



TWRF 颱風數值預報系統提高解析度 對颱風預報之效應

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中央氣象署科技發展組



大綱

1. TWRF模式現況介紹
2. 模式解析度提升至10/2km之影響評估
3. 颱風降雨個案
4. 總結及未來工作

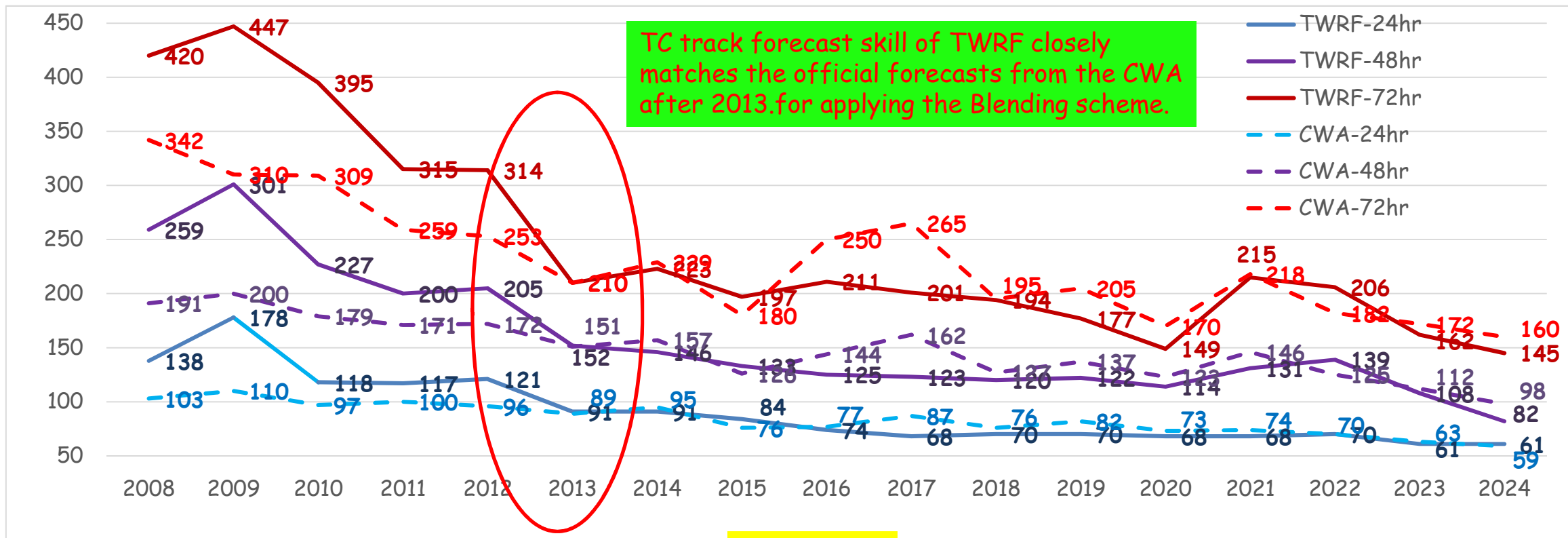
Comparison between TWRF & CWA for the TC Track Forecast Errors

WRF(2008-2009)

TWRF V1(2010-2015)

TWRF V2(2016-2024)

Track mean forecast errors (km)



TC track forecast skill of TWRF closely matches the official forecasts from the CWA after 2013 for applying the Blending scheme.

WRF Operation

TC bogus

Partial cycling
Outer loop
New trigger KF

Blending
45km(2013) →→
45/15km(2014)

Two-way interaction

TWRF V2
→15/3km
CLS of Blending
300km

WRF_V3.3.1
→ V3.8.1

3DVAR→
Hybrid 3DVAR

FV3 GFS

LBC 29→
45 layers

Update SST
Hybrid ICBC
by EC+NCEP

TC Relocation

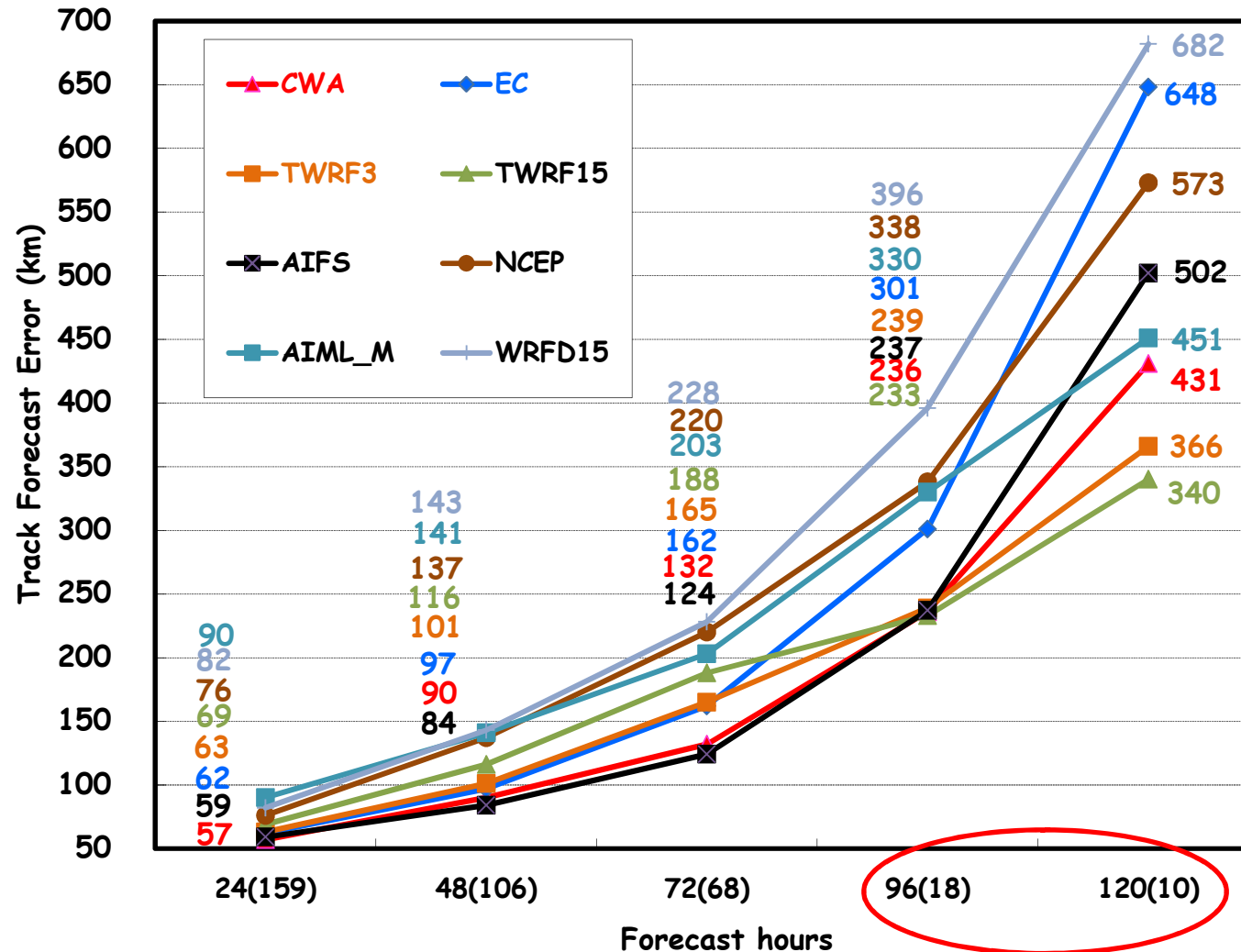
New TC
initialization

Note: TWRF with
6hr lag to CWA

Hsiao et al. 2010, 2012, 2013, 2015, 2020



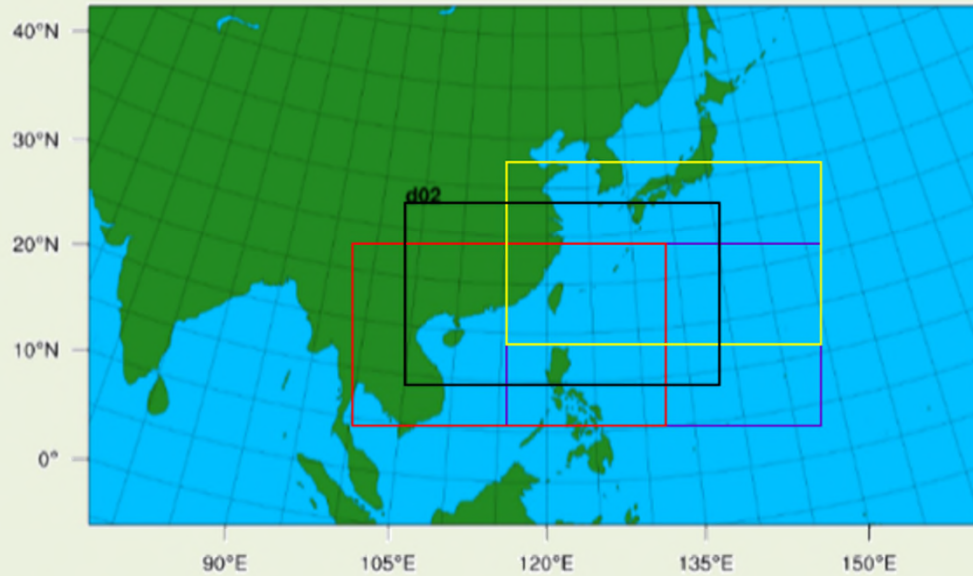
TWRF、WRFD、EC、AIFS、AIML、NCEP、CWA Typhoon track forecast error (homogeneous) -- 2025



TWRF模式解析度提升至10/2公里之影響評估

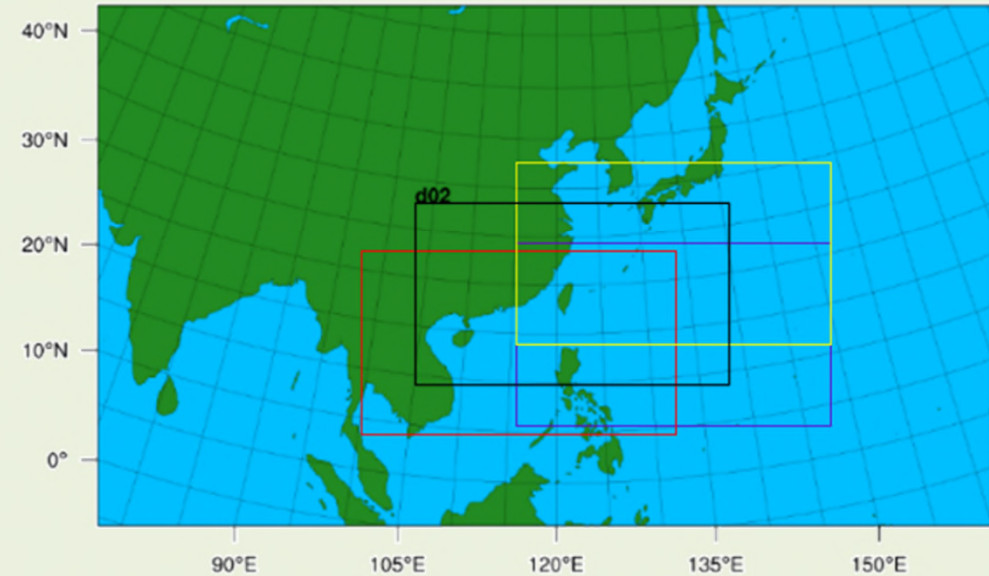
TWRF Domain Configuration

TWRF_OP



Resolution	Grid points	Vertical level	Model top
15 km	662 X 386	52	20 hPa
3 km	1161 X 676	52	20 hPa

TWRF_102



Resolution	Grid points	Vertical level	Model top
10 km	993 X 579	64	10 hPa
2 km	1741 X 1016	64	10 hPa

- 使用相同運算資源，10/2km花費時間約為目前作業版本的3.5倍
- 提高運算資源，10/2km 預報120小時需花費2小時 (目前作業約1.5小時)

TWRF模式解析度提升至10/2公里之影響評估

實驗設計及個案選取

	Resolution	Model Ver.	Blending cut-off length
TWRF_OP	15/3 km	OP44 (WRF 381)	300 km
OP50_153_1200	15/3 km	OP50 (WRF 442)	1200 km
OP50_102_1200	10/2 km	OP50 (WRF 442)	1200 km
OP50_102	10/2 km	OP50 (WRF 442)	300 km

#	typhoon	Intensity	Movement	Date	Cases no. (15km / 3km)
1	* KOMPASU (圓規) (2118)	weak	Westward	2021/10/08/06Z~10/11/18Z	14 / 13
2	* HINNAMNOR (軒嵐諾) (2211) @	Strong	Recurved	2022/08/28/06Z~08/31/06Z	13 / 13
3	* MUIFA (梅花) (2212)	Medium-strength	Recurved	2022/09/08/00Z~09/10/12Z	11 / 11
4	NALGAE (奈格) (2222)	weak	Westward	2022/10/27/00Z~10/29/18	12 / 11
5	* MAWAR (瑪娃) (2302) @	Strong	Recurved	2023/05/25/00Z~05/28/18Z	16 / 16
6	* GAEMI (凱米) (2403)	Strong	Westward	2024/07/20/06Z~07/23/18Z	15 / 15
7	* KRATHON (山陀兒) (2418)	Strong	Recurved	2024/09/28/00Z~10/03/00Z	21 / 20
8	JEBI (燕子) (2417)	Medium-strength	Northward	2024/09/28/00Z~10/02/06Z	17 / 0
9	* KONG-REY (康芮) (2421)	Strong	Westward	2024/10/25/00Z~10/31/00Z	25 / 24
10	* USAGI (天兔) (2425)	Medium-strength	Westward	2024/11/11/18Z~11/15/00Z	14 / 14
11	MAN-YI (萬宜) (2424)	Strong	Westward	2024/11/11/18Z~11/15/00Z	13 / 10
Total cases (2021年 ~ 2024年, 11個颱風)					172 / 146

註：*，發佈警報之颱風。@，慢速颱風，作業強度預報過強

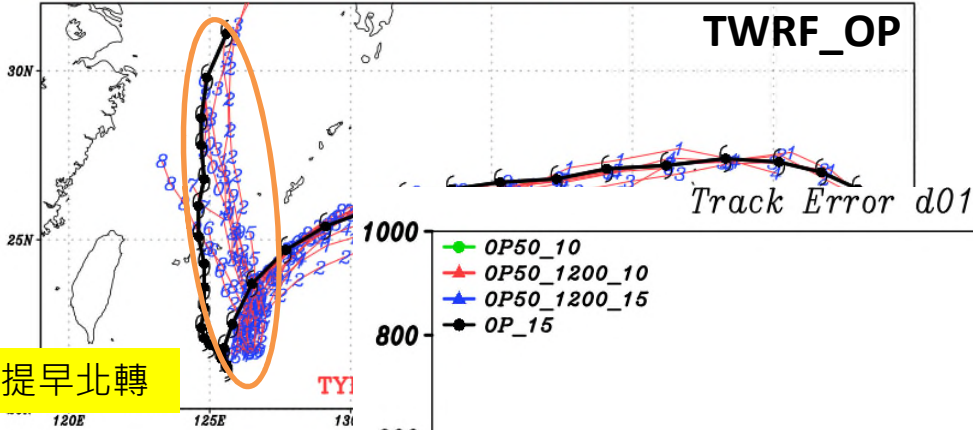
- IC : partial cycling + analysis blending with hybrid of NCEP/EC
- LBC : hybrid of NCEP/EC
- BBC : ECMWF SST

OP44->OP50

- WRF & WPS由V3.8.1升級至V4.4.2
- GCE -> TCWA1
- GWD1 -> GWD3
- Noah LSM的都市地區物理過程調整
- Static data (terrain height、green vegetation fraction、landuse)

112年天氣分析研討會 (黃小玲)

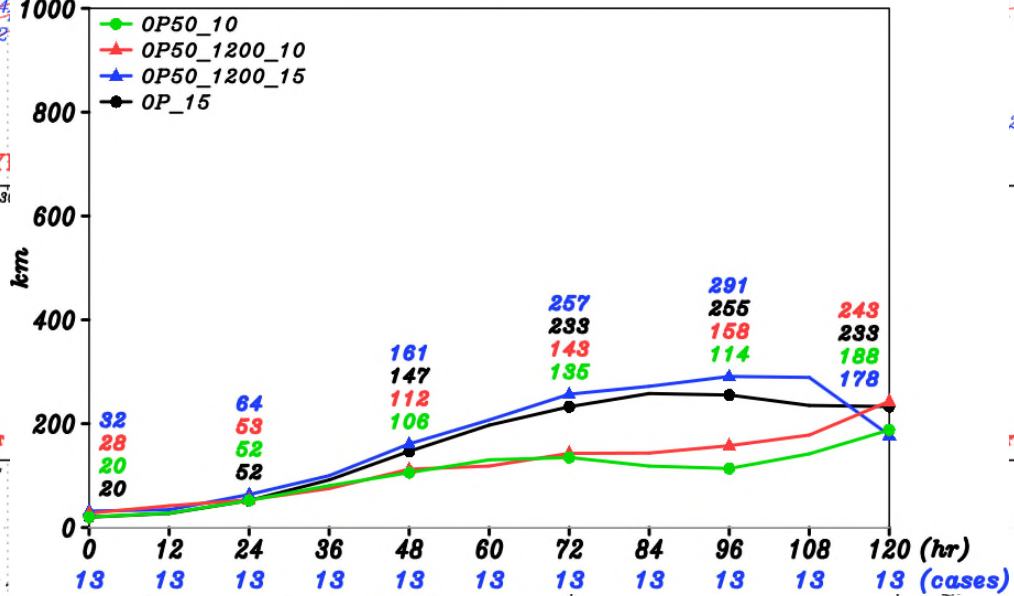
TWRF (15KM) TYPHOON TRACK FORECAST (22/08/28/06Z ~ 22/08/31/06Z)



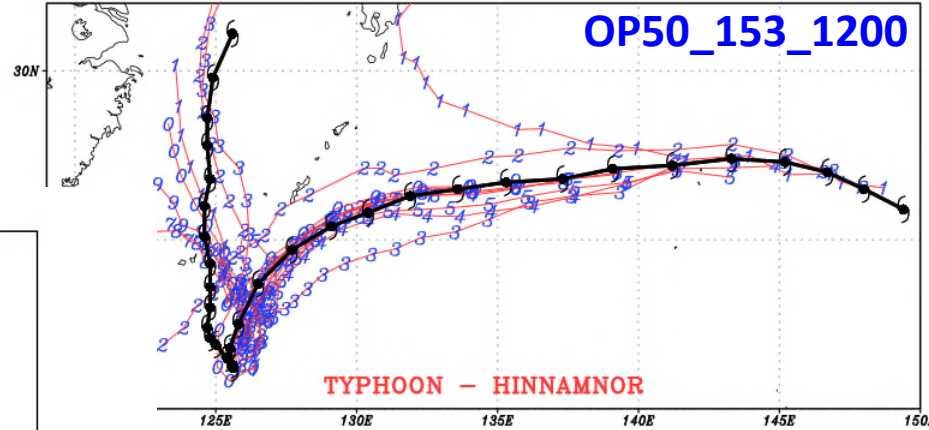
提早北轉

TWRF_OP

Track Error d01



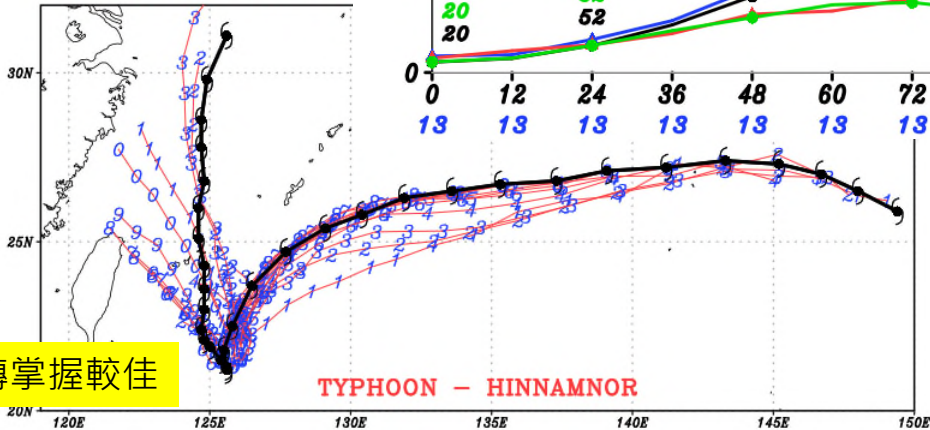
TWRF (15KM) TYPHOON TRACK FORECAST (22/08/28/06Z ~ 22/08/31/06Z)



