

WRF雷達資料同化對颱風短時定量降雨預報 之效益評估

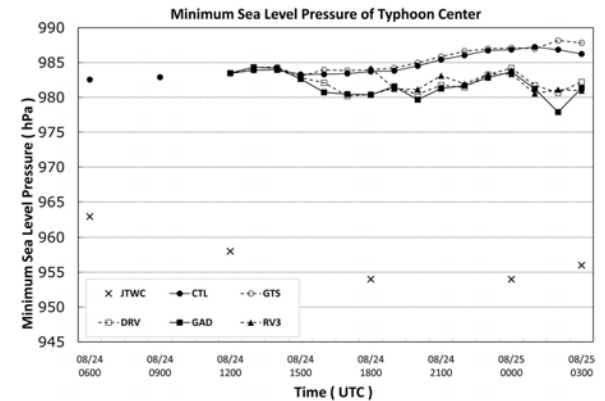
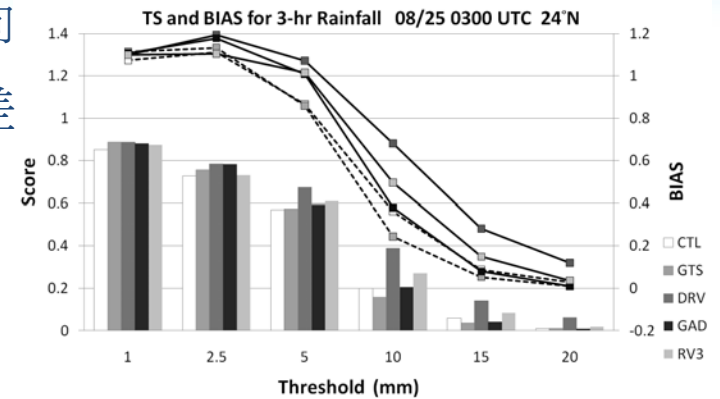
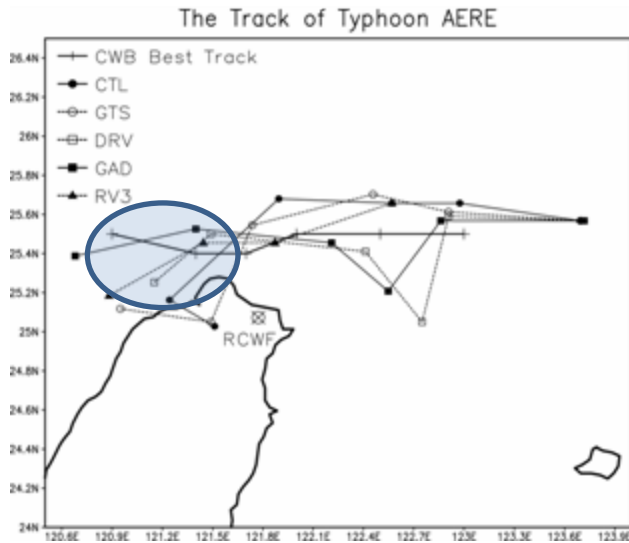
林欣弘、林沛練

國家災害防救科技中心



- 前言
- 同化與模擬實驗
- 模擬降水分布
- 降水得分統計
- 結論

- Lin et. al (2011) MM5 3D-VAR同化雷達徑向風，改進颱風路徑模擬與改善颱風強度誤差20%，3小時累積降雨模擬改善不明顯

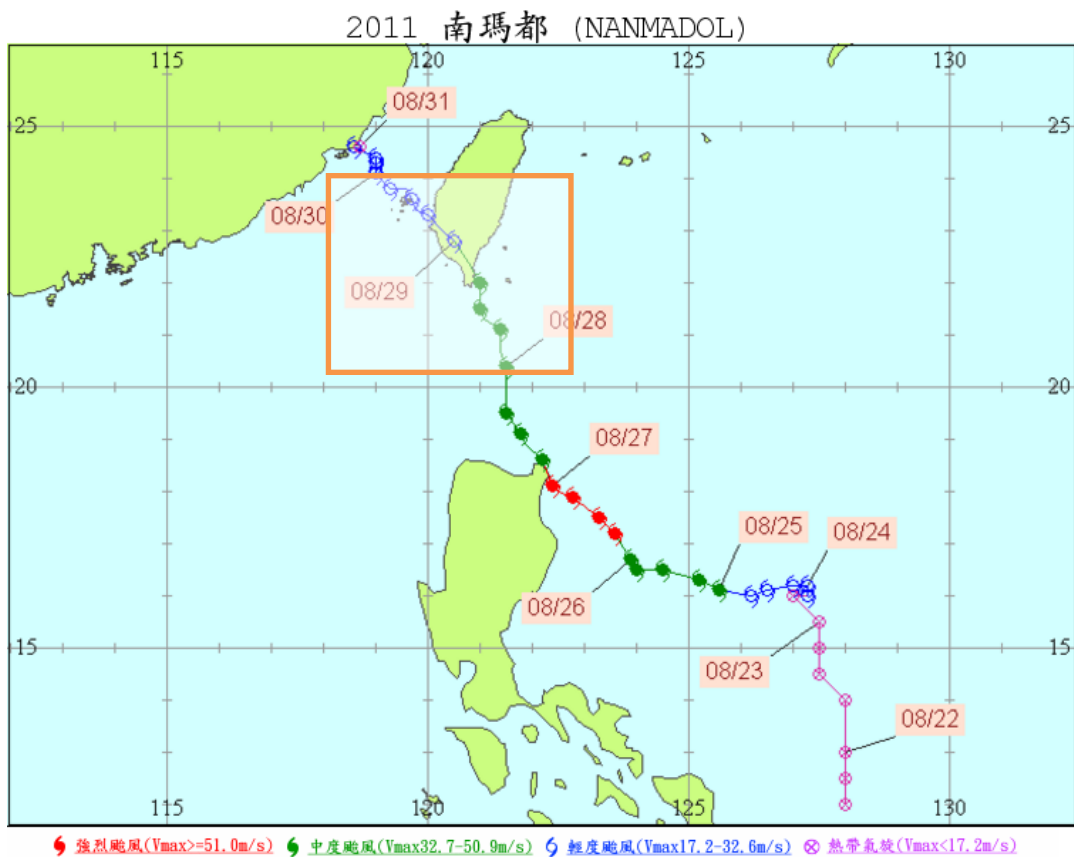
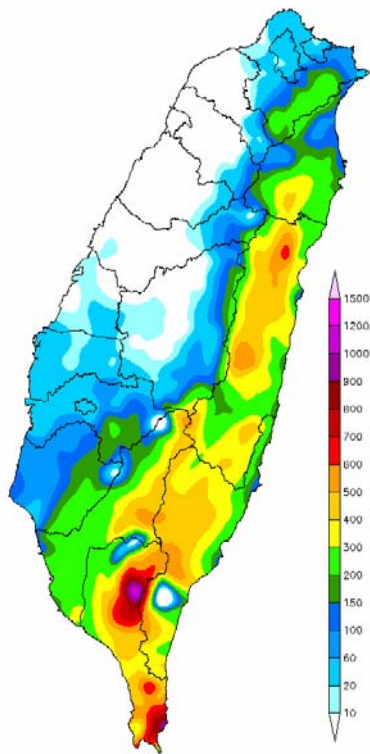


- 陳(2012) WRFVAR同化雷達徑向風，探討墾丁雷達資料同化對南瑪都颱風模擬的影響，另外也比較同化影響半徑對雷達資料同化效果。

- 區域模式每六小時使用全球模式當初始場所做的預報，這樣的時間間隔是否足以應付即時天氣預報的需求？
- 如何提高數值天氣模式更新預報的時間頻率？
- 目前數值天氣預報技術能否能落實於實際的天氣預報？

