

Central Weather Administration

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AI/ML模型對凱米颱風預報結果分析

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113年天氣分析與預報研討會
凱米颱風氣象與災防特輯

AI/ML模型

監測
0小時

即時預報
0-1小時

極短期
0-6小時

短期
1-3日

短中期
3-7日

中期
7-15日

中長期(月)
15-30日

季
30-90日

年、代、際
~

0小時	0-1小時	0-6小時	1-3日	3-7日	7-15日	15-30日	30-90日	~
MetNet-3 (Andrychowicz et al., 2023)	AIFS (ECMWF, 2023)	Pangu-Weather (華為, 2022)	FuXi-S2S (Chen et al., 2023)	ClimaX (Nguyen et al., 2023)				
Nowcasnet (Zhang et al., 2023)	Conformer (Saleem et al., 2024)	GraphCast (DeepMind, 2022)	ChaosBench (Nathaniel et al., 2024)	ACE (Watt-Meyer et al., 2023)				
Prediff (Gao et al., 2023)	KARINA (Cheon et al., 2024)	FourCastNet v1, v2 (NVIDIA, 2023)		Neural GCM (Kochkov et al., 2023)				
Diffcast (Yu et al., 2023)	Aardvark (Vaughan et al., 2024)	FuXi (上海復旦大學, 2023)						
SCAN (Pan et al., 2024)	HEAL-ViT (Ramavajjala 2024)	FengWu (上海AI實驗室, 2023)						
CastCast (Gong et al., 2024)	Neural-LAM (Oskarsson et al., 2023)	FengWu-GHR (上海AI實驗室, 2024)						
	YingLong (Xu et al., 2023)	ExtremeCast (上海AI實驗室, 2024)						
	Zhiji (深圳氣象局及華為, 2024)	Aurora (Microsoft, 2024)						

*A7-2 劉正欽等

CWA AI/ML模型介紹

模型名稱*	訓練資料長度 (年)	氣象變數		採用模型 (參數量)
		垂直層	單一層	
Pangu-Weather	1979-2017 (39)	(z、t、q、u、v) ⁺	t2, u10, v10, mslp	Transformer (7.4億)
GraphCast	1979-2015 (37)	(z、t、q、u、v、w) [#]	t2,u10,v10,mslp,tp	圖神經網路 (0.6億)
FourcastNet v2	1979-2015 (37)	(z、t、rh、u、v) ⁺	t2, u10, v10, sp, mslp, tcwv, u100,v100	Transformer (4.3億)
FuXi	1979-2015 (37)	(z、t、rh、u、v) ⁺	t2,u10,v10,mslp,tp	Transformer (15.5億)
FengWu	1979-2015 (37)	(z、t、q、u、v) [#]	t2,u10,v10,mslp	Transformer (7.5億)

⁺50, 100, 150, 200, 250, 300, 400, 500, 600, 700, 850, 925, and 1000 hPa

[#]1, 2, 3, 5, 7, 10, 20, 30, 50, 70, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 775, 800, 825, 850, 875, 900, 925, 950, 975, 1000 hPa

註：GraphCast使用的是垂直層數13層的作業版本、FengWu使用的是僅開源的垂直層數13層版本

水平解析度**0.25°**，垂直層數**13層**

CWA AI/ML模型計算時間

氣象署FX1000 GPU(A100)

單位: 分鐘

模型名稱	資料前處理 (變數量)	預報	輸出	共計
Pangu-Weather	3 (69)	2	2	7
GraphCast	6 (83)	4	2	12
FourcastNet v2	3 (73)	1	2	6
FuXi	3 (70)	3	2	8
FengWu	3 (69)	2	2	7

今年Q1平行作業，每日預報4次(00, 06, 12, 18 UTC)，每次預報10天(預報間隔6小時)

CWA AI/ML模型介紹

- AI/ML模式中**最早8天前**可預報凱米颱風侵台(以EC為初始場)
24071600 +192h fcst

AI/ML模型(15個)

