

# HYBRID 資料同化系統 對颱風預報之初步分析



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# Outline

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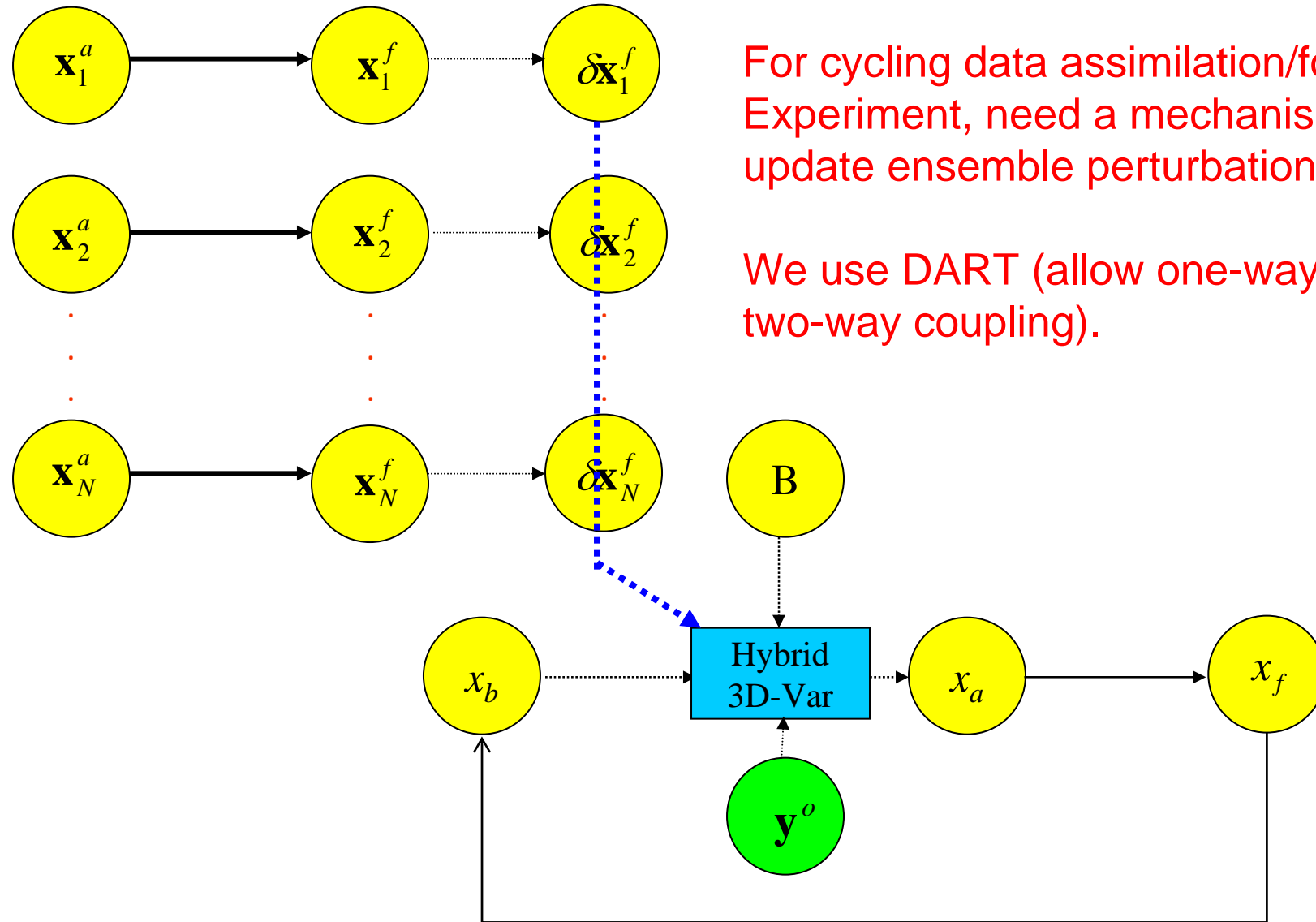
- 前言
- 單點測試
- 颱風個案模擬
- 結論

# HYBRID DA data flow

Ensemble Perturbations (extra input for hybrid)

For cycling data assimilation/forecast Experiment, need a mechanism to update ensemble perturbations.

We use DART (allow one-way or two-way coupling).



# 單點測試

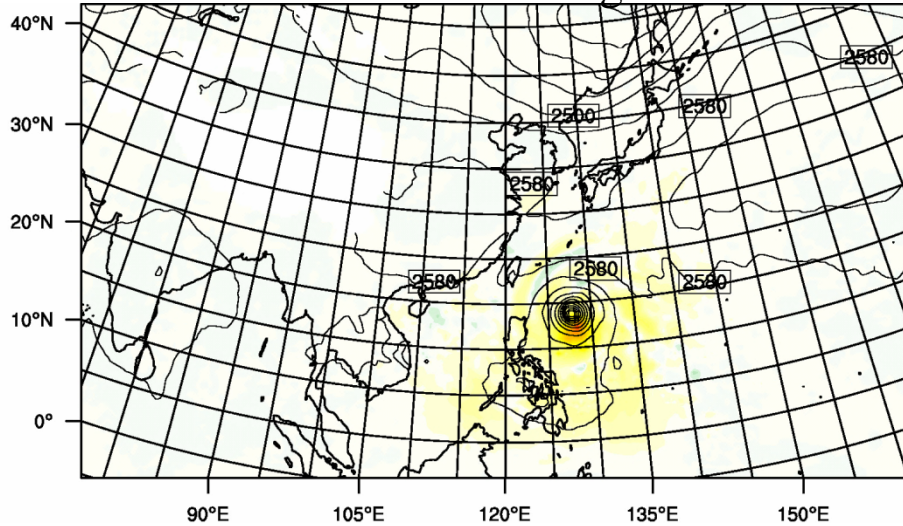
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# 實驗設計(1)

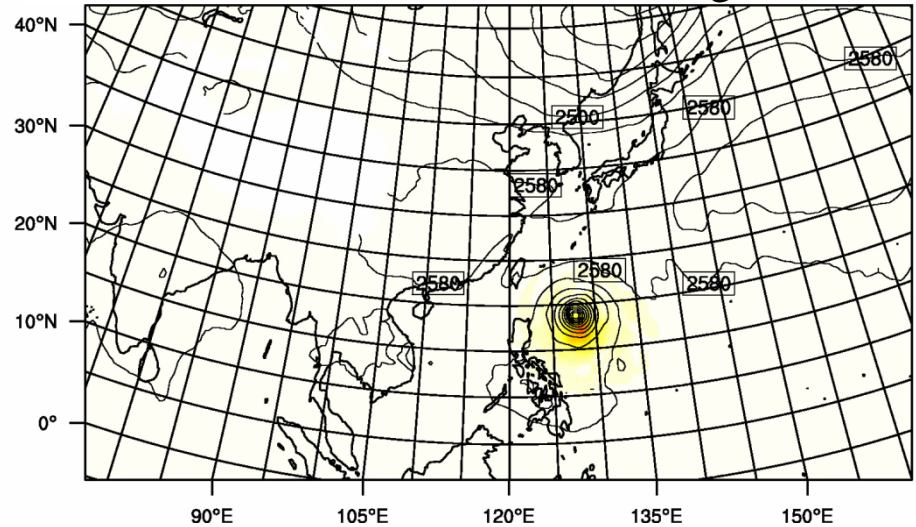
- 2010101700
- Pseudo position  $x=133$ ,  $y=41$ ,
- T @ 750mb ( $\sigma =15$ )
- O-B: (T) 1K, obserr: 1K
- Ensemble members: 32
- Je\_factor=2.0
- 評估localization的影響

# T Analysis increments from a single obs at 750mb

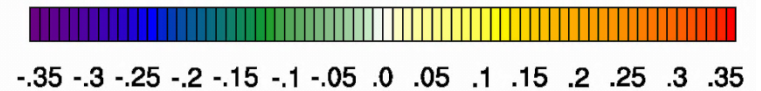
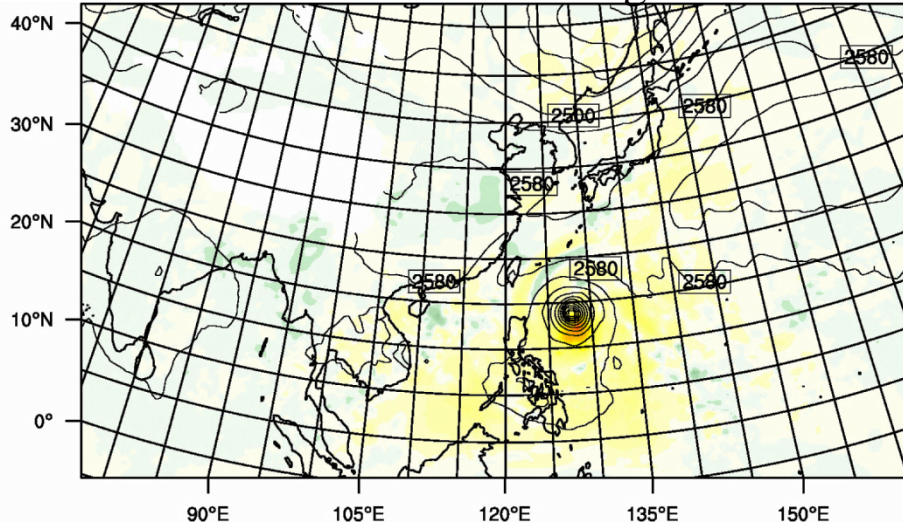
## 750 km recursive filter length-scale