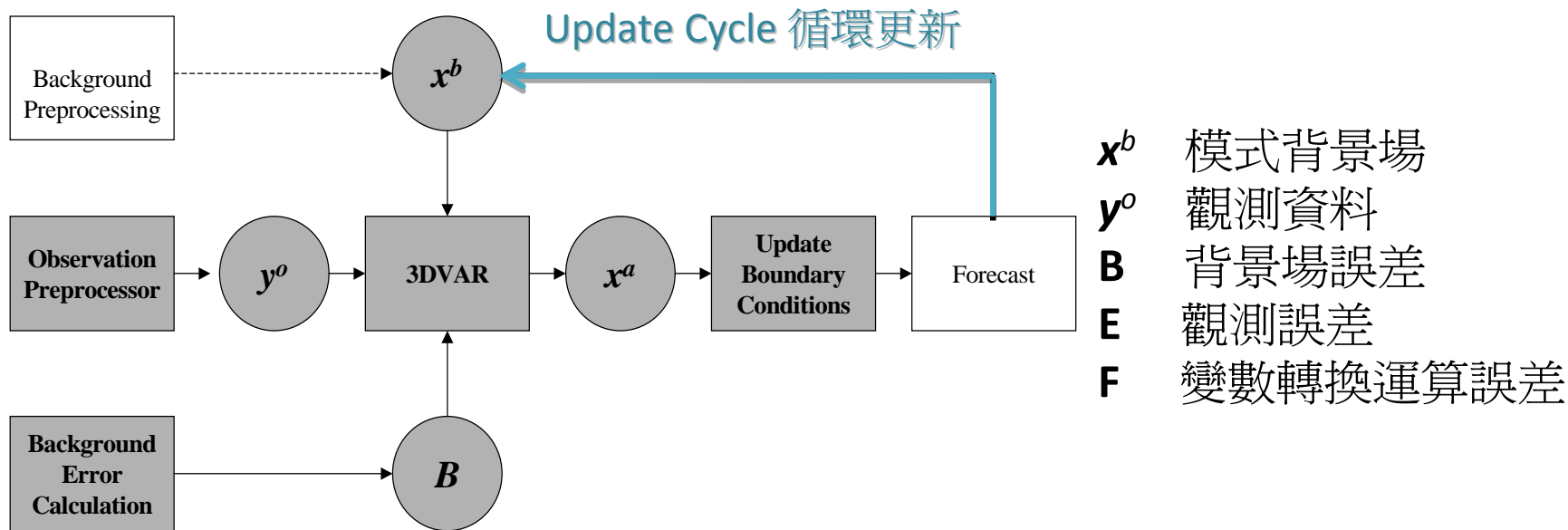
- 2011 年 8 月 28~30 南瑪都颱風
- 在屏東山區降雨超過 800 mm

2011-08-28 00:00 - 2011-08-30 12:00 LST (60 hours)



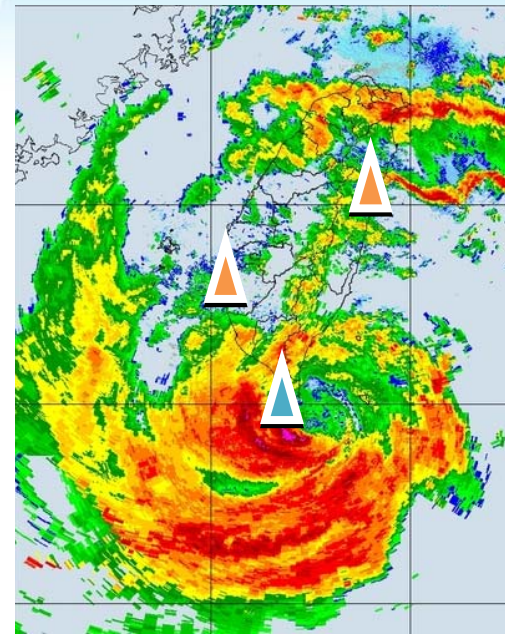
- WRFVAR V3 同化系統的3D-VAR
- 同化雷達徑向風

$$J(\mathbf{x}) = J^b + J^o = \frac{1}{2}(\mathbf{x} - \mathbf{x}^b)^T \mathbf{B}^{-1}(\mathbf{x} - \mathbf{x}^b) + \frac{1}{2}(\mathbf{y} - \mathbf{y}^o)^T (\mathbf{E} + \mathbf{F})^{-1}(\mathbf{y} - \mathbf{y}^o).$$



- 00R0** : 初始時間**2011/08/28 00** UTC , 冷啟動模擬
- 00R1** : 循環更新同化預報(Update cycle) , 同化**墾丁**雷達資料
- 00R3** : 同化**墾丁**、**花蓮**、**七股**雷達資料

- 12R0** : 初始時間**2011/08/28 12** UTC , 冷啟動模擬
- 12R1** : 循環更新同化預報(Update cycle) , 同化**墾丁**雷達資料
- 12R3** : 同化**墾丁**、**花蓮**、**七股**雷達資料



初始時間

6 小時

冷啟動模擬 **Cold Start**

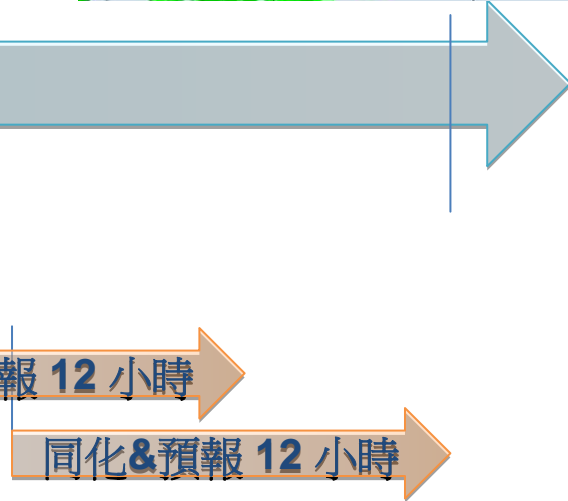
同化&預報 **12 小時**

3 小時

同化&預報 **12 小時**

同化&預報 **12 小時**

同化&預報 **12 小時**



- 三層槽狀網格，分別為 **45**、**15** 及 **5** 公里
- **WSM 5-class scheme** 微物理參數化
- **YSU scheme** 邊界層參數化
- **Kain-Fritsch scheme** 積雲參數化
- **thermal diffusion scheme** 土壤參數化



初步結果

- 12小時累積降雨分布
- 降雨得分統計分析



12小時累積雨量

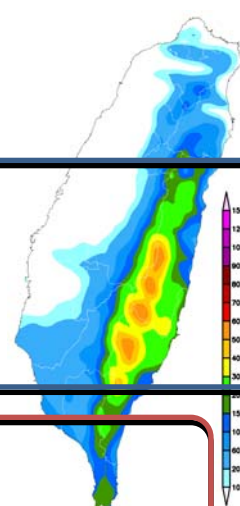
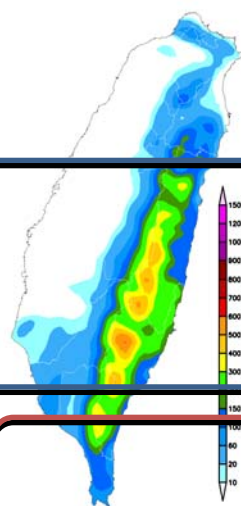
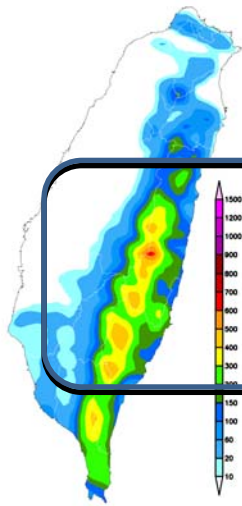
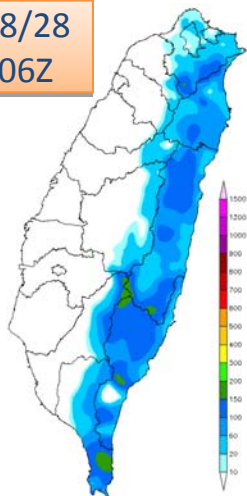
OBS

