

評估提高TWRF解析度及運用FDDA同化雙都風 對颱風與降雨模擬之效應

徐驊 陳得松 謝佳宏 鄭浚騰 蕭玲鳳 張保亮 洪景山

Central Weather Administration, Taiwan (CWA)

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Outline

1. Chanthu (2021) 預報表現有待改進: 路徑、強度、size、
台灣地區降雨
2. 現行 TWRF 對於 Chanthu 颱風的預報表現
3. 使用 FDDA 納進雙都風，對於颱風模擬的改善
4. 增加模式解析度至 1 km，對於颱風模擬的改善

誤差來源

雖然TWRP預報燦樹颱風造成台灣地區降雨預報

誤差不大，然而

1. 預報之颱風移速過慢

24-h 路徑誤差~140 km

2. 24-h 內強度誤差持續很大，~20 hPa

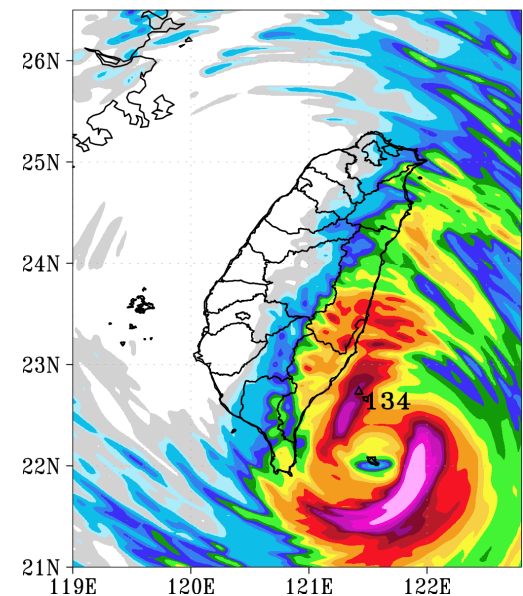
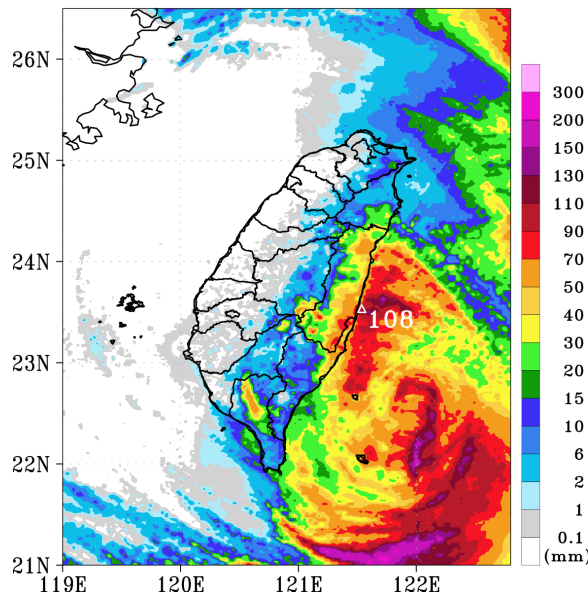
顯示模式對於此類型預報仍有改進空間

QPEsums

OP50

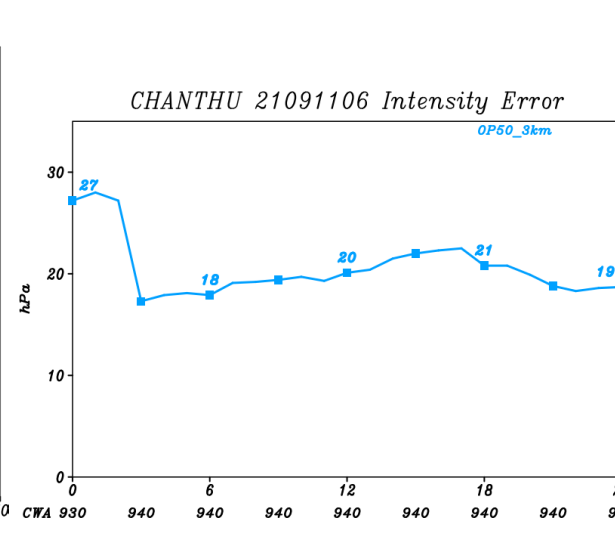
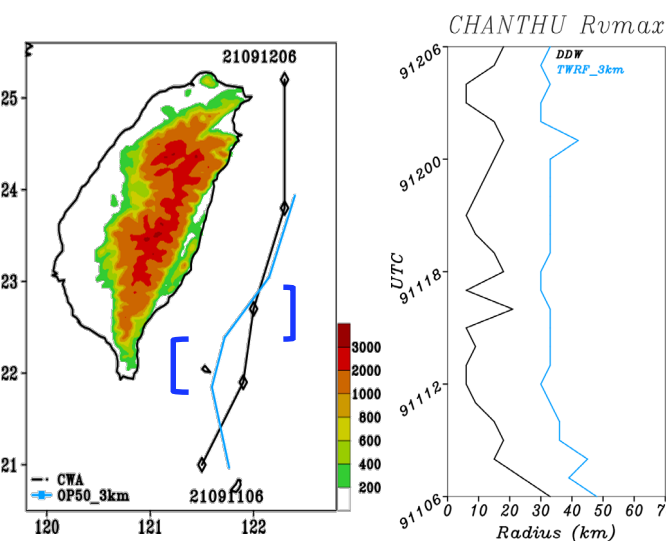
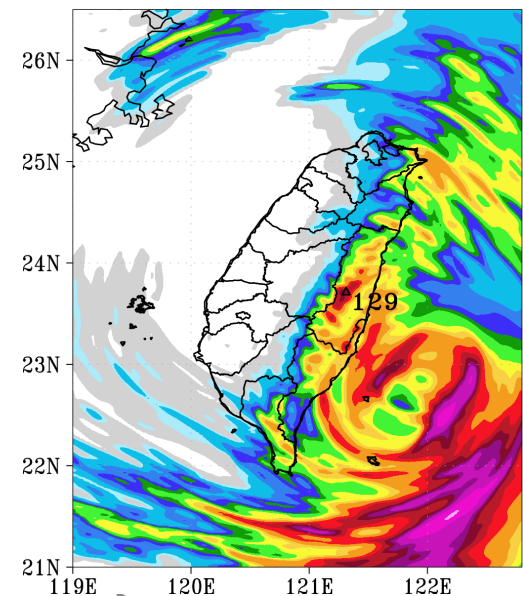
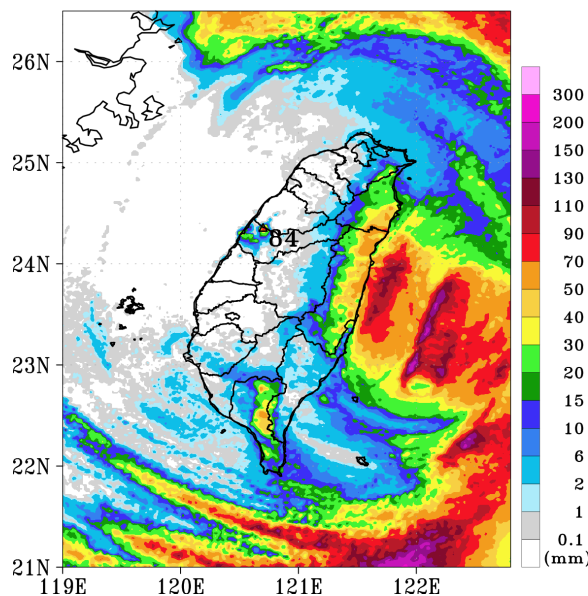
21/09/11 12~18 UTC