## 200 km recursive filter length-scale



## 1500 km recursive filter length-scale

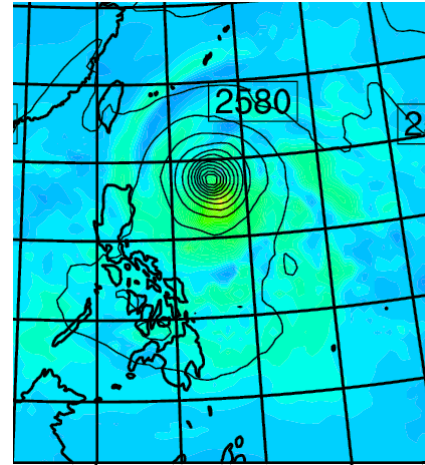
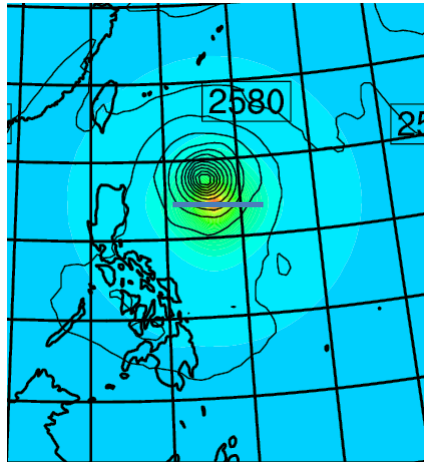


## 實驗設計(2)

- 2010101700
- Pseudo position  $x=133$ ,  $y=41$ ,
- T @ 750mb ( $\sigma = 15$ )
- O-B: (T) 1K, obserr: 1K
- Ensemble members: 32
- Hybrid horizontal correlation: 750km
- Je\_factor

# T Analysis increments from a single obs at 750mb

**3DVAR**

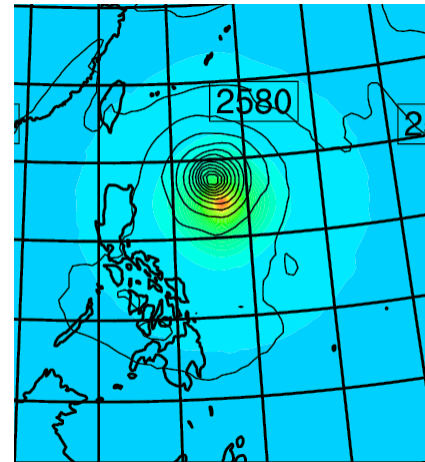
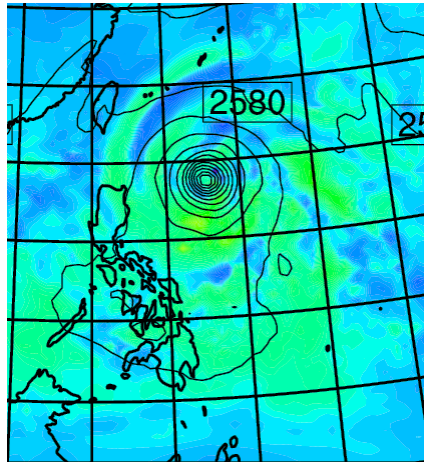


**Je\_factor=2.0**

50% ensemble,  
50% static

**Je\_factor=1.0**

100% ensemble,  
0% static



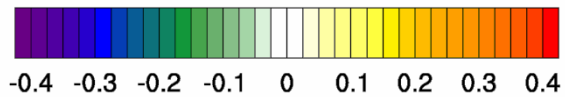
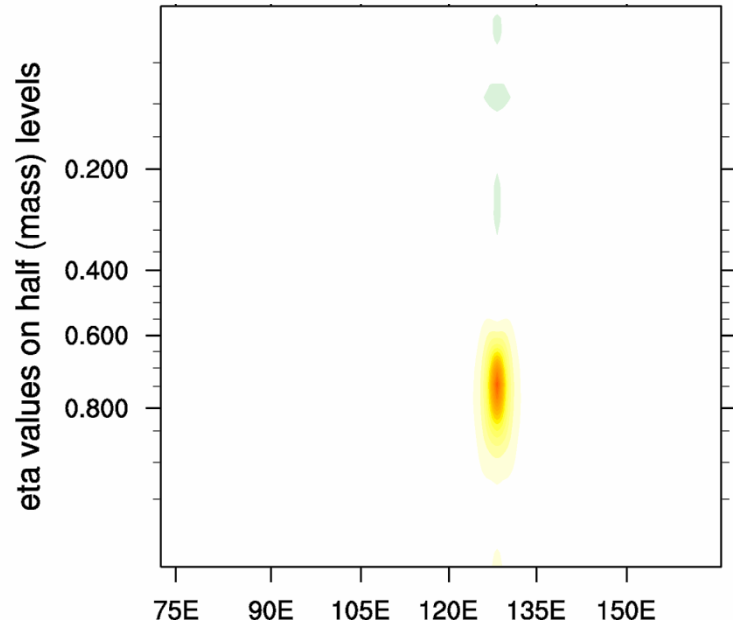
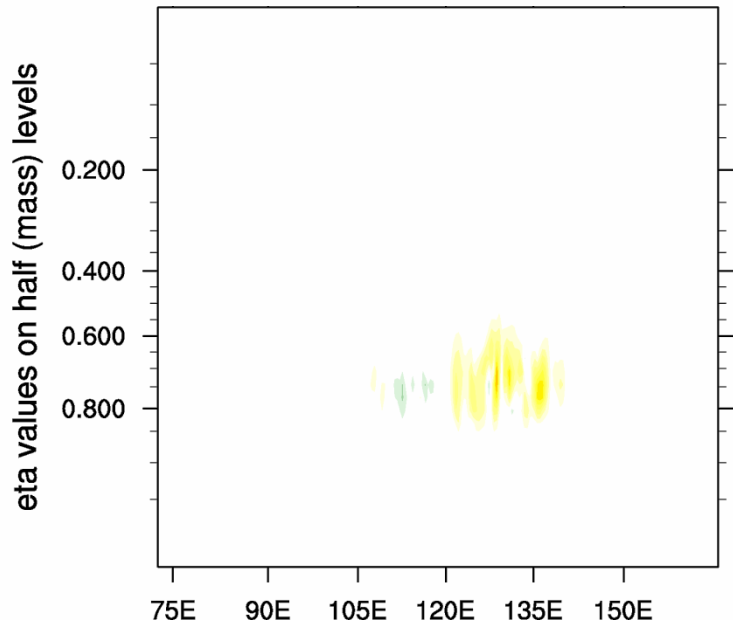
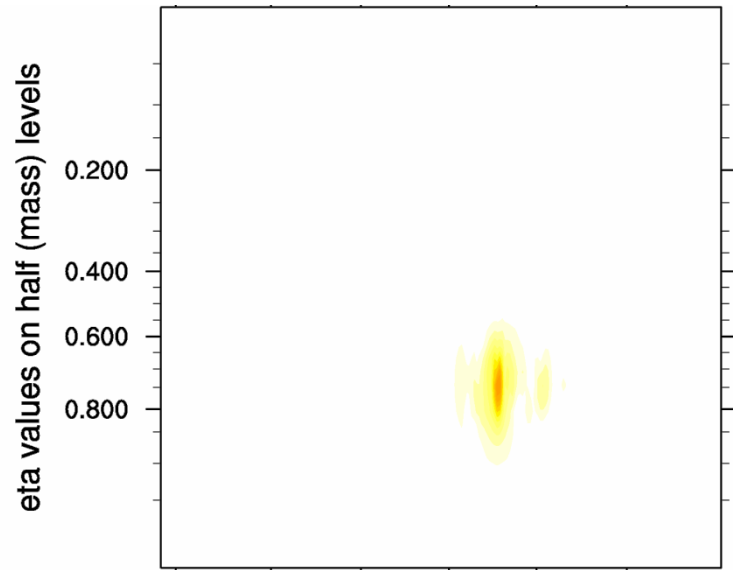
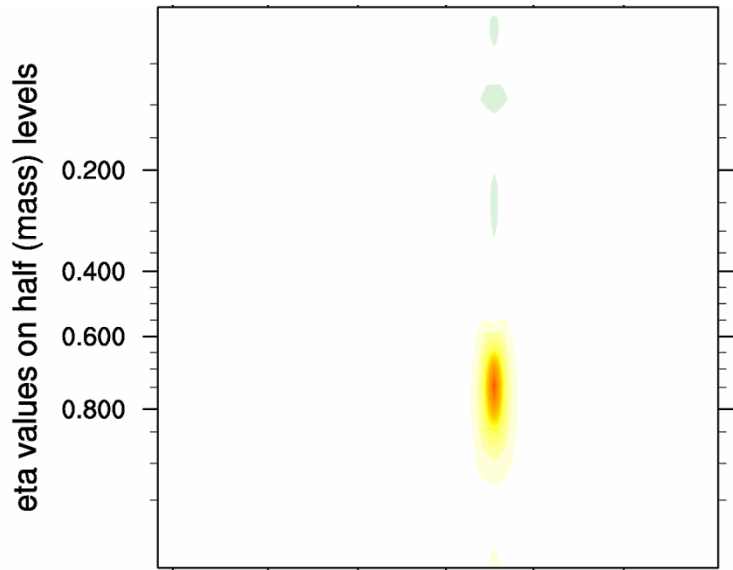
**Je\_factor=100.0**

