利用局地系集卡爾曼濾波系統同化熱動力變數與雷達資料：敏感度實驗測試

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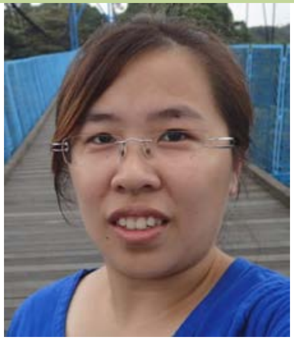

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Outline

1. Motivation

2. Examination of background errors (covariance) at convective scale

3. Results of OSSEs
   (a)Analysis (B) Short-term forecast

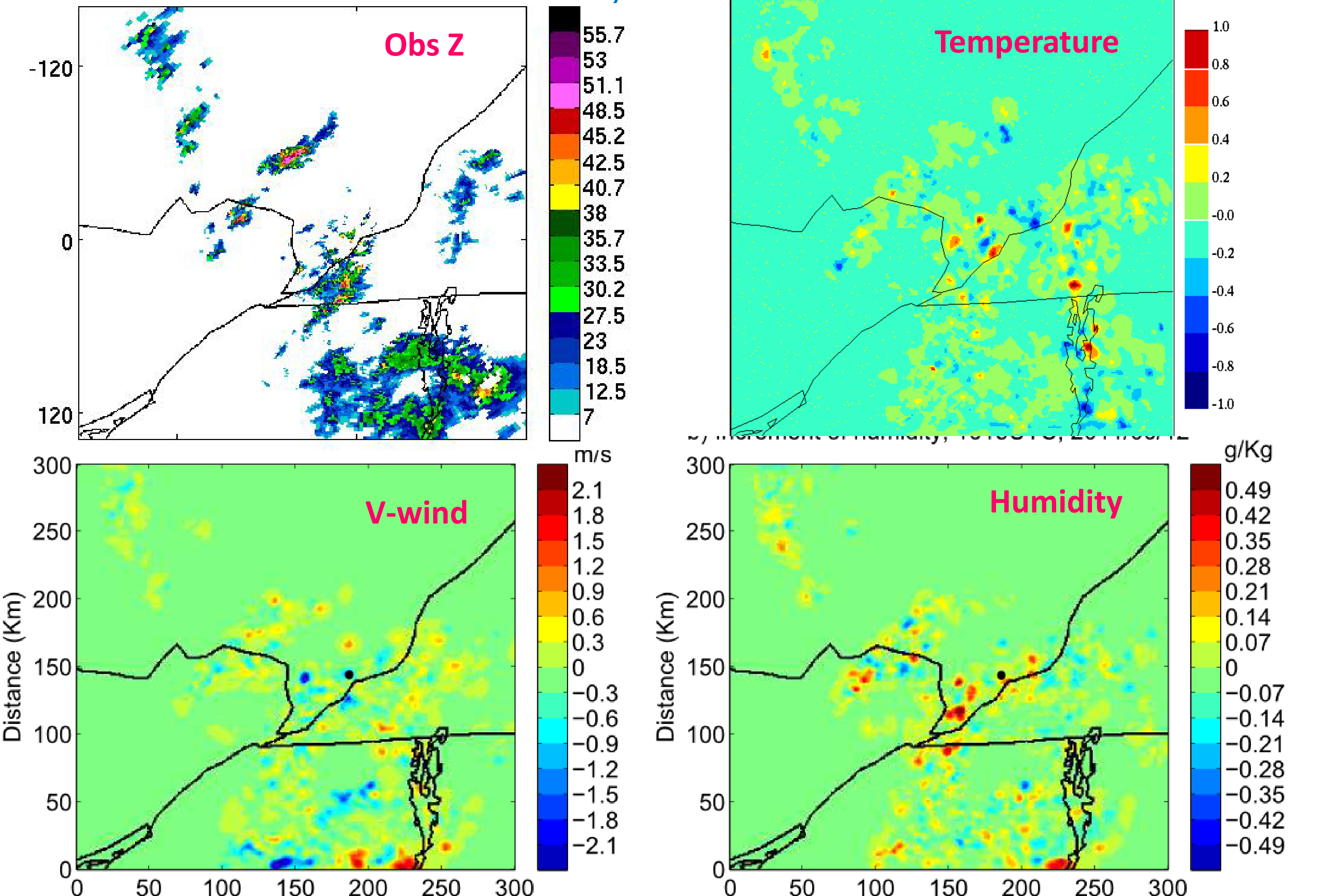
4. Summary

By using Canadian HREnKF and assimilating Vr from single Doppler radar

It is able to propagate information to other control variables.