Lead Time: 6~12 h

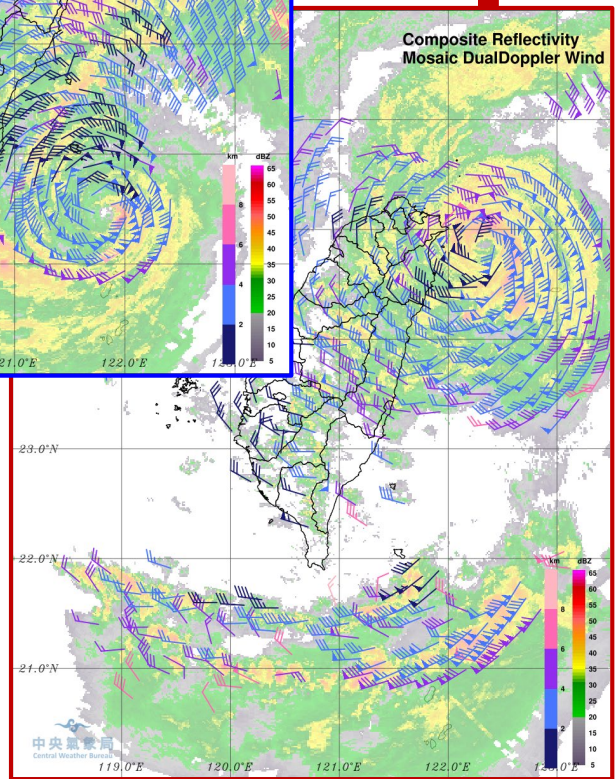
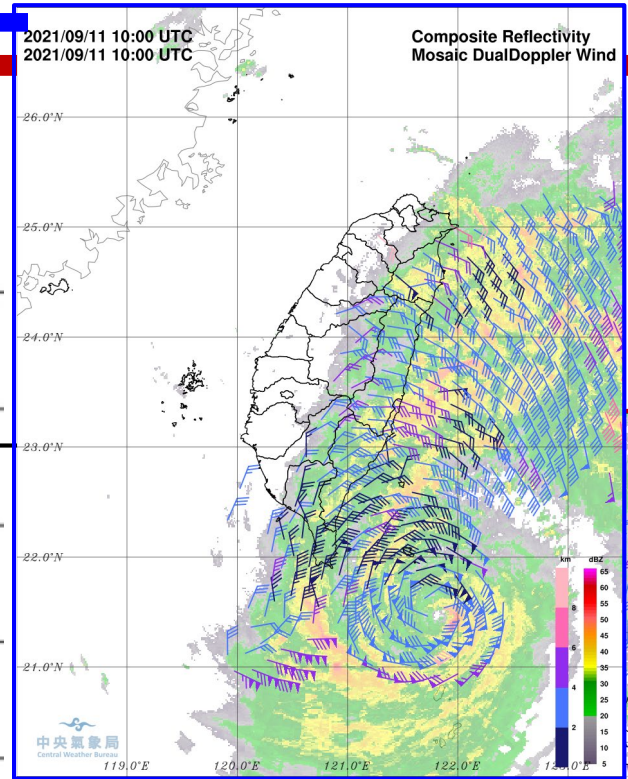
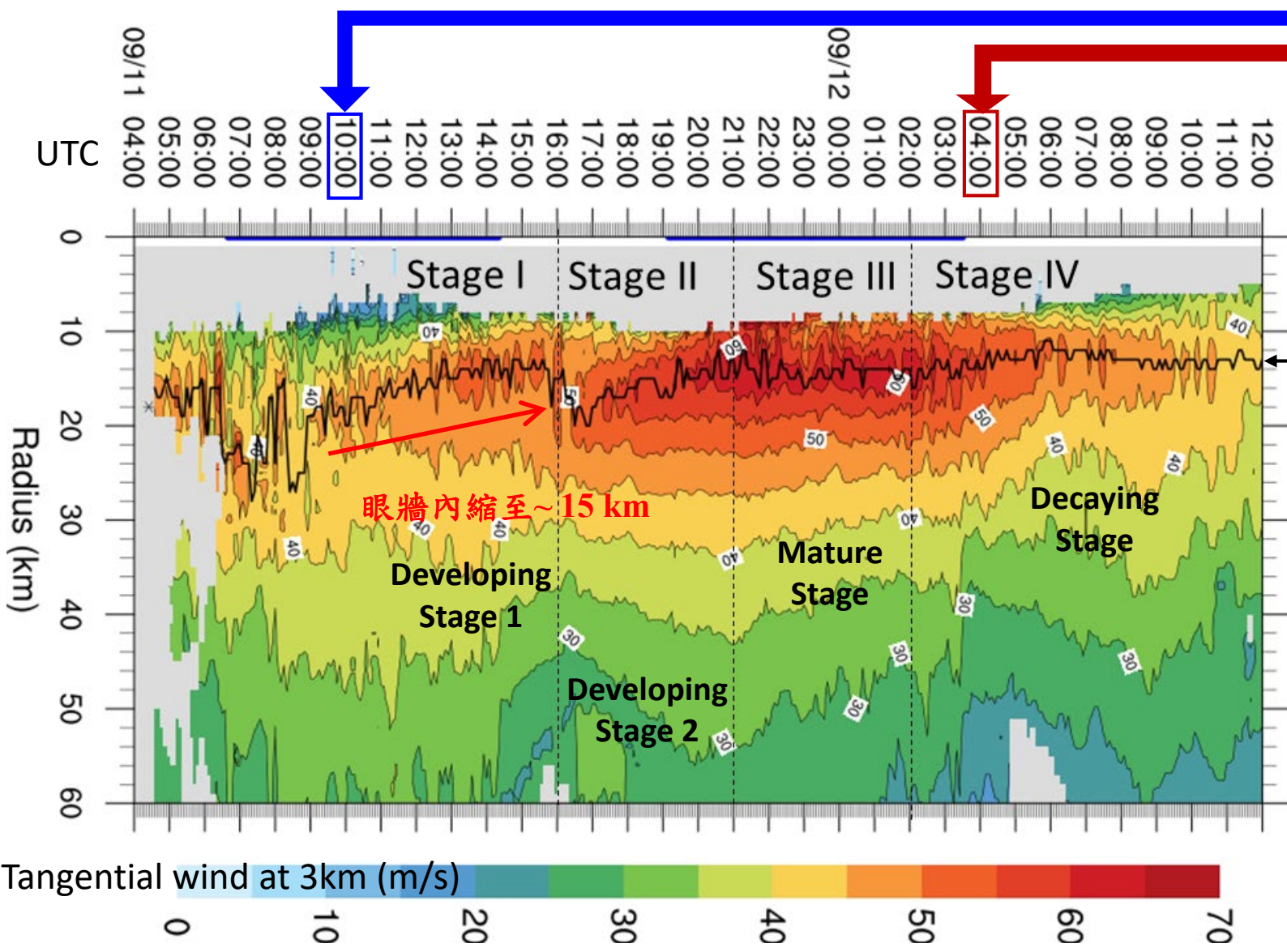


21/09/11 18~09/12 00 UTC

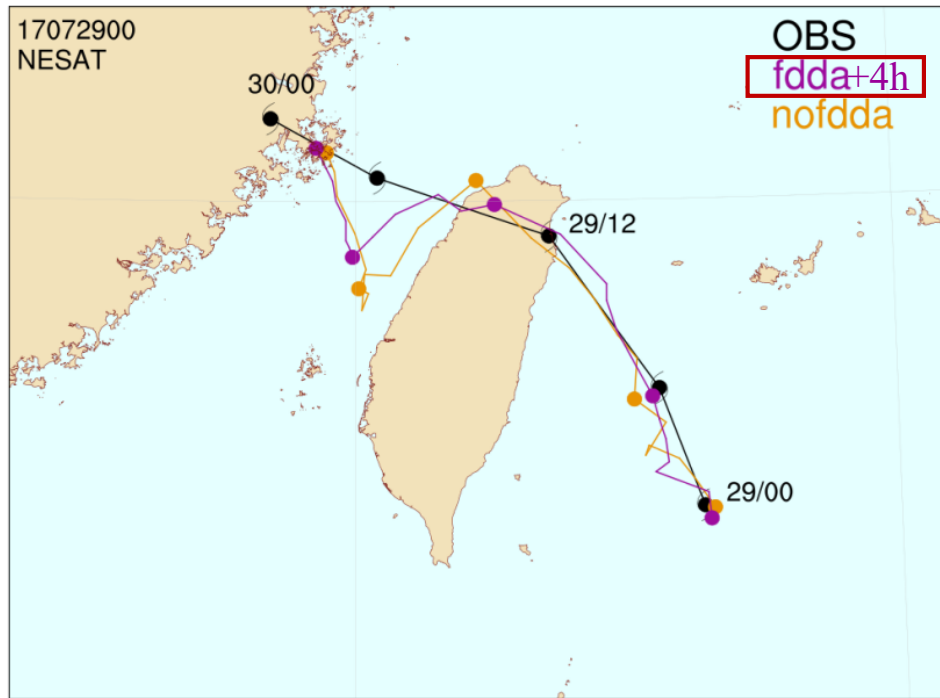
Lead Time: 12~18 h



Tangential Wind at 3-km Altitude for Typhoon Chanthu

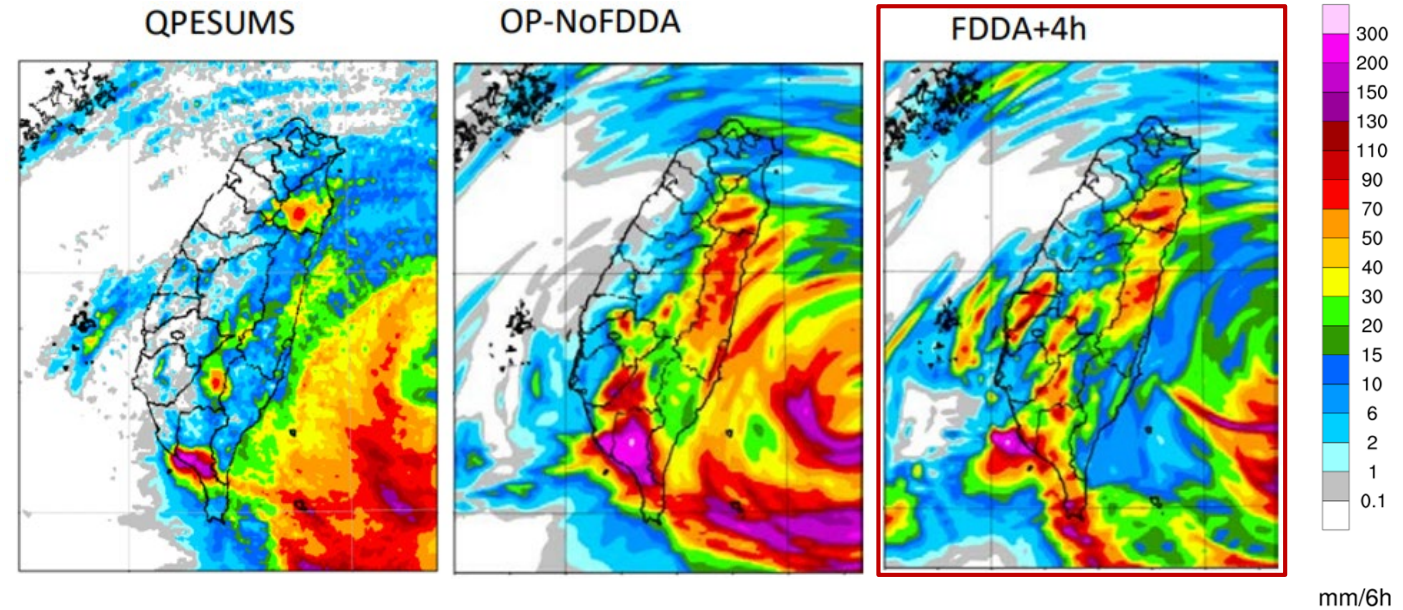


FDDA Assimilates Dual-Doppler Radar-retrieval Wind



FDDA improves track forecast by **reducing ~ 20 km track error** during 6~18-hour forecast period

