

107年天氣分析與預報研討會

雷達觀測外延與數值動力模式 客觀融合預報實作評估

A3-IV

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預報融合

■ 外延預報

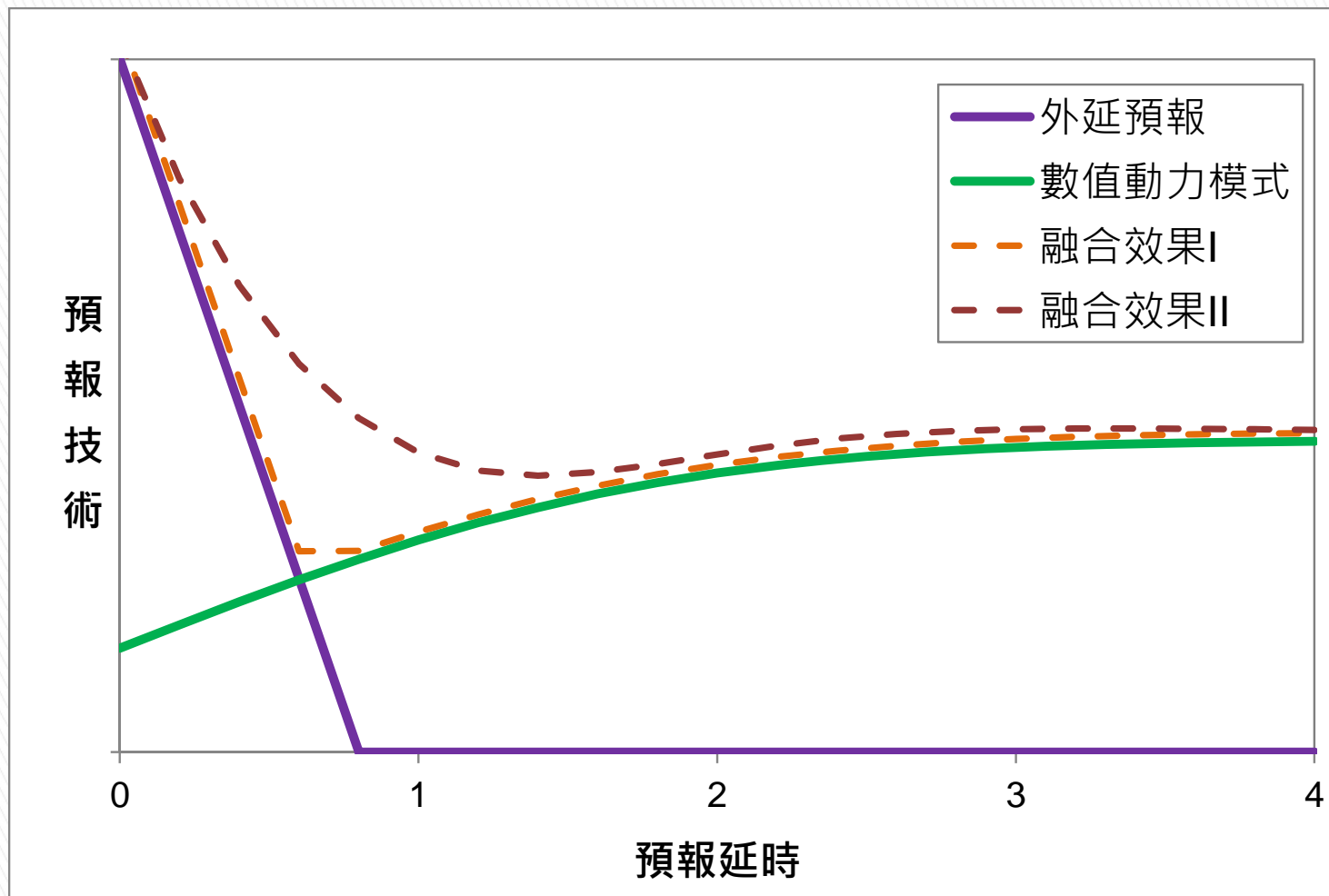
- ▶ 極短期預報技術通常很高，但預報技術隨時間快速遞減
- ▶ 雷達整合降水觀測QPESUMS，以ABLER方法外延

■ 數值模式預報

- ▶ 極短期預報技術較差，但技術在短期可維持至數日
- ▶ iTEEN系集預報產品

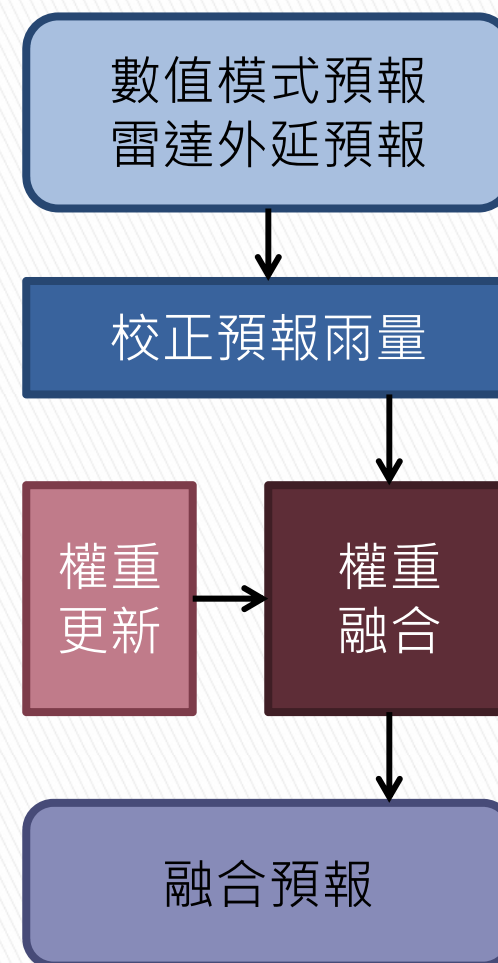
$$F_{fusion} = w_1 F_{Extrapolation} + w_2 F_{NWP}$$

預報融合



融合機制

- 依據預報的不確定性進行融合
 - ▶ 以相關係數估計不確定性(Joyce & Xie, 2011)
 - ▶ 利用時間衰退平均更新預報不確定性
- 融合前將預報先校正至接近觀測
 - ▶ 避免融合量值不守恆而偏估
- 逐網格權重融合



融合權重

融合預報

雷達外延預報

數值預報

$$F_{Fusion} = \underbrace{\frac{\sigma_{iTEEN}^2}{\sigma_{ABLER}^2 + \sigma_{iTEEN}^2}}_{\text{權重係數}} QPF_{ABLER} + \underbrace{\frac{\sigma_{ABLER}^2}{\sigma_{ABLER}^2 + \sigma_{iTEEN}^2}}_{\text{權重係數}} QPF_{iTEEN}$$

$$\sigma^2 = \sigma^2(r^2) = \begin{cases} \sigma_{ABLER}^2 = 1 - r_{ABLER}^2 \\ \sigma_{iTEEN}^2 = \begin{cases} 1 - r_{iTEEN}^2 \\ r_{ABLER}^2 \end{cases} \end{cases}$$

不確定性
(預報能力)

$$w = w(\sigma^2) = \begin{cases} \frac{\sigma_{ABLER}^2}{\sigma_{ABLER}^2 + \sigma_{iTEEN}^2} & , & \frac{\sigma_{iTEEN}^2}{\sigma_{ABLER}^2 + \sigma_{iTEEN}^2} \end{cases}$$