1% ensemble,  
99% static

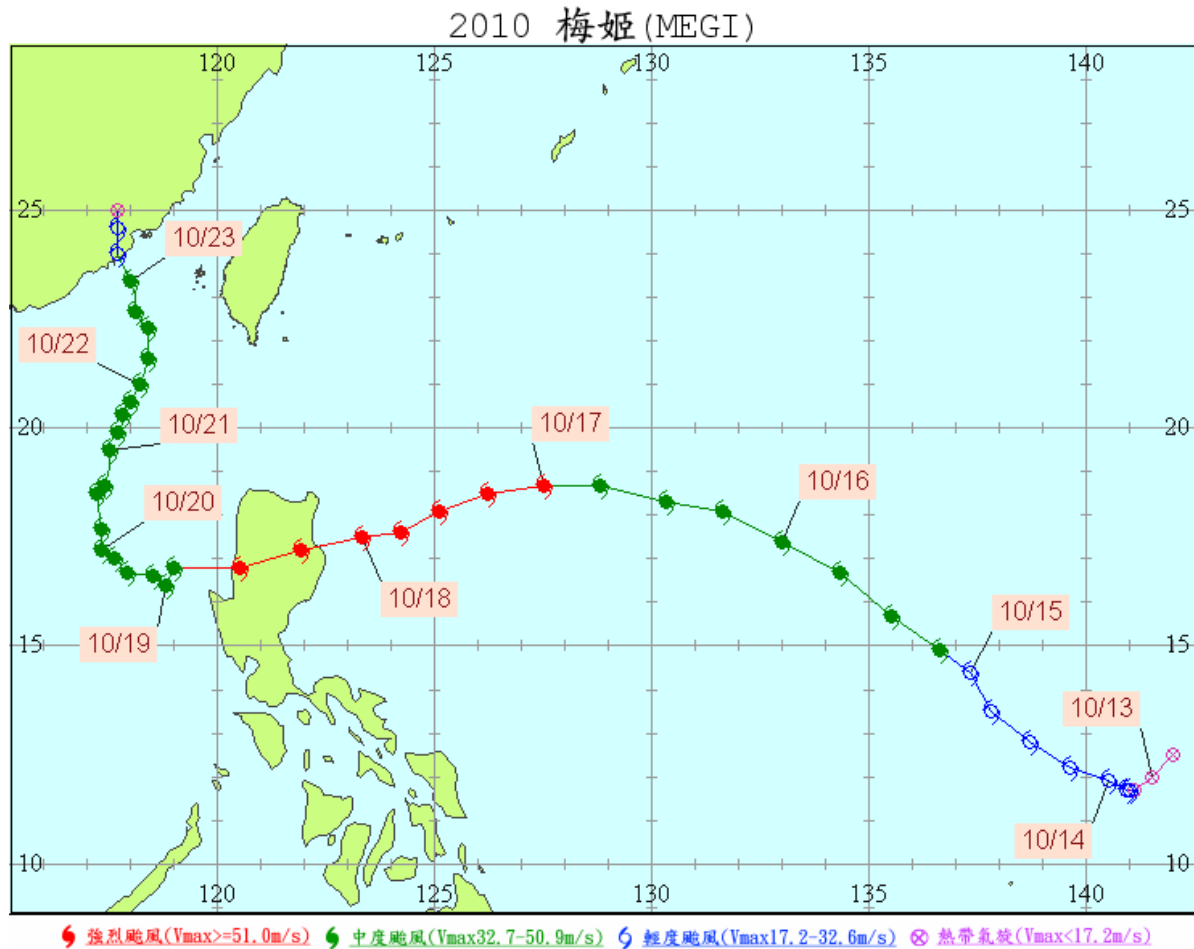


-0.2 -0.15 -0.1 -0.05 -0.0 .05 .1 .15 .2 .25 .3 .35 .4 .45



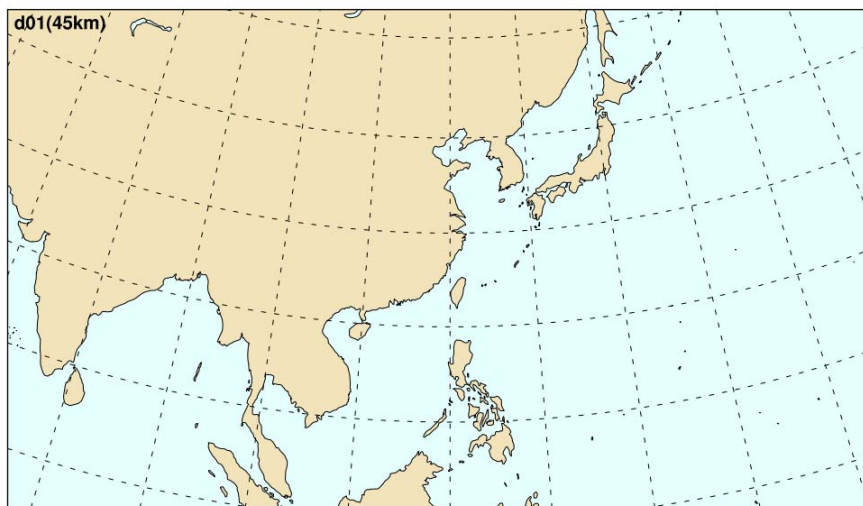


# Introduce the Typhoon cases



# 實驗設計(3)

- CWB OP24
- CWB operation domain 1
  - ( $\Delta x = 45 \text{ km}$ ,  $222 \times 128 \times 45$ )
- NCEP GFS 0.5 degree as IC & BC
- Used CWB TWRF WRFDA/WRF settings (in a full-cycling framework)

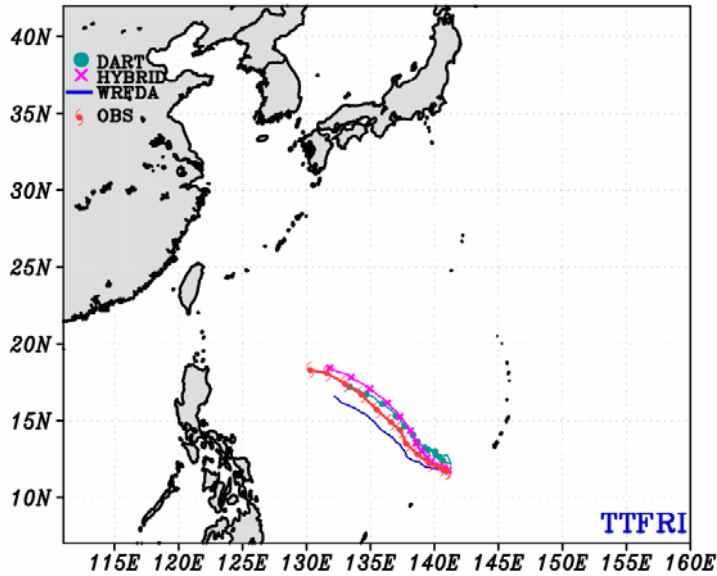


# RESULT

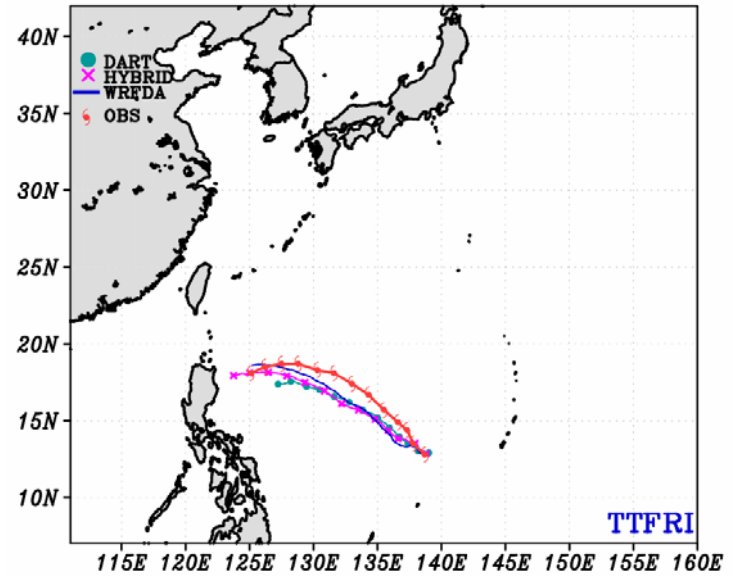
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# Forecast tracks