00R0

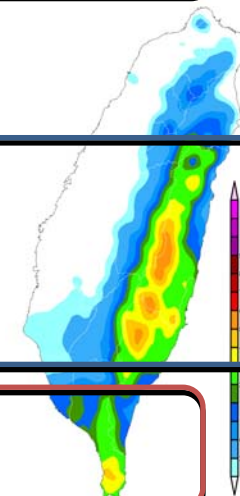
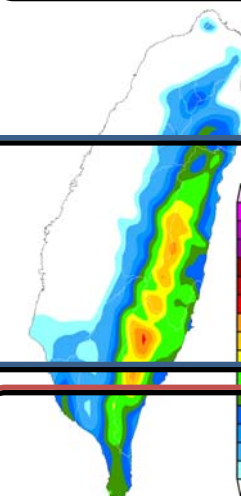
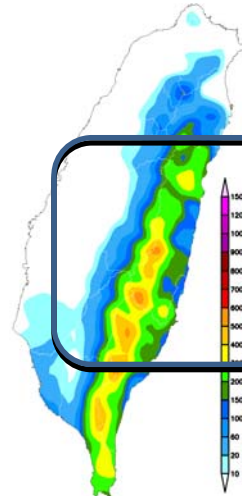
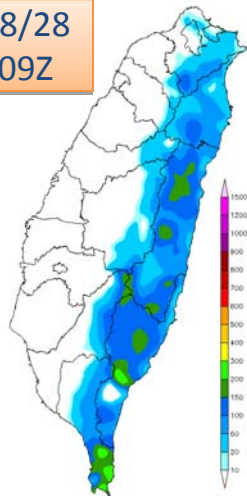
00R1

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08/28
06Z



08/28
09Z



12小時累積雨量

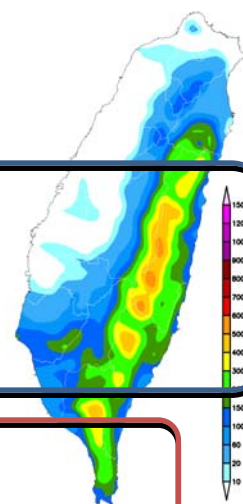
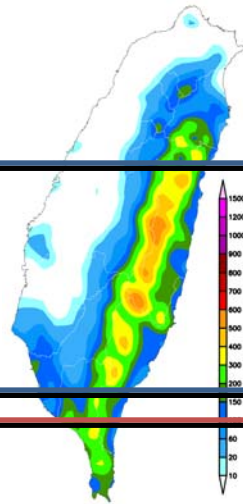
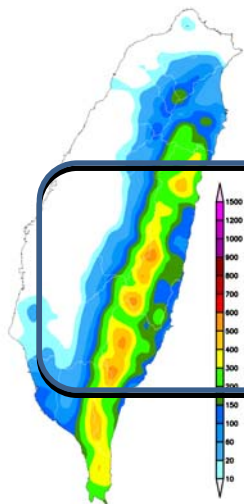
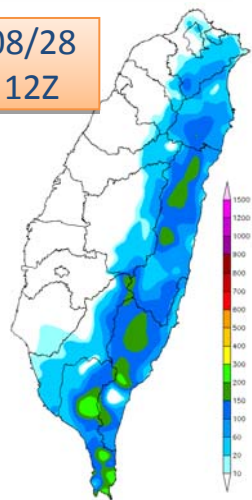
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OOR0

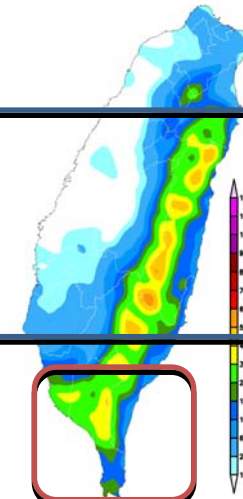
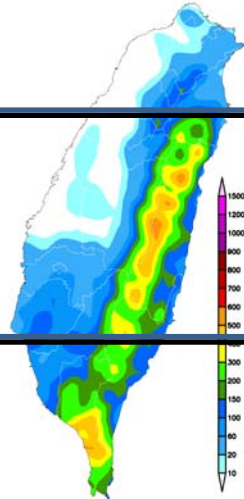
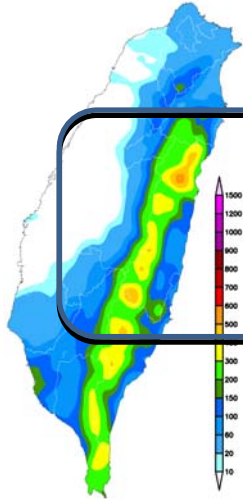
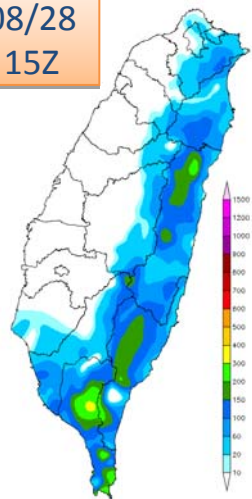
OOR1

OOR3

08/28
12Z



08/28
15Z



12小時累積雨量

OBS

00R0

00R1

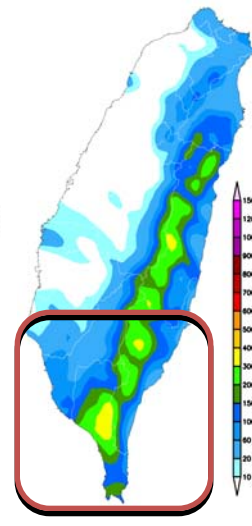
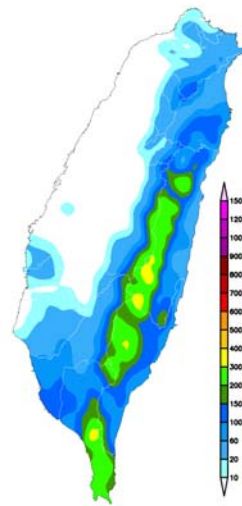
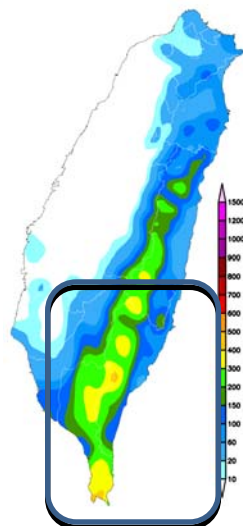
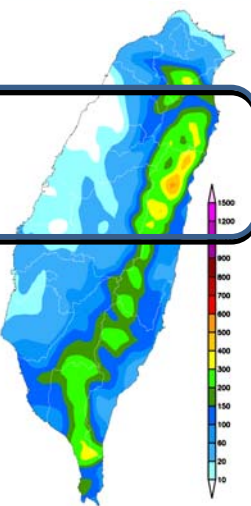
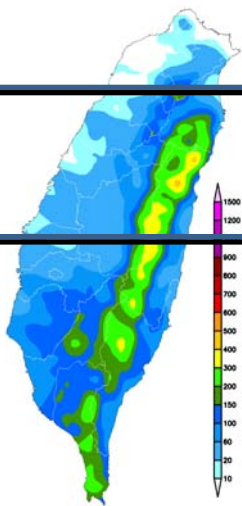
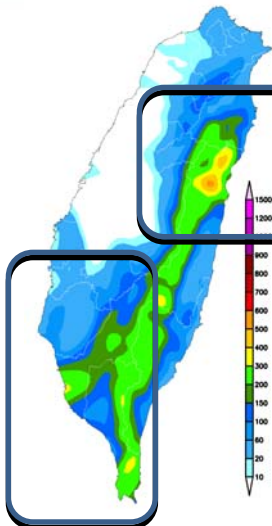
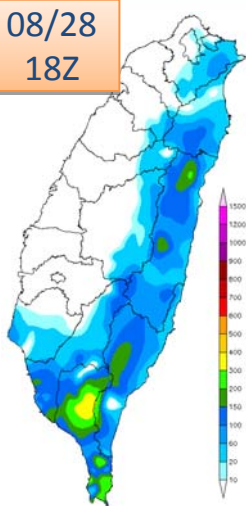
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12R0