6-hour accumulated rainfall 29/00~06 UTC



FDDA improves rainfall forecast by **reducing the large bias over the land**



Adopting FDDA to nudge DDW in the whole simulation period

Why do we adopt FDDA?

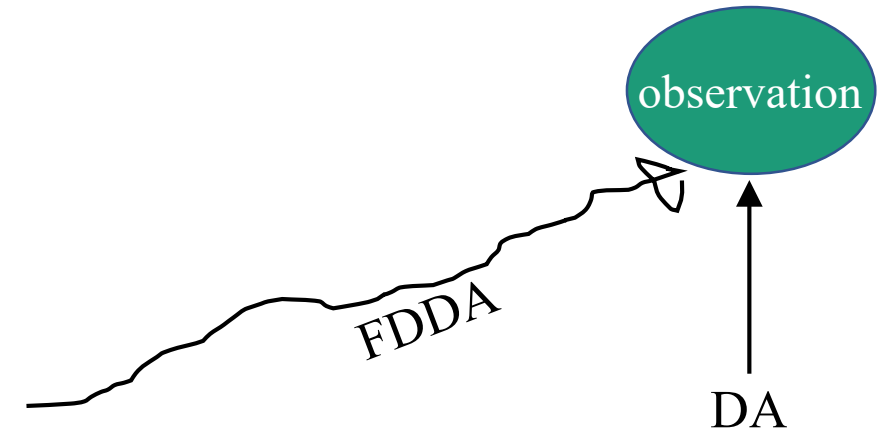
1. Computationally **simple**

Only requires adding an additional tendency term

Don't need the details of error covariance information

2. **Keep the model solution in balance** in every time step

Continuously assimilates observations into the mesoscale models through a nudging/Newtonian relaxation approach and **gradually forces** the model state toward the observational state



$$\frac{\partial q\mu}{\partial t}(x, y, z, t) = F_q(x, y, z, t) + \mu G_q \frac{\sum_{i=1}^N W_q^2(i, x, y, z, t) [q_o(i) - q_m(x_i, y_i, z_i, t)]}{\sum_{i=1}^N W_q(i, x, y, z, t)}$$

Model forecast variables (points to the left side of the equation)
 Dry hydrostatic pressure (points to F_q)
 Physical tendency term (points to F_q)
 Nudging coefficient (points to μ)
 Current observation index (points to i in the numerator)
 Observation value (points to $q_o(i)$)
 Model value at observation location (points to $q_m(x_i, y_i, z_i, t)$)
 Spatiotemporal weighting function (points to W_q in the denominator)

➡ Abundant dual-Doppler radar-retrieval wind (DDW) are available when typhoon is near Taiwan

Motivation

1. 台灣地區的颱風降雨主要受颱風位置與強度影響

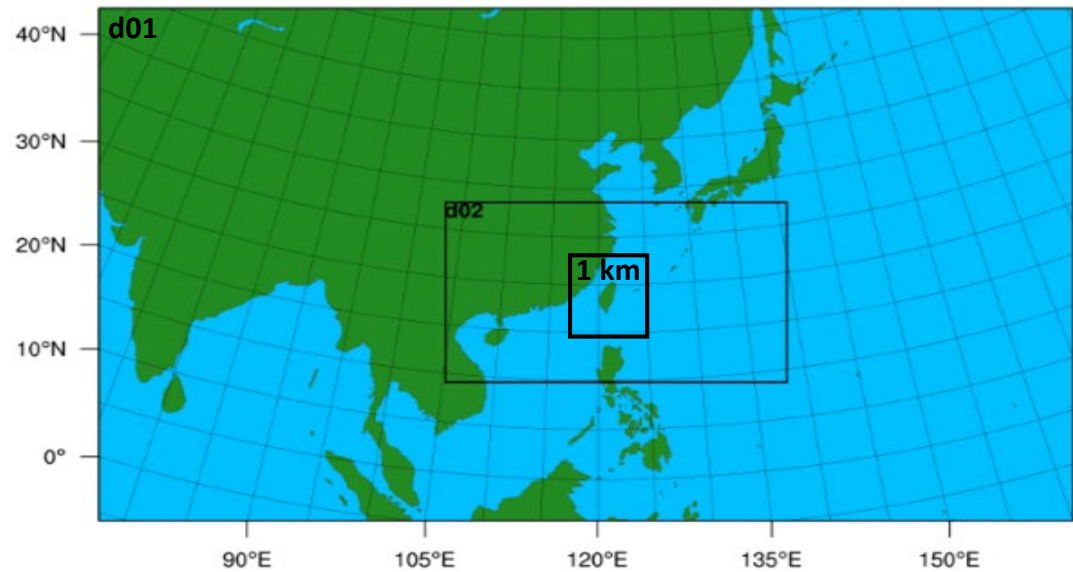
當颱風路徑與強度更接近實際觀測

TWRF模式對於降雨的掌握能力？

2. 提高TWRF解析度對於颱風眼是否有更好的掌握？

3. 提高TWRF解析度對於台灣地區降雨的改善程度為何？

Configuration of TWRF



Domain	D01	D02	1 km
Grid points	662*386	1161*676	799*919
Resolution (km)	15	3	1
Vertical level		52	
Physical scheme		Goddard	
Cumulus parameterization scheme	Kain-Fritsch		-----
Planetary boundary layer scheme		YSU	
Land surface process scheme	Noah land surface model		-----
Radiation process scheme		RRTMG	
Cold start initial boundary condition	NCEP GFS analysis		D02

