



群集分析技術於颱風系集 定量降水預報系統之應用

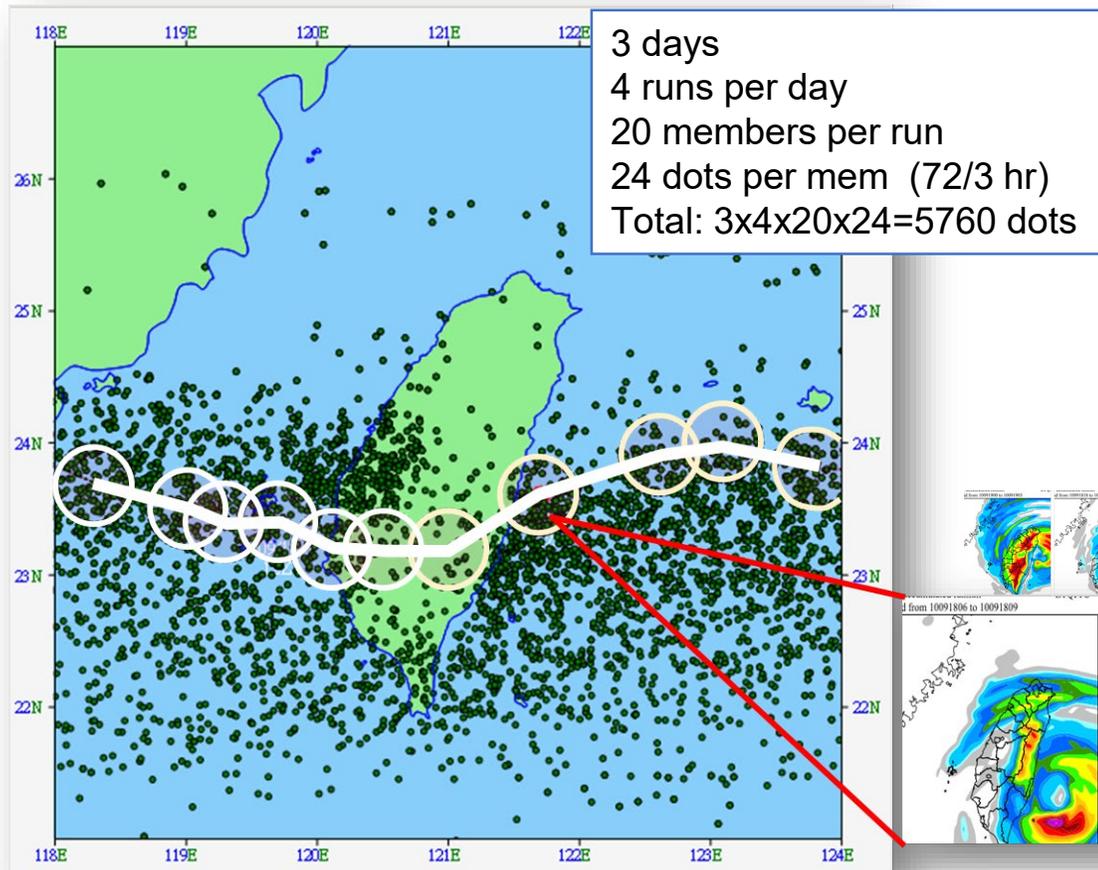
蘇奕勸、李志昕

科技發展組

中央氣象署

ETQPF 簡介

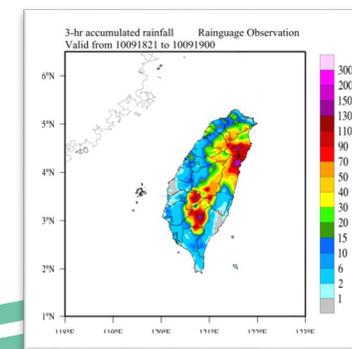
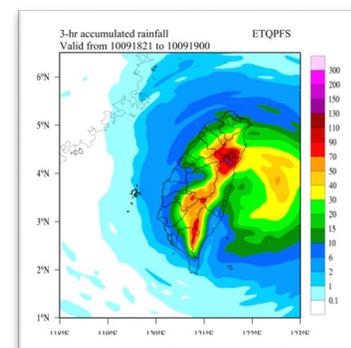
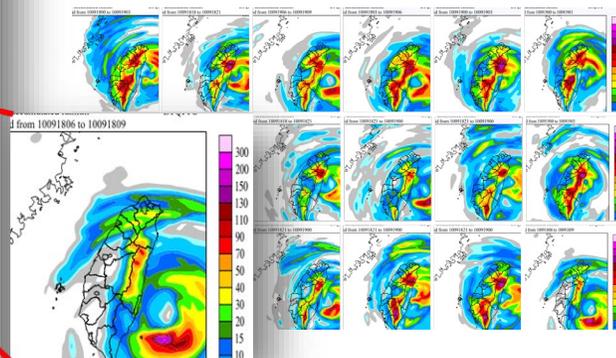
ETQPF (Ensemble Typhoon Quantitative Precipitation Forecasts , 系集颱風定量降水預報系統; Hong et al. 2015)



- 原理: 颱風對台灣陸地的降水有地形鎖定效應(Terrain locking)。

- 每個綠點表示在颱風期間收集到的不同初始時間、不同預報時間及不同的不同系集成員的颱風位置

- 經由颱風中心位置的篩選，盡可能減少颱風模式預報誤差。



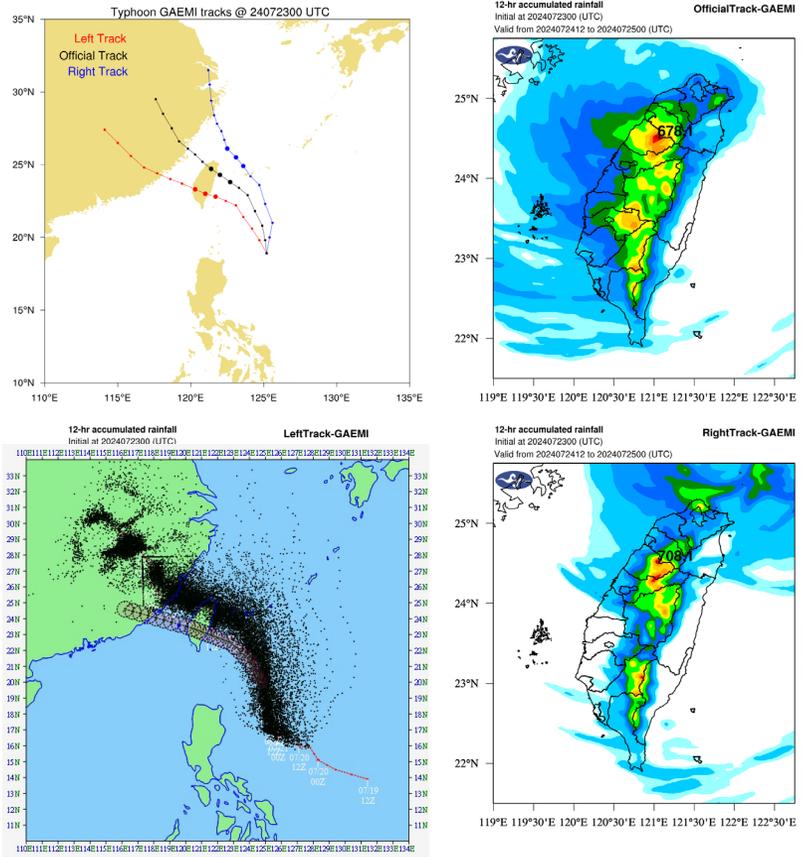
ETQPF現況

- 區域系集預報系統在颱風生成後，提供 ETQPF之預報資料，以供預報中心及防災單位進行防災決策。
- ETQPF目前提供之資訊：
 1. 官方路徑所得到的ETQPF。
目的：期望提供最佳的QPF
 2. 使用氣候法得到偏左及偏右路徑所得到之ETQPF。
目的：期望提供不同路徑之情資研判



問題

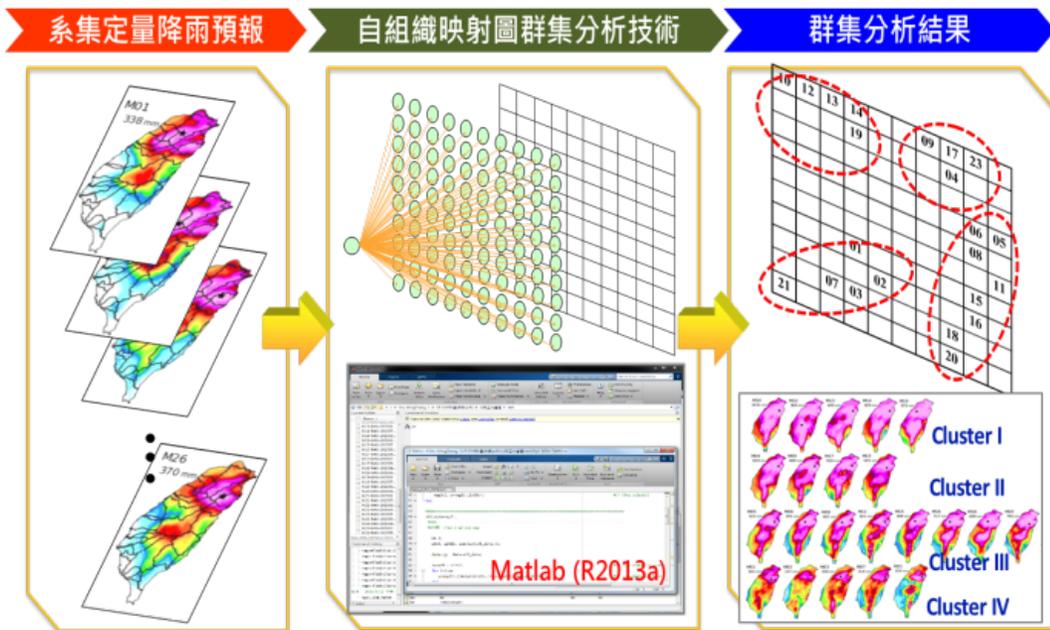
1. 偏左偏右路徑之情資研判是否能更具客觀性？
2. 偏左偏右路徑有時可能較為極端，導致無法獲得足夠成員產製合理之QPF。



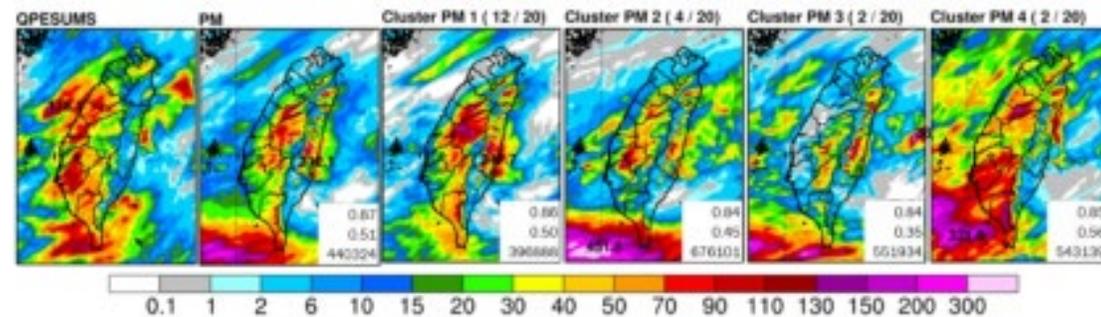
是否能透過cluster方法提供客觀的路徑，進而提供QPF

CWA Cluster 發展

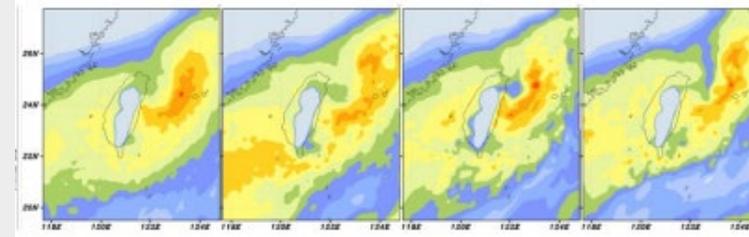
- 2016年與颱洪中心合作發展WEPS降雨群集分析，將WEPS之20組系集成員，透過自組織映射圖 (SOM) 方法分為4群，提供情境分析。
- 2022年利用降水群集連結於所伴隨的天氣環境，探討可能造成群集降雨情境差異的天氣條件特徵。



系集分群降雨



cluster對應之
850 hPa theta-e



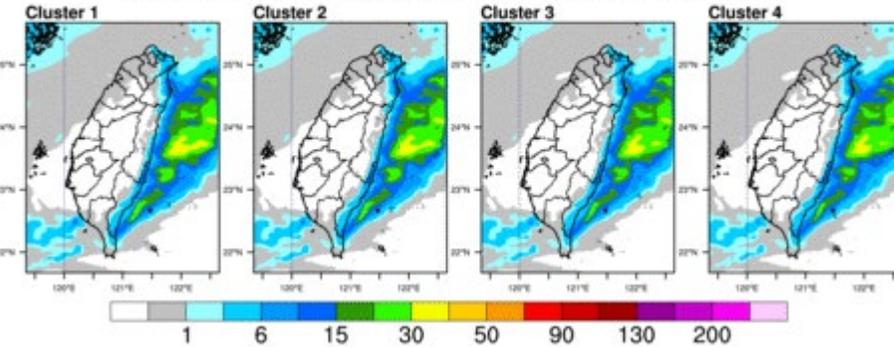
SOM

Self-Organizing Maps, 自組織映射圖

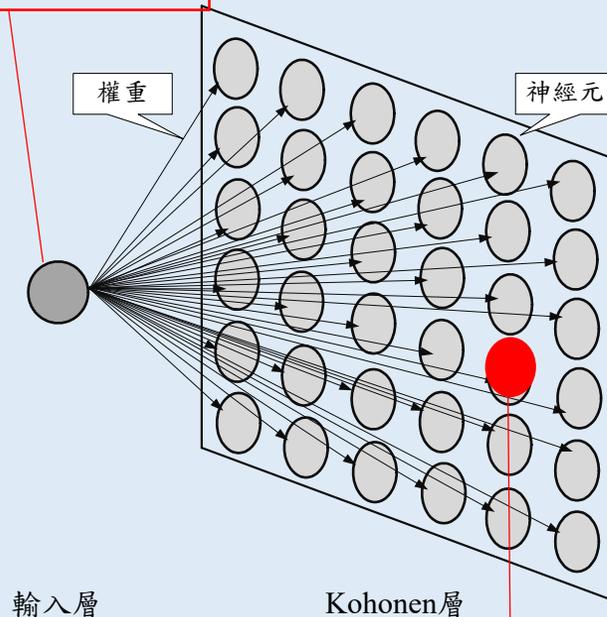
Example:

6, 10, 12 14, 15, 21, 26	5, 22, 24	13, 17, 23	8, 18
Cluster		Cluster	1, 11, 16 20, 29, 30
2, 3, 4, 25, 27, 28		19	7, 9
		Cluster	

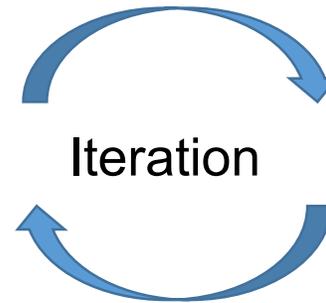
100 th Cluster Initial at 2017031808 LST
12-24 hr fcst & accumulated from 2017031820 - 2017031908 LST



$$X = [x_1, x_2, \dots, x_N]$$



透過競爭過程，找出與資料最為近似的**優勝神經元**

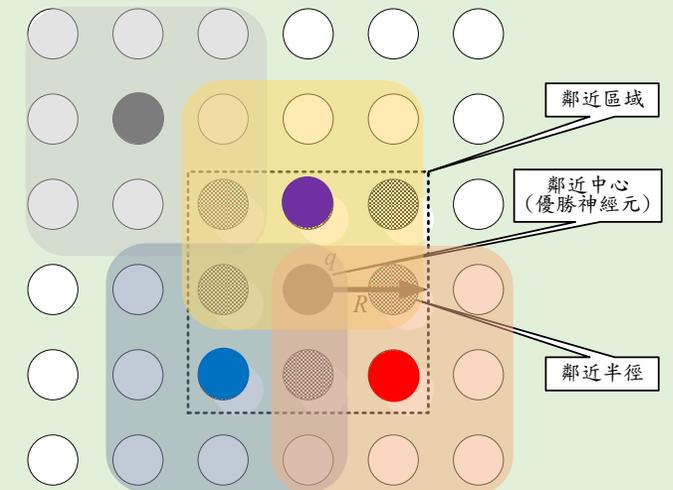


系集的調整值組合在一起，會得到新的**權重值**

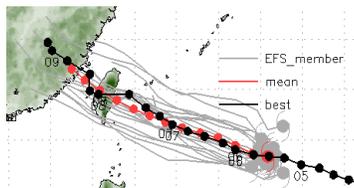
$$w_j = [w_{j1}, w_{j2}, \dots, w_{jN}] \quad j = 1, 2, \dots, M$$

$$h_{qj} = \exp\left(-\frac{\|r_j - r_q\|^2}{\alpha}\right)$$

$$\Delta w_j(k) = \eta(k) h_{qj}(k) [x(k) - w_j(k)]$$



研究方法

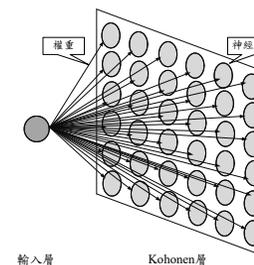


收集路徑

EC(M00) · NCEP(mean) · WRFD · TWRF跟WEPS20組成員，總共24組路徑

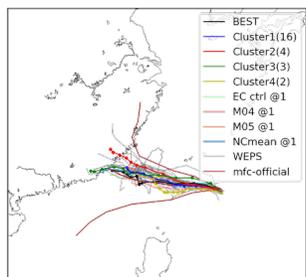
群集分析

以自組織映射圖(SOM)方法，產製4條群集分析路徑。



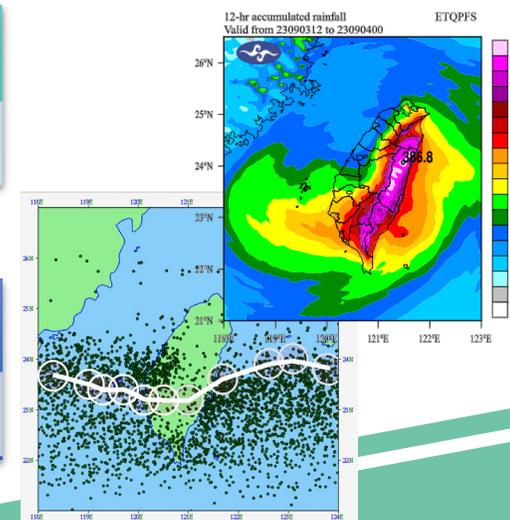
分類分析

將24條預報路徑和SOM結果進行相關性分析，再依據分類到的成員數進行排序



颱風產品

將分析路徑傳送至ETQPF系統進行系集雨量合成



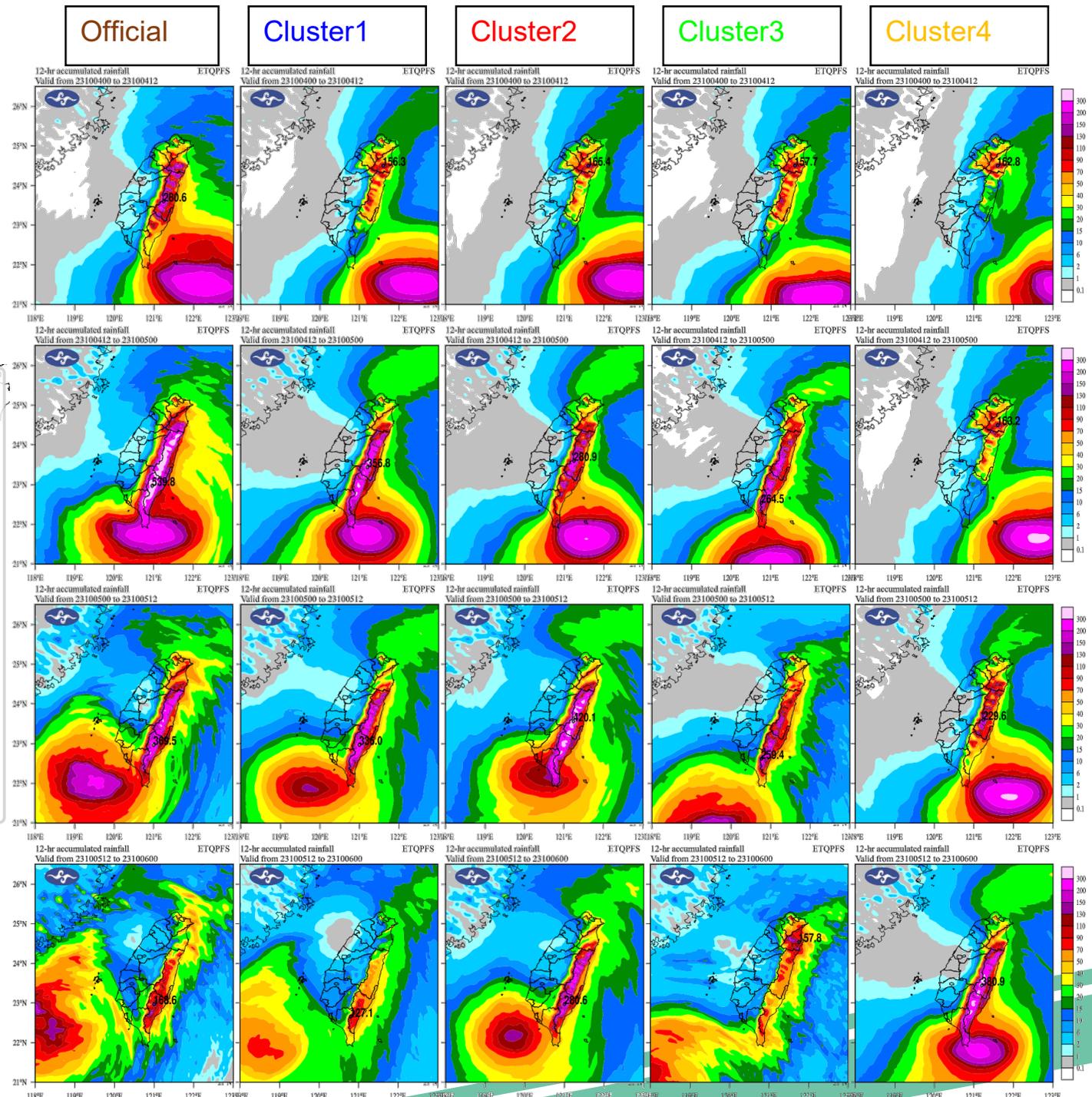
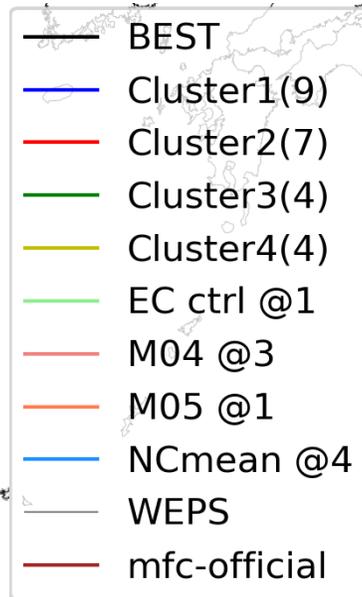
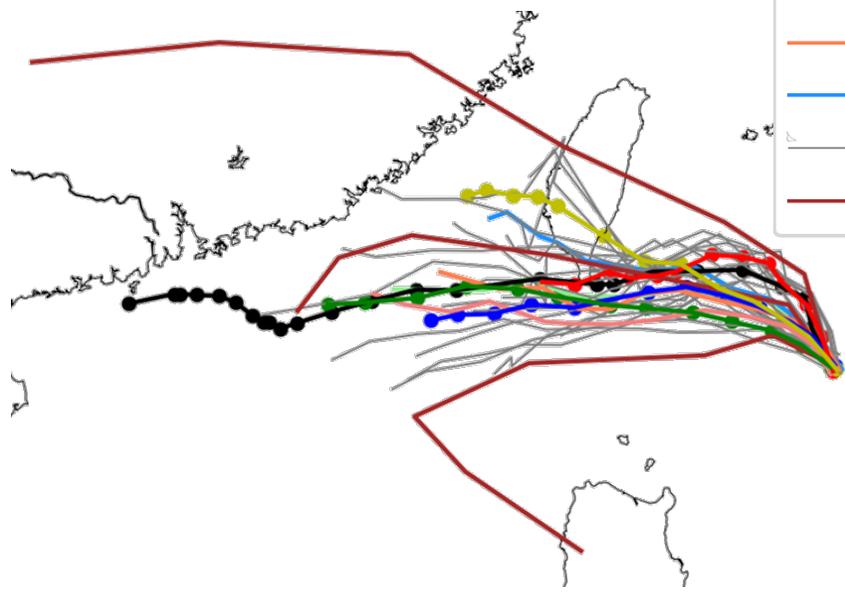
研究方法

- 針對WEPS之20組成員路徑，並加入ECMWF、NCEP、WRFD、TWRF的路徑，進行路徑預報分群，提供4組可能的颱風路徑，及此4組路徑之相對應ETQPF的雨量（此雨量不加入全球模式雨量）
- 標示ECMWF、NCEP、WRFD、TWRF 於哪個分群中，提供情資判斷。
 1. 能提供更客觀之路徑情境。
 2. ECMWF或NCEP因為解析度過大，造成雨量預報較差，透過分群可提供可能的高解析度降雨預報。
 3. 提供機率預報概念資訊，若有較多成員在同一群集中，可提供較高可信度的資訊，例如ECMWF、TWRF在同一群，此一群集的降雨表現可能較高機會發生。