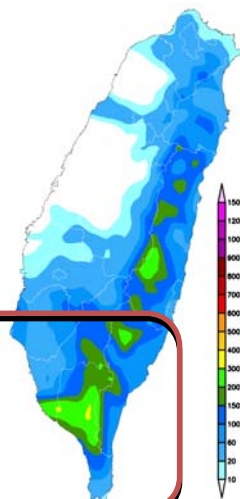
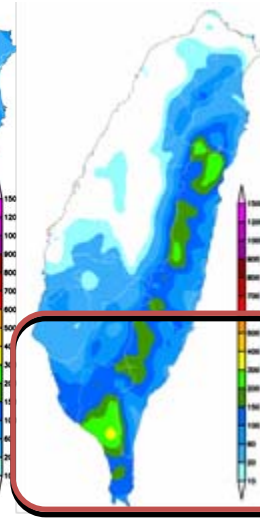
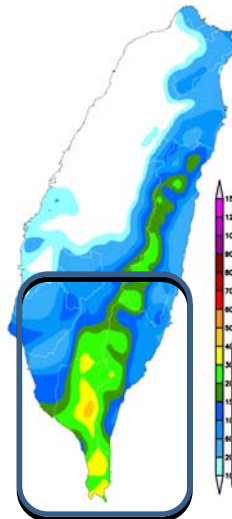
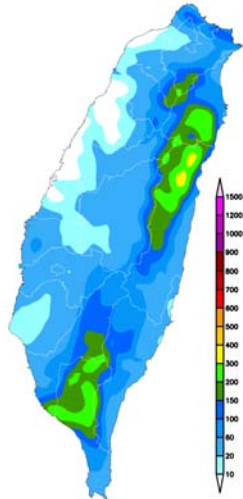
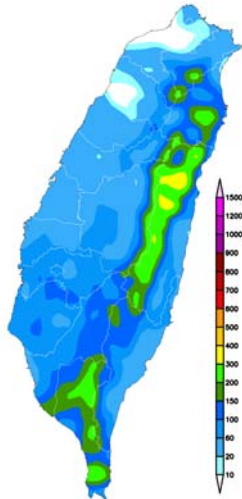
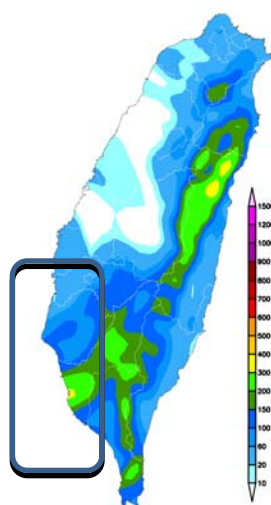
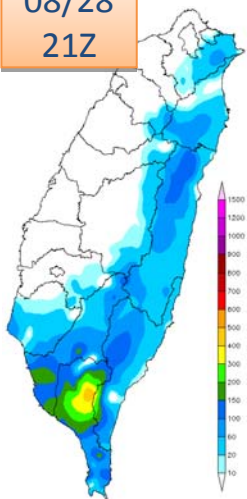
12R1

12R3

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18Z



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21Z



12小時累積雨量

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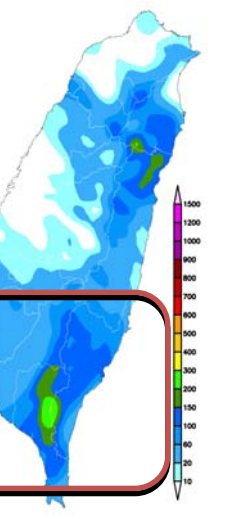
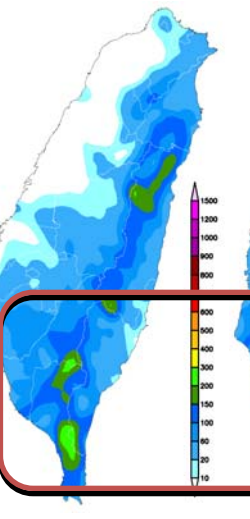
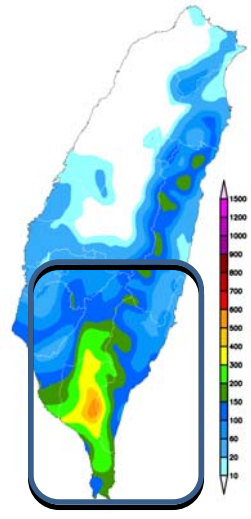
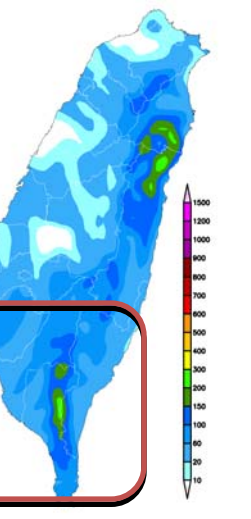
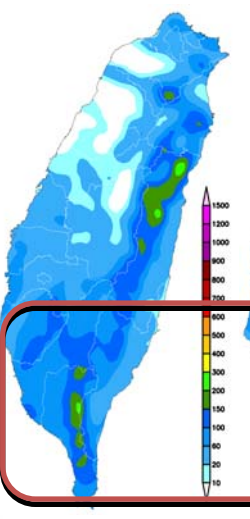
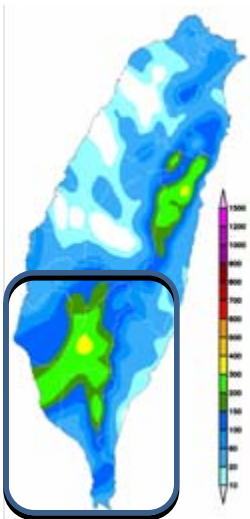
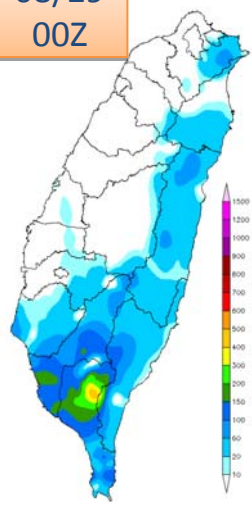
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12R0