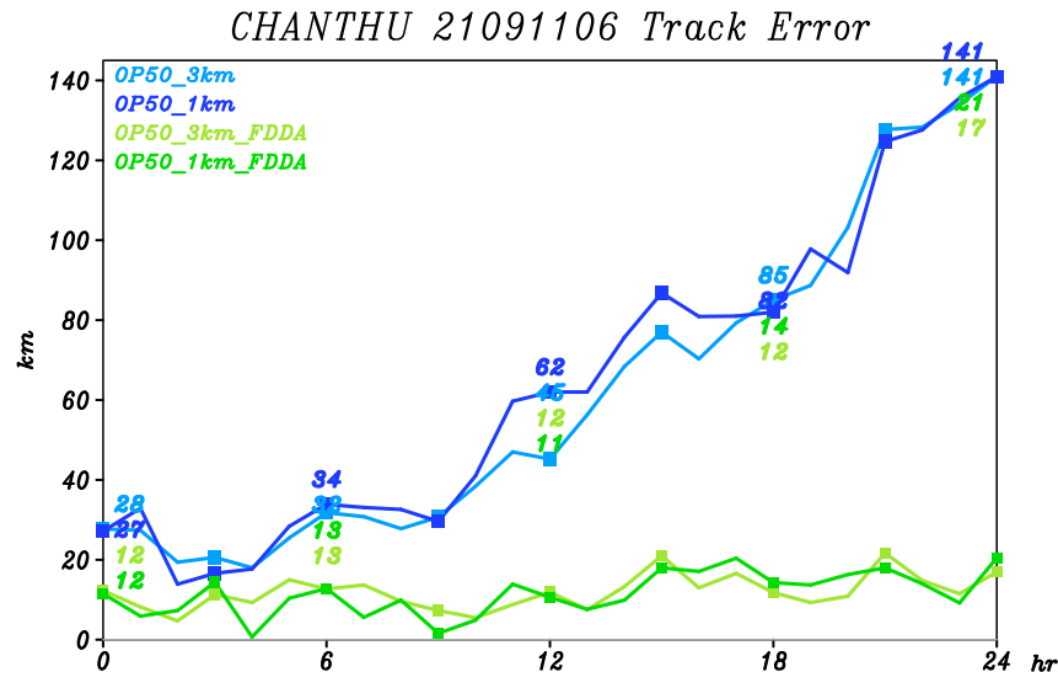
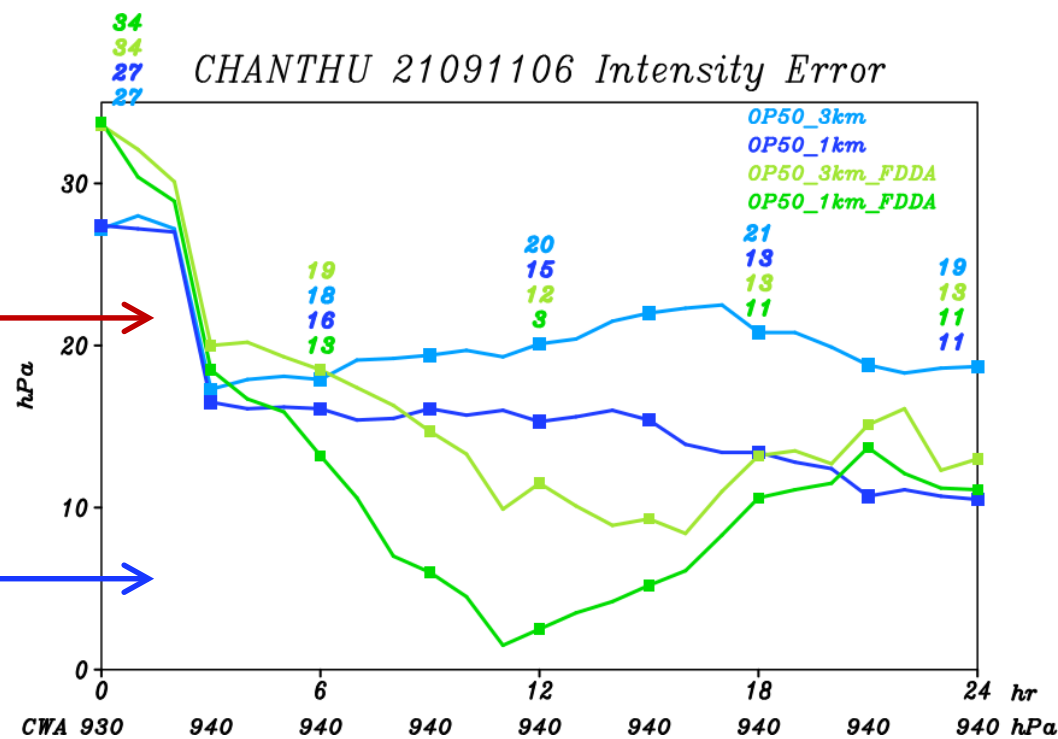
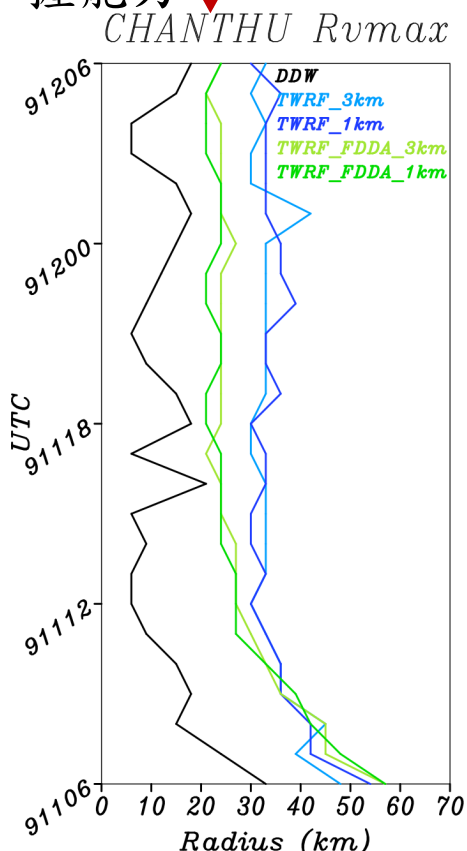
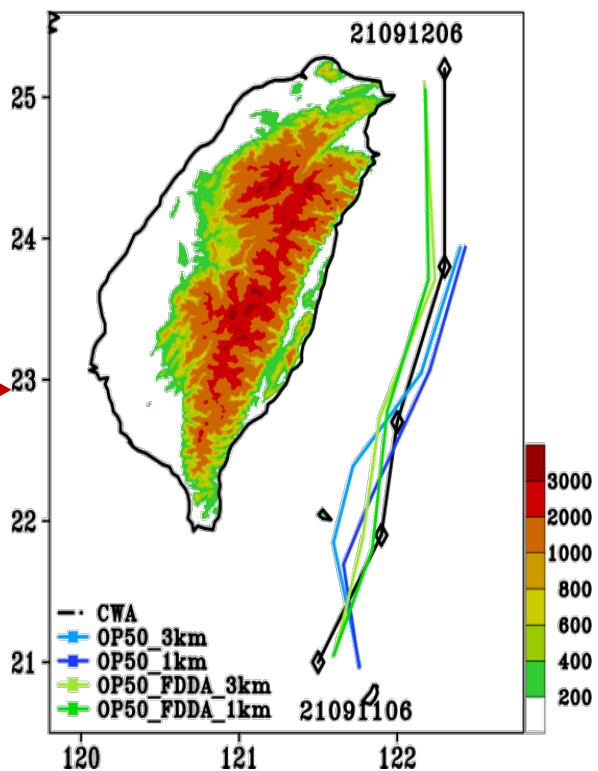
Variation of Track, Intensity, Radius of $V_{max_{3km}}$