KOINU

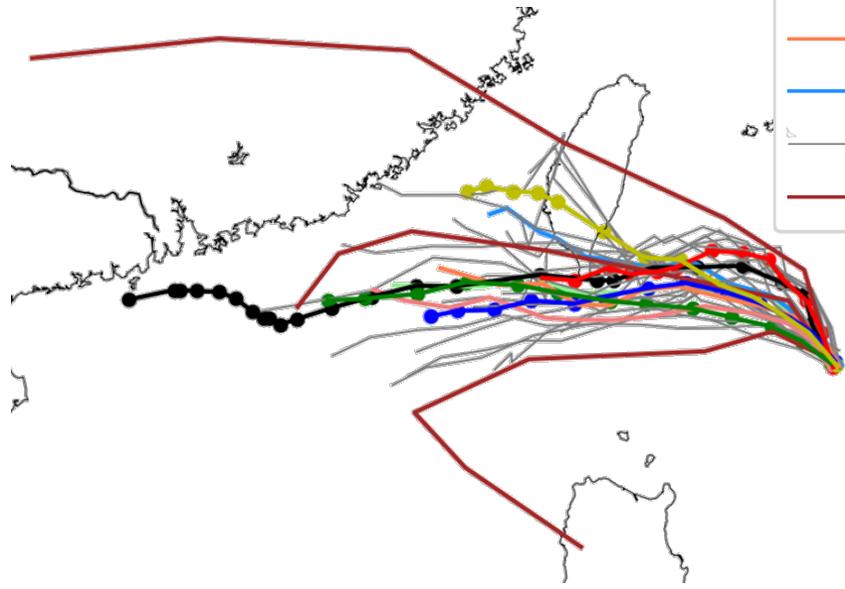
說明：

- 黑線為best track
- 四條點線分別為cluster1~4，括弧代表包含的成員數
- 決定性預報後@數字代表其被分到的cluster編號

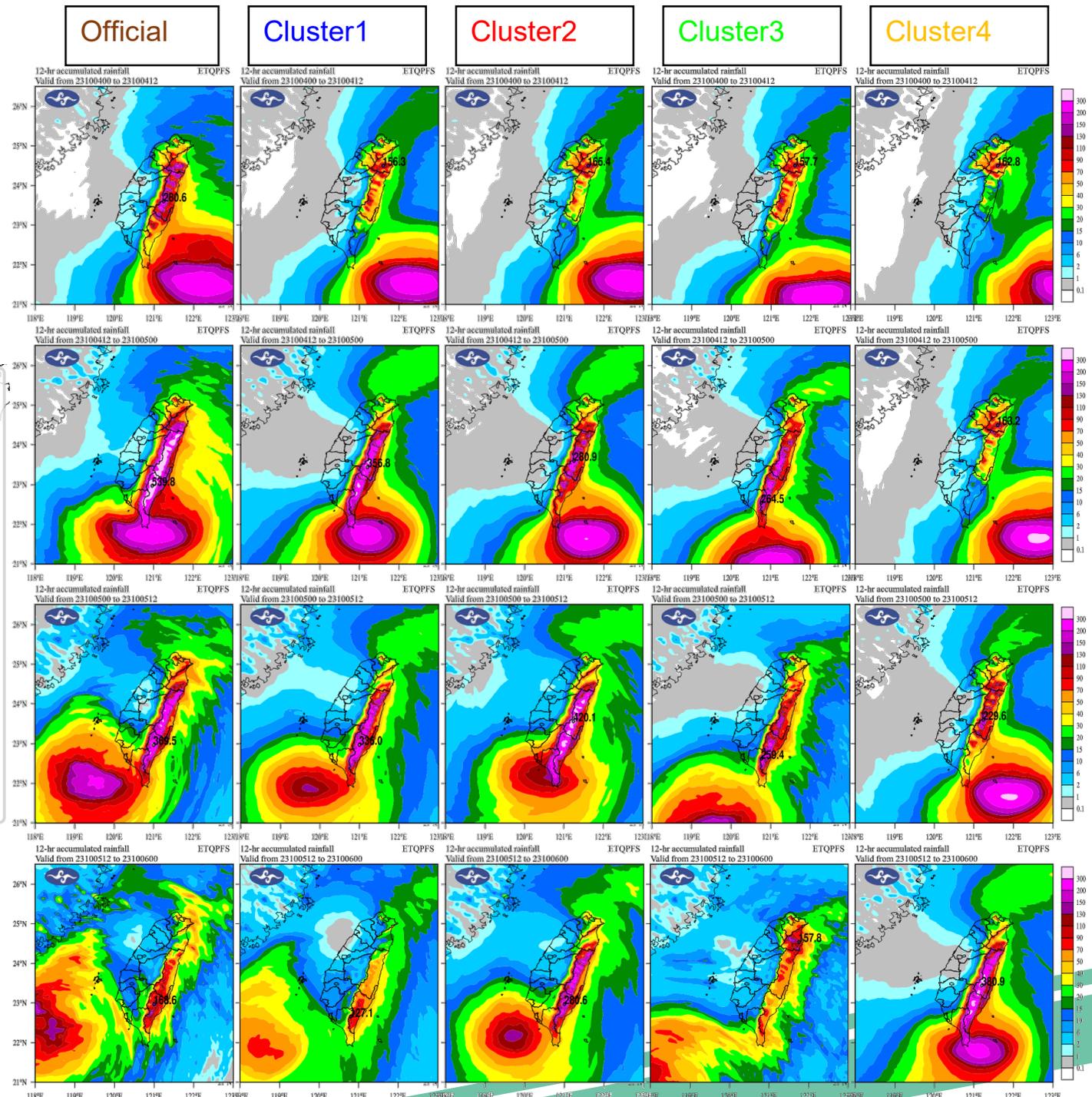


KOINU

23100300 小犬
 小犬的個案中，除了Cluster4明顯偏北外，其他成員的差異主要在移速不同，依序為C3>C1>C2，移速上C1跟official較接近。

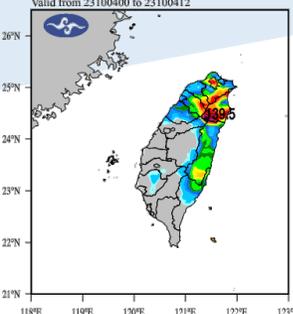


- BEST
- Cluster1(9)
- Cluster2(7)
- Cluster3(4)
- Cluster4(4)
- EC ctrl @1
- M04 @3
- M05 @1
- NCmean @4
- WEPS
- mfc-official

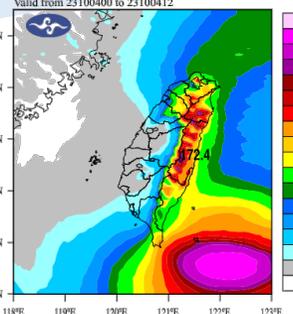


QPE**Official****Ref1****Cluster1****Cluster2****Cluster3****Cluster4**

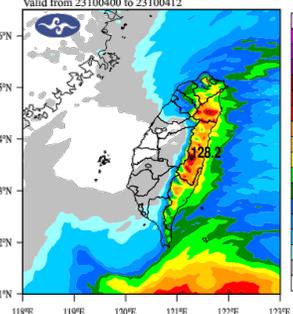
12-hr accumulated rainfall Rainguage Observation



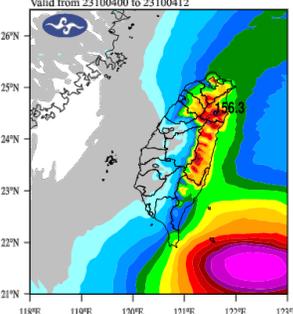
12-hr accumulated rainfall ETQPFs



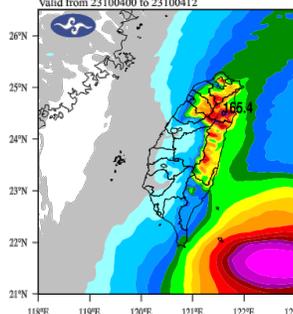
12-hr accumulated rainfall ETQPFs



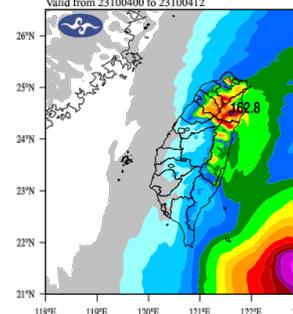
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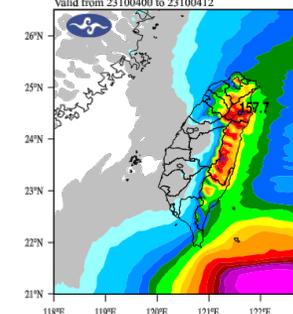
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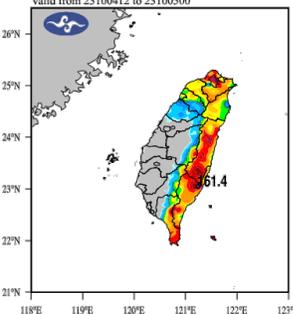
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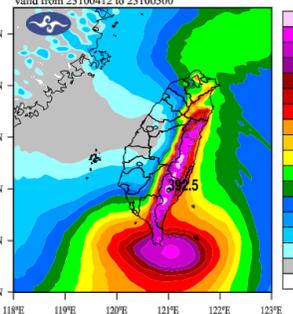
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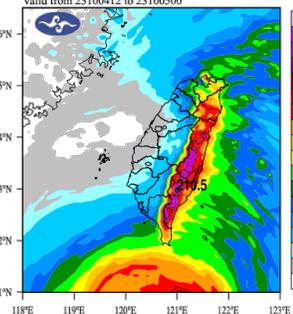
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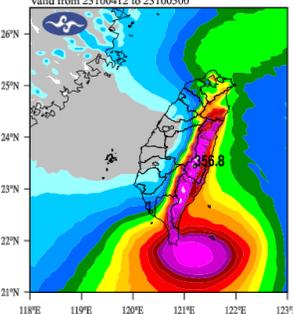
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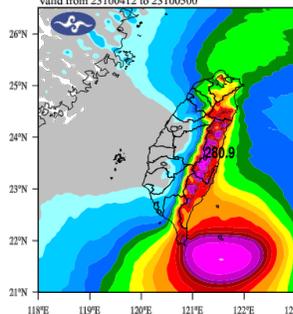
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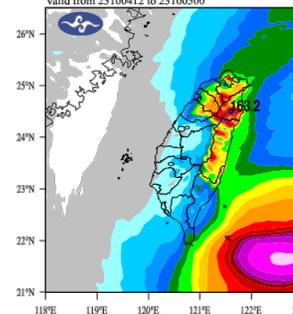
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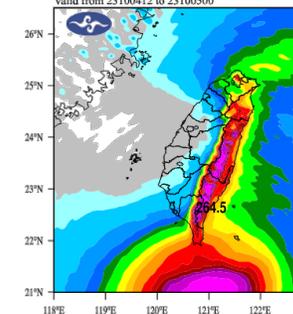
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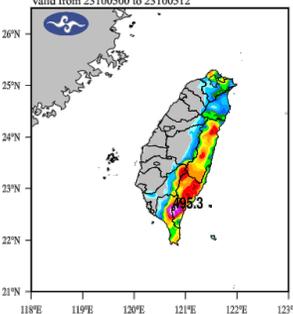
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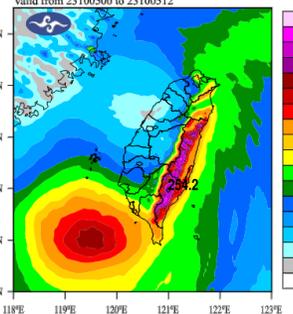
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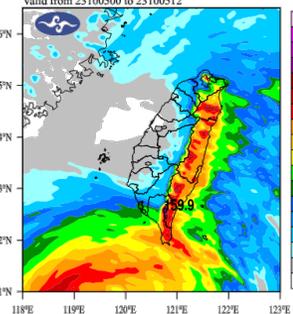
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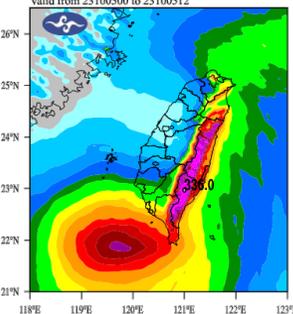
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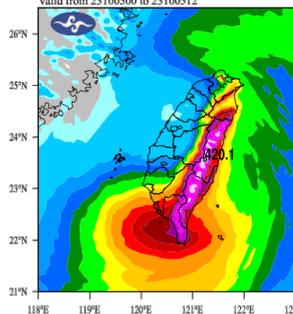
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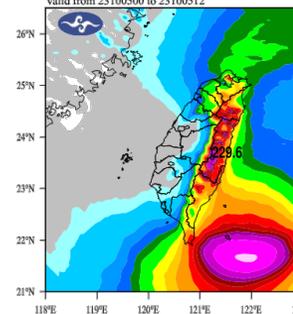
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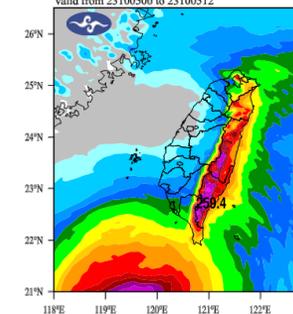
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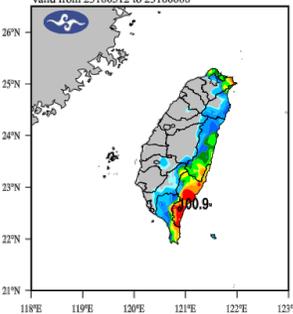
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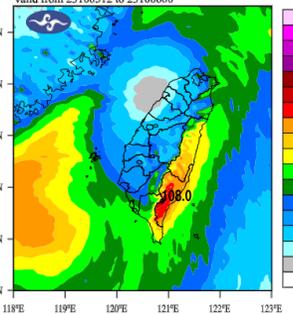
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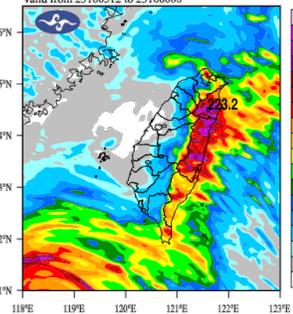
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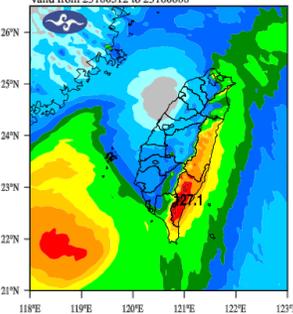
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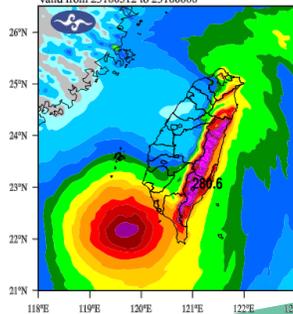
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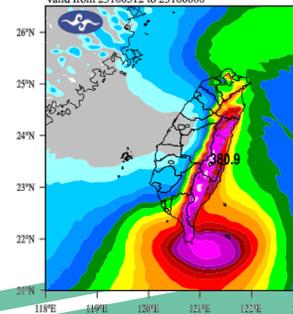
12-hr accumulated rainfall ETQPFs