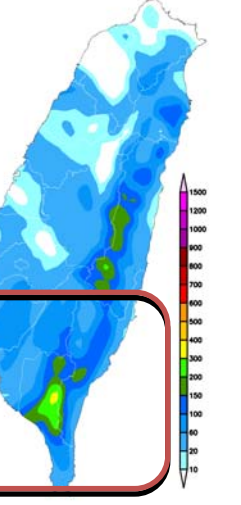
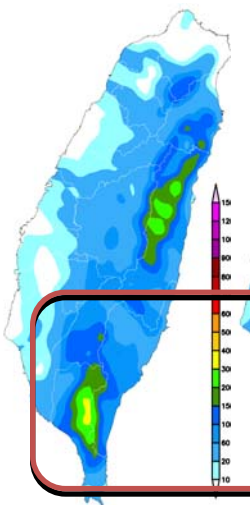
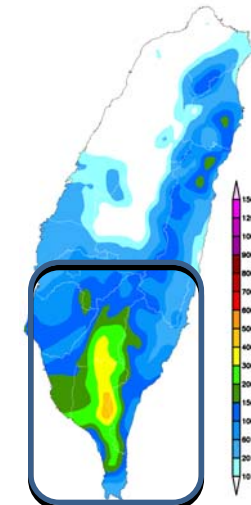
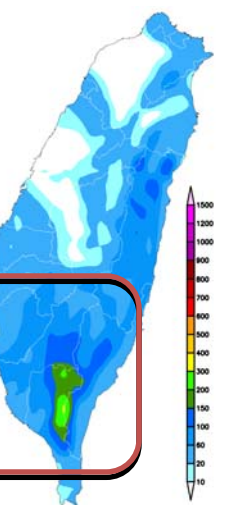
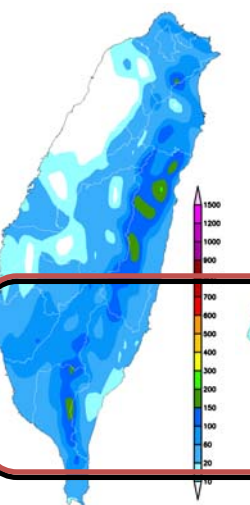
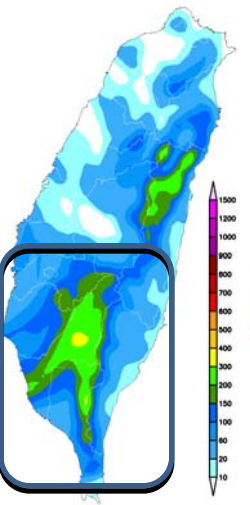
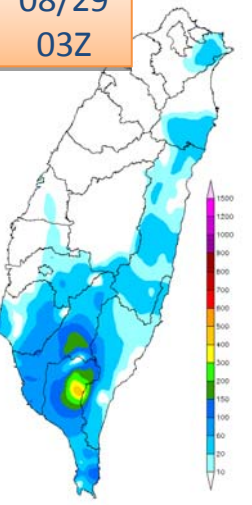
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12R3

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00Z



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03Z



12小時累積雨量

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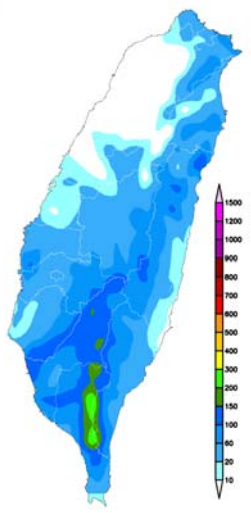
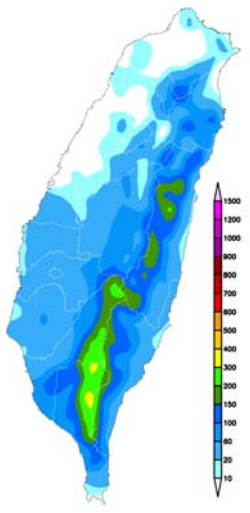
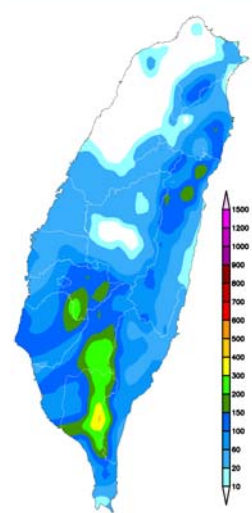
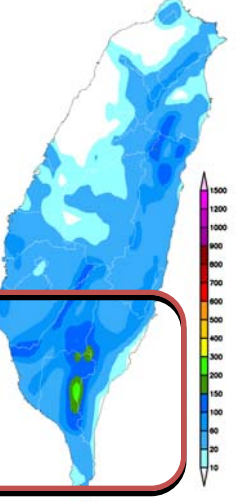
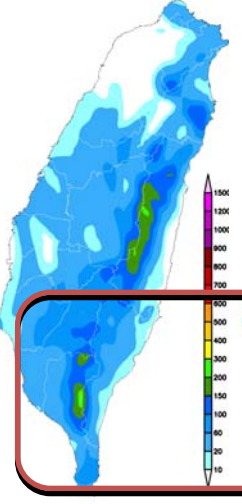
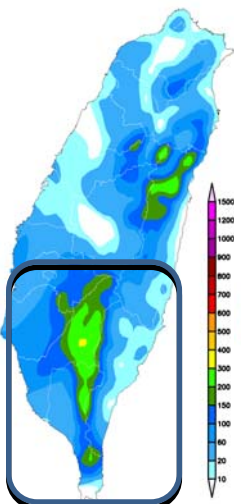
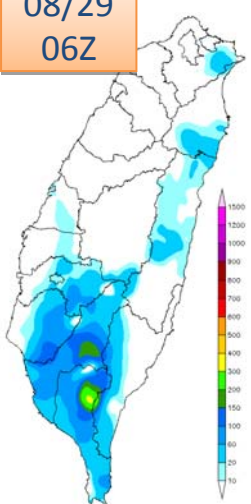
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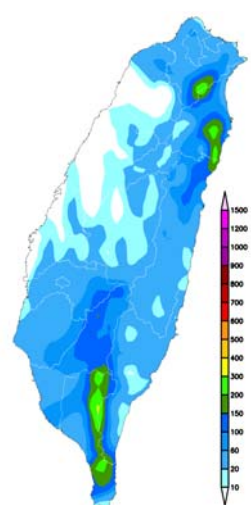
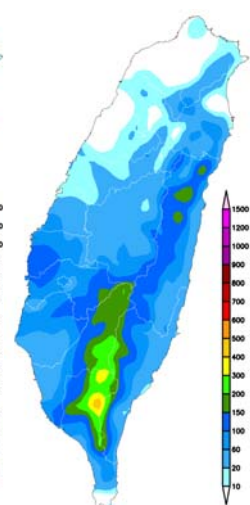
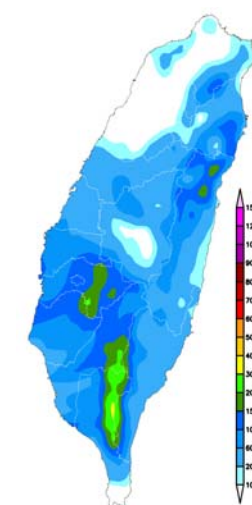
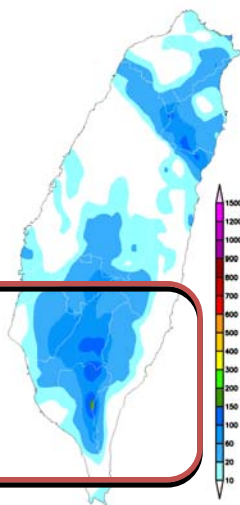
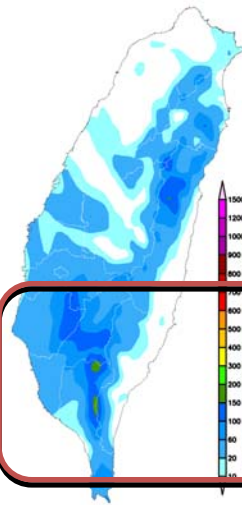
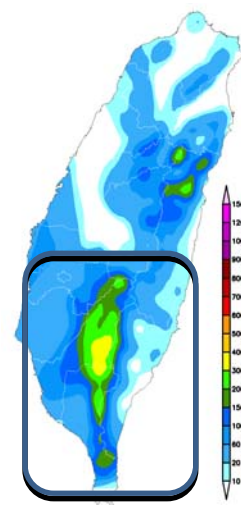
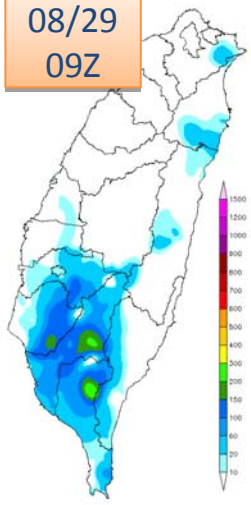
12R1