OP50_153_1200

TYPHOON - HINNAMNOR

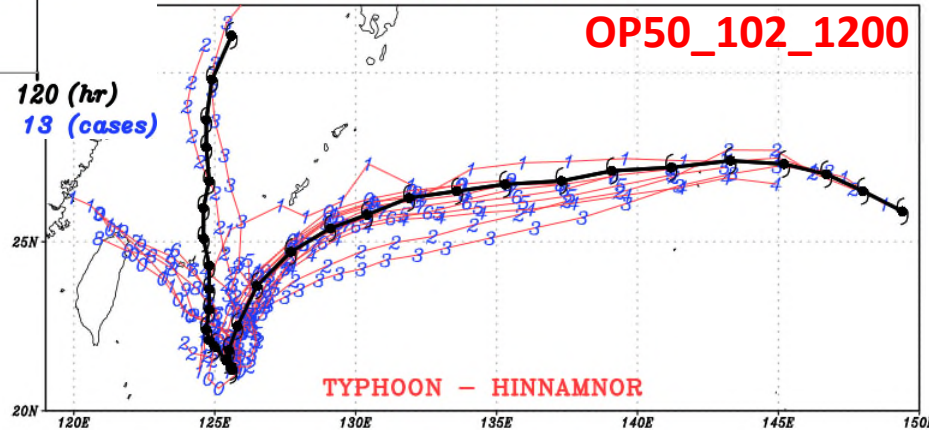
TWRF (10KM) TYPHOON TRACK FORECAST



北轉掌握較佳

TYPHOON - HINNAMNOR

TYPHOON TRACK FORECAST (22/08/28/06Z ~ 22/08/31/06Z)



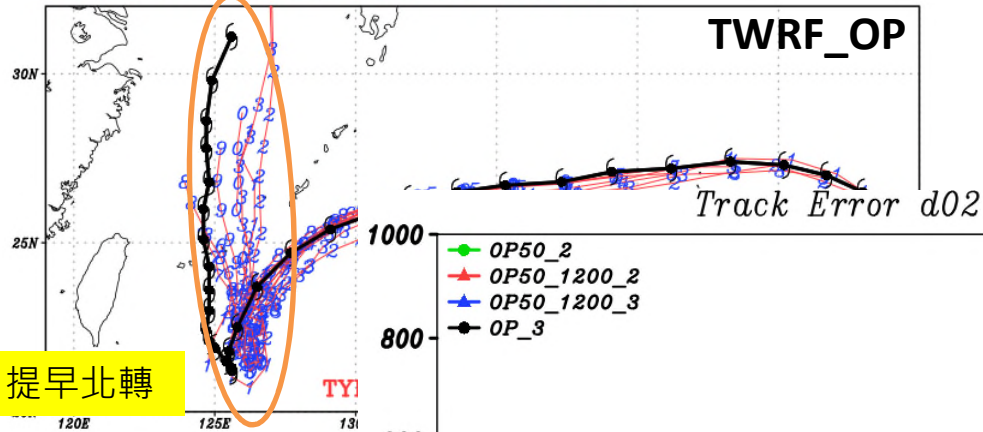
OP50_102_1200

TYPHOON - HINNAMNOR

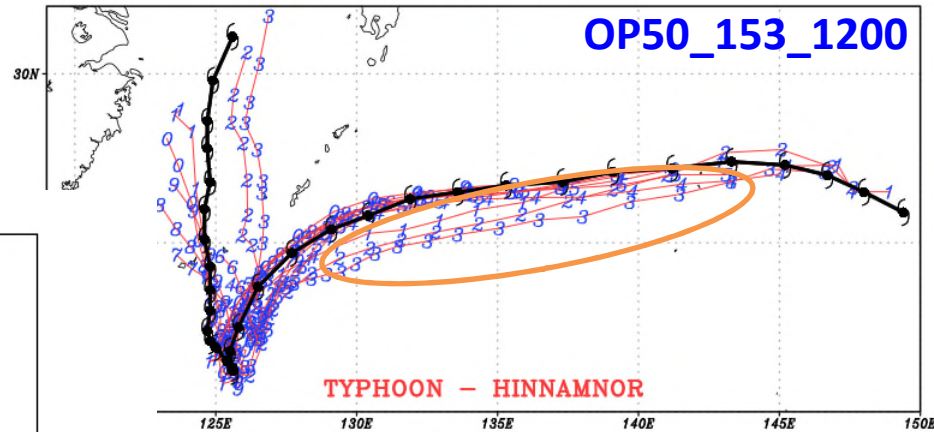
TY HINNAMNOR (2022)

D01: Domain 1 (15 or 10 km)

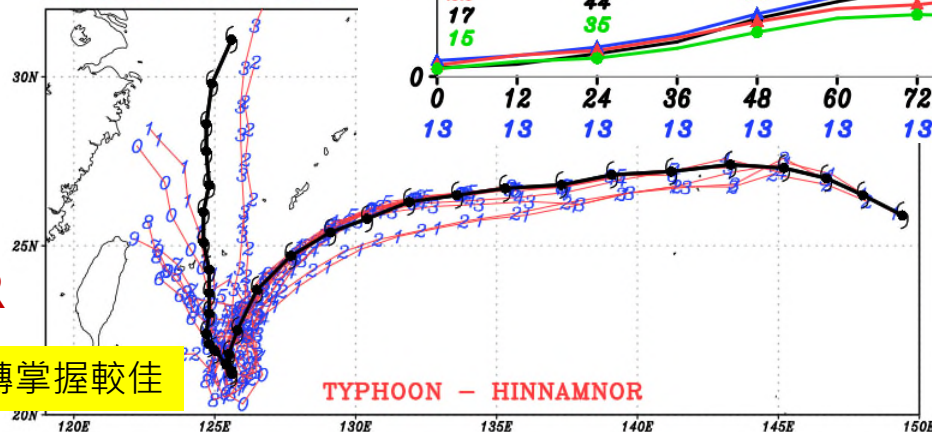
TWRF (3KM) TYPHOON TRACK FORECAST (22/08/28/06Z ~ 22/08/31/06Z)



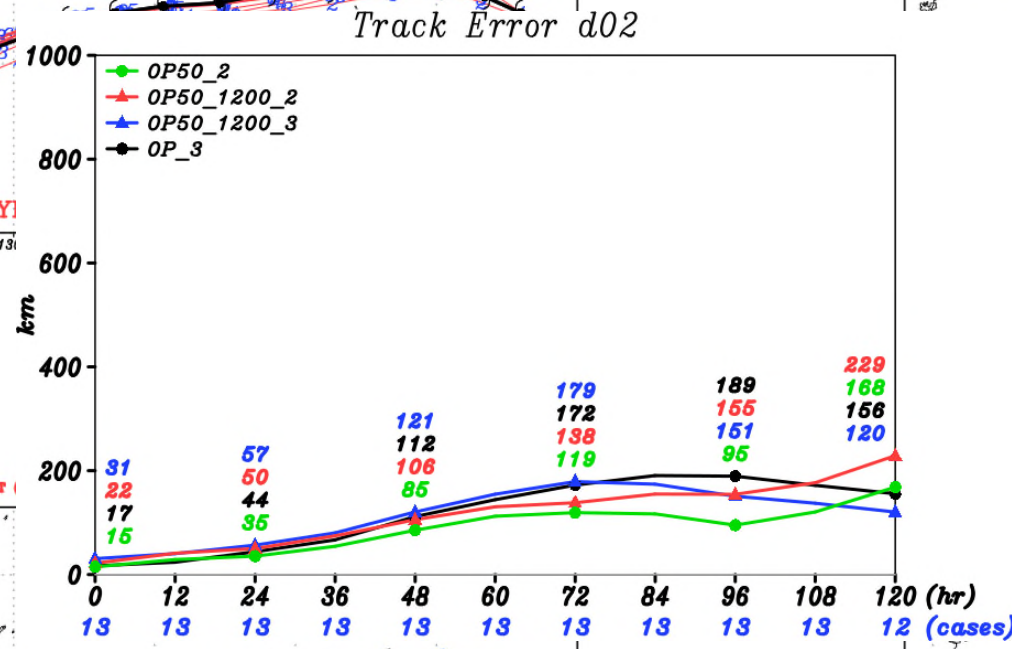
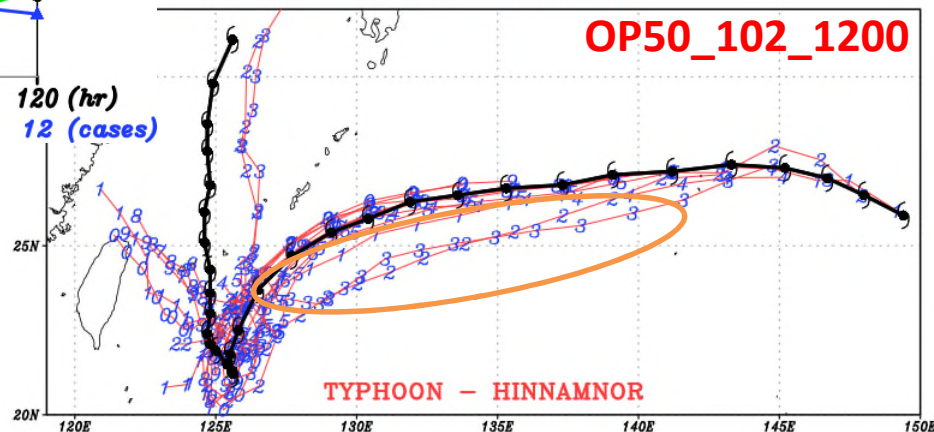
TWRF (3KM) TYPHOON TRACK FORECAST (22/08/28/06Z ~ 22/08/31/06Z)



TWRF (2KM) TYPHOON TRACK FORECAST (22/08/28/06Z ~ 22/08/31/06Z)

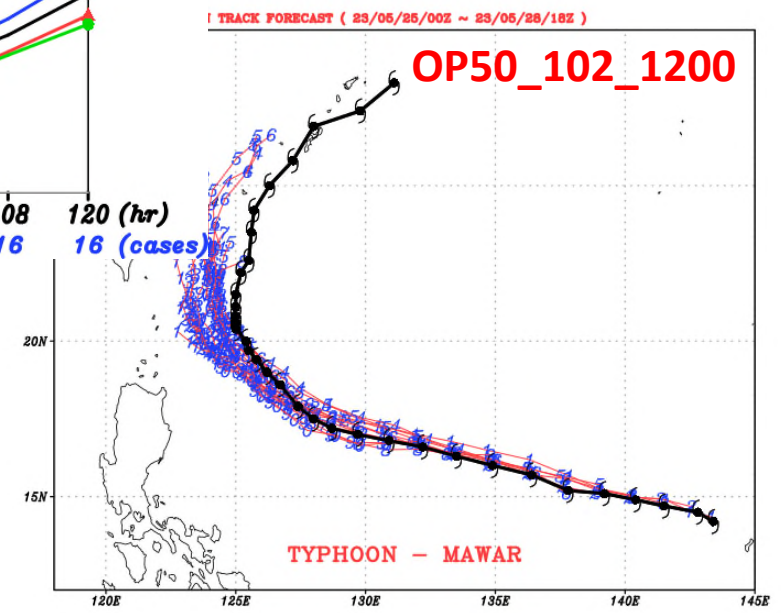
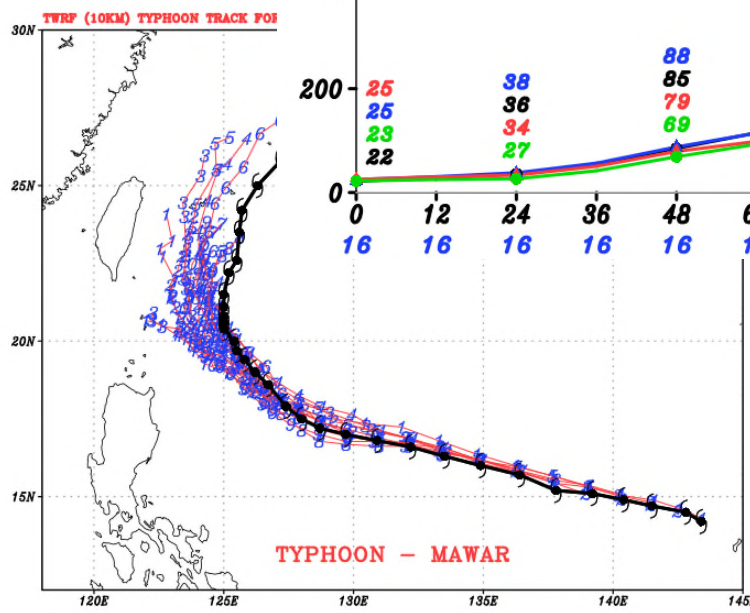
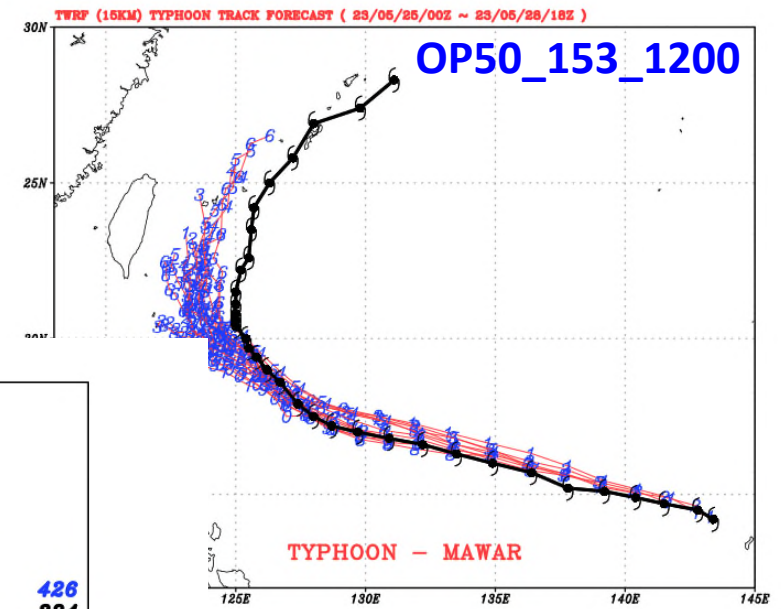
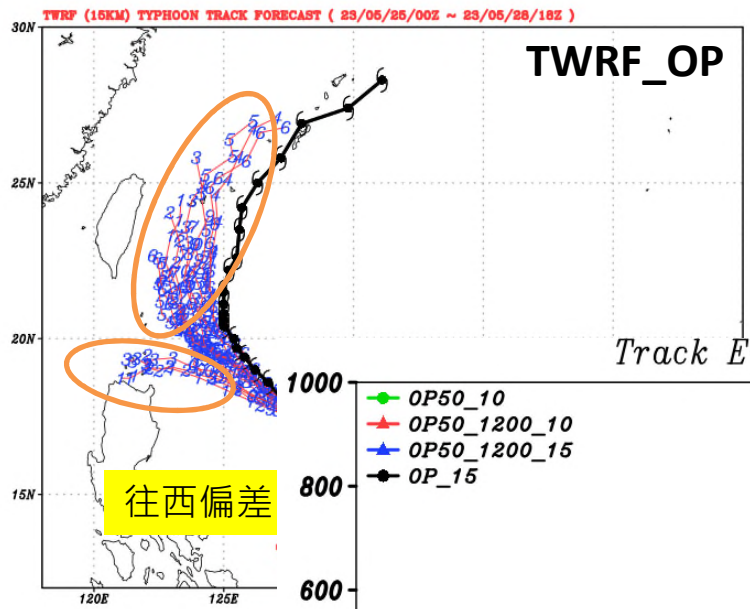


TYPHOON TRACK FORECAST (22/08/28/06Z ~ 22/08/31/06Z)



TY HINNAMNOR (2022)

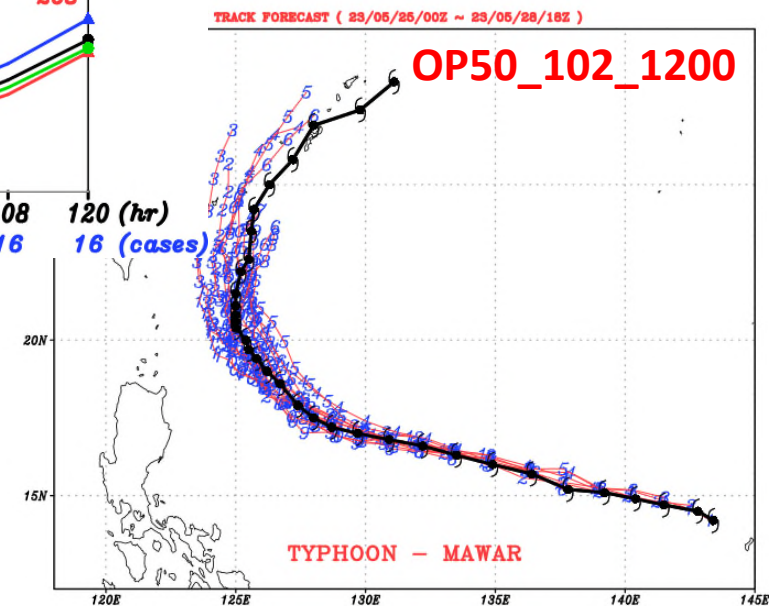
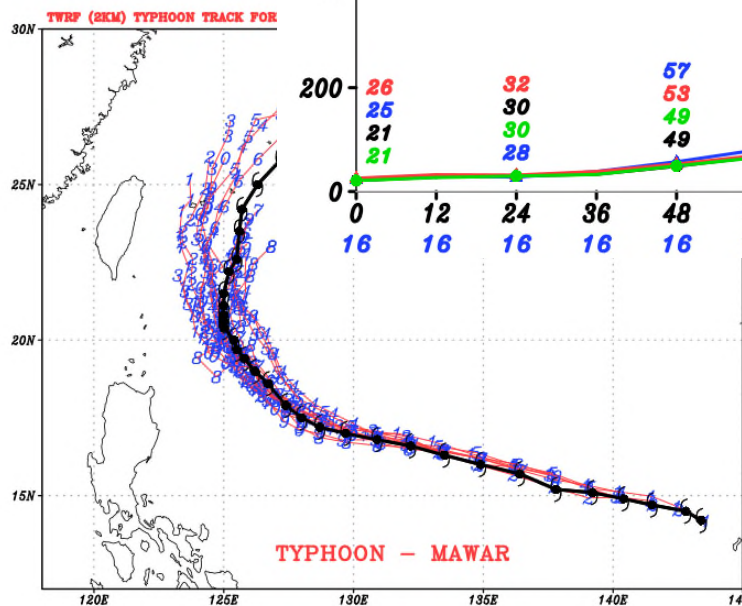
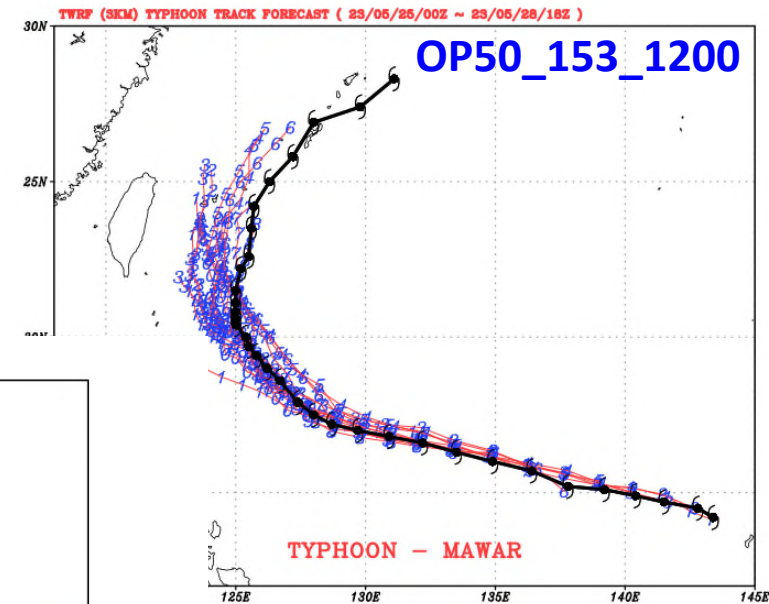
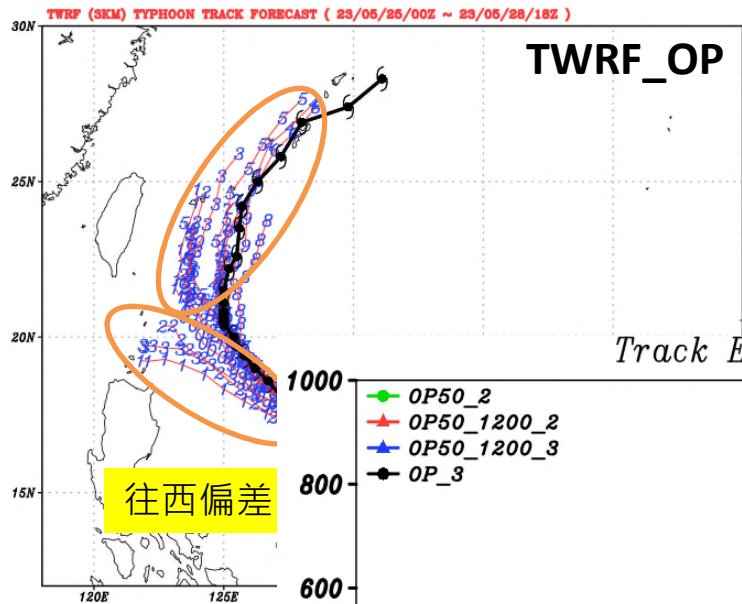
D02: Domain 2 (3 or 2 km)