融合權重

σ^2 : 系統不確定性
 r : 相關係數
 w : 融合權重

融合權重設計

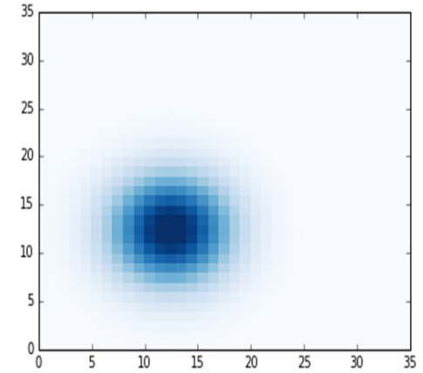
$$F_{Fusion} = \frac{\sigma_{iTEEN}^2}{\sigma_{ABLER}^2 + \sigma_{iTEEN}^2} QPF_{ABLER} + \frac{\sigma_{ABLER}^2}{\sigma_{ABLER}^2 + \sigma_{iTEEN}^2} QPF_{iTEEN}$$

$$\sigma_{ABLER}^2 = 1 - r_{ABLER}^2$$

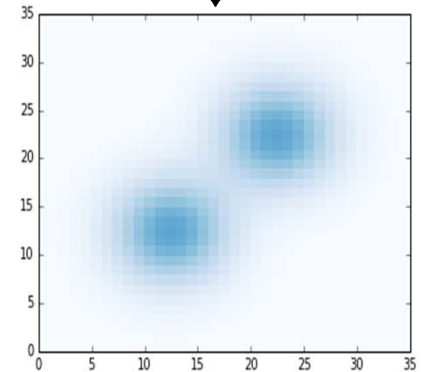
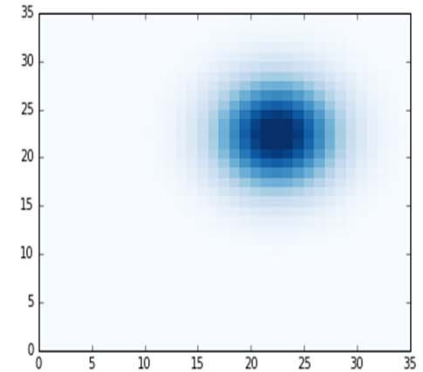
$$\sigma_{iTEEN}^2 = 1 - r_{iTEEN}^2$$

$$\sigma_{ABLER}^2 = 1 - r_{ABLER}^2$$

$$\sigma_{iTEEN}^2 = r_{ABLER}^2$$



+



σ^2 : 系統不確定性

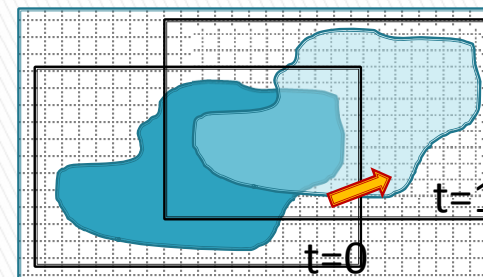
r : 相關係數

w : 融合權重

雷達外延預報ABLER

- TREC (Rinehart & Garvey, 1978) :

- ▶ 追蹤雨胞位置變化 (Eulerian)

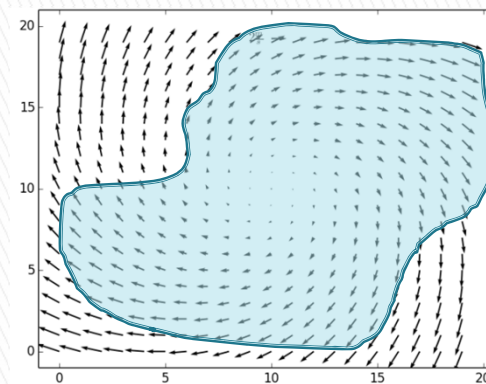


- Shiiba (Takasao & Shiiba, 1984) :

- ▶ 迴歸估計雨胞形狀變化 (Lagrangian)

- ABLER (李天浩等人, 2013)

- ▶ 結合同時考量雨胞位置和形狀變化



TREC : Tracking Radar Echoes by Correlation

ABLER : Advection-Based Lagrangian Eulerian Regression

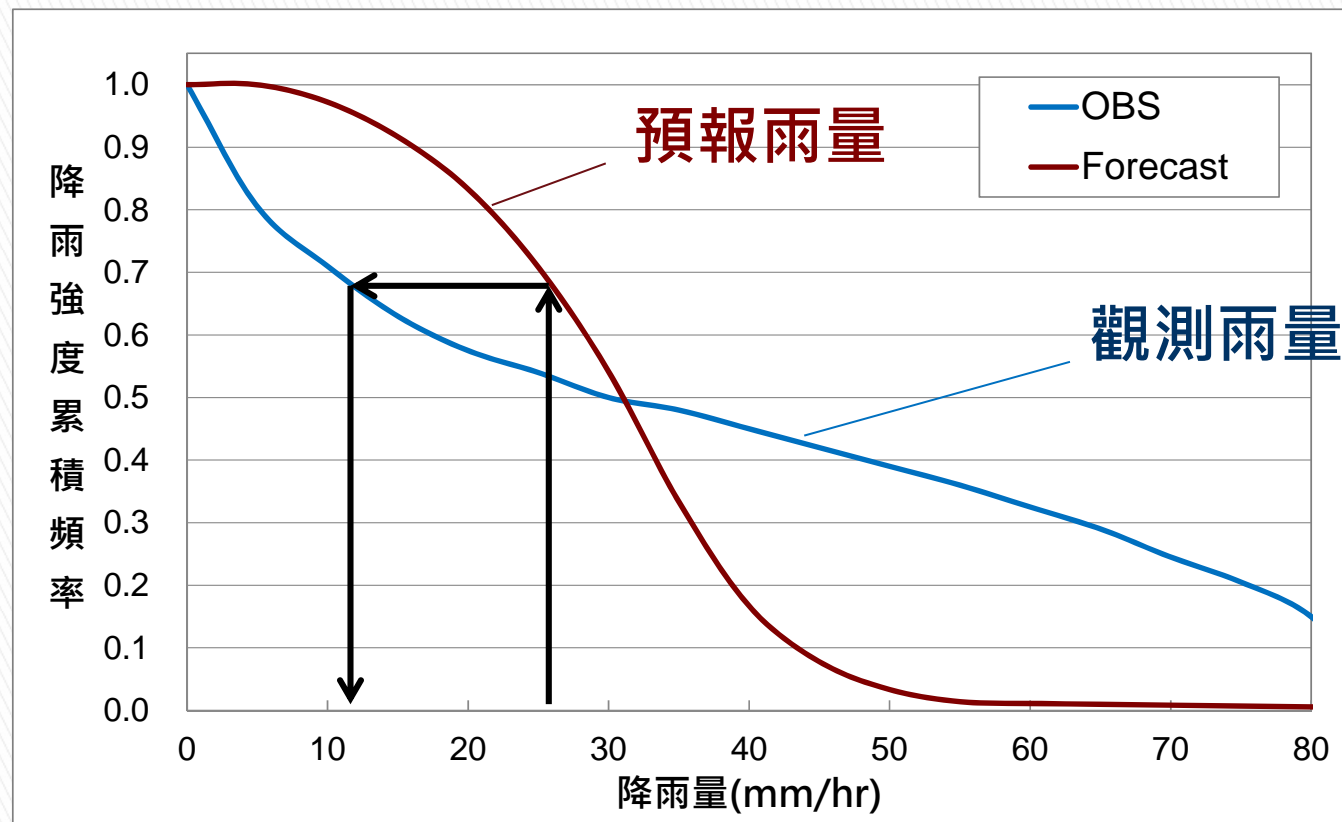
數值模式預報iTEEN

- iTEEN(陳新淦等人, 2016)
- 辨識預報相似度
 - ▶ 不限預報時間，比對與當下觀測之相似度，排序系集成員預報
- 篩選
 - ▶ 取相似度最高之若干成員之後續預報時間
 - ▶ 合成系集預報場

