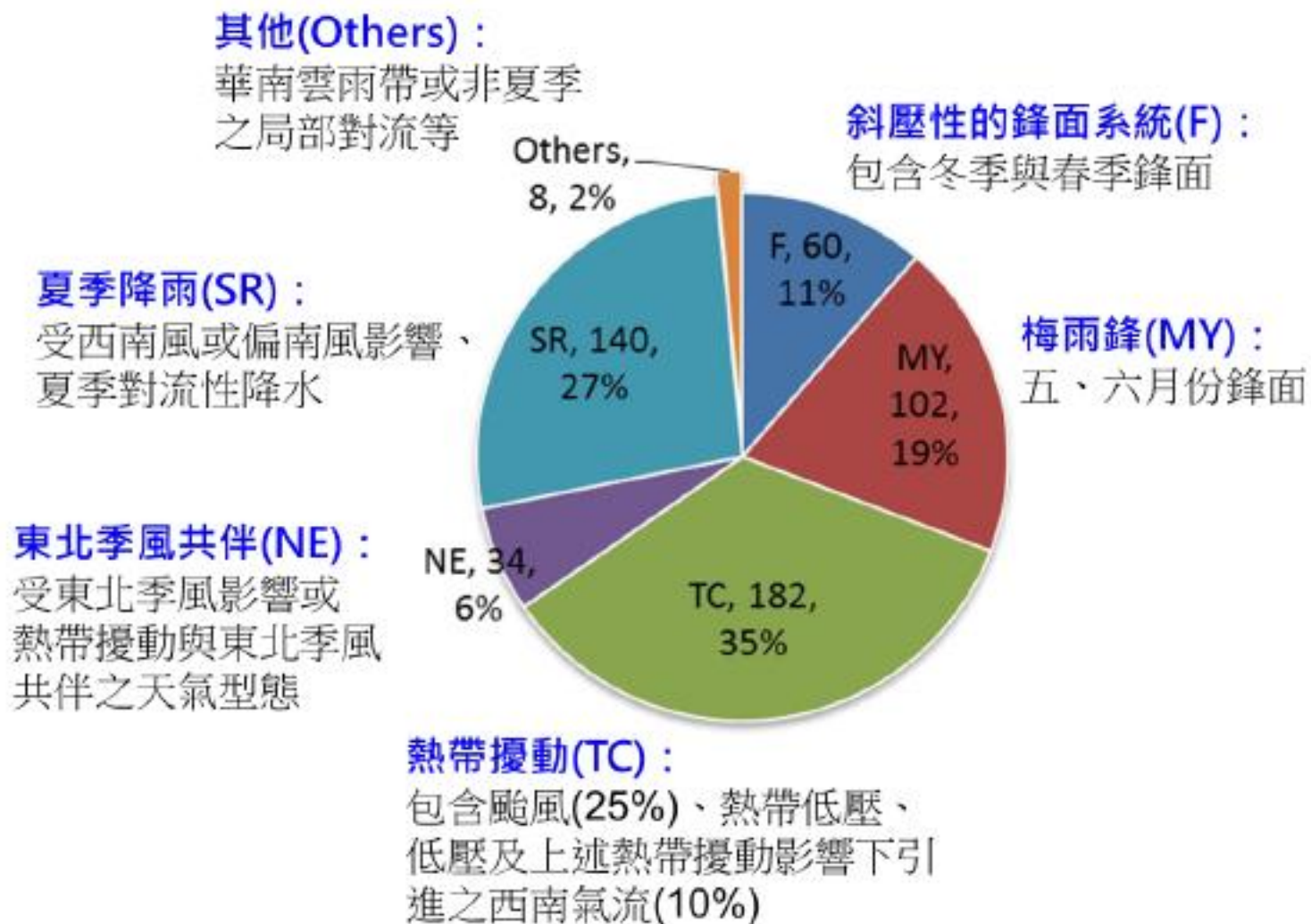
# 影響台灣的天氣系統



台灣在海陸分佈、山脈地形、緯度及季風等多重因素影響下，四季分明、天氣多變，各季節均有災變天氣。

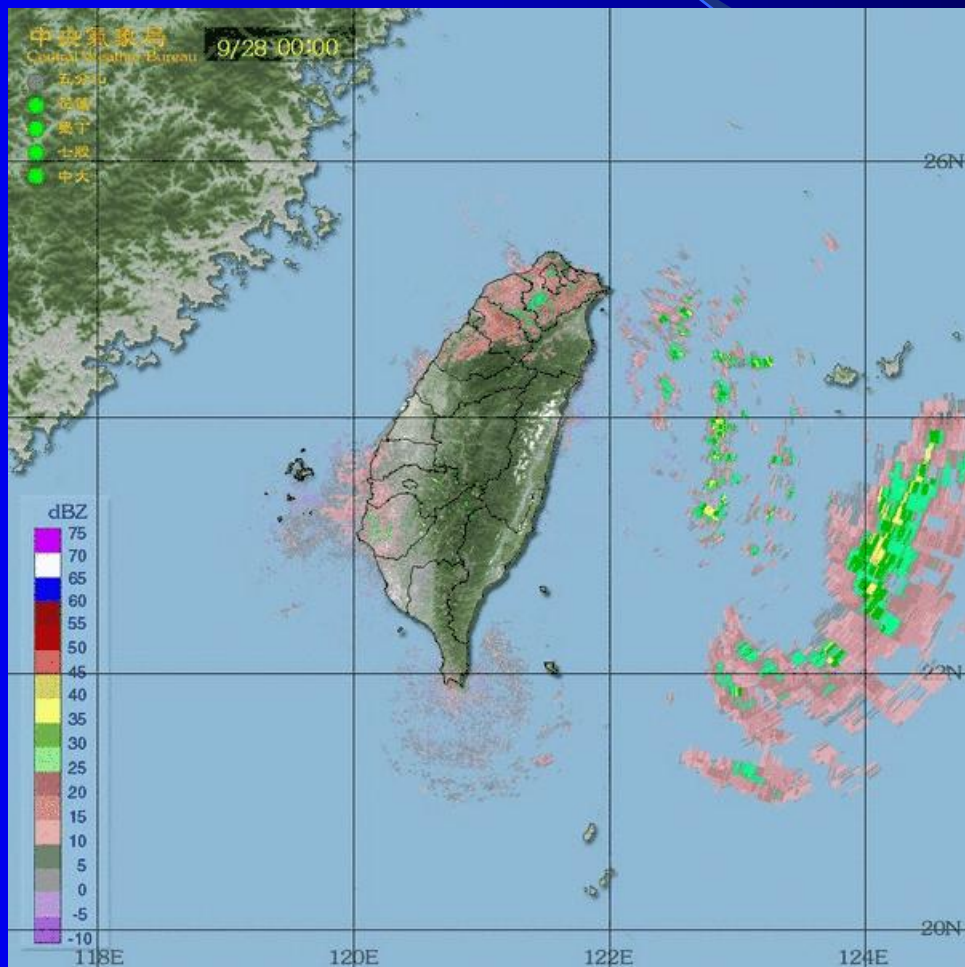
取自陳泰然(2003)





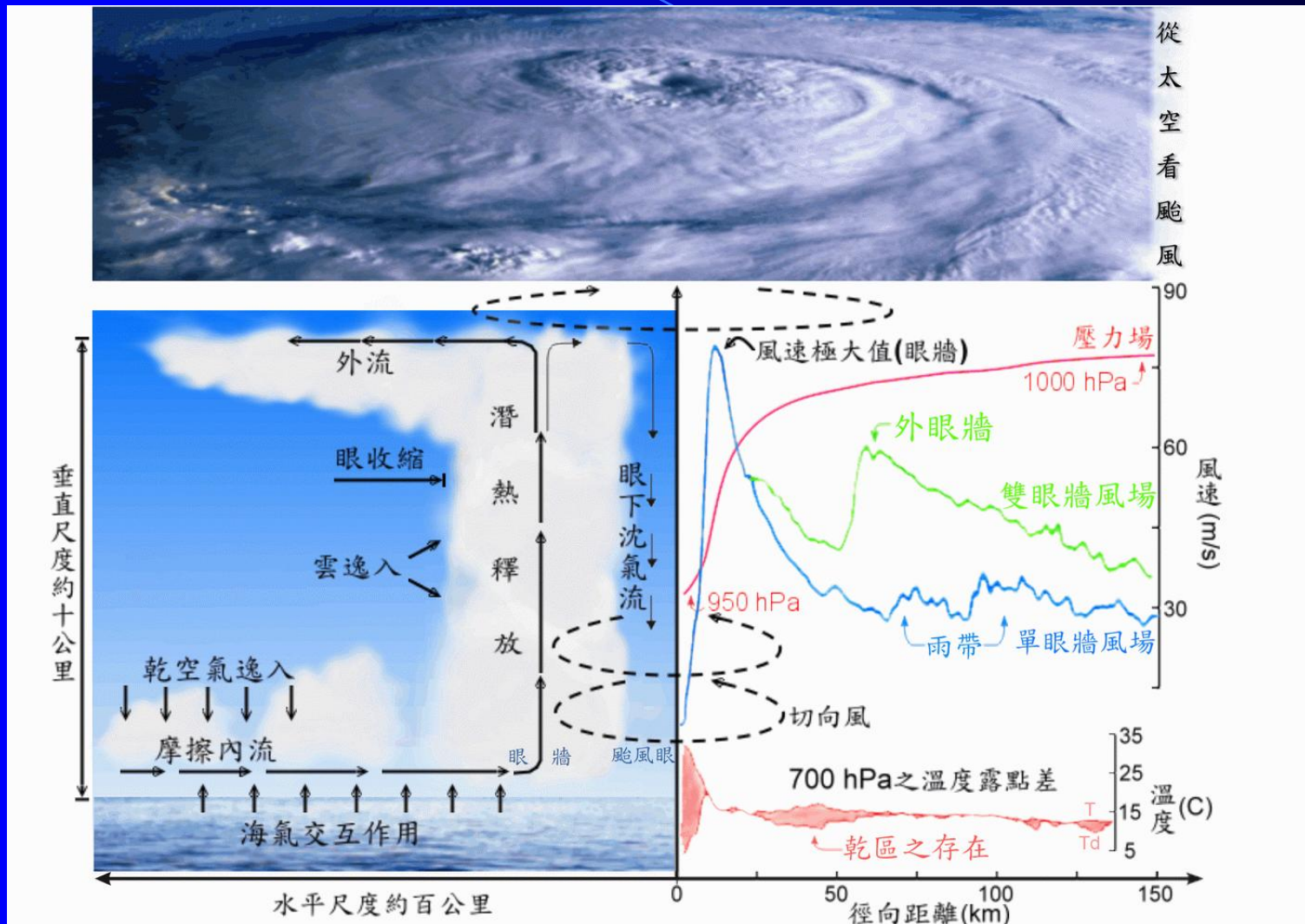
圖一 短延時致災降雨受各類天氣影響的日數與比例

# 杜鵑(2015)颱風的雷達回波圖



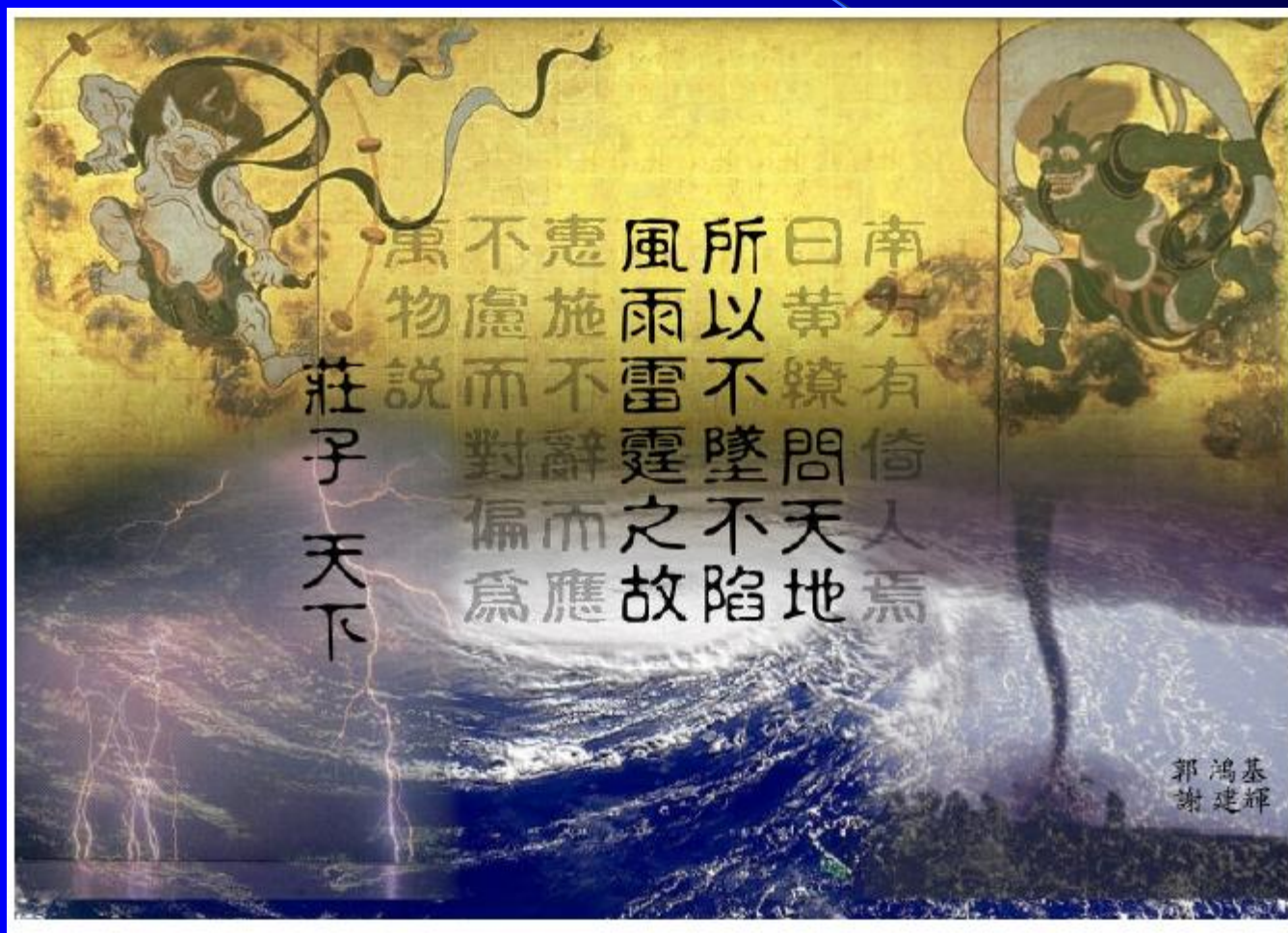


# 揭開颱風的面紗---颱風的基本結構



取自郭鴻基,李清勝,吳俊傑(2001)

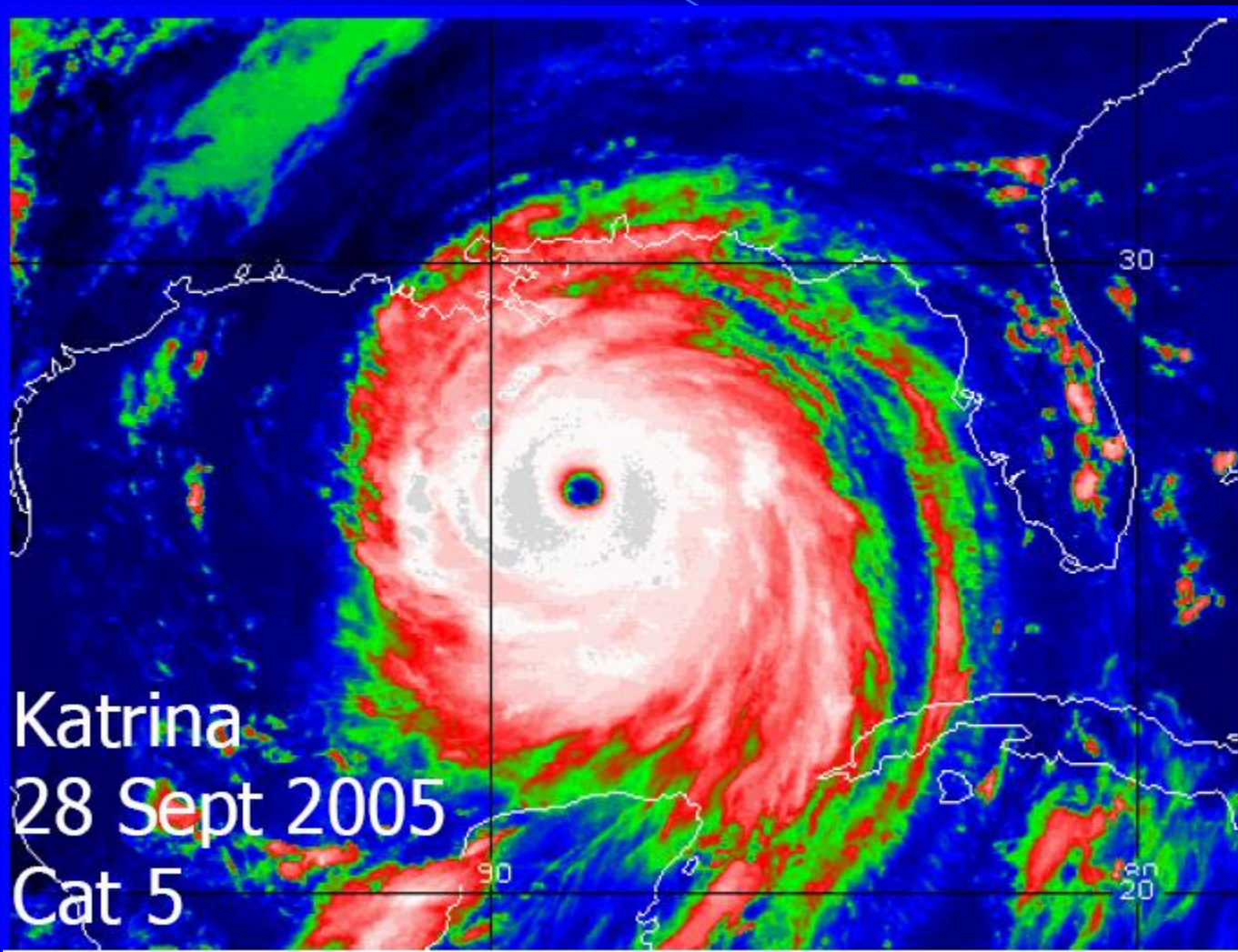
# 颱風災害—豪雨及強風所致



取自郭鴻基(2004)



# 卡翠納(2005)颶風





# 美國紐奧良市一片汪洋



**A DROWNED CITY**  
When levees broke after the storm, New Orleans' low topography betrayed it. Water rose as high as 6 m, flooding 80% of the city, including this area east of downtown.  
Photograph by Smiley N. Pool—Dallas Morning News/Corbis/TIME