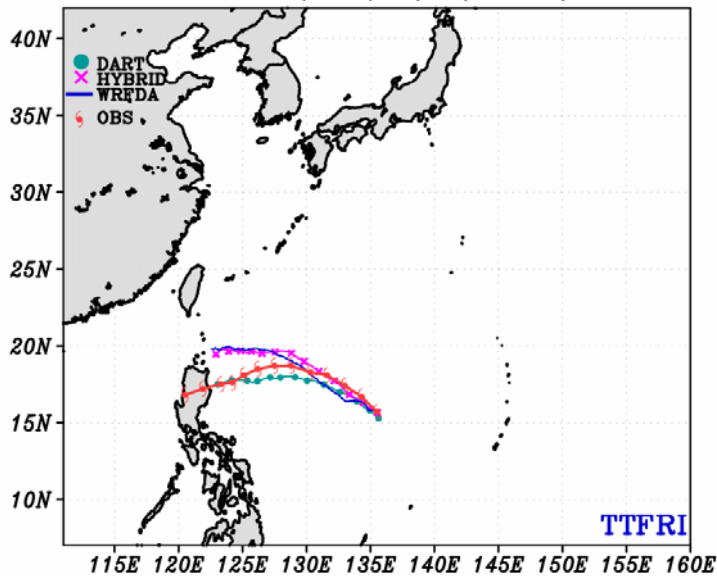
TYPHOON MEGI (2010/10/13/12UTC) BY PS



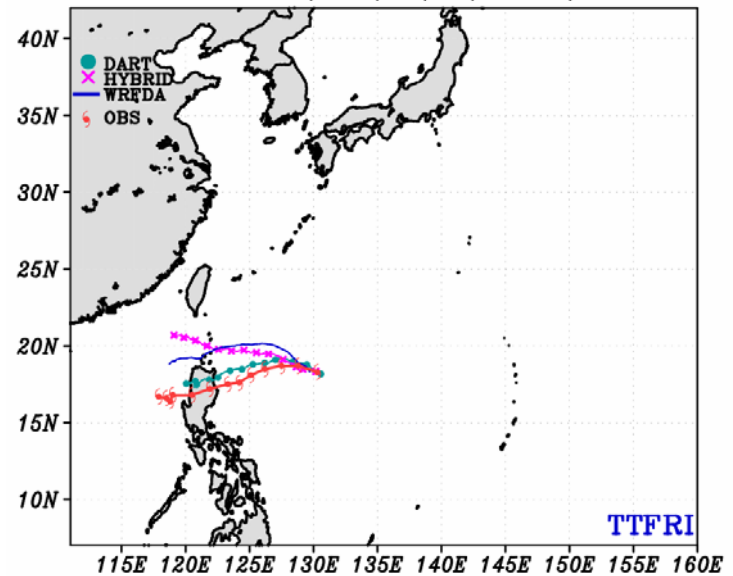
TYPHOON MEGI (2010/10/14/12UTC) BY PS



TYPHOON MEGI (2010/10/15/12UTC) BY PS

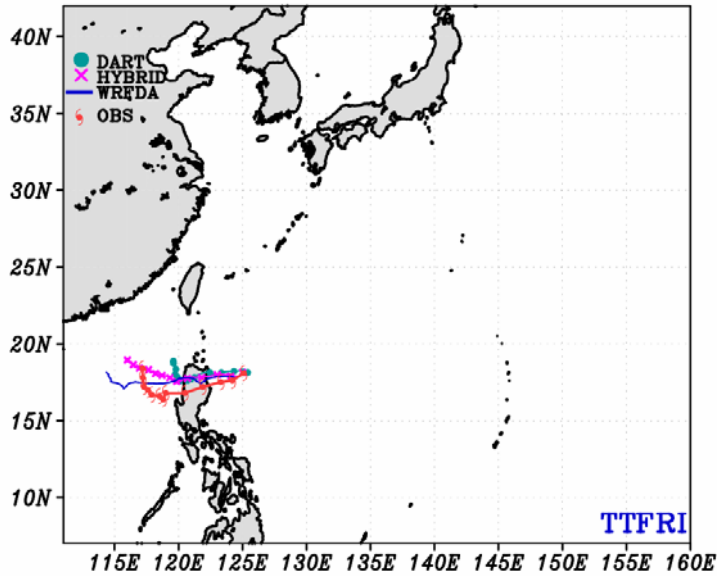


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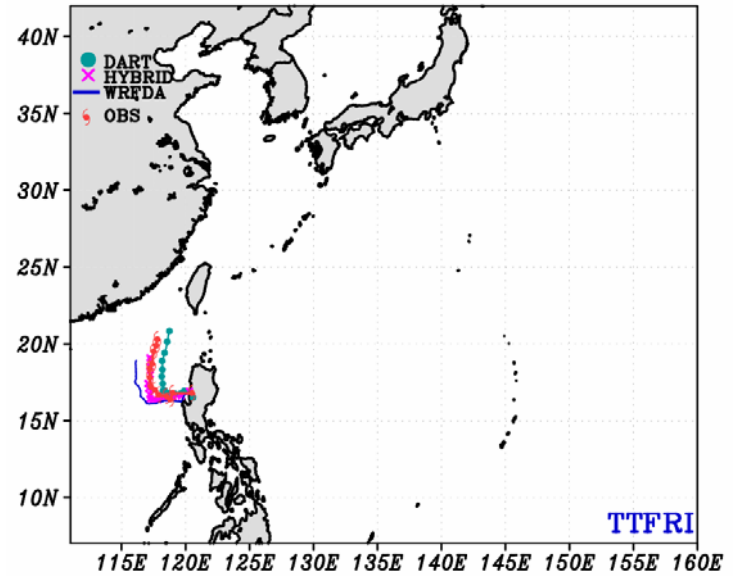