雨量頻率配對校正FMM

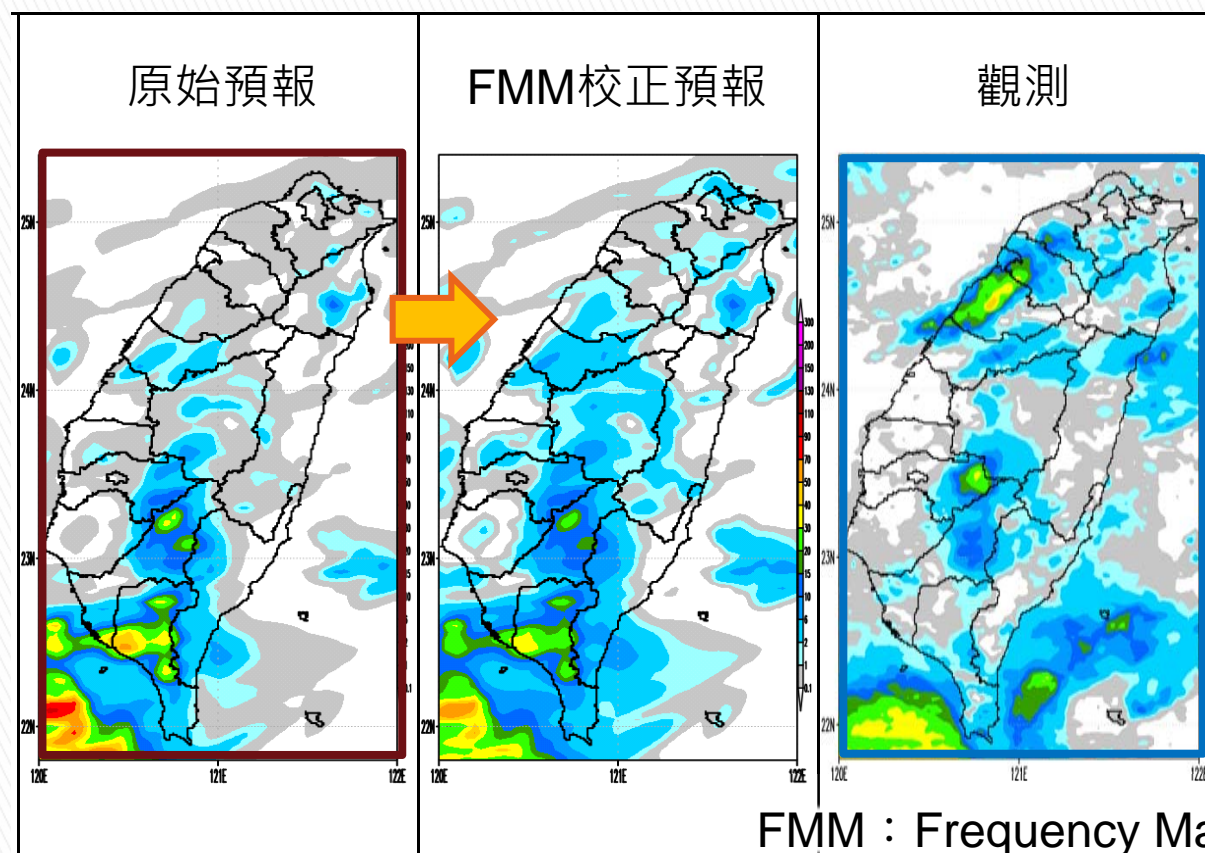
- 透過降雨強度比例調整降雨量值
- ▶ 降低融合雨量偏估

Zhu & Luo
2015



雨量頻率配對校正FMM

- 透過降雨強度比例調整降雨量值
- ▶ 降低融合雨量偏估



FMM : Frequency Matching Method

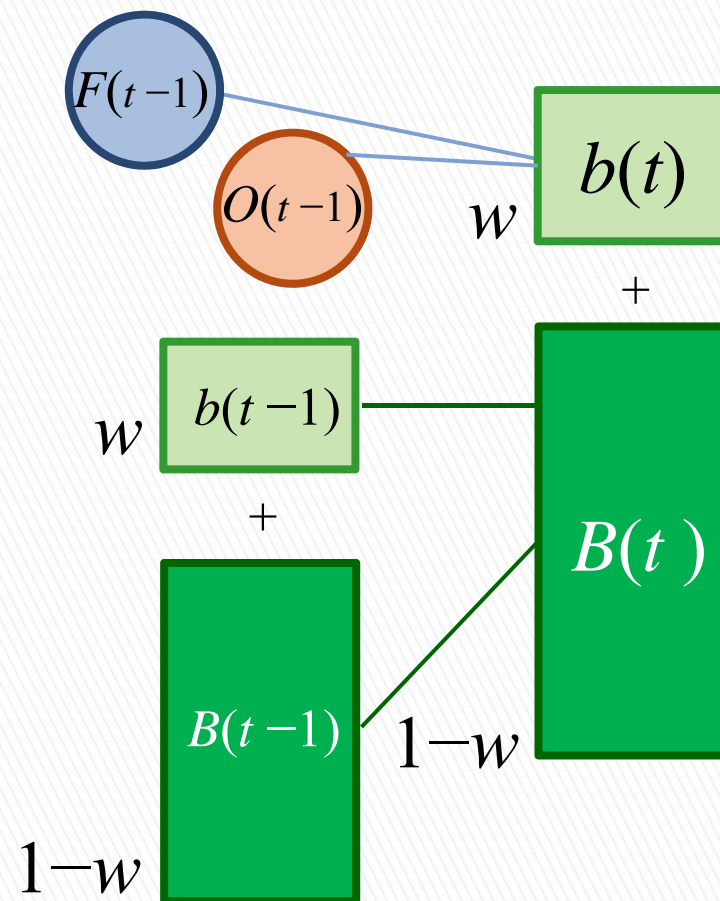
時間衰退平均DCA

- Decaying Average : Homleid, 1995
- 隨時間累積系統性偏差

$$b(t) = \overset{\text{預報}}{F(t-1)} - \overset{\text{觀測}}{O(t-1)}$$

$$\overset{\text{系統}}{B(t)} = (1-w)B(t-1) + w \cdot \underset{\text{更新}}{b(t)}$$

$$F_{DCA}(t) = F(t) - B(t)$$



DCA : Decaying Average

時間衰退平均DCA

■ 利用DCA更新相關係數

$$r_{xy} = \frac{S_{xy}}{\sqrt{S_{xx}}\sqrt{S_{yy}}} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2} \sqrt{\sum(y_i - \bar{y})^2}}$$