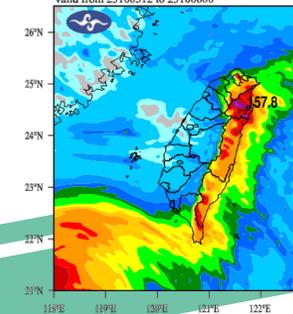
12-hr accumulated rainfall ETQPFs



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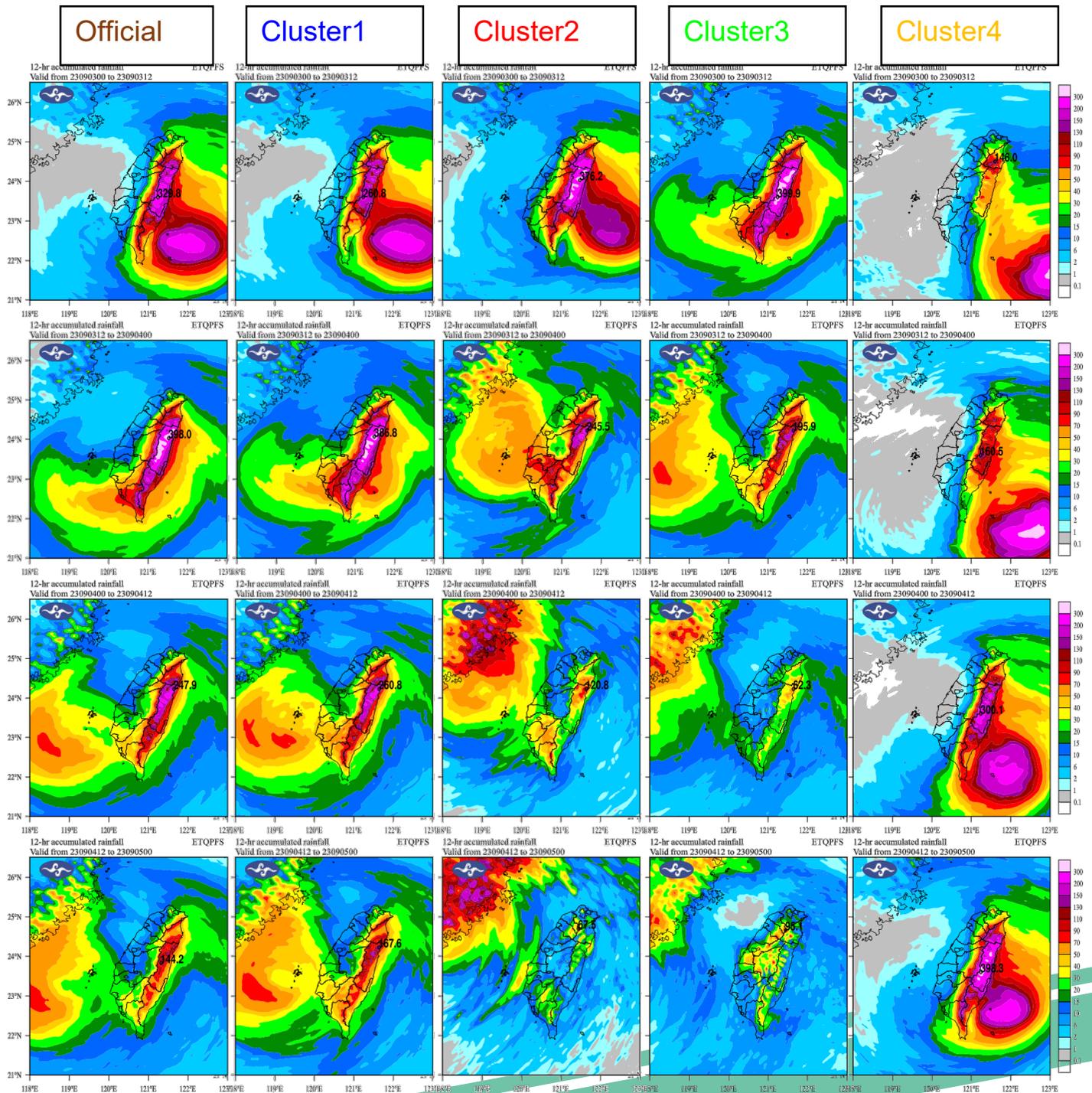
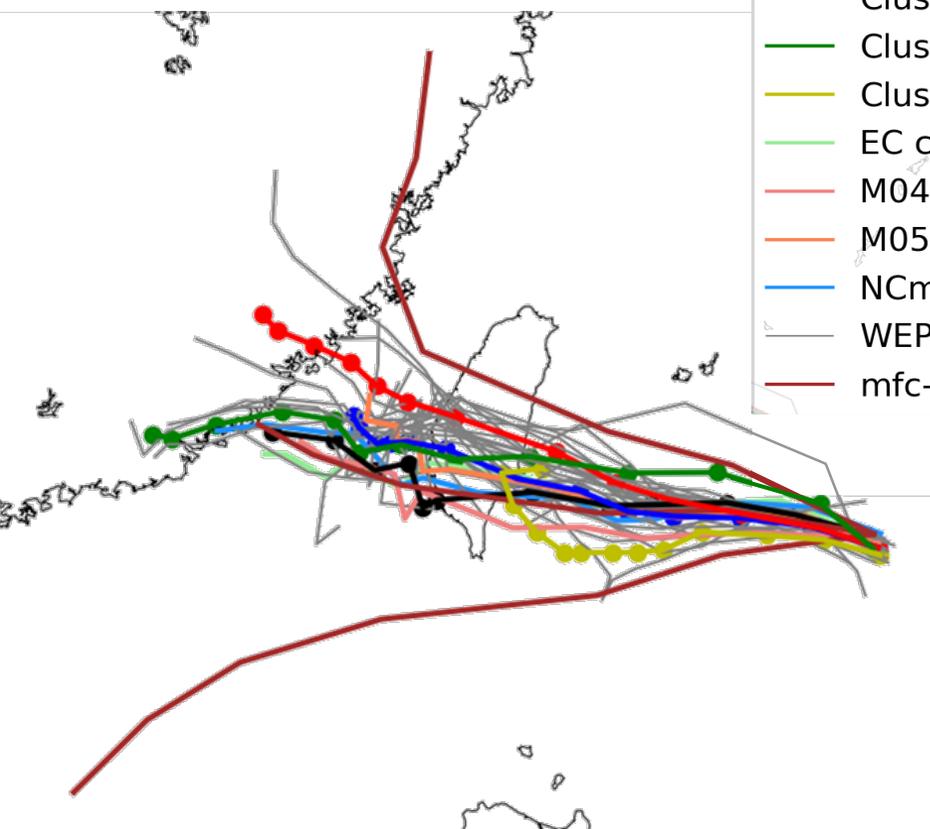
12-hr accumulated rainfall ETQPFs



HAIKUI

23090200 海葵
 多數的成員是屬於 C1跟official相似，
 其他如 C2 偏北，
 而 C4 偏南且移速緩慢等，
 都能展現不同路徑的情境。

- BEST
- Cluster1(16)
- Cluster2(4)
- Cluster3(3)
- Cluster4(2)
- EC ctrl @1
- M04 @1
- M05 @1
- NCmean @1
- WEPS
- mfc-official



QPE

Official

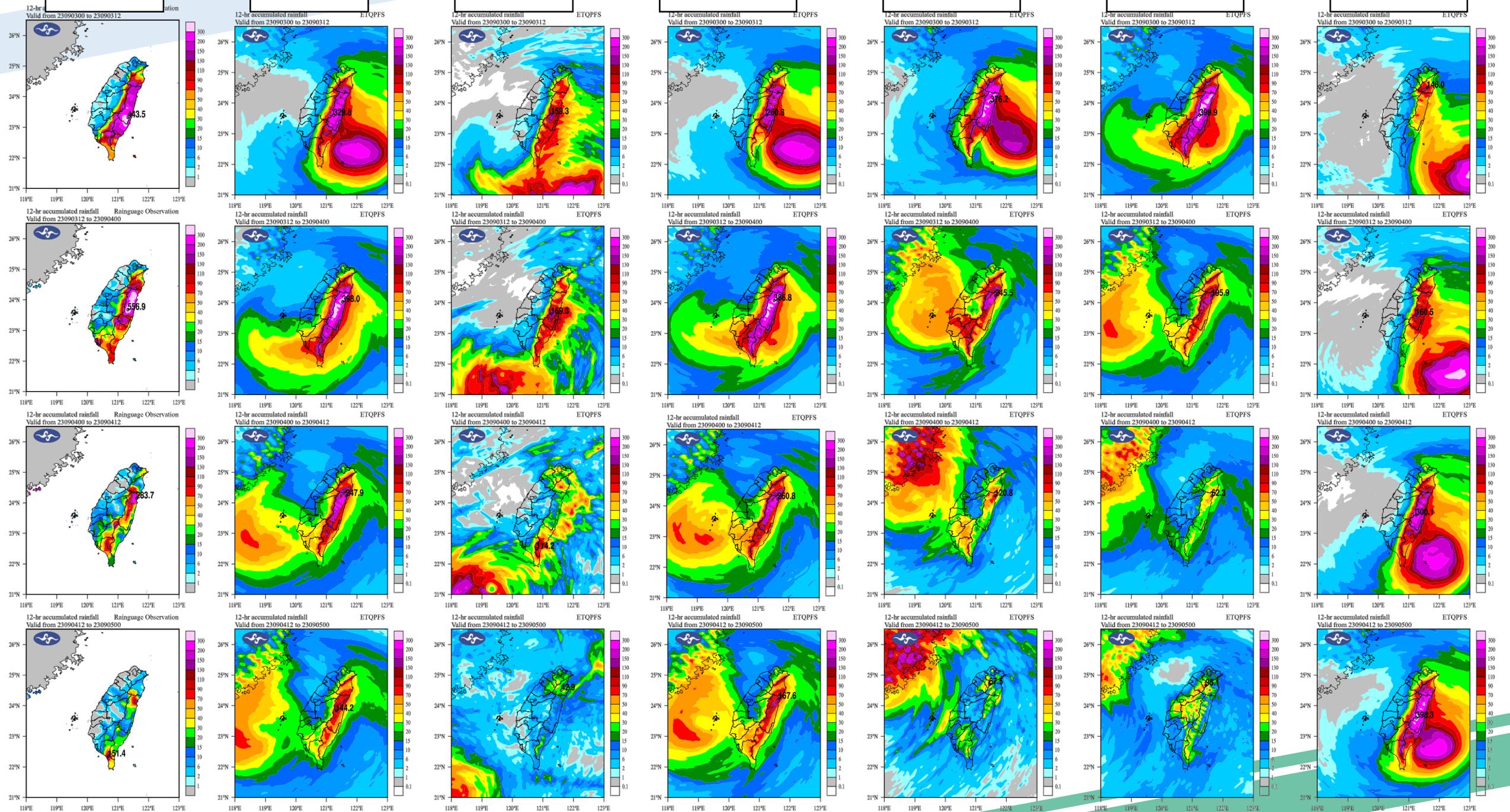
Ref1

Cluster1

Cluster2

Cluster3

Cluster4

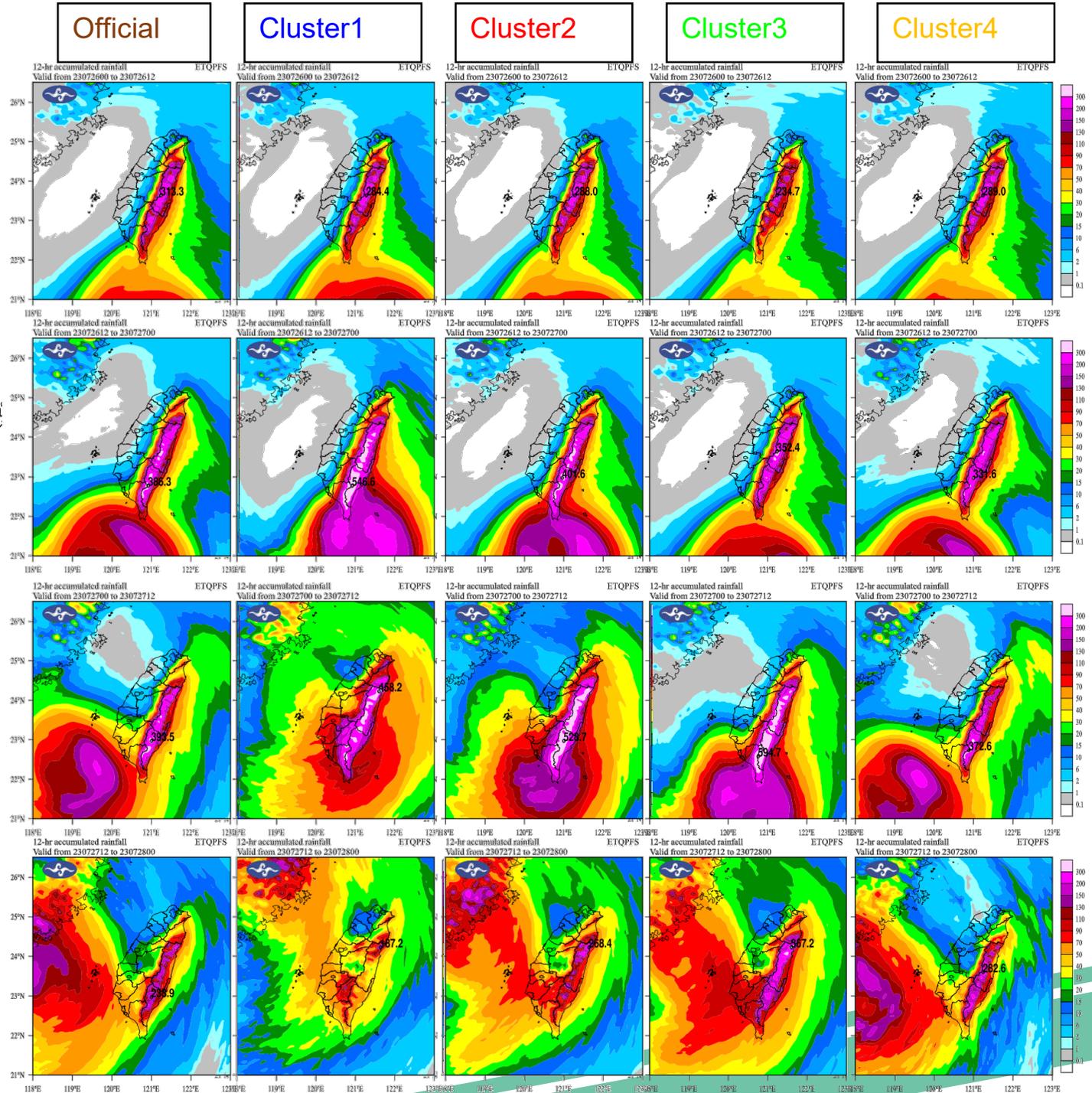
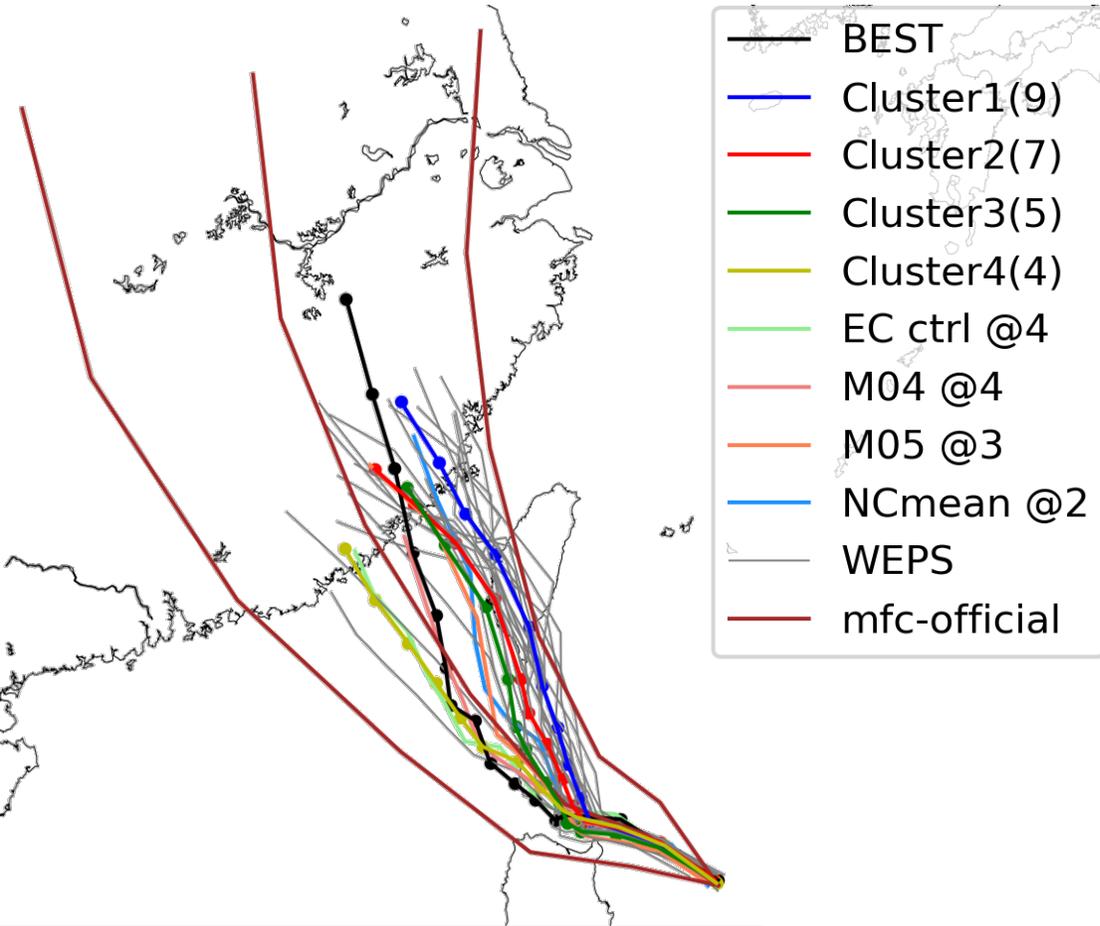