Photo from the Time magazine





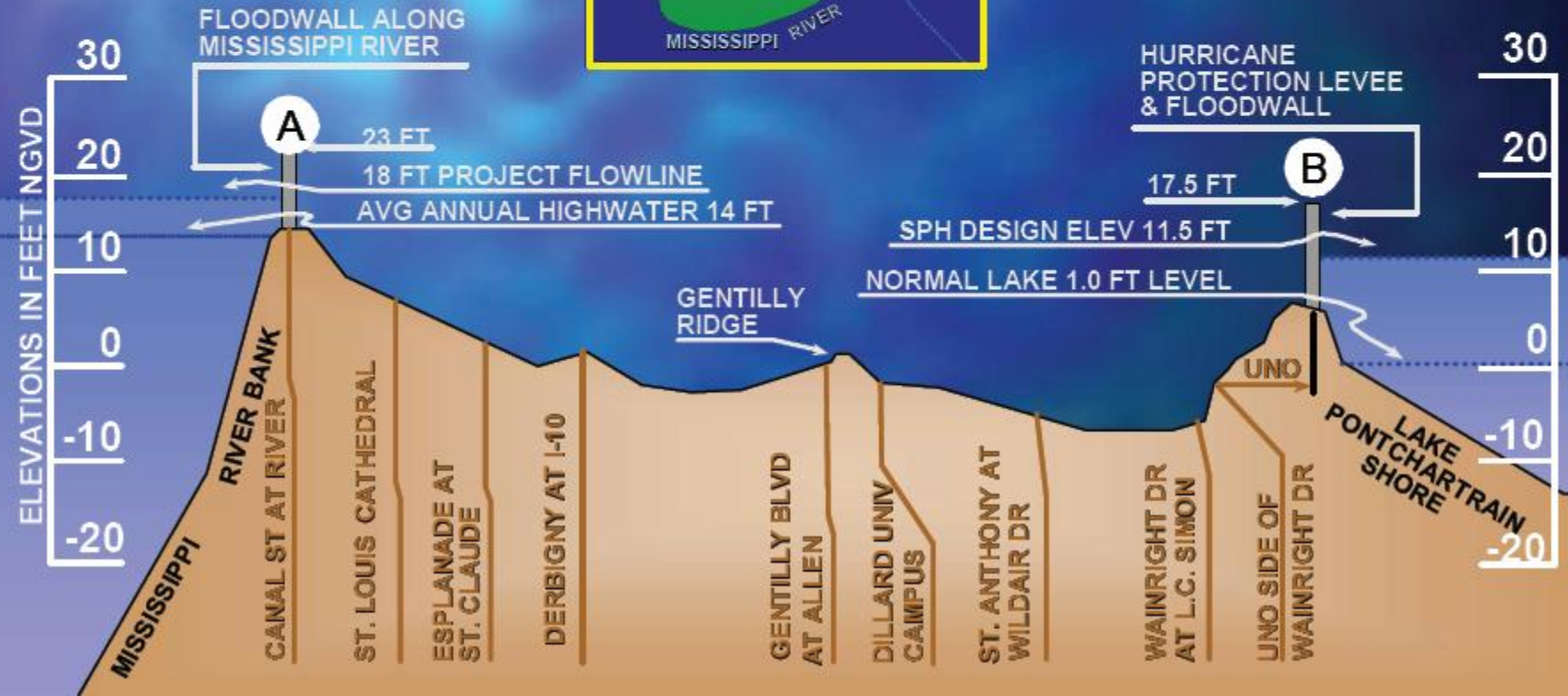


# 紐奧良市多數地區位於海平面以下!

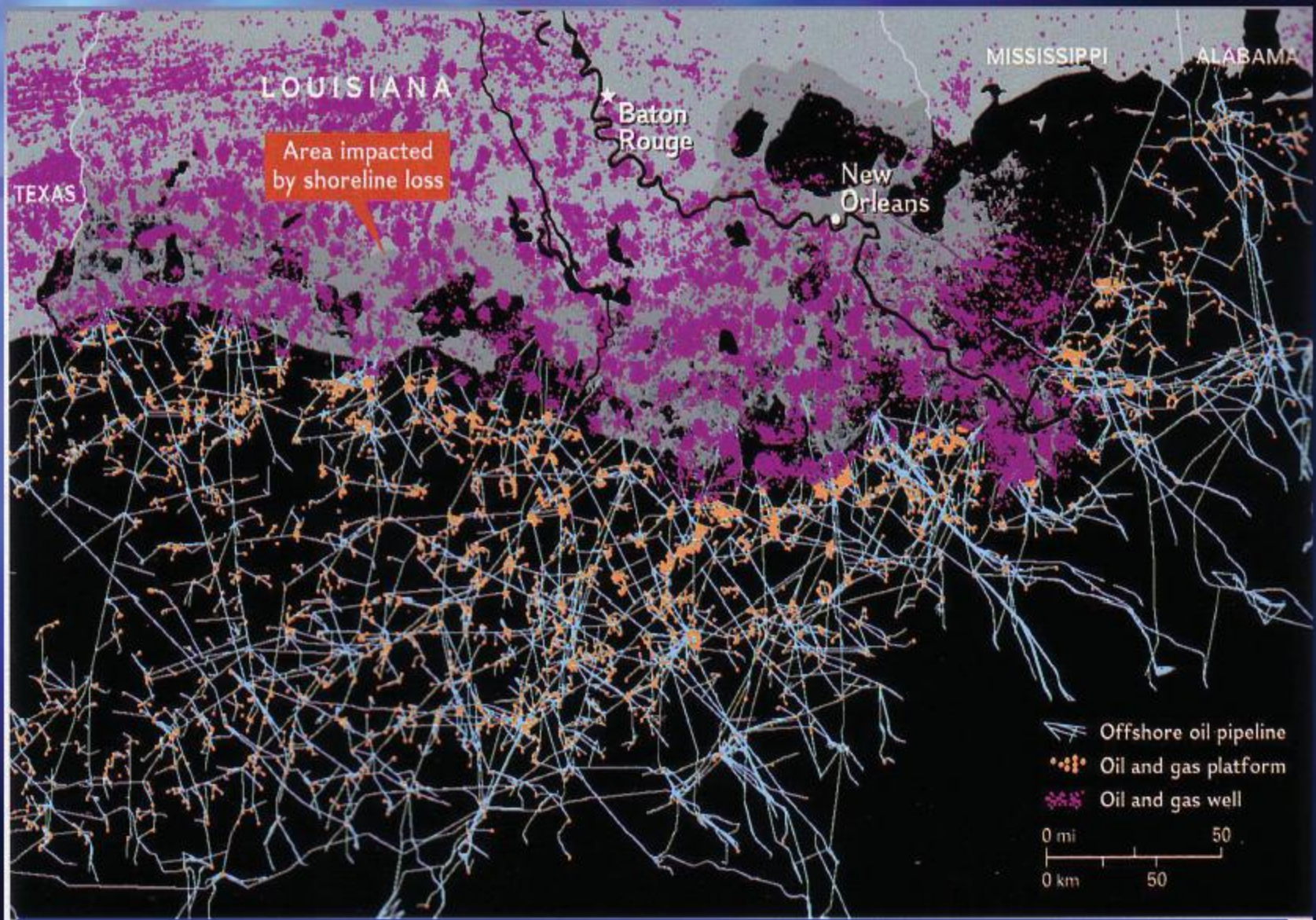
## City of New Orleans Ground Elevations



## From Canal St. at Mississippi River to the Lakefront at U.N.O.





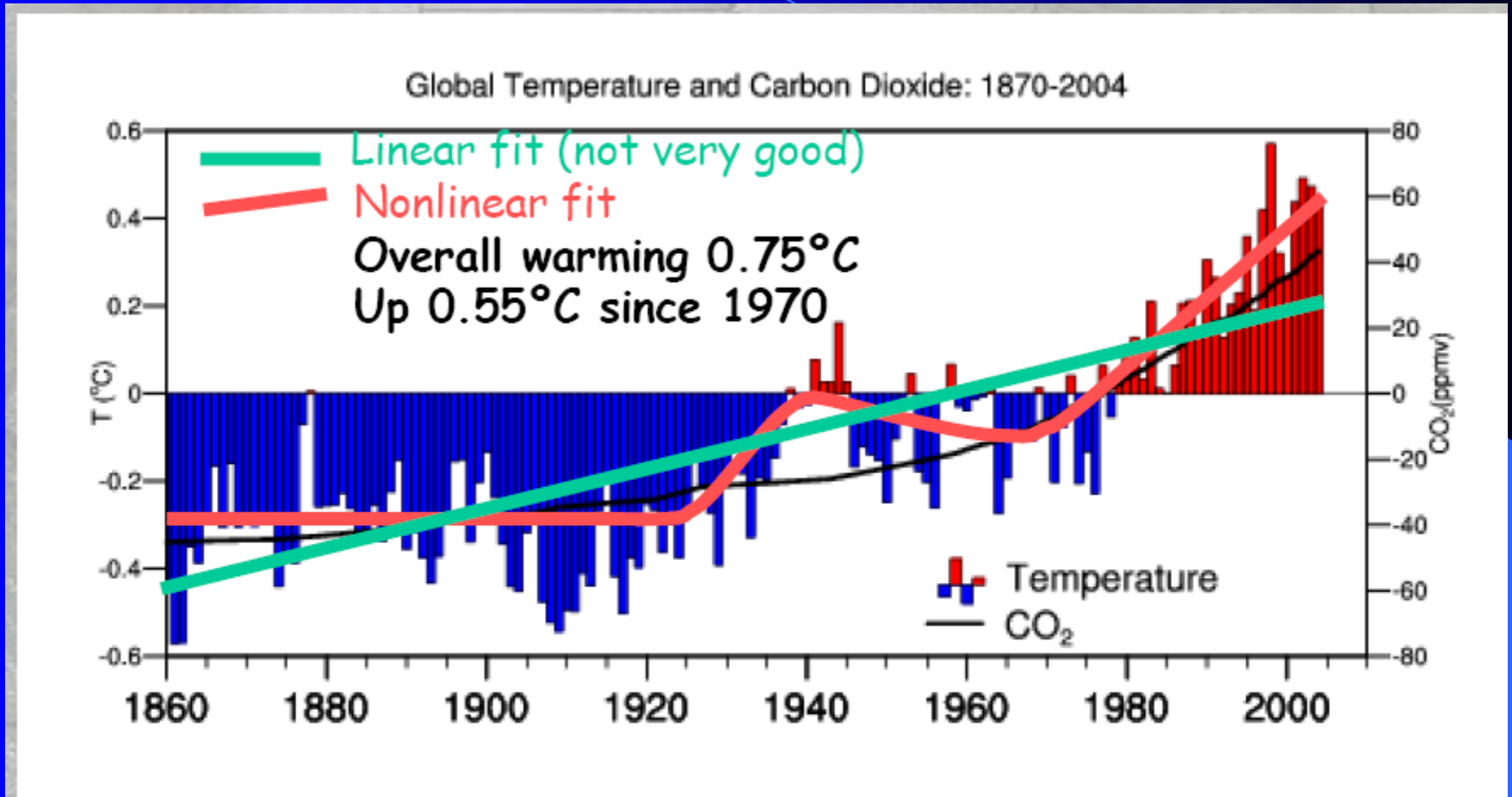


Coastline Oil & Gas Wells and Pipelines from Offshore

## North Atlantic Tropical Cyclone Statistics, 2000-2004

| Year | Named storms | Hurricanes | US Landfalls | Major hurricane landfalls |
|------|--------------|------------|--------------|---------------------------|
| 2004 | 14           | 9          | 5            | 3                         |
| 2003 | 16           | 7          | 2            | 0                         |
| 2002 | 12           | 4          | 1            | 0                         |
| 2001 | 15           | 9          | 0            | 0                         |
| 2000 | 14           | 8          | 0            | 0                         |

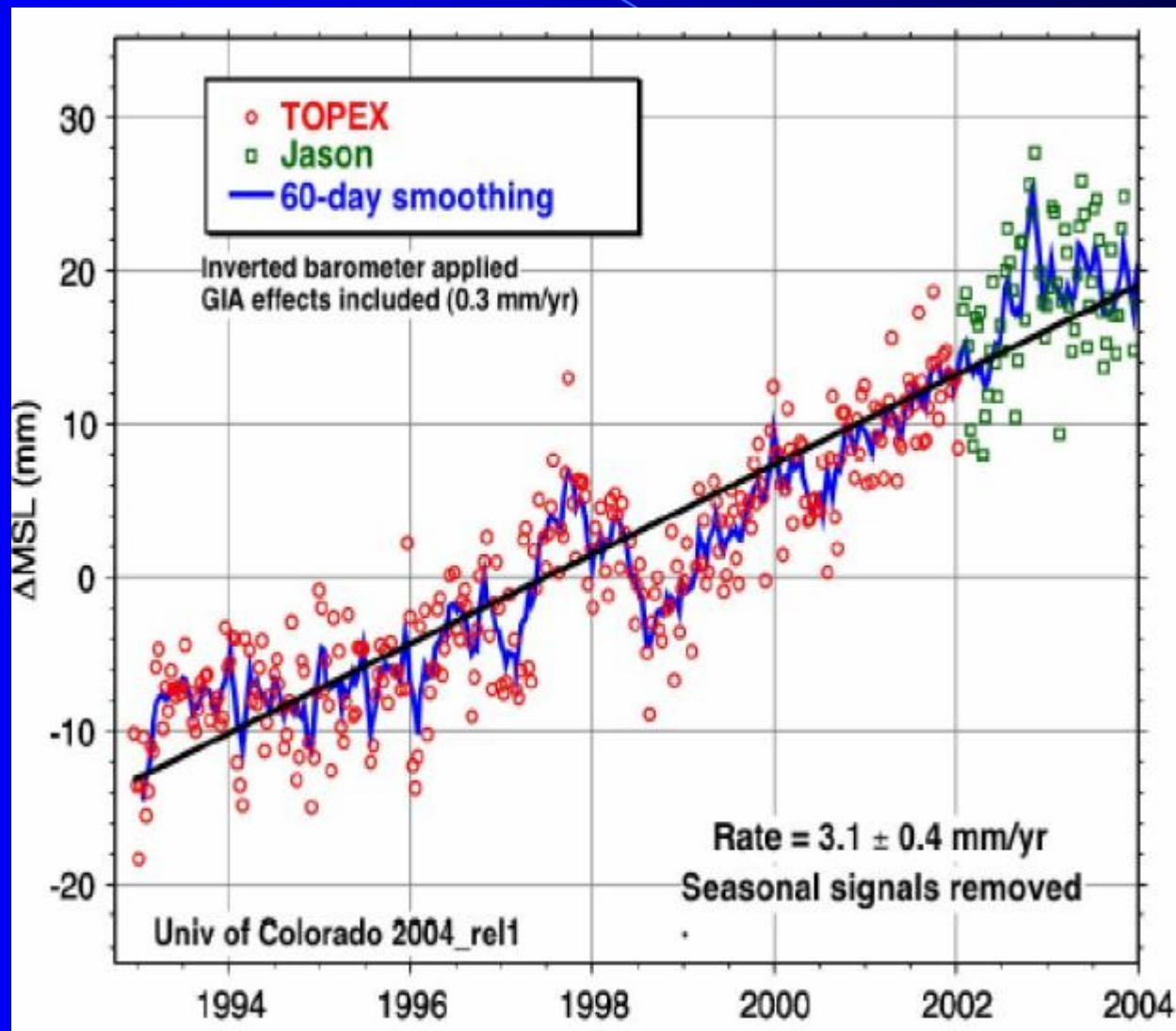
# 氣候暖化趨勢明顯



Annual mean departures from the 1961-90 average for global temperatures, mean 14.0°C, and carbon dioxide concentrations from ice cores and Mauna Loa (1958 on), mean 333.7 ppmv. Updated from Karl and Trenberth 2003.