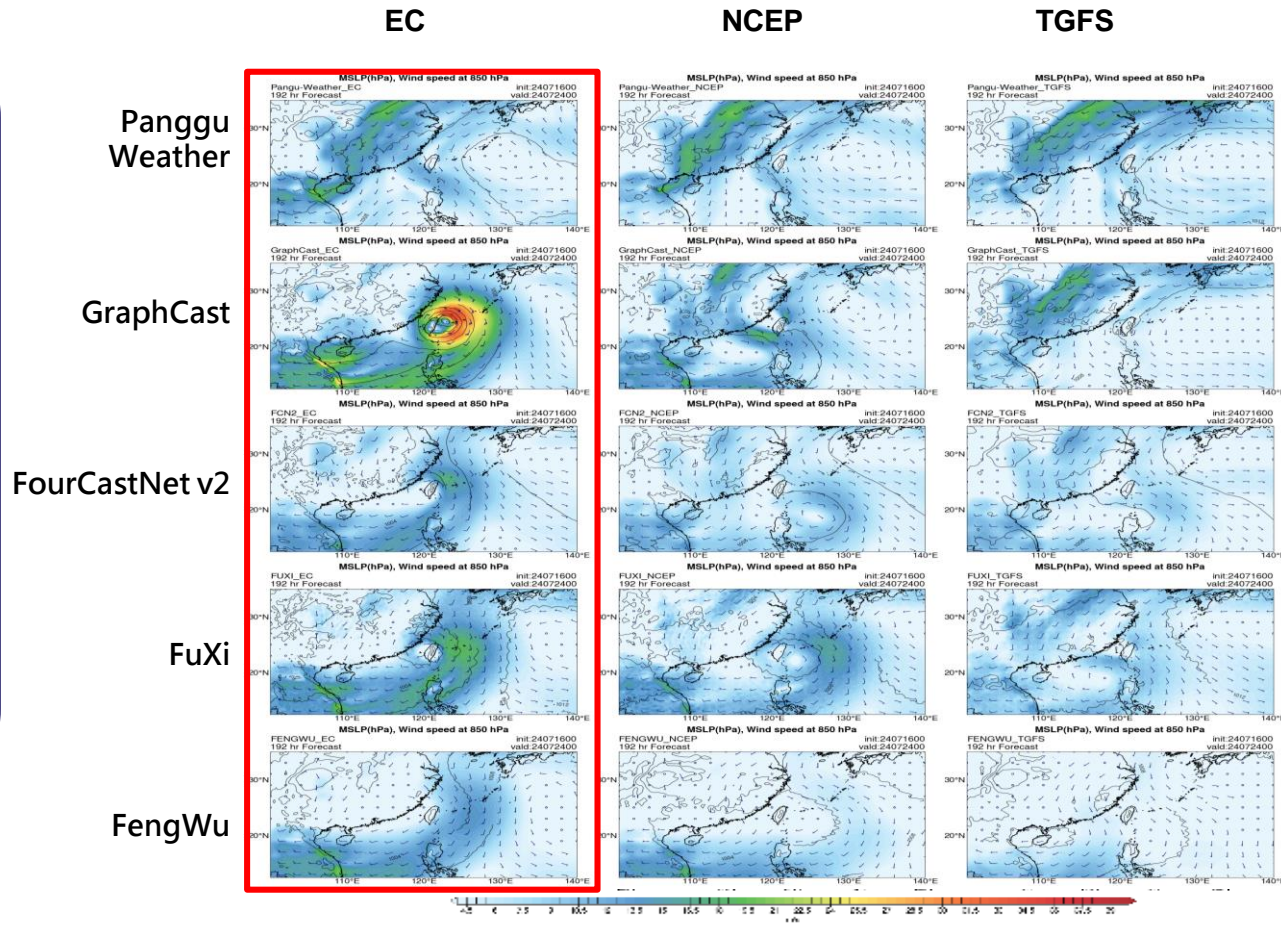
3個初始場

- NCEP GFS
- EC IFS
- CWA TGFS*
*A2-16 ~ A2-20

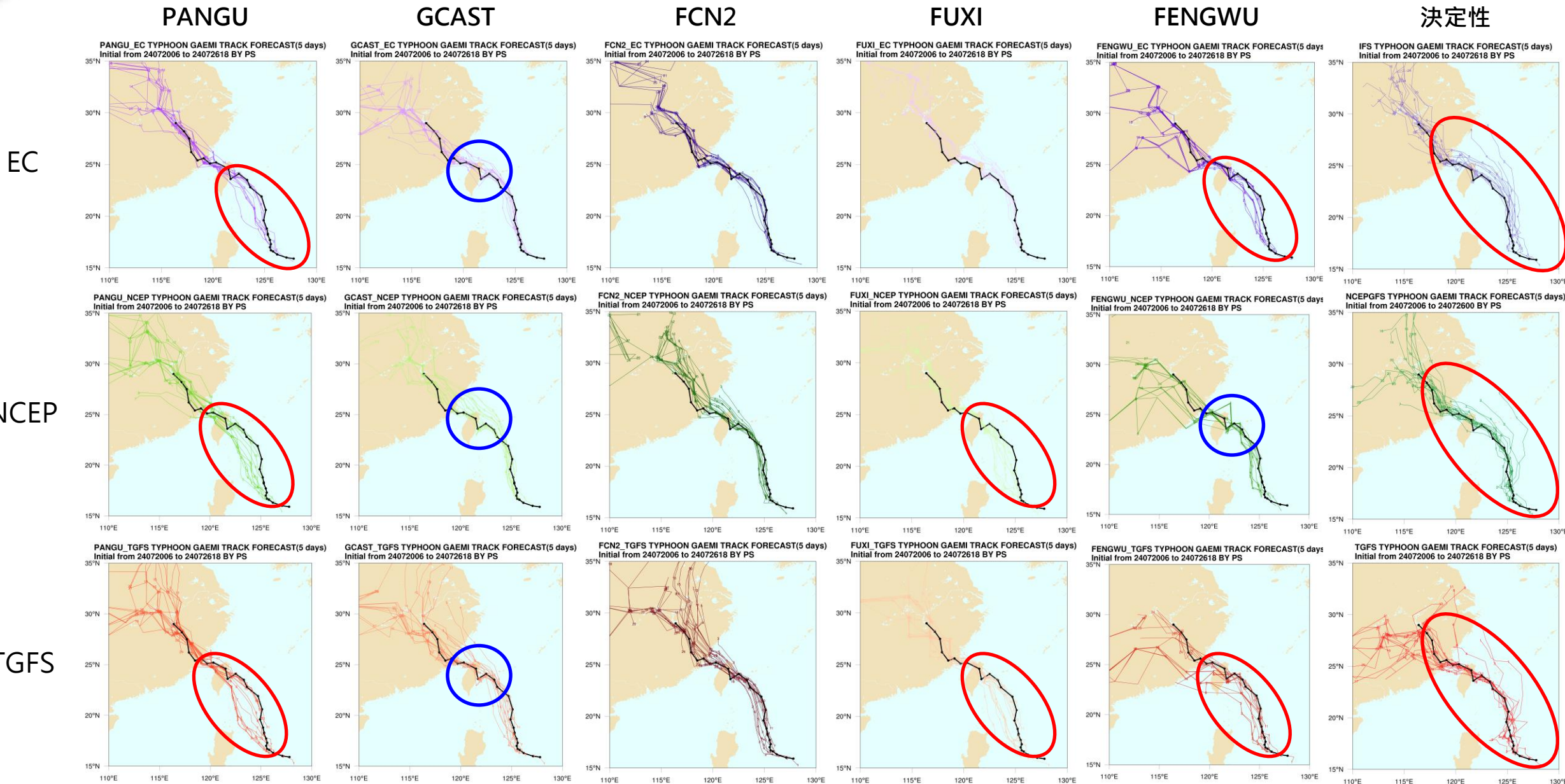
+

5種模型

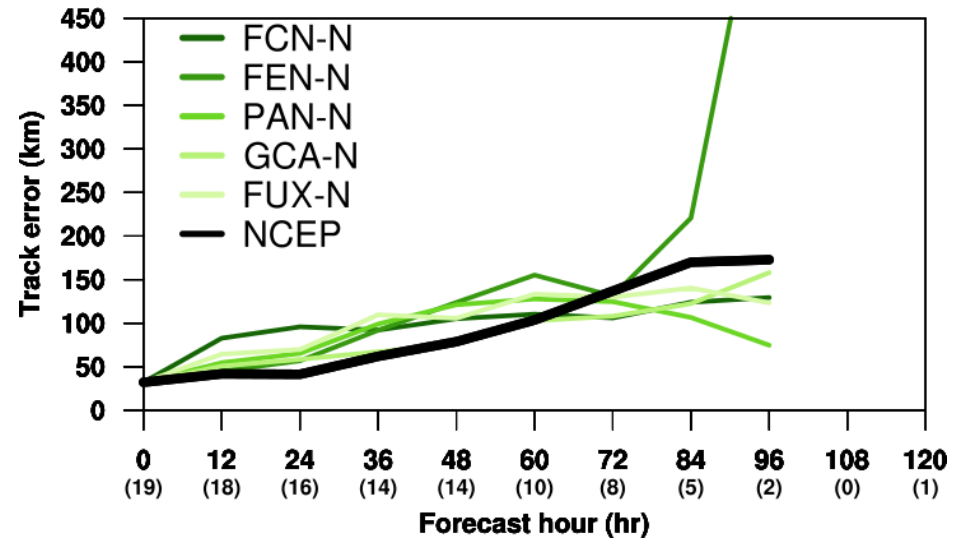
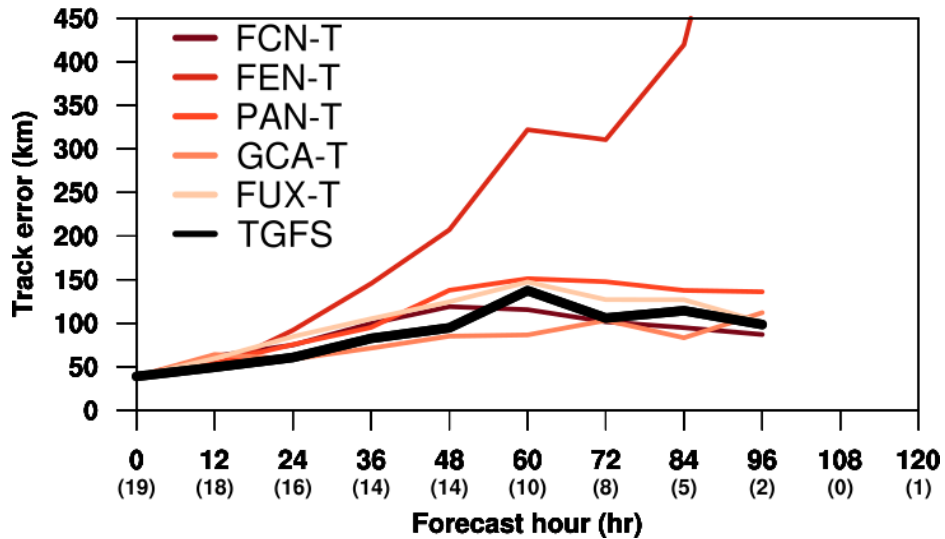
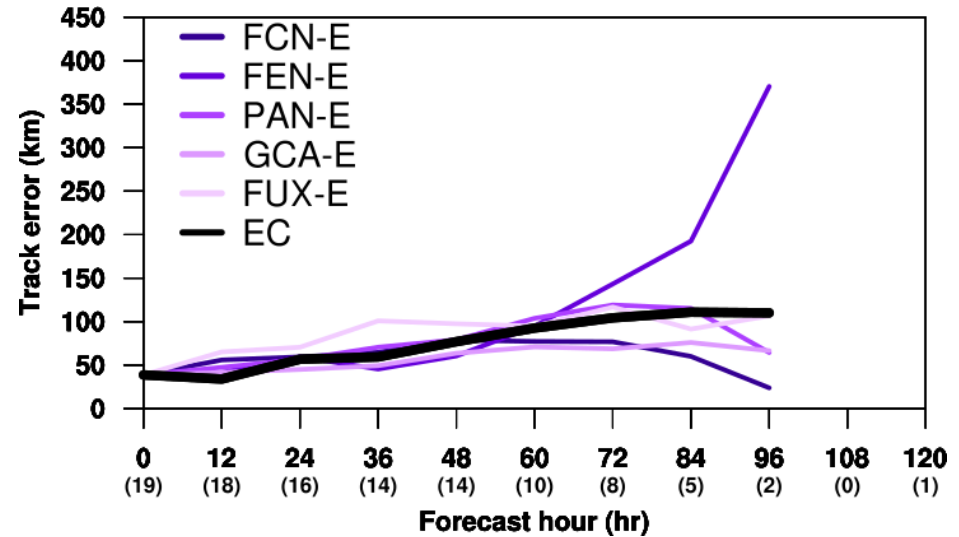
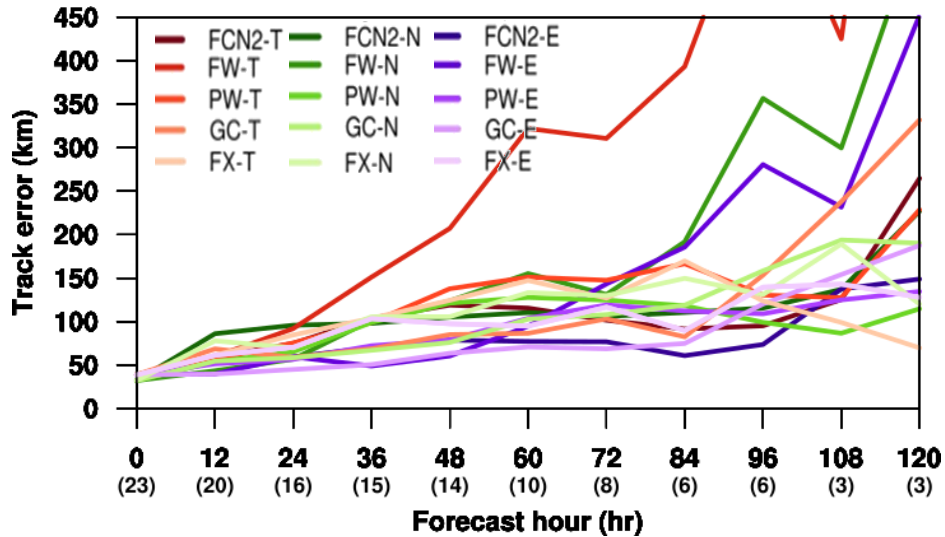
- Pangu-Weather
- GraphCast
- FourcastNet v2
- FuXi
- FengWu