DOKSURI

23072500 杜蘇芮

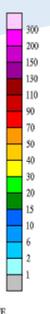
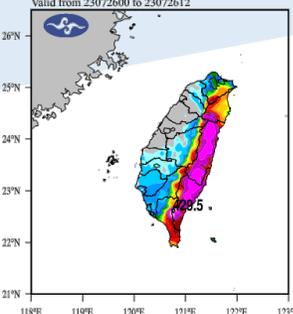
系集成員路徑皆偏北從cluster1~4依序偏南，
顯示系集整體有靠近向北的誤差，

official run 和Cluster4所包含的M04跟EC皆是偏南
的路徑。

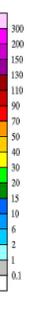
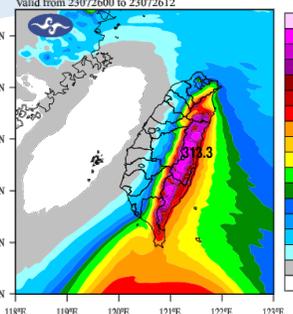


QPE**Official****Ref1****Cluster1****Cluster2****Cluster3****Cluster4**

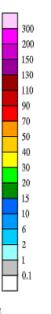
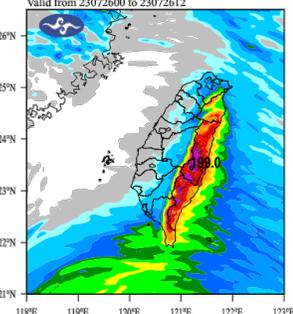
12-hr accumulated rainfall Rainguage Observation



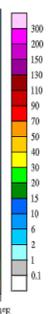
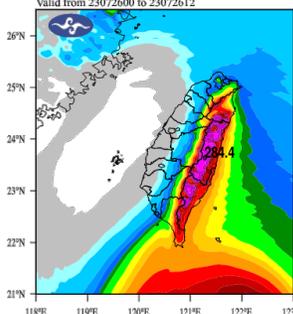
12-hr accumulated rainfall ETQPF5



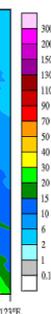
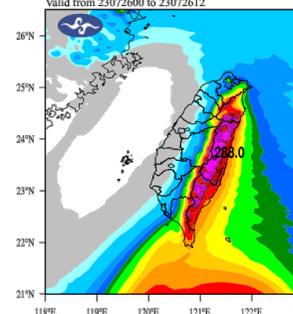
12-hr accumulated rainfall ETQPF5



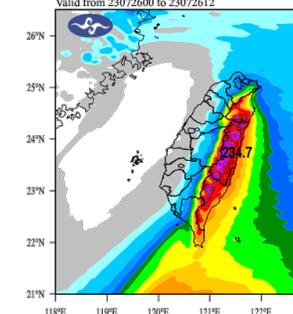
12-hr accumulated rainfall ETQPF5



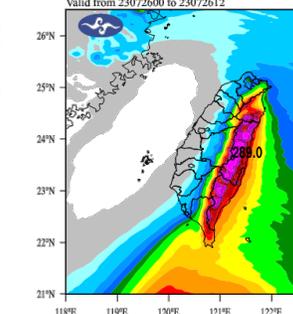
12-hr accumulated rainfall ETQPF5



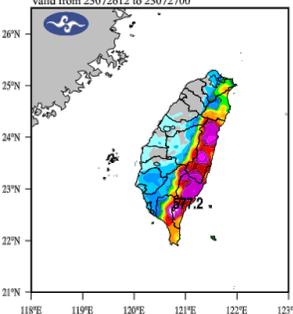
12-hr accumulated rainfall ETQPF5



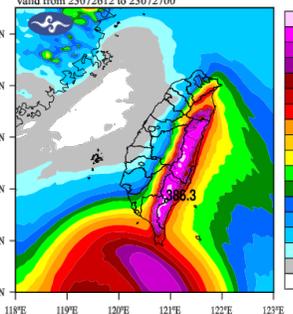
12-hr accumulated rainfall ETQPF5



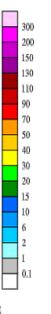
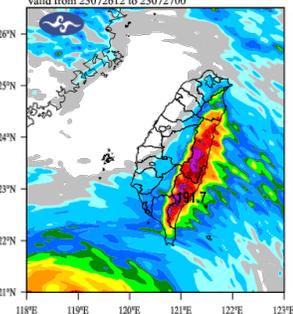
12-hr accumulated rainfall Rainguage Observation



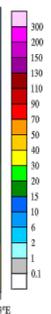
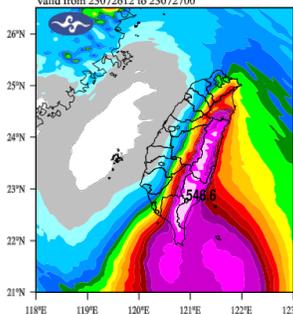
12-hr accumulated rainfall ETQPF5



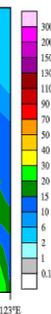
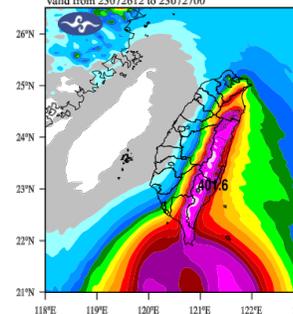
12-hr accumulated rainfall ETQPF5



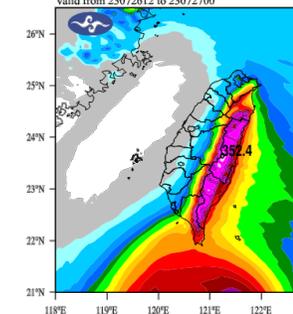
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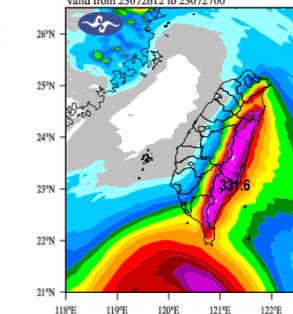
12-hr accumulated rainfall ETQPF5



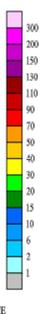
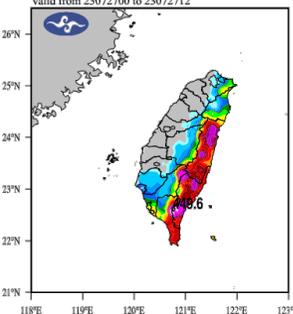
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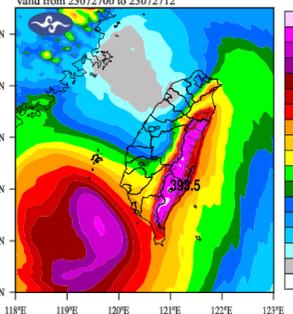
12-hr accumulated rainfall ETQPF5



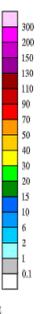
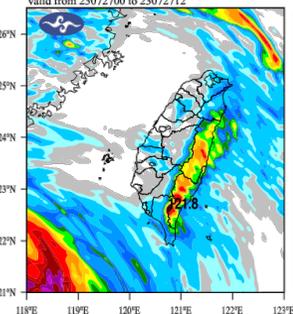
12-hr accumulated rainfall Rainguage Observation



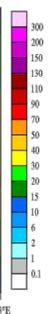
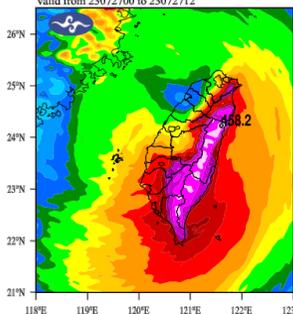
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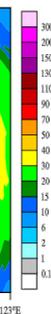
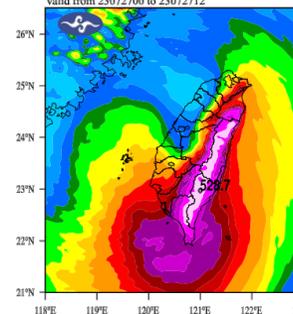
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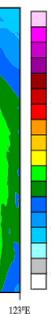
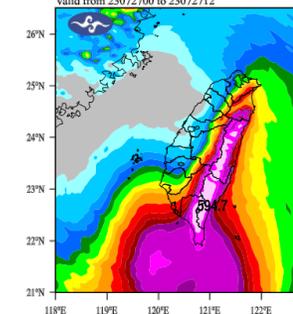
12-hr accumulated rainfall ETQPF5



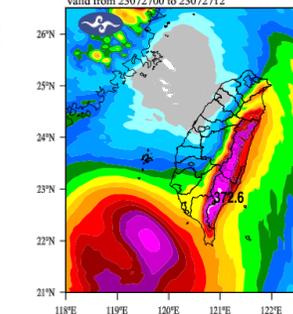
12-hr accumulated rainfall ETQPF5



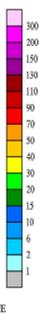
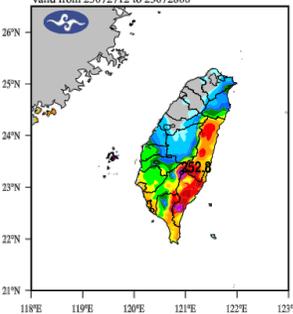
12-hr accumulated rainfall ETQPF5



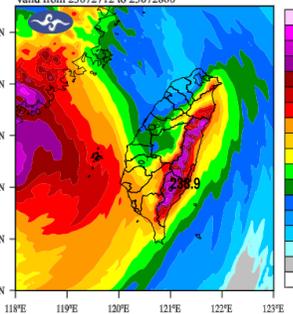
12-hr accumulated rainfall ETQPF5



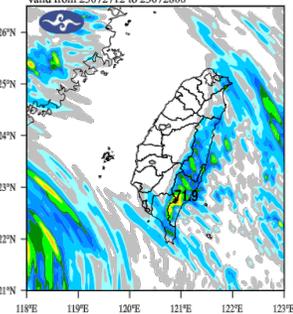
12-hr accumulated rainfall Rainguage Observation



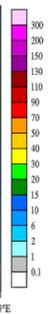
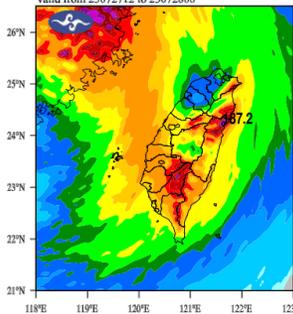
12-hr accumulated rainfall ETQPF5



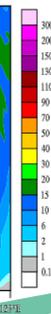
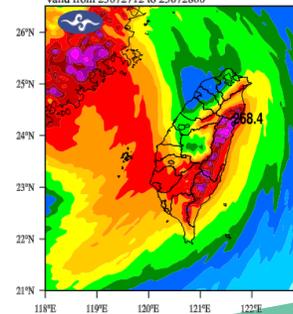
12-hr accumulated rainfall ETQPF5