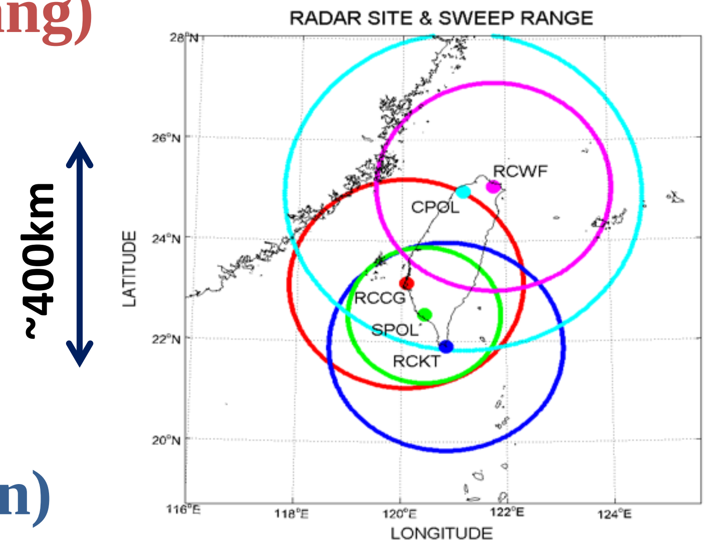
(Chang et al. 2014 M.W.R.)

Localized convection on June 12, 2011



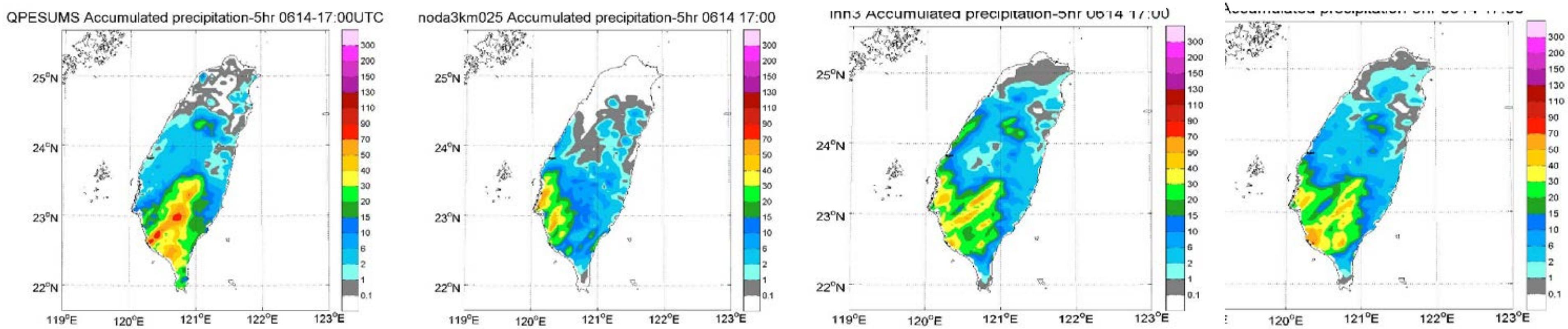
➢ Assimilating Vr and Z of radar network in Taiwan [3-km] (Prof. Yu-Cheing Liou and Shu-Chih Yang)

WRF-LETKF Radar Assimilation System
WLRAS (Tsai et al 2014)
Assimilating both radial wind and reflectivity
Case study on 2008/06/14-15 SoWMEX IOP8 (MCS)