12R3

08/29
06Z



08/29
09Z



12小時累積雨量

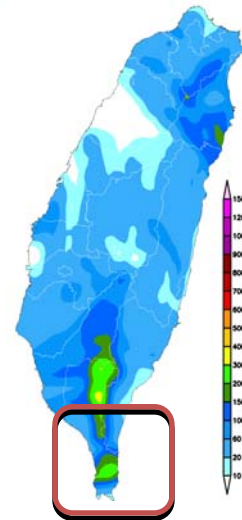
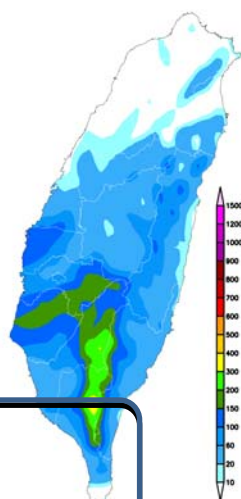
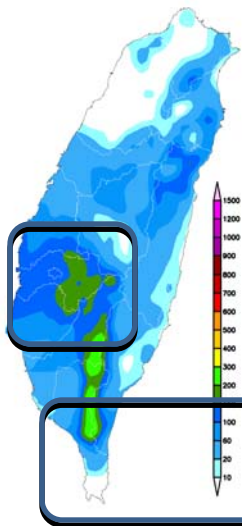
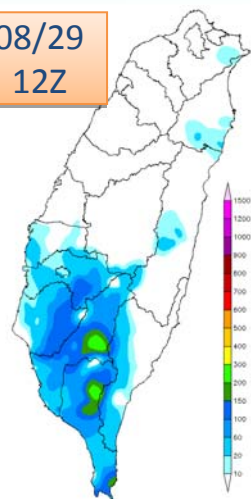
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12R0

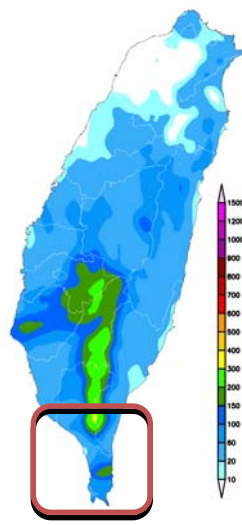
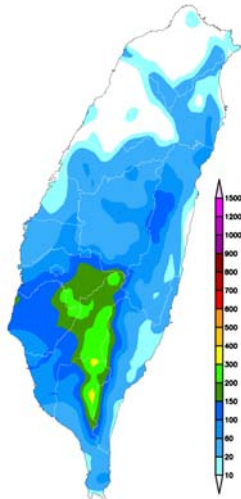
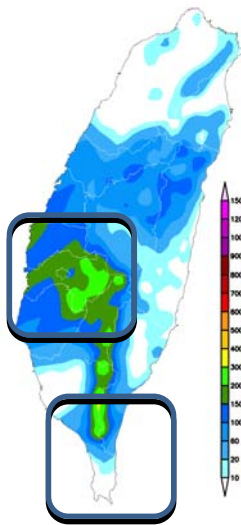
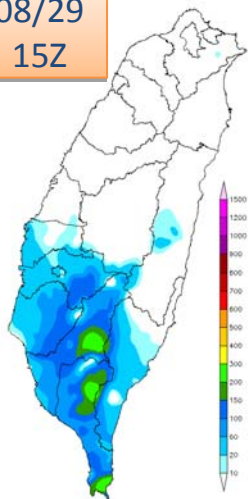
12R1

12R3

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12Z



08/29
15Z



12小時累積雨量

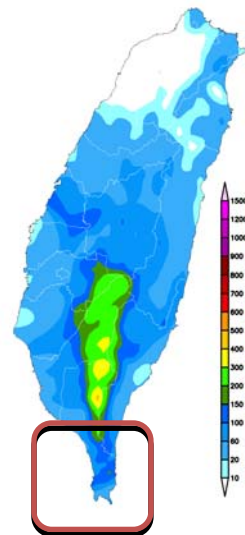
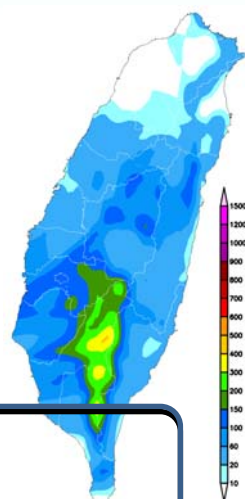
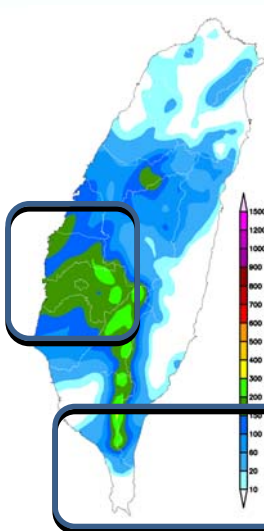
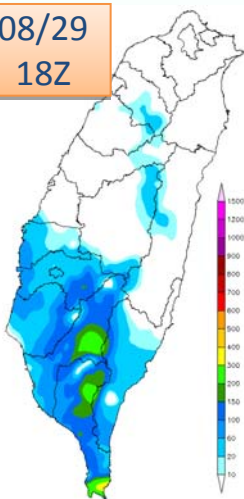
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12R0

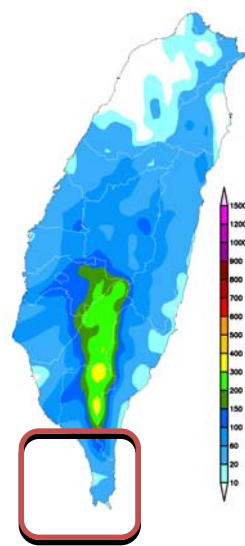
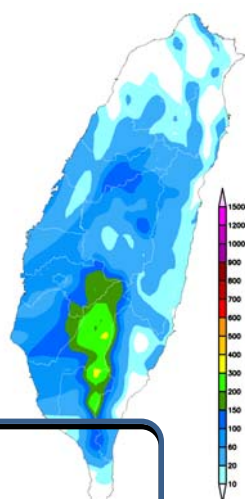
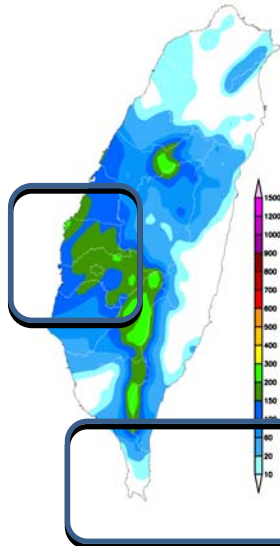
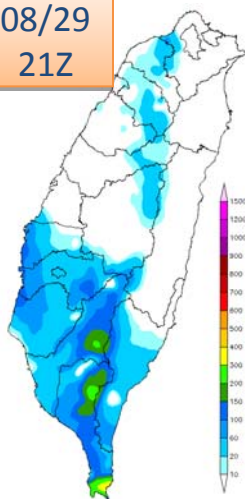
12R1

12R3

08/29
18Z



08/29
21Z



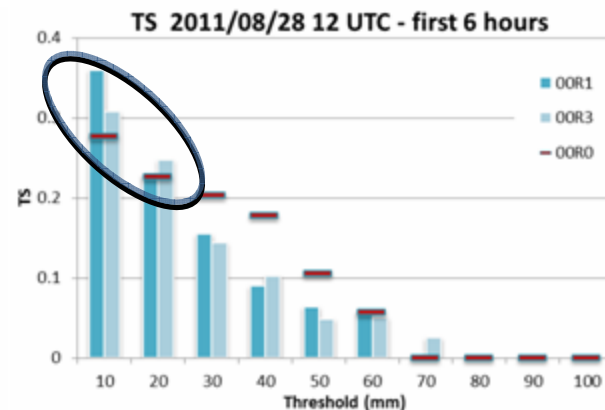
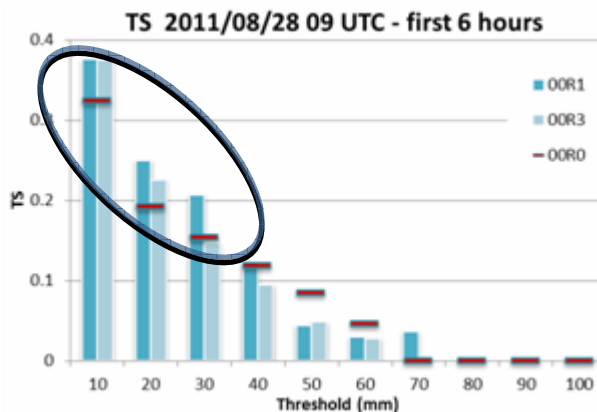
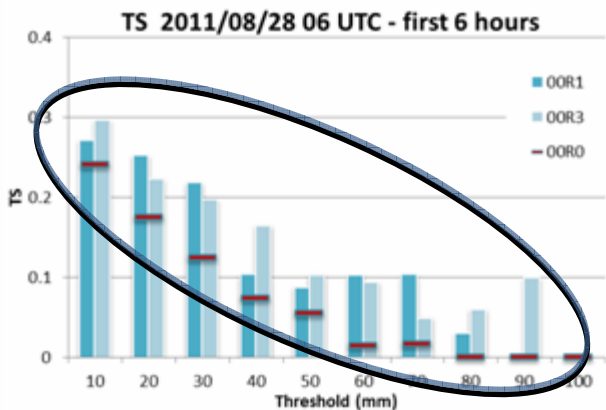
初始時間00Z