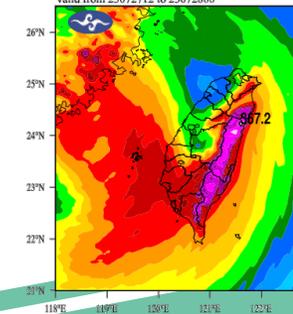
12-hr accumulated rainfall ETQPF5



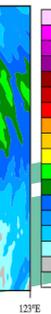
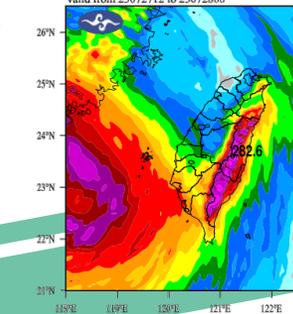
12-hr accumulated rainfall ETQPF5



12-hr accumulated rainfall ETQPF5



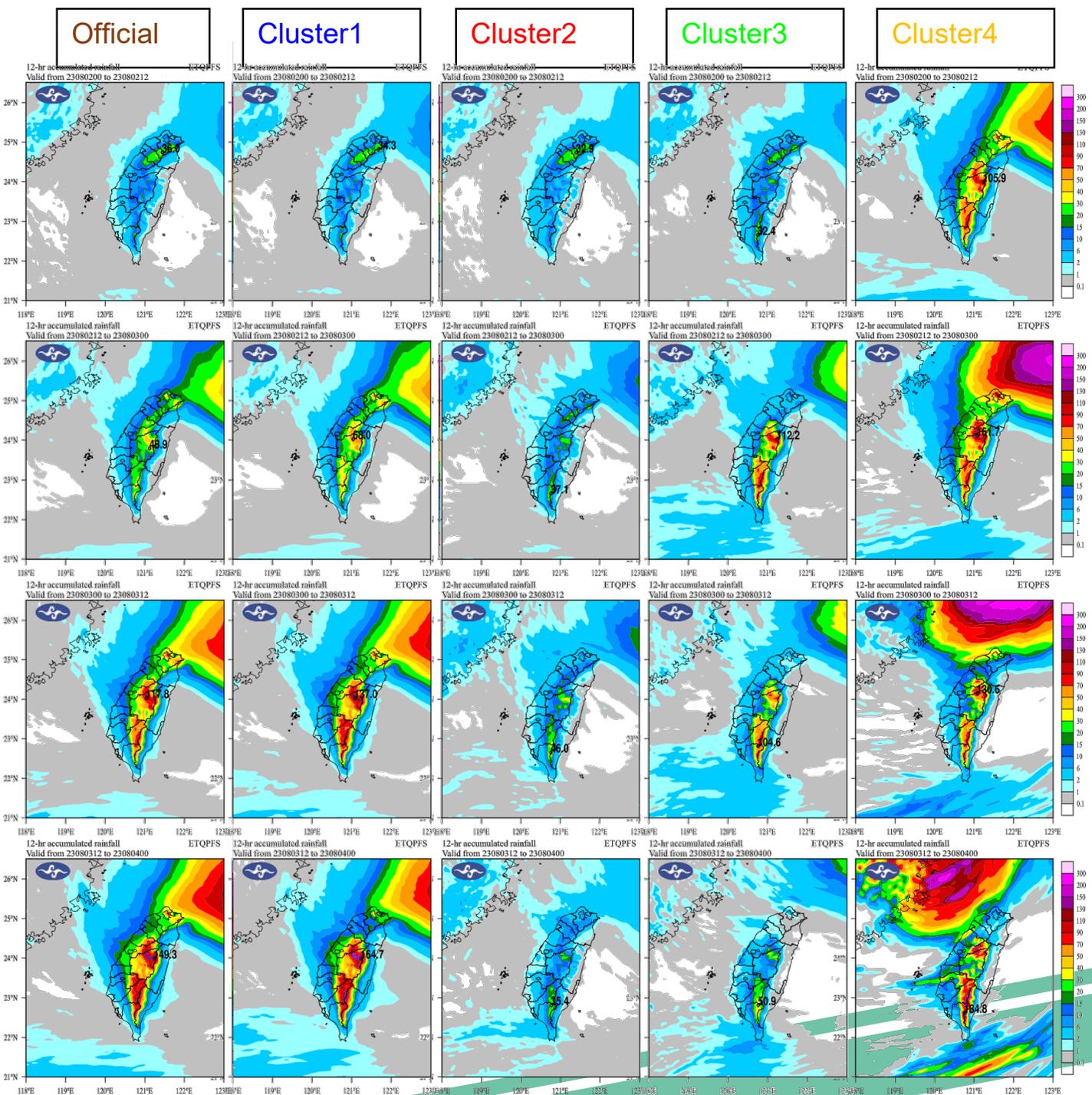
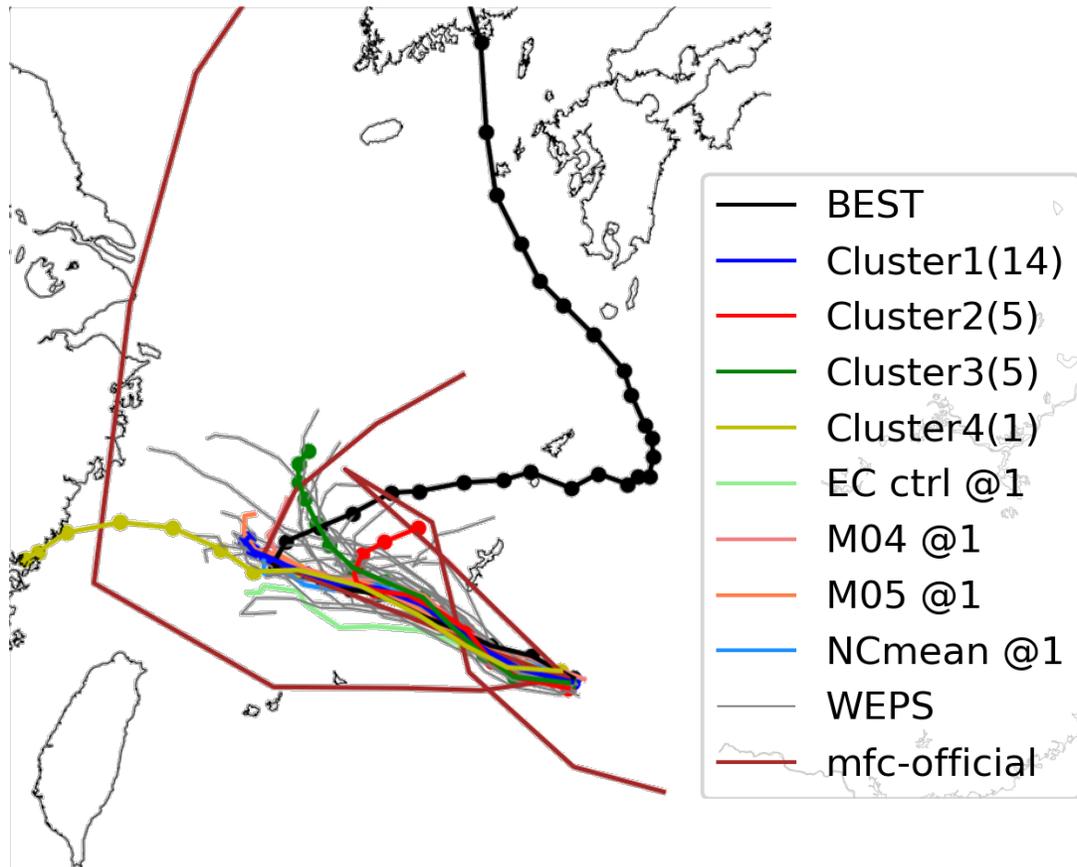
12-hr accumulated rainfall ETQPF5



KHANUN

23080100 卡努

該颱風中心尚離台灣有段距離，從路徑上偏折可以看到此時對於颱風轉折的方向有很大的不確定性。但大多數成員還是走cluster1跟official相近的路線。而兩條ref路徑不合理。



QPE

Official

Ref1

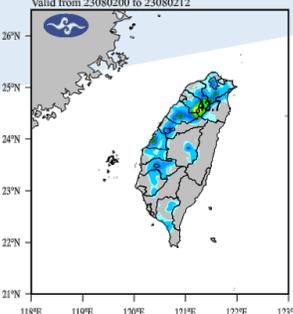
Cluster1

Cluster2

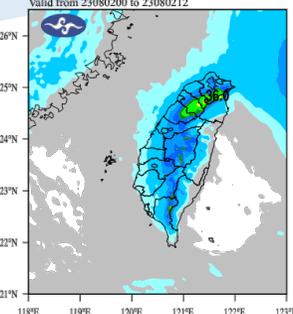
Cluster3

Cluster4

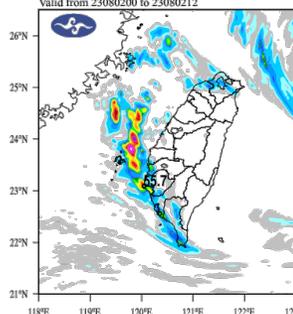
12-hr accumulated rainfall Rainguage Observation Valid from 23080200 to 23080212



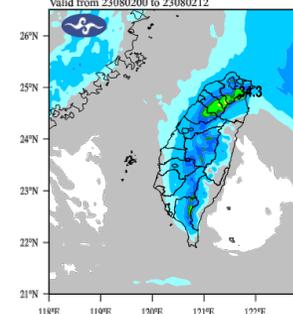
12-hr accumulated rainfall ETQPFs Valid from 23080200 to 23080212



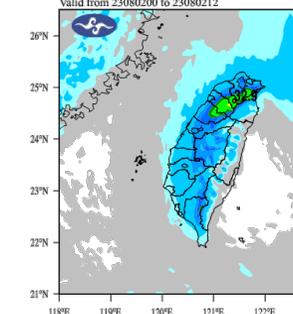
12-hr accumulated rainfall ETQPFs Valid from 23080200 to 23080212



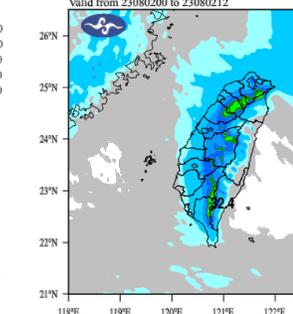
12-hr accumulated rainfall ETQPFs Valid from 23080200 to 23080212



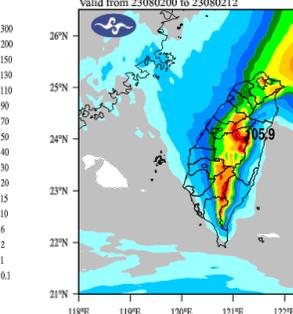
12-hr accumulated rainfall ETQPFs Valid from 23080200 to 23080212



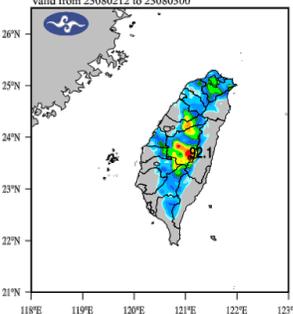
12-hr accumulated rainfall ETQPFs Valid from 23080200 to 23080212



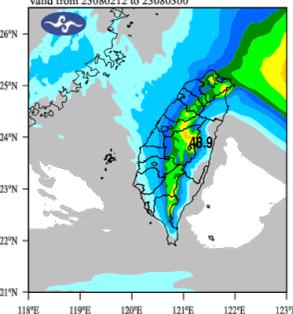
12-hr accumulated rainfall ETQPFs Valid from 23080200 to 23080212



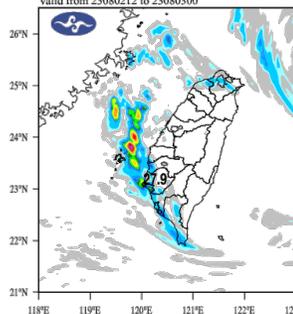
12-hr accumulated rainfall Rainguage Observation Valid from 23080300 to 23080312



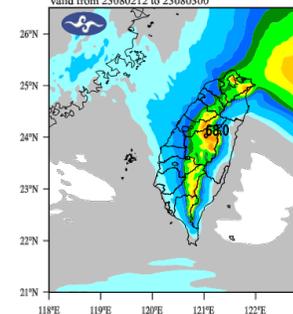
12-hr accumulated rainfall ETQPFs Valid from 23080300 to 23080312



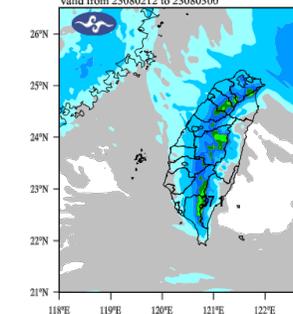
12-hr accumulated rainfall ETQPFs Valid from 23080300 to 23080312



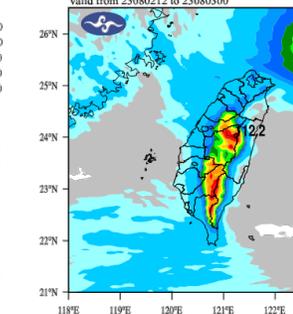
12-hr accumulated rainfall ETQPFs Valid from 23080300 to 23080312



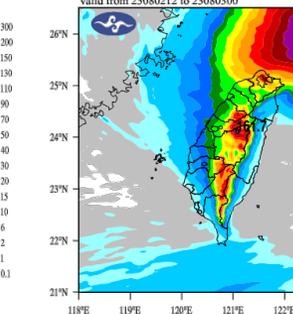
12-hr accumulated rainfall ETQPFs Valid from 23080300 to 23080312



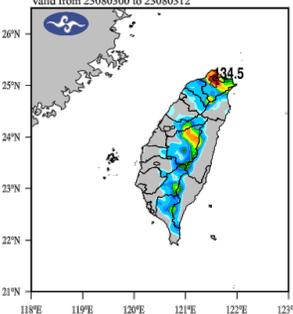
12-hr accumulated rainfall ETQPFs Valid from 23080300 to 23080312



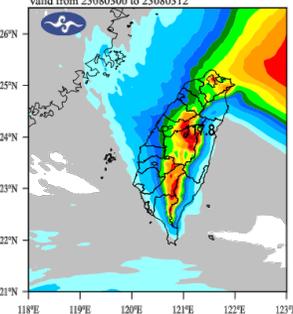
12-hr accumulated rainfall ETQPFs Valid from 23080300 to 23080312