QPF(5-hr accumulated precipitation)

◆ observation ◆ No DA ◆ 1-hr DA ◆ 2-hr DA

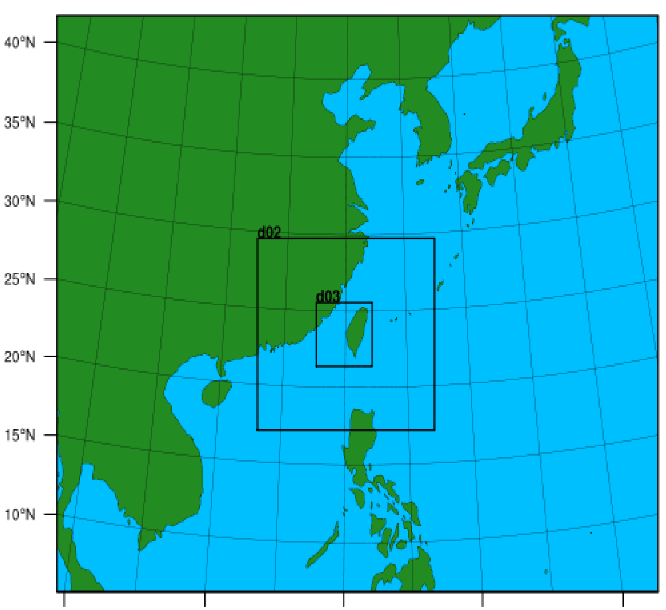


[Motivation]

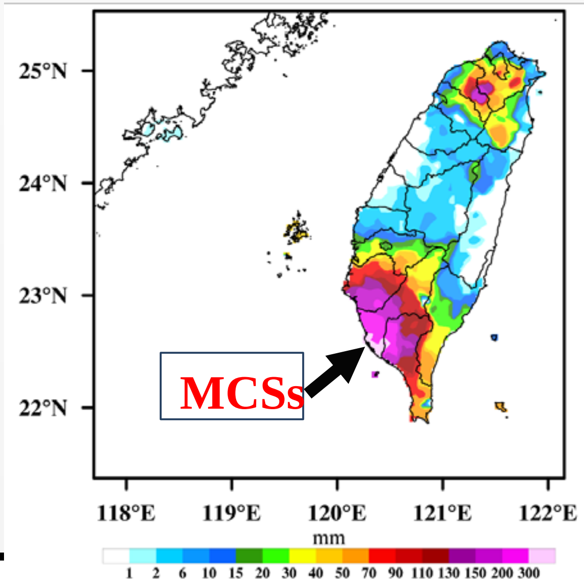
Q: By assimilating radial wind and reflectivity of radar network, why we still need a long assimilation window to improve QPF?

2. Examination of background (forecast) error

Model Version	WRF 3.2.1
Domains	D01(27-km) 180×150 D02(9-km) 160×150 D03(3-km) 150×150 27 layers, top at 50 hPa
Physical Parameterizations	Longwave Radiation: RRTM scheme Shortwave Radiation: Dudhia scheme PBL: YSU scheme Cumulus: G-D ensemble scheme Microphysics: GCE scheme
Initial Time	1200 UTC 15^{th} Jun., 2008
Initial Condition	WRF-LETKF analysis ensemble (conventional data, AMV, GPS-RO) (Yang et al. 2014 M.W.R.)
Ensemble Members	36→72