CYCLE 1

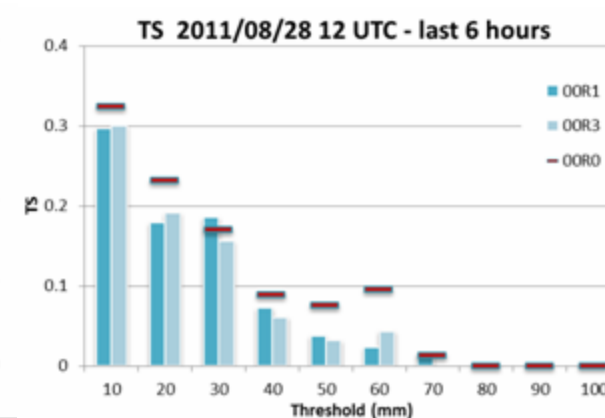
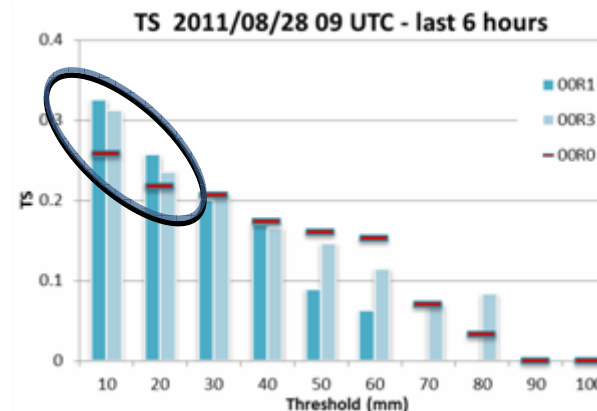
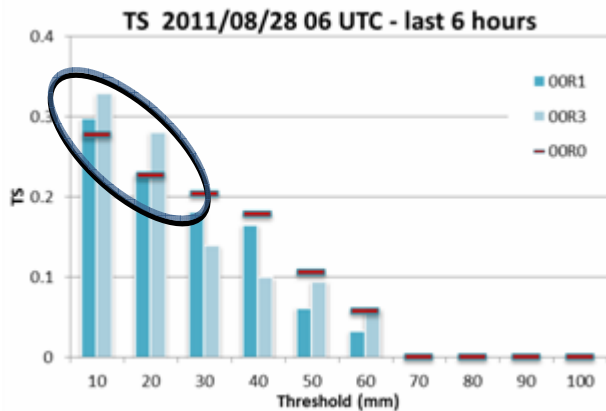
CYCLE 2

CYCLE 3

前6小時



後6小時



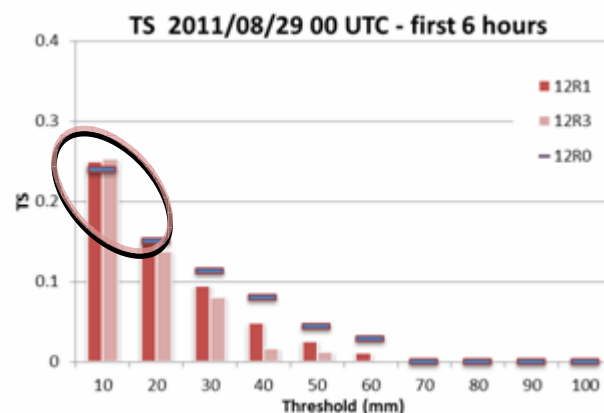
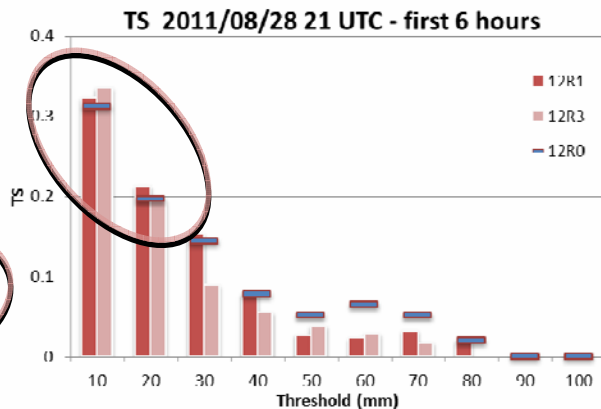
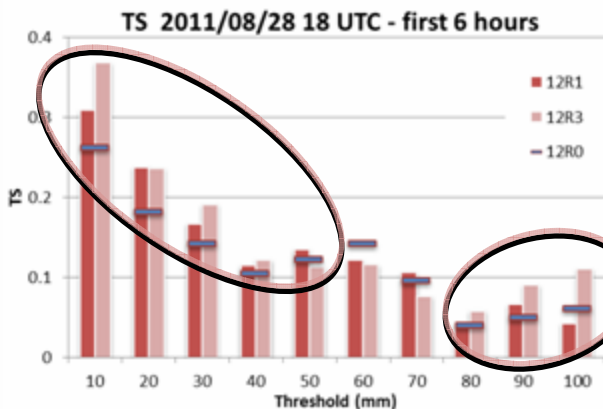
初始時間**12Z**

CYCLE 1

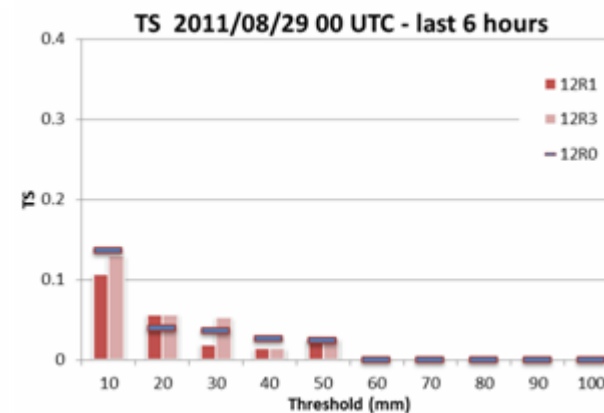
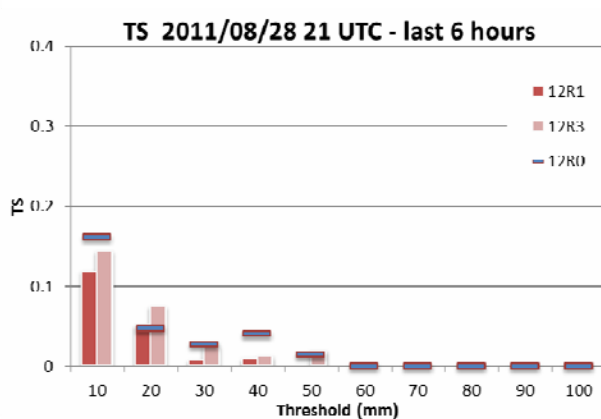
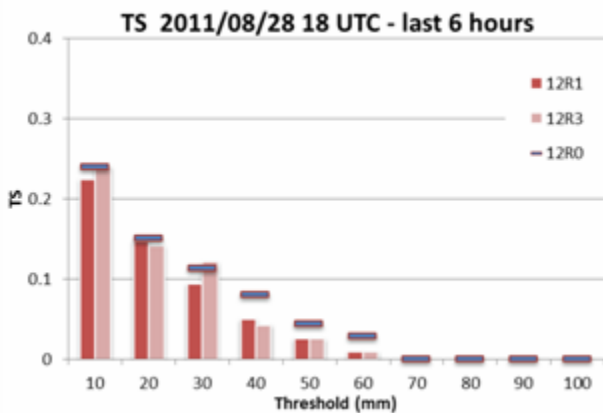
CYCLE 2