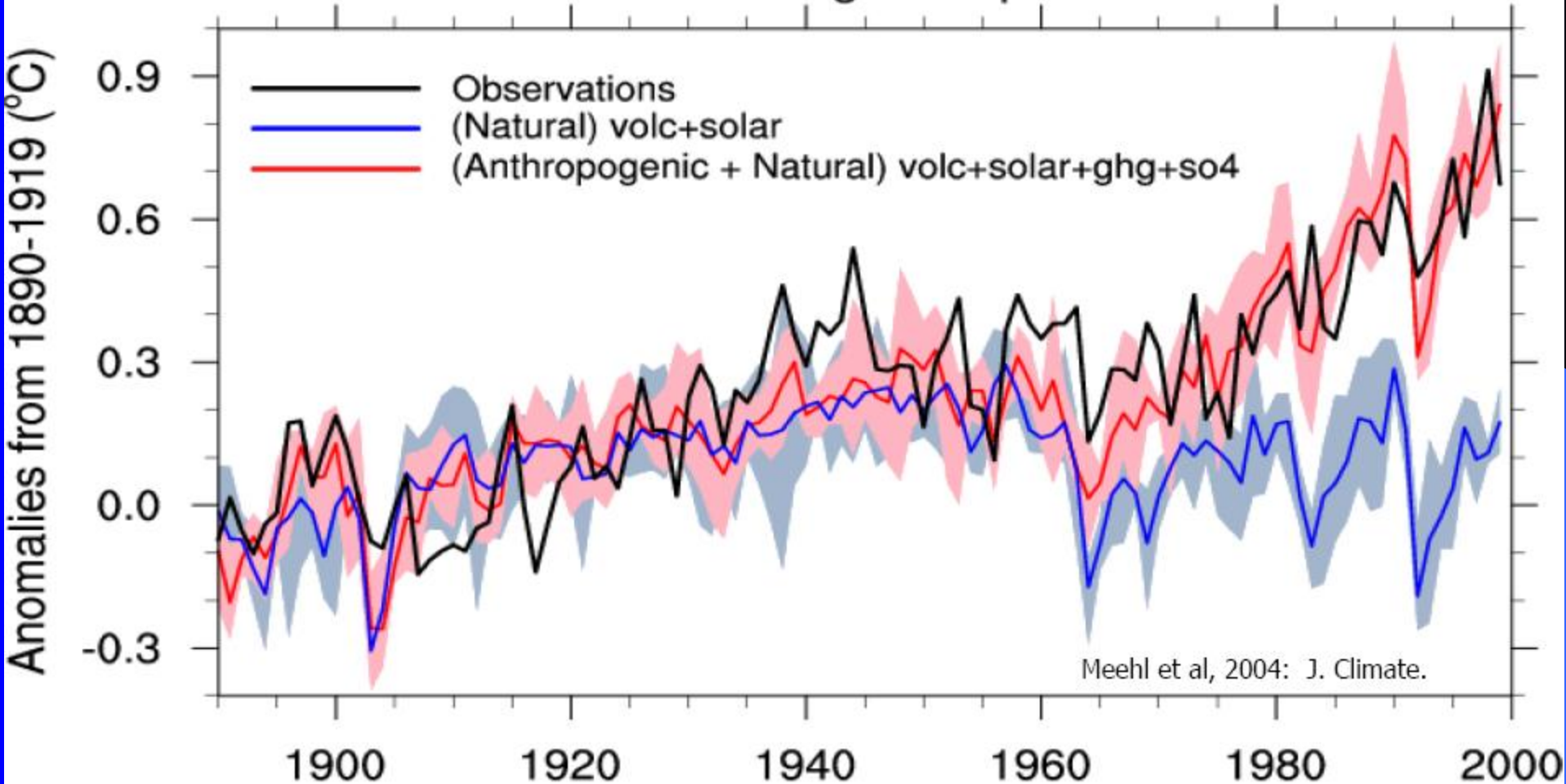


# 海平面高度正在上升

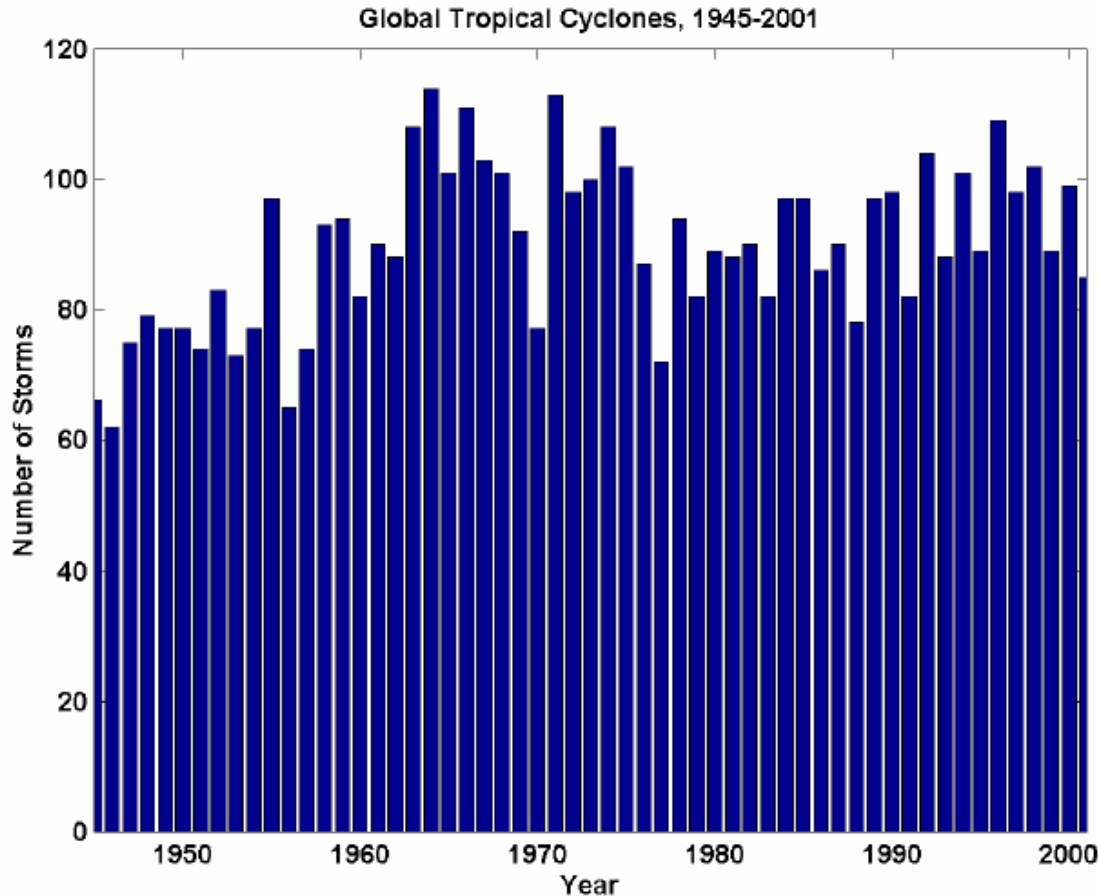


# Natural forcings do not account for observed 20<sup>th</sup> century warming after 1970

## Global Average Temperature



# No Long-Term Trend in Frequency

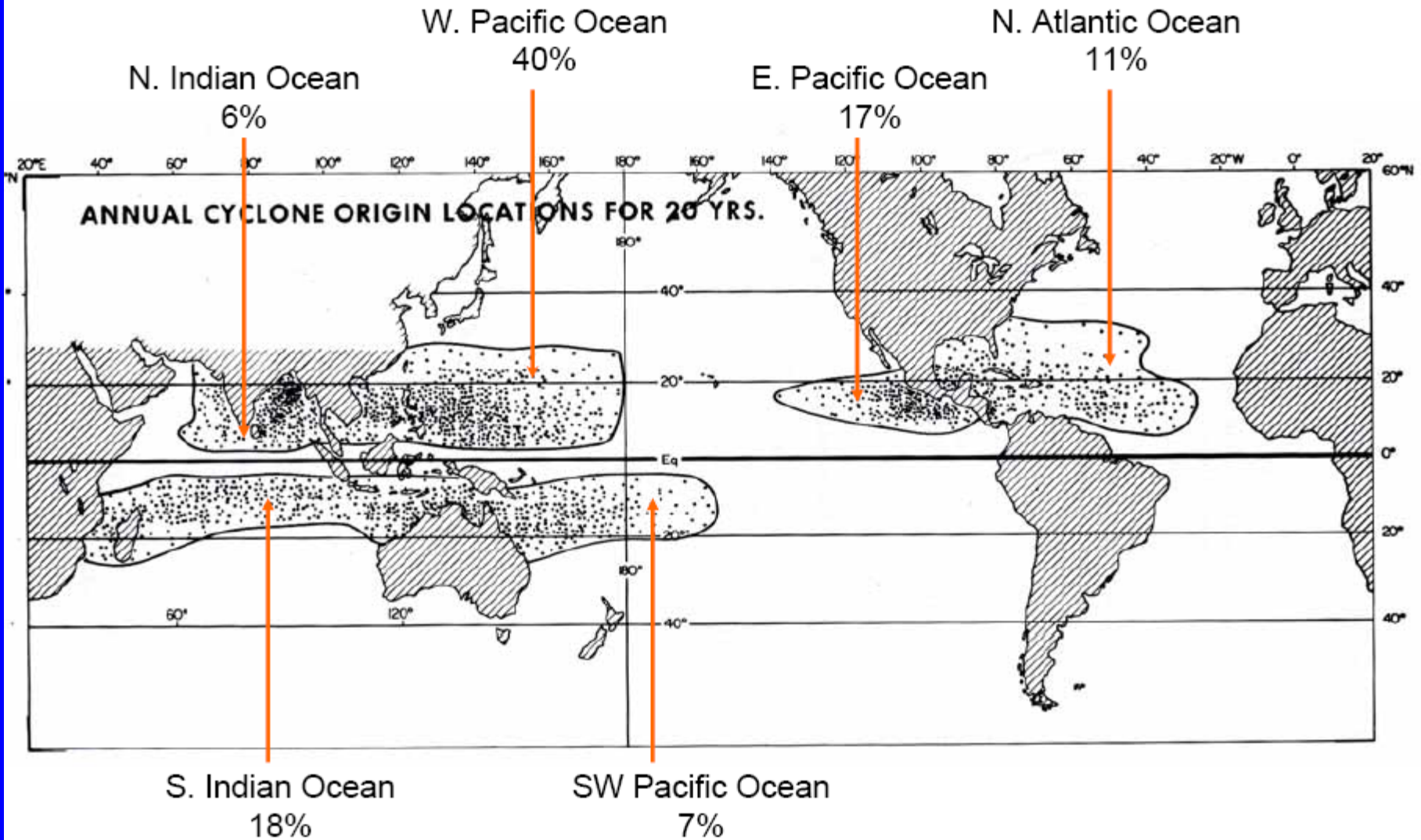


全球颱風個數沒有明顯加趨勢

Emanuel (2005; Nature)

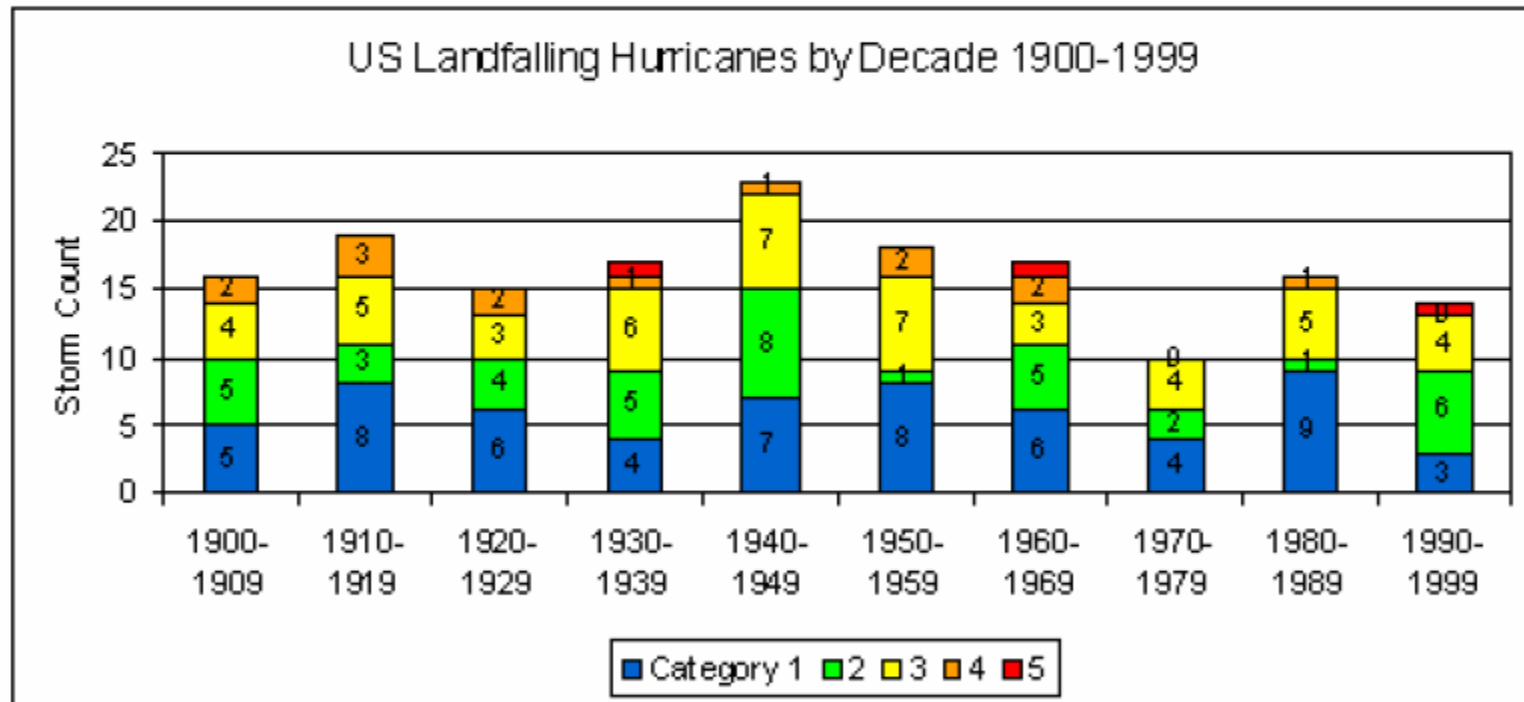


# Number of tropical storms



Curry and Webster (2005; Nature)

# U.S. land falling hurricanes



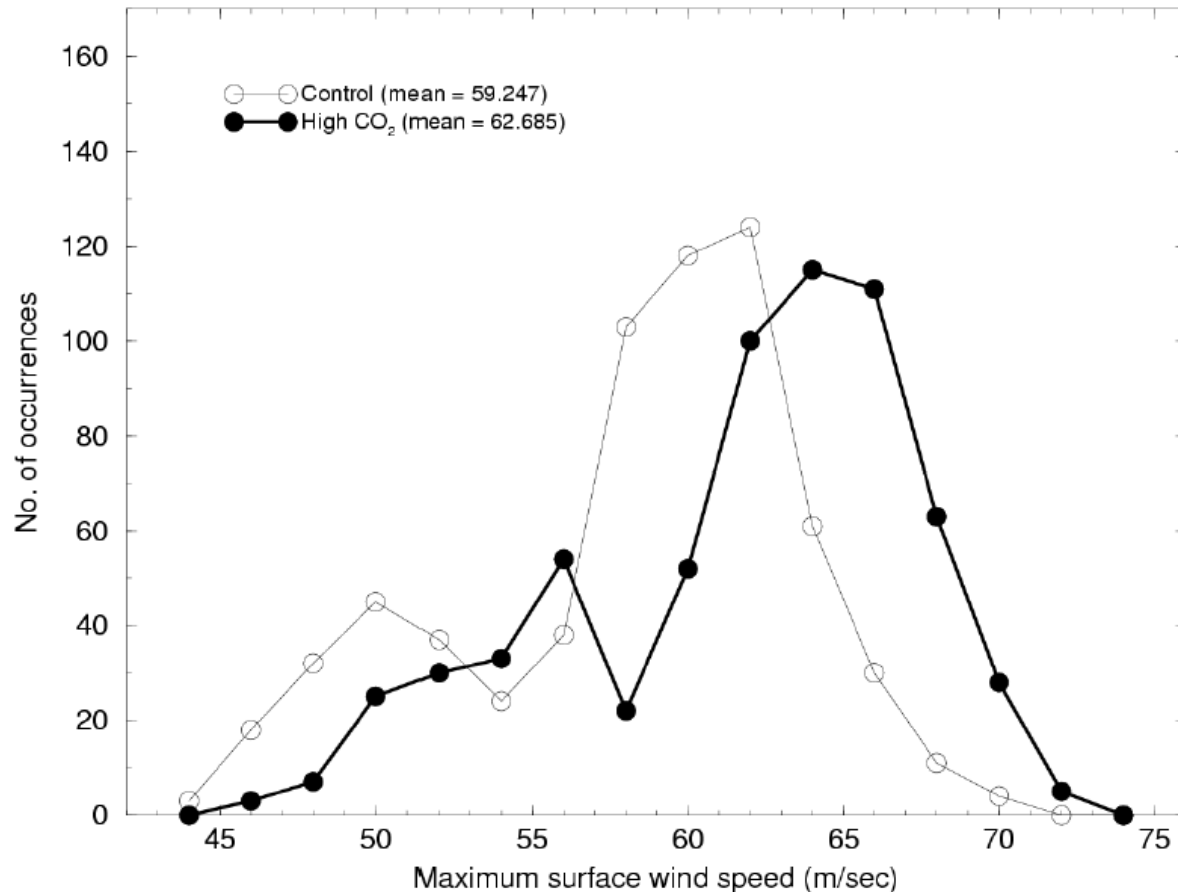
"This is not supportive of the hypothesis that the globe is warming catastrophically or that there are more and more severe storms occurring."

Curry and Webster (2005; Nature)



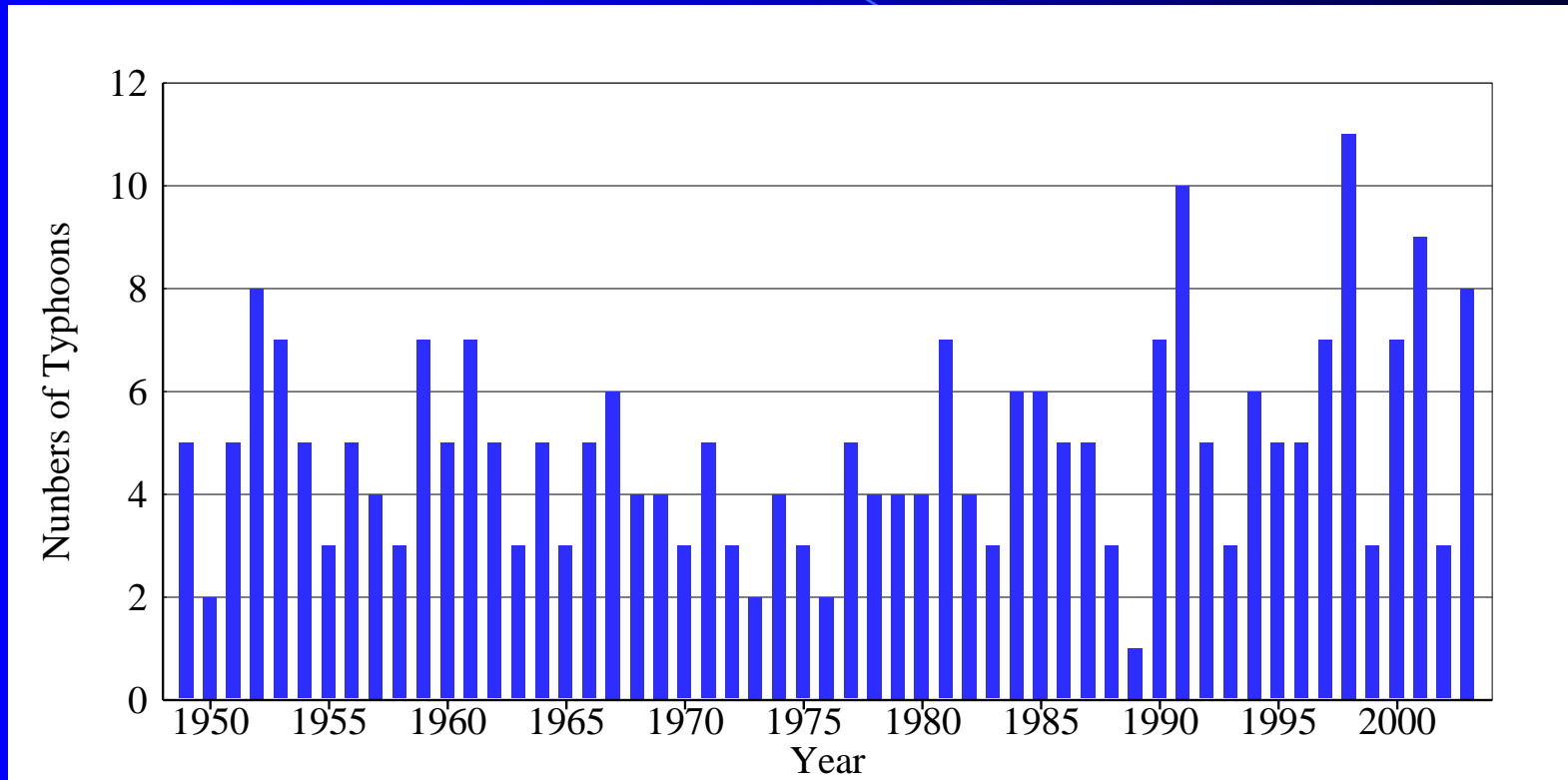
## Idealized hurricane simulations

Aggregate results: 9 GCMs, 3 basins, 4 parameterizations, 6-member ensembles



氣候模式模擬全球暖化情境下颱風個數之變化圖 (Knutson and Tuleya 2004)。空心實線為目前氣候情境下結果，實心深實線為全球持續暖化情境下結果。  
=>於全球暖化情境下, 氣候模式預測颱風強度可能將增加

# 台灣地區附近颱風個數沒有明顯加趨勢



經過臺灣臨近區域之颱風個數的逐年分佈圖  
Li, Yang, Soong, and Huang (2005; JHM)



## 小結

- \* 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。
- \* 全球氣候暖化是否會增加颱風個數及強度，目前仍不確定，有待後續研究。

# 颱風災害→數十至百億台幣經濟影響

直接颱風災害（風災、水災、土石流）

颱風放假與防救災動員（經濟產值 vs. 民怨）

水資源規劃管理（水庫操作、自來水供應）

## 科學議題：

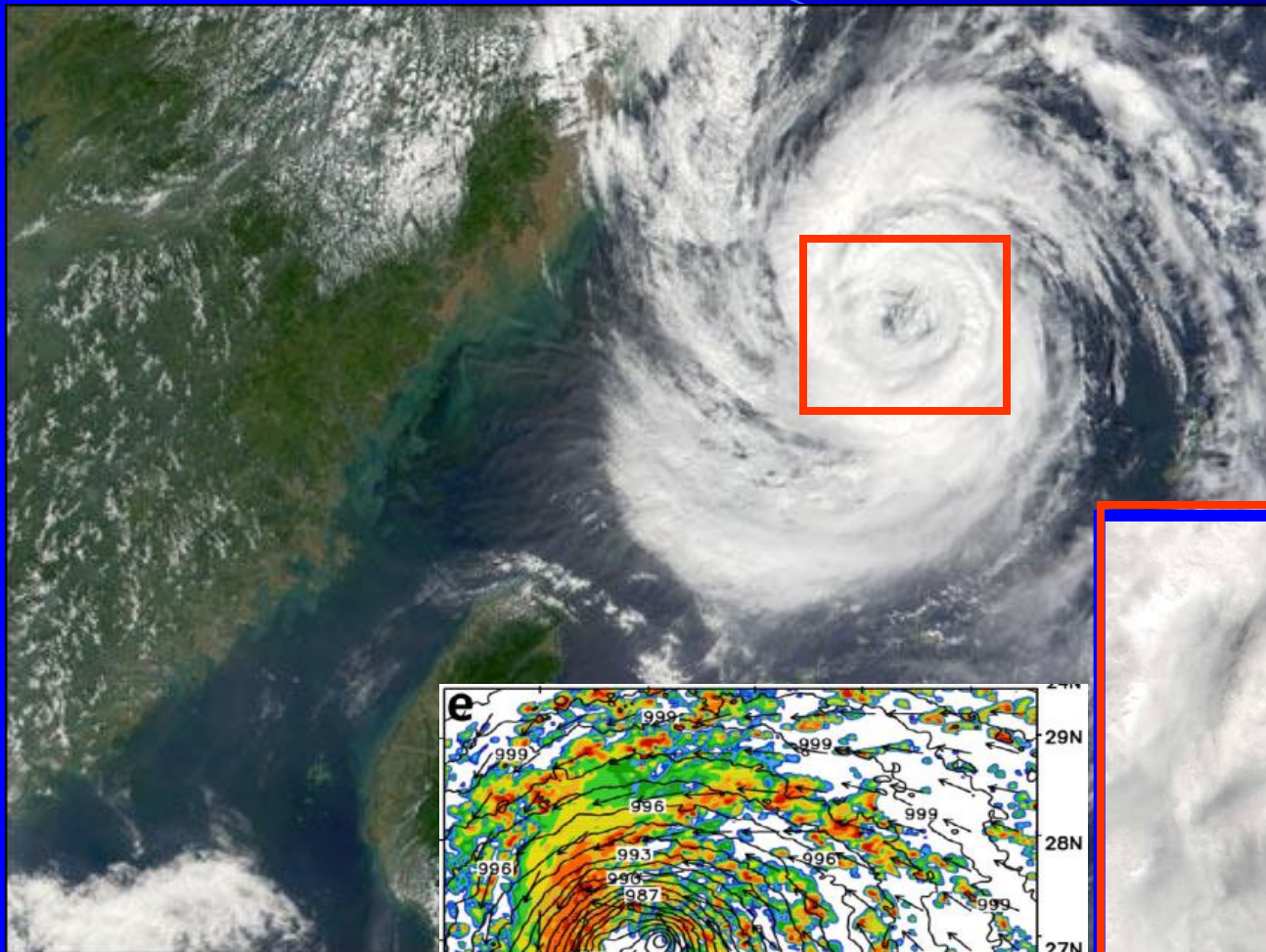
颱風路徑預報

颱風伴隨風雨預報

颱風個數季節預報

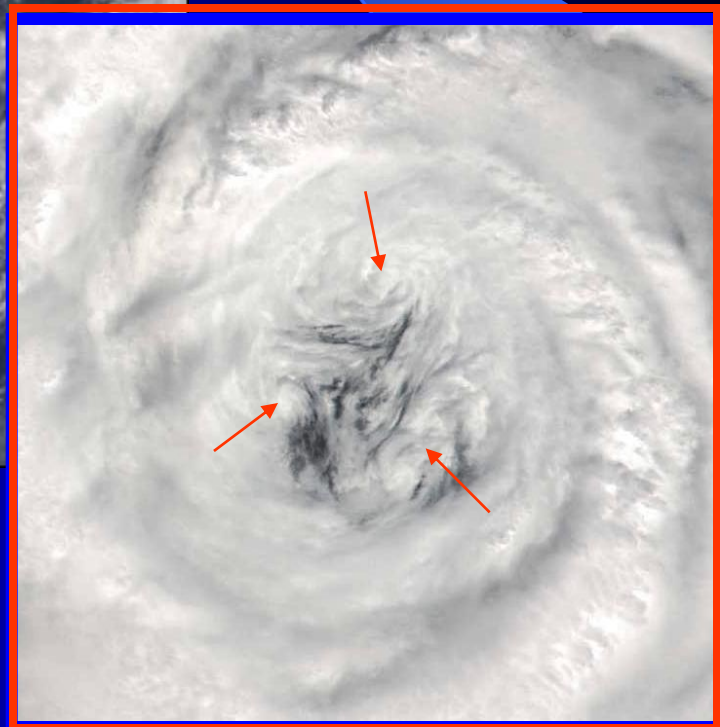
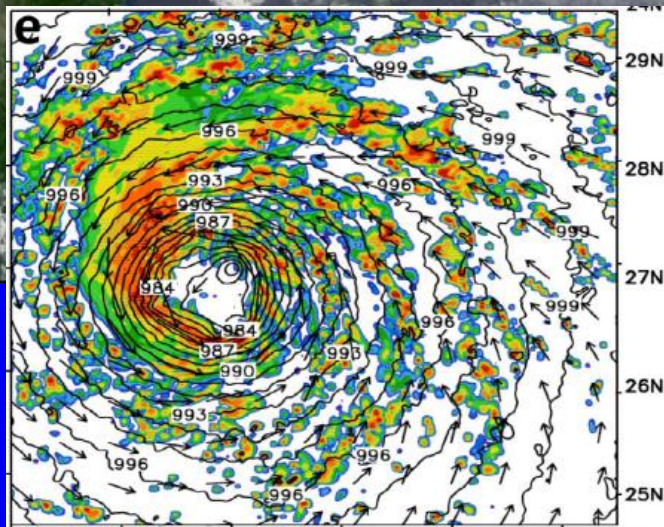