相關係數

$$\bar{x}(t) = \bar{x}(t-1) * (1-w) + x(t) * w$$

$$\bar{y}(t) = \bar{y}(t-1) * (1-w) + y(t) * w$$

$$S_{xy}(t) = \sum(x_i - \bar{x})(y_i - \bar{y})$$

$$S_{xx}(t) = \sum(x_i - \bar{x})^2$$

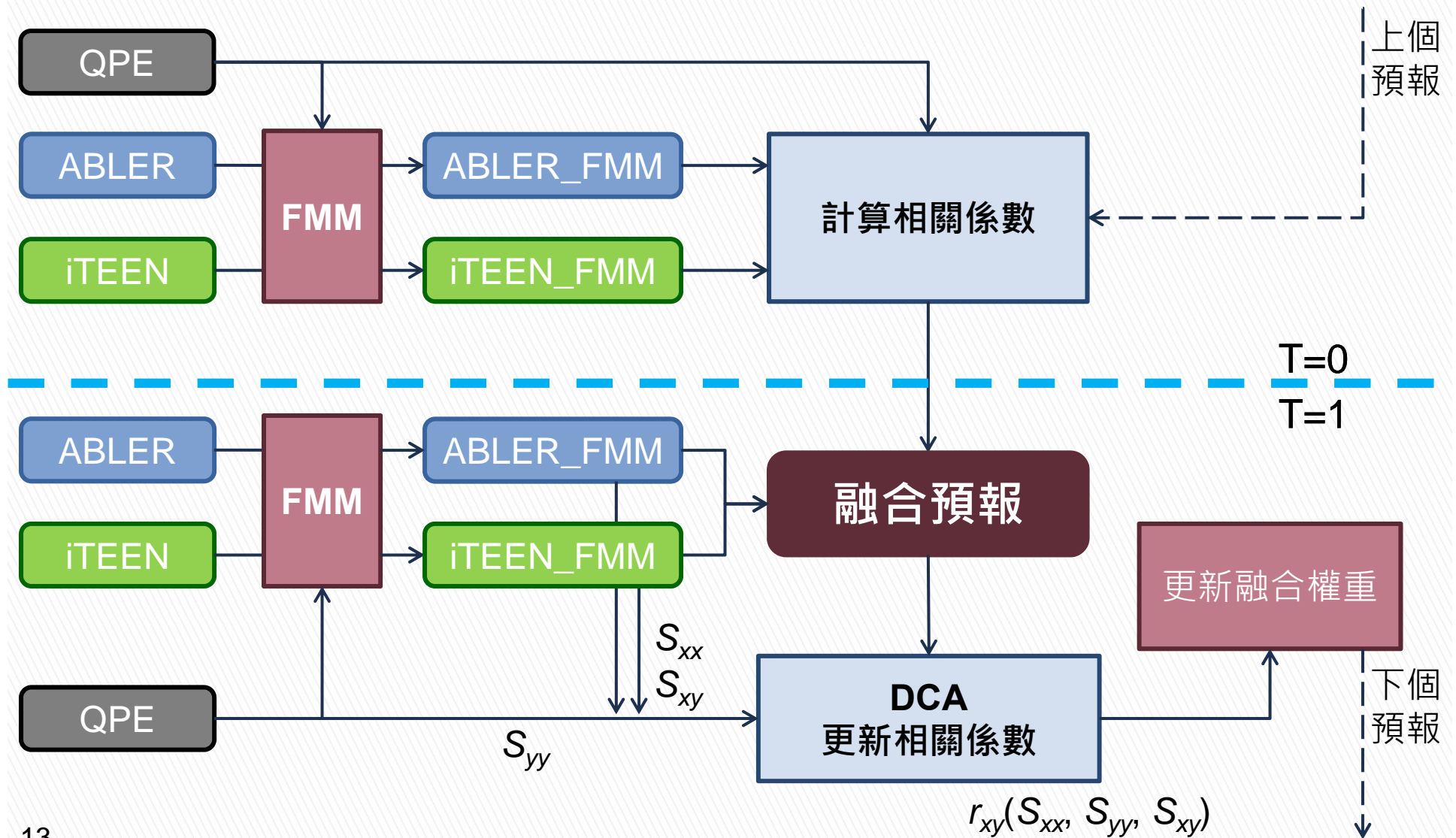
$$S_{yy}(t) = \sum(y_i - \bar{y})^2$$

$$\overline{S_{xy}}(t) = \overline{S_{xy}}(t-1) * (1-w) + S_{xy}(t) * w$$

$$\overline{S_{xx}}(t) = \overline{S_{xx}}(t-1) * (1-w) + S_{xx}(t) * w$$

$$\overline{S_{yy}}(t) = \overline{S_{yy}}(t-1) * (1-w) + S_{yy}(t) * w$$

融合流程



測試案例

- 測試時段2017年6/1~6/30共720小時
- 0.02度解析度臺灣陸地網格共8396格點
- QPESUMS
- iTEEN：以相關係數篩選成員，NewPM法平均
- 以公正預兆得分ETS評估預報技術