# Forecast tracks

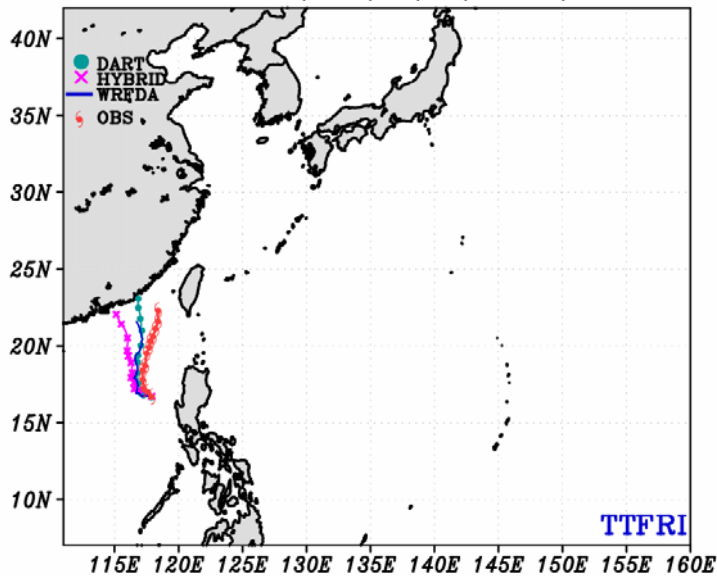
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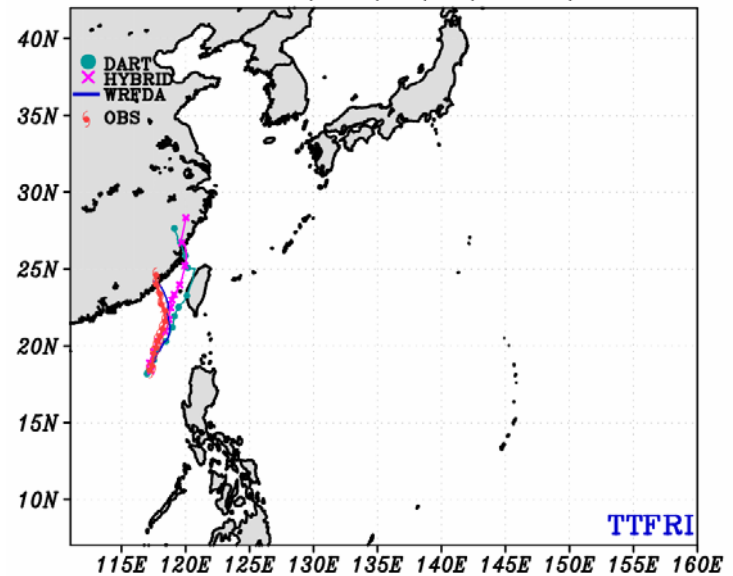
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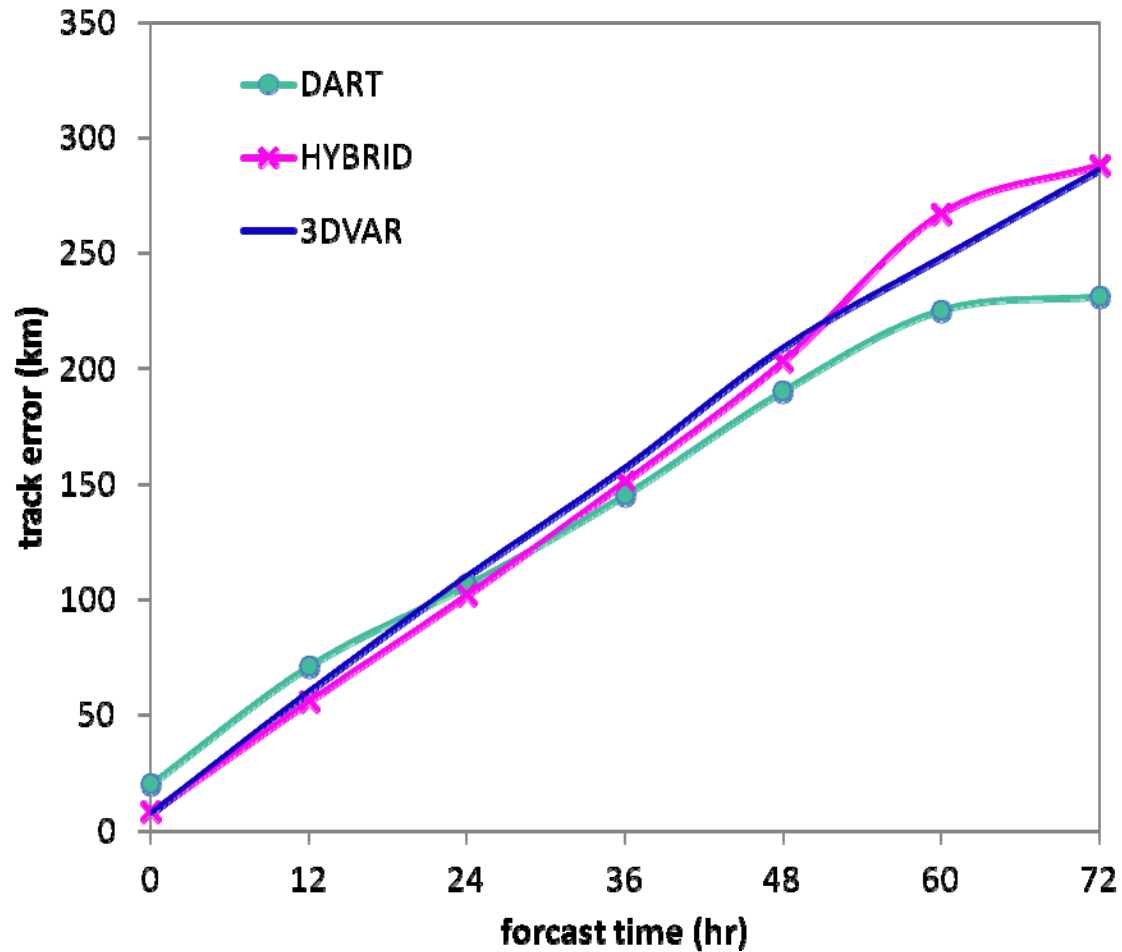
TYPHOON MEGI (2010/10/19/12UTC) BY PS



TYPHOON MEGI (2010/10/20/12UTC) BY PS



# Track error

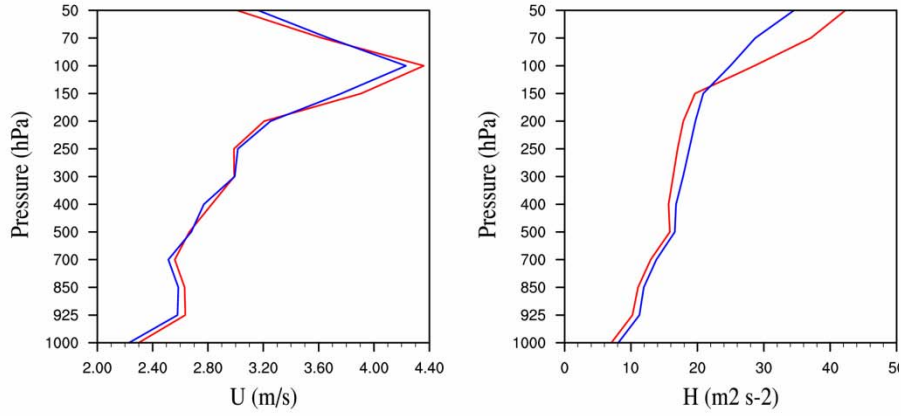


# Verification AGAINST 「EC ANALYSIS」

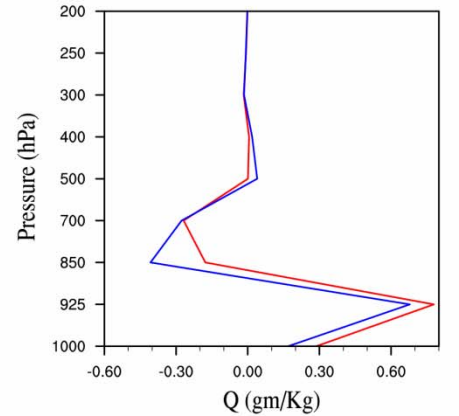
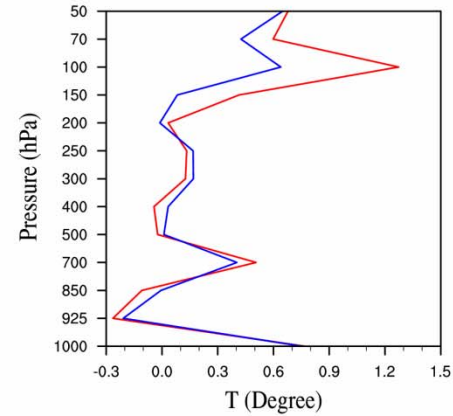
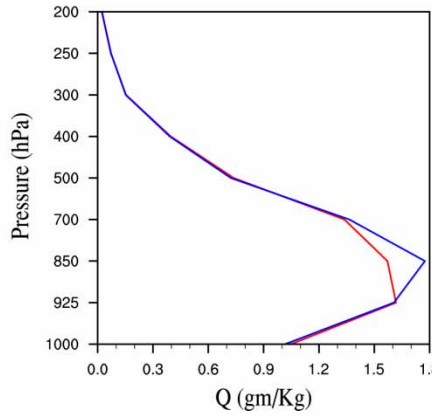
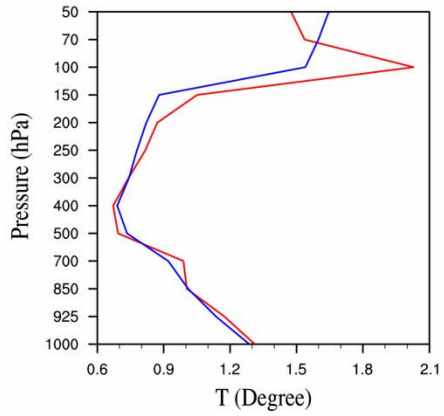
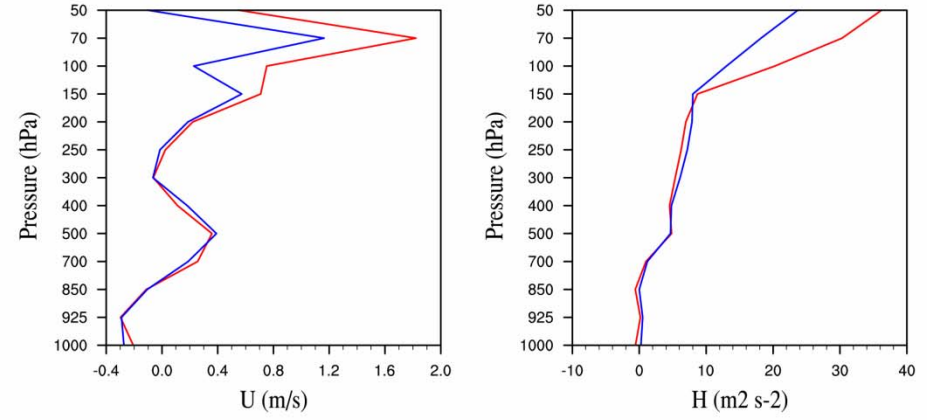
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RMSE 2010101312-2010102300 (Fcst 00h)