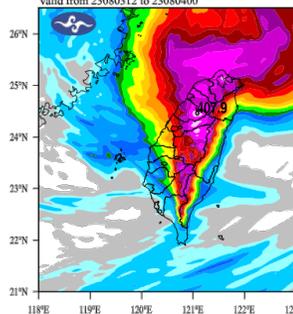
12-hr accumulated rainfall Rainguage Observation Valid from 23080312 to 23080400



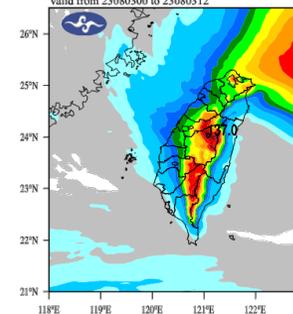
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



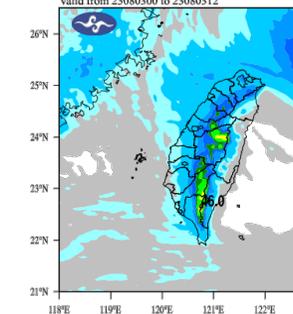
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



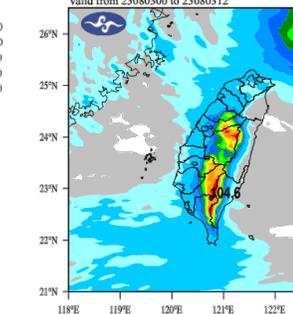
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



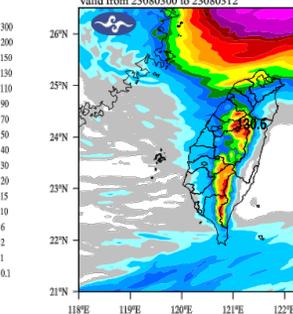
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



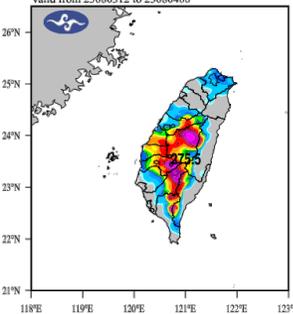
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



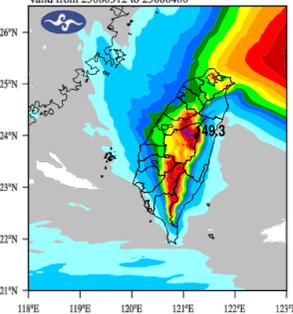
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



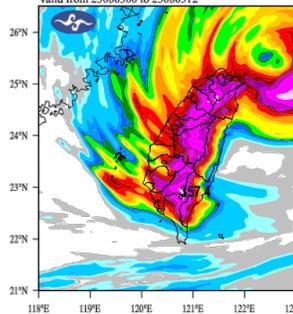
12-hr accumulated rainfall Rainguage Observation Valid from 23080312 to 23080400



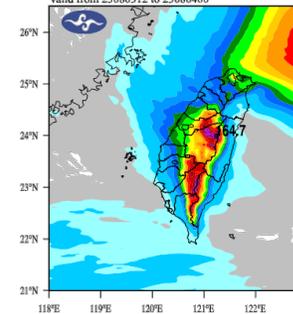
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



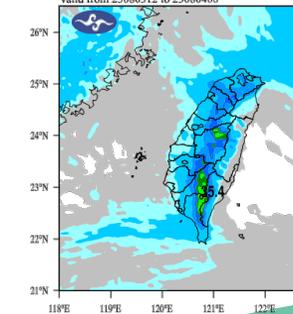
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



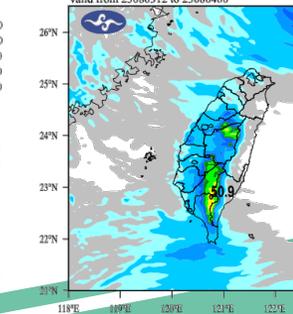
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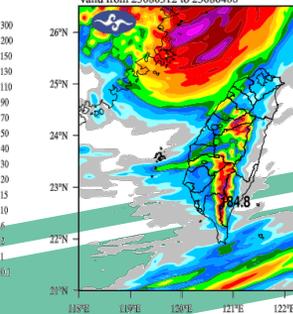
12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400



12-hr accumulated rainfall ETQPFs Valid from 23080312 to 23080400

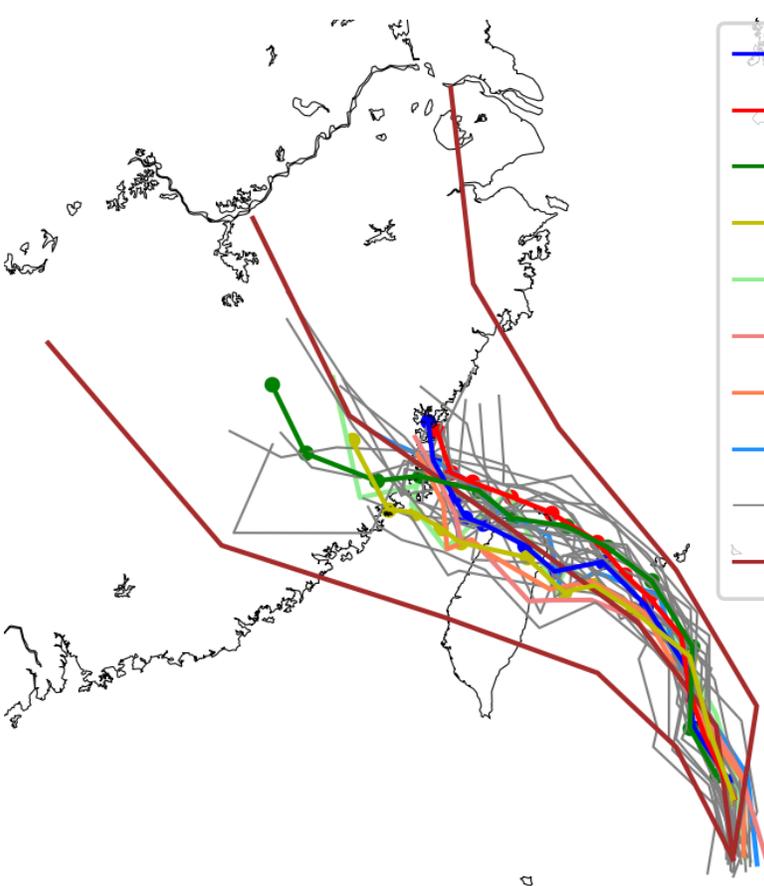


GAEMI

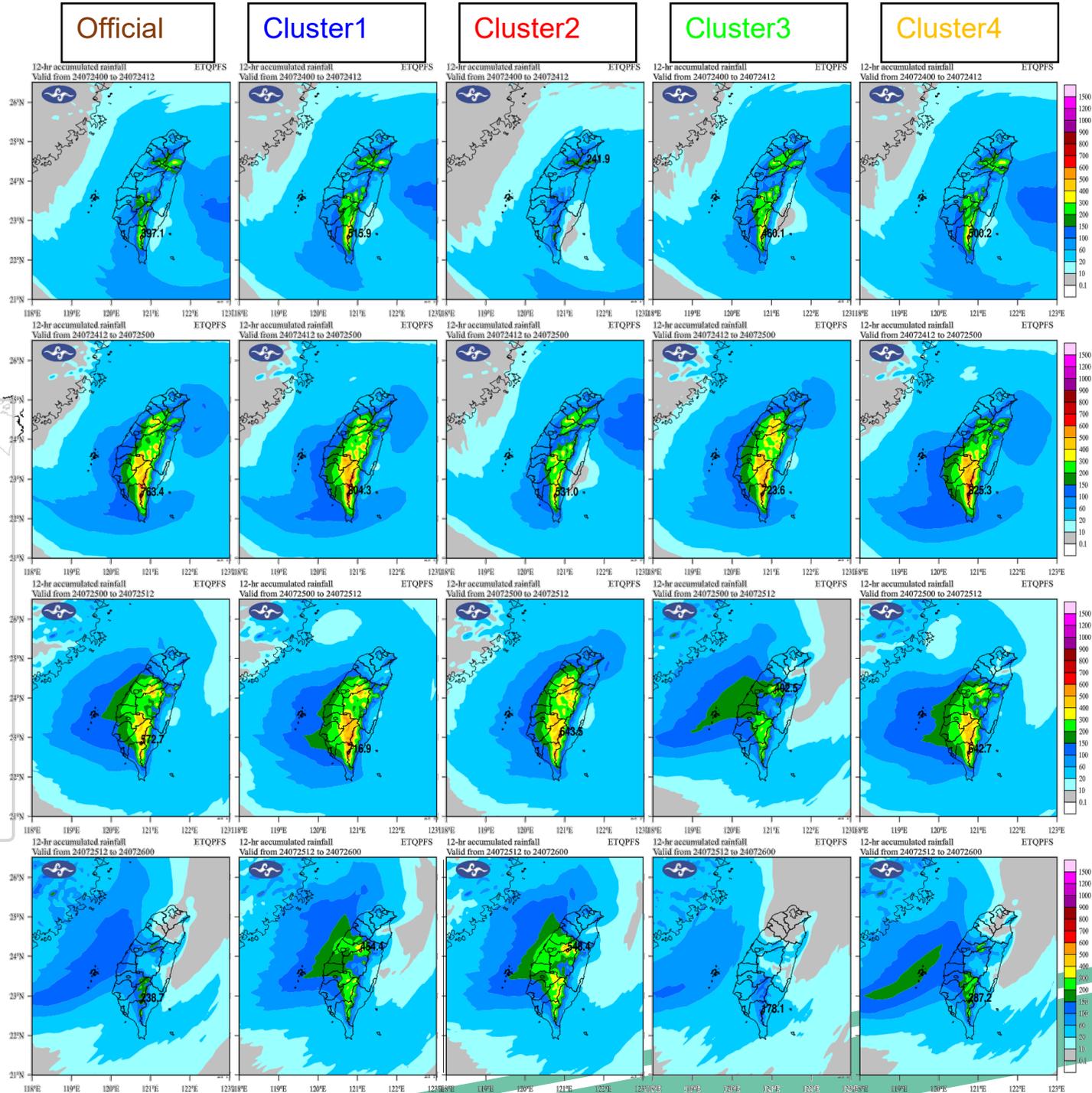
24072300 凱米

Cluster1~3在初始都是偏北，
在不同時間有往北轉折，

Official則是跟偏南Cluster4較相近。



- Cluster1(10)
- Cluster2(6)
- Cluster3(5)
- Cluster4(4)
- EC ctrl @4
- M04 @1
- M05 @1
- NCmean @1
- WEPS
- mfc-official