CWA AI/ML模型 凱米颱風路徑預報 (24072006~24072618)



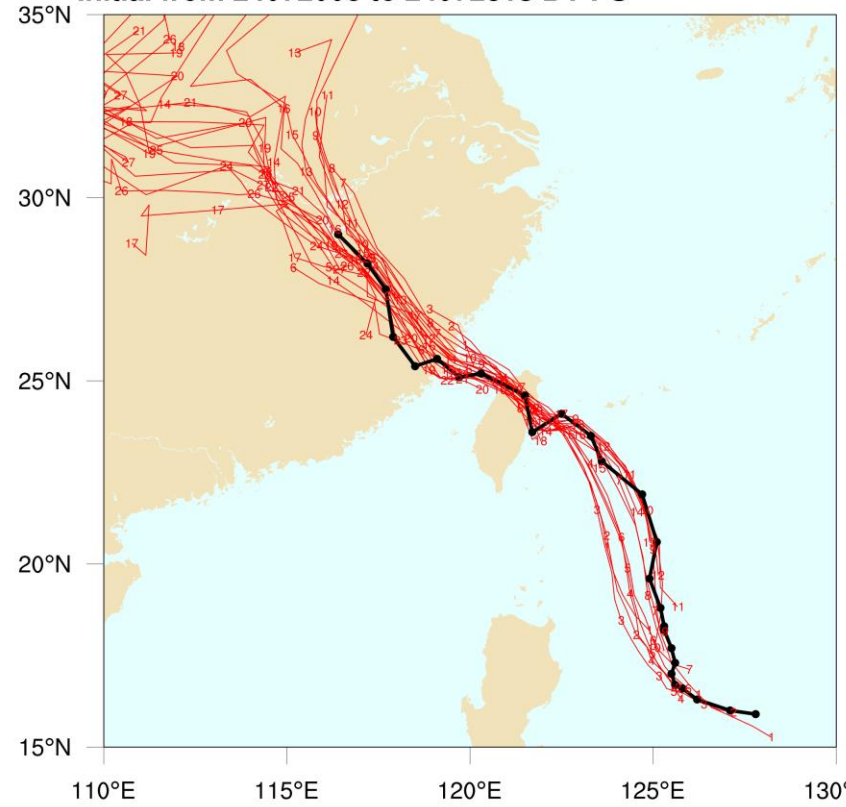
CWA AI/ML模型 凱米颱風路徑預報誤差



CWA AI/ML模型 凱米颱風路徑預報

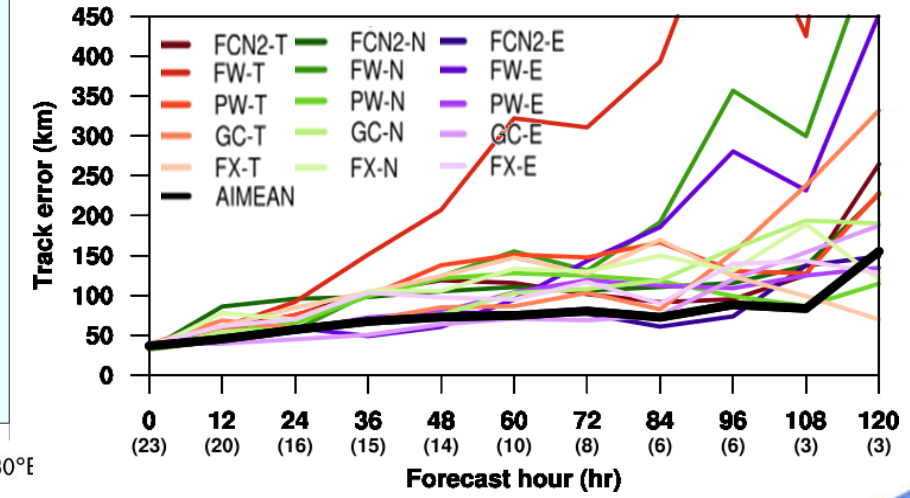
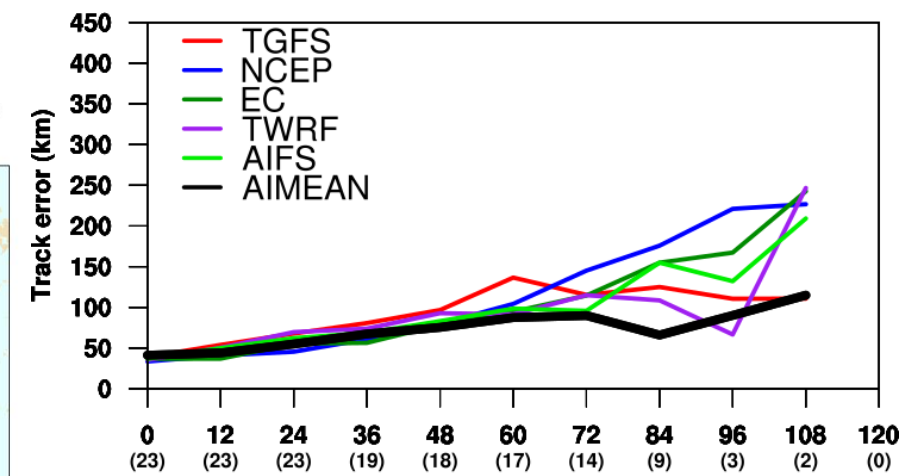
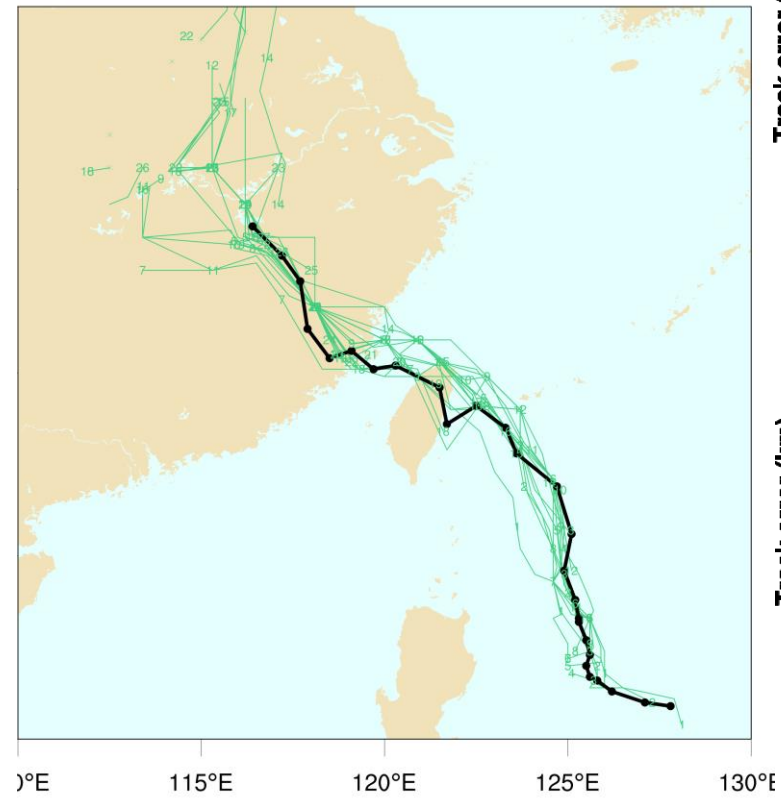
AIMEAN