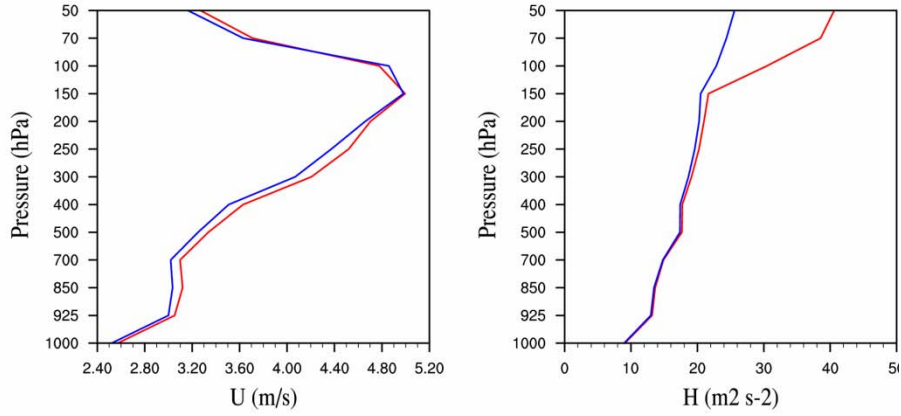
Bias 2010101312-2010102300 (Fcst 00h)



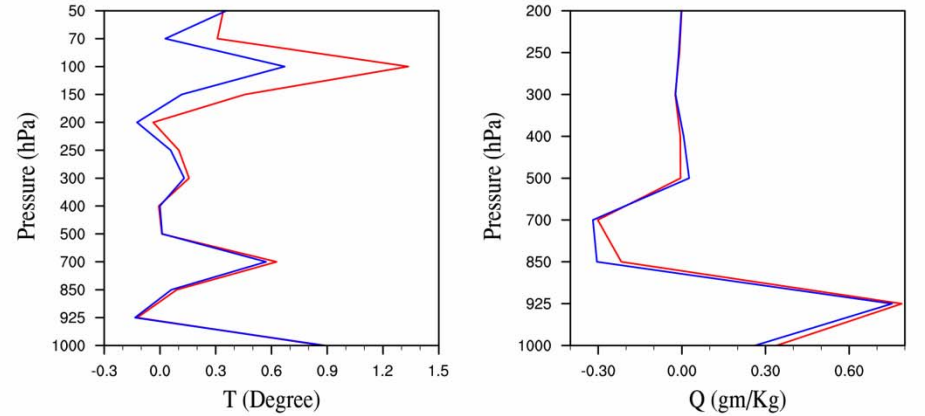
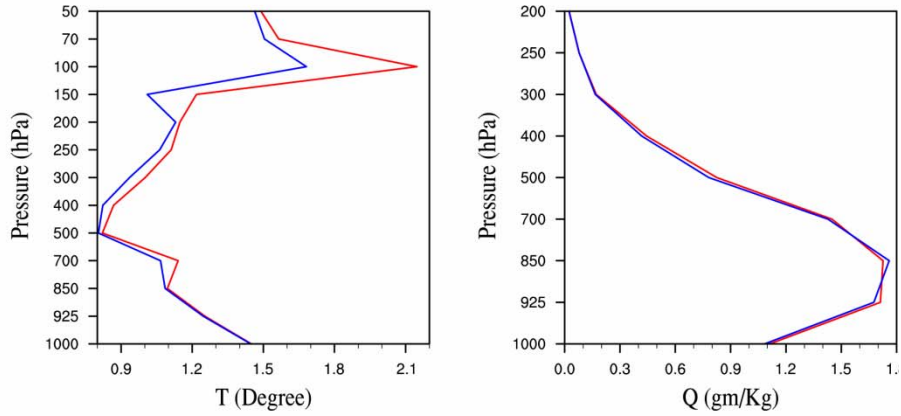
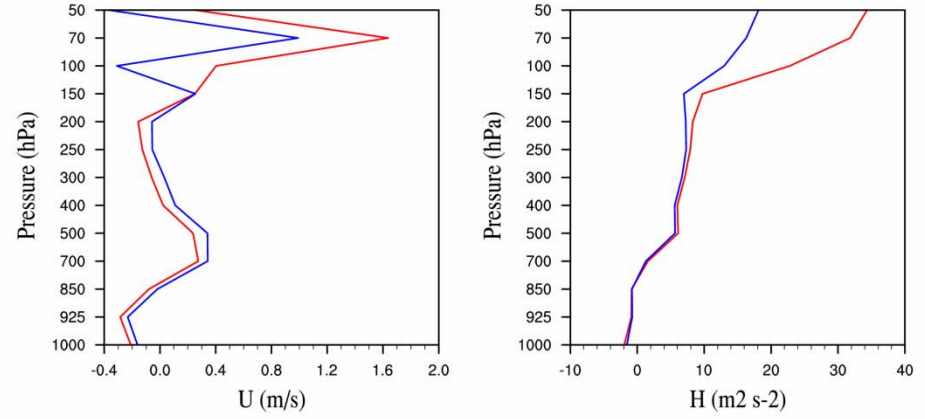
— HYBRID —  
— 3DVAR —

— HYBRID —  
— 3DVAR —

RMSE 2010101412-2010102300 (Fcst 24h)



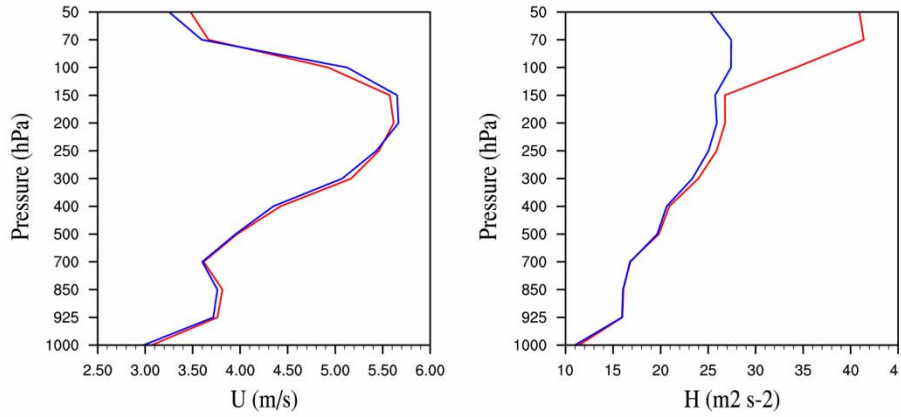
Bias 2010101412-2010102300 (Fcst 24h)



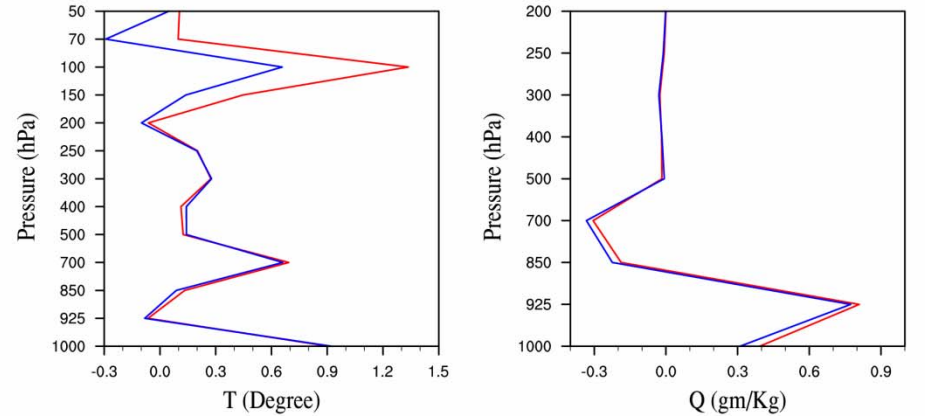
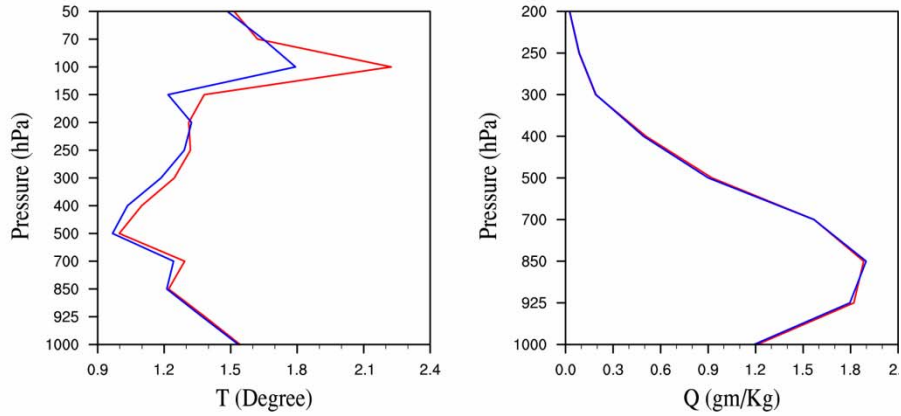
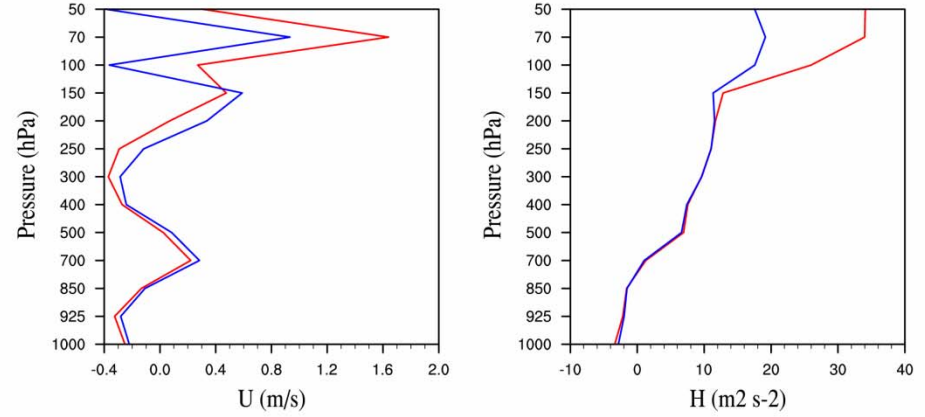
— HYBRID —  
— 3DVAR —