北轉掌握稍佳

TY MAWAR (2023)

D01: Domain 1
(15 or 10 km)

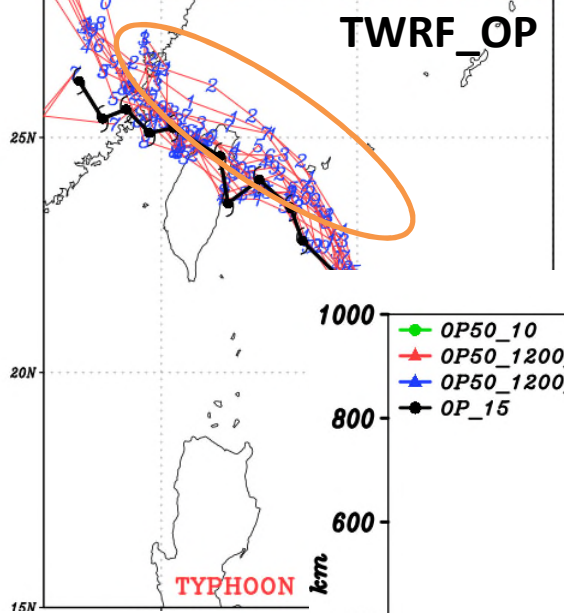


北轉掌握稍佳

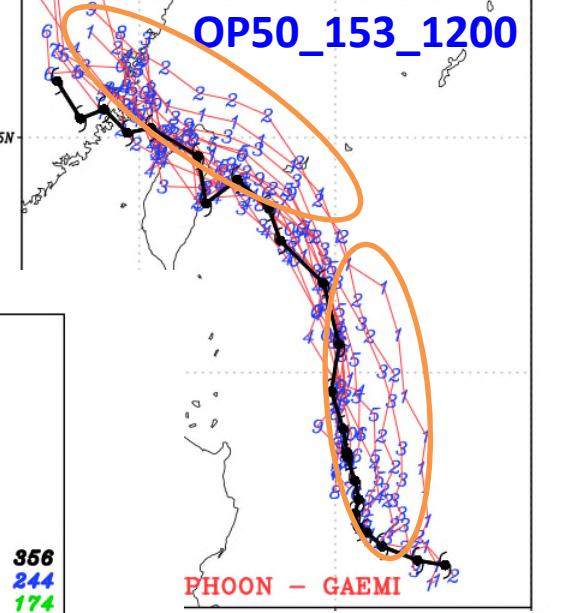
TY MAWAR (2023)

D02: Domain 2
(3 or 2 km)

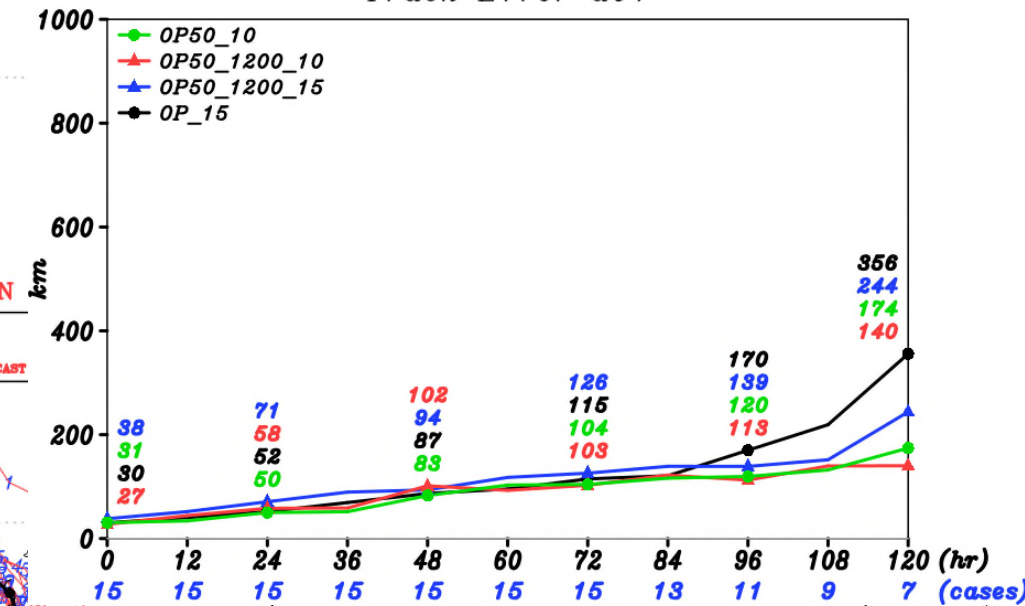
TWRF (16KM) TYPHOON TRACK FORECAST (24/07/20/06Z ~ 24/07/23/18Z)



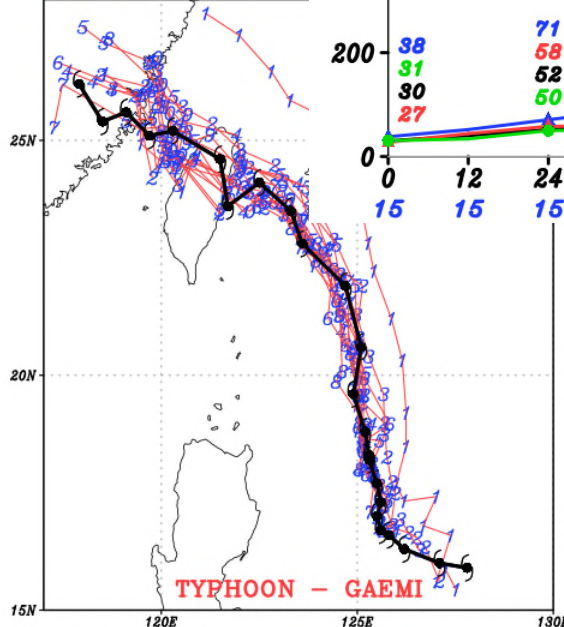
TWRF (16KM) TYPHOON TRACK FORECAST (24/07/20/06Z ~ 24/07/23/18Z)



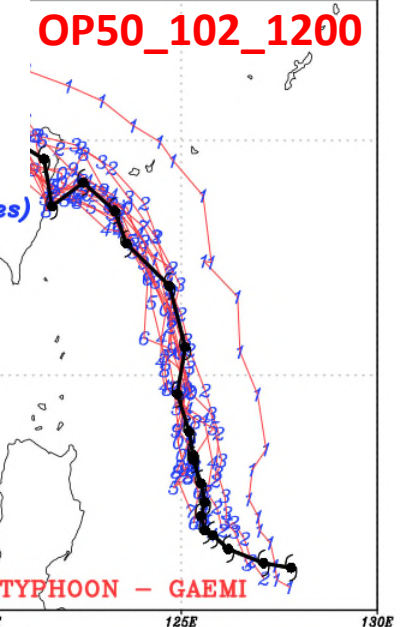
Track Error d01



TWRF (10KM) TYPHOON TRACK FORECAST

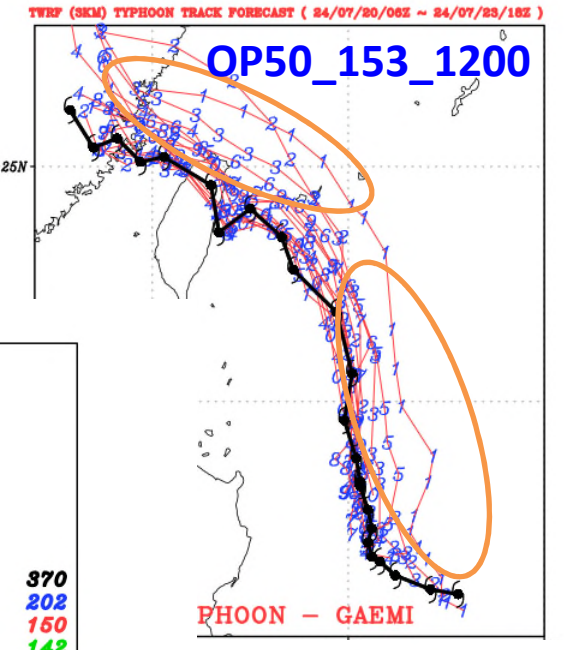
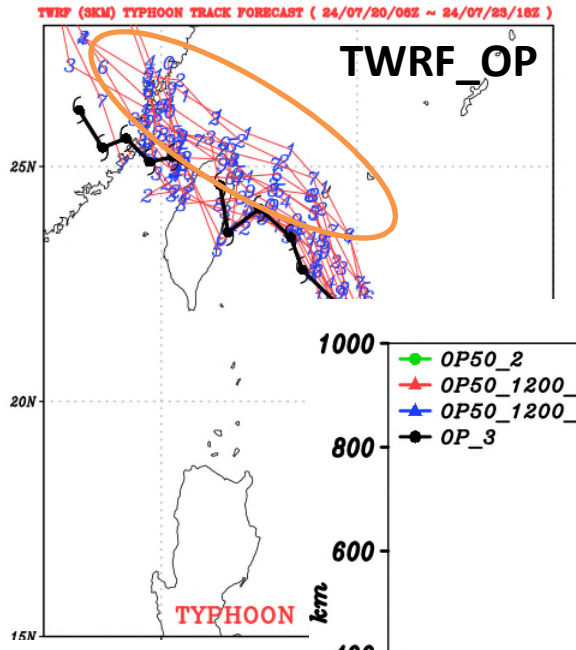


TWRF (10KM) TYPHOON TRACK FORECAST

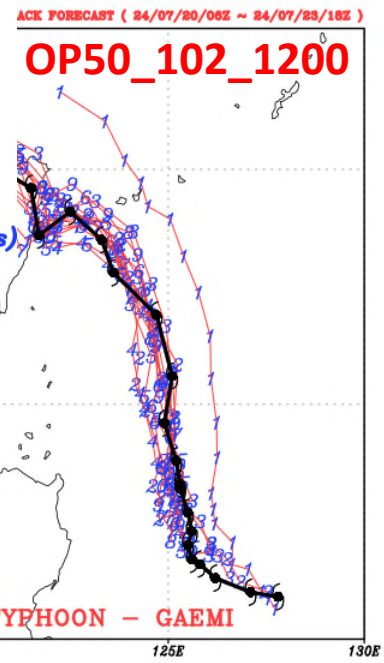
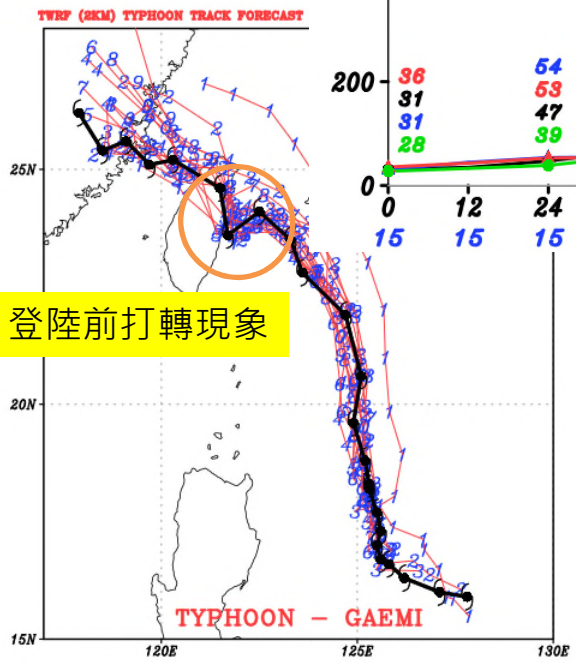
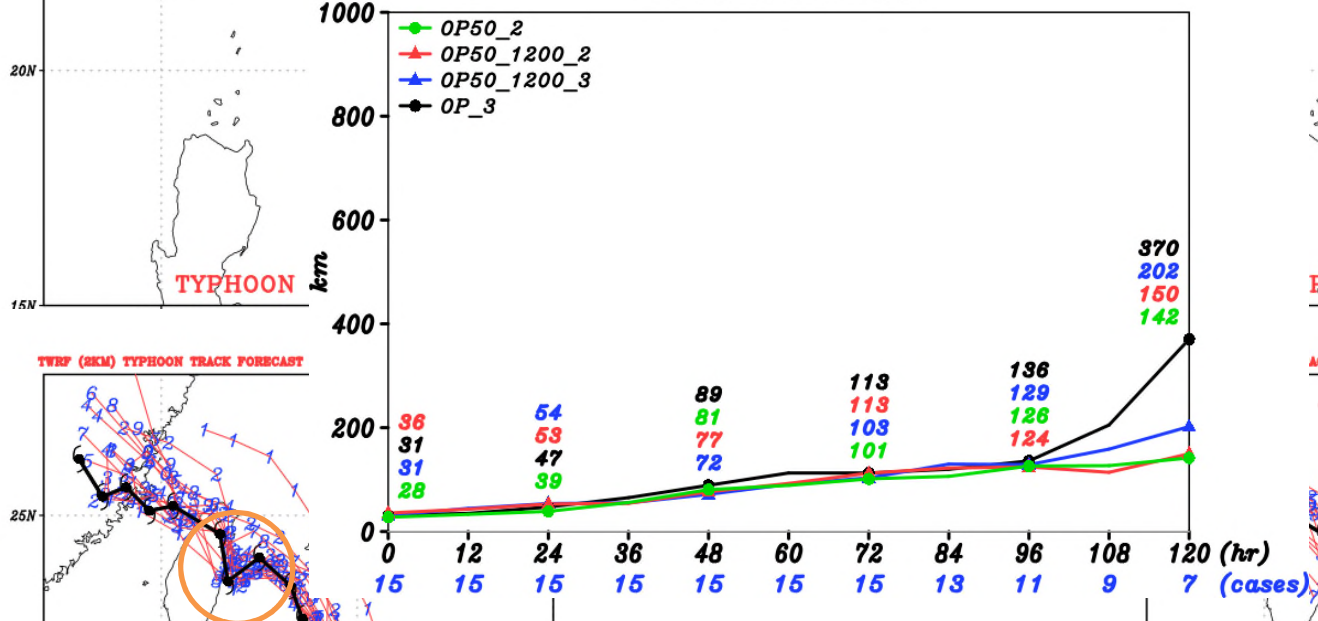


TY GAEMI (2024)

D01: Domain 1
(15 or 10 km)