AIML_ENS TYPHOON GAEMI TRACK FORECAST(5 days)
Initial from 24072006 to 24072618 BY PS



AIFS

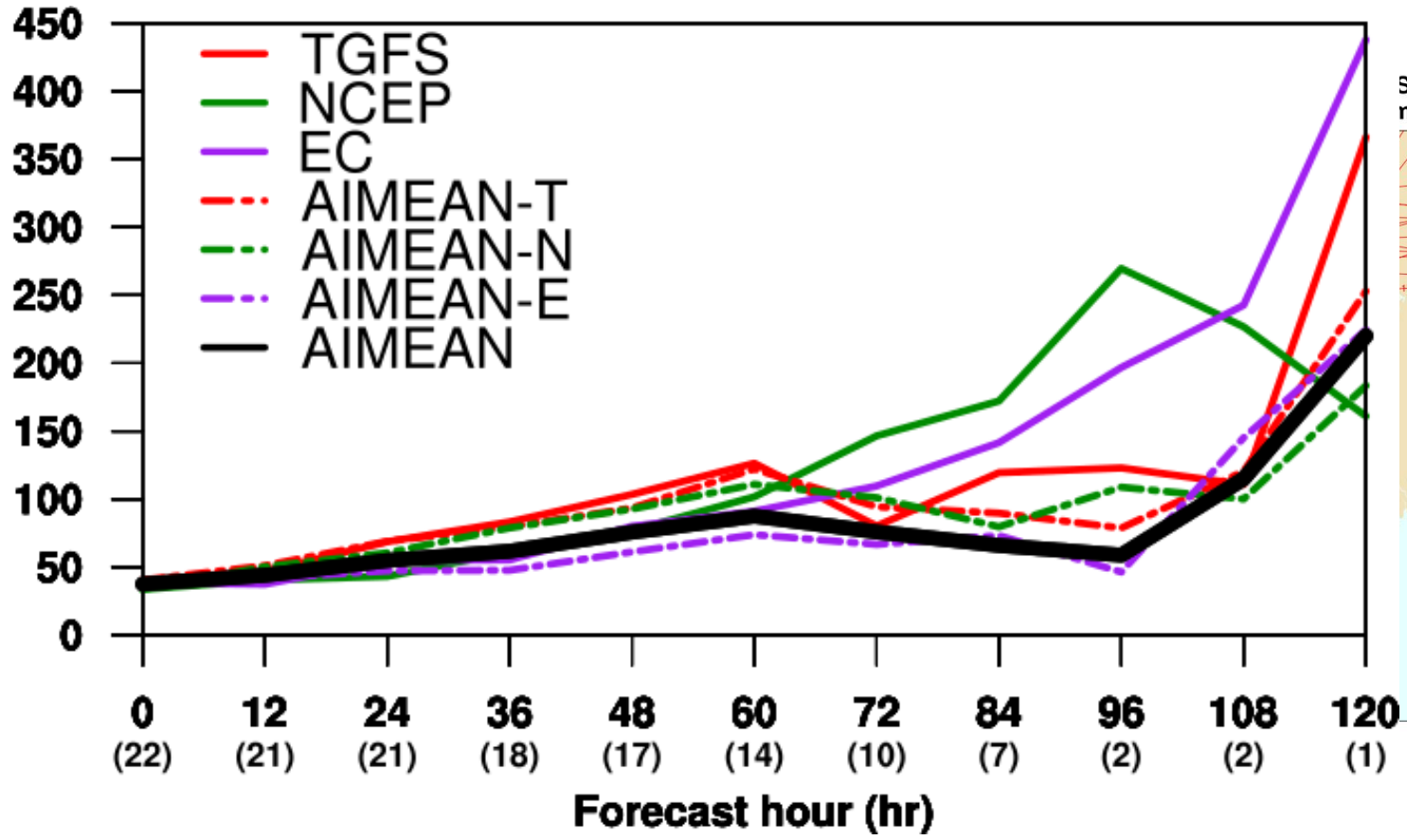
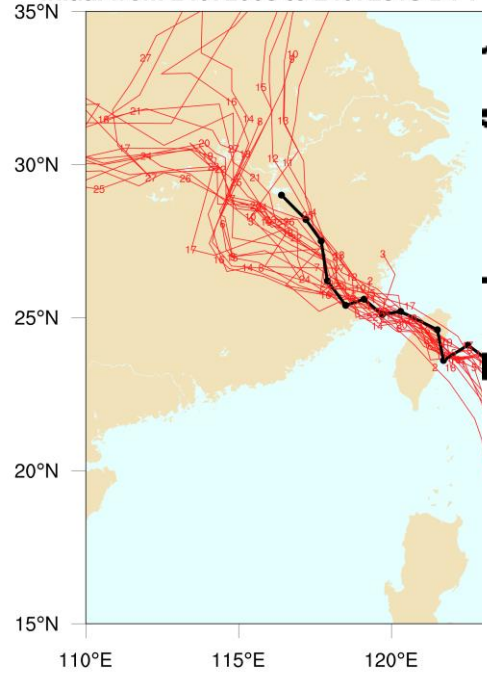
AIFS TYPHOON GAEMI TRACK FORECAST(5 days)
Initial from 24072006 to 24072618 BY PS