# 納莉(2001)颱風眼附近的中尺度渦旋



取自郭鴻基(2004)

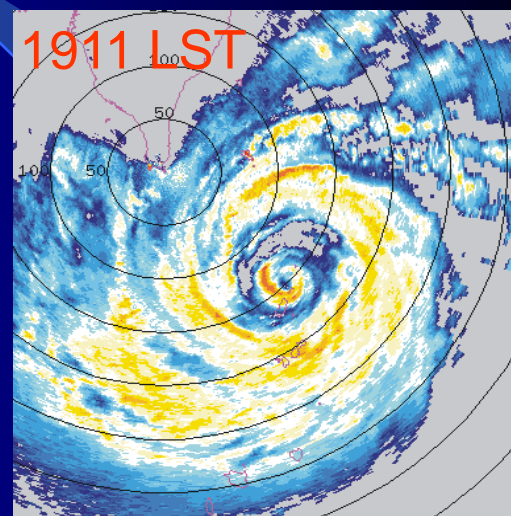
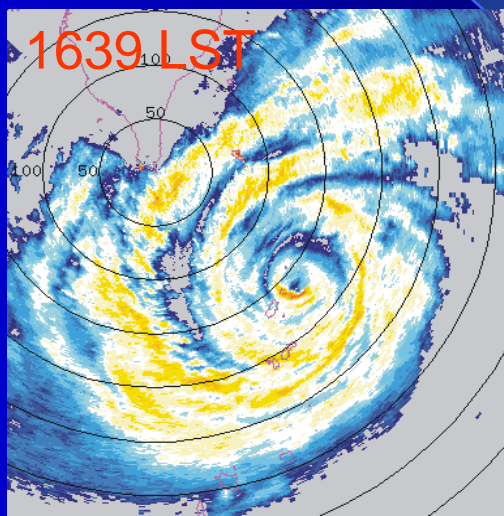
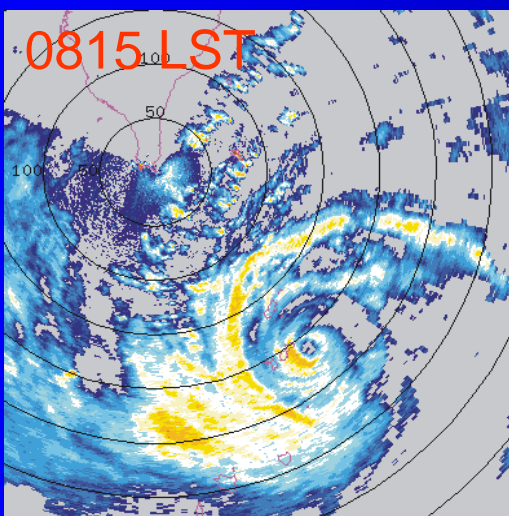
侵台納莉颱風登陸前  
颱風眼附近觀測到  
3個中尺度渦旋



Zhang, Tien, Yang  
(2011; JGR)

# 利奇馬(2001)颱風：雙眼牆的形成

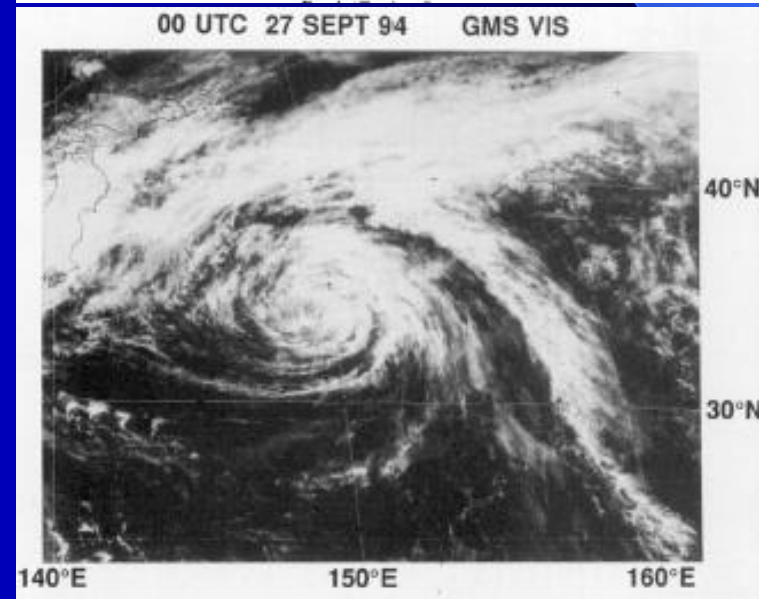
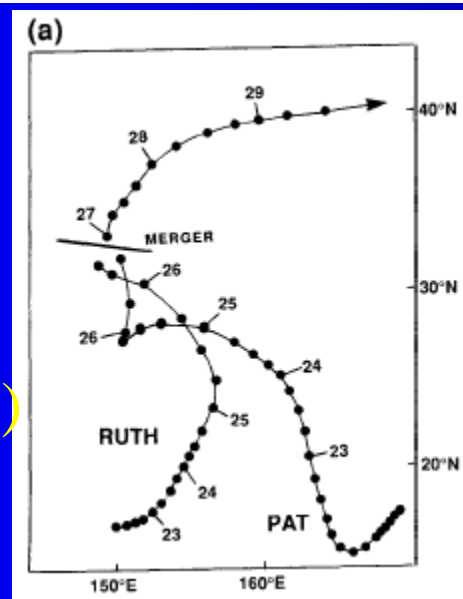
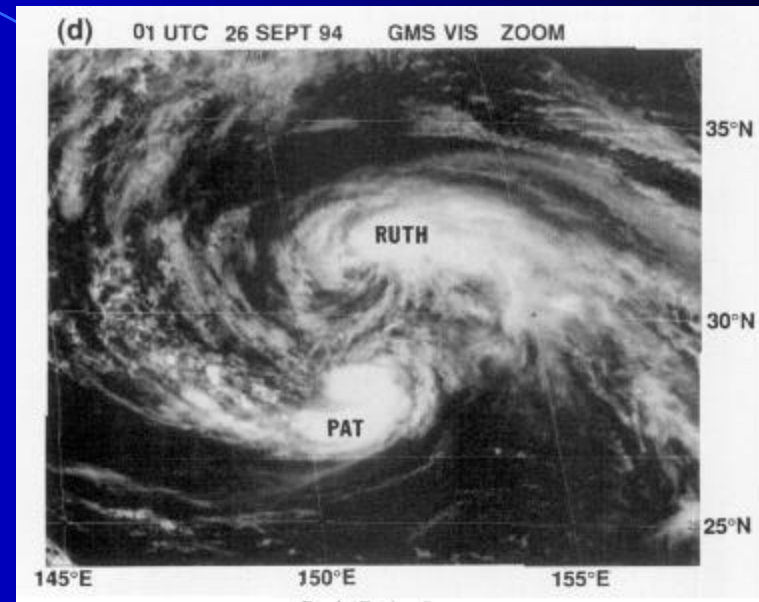
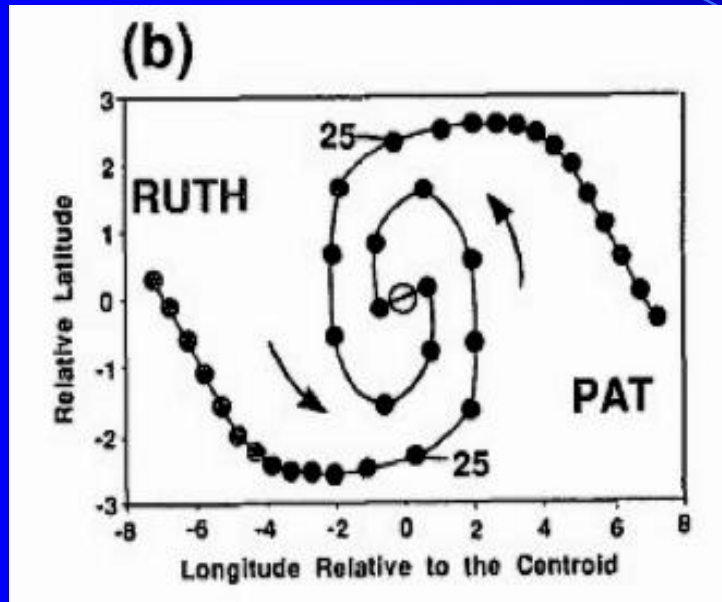
墾丁雷達  
站觀測圖



取自郭鴻基(2004)

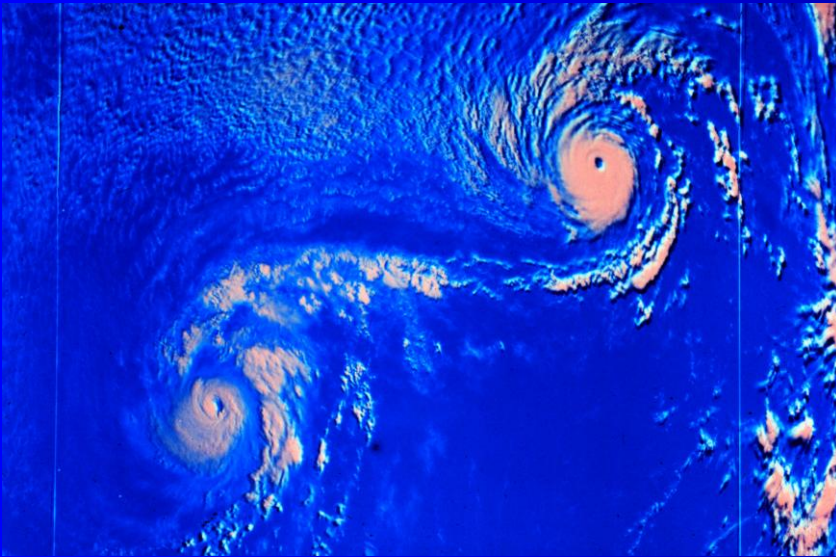


# 雙颱風合併：颱風派特(PAT) 與羅絲(RUTH)

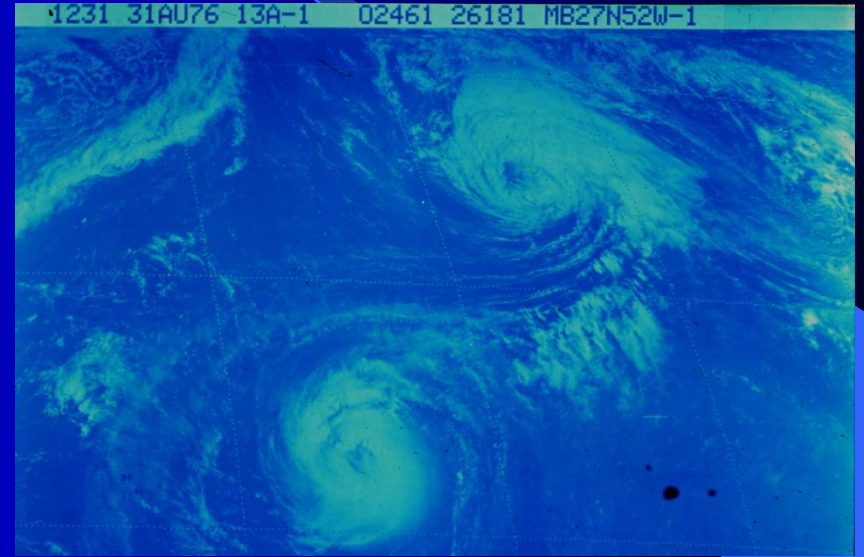


取自郭鴻基(2004)

# 雙颱風的互繞 --- 藤原效應



颱風 Ione 與 Kristen



颱風 Emmy 與 Frances



# 颱風導致的災害---土石流



南投縣神木村一般型土石流堆積物，會有豐富的黏土、砂、礫石及巨石。

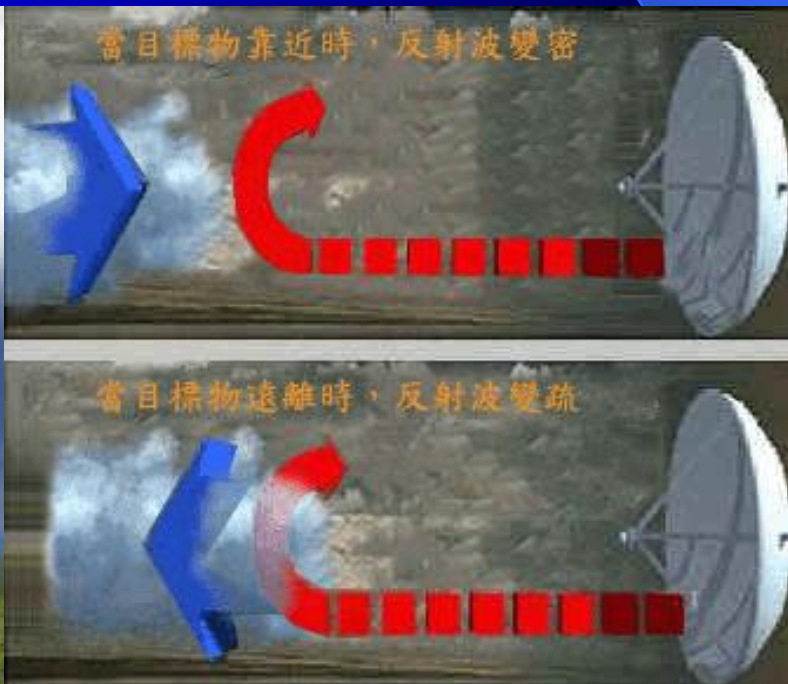
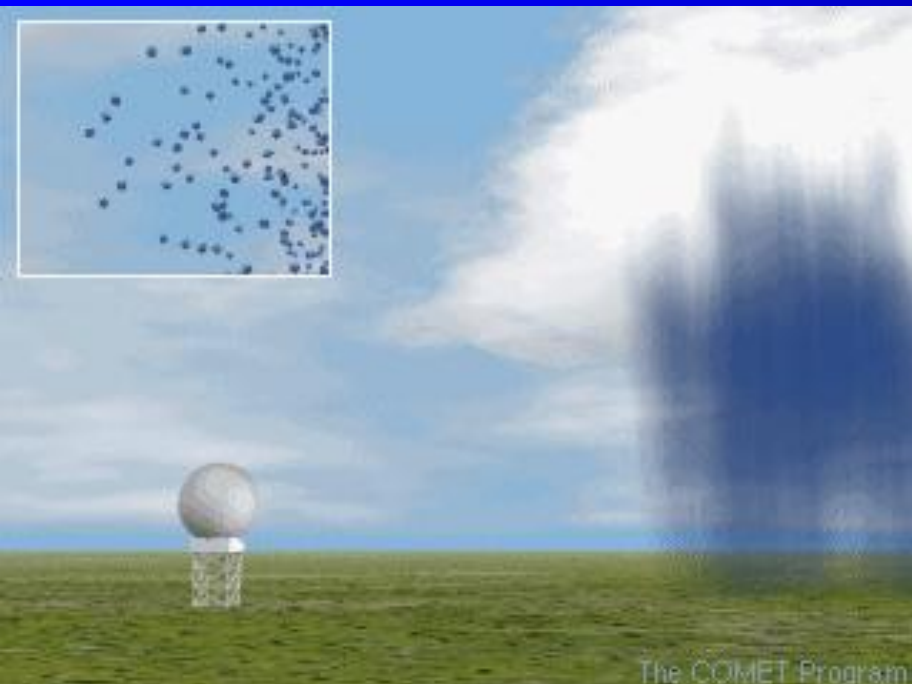
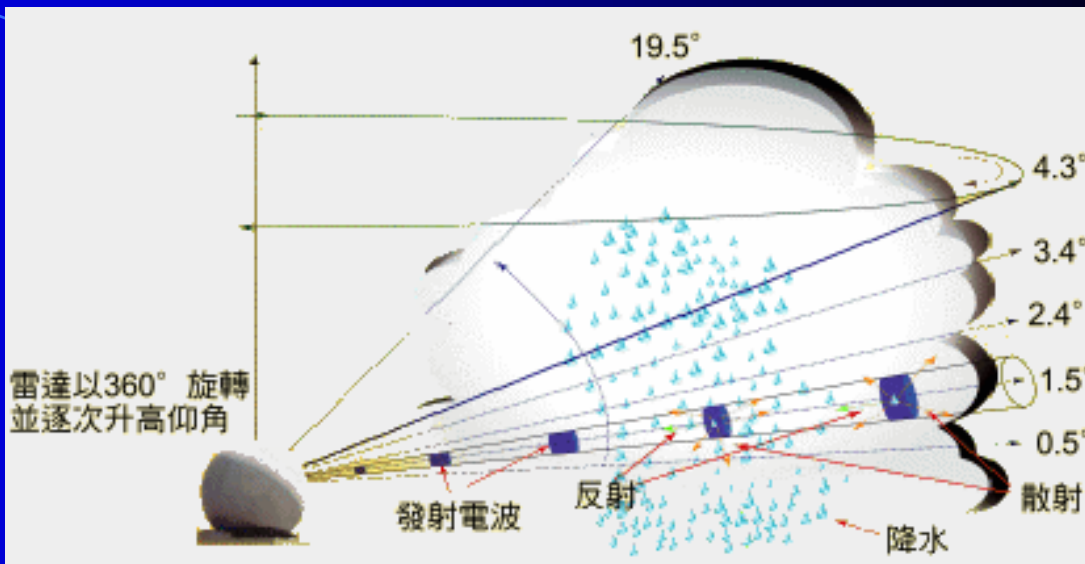


土石流淹沒廟宇 土石流發生時，即便是神明也自身難保，所以平日的防患與預警，實為保全性命財物的不二法門。

取自詹錢登(2004)