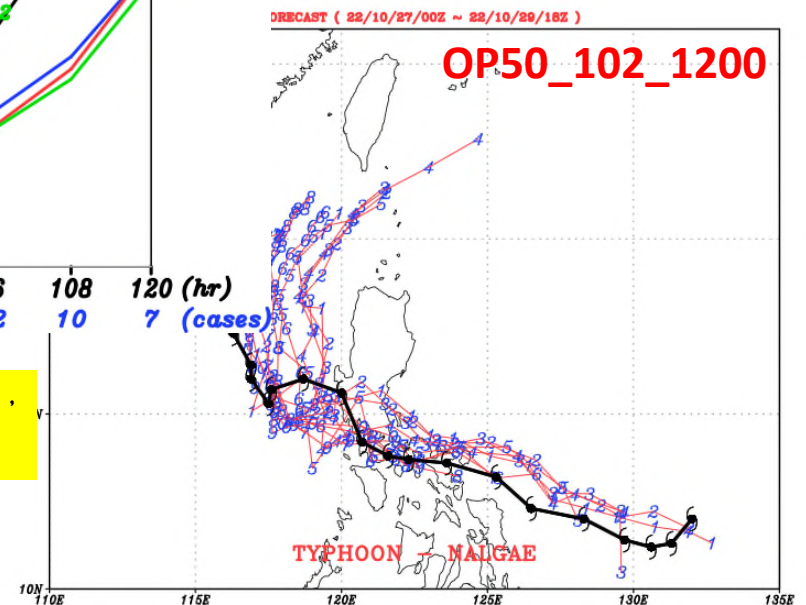
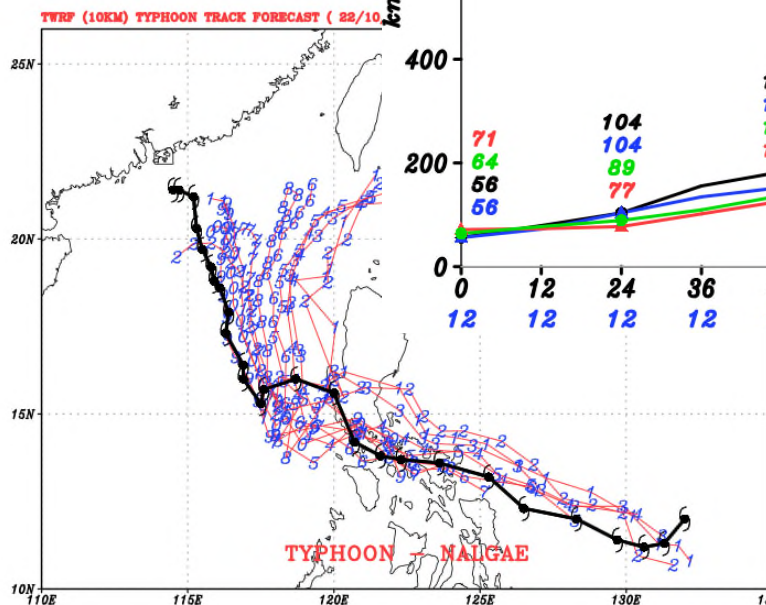
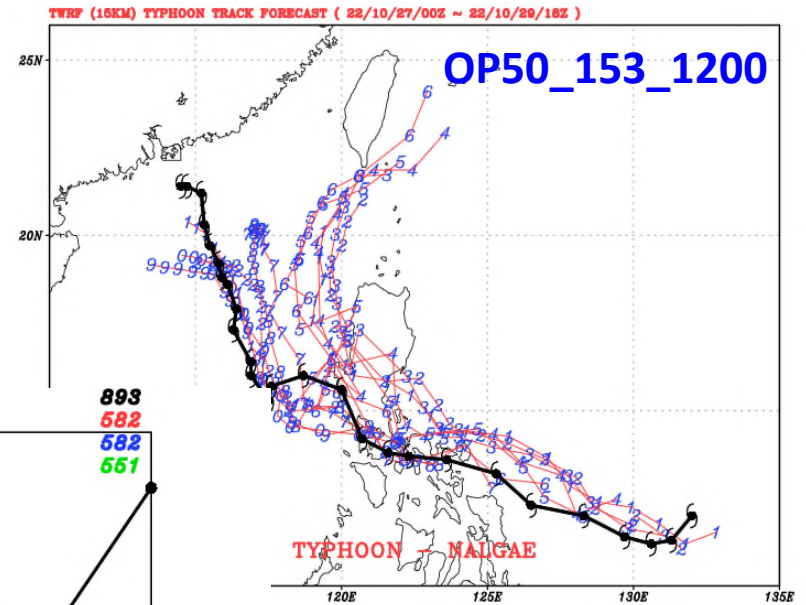
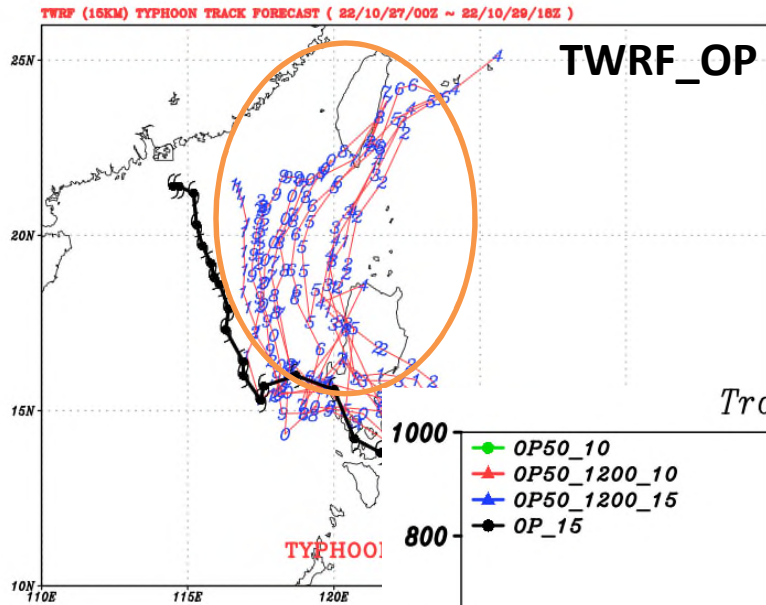


Track Error d02

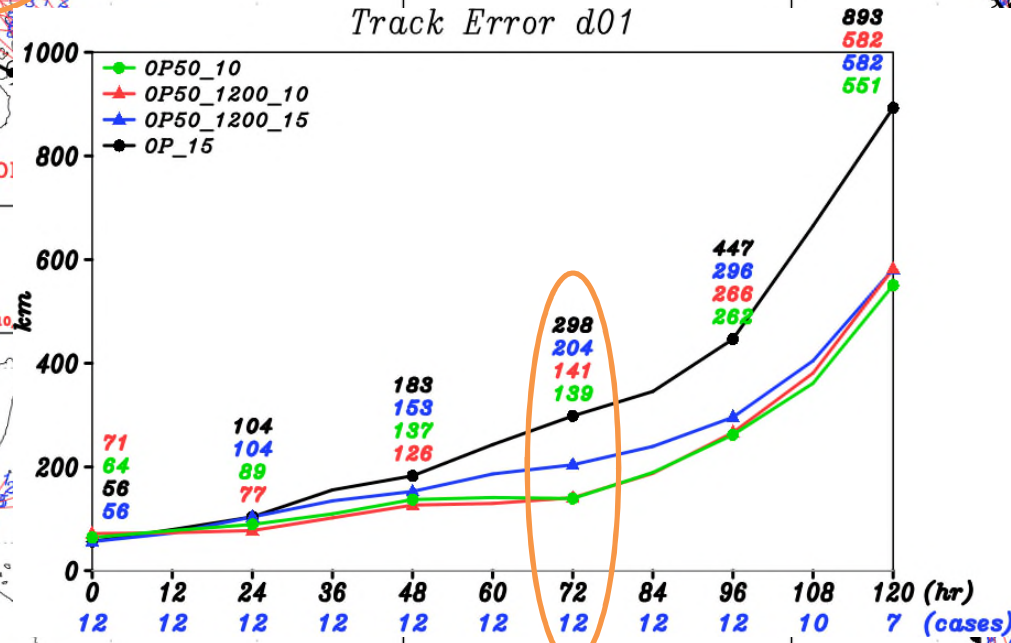


TY GAEMI (2024)

D02: Domain 2
(3 or 2 km)

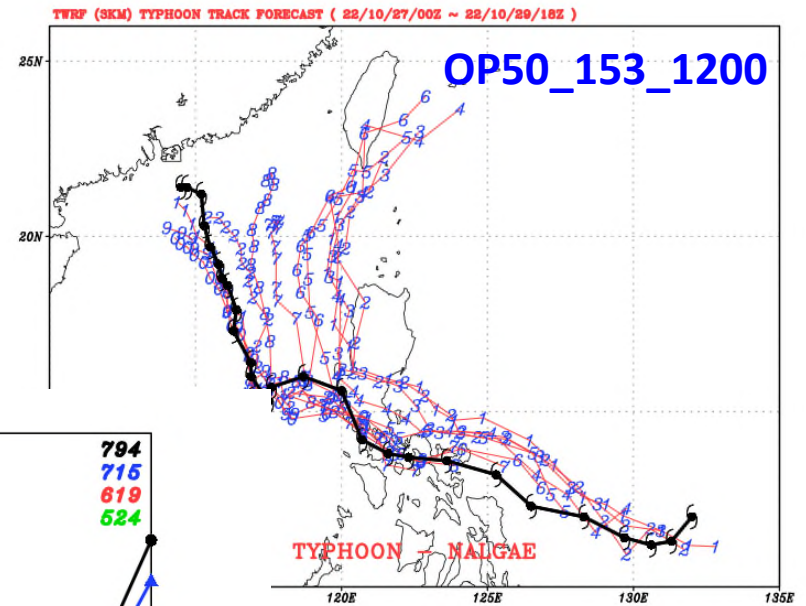
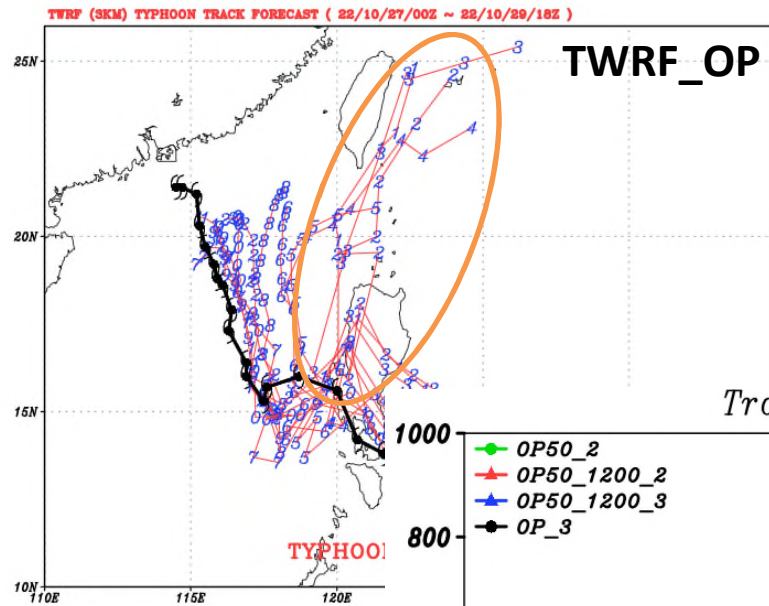


Track Error d01

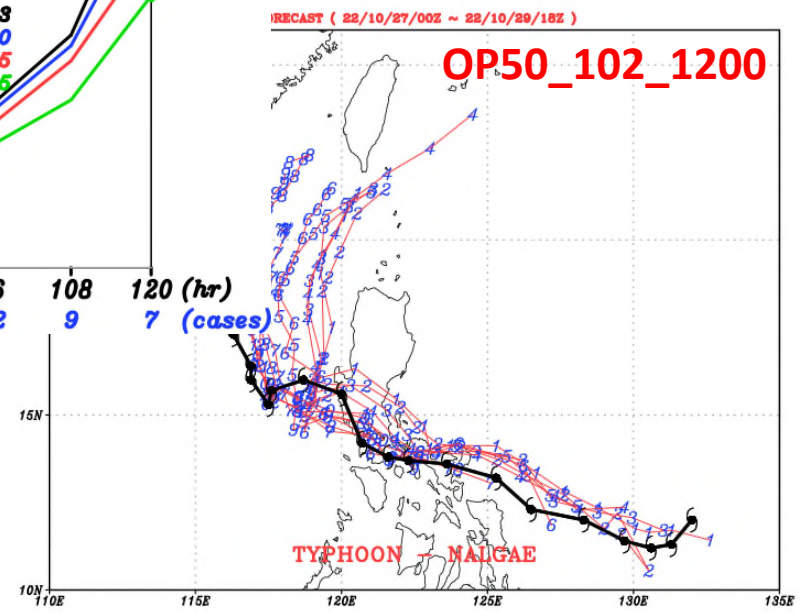
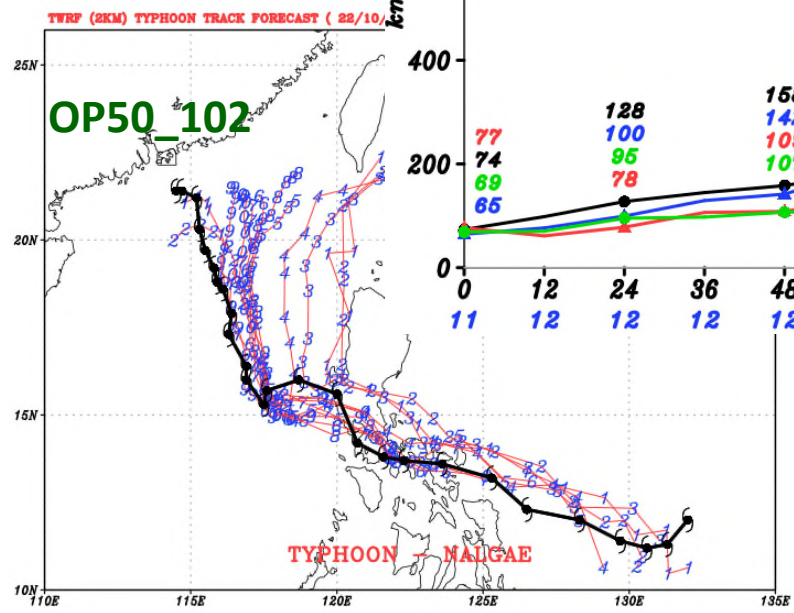
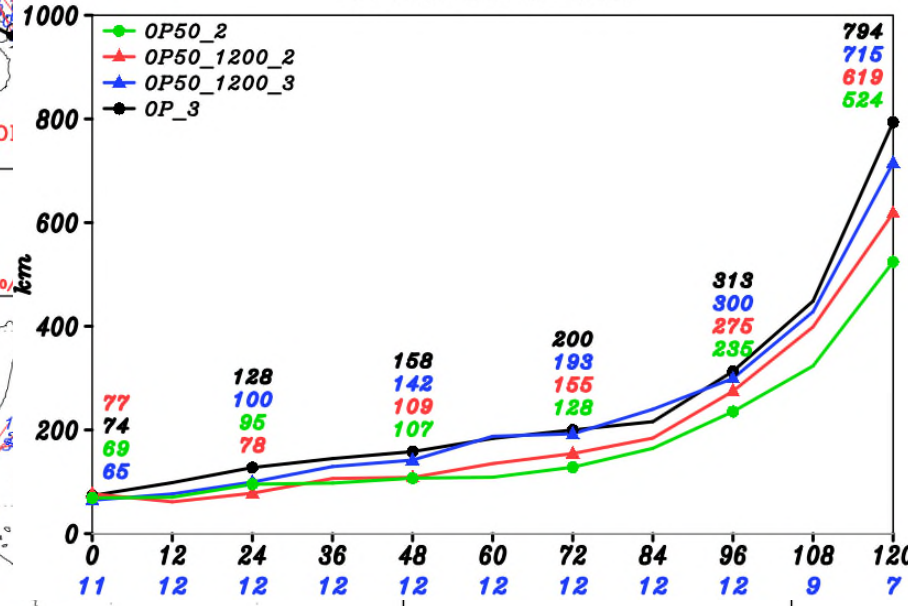


五天預報改進雖多，
但誤差仍偏大

TY NALGAE (2022)
D01: Domain 1
(15 or 10 km)

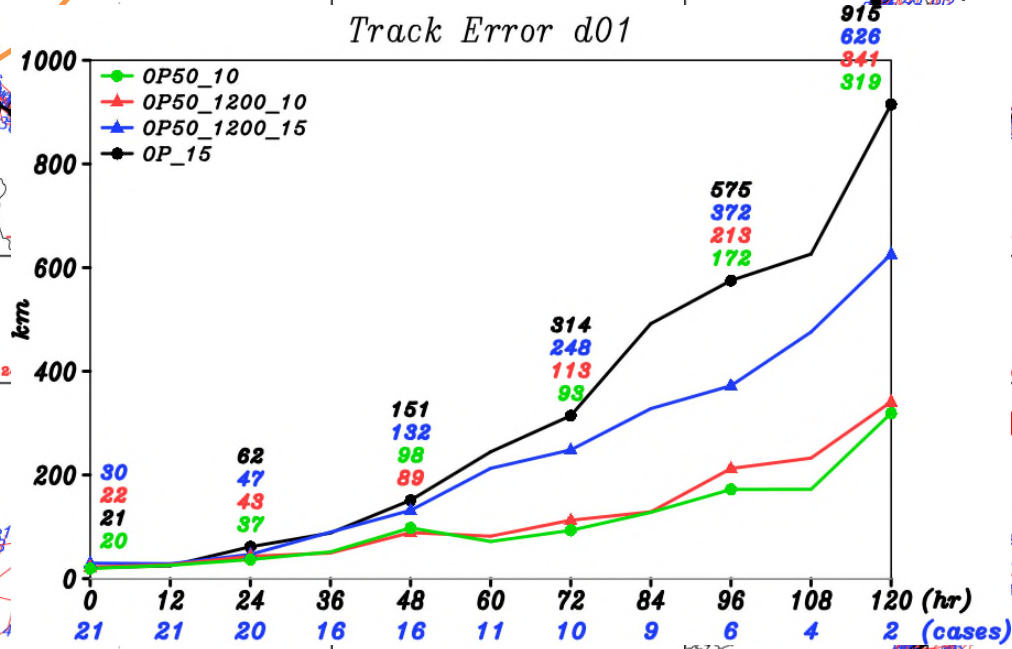
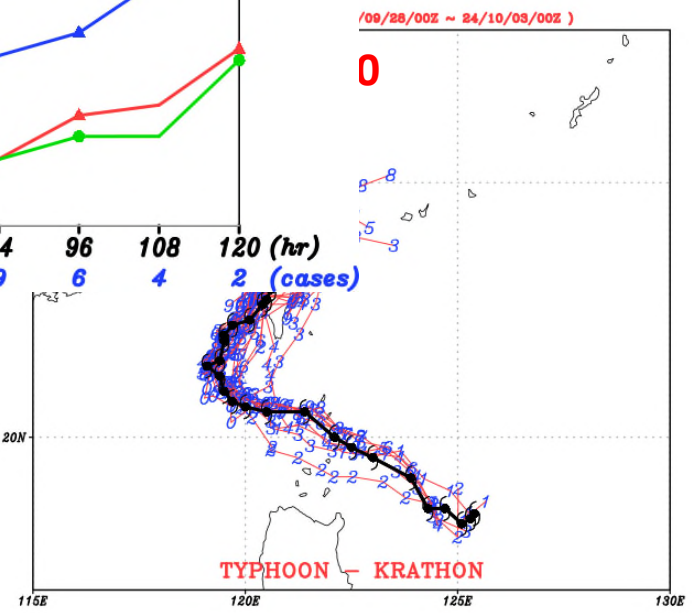
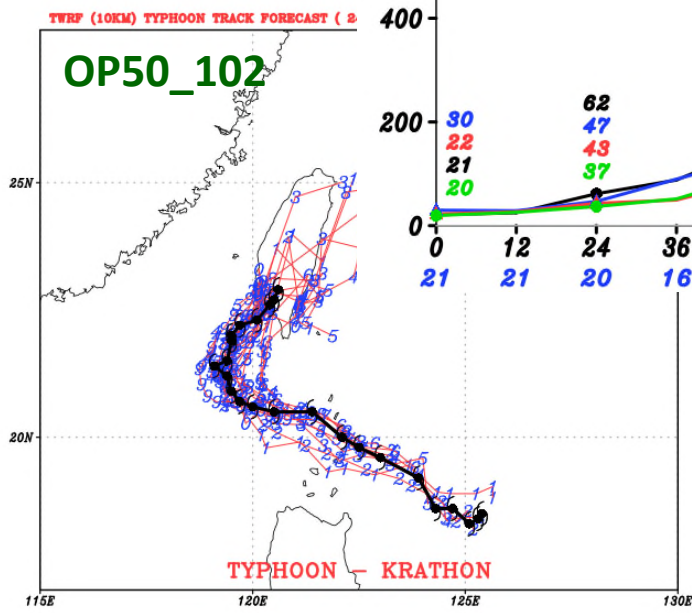
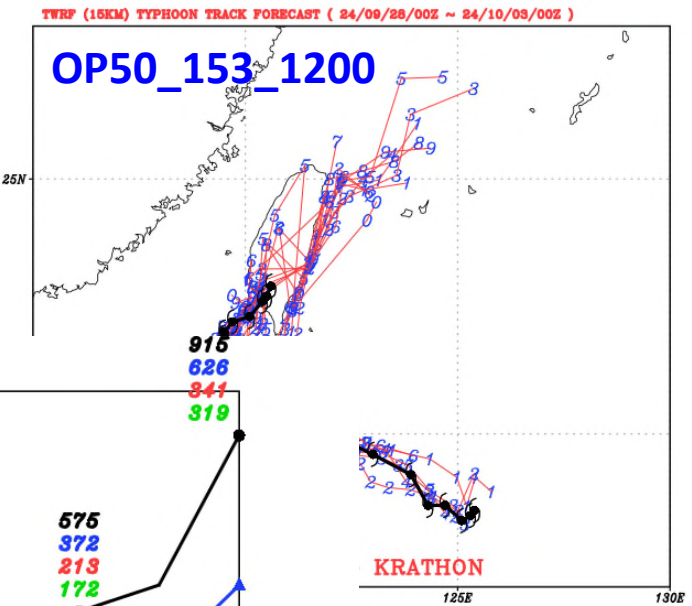
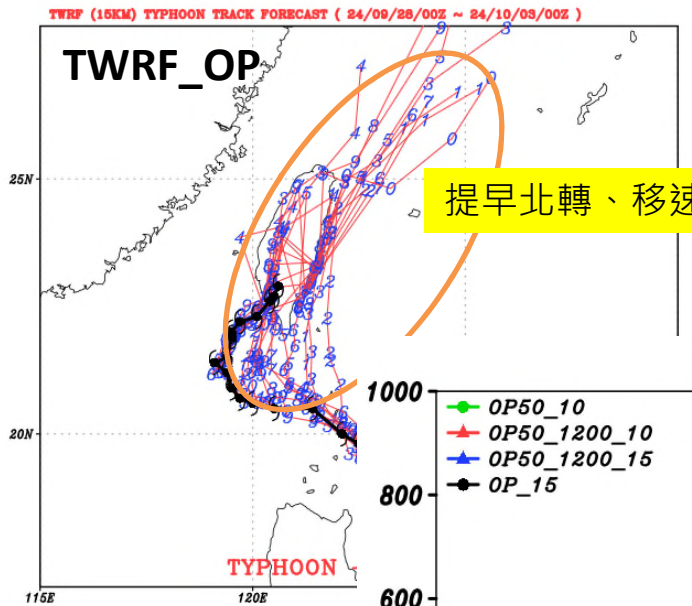