CWA AI/ML模型初始場系集平均

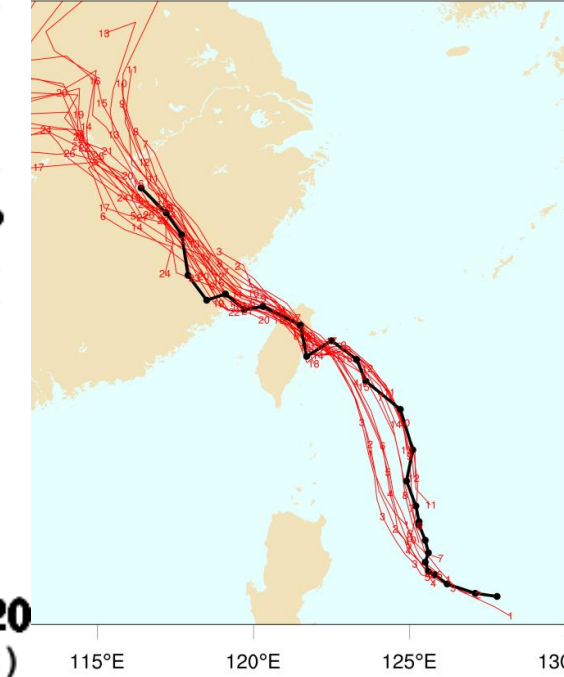
AIMEAN-TG

AIMEAN-TGFS TYPHOON GAEMI TRACK
Initial from 24072006 to 24072618 BY P

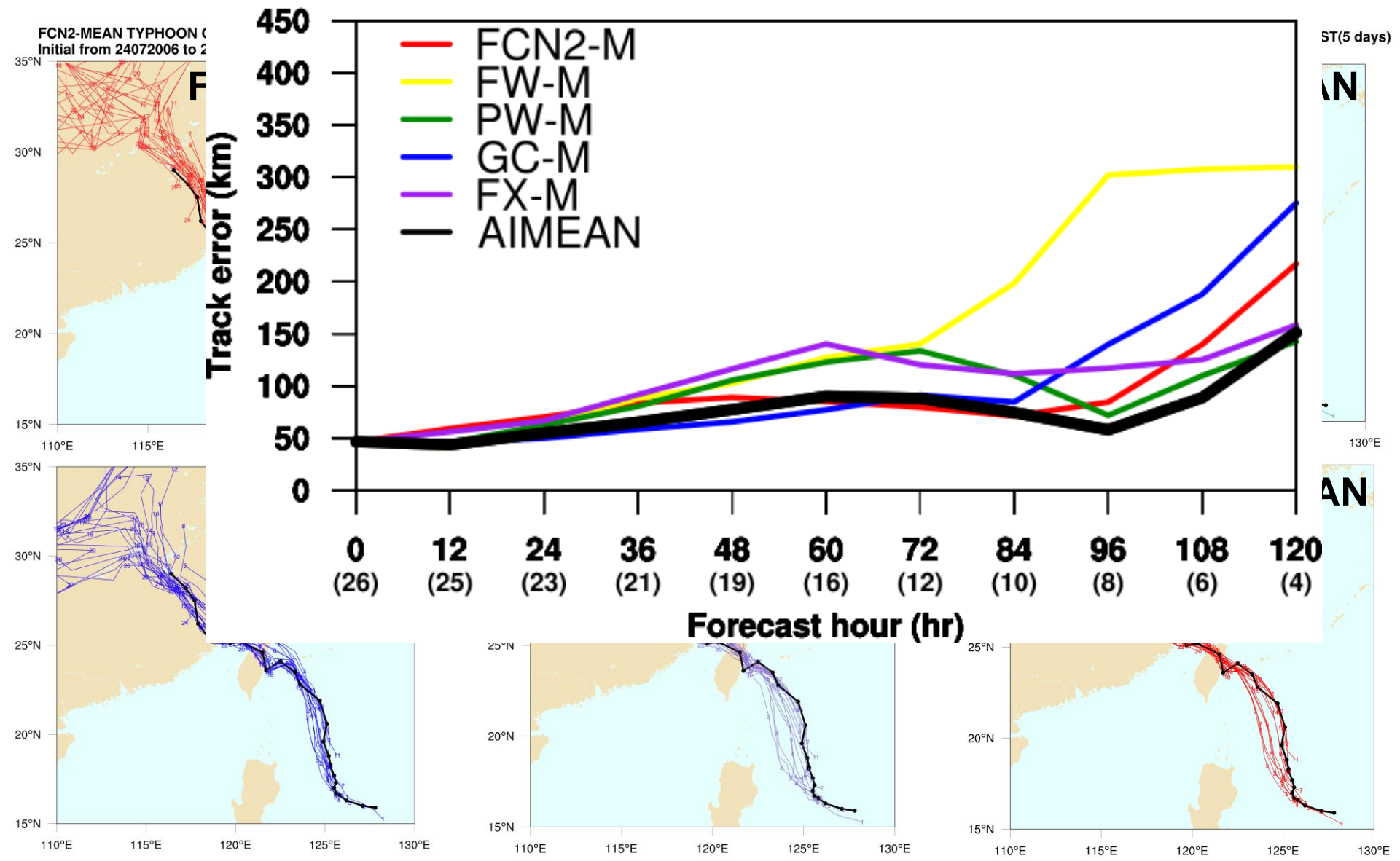


AIMEAN

S TYPHOON GAEMI TRACK FORECAST(5 days)
Initial from 24072006 to 24072618 BY PS

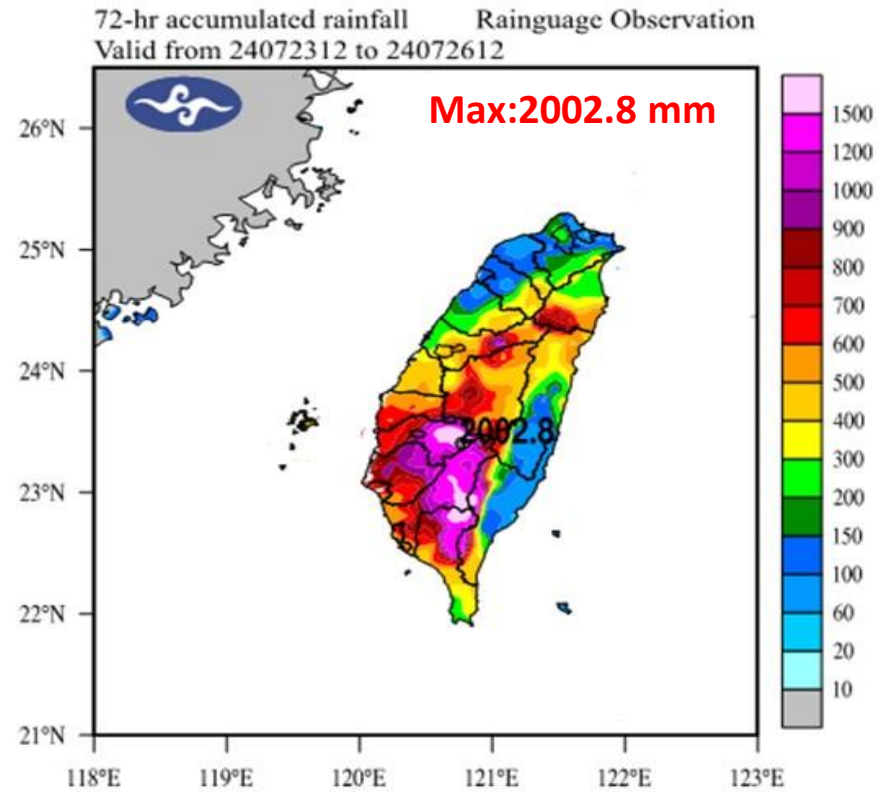


CWA AI/ML各模型系集平均

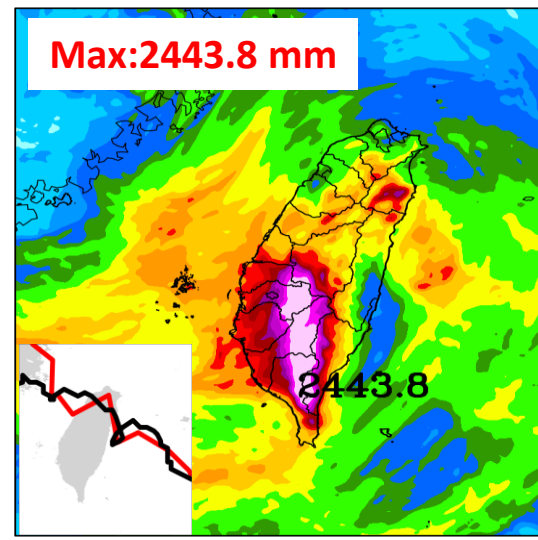


凱米颱風雨量預報 (24072312 72小時累積雨量)