QPE

Official

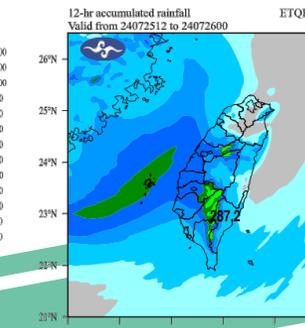
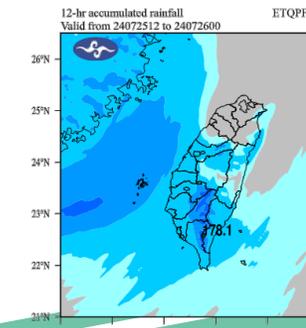
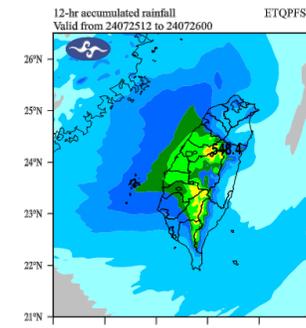
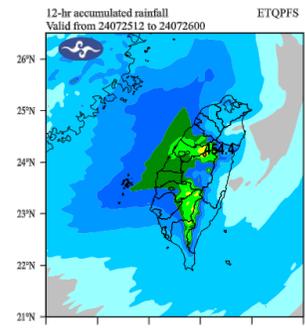
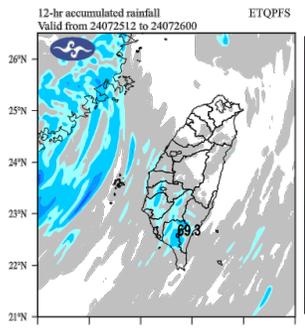
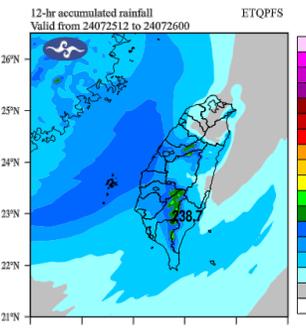
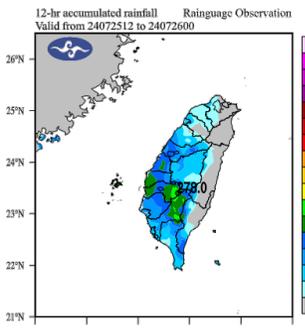
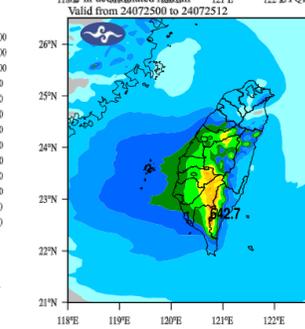
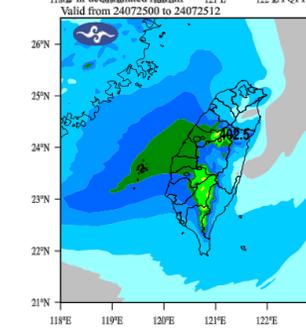
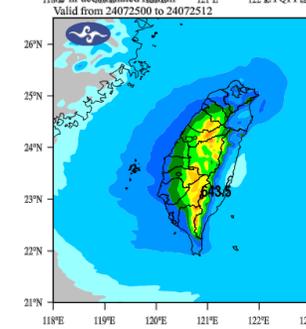
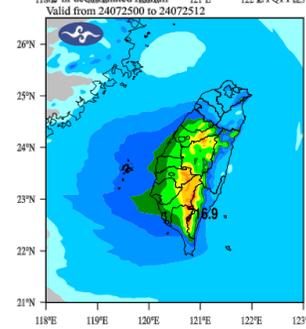
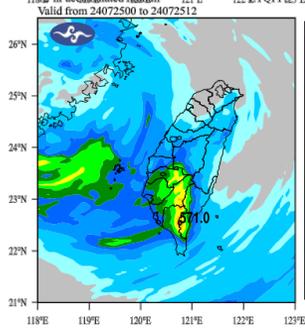
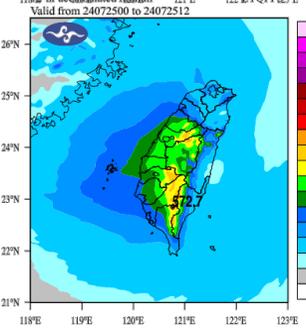
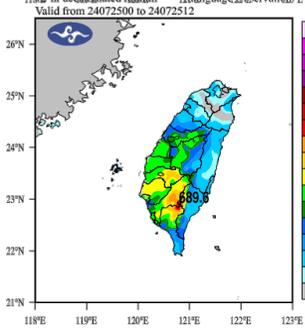
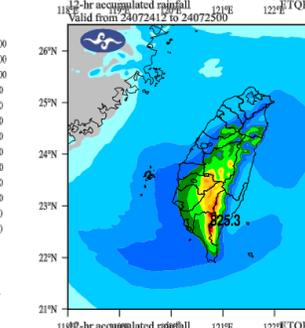
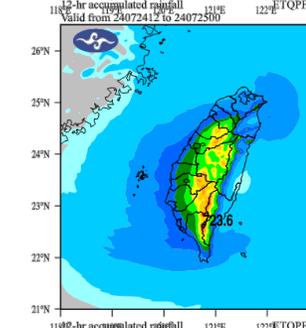
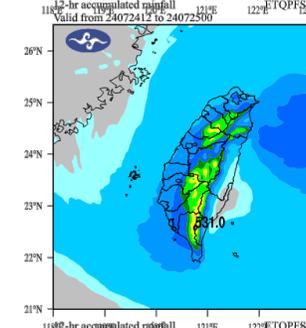
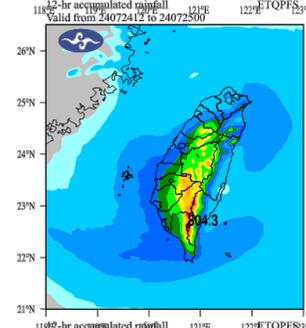
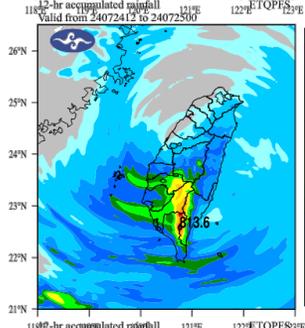
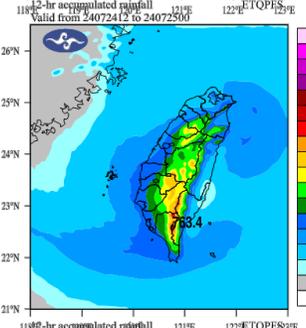
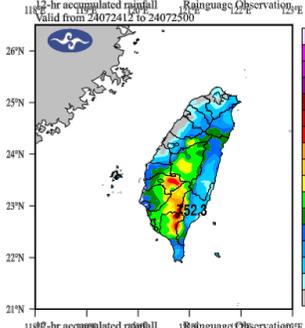
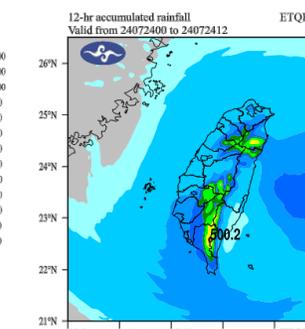
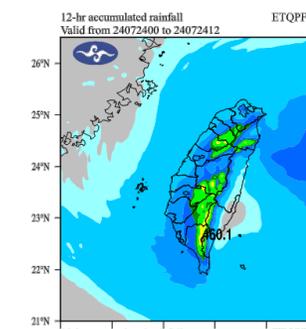
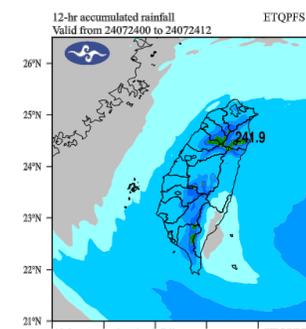
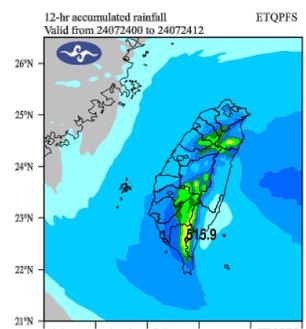
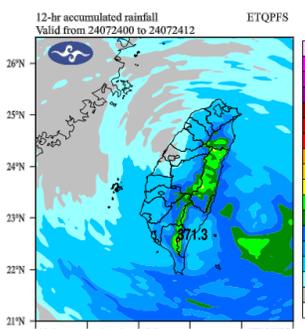
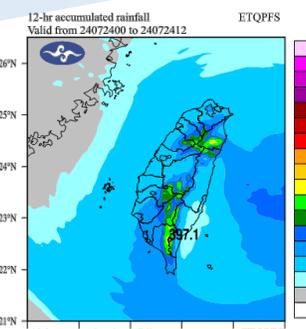
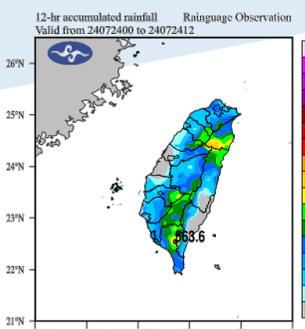
Ref1

Cluster1

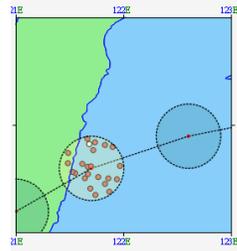
Cluster2

Cluster3

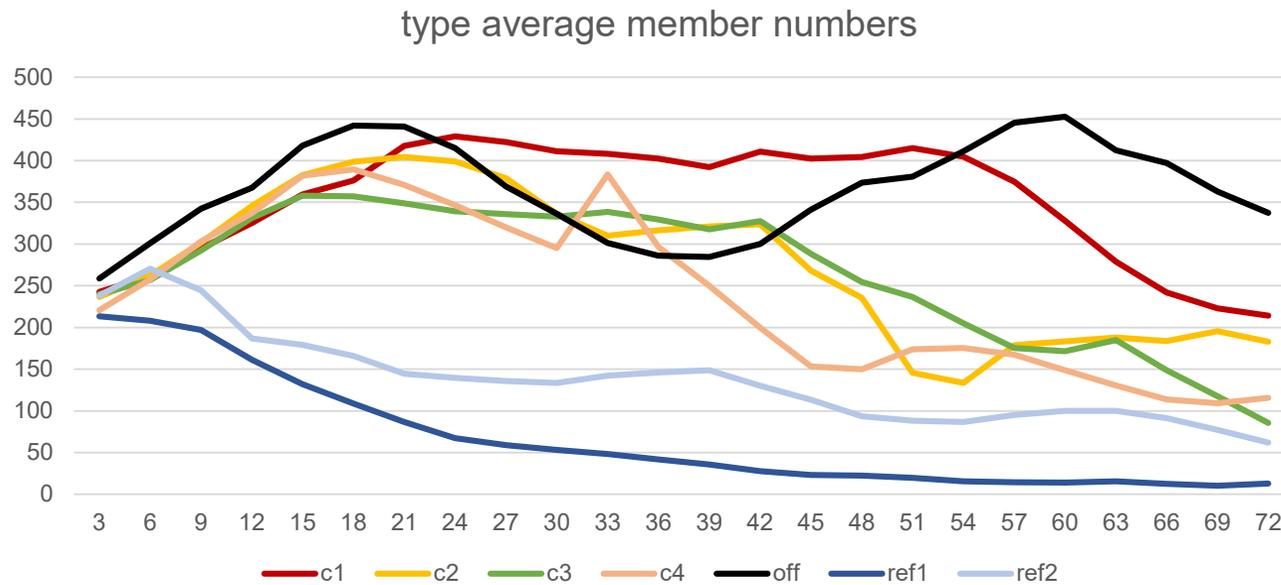
Cluster4



ETQPF篩選統計



ETQPF會進行每3小時會在路徑50KM範圍內進行篩選，篩選到越多系集成員代表該路徑之降水越有代表性

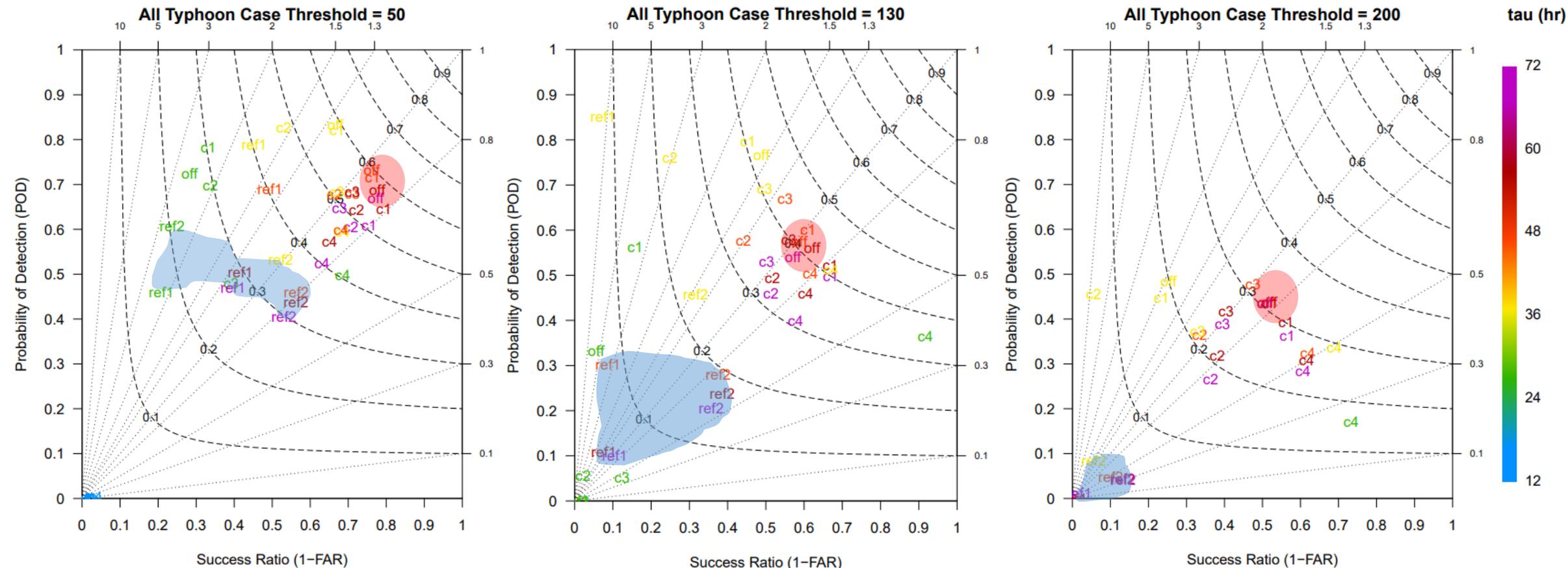


統計2023年五個颱風個案
(DOKSURI, HAIKUI, KHANUN, SAOLA, KOINU)

- 統計五個颱風個案的成員數
- 發現ref1&2(深淺藍色)的成員數都偏低，連帶影響後期的降水預報的代表性。
- 四組cluster在各個時間都維持一定的預報成員數。

Performance diagram

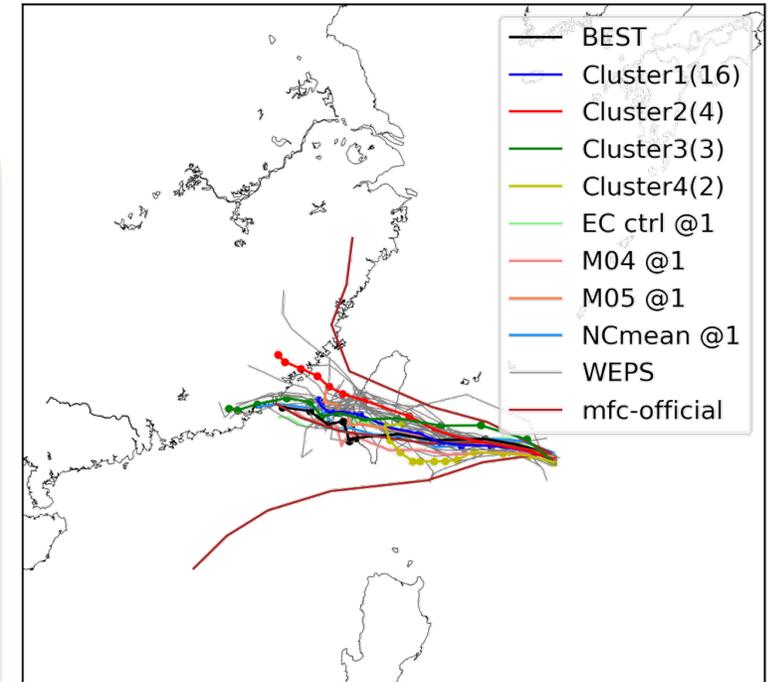
$$\text{POD} = a / (a + b)$$
$$\text{SR} = 1 - (c / (a + c))$$



- Off 路徑在多數個案中還是最有代表性
- Cluster路徑的成員皆比ref1跟ref2更有預報能力。

結論

- 本研究期望透由分群方法，客觀產製極端情境之颱風路徑預報，以取代原本偏左偏右之氣候法路徑，提供防災決策參考。
- 藉由路徑分群，能利用決定性預報在系集分群的分歧度來推測預報的不確定程度。
- 群集分析的極端路徑能改善原本氣候法偏左偏右路徑篩選不到成員的問題，且能表現不同移速的情境。
- 在降水預報的校驗上，群集分析得到的路徑亦會較氣候法路徑更有機會掌握偏離預報的極端情境降水。





Thanks for your attention