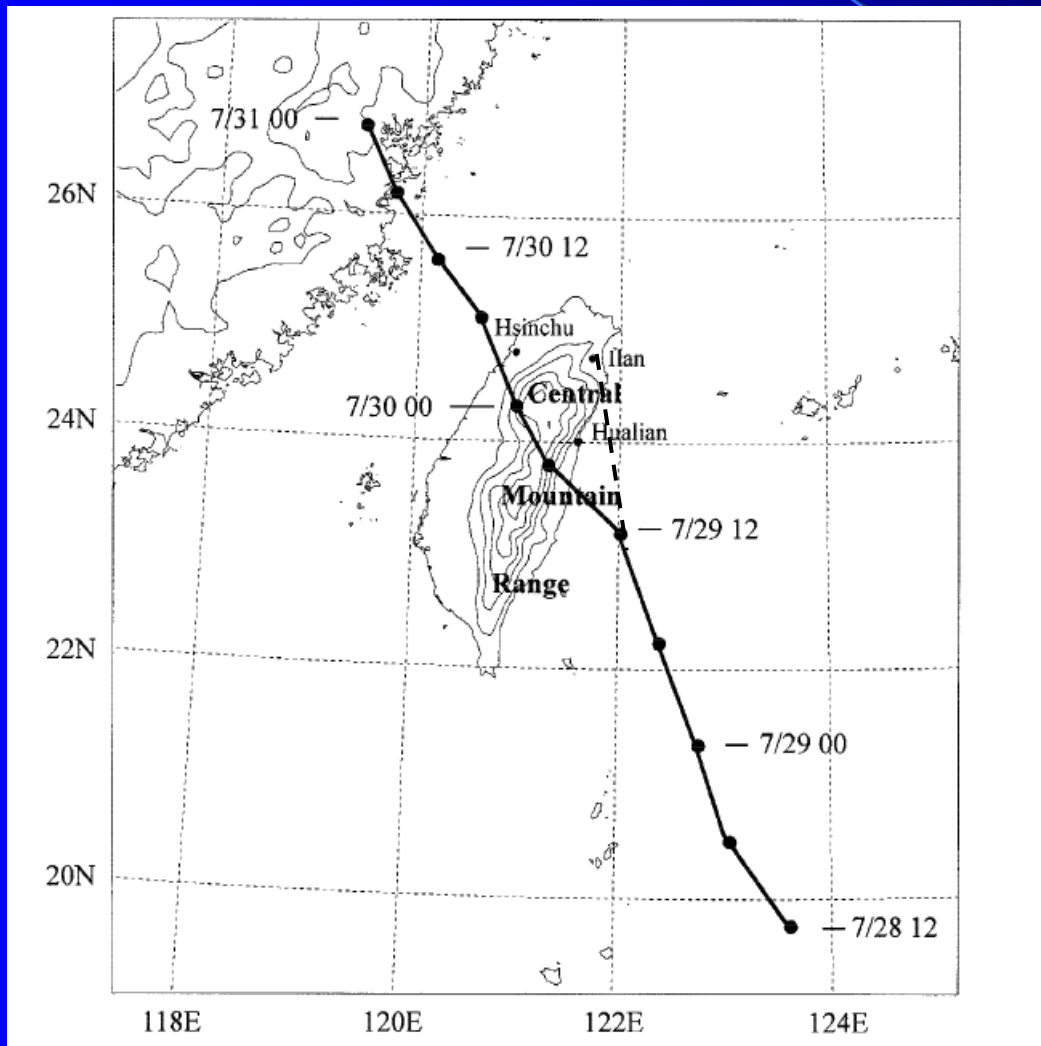
# 都卜勒氣象雷達

- a. 利用反射波強度知雨滴大小
- b. 利用反射波波長變化知移動速度及方向





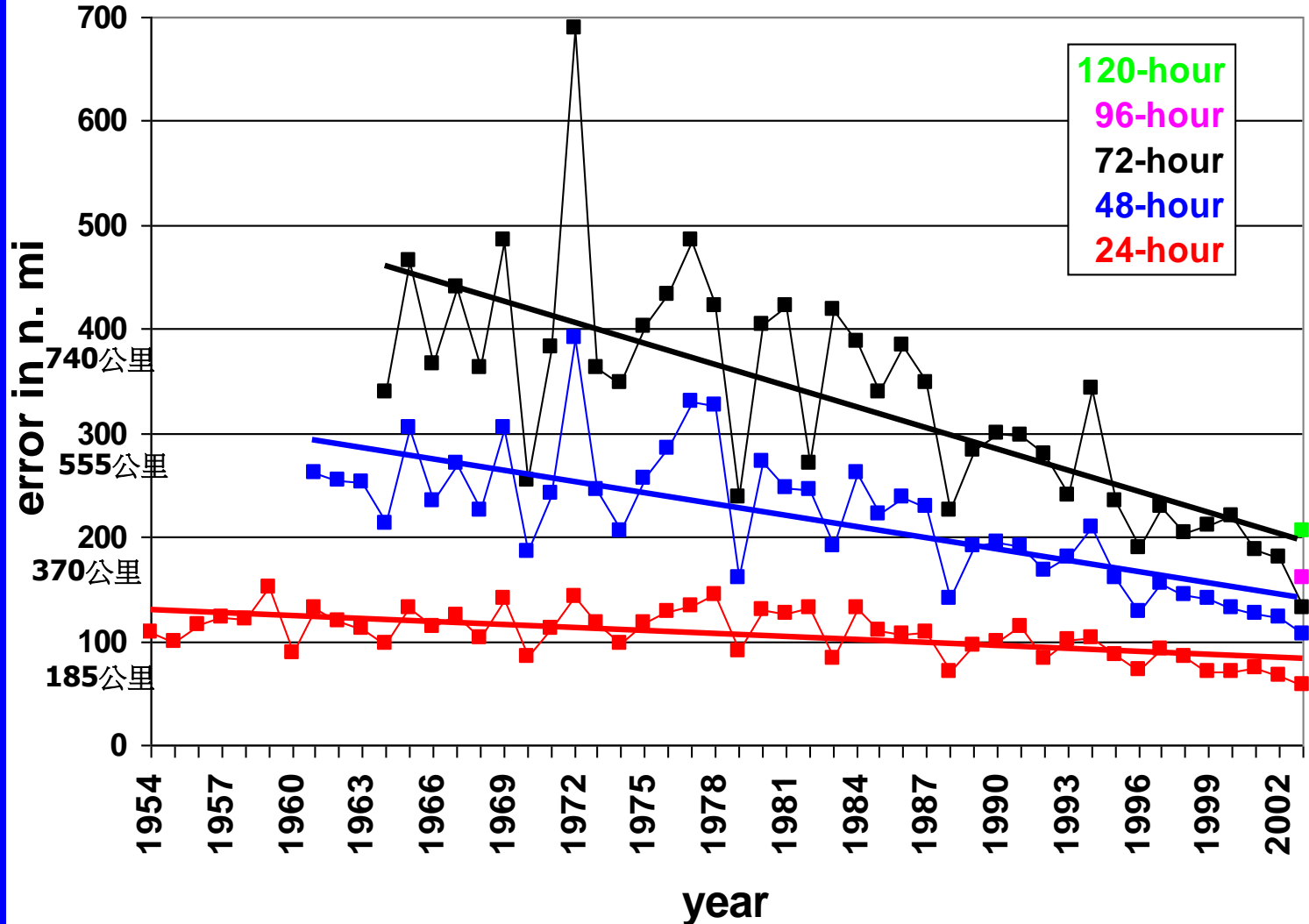
# 桃芝(2001)颱風



Yang and Ching  
(2005; TAO)

# Tropical Prediction Center Performance Measures

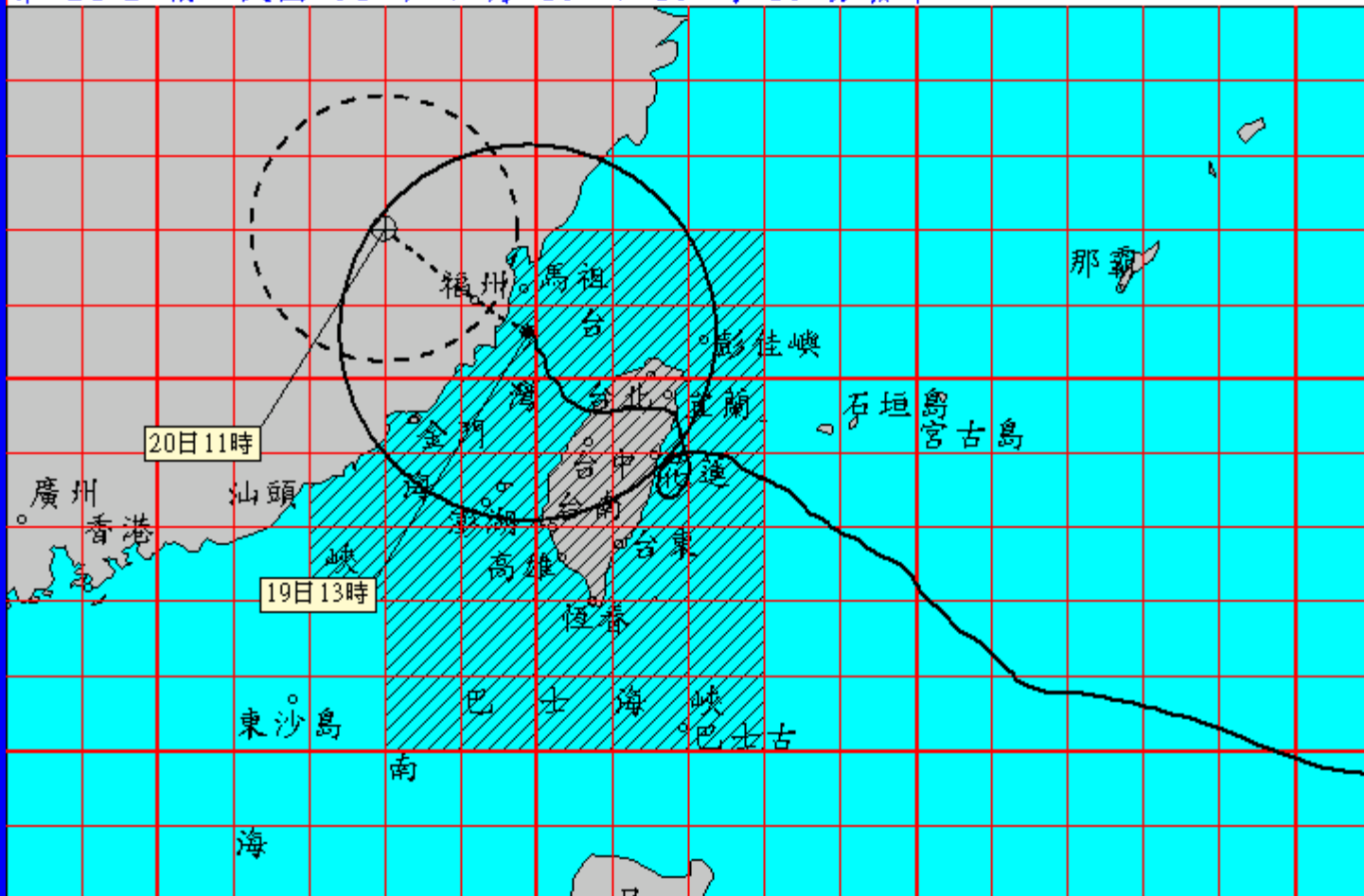
yearly-average official track forecast errors and trend lines, Atlantic basin



Source: US Weather Service

# 海棠(2005)颱風

中度颱風 編號第 5 號 (國際命名: HAITANG, 中文譯名: 海棠)  
第 24-2 報 民國 94 年 7 月 19 日 13 時 15 分發布



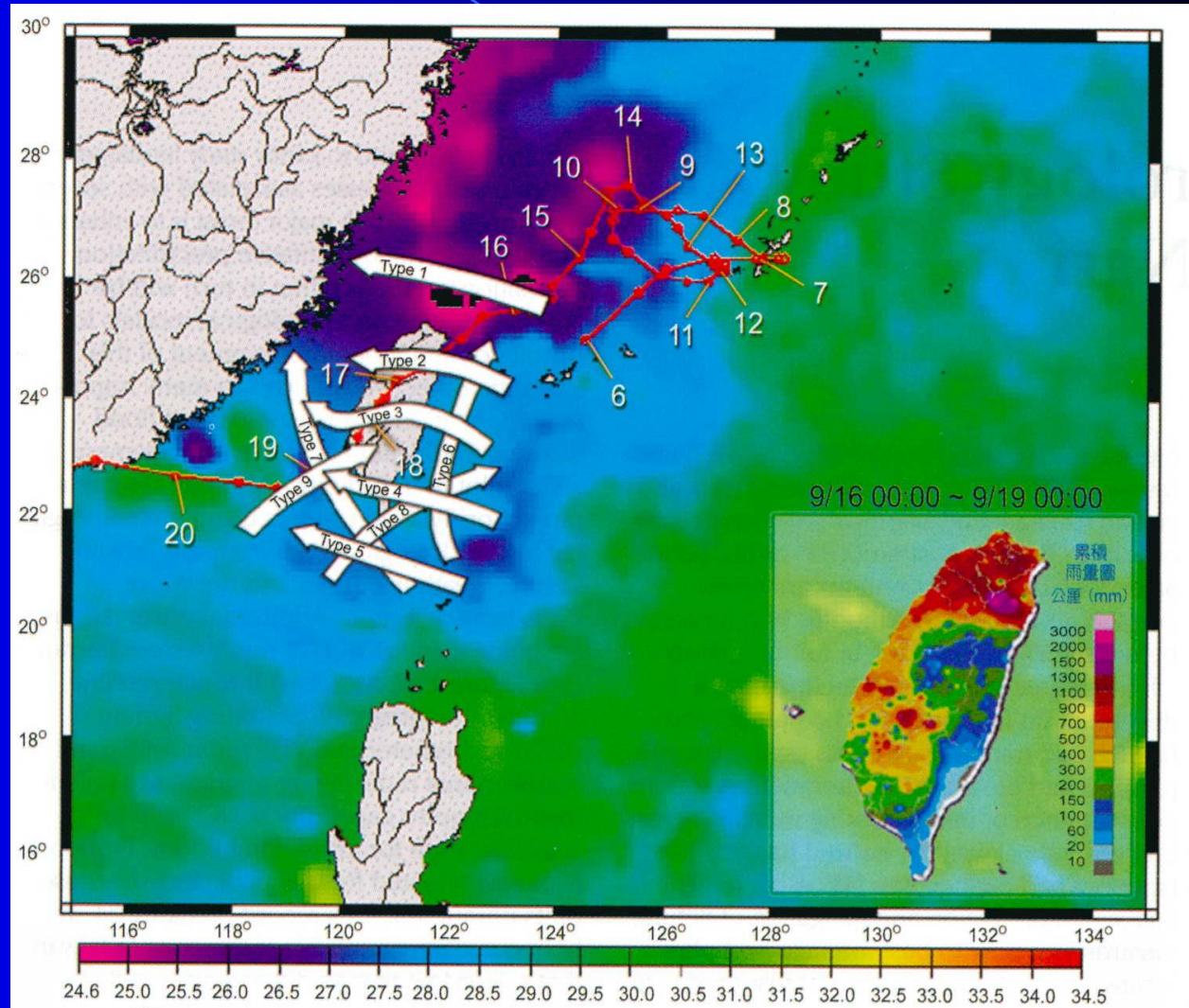


# 海棠(2005)颱風



# 納莉(2001)颱風獨特之處

- 獨特的路徑
- 移動十分緩慢
- 生命期非常長
- 溫暖的海水
- 異常豪雨
- 河水氾濫成災





# 豪雨成災



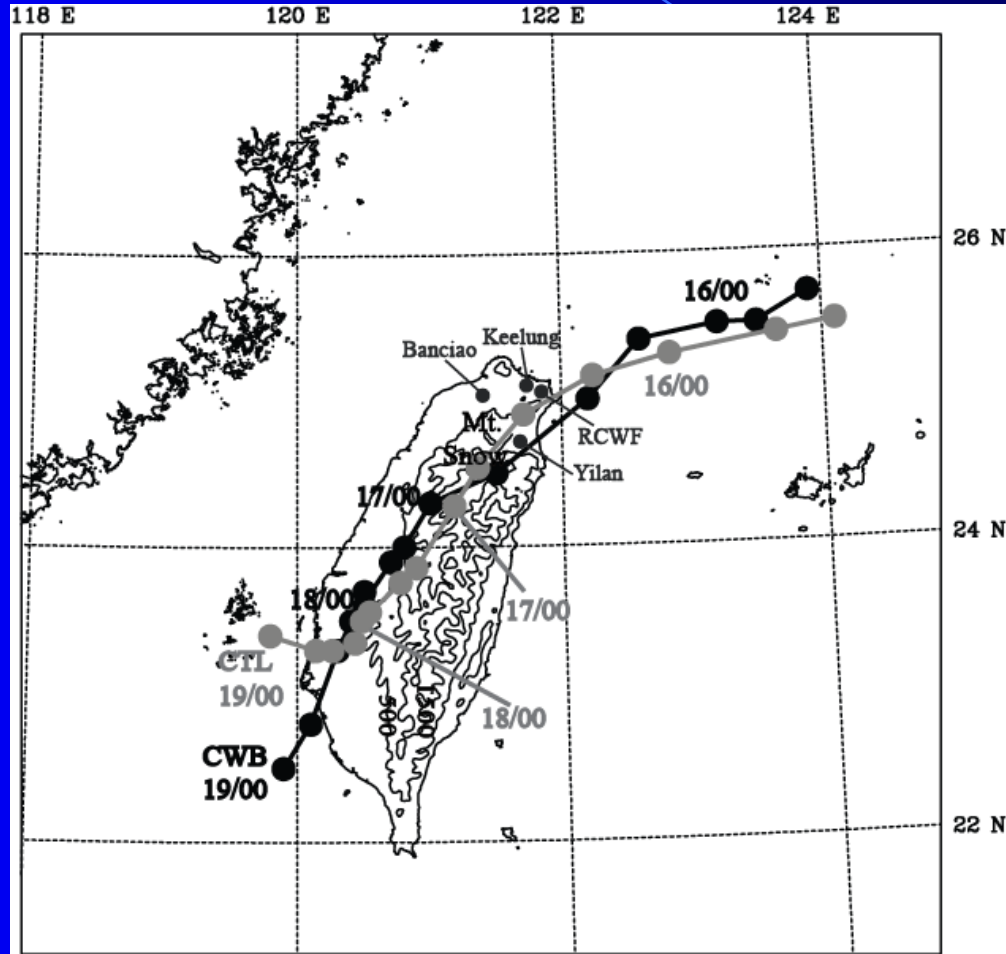
# 河水越堤氾濫



[http://www.dnrc.csie.ntu.edu.tw/~cdm/photoc/其他/pages/010917\\_納利颶風\\_2.htm](http://www.dnrc.csie.ntu.edu.tw/~cdm/photoc/其他/pages/010917_納利颶風_2.htm)