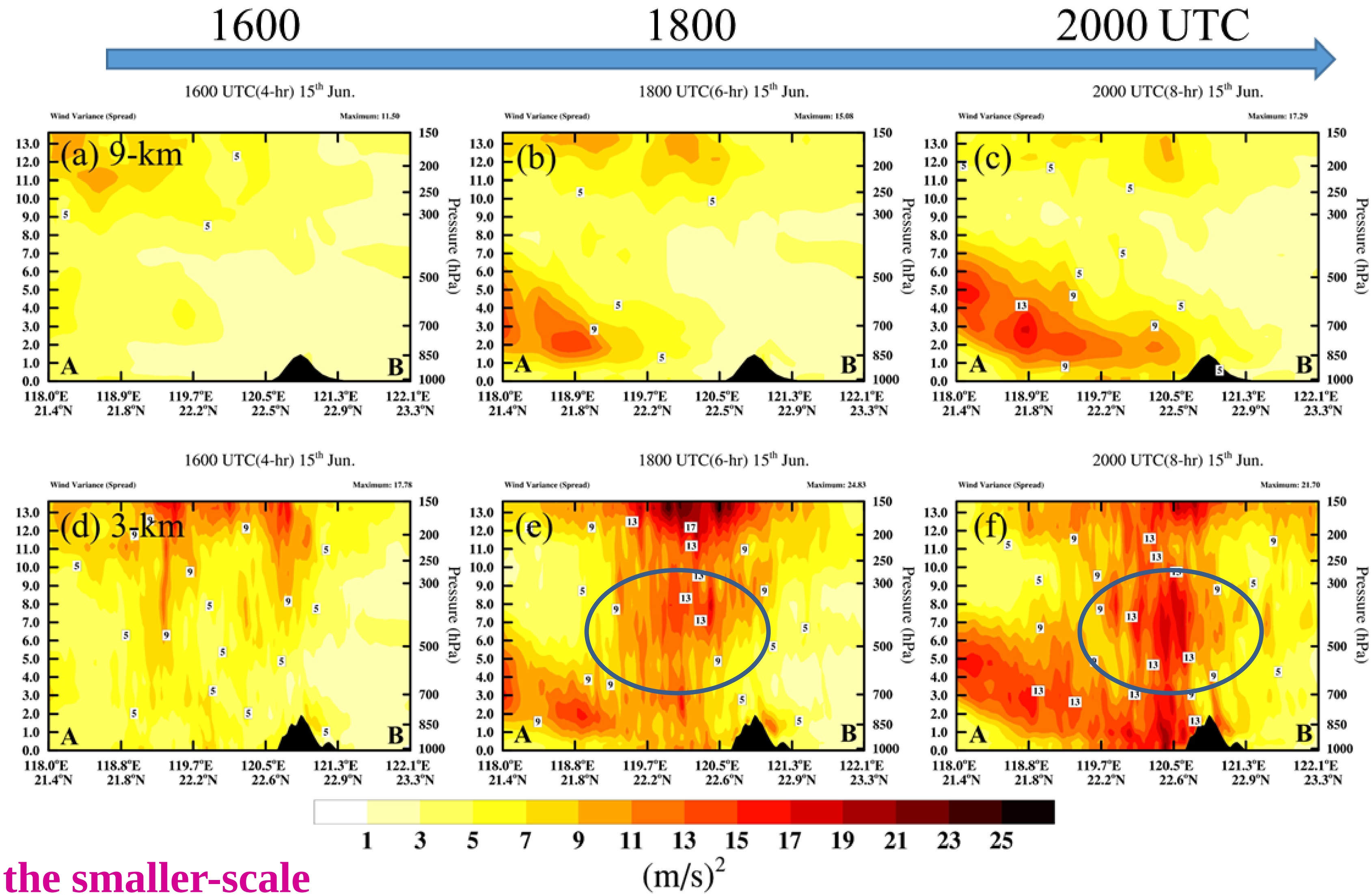
Observed 24-hr Accumulated Precipitation