■ ABLER ■ iTEEN

AiQPF_0

■

$$\sigma_{ABLER}^2 = 1 - r_{ABLER}^2$$

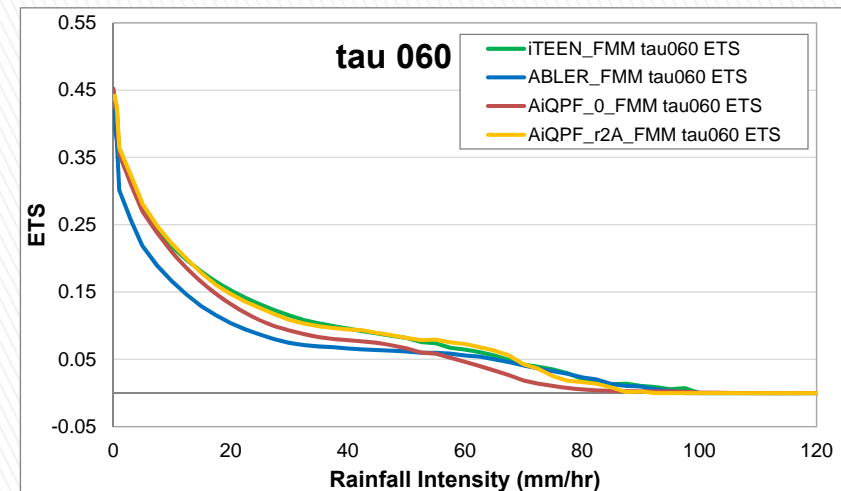
$$\sigma_{iTEEN}^2 = 1 - r_{iTEEN}^2$$

AiQPF_r2A

■

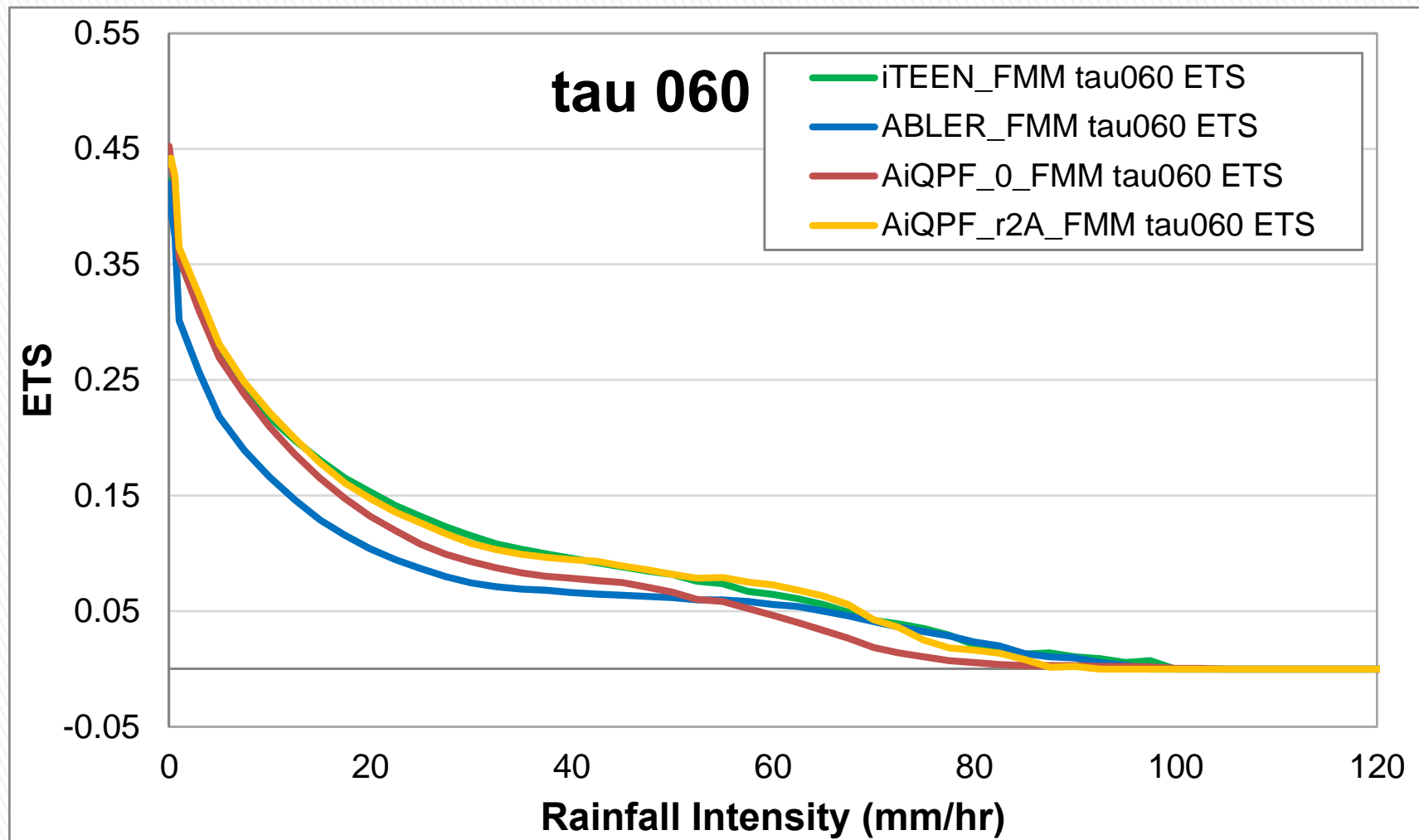
$$\sigma_{ABLER}^2 = 1 - r_{ABLER}^2$$

$$\sigma_{iTEEN}^2 = r_{ABLER}^2$$