使用 FDDA

1. 使颱風路徑更貼近觀測，改善模式原先颱風移速過慢的情形
2. 改善模式對於颱風強度變化的掌握
3. 最強風速半徑可模擬至 25 km

提高模式解析度至 1 km

1. 主要改善模式對於颱風強度的掌握能力



6-h QPE & QPF

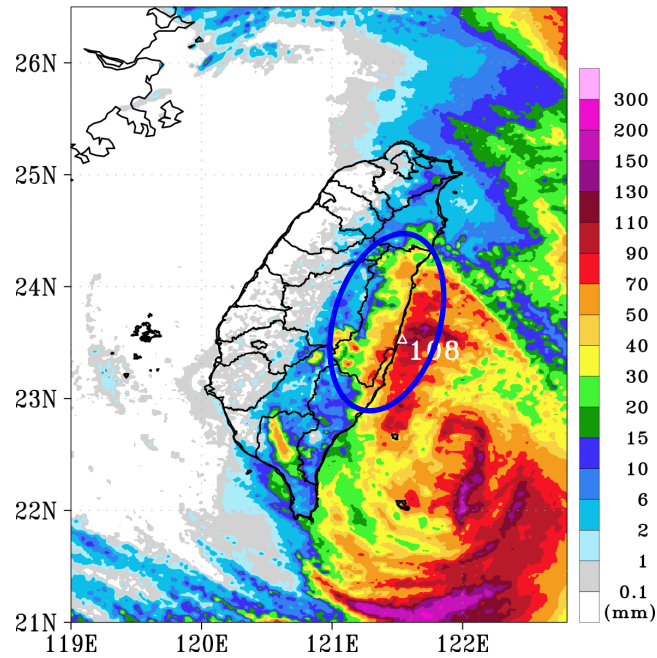
lead time 6 ~ 12 h

initial time 21/09/11 06 UTC

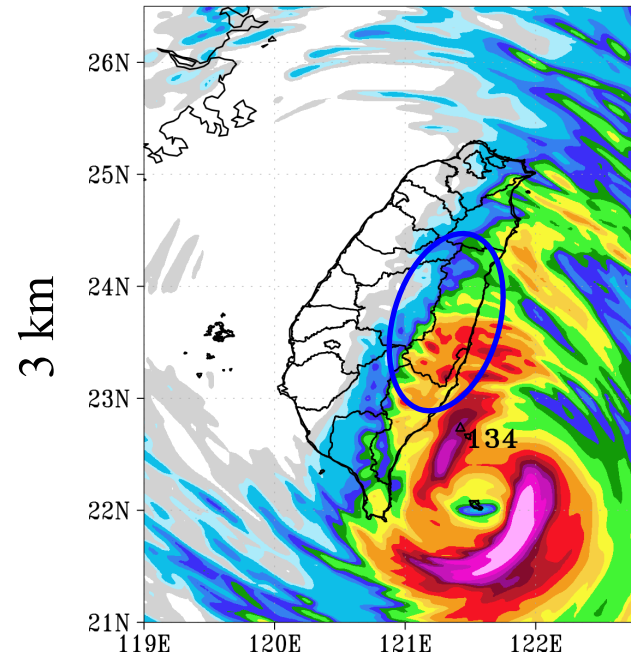
valid time 21/09/11 12~18 UTC

1. 路徑差異不大時，
FDDA可使模式降
雨位置更接近觀測

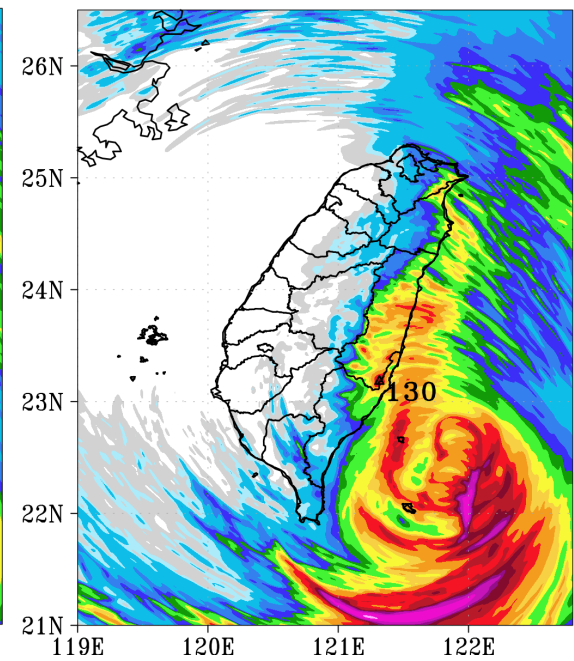
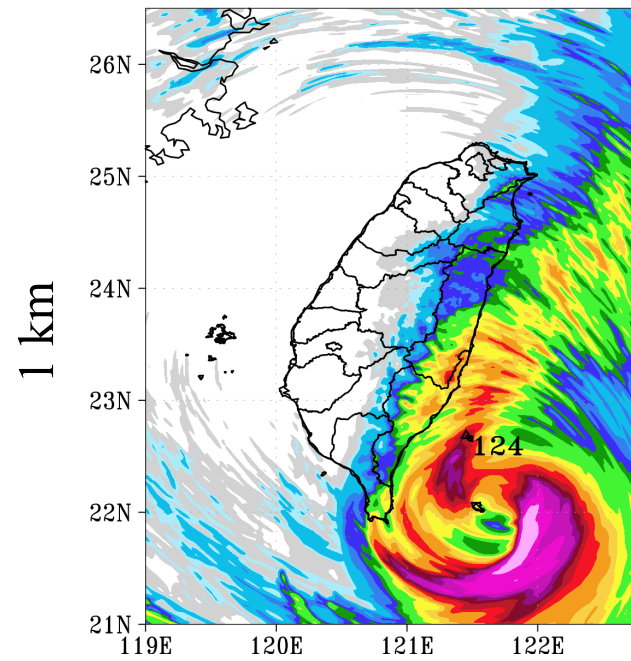
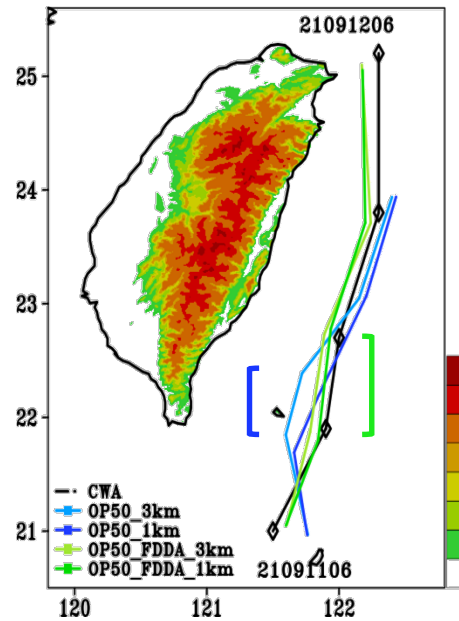
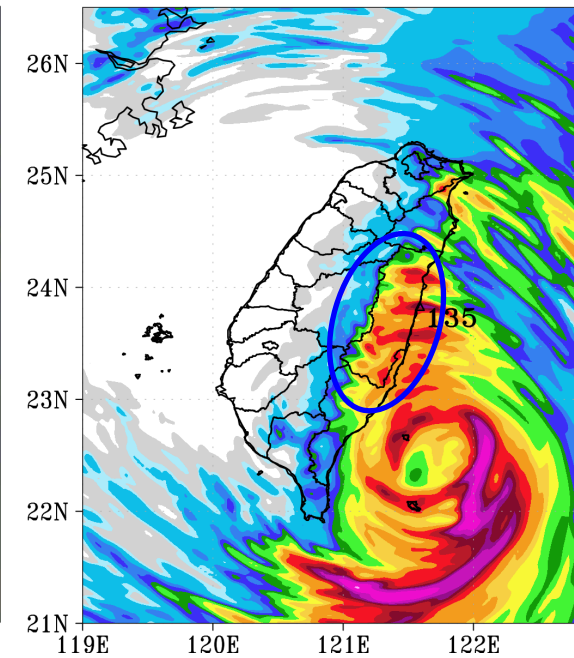
QPEsums



OP50



OP50_FDDA_DDW



6-h QPE & QPF

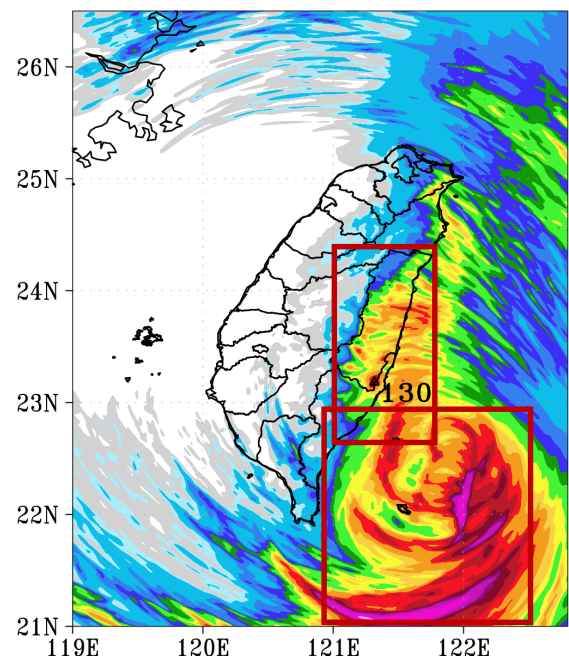
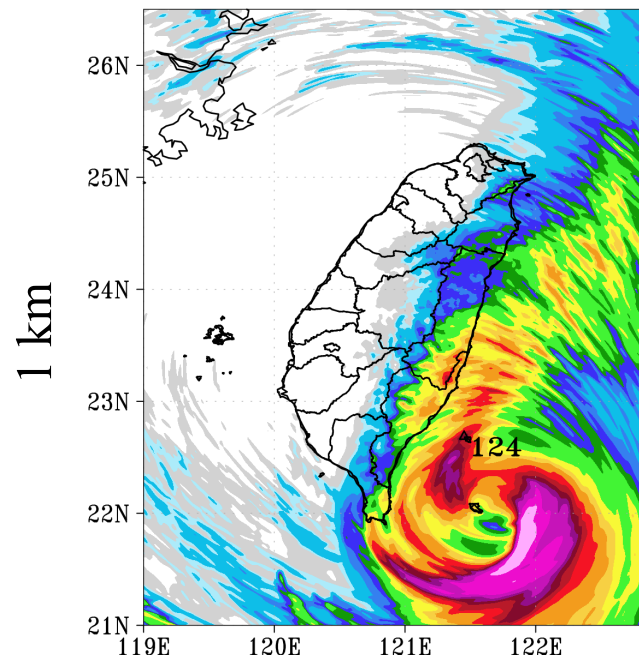
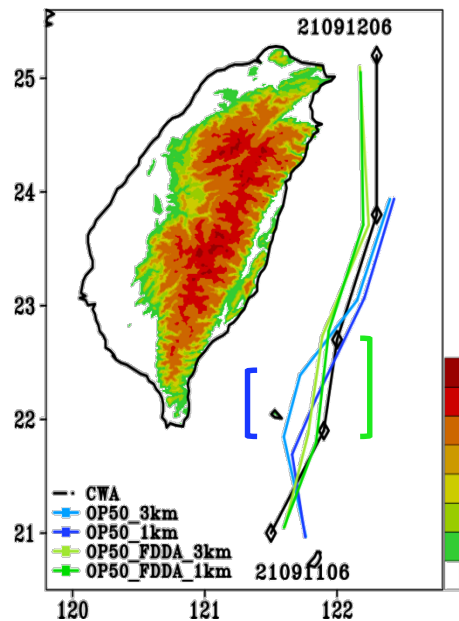
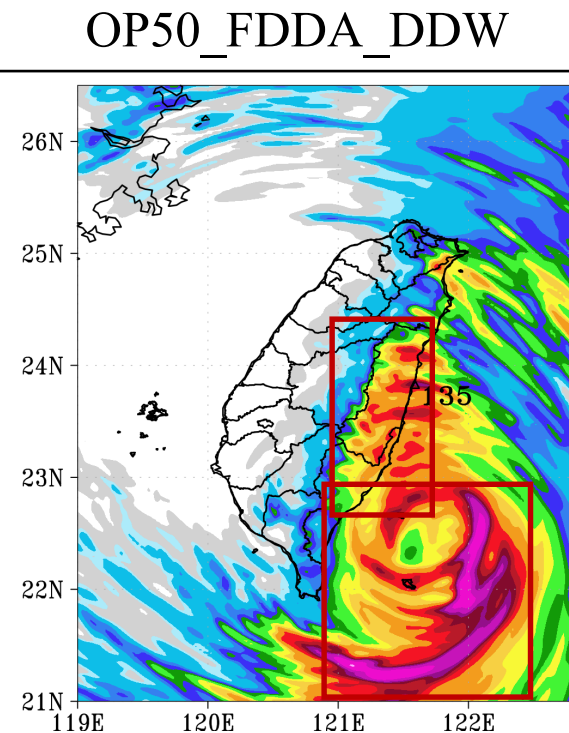
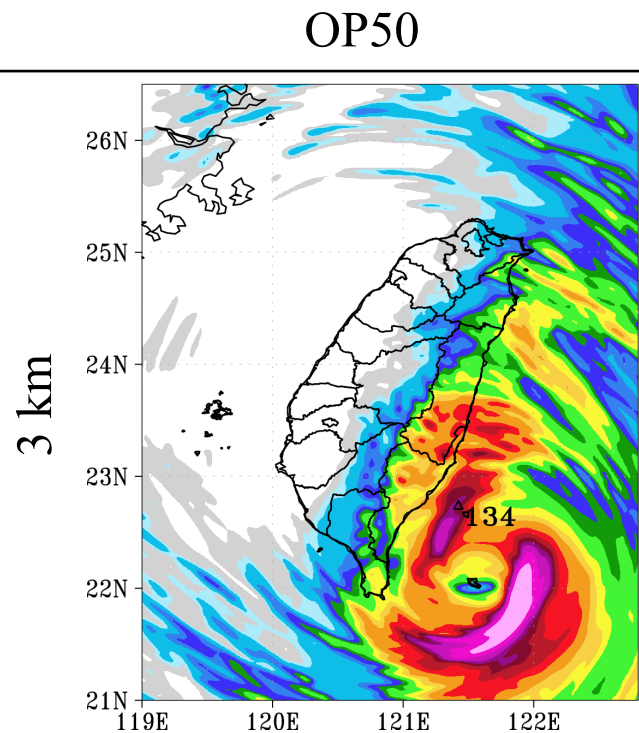
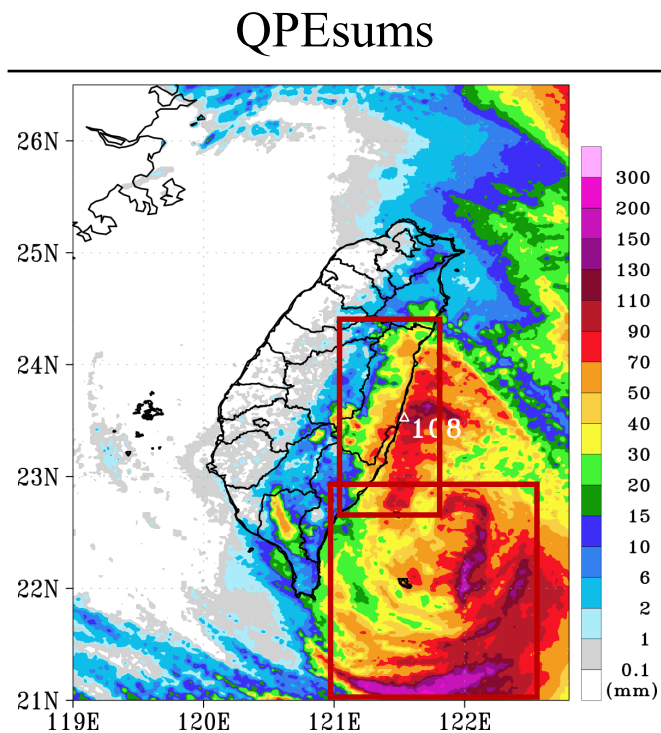
lead time 6 ~ 12 h