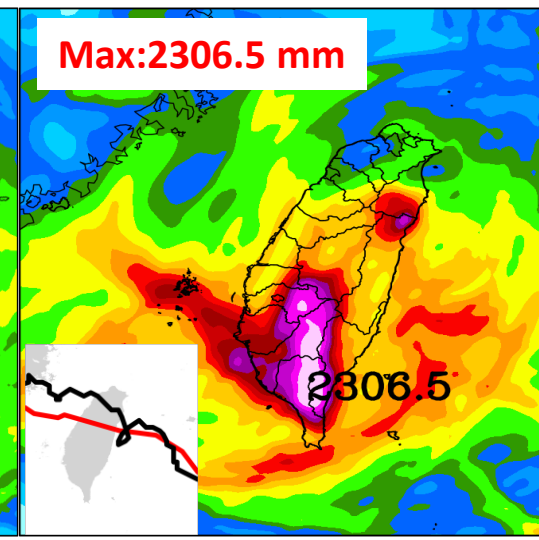
OBS



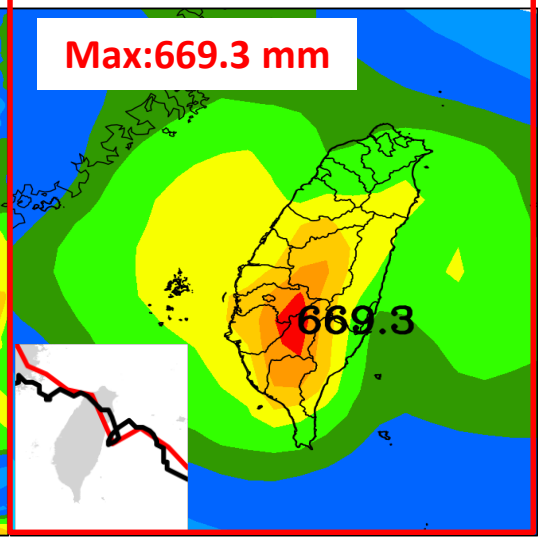
TWRF



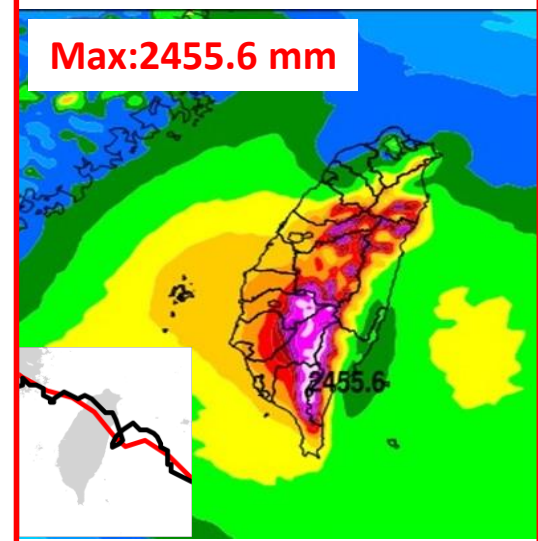
TGFS-nest



GRAPHCAST-EC



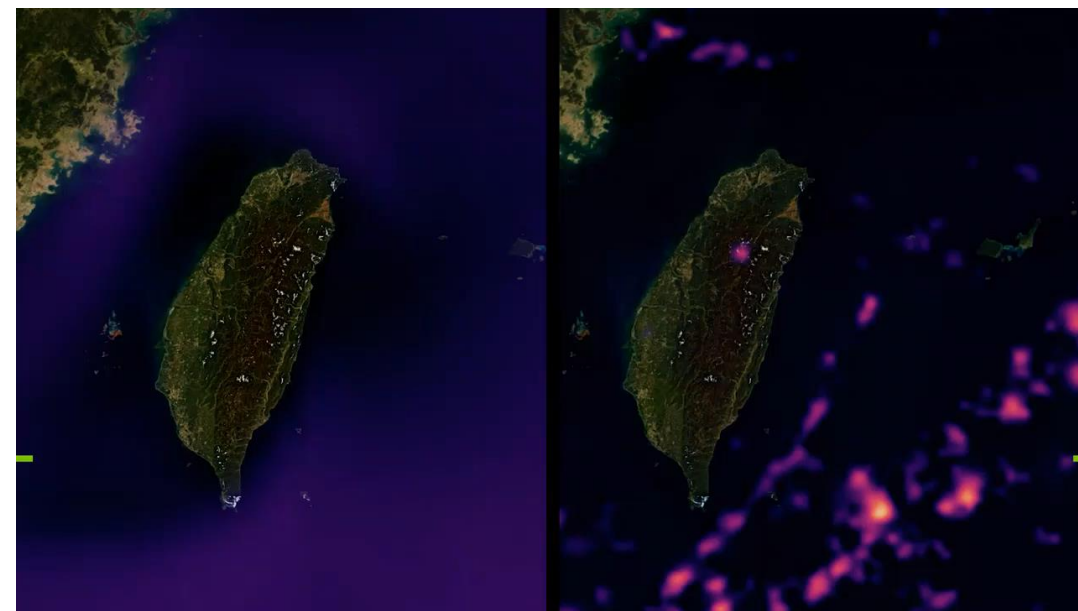
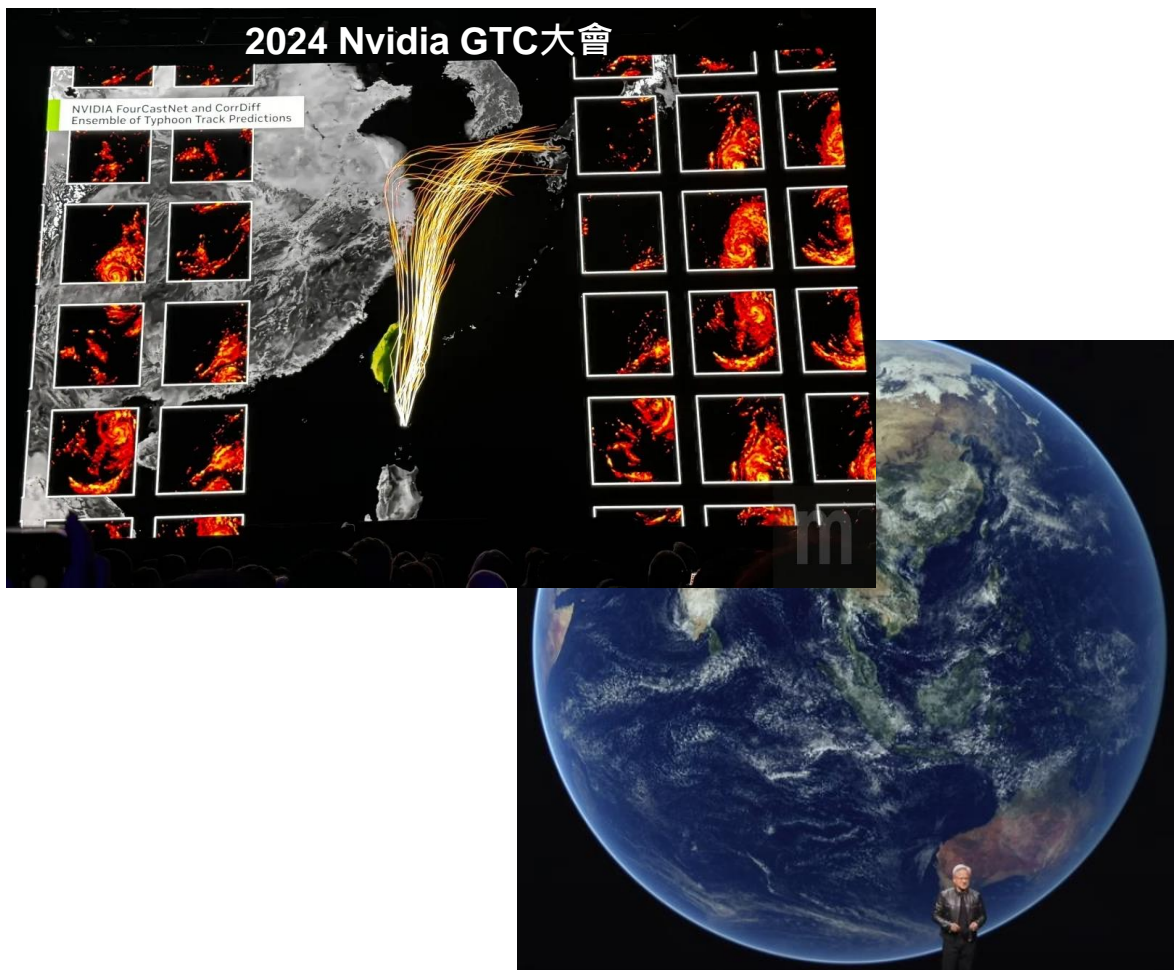
ETQPF



CWA與NVIDIA合作發展CorrDiff

Corrector Diffusion (CorrDiff)