— HYBRID —  
— 3DVAR —

RMSE 2010101512-2010102300 (Fcst 48h)



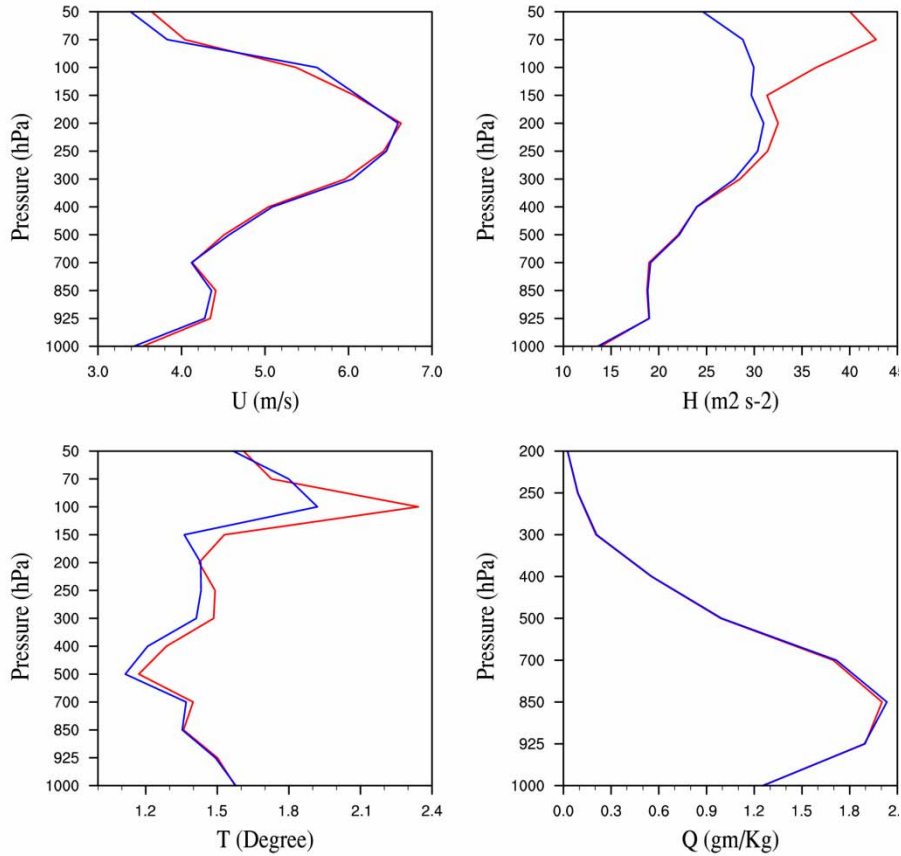
Bias 2010101512-2010102300 (Fcst 48h)



— HYBRID —  
— 3DVAR —

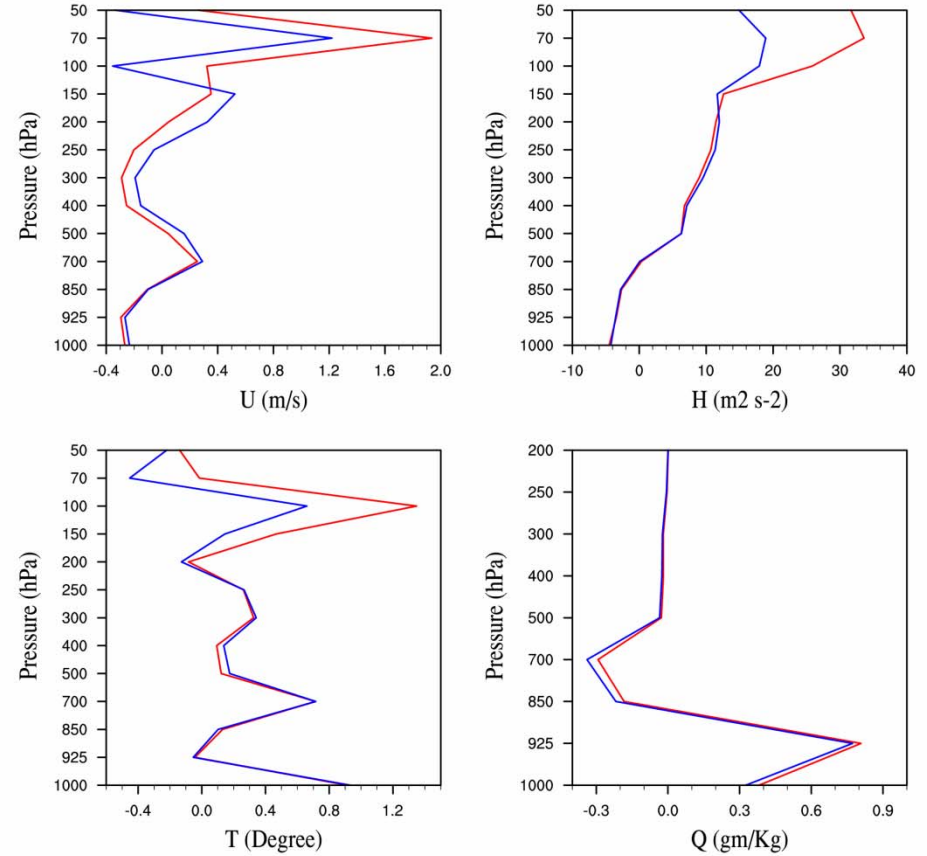
— HYBRID —  
— 3DVAR —

RMSE 2010101612-2010102300 (Fcst 72h)