initial time 21/09/11 06 UTC

valid time 21/09/11 12~18 UTC

1. 路徑差異不大時，
FDDA可使模式降雨位置更接近觀測

2. 提高解析度使得颱風附近與台灣地區的降雨更接近觀測



6-h QPE & QPF

lead time 12 ~ 18 h

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valid time 21/09/11 18 ~ 09/12 00

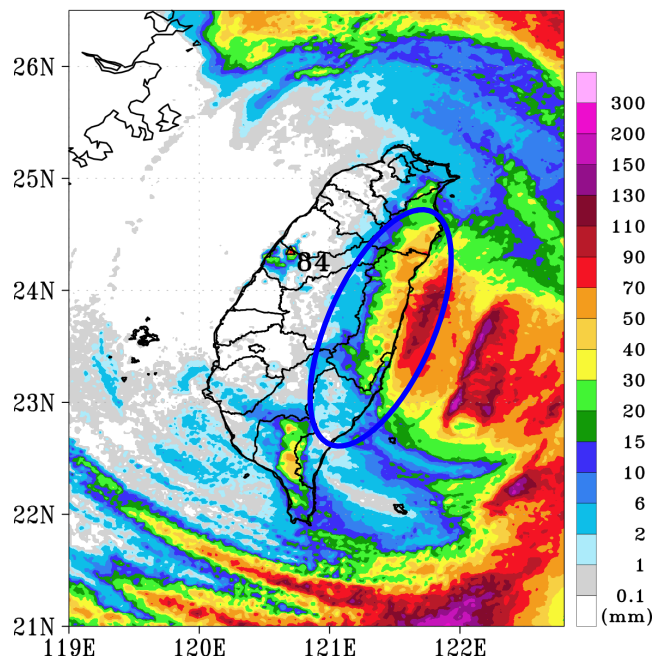
UTC

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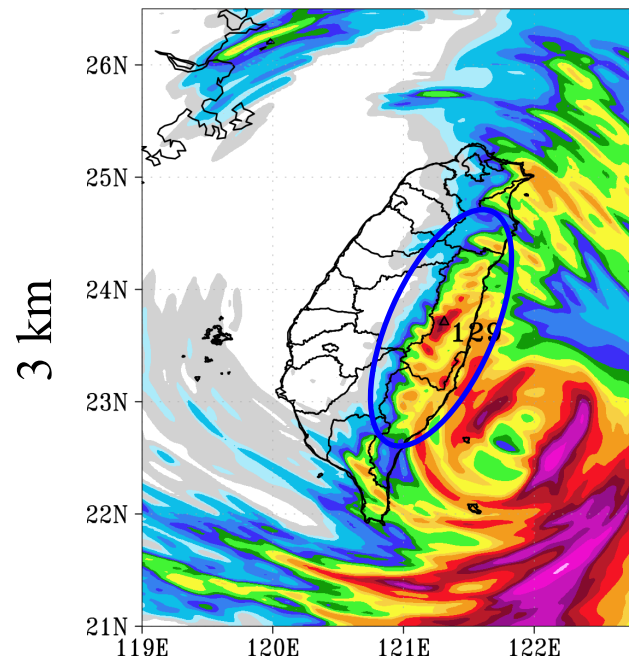
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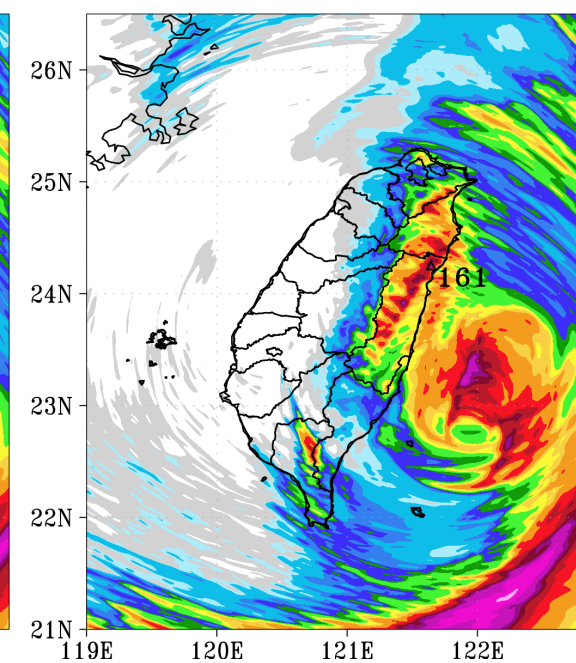
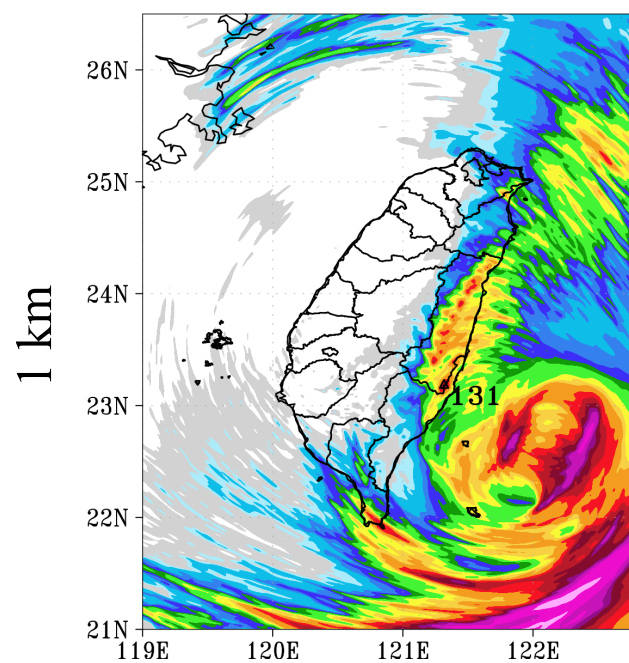
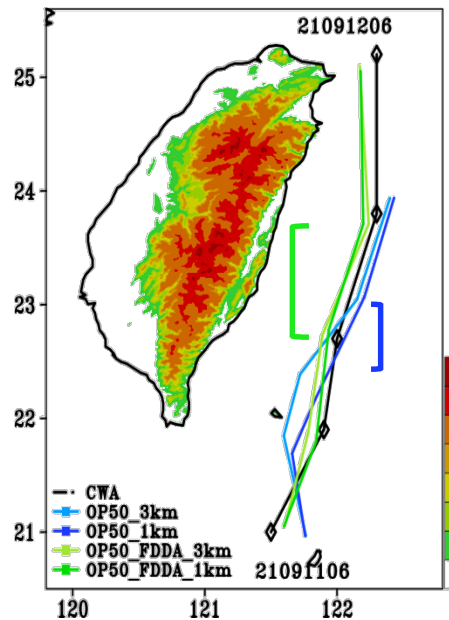
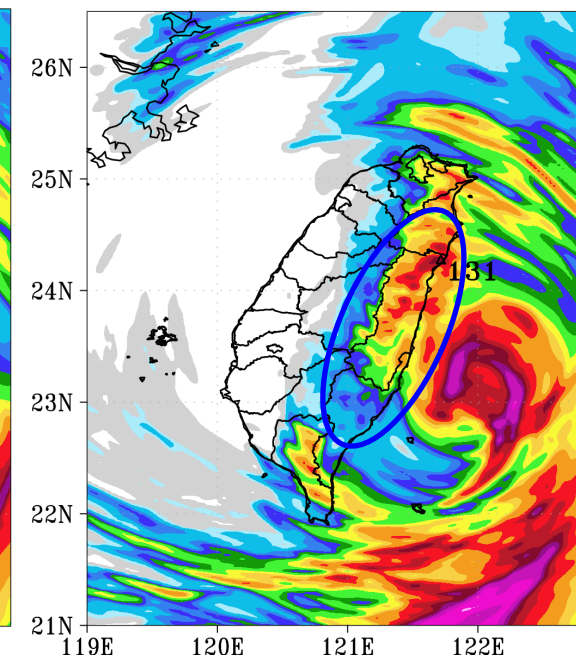
QPEsums