Track Error d02



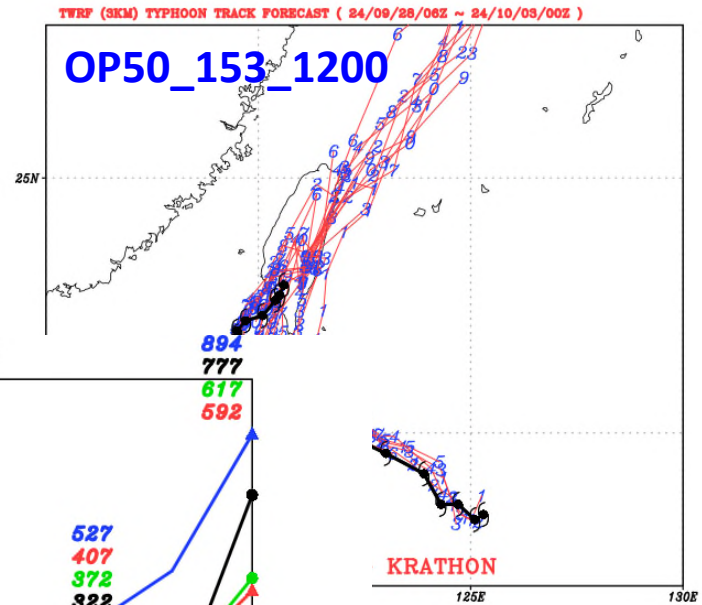
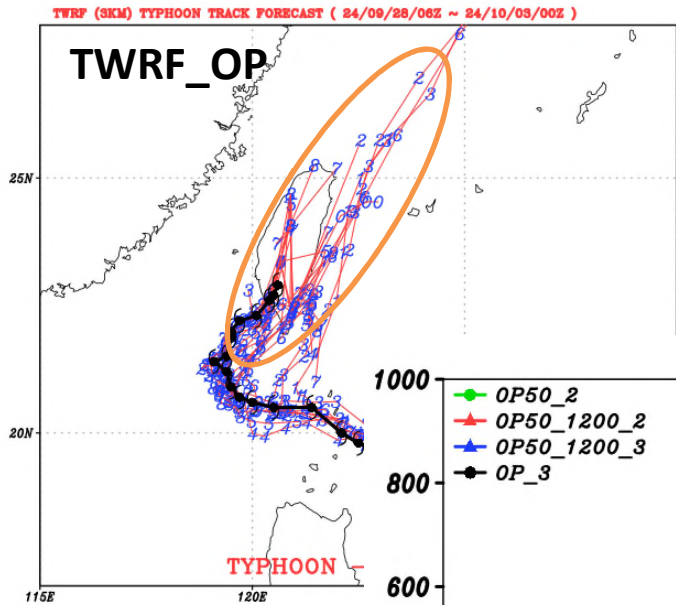
TY NALGAE (2022)

D02: Domain 2
(3 or 2 km)

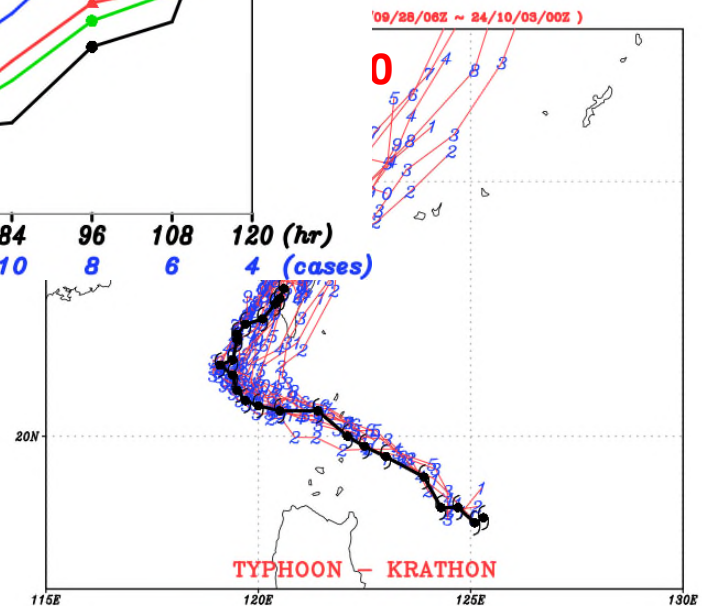
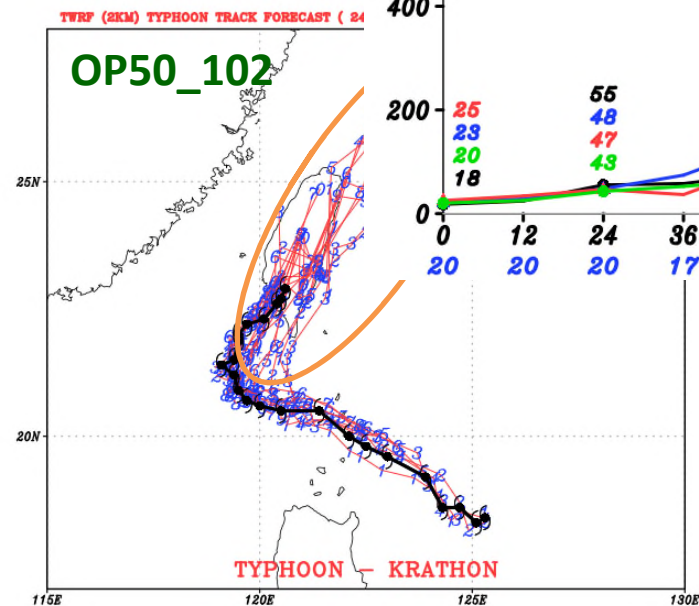
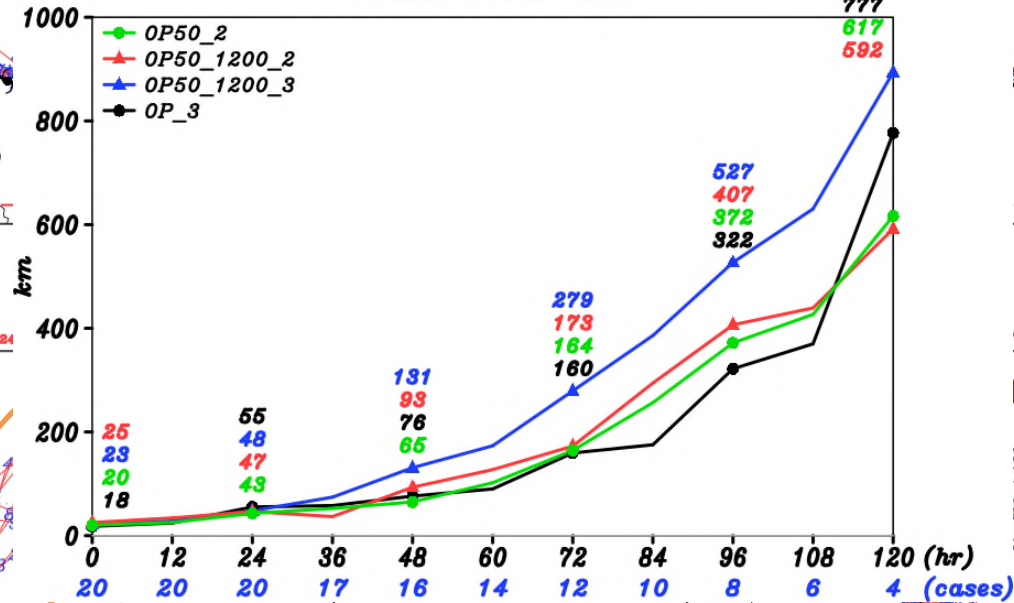


TY KRATHON (2024)

D01: Domain 1
(15 or 10 km)



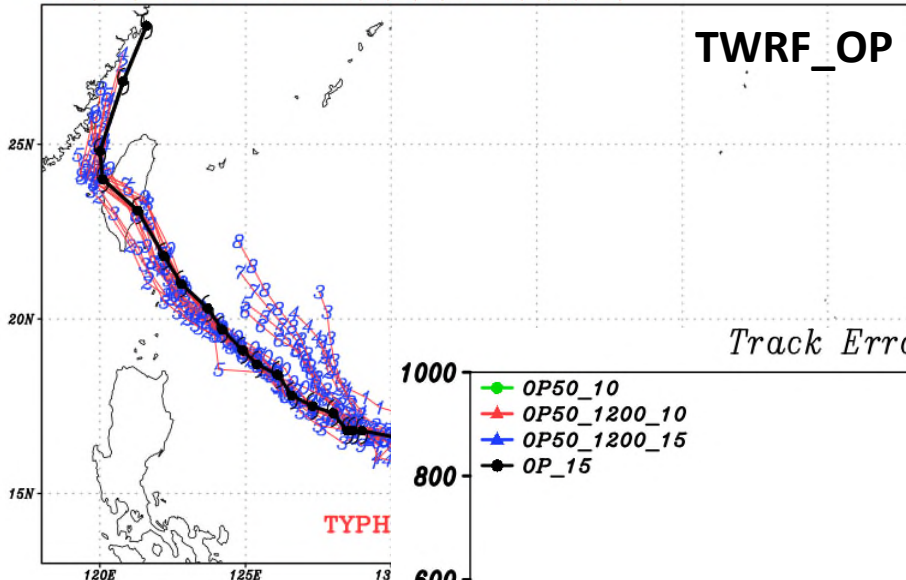
Track Error d02



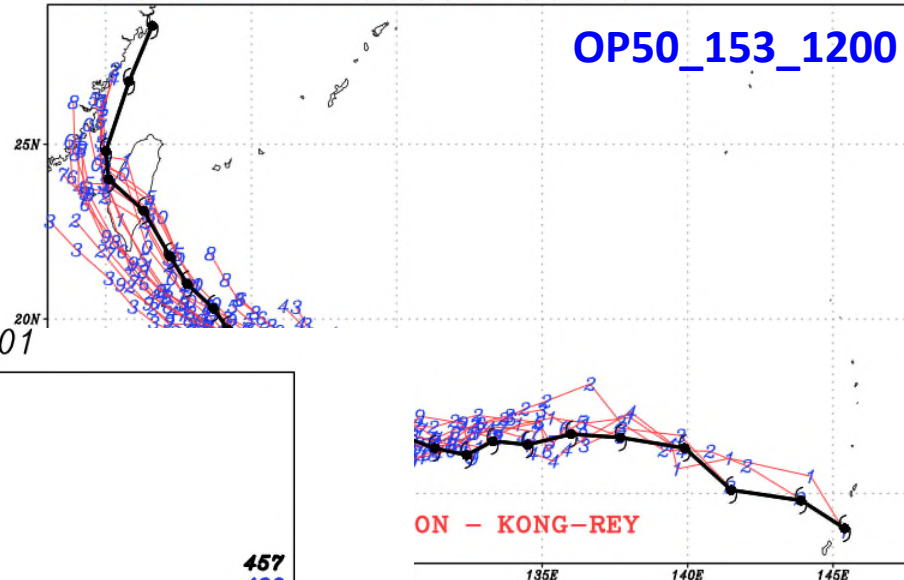
TY KRATHON (2024)

D02: Domain 2
(3 or 2 km)

TWRF (15KM) TYPHOON TRACK FORECAST (24/10/25/00Z ~ 24/10/31/00Z)



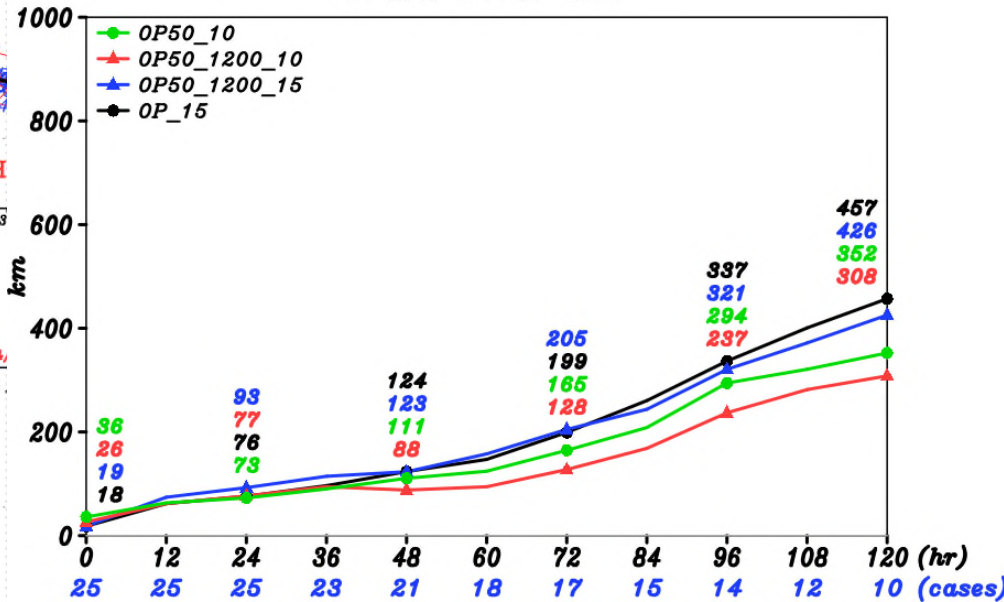
TWRF (15KM) TYPHOON TRACK FORECAST (24/10/25/00Z ~ 24/10/31/00Z)



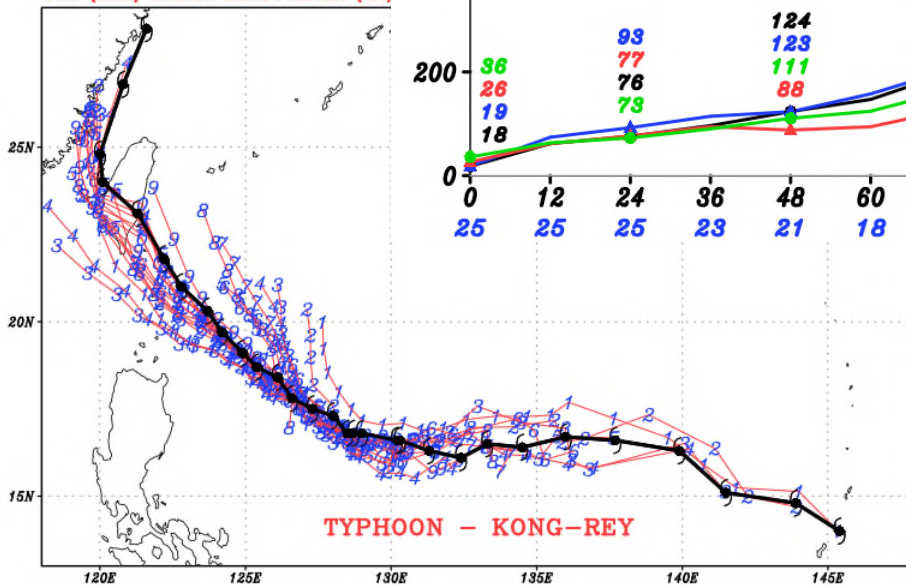
TWRF_OP

OP50_153_1200

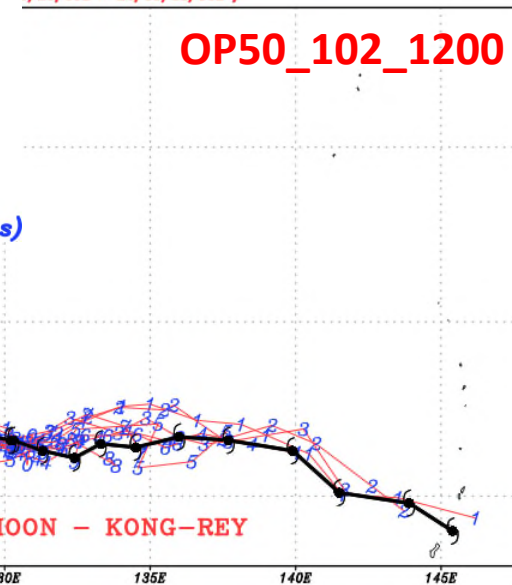
Track Error d01



TWRF (10KM) TYPHOON TRACK FORECAST (24/10/25/00Z ~ 24/10/31/00Z)



1/25/00Z ~ 24/10/31/00Z)



OP50_102_1200

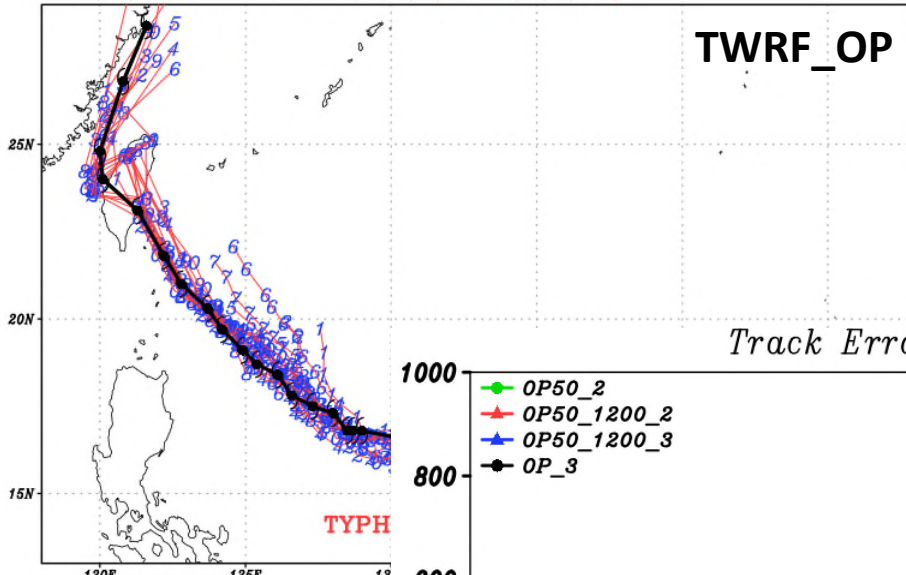
TYPHOON - KONG-REY

TYPHOON - KONG-REY

TY KONG-REY (2024)