Variance in time

9-km

3-km

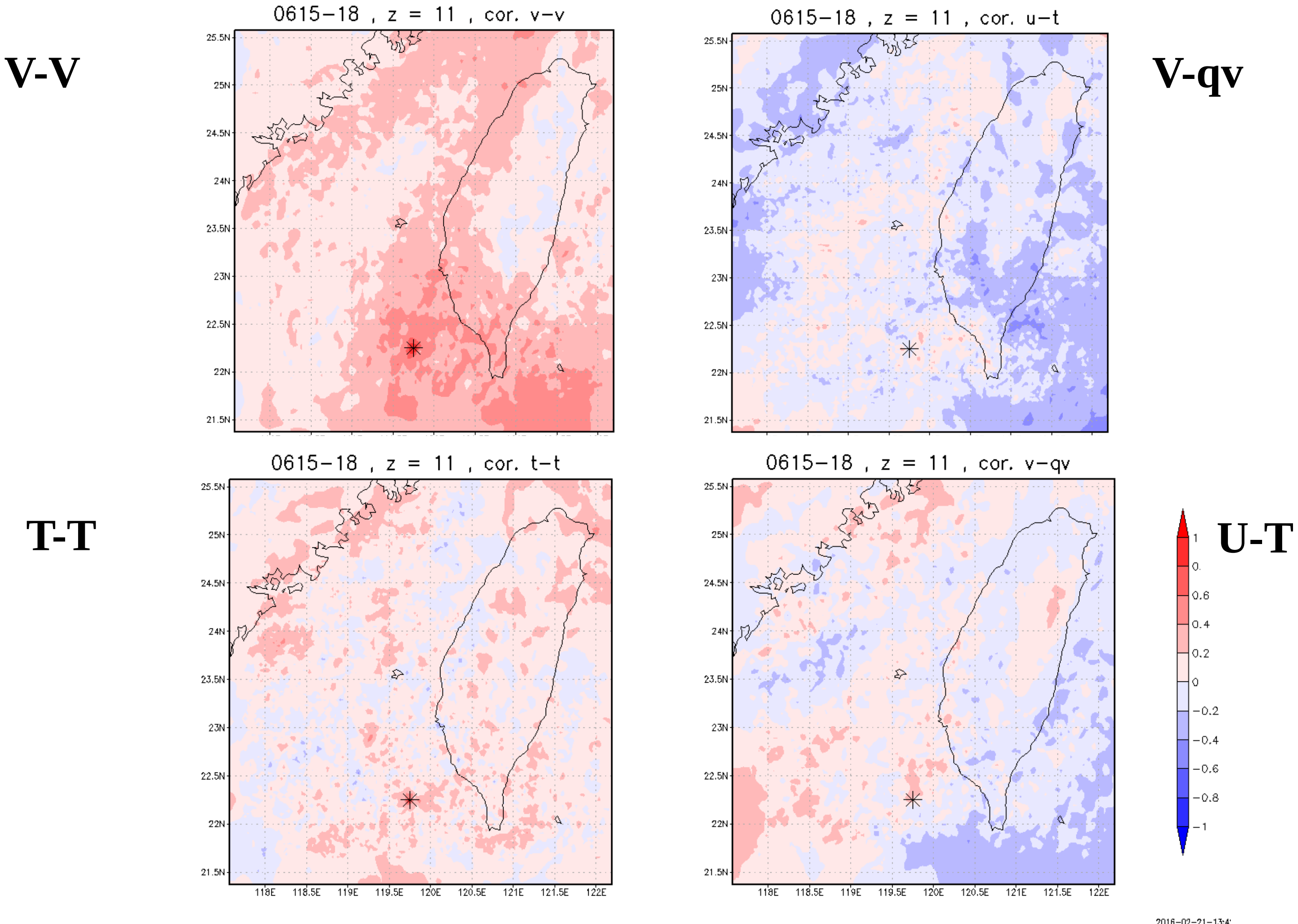


Capture the smaller-scale weather features

- **multi-scale interactions at 3-km resolution**

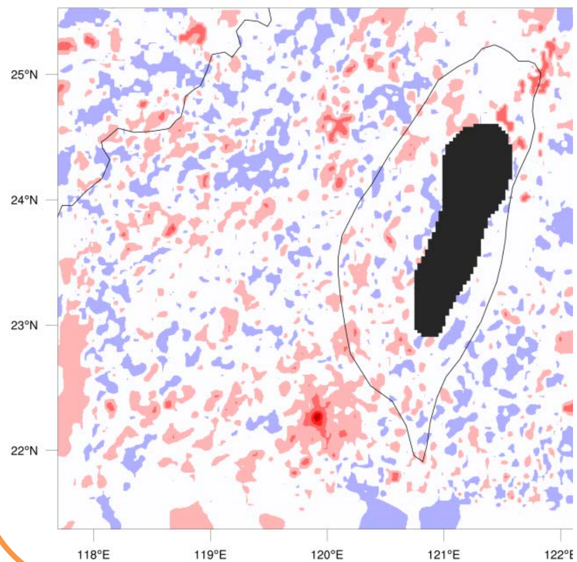
2. Examination of background error at convective scale