OP50



OP50_FDDA_DDW

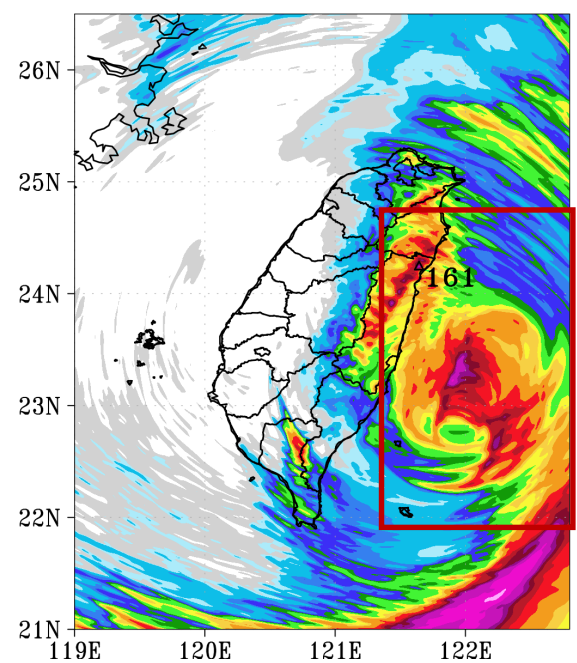
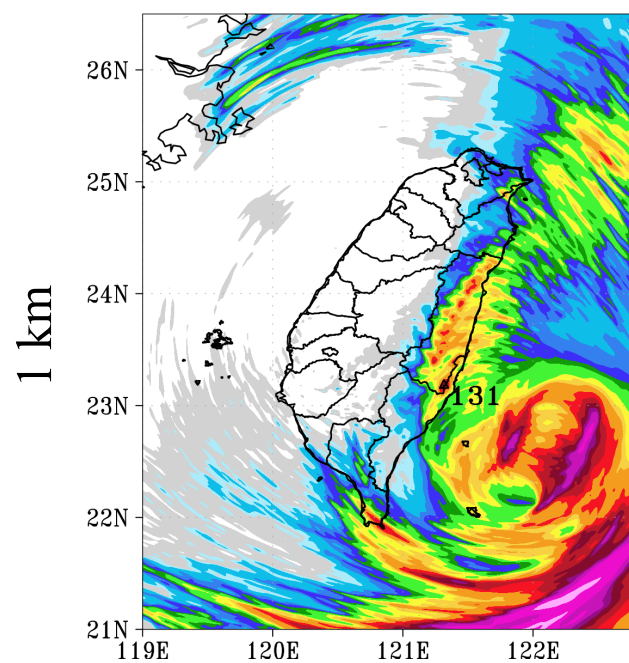
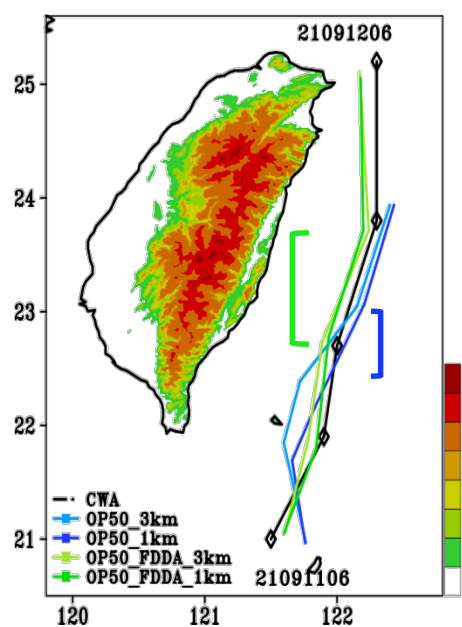
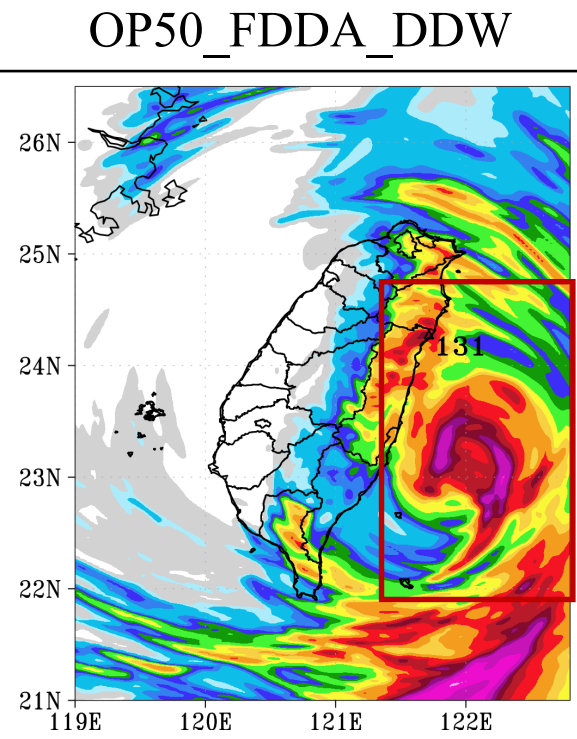
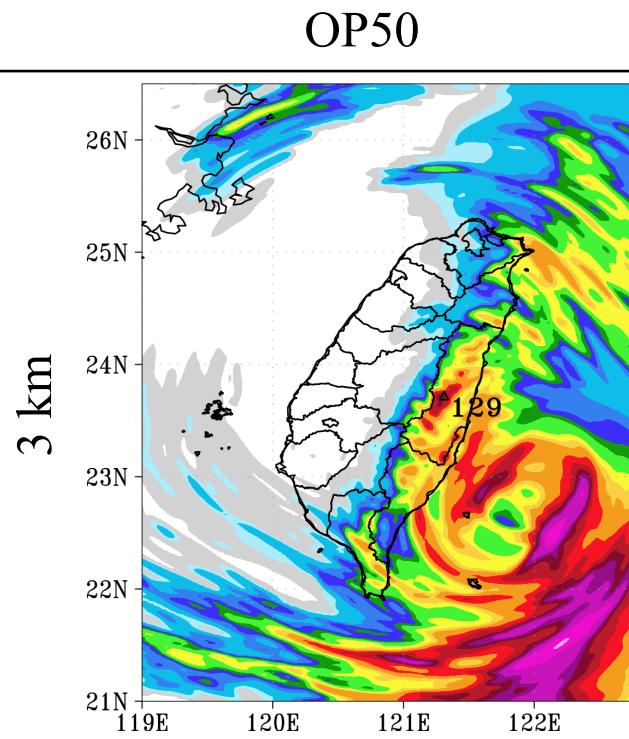
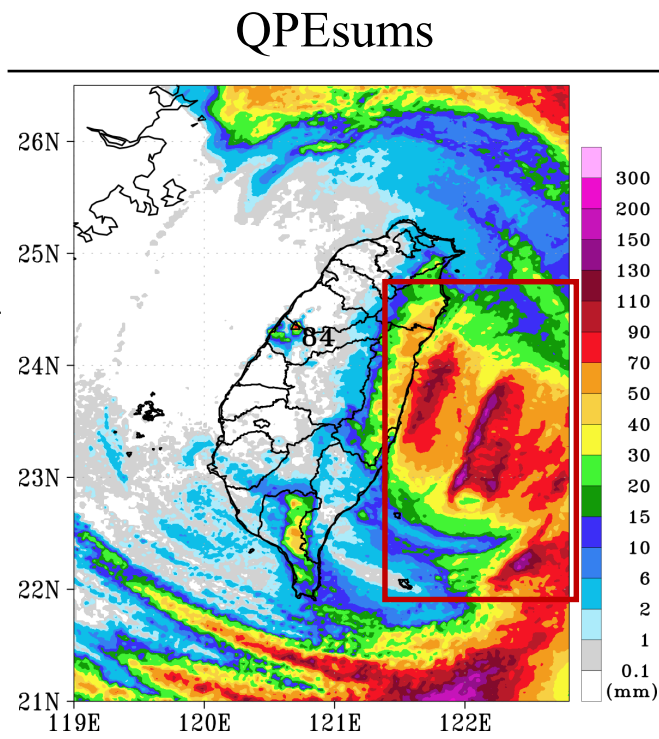