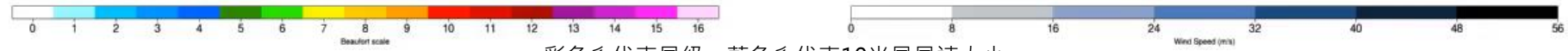
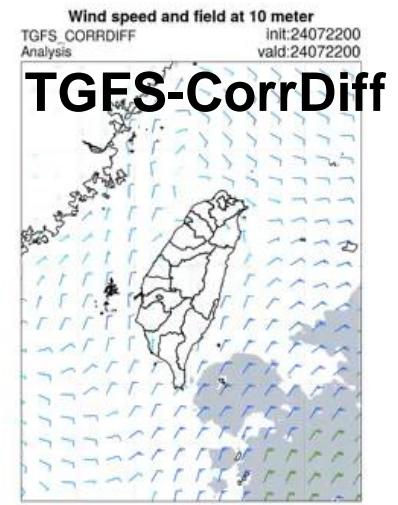
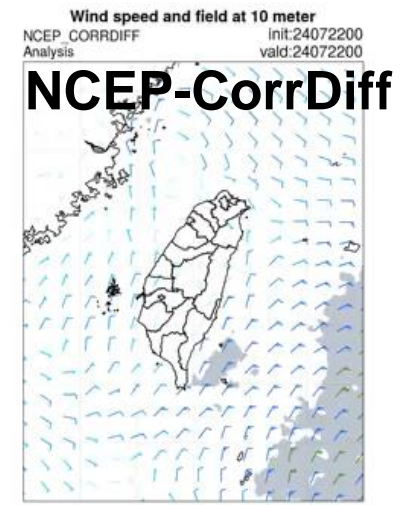
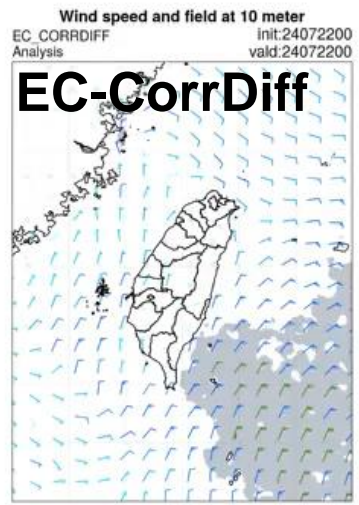
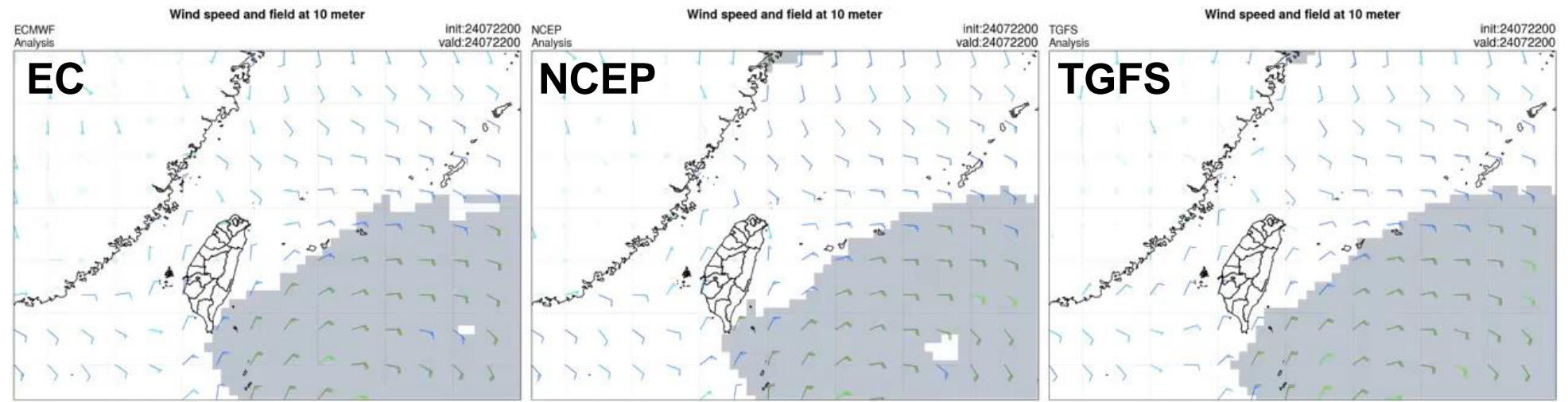
氣象署提供4年的2公里解析度數值模式分析資料 (RWRF)，與NVIDIA合作發展CorrDiff 的AI降尺度技術，將全球模式25公里資料解析度提升為2公里*。



可產生符合物理認知的二維氣象場型態
如：颱風眼牆附近的小範圍軸對稱高風速結構

*目前使用變數：最大雷達回波、地面氣溫與地面風

凱米颱風CorrDiff初步測試(24072200 0~84小時10米風預報)



彩色系代表風級；藍色系代表10米風風速大小

CorrDiff降尺度結果明顯強化颱風結構及臺灣海峽風速

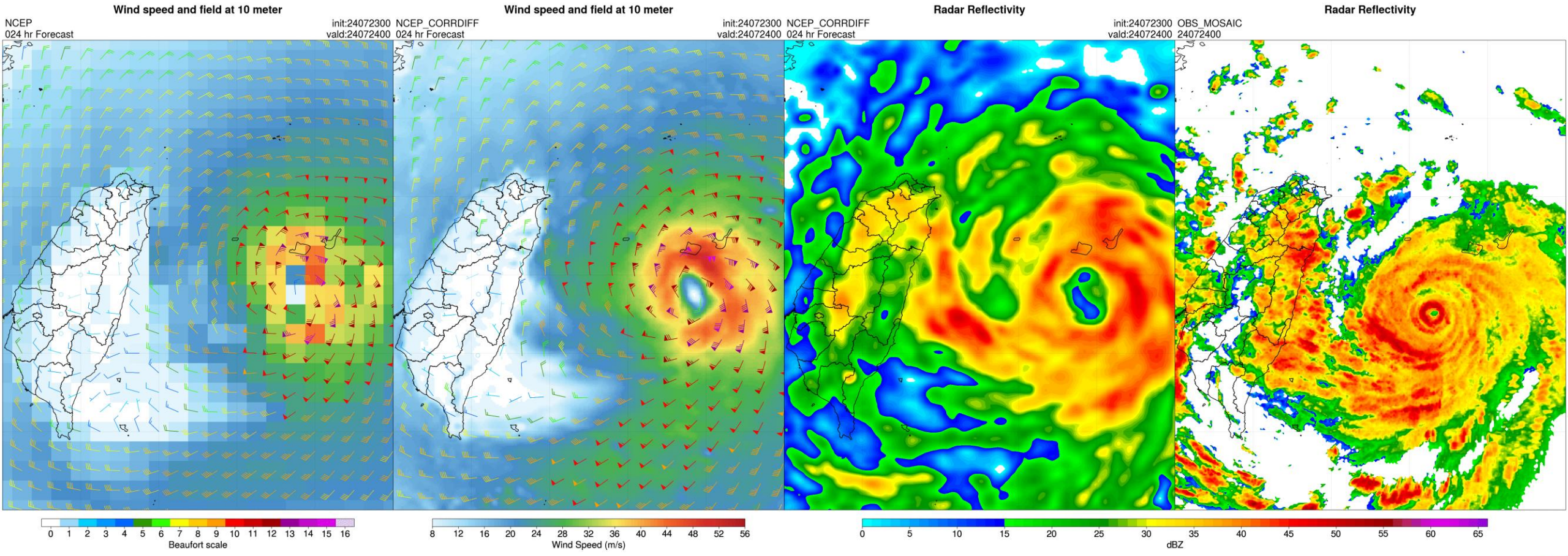
凱米颱風CorrDiff初步測試(24072300 24~48小時預報)

NCEP 10米風場

NCEP-CorrDiff 10米風場

NCEP-CorrDiff 最大回波

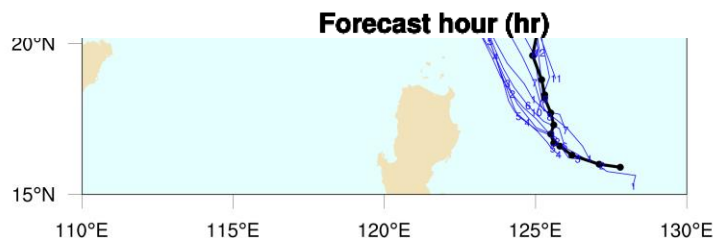
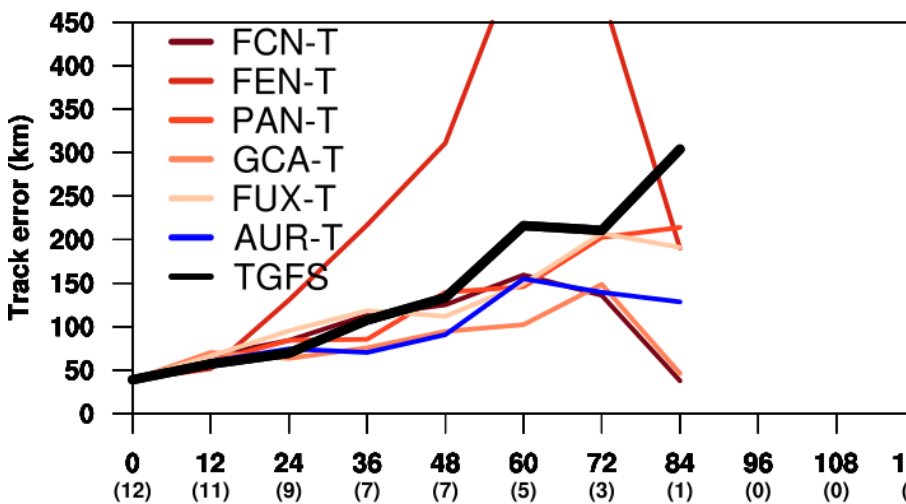
MOSAIC