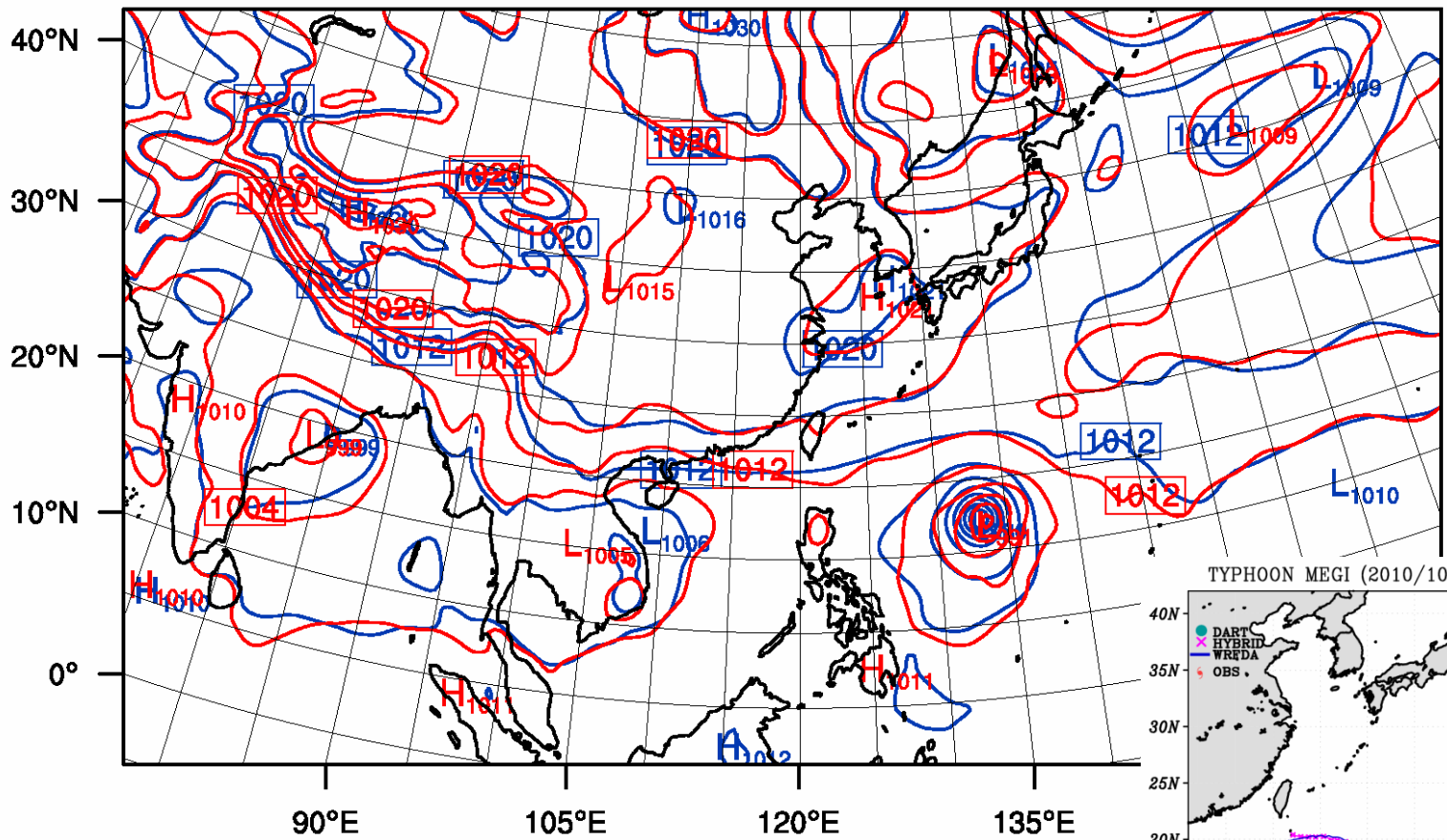
— HYBRID —  
— 3DVAR —

Bias 2010101612-2010102300 (Fcst 72h)



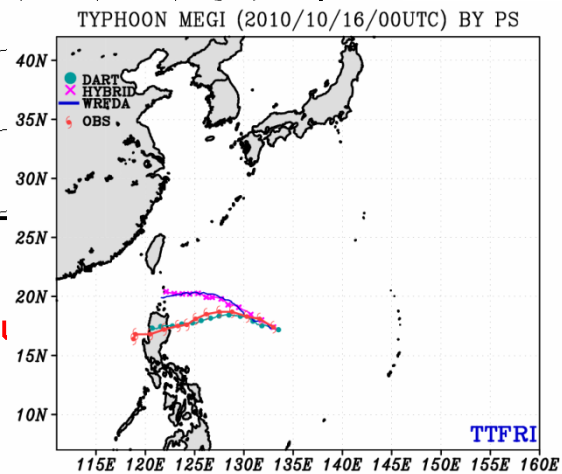
— HYBRID —  
— 3DVAR —

# Sea Level Pressure

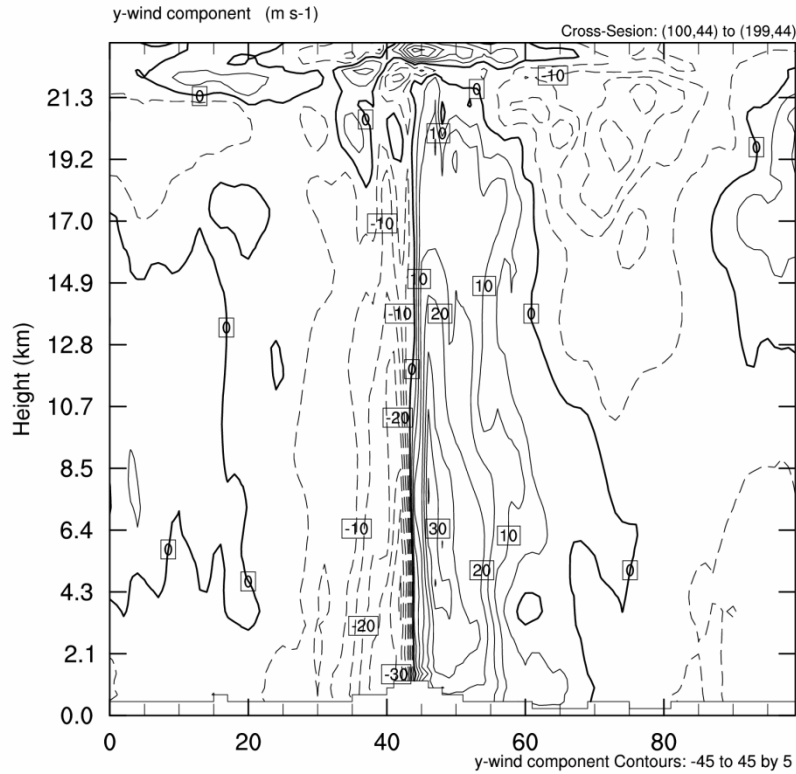


Sea Level Pressure Contour

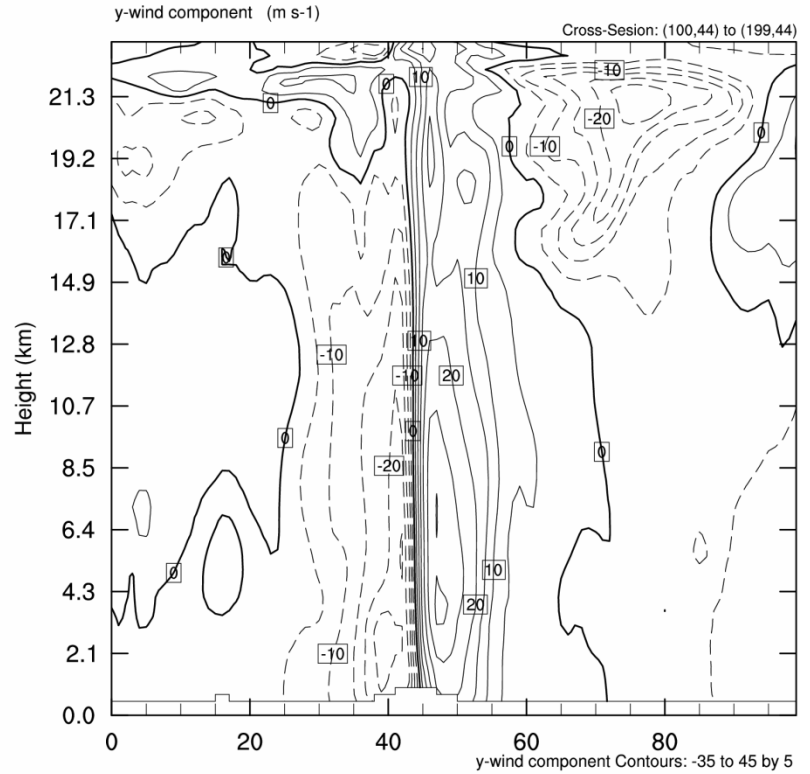
Hybrid analyzed TC is stronger



# HYBRID



# DART



**Hybrid analyzed TC is stronger**



# Summary

- 我們透過單點觀測實驗，檢視混合分析方法背景誤差協方差矩陣作用，顯示觀測訊息有效地反應所在位置具有的狀態。
- 初步的研究結果顯示，HYBRID資料同化系統對颱風預報有微幅改善，需要進行更多測試，找到一組適合颱風預報的設定。

~END~



# Hybrid formulation in WRFDA

- Incorporate ensemble perturbations directly into variational cost function through extended control variable
  - Lorenc (2003), Buehner (2005), Wang et. al. (2007), etc.

$$J(\mathbf{x}'_f, \boldsymbol{\alpha}) = \beta_f \frac{1}{2} (\mathbf{x}'_f)^T \mathbf{B}_f^{-1} (\mathbf{x}'_f) + \beta_e \frac{1}{2} \sum_{n=1}^N (\boldsymbol{\alpha}^n)^T \mathbf{L}^{-1} (\boldsymbol{\alpha}^n) + \frac{1}{2} (\mathbf{H}\mathbf{x}'_t - \mathbf{y}')^T \mathbf{R}^{-1} (\mathbf{H}\mathbf{x}'_t - \mathbf{y}')$$

$$\mathbf{x}'_t = \mathbf{x}'_f + \sum_{n=1}^N (\boldsymbol{\alpha}^n \circ \mathbf{x}_e^n)$$

$\beta_f$  &  $\beta_e$ : weighting coefficients for fixed and ensemble covariance respectively  
 $\mathbf{x}'_t$ : (total increment) sum of increment from fixed/static  $\mathbf{B}$  ( $\mathbf{x}'_f$ ) and ensemble  $\mathbf{B}$   
 $\boldsymbol{\alpha}_k$ : extended control variable;  $\mathbf{x}_k^e$ : ensemble perturbations  
 - analogous to the weights in the LETKF formulation

$\mathbf{L}$ : correlation matrix [effectively the localization of ensemble perturbations]

$\beta_f$  and  $\beta_e$  ( $1/\beta_f + 1/\beta_e = 1$ ) can be tuned to have different weight between static and ensemble part.