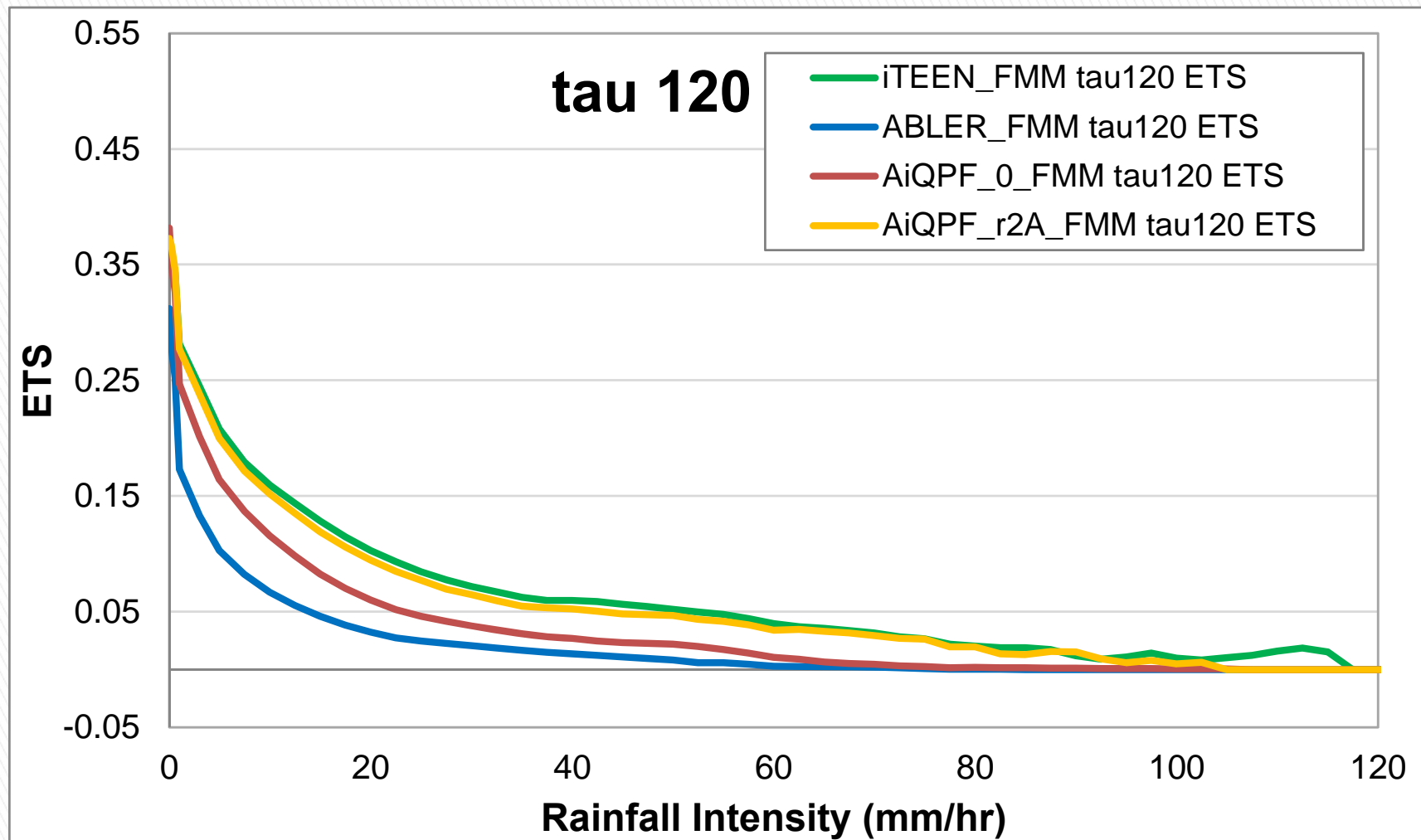


ETS : Equitable Threat Score

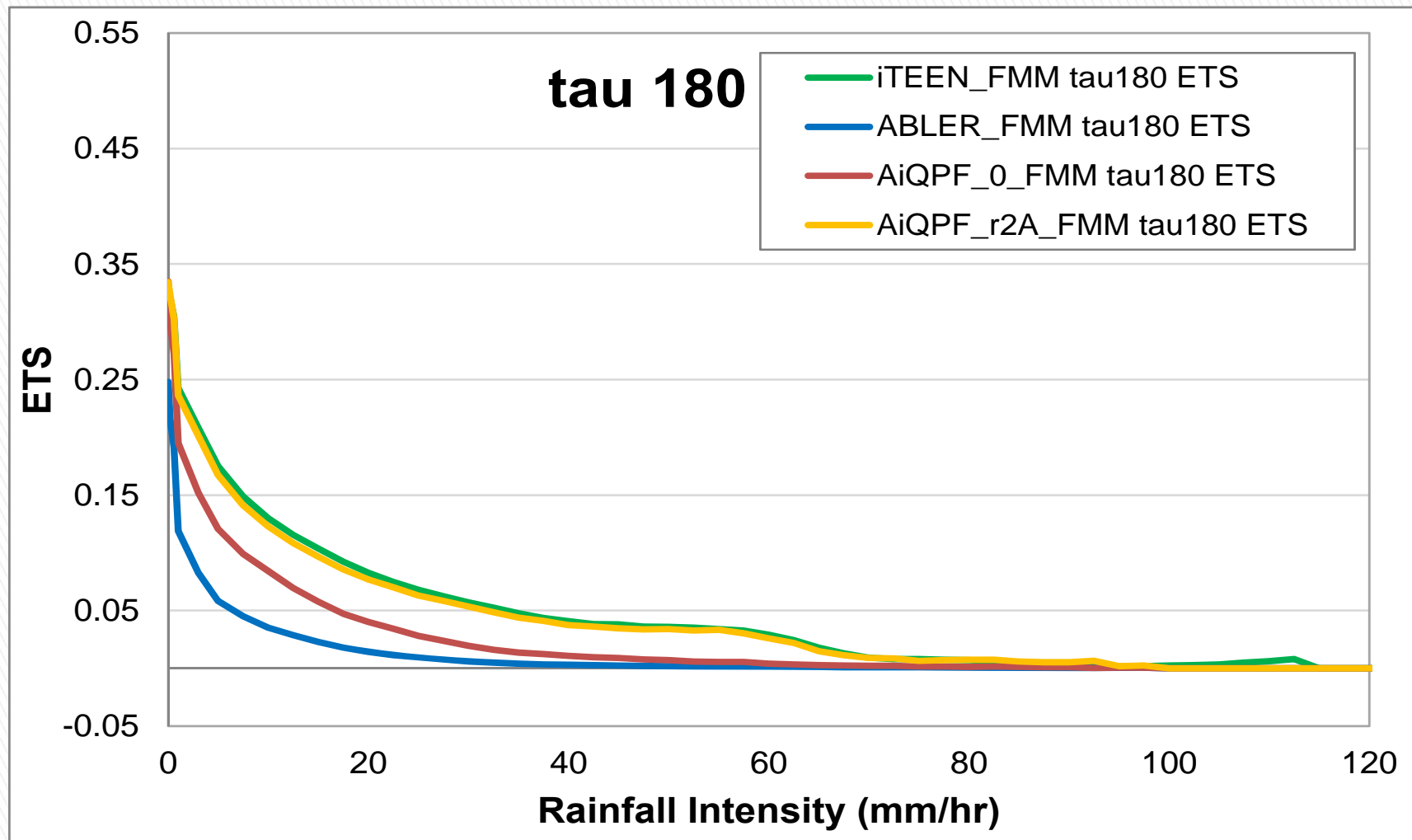
測試結果



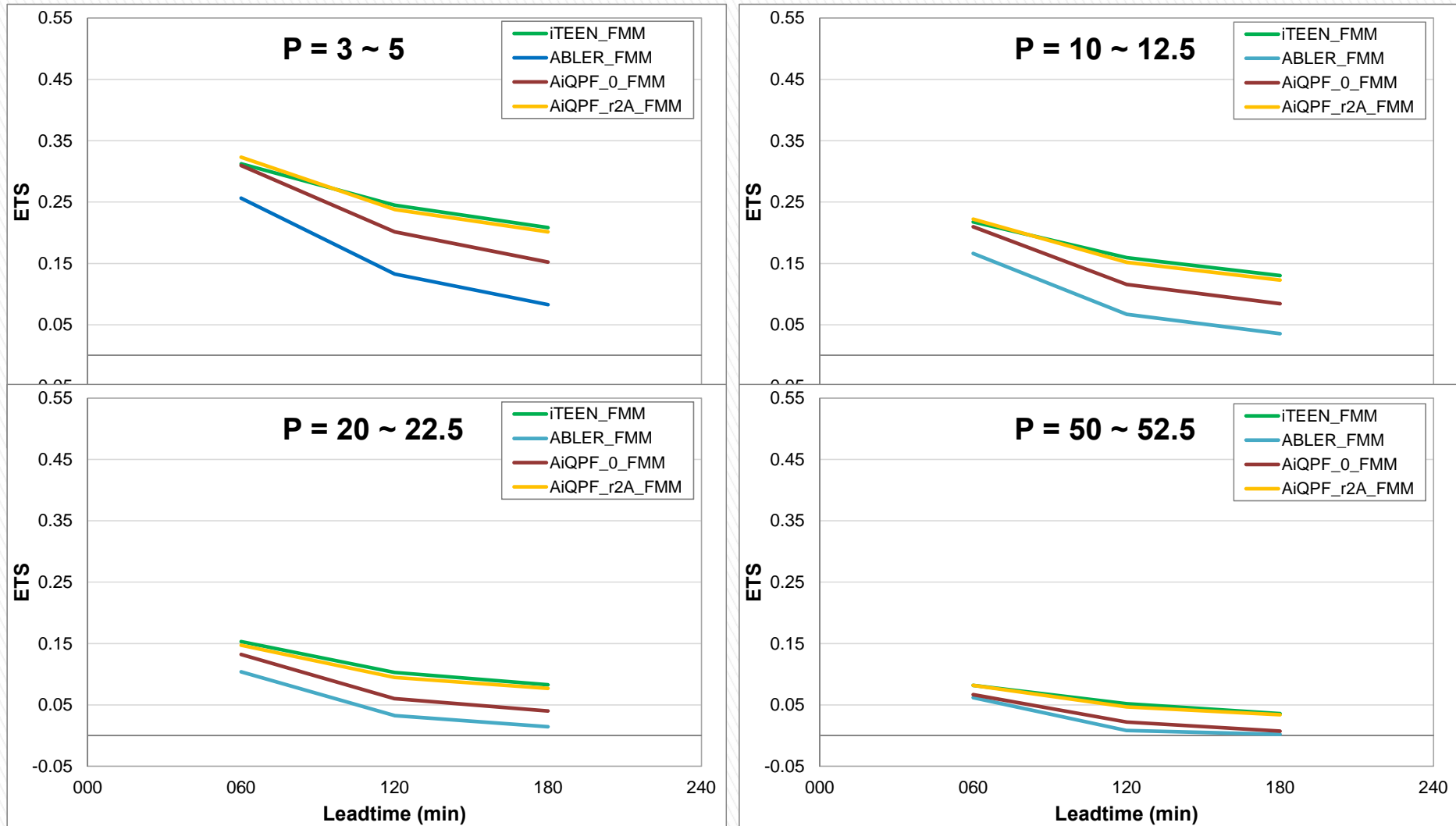
測試結果



測試結果



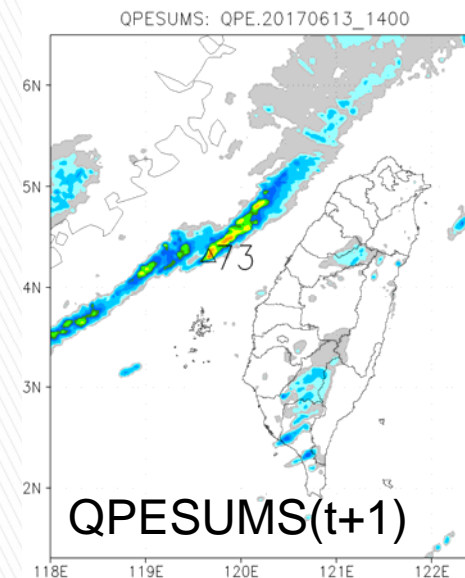
測試結果



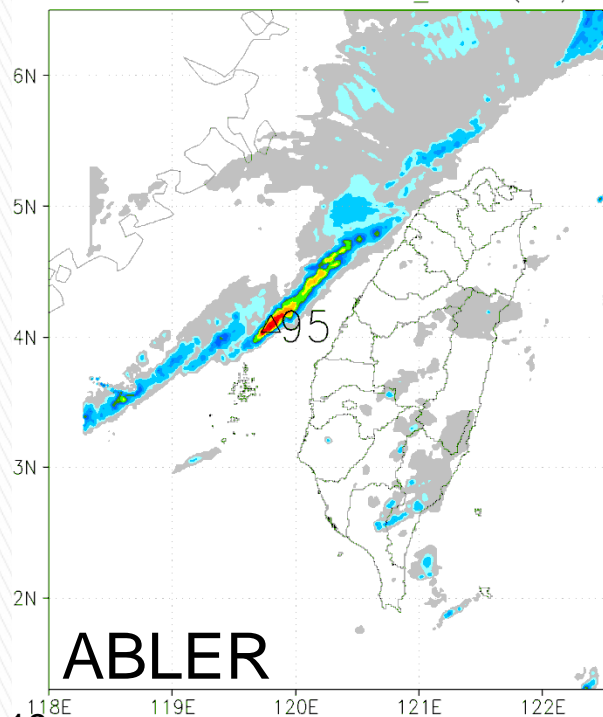