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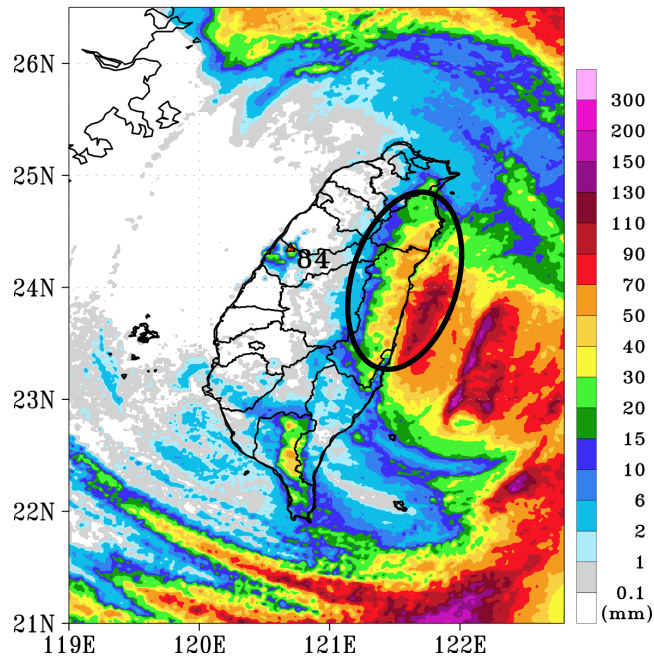
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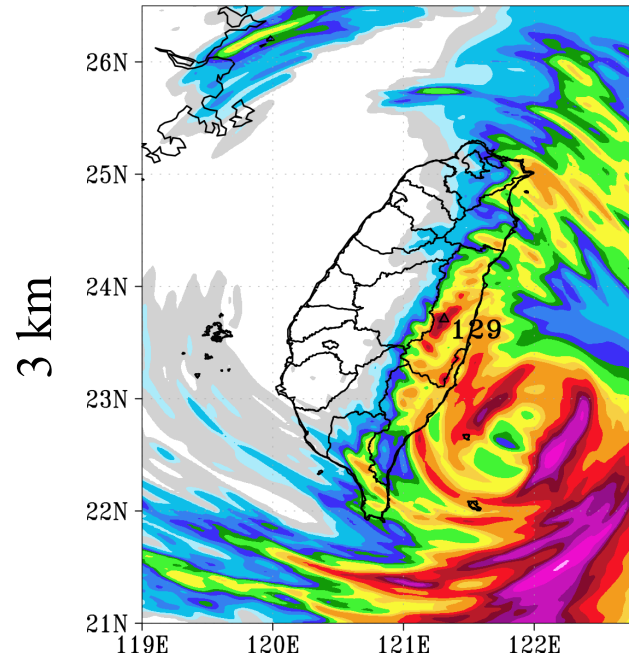
1 km FDDA的模擬顯示
當颱風路徑與強度誤差
很小時，模式模擬之台
灣地區降雨仍過強

測試雲微物理參數法

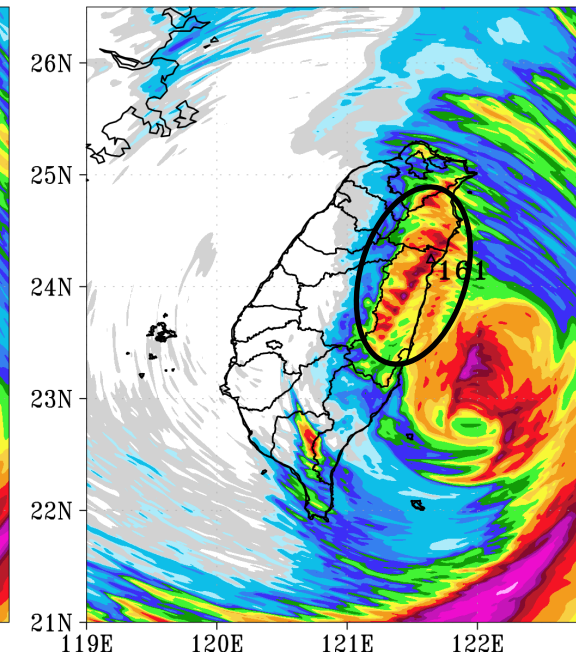
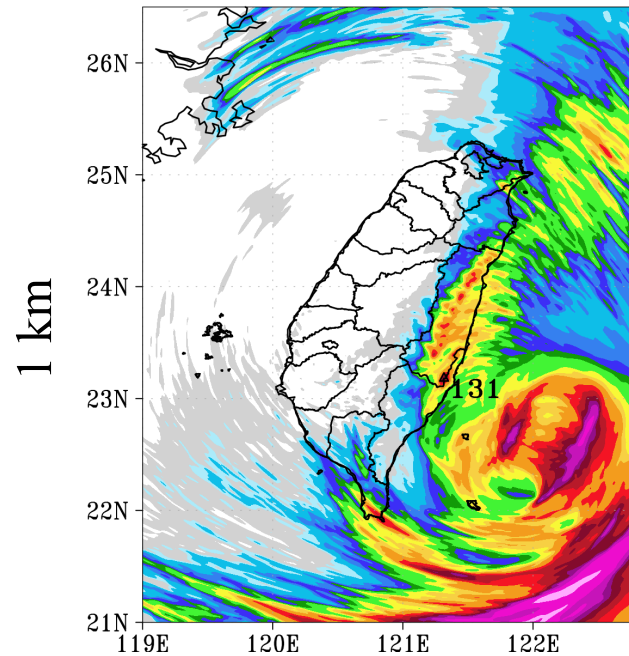
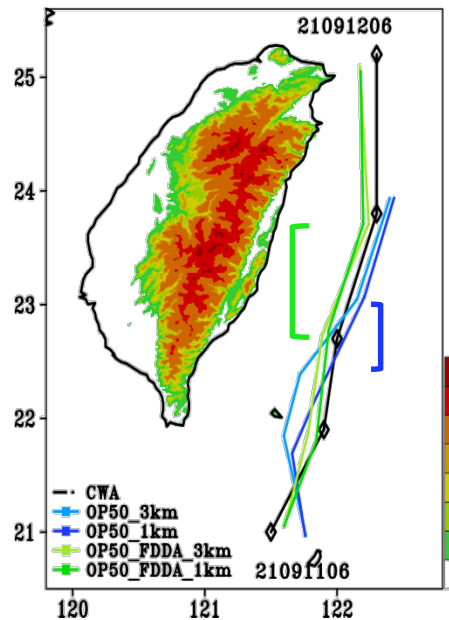
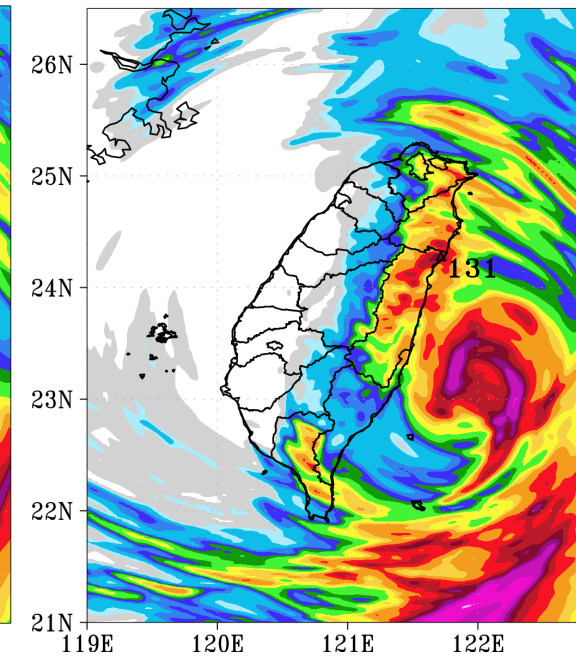
QPEsums



OP50



OP50_FDDA_DDW



Summary

1. **Typhoon Chanthu (2021)** 9/11 06 UTC was chosen to understand the improvements of TWRP **TC simulation ability** by adopting **FDDA to nudge dual-Doppler radar-retrieval wind** to TWRP and increase TWRP **resolution from 3 km to 1 km**.
2. 使用**FDDA**可以改善模式對於**颱風路徑、強度、眼牆結構、以及台灣主要降雨區域**的掌握能力
3. 提高模式**解析度至1 km**，可改善模式對於**颱風強度、颱風附近與台灣地區降雨**的掌握能力
4. 然而使用FDDA之1 km模式仍顯示模式對於**台灣地區的降雨有過報**的情形，未來將不同**雲微物理參數法**進行測試



TCWA (Taiwan Central Weather Administration) 雲微物理參數法
(A2-28游承融、A2-30蔡子衿)