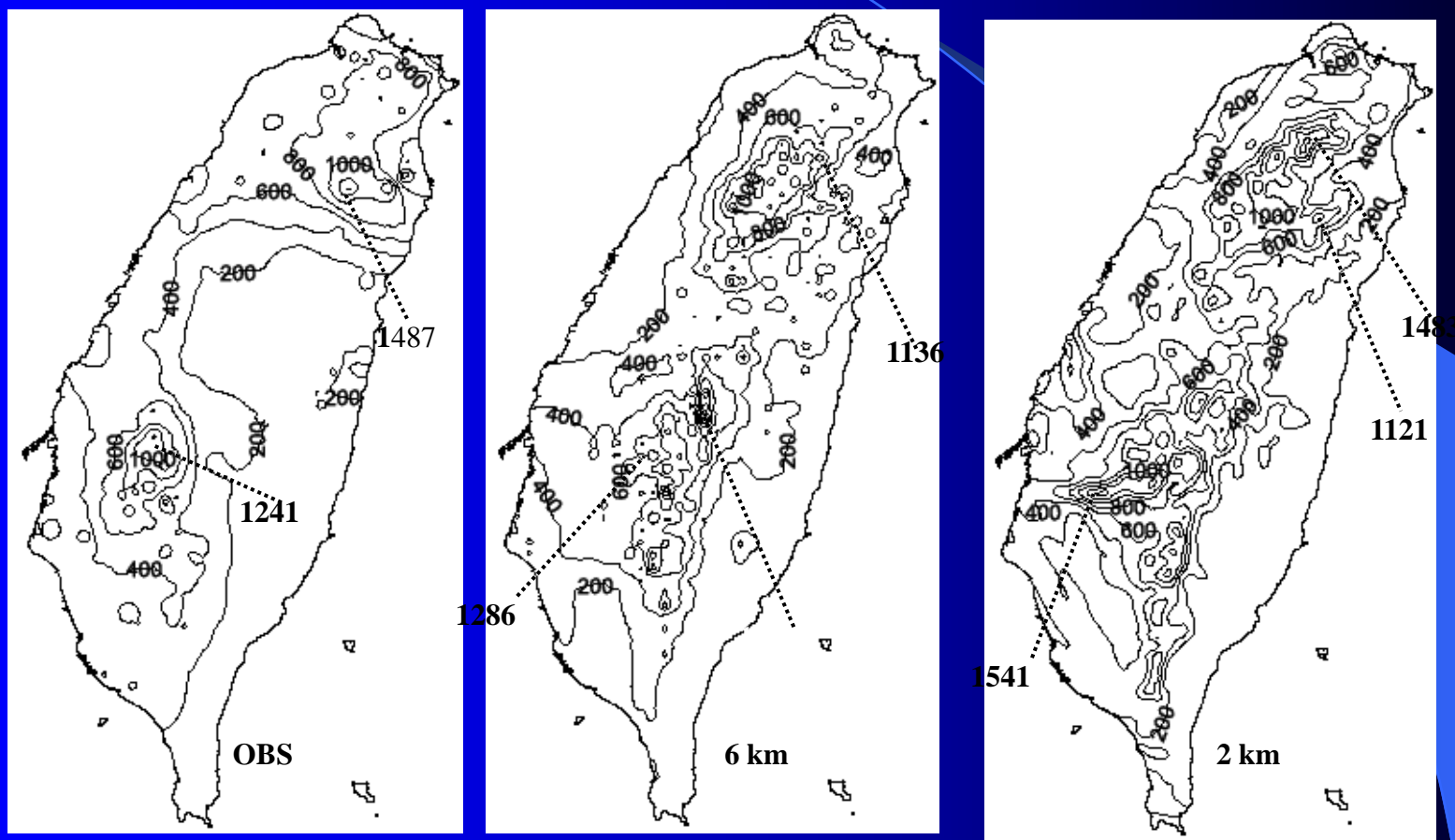


# 電腦模擬納莉颱風之路徑



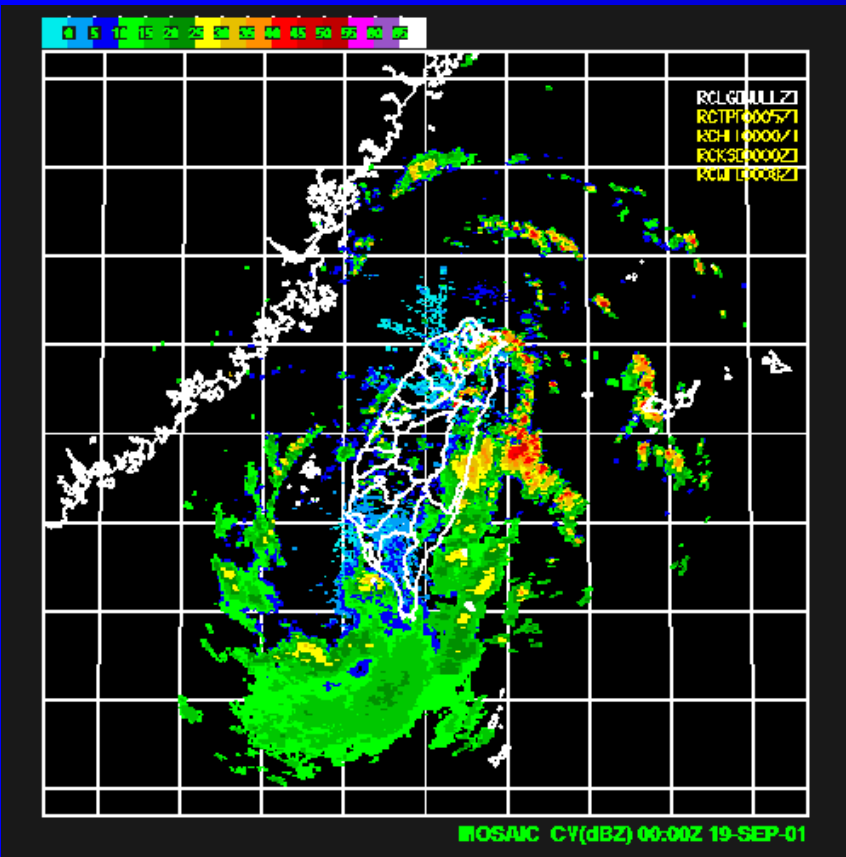
取自 Yang, Zhang, and Huang (2008; JAS)

# 電腦模擬納莉颱風之累積雨量

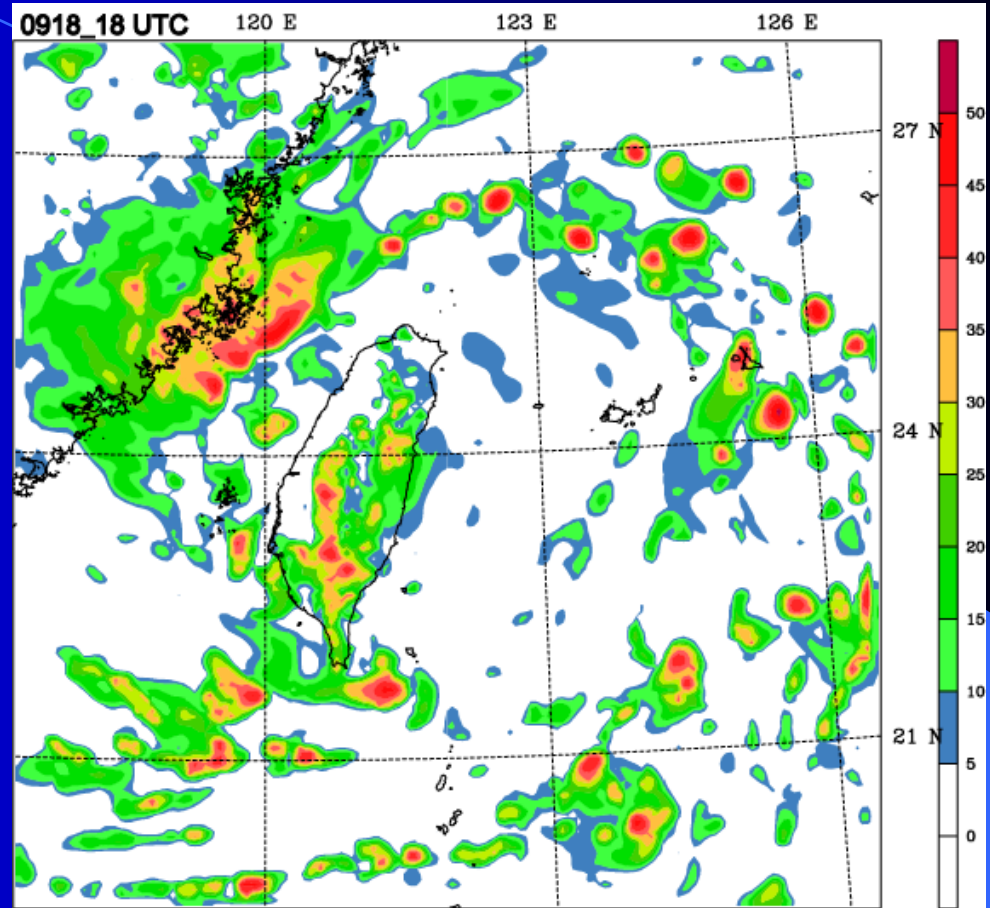


取自 Yang, Zhang, and Huang (2008; JAS)

# 雷達回波觀測

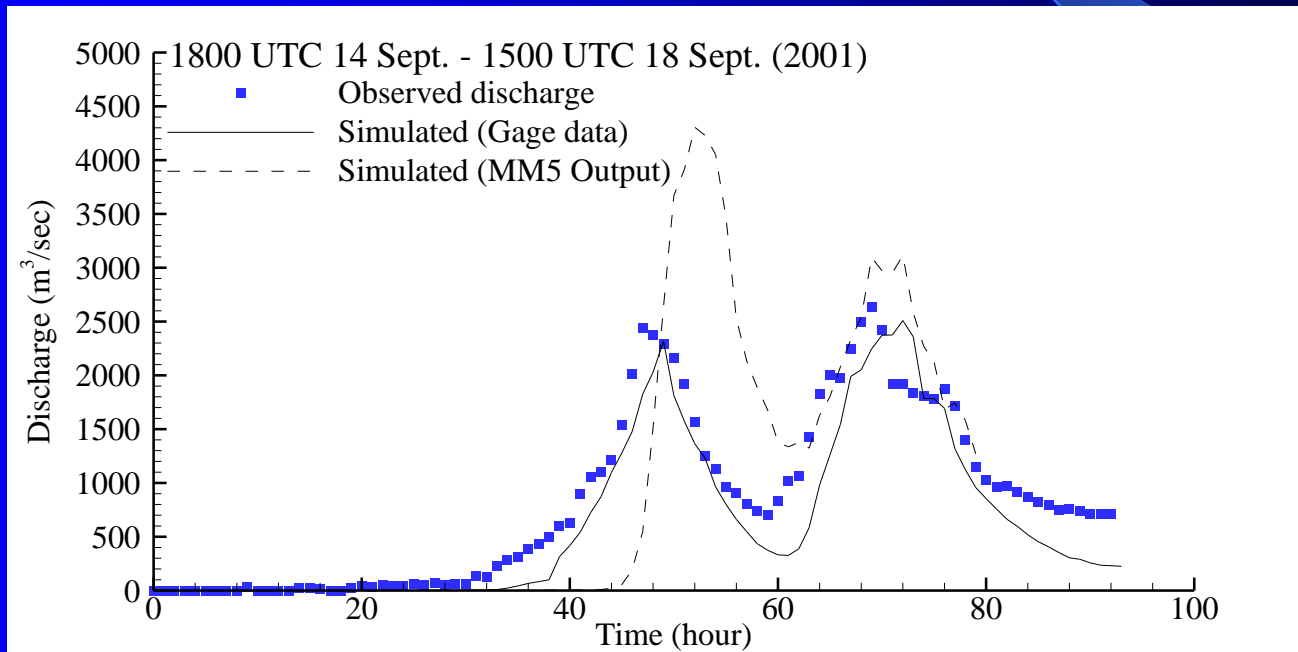


# 電腦模擬雷達回波



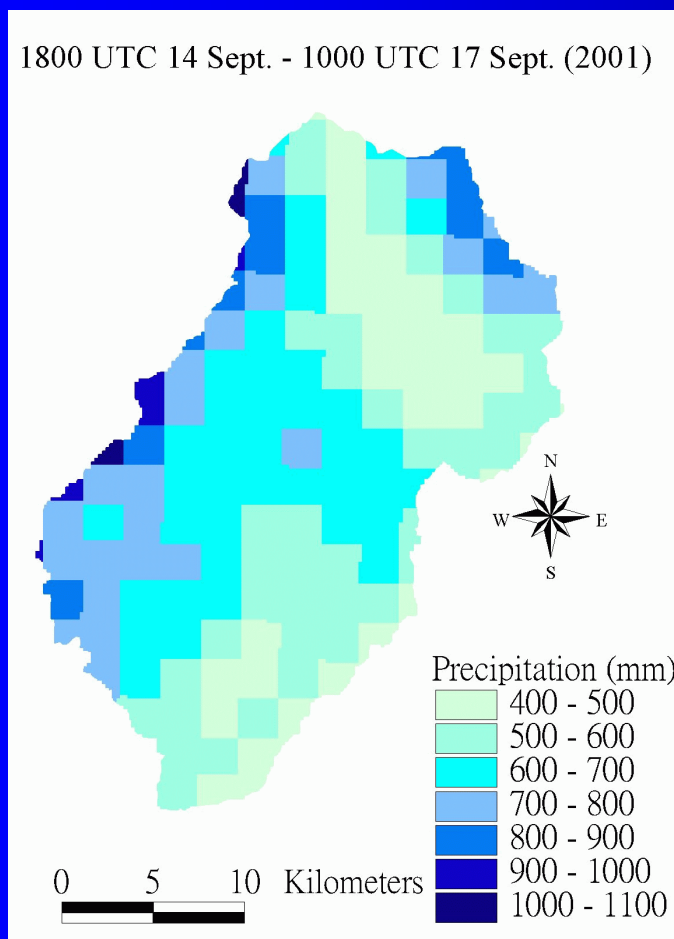


# 納莉颱風期間大漢溪流量模擬

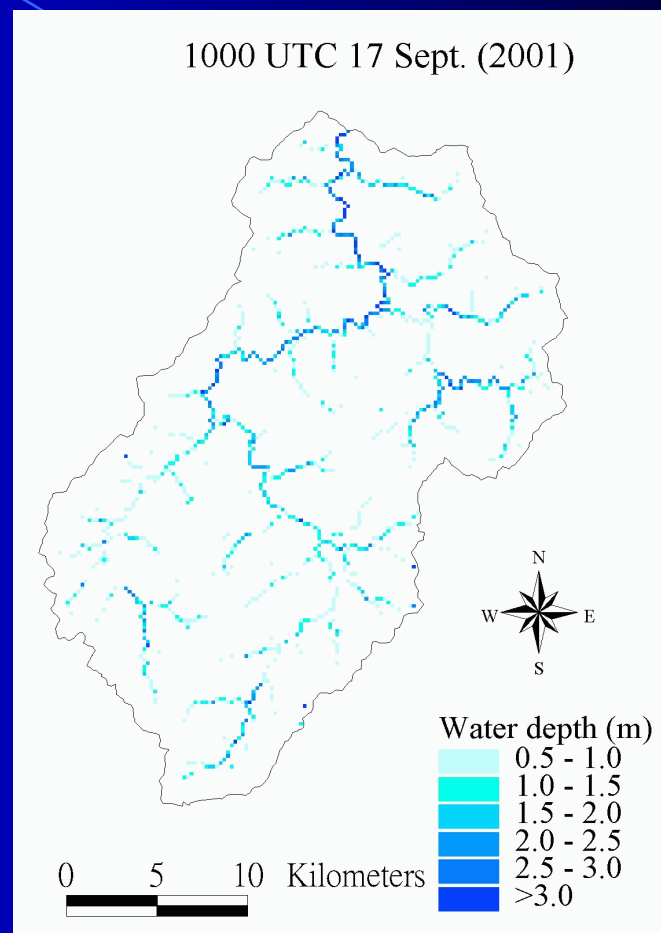


Li, Yang, Soong, and Huang (2005; JHM)

# 納莉颱風期間石門水庫流域水文模擬



累積雨量模擬



河川水位模擬

Li, Yang, Soong, and Huang (2005; JHM)

# 侵台颱風之飛機偵察及投落送觀測實驗

代號：追風計畫

Dropsonde Observation for Typhoon Surveillance  
near the TAIWAN Region (DOTSTAR)

吳俊傑 (計畫主持人)、林博雄 (共同主持人)

國立台灣大學大氣科學系

葉天降 (共同主持人)

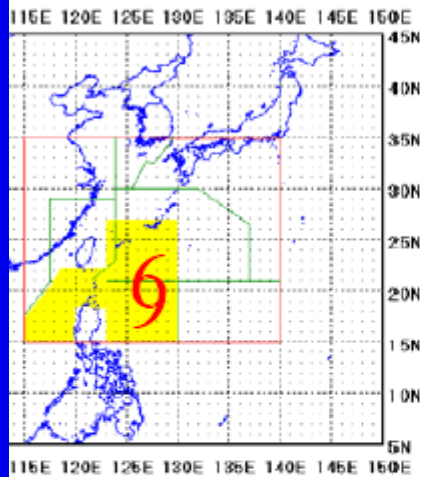
中央氣象局

謝：國科會、行政院科技顧問組、中央氣象局、民航局、漢翔公司、適航驗證中心等





# Astra jet



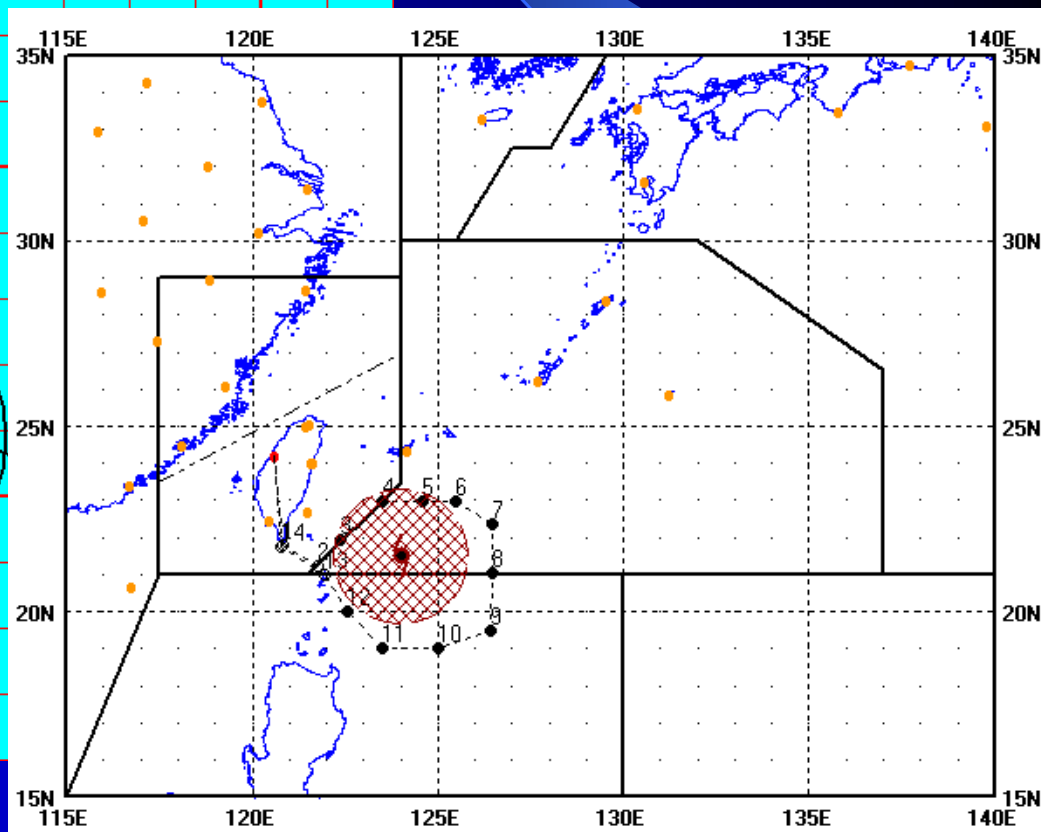
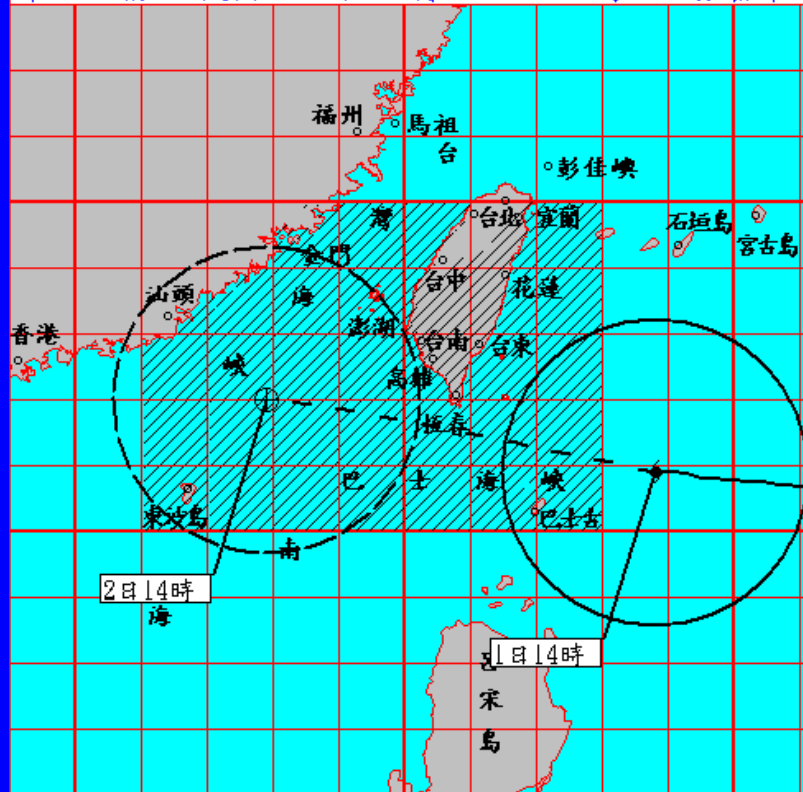
## GPS Dropsonde