融合雨量場

2017/06/13 13:00Z

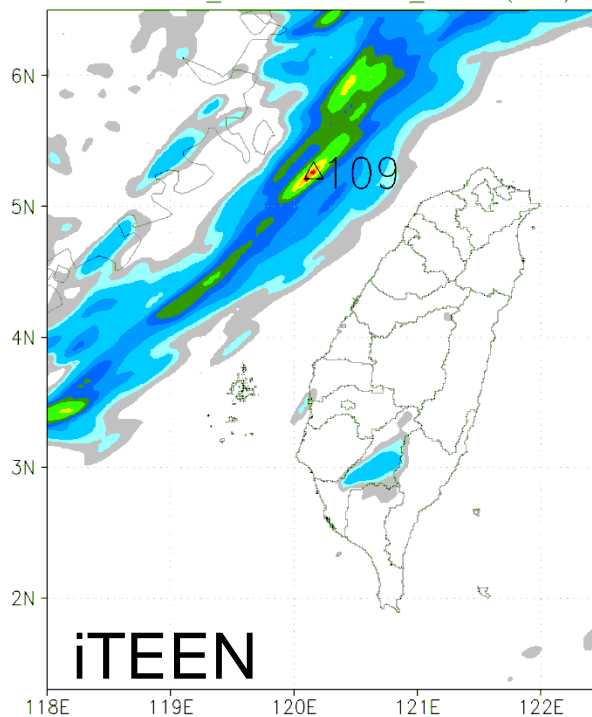
預報：t+1hr



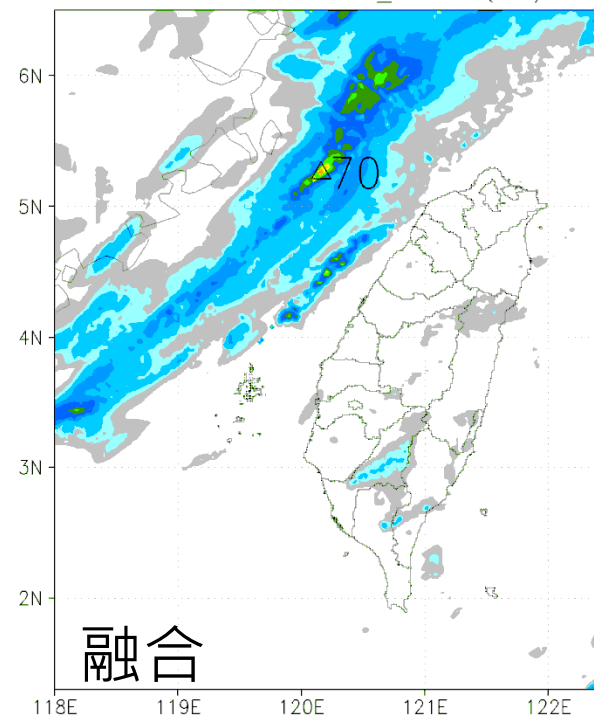
ABLER-FMM: QPF.20170613_1300 t(1hr)



NCtest-NPM_FMM: 20170613_1300+(0-1)h



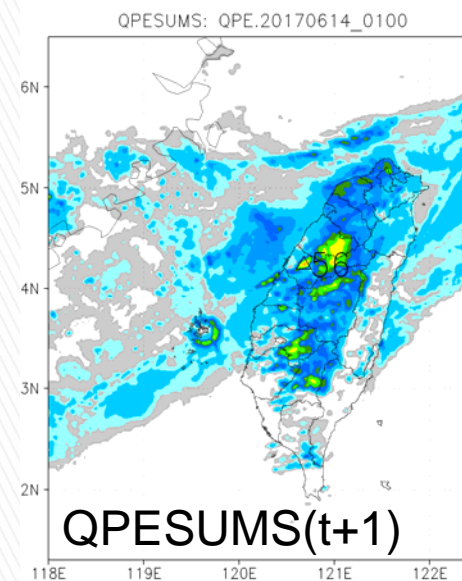
AiQPF: QPF.20170613_1300 +(1hr)