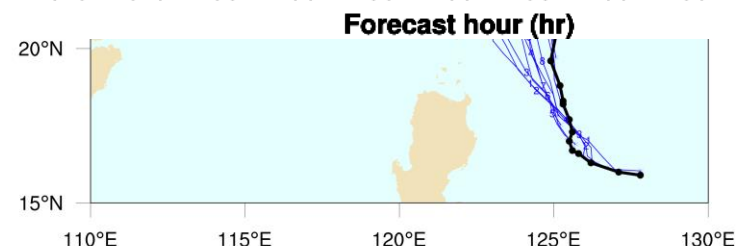
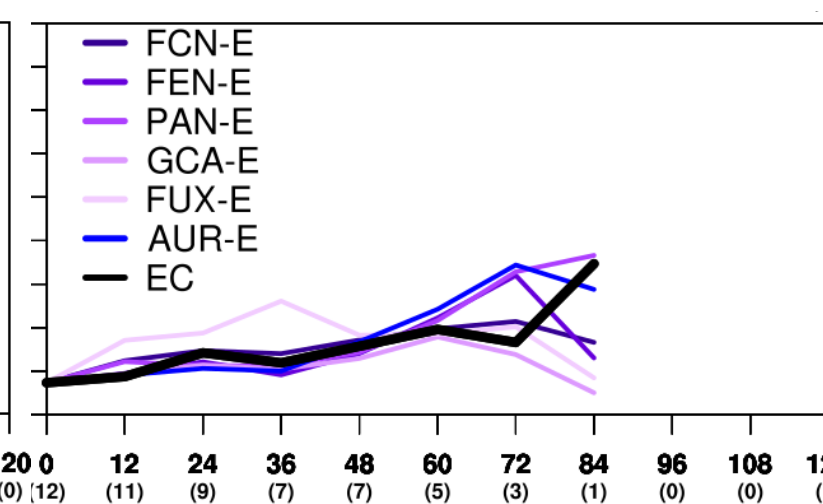
此個案經CorrDiff降尺度後，凱米颱風登陸前出現打轉之路徑預報

Microsoft Aurora模型凱米颱風路徑預報

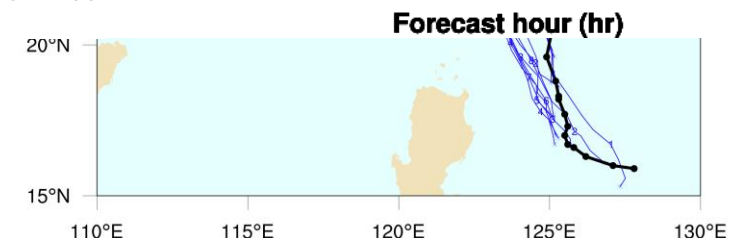
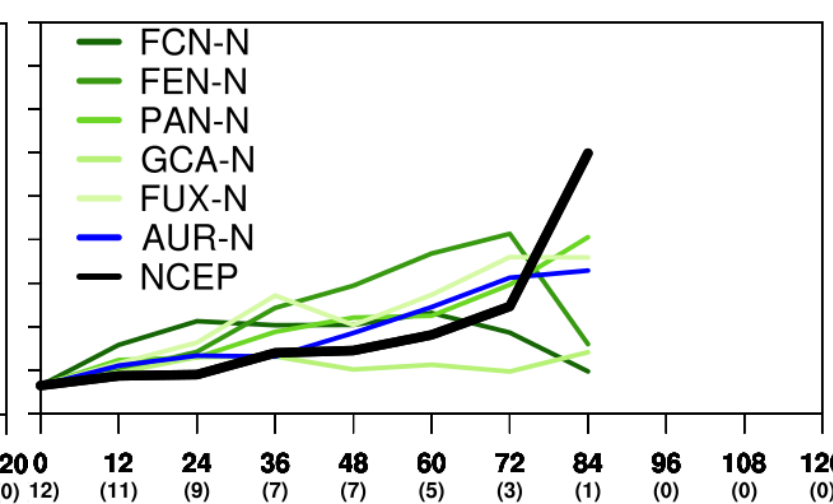
TGFS



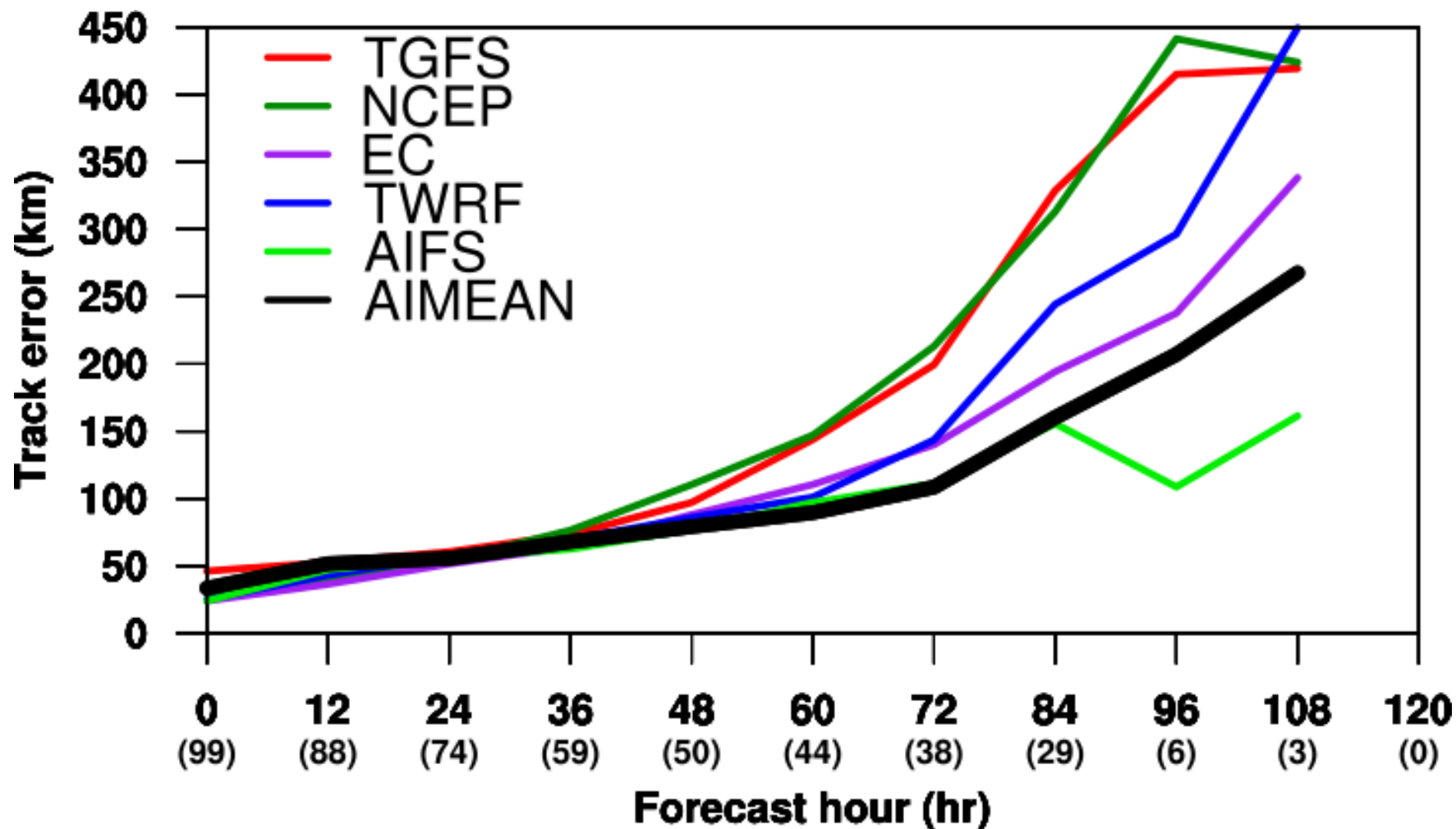
EC



NCEP



AI/ML模型 (2024年凱米颱風 ~ 珊珊颱風)



AI/ML天氣預報模型總結

目前可做到

- ✓ 快速提供準確的凱米颱風路徑預報
- ✓ 最早8天前可預報凱米颱風侵臺
- ✓ 利用ETQPF提供雨量預報 (需靠近臺灣)
- ✓ AI/ML 系集預報 (A7-4 趙子瑩等)

有待改善

- 強度預報
- 雨量預報
- 細緻的地形效應

未來可做

- CorrDiff 2.0 (更多變數，如海平面氣壓、2米濕度、雨量等)
- 臺灣高解析AI天氣預報模型 (A7-1 台大團隊)
- AI/ML天氣預報模型選取策略(初始場與AI/ML模型)