CYCLE 3

前**6**小時



後**6**小時

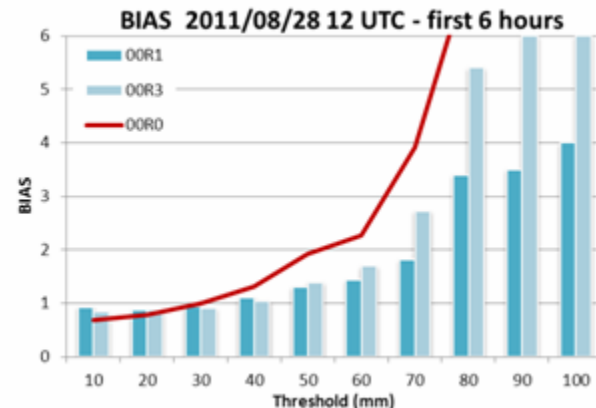
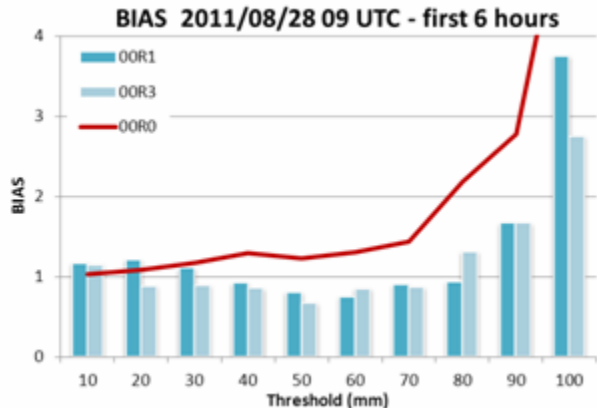
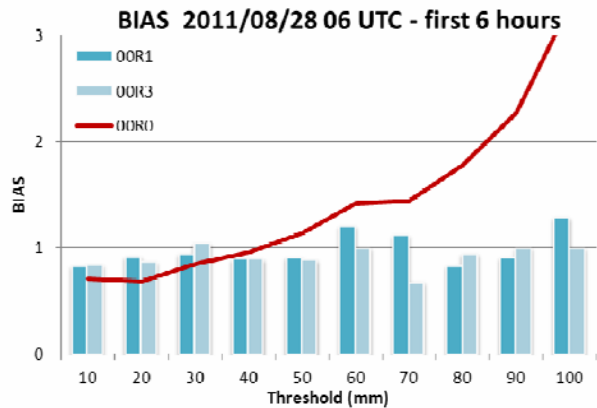


CYCLE 1

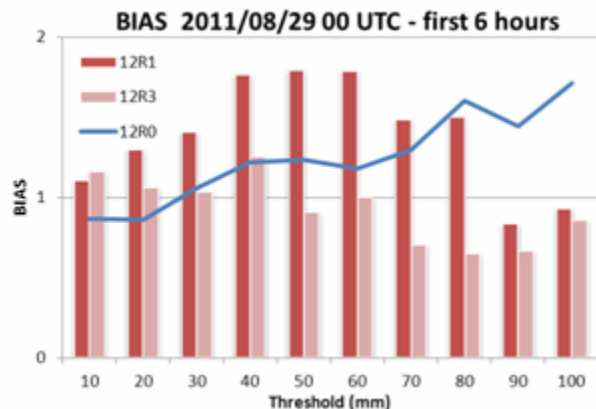
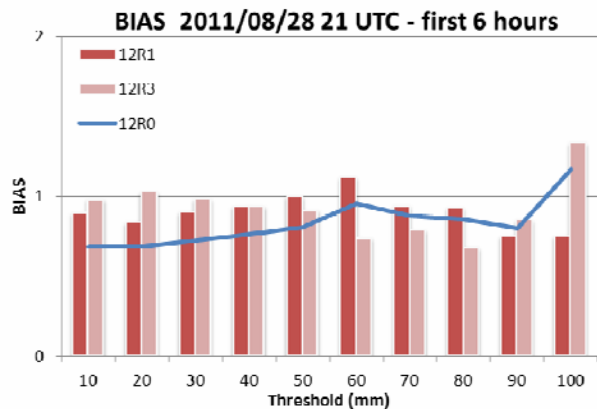
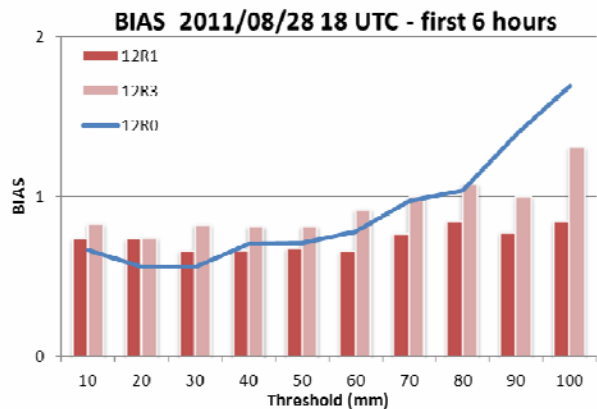
CYCLE 2

CYCLE 3

初始時間**00Z** 前6小時



初始時間**12Z** 前6小時



- 主觀判定模擬降雨分布結果，雷達資料同化後的降雨模擬比無同化組的結果好。而多雷達資料同化的結果也略比單雷達資料同化降雨分布改善效果好。
- 由客觀統計分析**TS**降雨得分結果，較明顯的改善結果僅在冷啟動模擬後的第一次資料同化的模擬，不論降雨門檻值多寡，在前**6**小時的模擬降雨皆可看出改善效果。而在之後的循環預報結果，僅在雨量較小的門檻值有改善。
- **BIAS**分析上，同化亦可降低強降雨次數高估的結果。

END

3D-VAR

雷達徑向風觀測變數轉換 Observation Operator

$$V_{r,i} = u \frac{x - x_i}{r_i} + v \frac{y - y_i}{r_i} + (w - V_T) \frac{z - z_i}{r_i}$$

雨滴終端速度 V_T Sun and Crook (1997)

$$V_T = 5.40a(\rho q_r)^{0.125} \quad a = (p_0 / \bar{p})^{0.4}$$

模式初始場不包含液態水含量 (q_r)

Sun and Andrew (1997)的雷達回波與液態水含量的關係式

$$Z = 2.04 \times 10^4 (\rho q_r)^{1.75}$$

3D-VAR

平衡方程是以理查森方程為基礎，利用連續方程、絕熱的熱動力方程以及靜力方程所求得

$$\gamma p \frac{\partial w}{\partial z} = -\gamma p \vec{\nabla} \cdot \vec{V}_h - \vec{V}_h \cdot \vec{\nabla} p + g \int_z^\infty \vec{\nabla} \cdot (\rho \vec{V}_h) dz$$

- (1) 其中的連續方程比不可壓縮連續方程以及非彈性連續方程有較高階的近似
- (2) 理查森方程直接包含熱動力方程，因此它能有效的連結動力與熱動力場之間的關係
- (3) 假設在靜力與絕熱大氣條件下，連續方程中的空氣密度項則可以省略，避免了複雜的計算過程