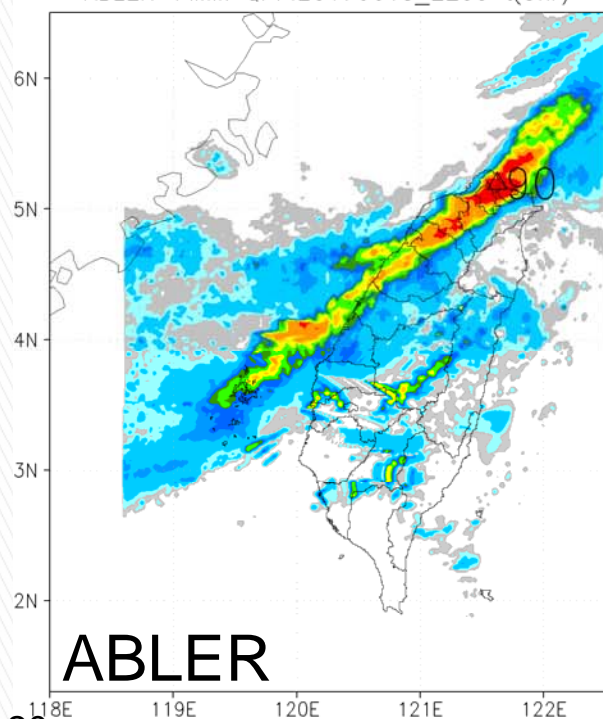
融合雨量場

2017/06/13 22:00Z

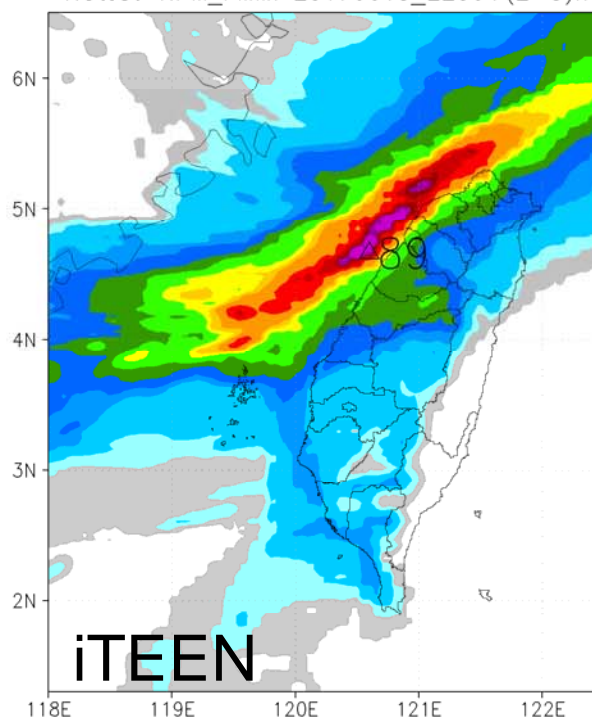
預報：t+3hr



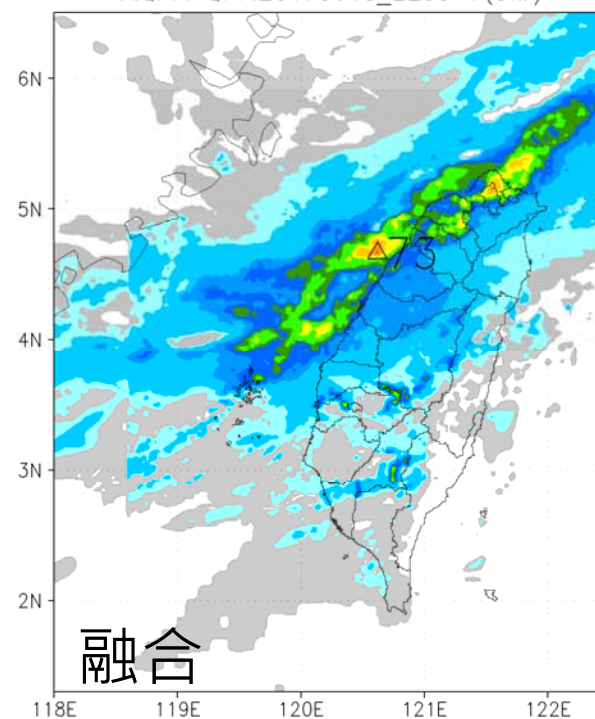
ABLER-FMM: QPF.20170613_2200 t(3hr)



NCtest-NPM_FMM: 20170613_2200+(2-3)h



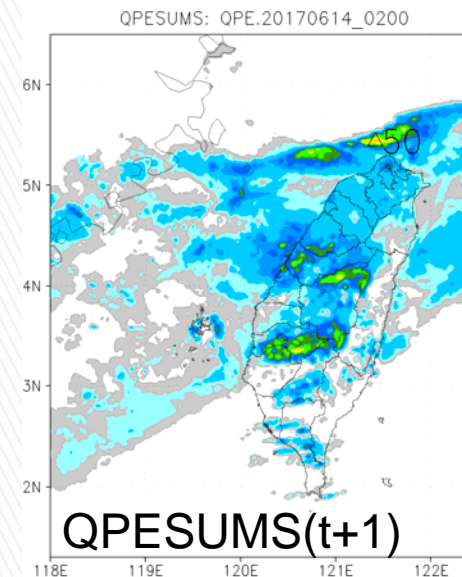
AiQPF: QPF.20170613_2200 +(3hr)



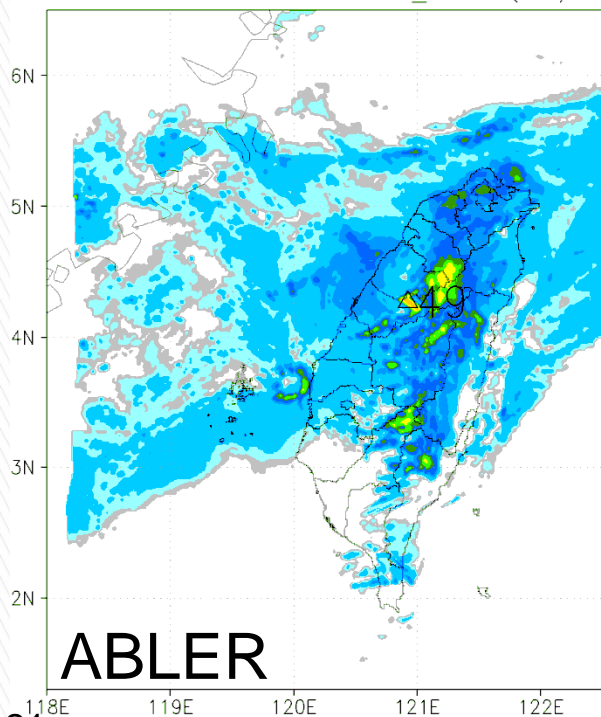
融合雨量場

2017/06/14 01:00Z

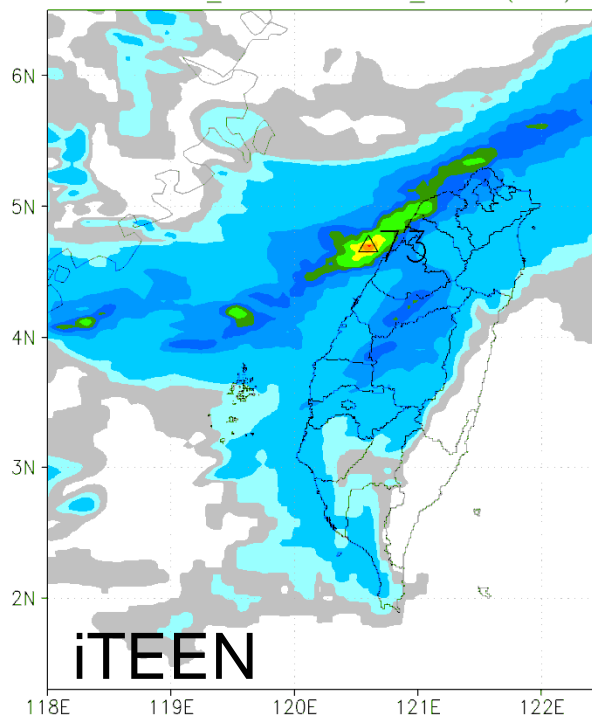
預報 : t+1hr



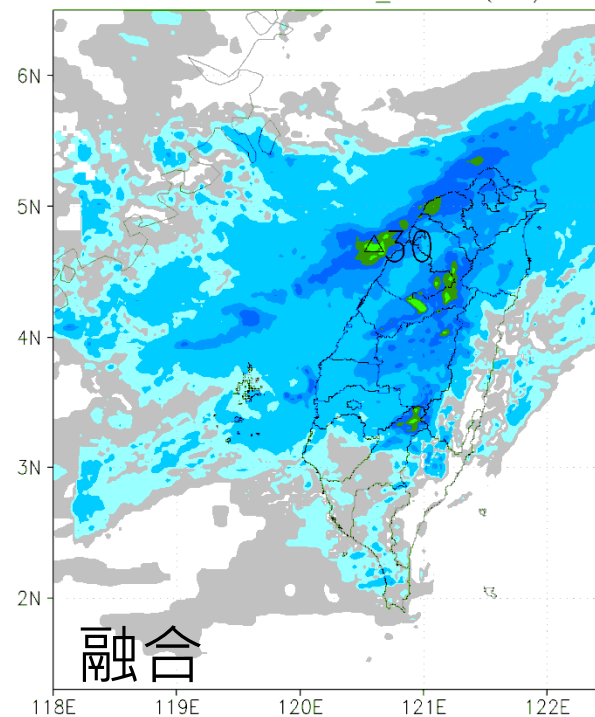
ABLER-FMM: QPF.20170614_0100 t(1hr)



NCtest-NPM_FMM: 20170614_0100+(0-1)h



AiQPF: QPF.20170614_0100 +(1hr)



實作技術應用

校正雨量

將外延與數值預報都校正至接近觀測降雨

- 利用頻率配對校正(FMM)
- 避免融合導致偏估

更新權重

利用時間衰退方式動態更新權重

- 利用時間衰退平均法(DCA)
- 使權重反映近期預報特性

權重設計

測試線性和切換式權重

- 切換式權重減少融合低估問題
- 融合結果可貼近較具能力之預報

結論

權重方法

不同的權重方法影響融合效果

- 較佳的權重方式
- 其他的預報技術指標

雨量校正

先校正原始預報雨量降低偏估

- 將雨量置於相同的基準
- 降低融合後偏估問題

融合表現

融合預報有機會優於原始預報

- 緊貼較佳之預報
- 得到較原兩預報皆優之預報

簡報結束 敬請指教

雷達觀測外延與數值動力模式客觀融合預報實作評估
Forecast fusion of ABLER & ITEEN

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