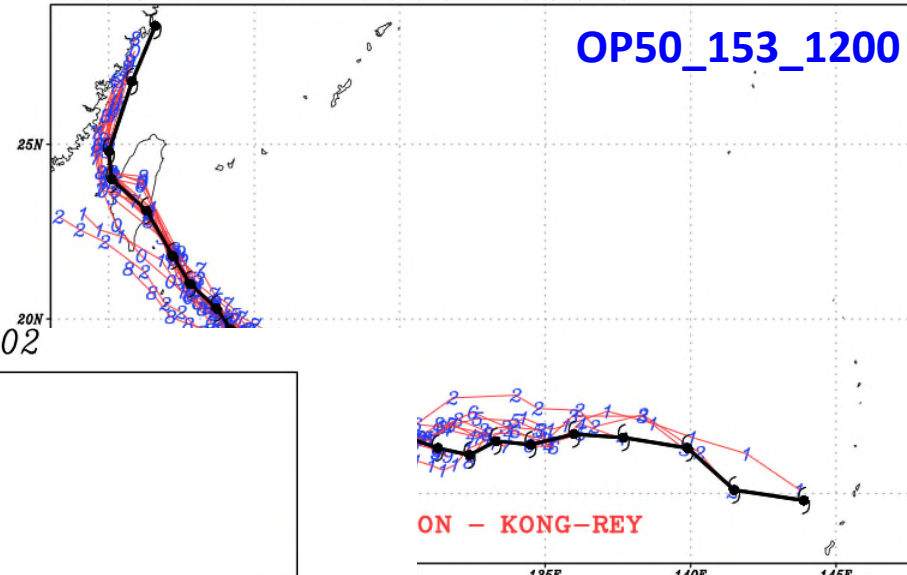
D01: Domain 1
(15 or 10 km)

TWRF (3KM) TYPHOON TRACK FORECAST (24/10/25/06Z ~ 24/10/31/00Z)



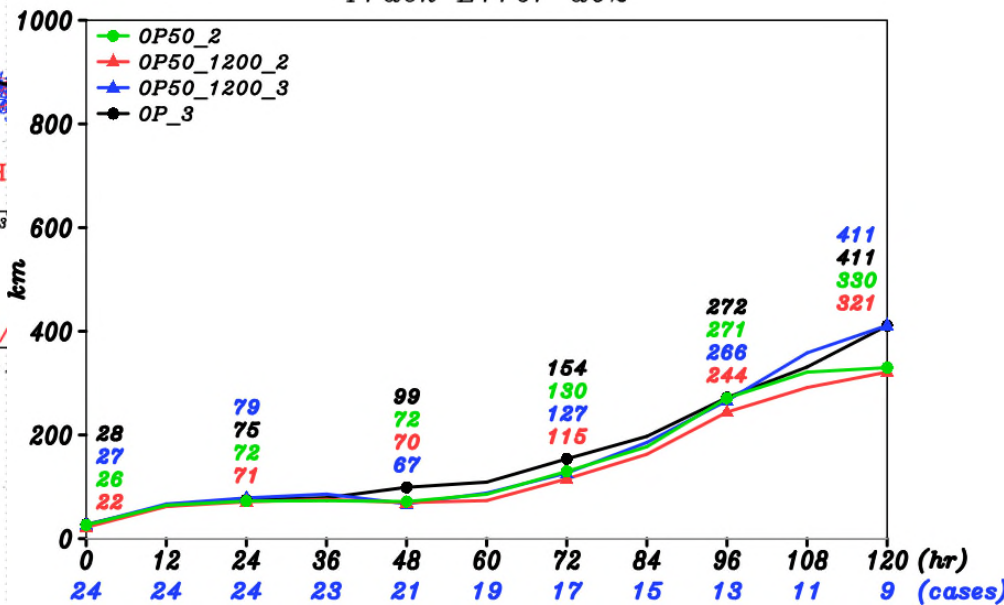
TWRF_OP

TWRF (3KM) TYPHOON TRACK FORECAST (24/10/25/06Z ~ 24/10/31/00Z)

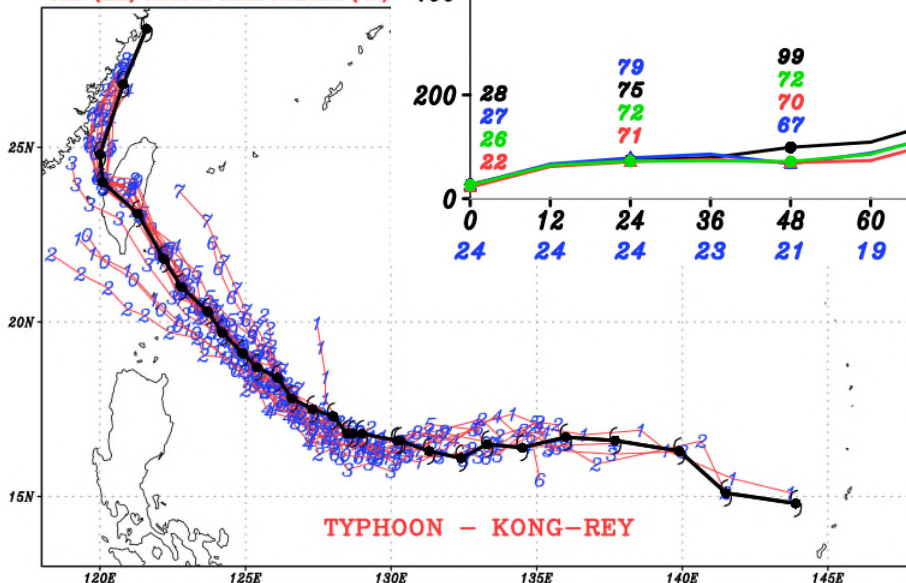


OP50_153_1200

Track Error d02

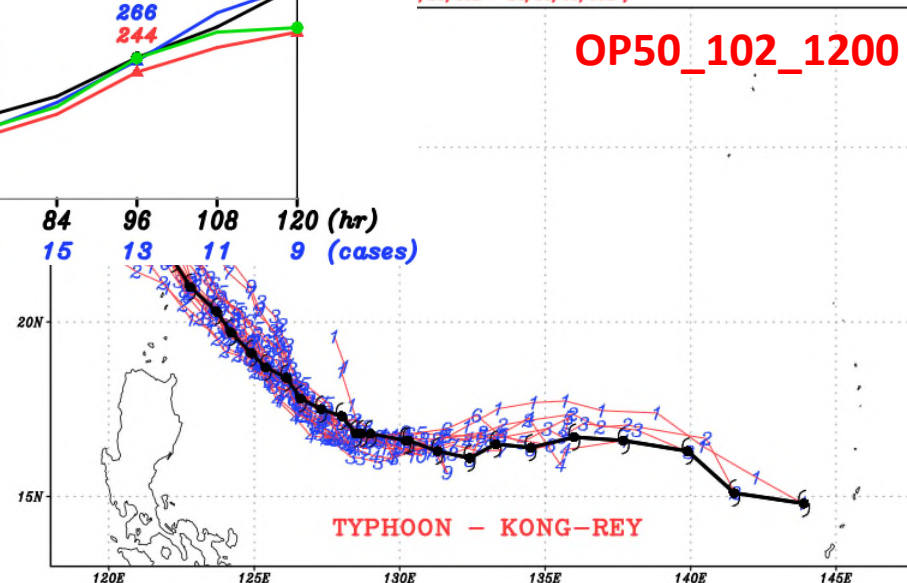


TWRF (2KM) TYPHOON TRACK FORECAST (24/10/25/06Z ~ 24/10/31/00Z)



TYPHOON - KONG-REY

TWRF (2KM) TYPHOON TRACK FORECAST (24/10/25/06Z ~ 24/10/31/00Z)



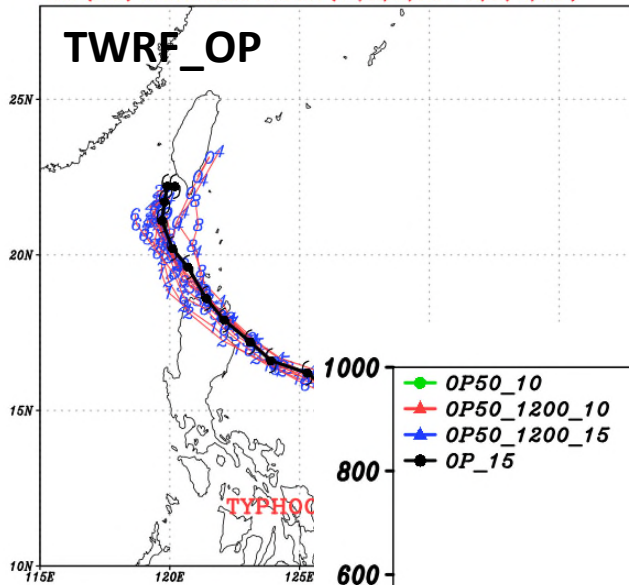
OP50_102_1200

TYPHOON - KONG-REY

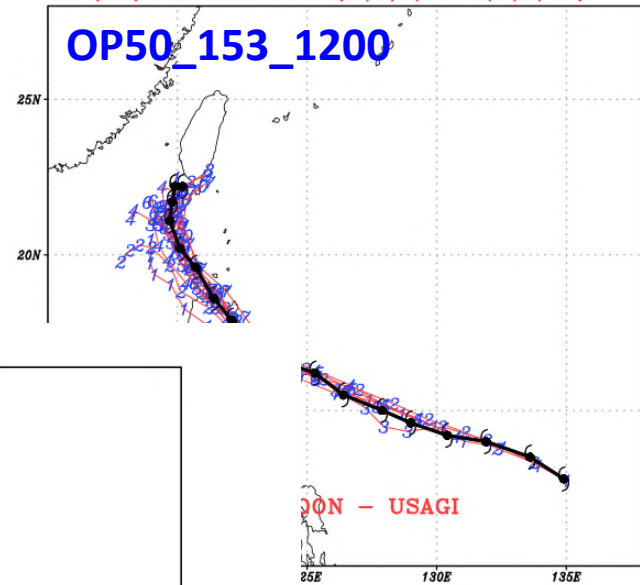
TY KONG-REY (2024)

D02: Domain 2
(3 or 2 km)

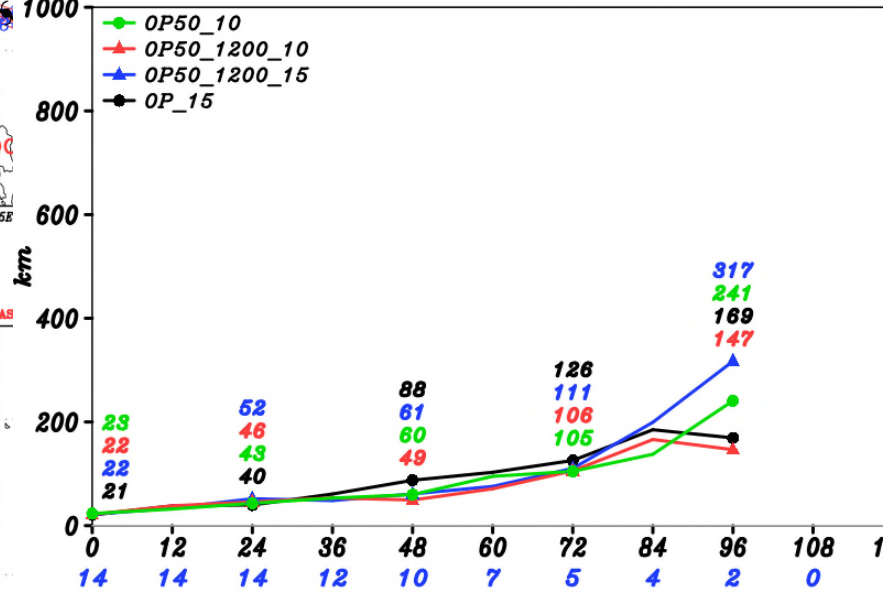
TWRF (15KM) TYPHOON TRACK FORECAST (24/11/11/18Z ~ 24/11/15/00Z)



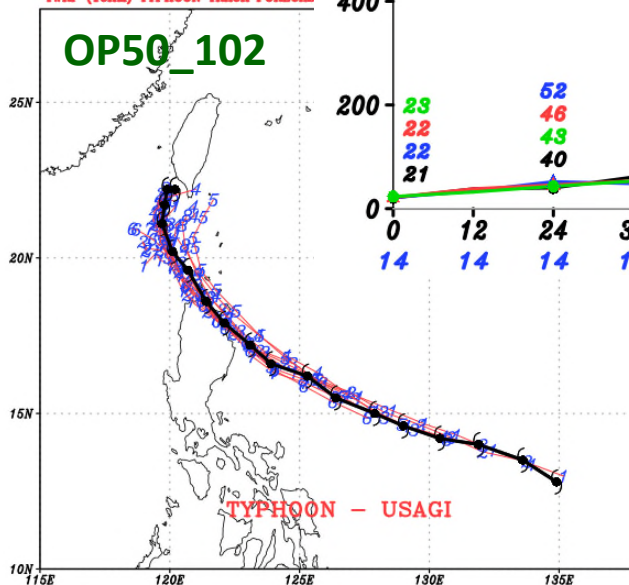
TWRF (15KM) TYPHOON TRACK FORECAST (24/11/11/18Z ~ 24/11/15/00Z)



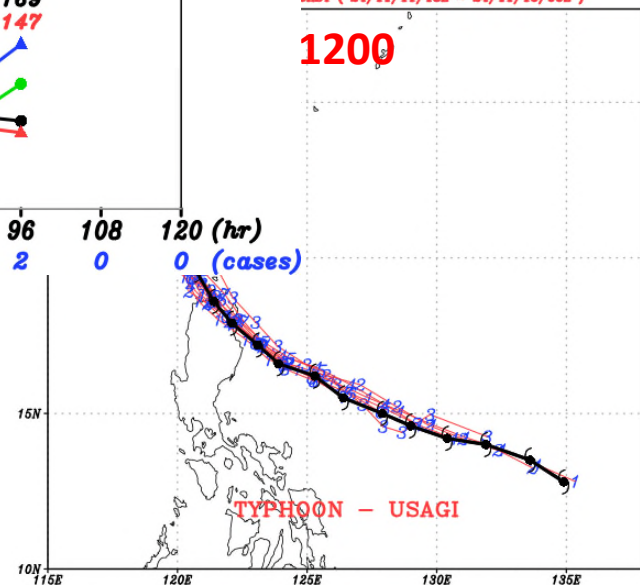
Track Error d01



TWRF (10KM) TYPHOON TRACK FORECAST



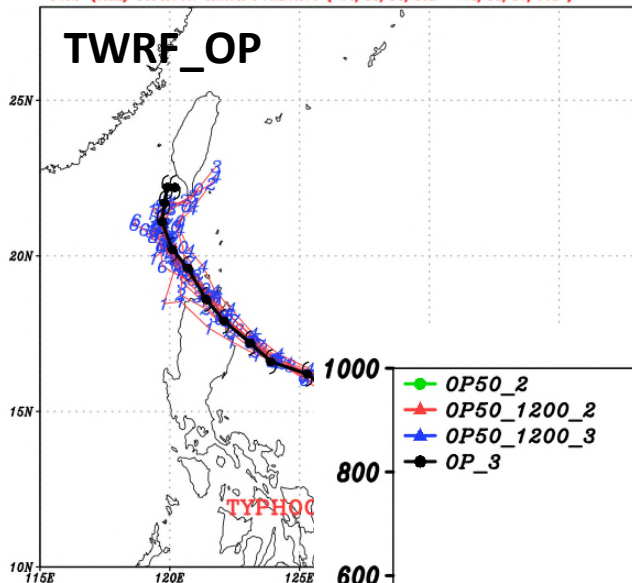
TWRF (10KM) TYPHOON TRACK FORECAST



TY USAGI (2024)

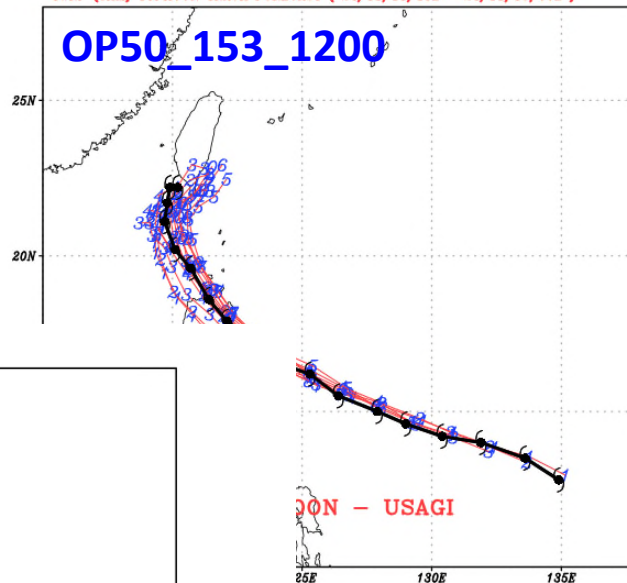
D01: Domain 1
(15 or 10 km)

TWRF (3KM) TYPHOON TRACK FORECAST (24/11/11/18Z ~ 24/11/15/00Z)



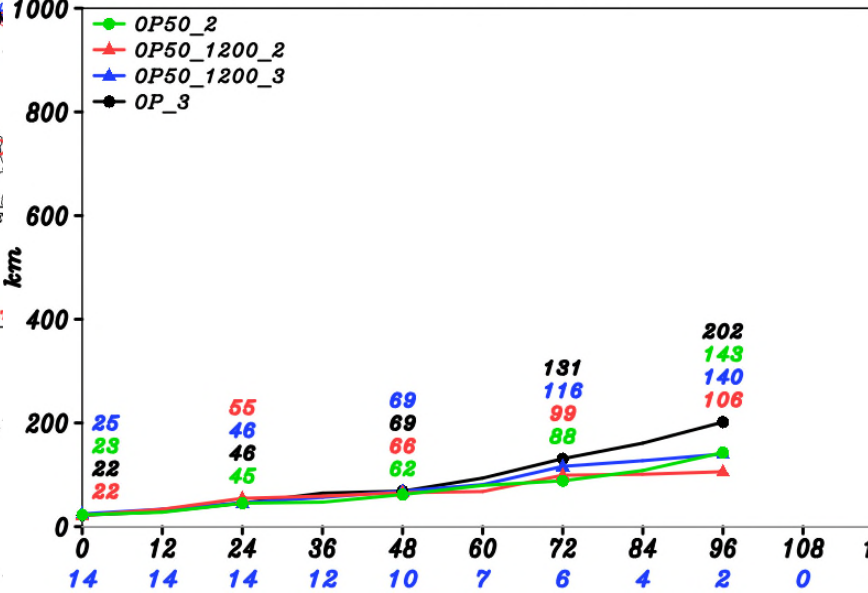
TWRF_OP

TWRF (3KM) TYPHOON TRACK FORECAST (24/11/11/18Z ~ 24/11/15/00Z)