取自吳俊傑(2004)

# 侵台颱風之飛機偵察及投落送觀測實驗首航——杜鵑颱風

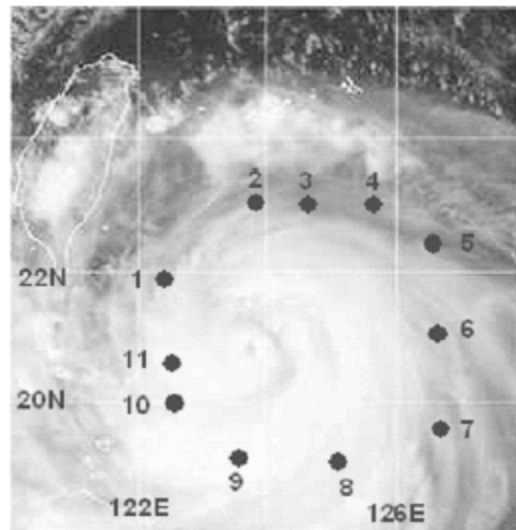
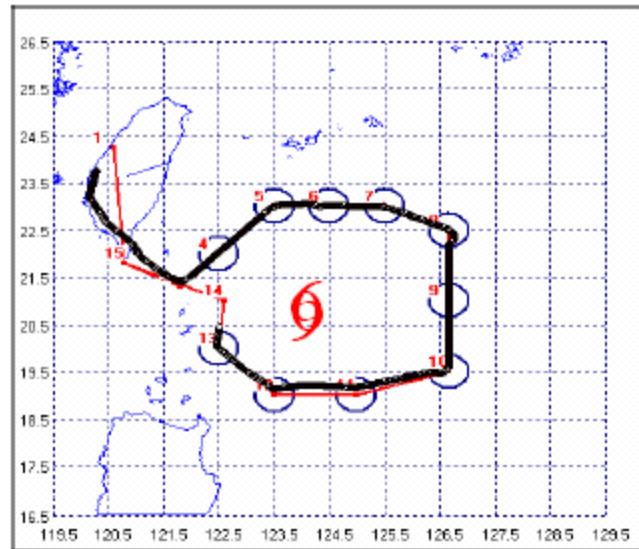
觀測時間：2003年9月1日 - 12:30 - 16:00

中度颱風 編號第 13 號 (國際命名: DUJUAN, 中文譯名: 杜鵑)  
第 10 報 民國 92 年 9 月 1 日 14 時 30 分發布



# #1 mission of DOSTAR - Dujan

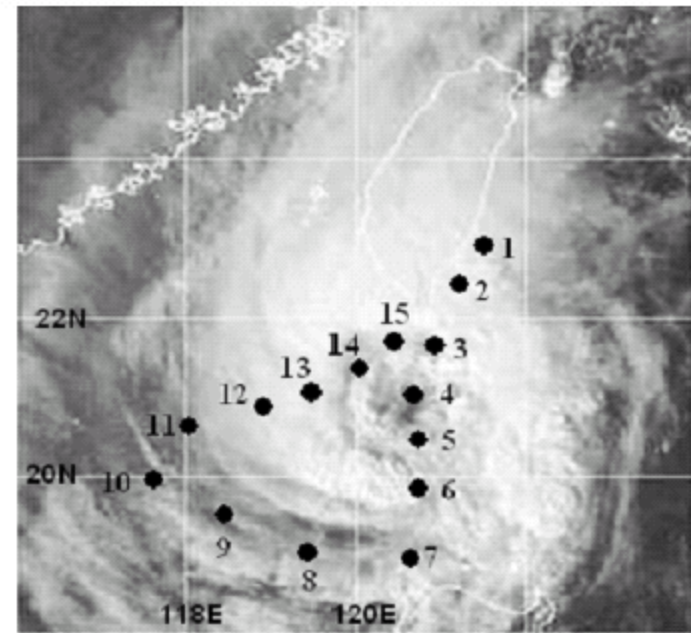
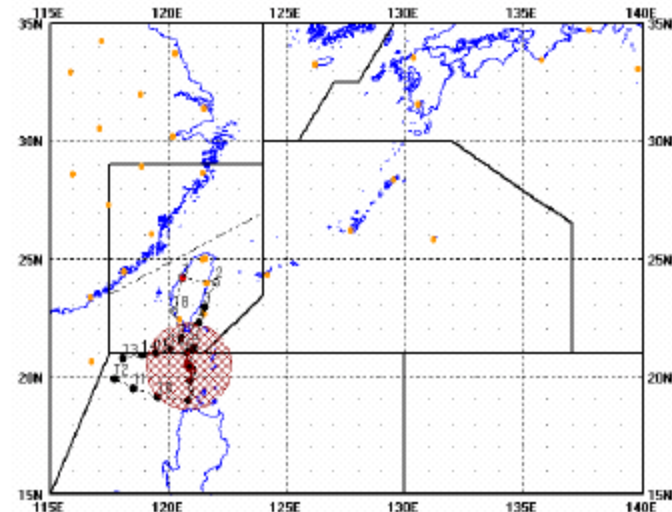
0430 – 0800 UTC 1 September 2003



VIS satellite image time:  
2003/09/01 0525UTC

# #2 mission of DOSTAR - Meior

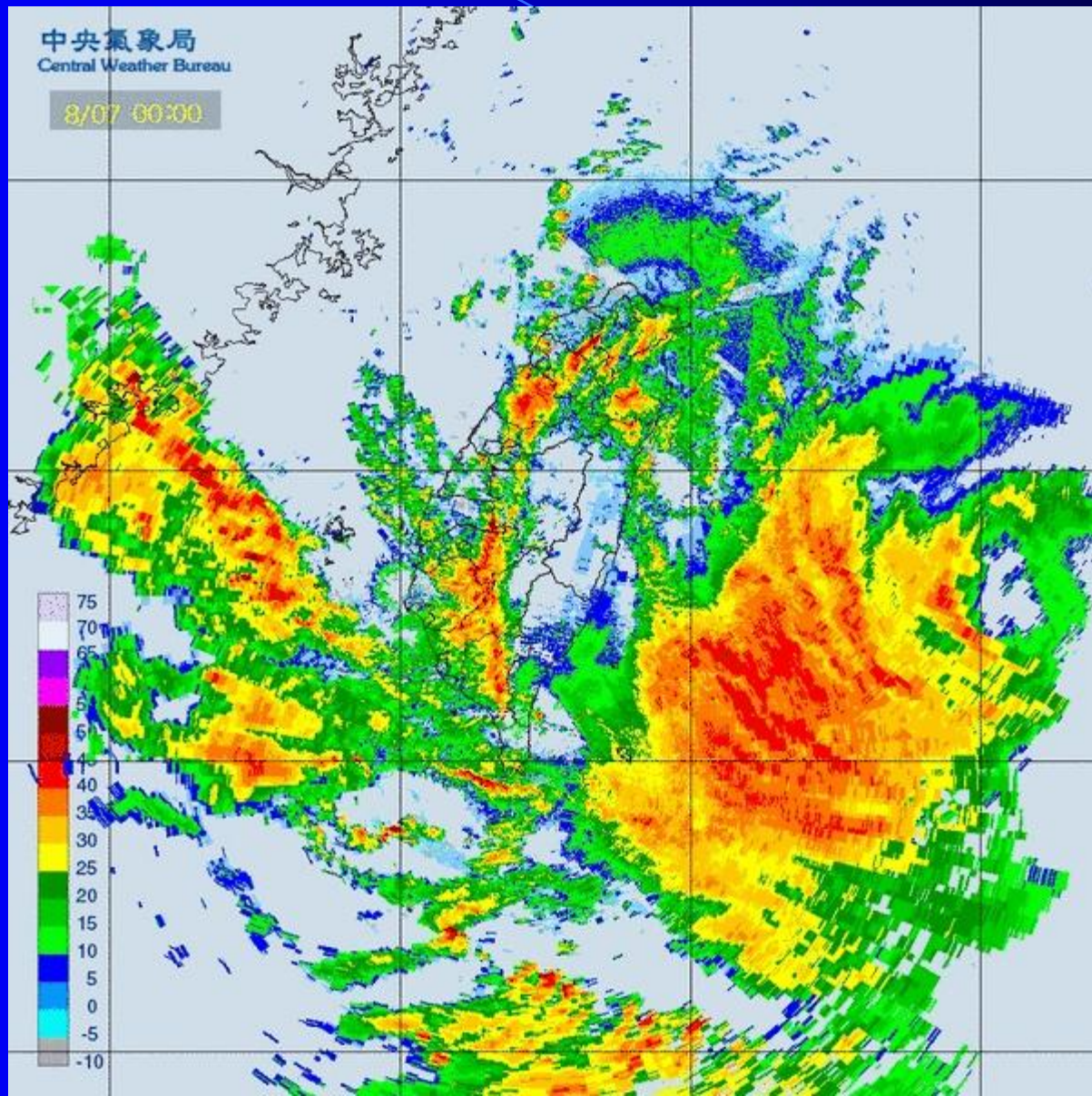
0400 – 0730 UTC 2 November 2003



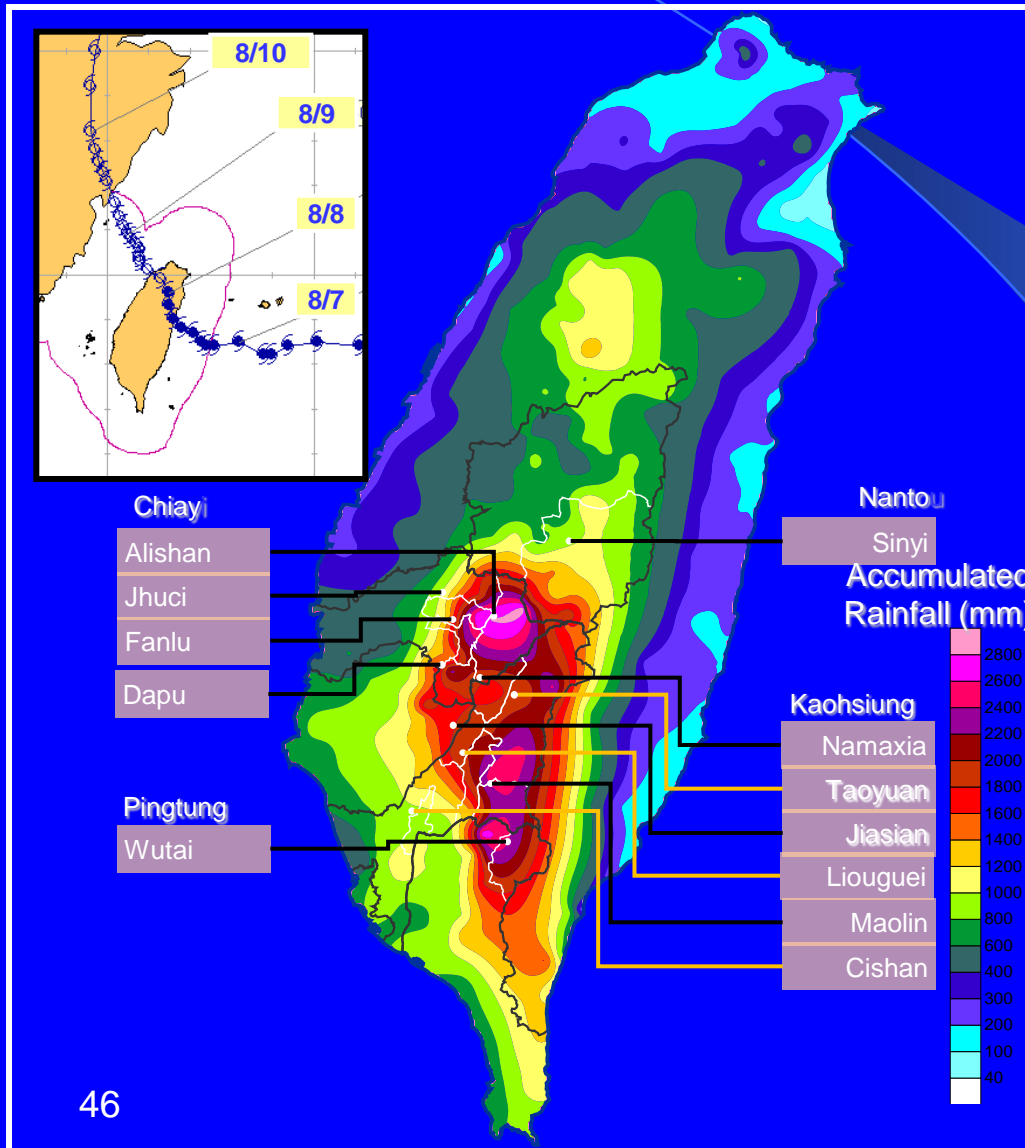
VIS satellite image time:



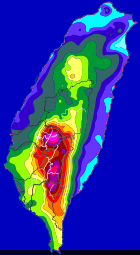
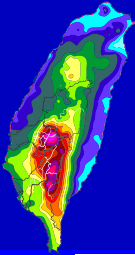
# 莫拉克(2009)颱風期間雷達回波



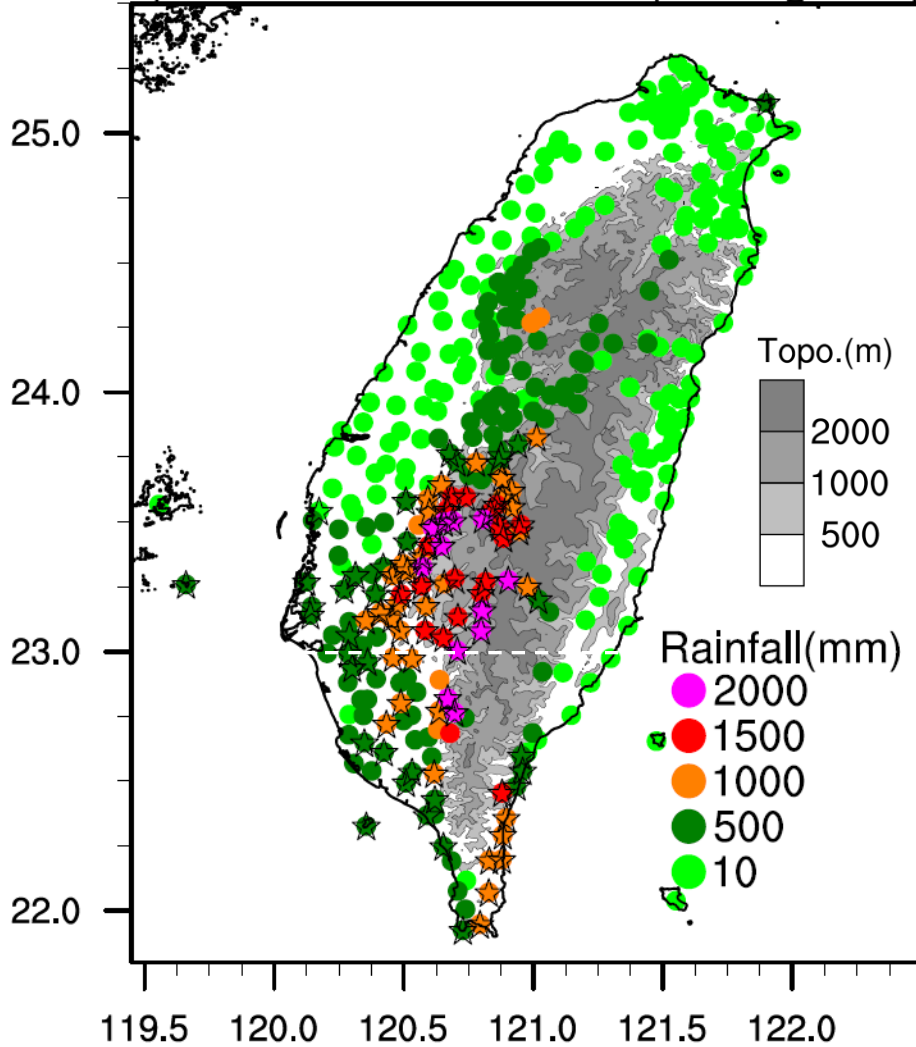
# 破紀錄超大豪雨 長延時的持續性降雨



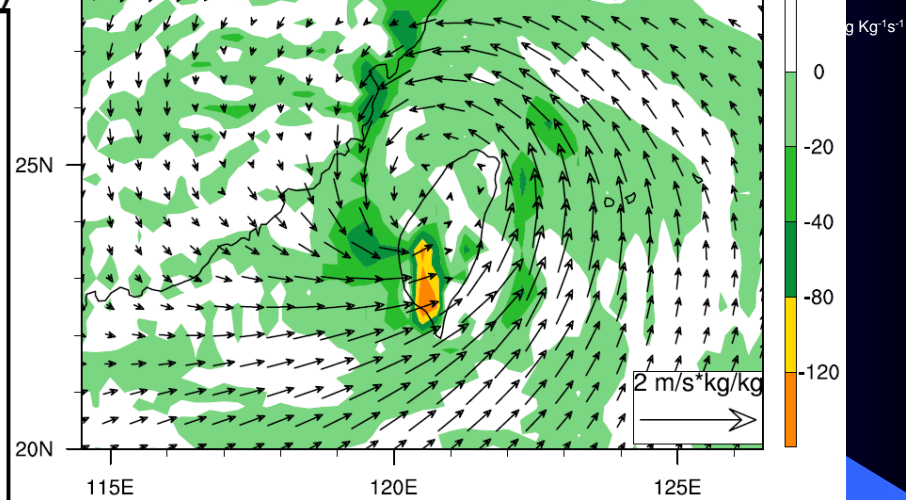
# 地形抬升作用



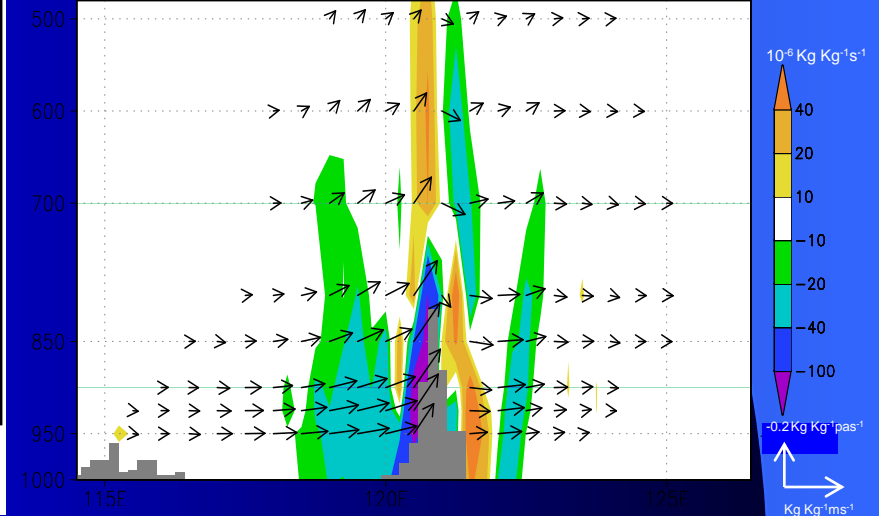
a) Taiwan Station Rainfall (7-9Aug2009)



b) moisture flux and div. at 925hPa (8Aug)