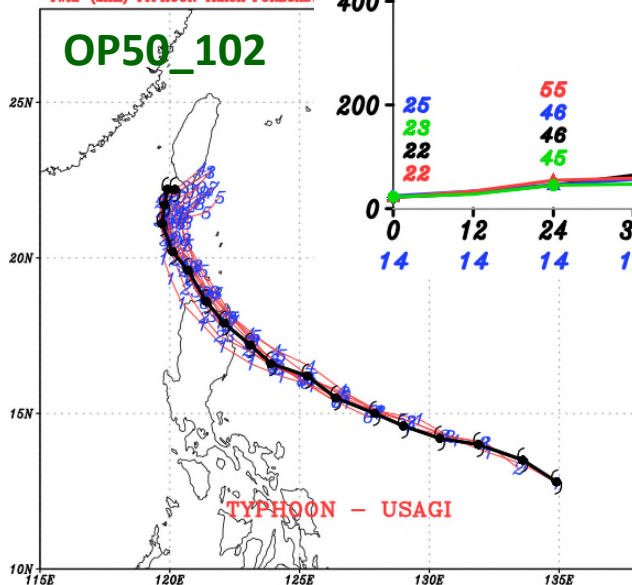


OP50_153_1200

Track Error d02

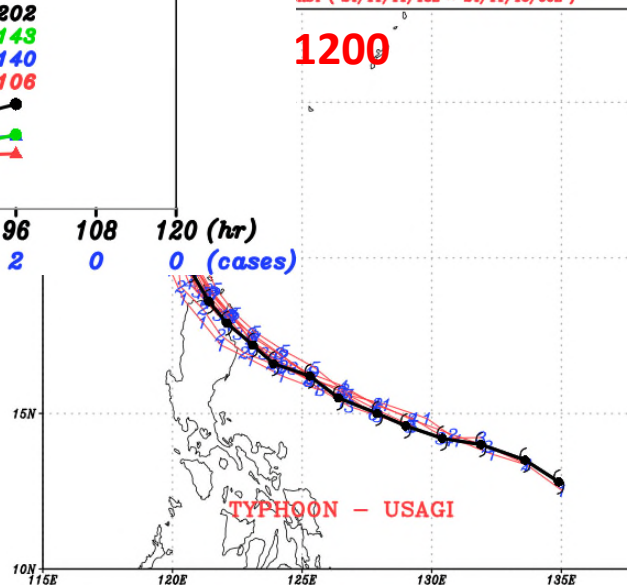


TWRF (2KM) TYPHOON TRACK FORECAST



OP50_102

TWRF (2KM) TYPHOON TRACK FORECAST (24/11/11/18Z ~ 24/11/15/00Z)



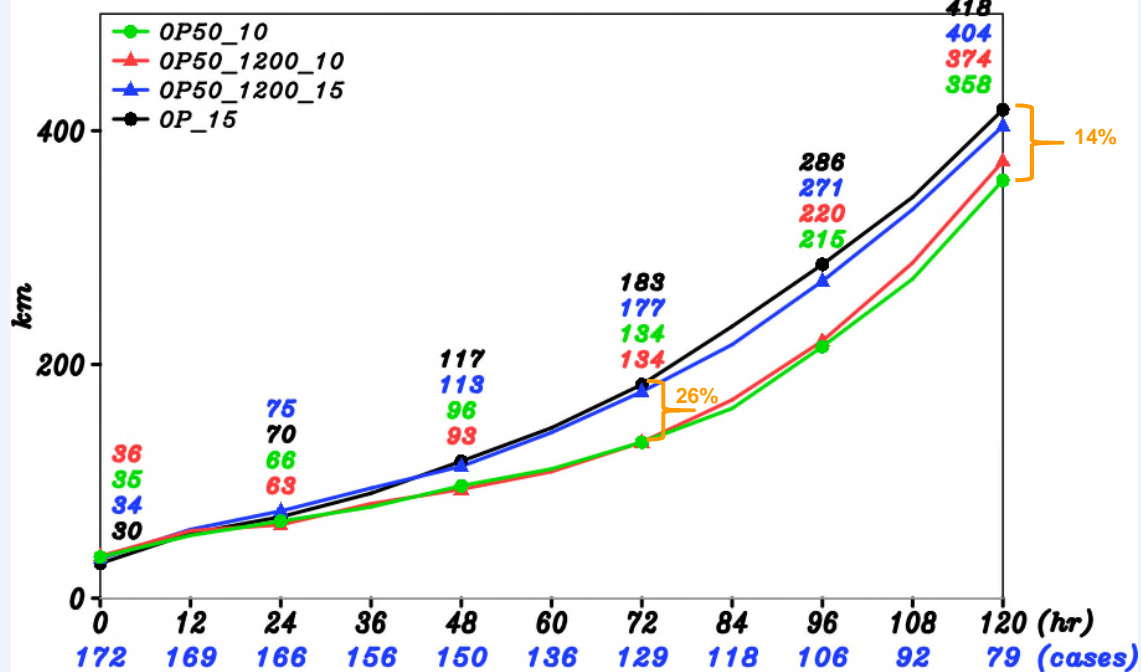
1200

TY USAGI (2024)

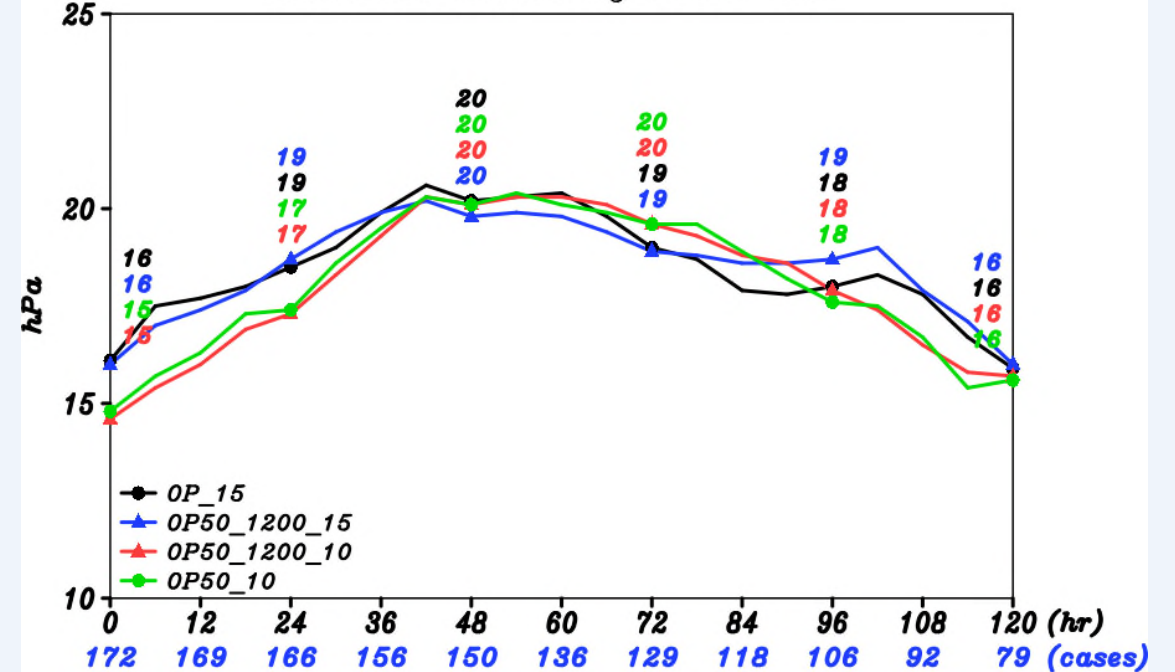
D02: Domain 2
(3 or 2 km)

Experiment result for TWRF_D01 11TCs 172cases

Track Error d01

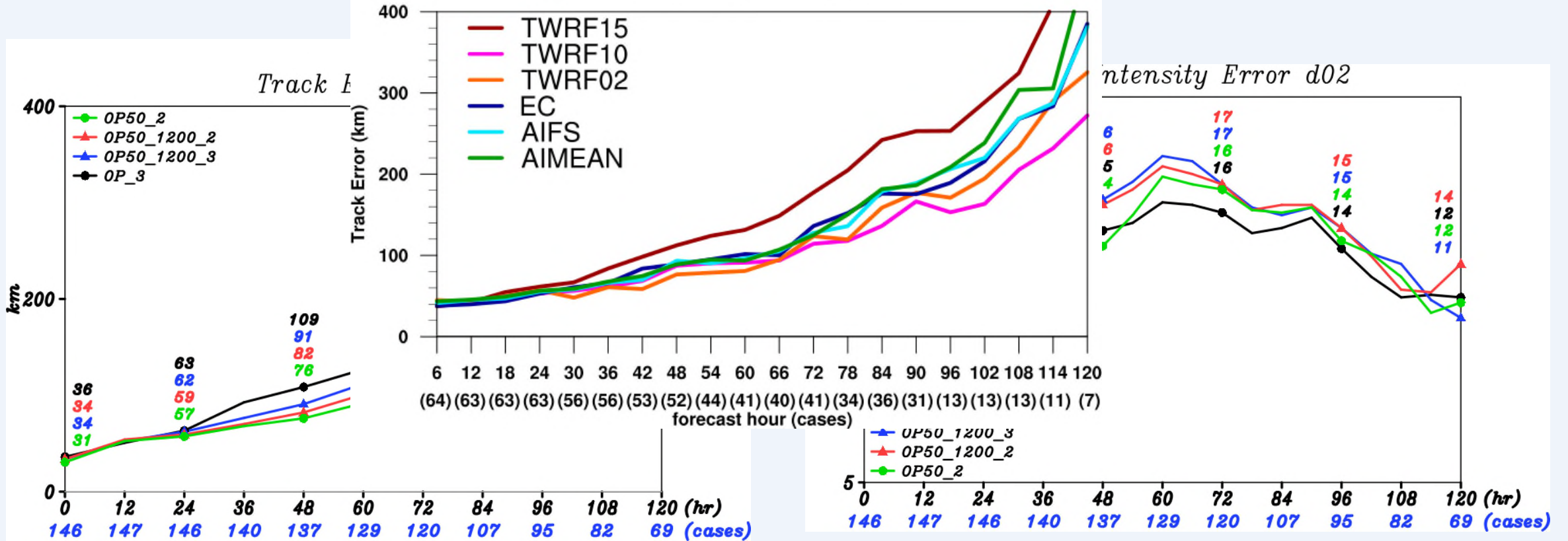


Absolute Intensity Error d01



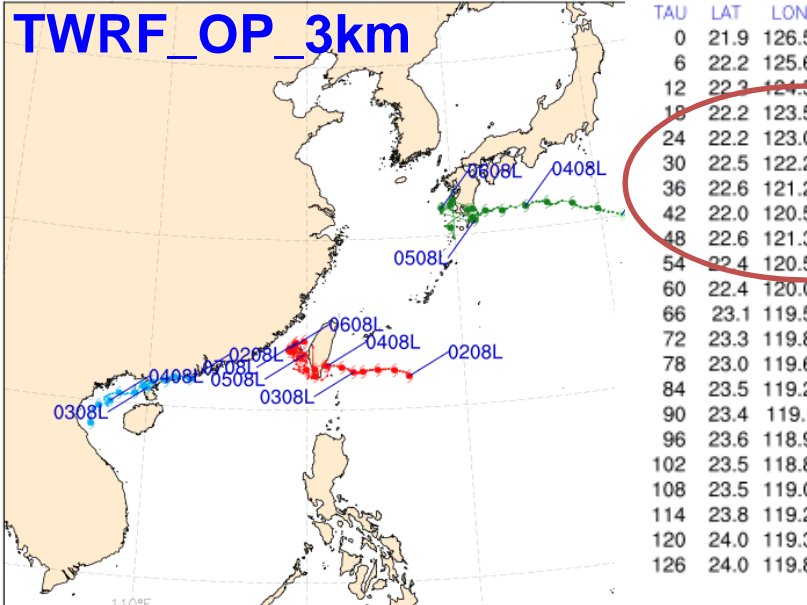
Experiment result for TWRF_D02 10TCs 146cases

24072006-24111500_TWRF



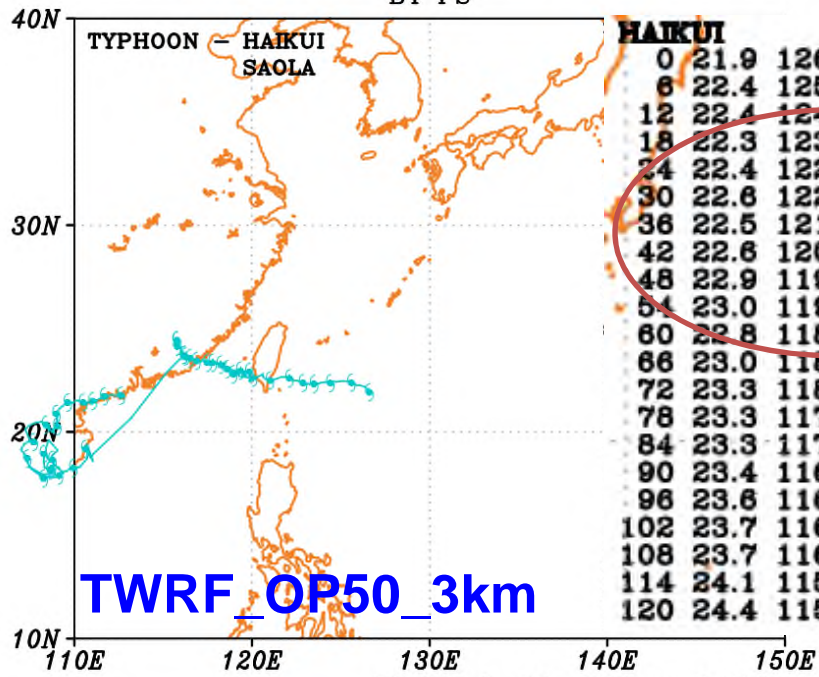
颱風登陸減弱太快

CWB/TWRF (3km) Typhoon Track Forecast
Initial at 2023090200 SLP



TYPHOON - HAIKUI				
TAU	LAT	Lon	PMIN	km/hr
0	21.9	126.5	945.6	
6	22.2	125.6	937.7	17.2
12	22.3	124.5	931.0	18.2
18	22.2	123.5	920.5	18.4
24	22.2	123.0	922.6	10.2
30	22.5	122.2	933.3	13.8
36	22.6	121.2	973.8	18.2
42	22.0	120.5	986.9	16.1
48	22.6	121.3	991.2	17.4
54	22.4	120.5	990.9	13.9
60	22.4	120.0	991.7	9.2
66	23.1	119.5	989.0	15.4
72	23.3	119.8	992.0	6.5
78	23.0	119.6	990.2	5.5
84	23.5	119.2	992.3	10.2
90	23.4	119.1	991.1	2.3
96	23.6	118.9	993.4	4.4
102	23.5	118.8	992.2	3.0
108	23.5	119.0	993.7	3.3
114	23.8	119.2	992.8	7.6
120	24.0	119.3	994.9	2.1
126	24.0	119.8	992.4	8.8

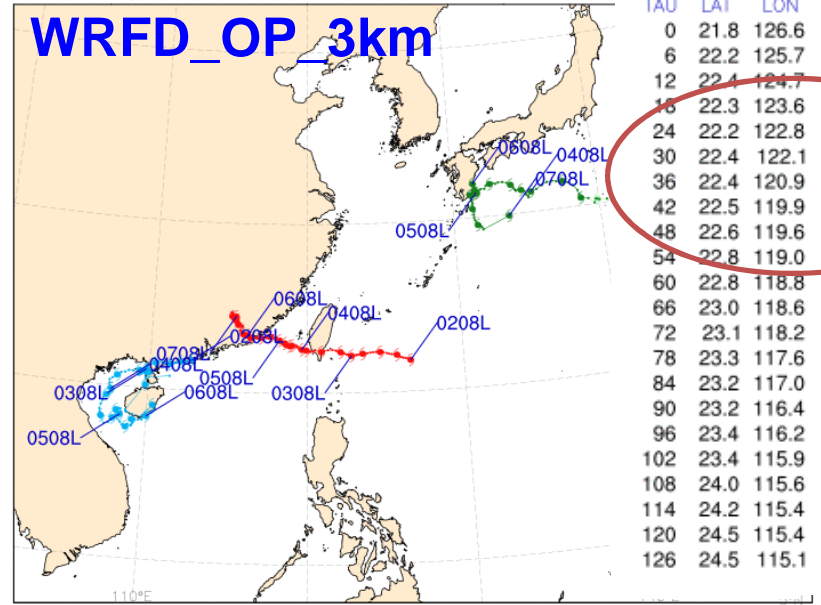
TWRF(3km) TYPHOON TRACK FORECAST(23/09/02/00UTC)
BY PS



TYPHOON - HAIKUI			
TAU	LAT	Lon	PMIN
0	21.9	126.6	946.9
6	22.4	125.6	944.0
12	22.4	124.4	934.0
18	22.3	123.5	926.3
24	22.4	122.9	922.5
30	22.6	122.1	926.8
36	22.5	121.0	954.0
42	22.6	120.1	975.8
48	22.9	119.8	977.2
54	23.0	119.3	975.8
60	22.8	118.9	976.3
66	23.0	118.6	973.5
72	23.3	118.2	971.9
78	23.3	117.8	971.4
84	23.3	117.5	974.8
90	23.4	116.9	977.3
96	23.6	116.5	983.0
102	23.7	116.2	985.9
108	23.7	116.2	991.1
114	24.1	115.8	993.4
120	24.4	115.8	997.0

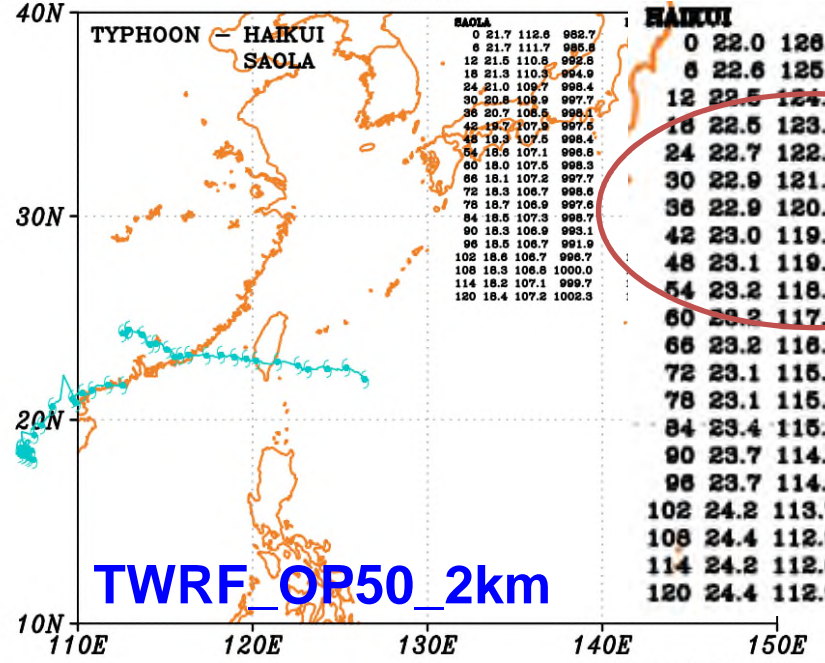
TWRF2.5_OP_153km_D1D2

CWB/WRFM04 (3km) Typhoon Track Forecast
Initial at 2023090200 SLP



TYPHOON - HAIKUI				
TAU	LAT	Lon	PMIN	km/hr
0	21.8	126.6	953.9	
6	22.2	125.7	954.8	16.0
12	22.4	124.7	950.8	18.6
18	22.3	123.6	939.6	19.2
24	22.2	122.8	931.6	12.7
30	22.4	122.1	933.7	12.5
36	22.4	120.9	963.7	21.2
42	22.5	119.9	973.2	16.5
48	22.6	119.6	977.8	5.2
54	22.8	119.0	977.1	11.4
60	22.8	118.8	980.4	3.1
66	23.0	118.6	980.6	5.8
72	23.1	118.2	981.1	6.6
78	23.3	117.6	979.3	10.8
84	23.2	117.0	980.9	10.6
90	23.2	116.4	983.2	10.8
96	23.4	116.2	986.1	4.6
102	23.4	115.9	989.2	5.0
108	24.0	115.6	993.1	11.6
114	24.2	115.4	995.1	5.0
120	24.5	115.4	998.6	4.8
126	24.5	115.1	997.9	4.0

TWRF(2km) TYPHOON TRACK FORECAST(23/09/02/00UTC)
BY PS



TYPHOON - HAIKUI			
TAU	LAT	Lon	PMIN
0	21.7	112.6	982.7
6	21.7	111.7	985.6
12	21.5	110.8	992.6
18	21.3	110.3	994.9
24	21.0	109.7	998.4
30	20.8	108.9	997.7
36	20.7	108.5	998.1
42	19.7	107.9	997.6
48	19.3	107.5	998.4
54	18.6	107.1	998.8
60	18.0	107.5	998.3
66	18.1	107.2	997.7
72	18.3	106.7	998.6
78	18.7	106.9	997.6
84	18.5	107.3	998.7
90	18.3	106.9	993.1
96	18.5	106.7	991.9
102	18.6	106.7	996.7
108	18.3	106.8	1000.0
114	18.2	107.1	999.7
120	18.4	107.2	1002.3

TWRF_OP50_102

TWRF模式解析度提升至10/2公里之影響評估

實驗設計及個案選取

	Resolution	Model Ver.
TWRF_OP	15/3 km	OP44 (WRF 381)
OP50_102	10/2 km	OP50 (WRF 442)
OP52_102	10/2 km	OP52 (WRF 442)

#	typhoon	Intensity	Movement	Date	Cases no. (15km / 3km)
1	* KONG-REY (康芮) (2421)	Strong	Westward	2024/10/25/00Z~10/31/00Z	25 / 24
2	* USAGI (天兔) (2425)	Medium-strength	Westward	2024/11/11/18Z~11/15/00Z	14 / 14
3	MAN-YI (萬宜) (2424)	Strong	Westward	2024/11/11/18Z~11/15/00Z	14 / 11
Total cases (2024年・3個颱風)					53 / 49

WRFD版本已更新至OP52

➤ OP51更新項目：

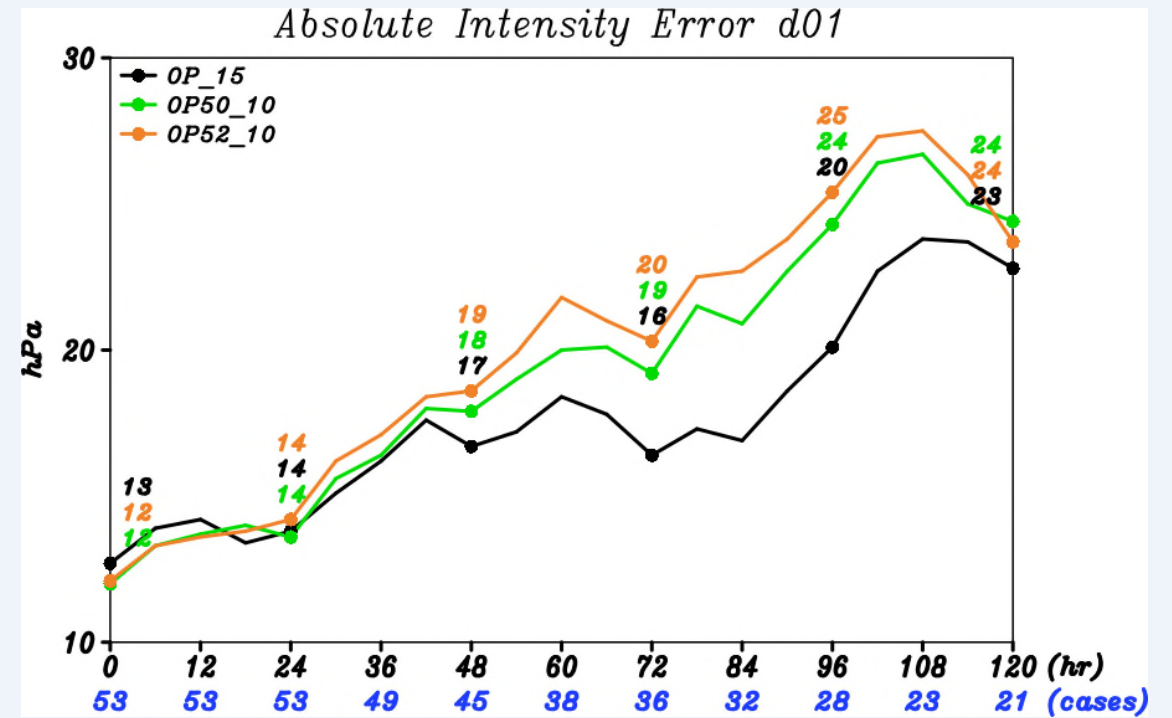
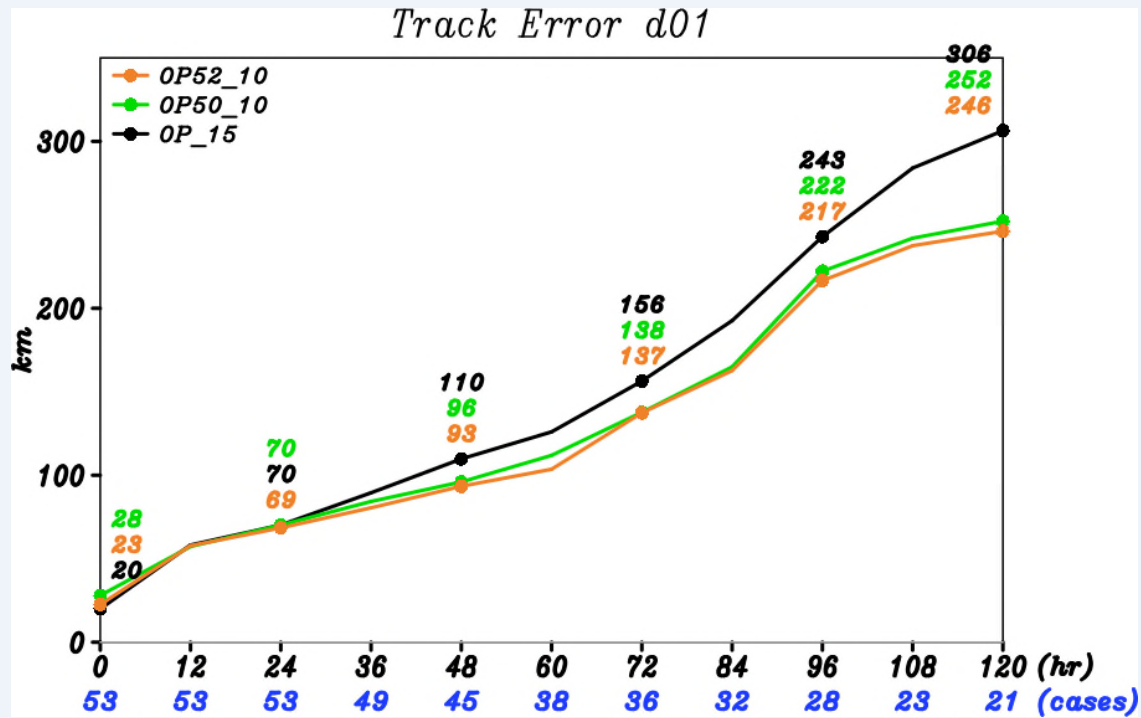
- Diffusion方案更換：diffopt=2 (改善Q2預報表現)
- NOAH土壤參數法優化 (改善urban之T2預報表現)
- ✓ 改善Q2夜間乾偏差及T2日間冷偏差，於113/12/12更新上線

➤ OP52更新項目：TCWA1優化

- ✓ 改善綜觀及強降水預報表現，於114/06/23更新上線
- 113年天氣分析研討會 (游承融)

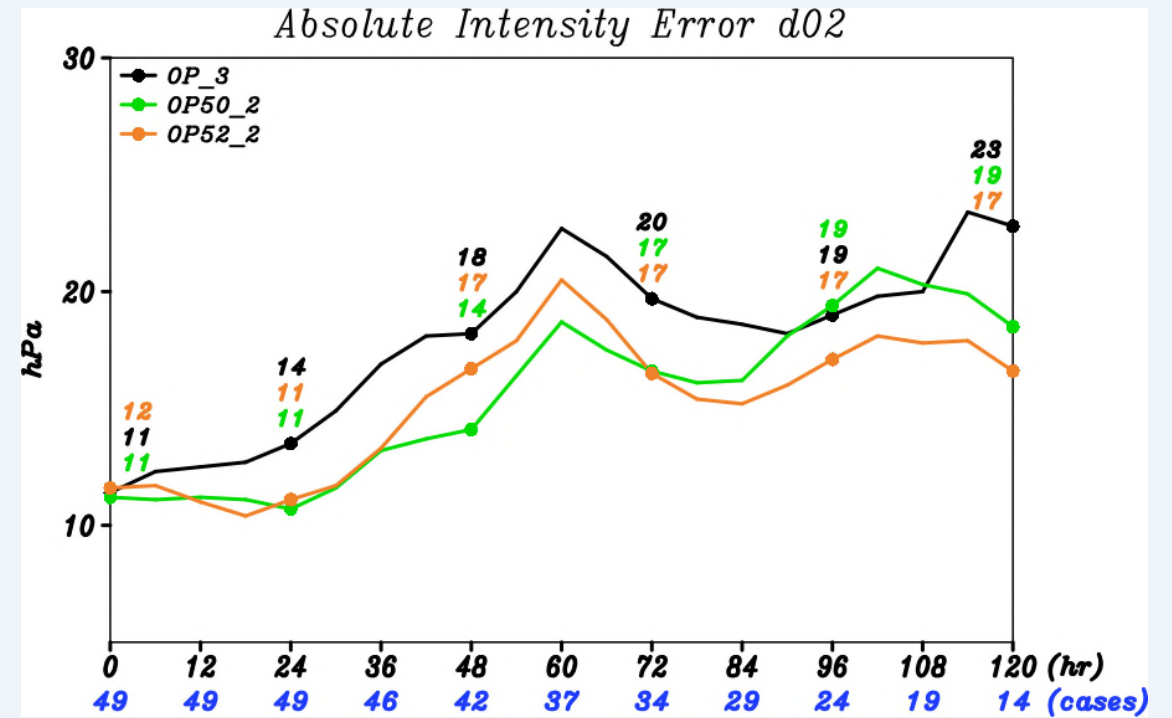
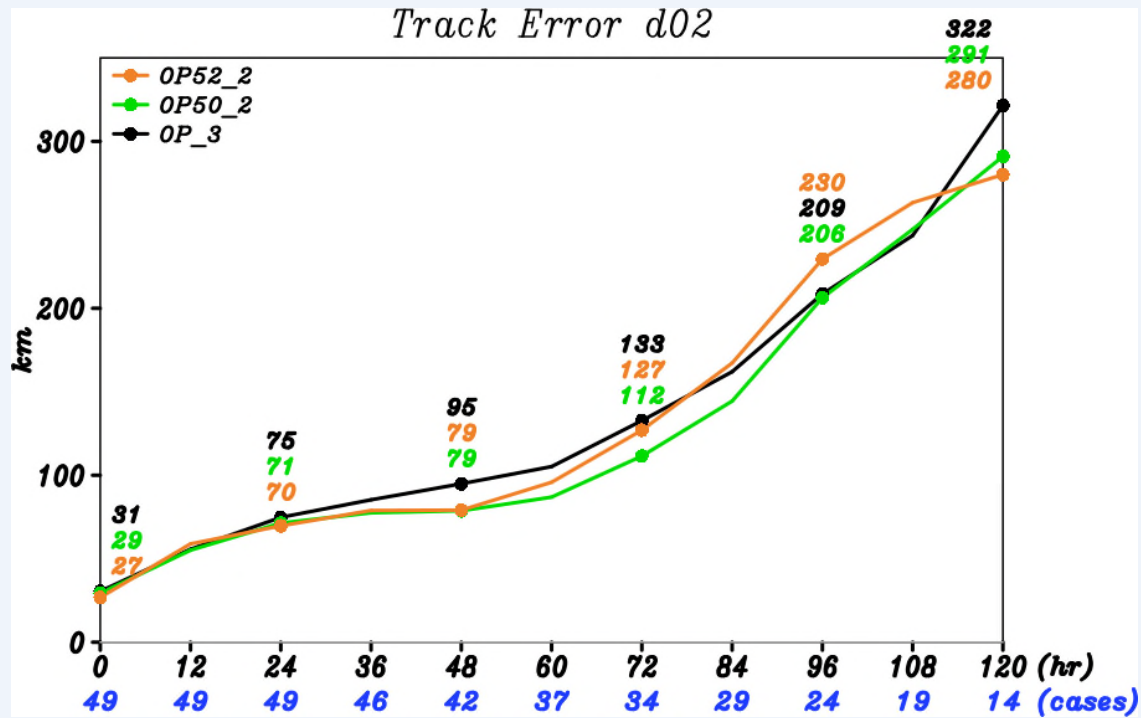
Experiment result for TWRF_D01

3TCs 53cases



Experiment result for TWRF_D02

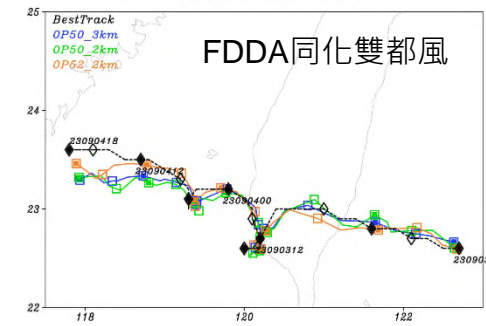
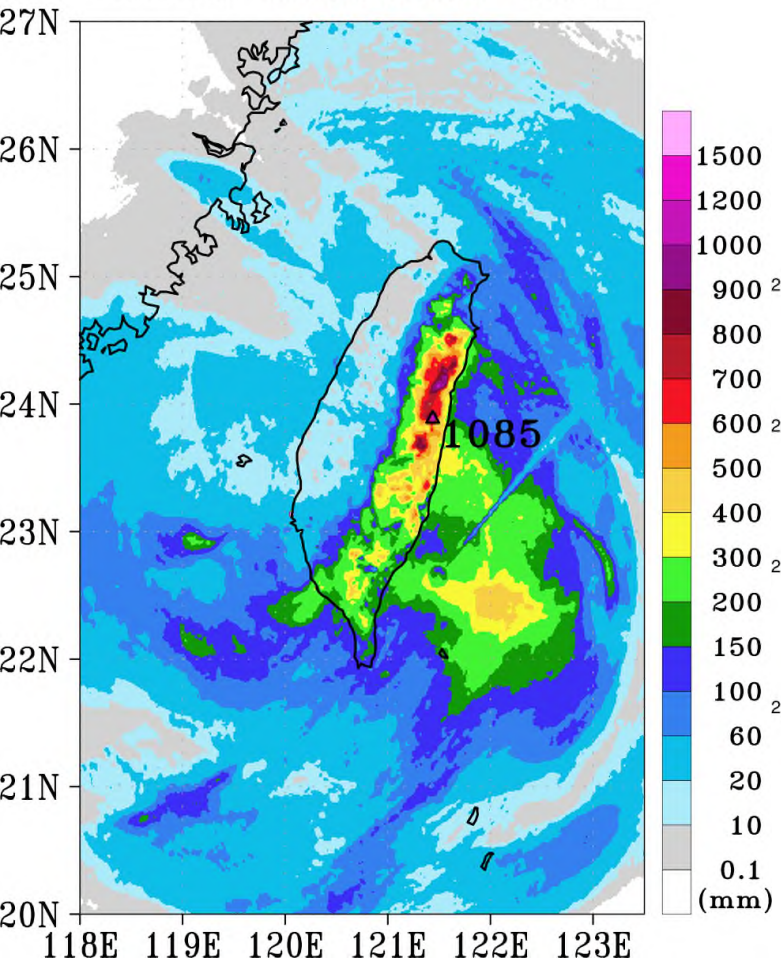
3TCs 49cases



QPESUMS

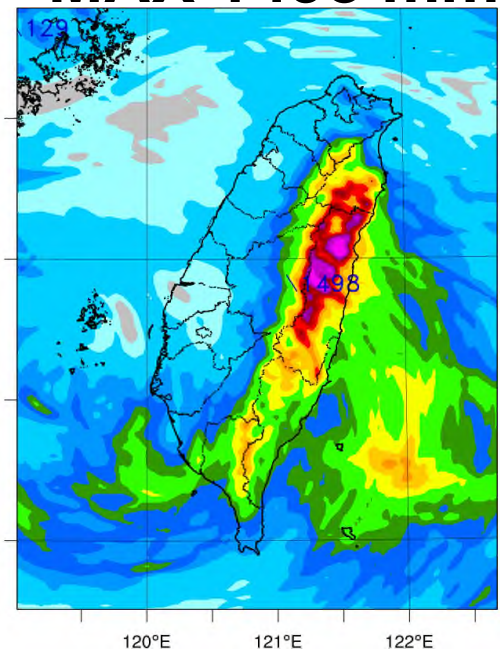
MAX 1085 mm

from 23090300 42h



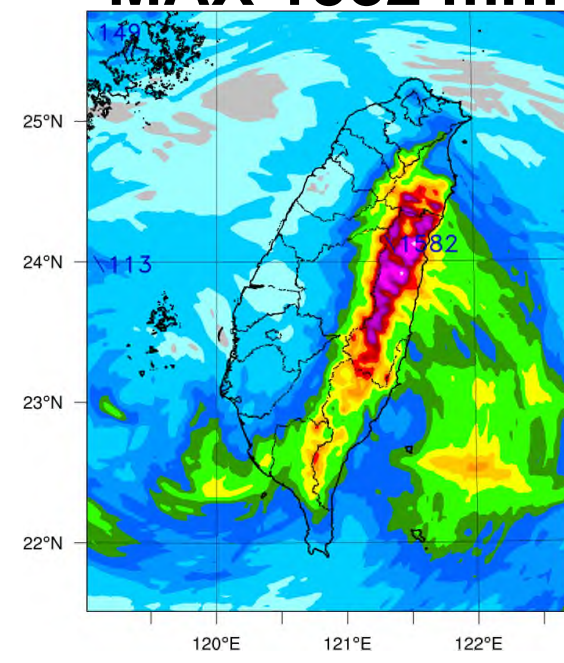
OP50 153

MAX 1498 mm



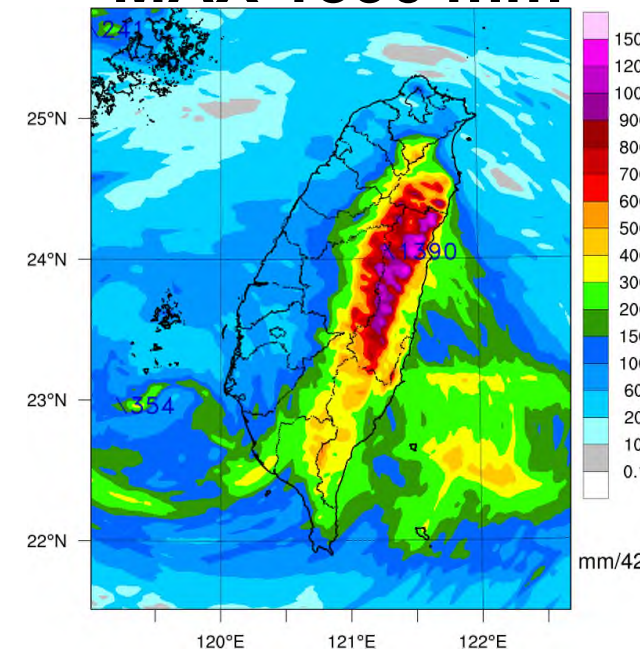
OP50 102

MAX 1582 mm



OP52 102

MAX 1390 mm





總結

- 提升模式網格解析度能明顯改進颱風路徑預報，72小時預報誤差提升**26%**，120小時預報誤差則可改善**14%**。
- 模式版本升級至OP50，可以改善颱風登陸之後強度迅速減弱的情況。
- 在颱風降雨個案中，顯示2公里網格可以模擬出更細緻的雨量分布，優化TCWA1微物理參數化，可改善山區降水過度預報。

未來工作

- 持續進行OP52颱風個案實驗，預計2026年提出上線作業申請。





謝謝聆聽
敬請指教