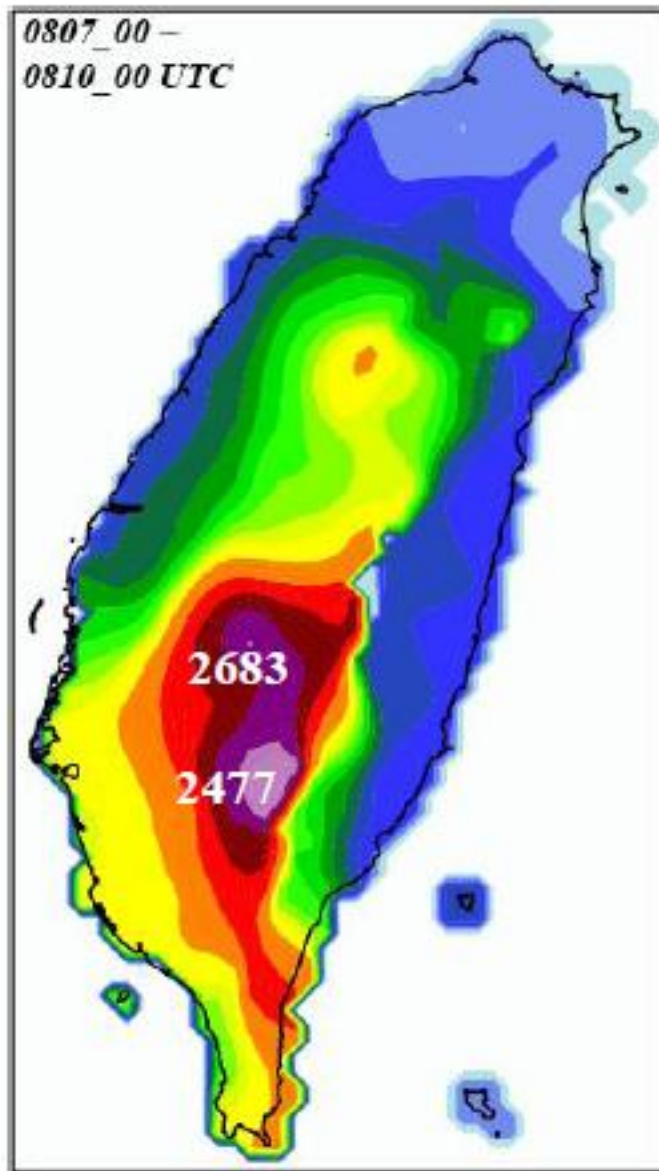


c) cross profile of moisture flux and div.(23N)

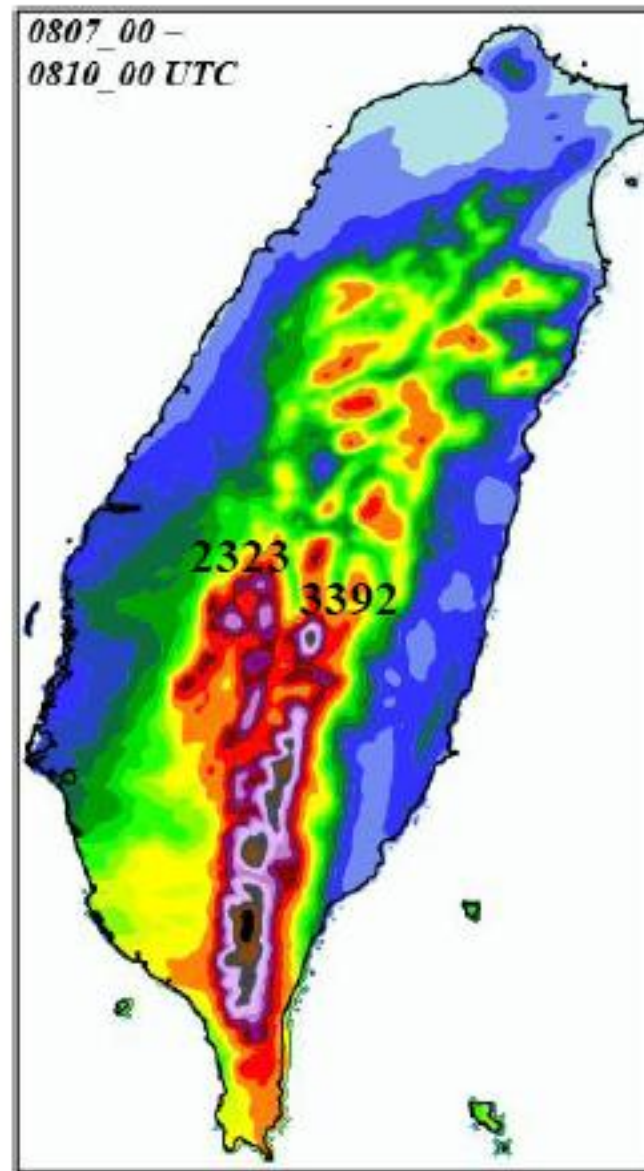




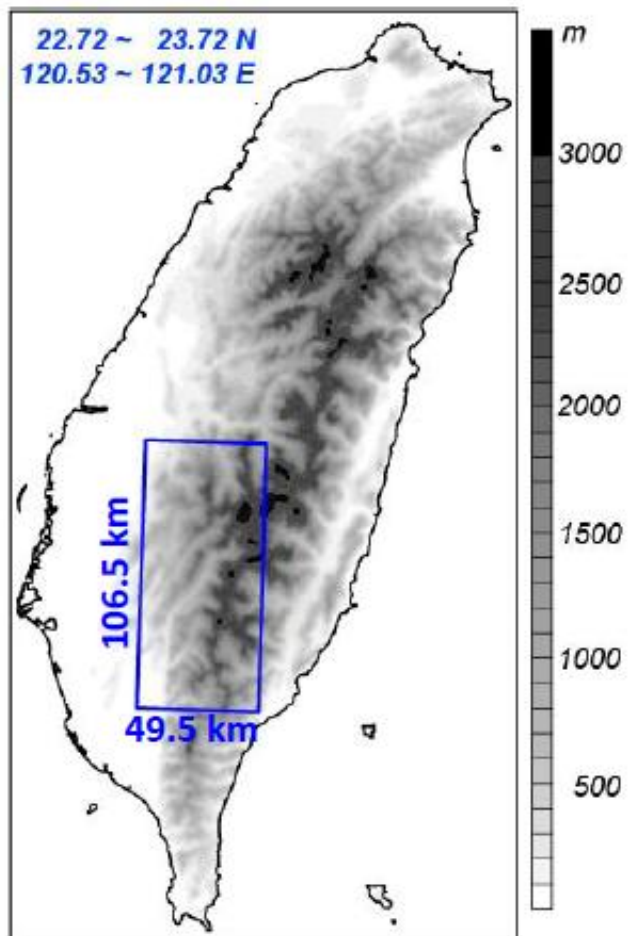
(d) OBS



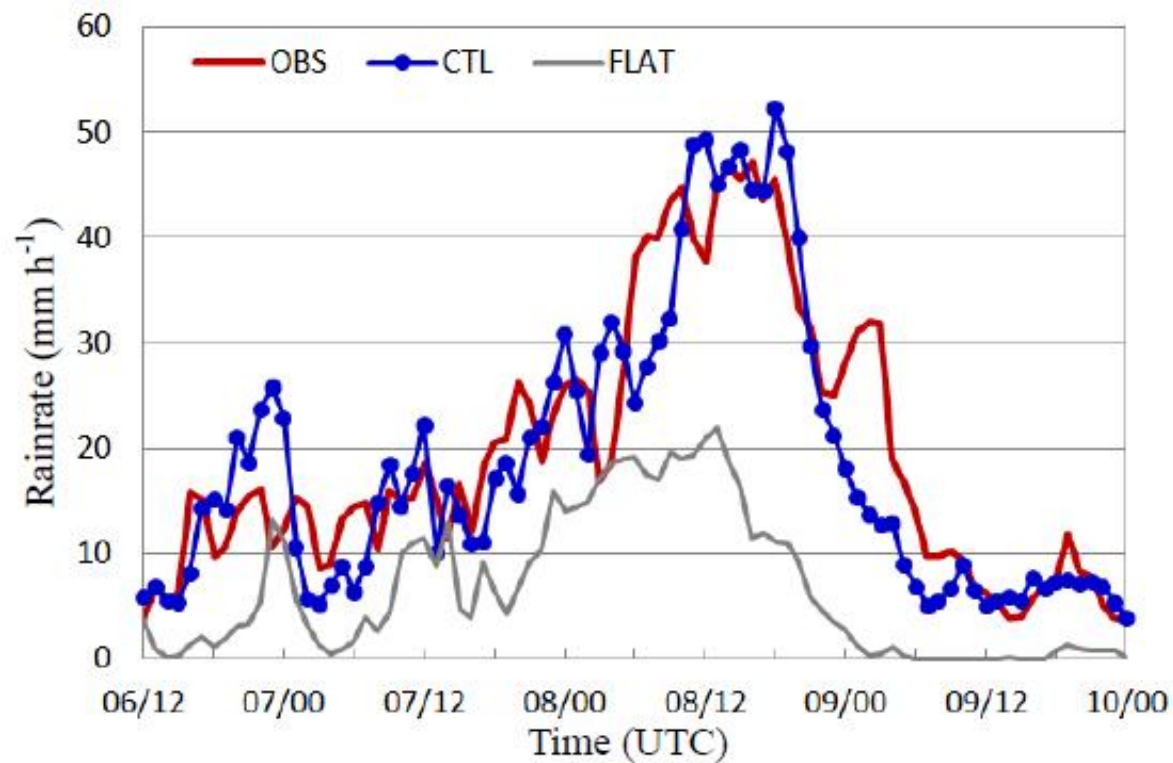
(e) CTL



(a)

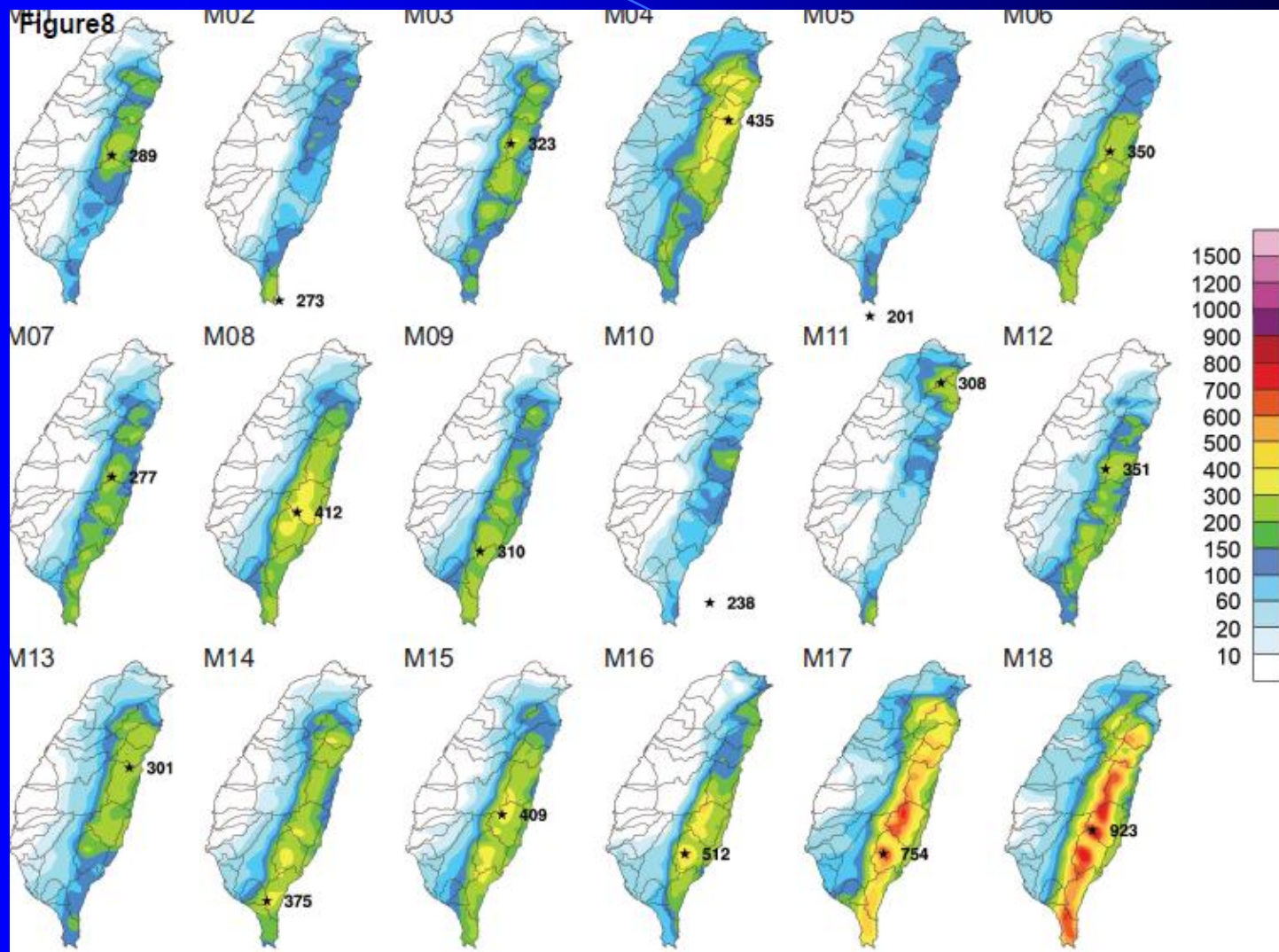


(b)



取自 Huang, Yang, and Sui (2014; JAS)

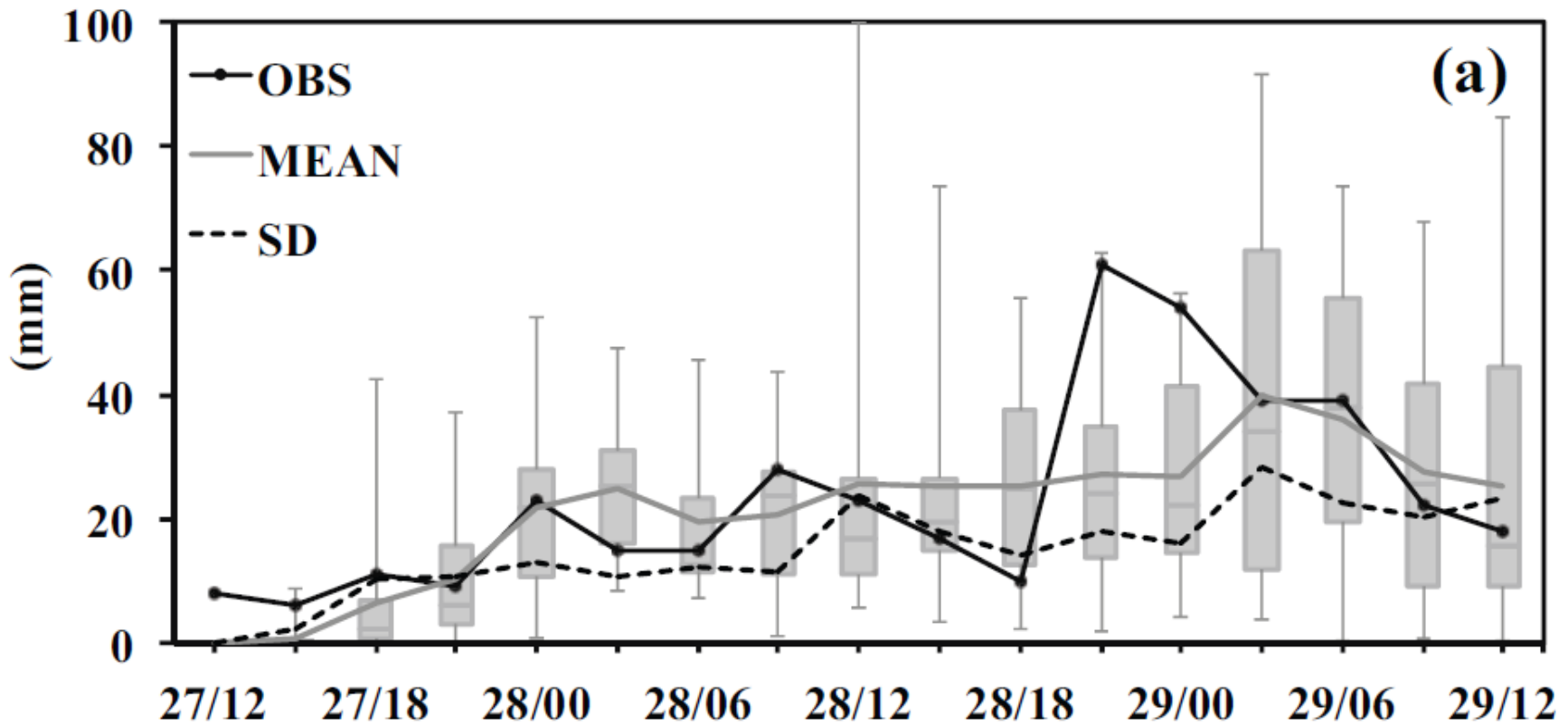
# 定量降水系集預報



取自 Hsiao, Yang, and others (2013; J. Hydrology)

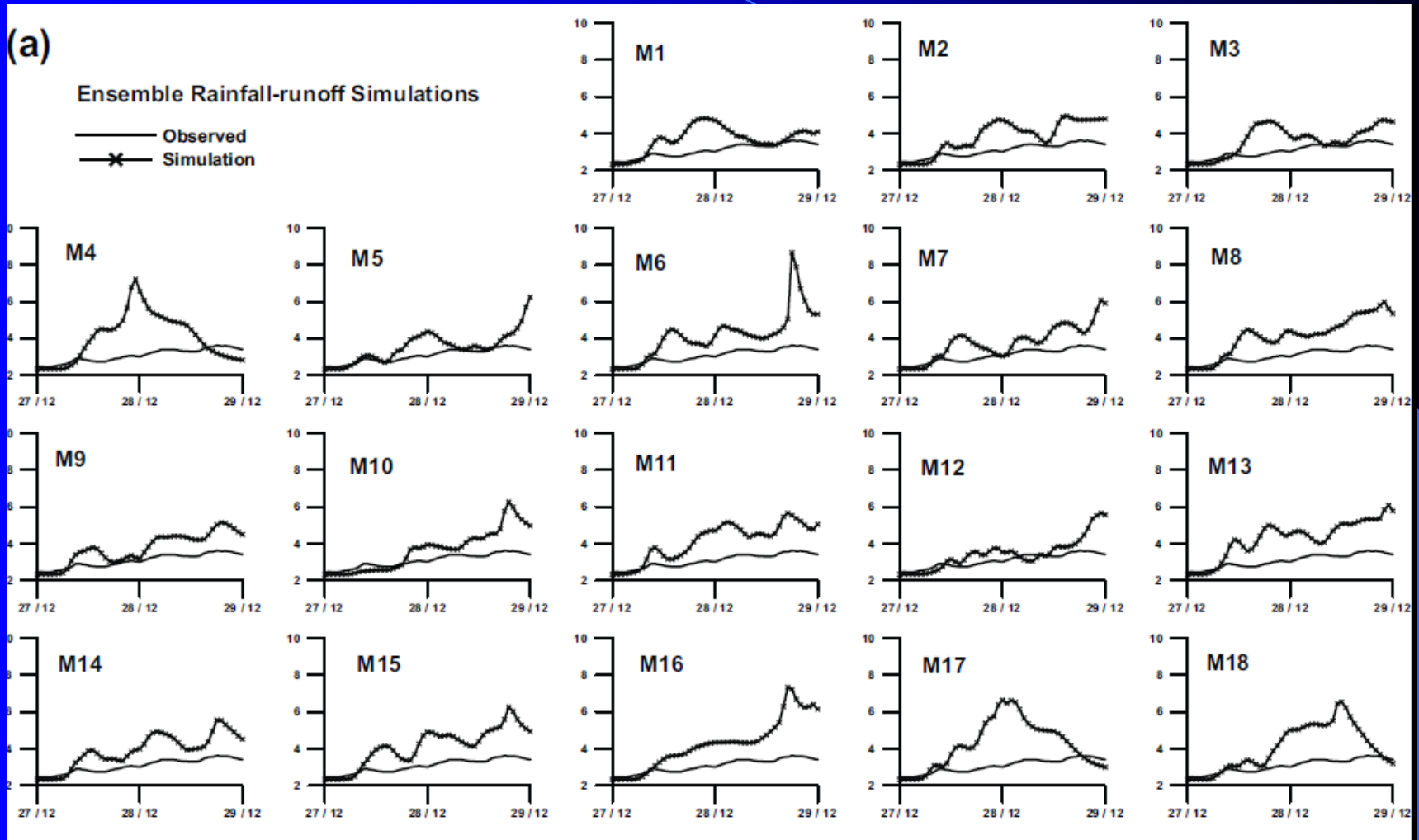


# 定量降水系集預報



取自 Hsiao, Yang, and others (2013; J. Hydrology)

# 河川水位系集預報



取自 Hsiao, Yang, and others (2013; J. Hydrology)

## 結論

- \* 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。
- \* 發展定量降水系集預報，配合雷達資料同化技術，提高風力及降雨預報準確度。
- \* 全球暖化造成極端氣候，異常降水現象如豪雨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！