◆ **Convective scale error correlation (3-km resolution, ~700mb)**

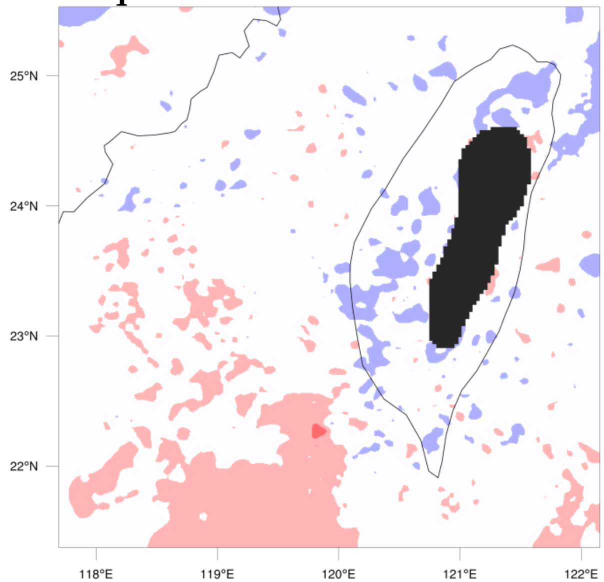


- *Compared to Temperature, Wind has longer correlation length.*
- *Less strong / very local correlations between state variables at convective scale*

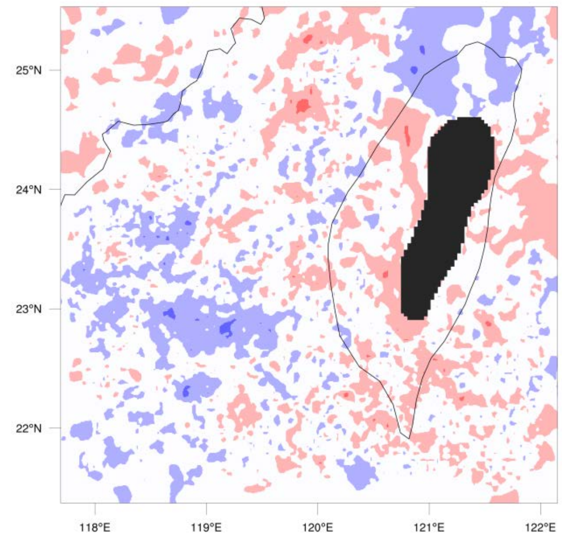
qr-qr auto-correlation



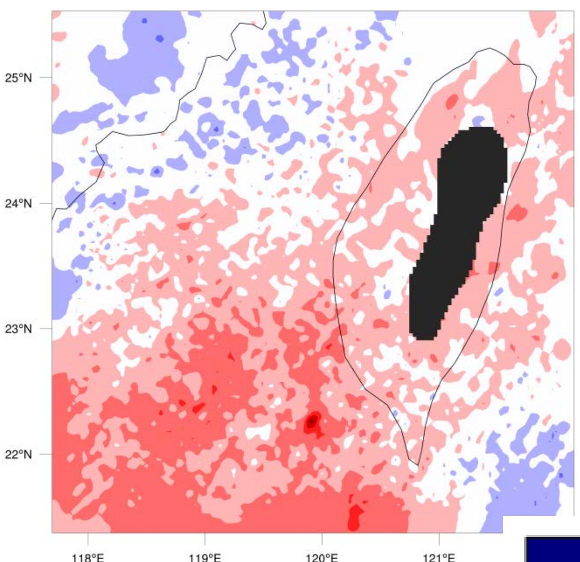
qr-U cross-correlation



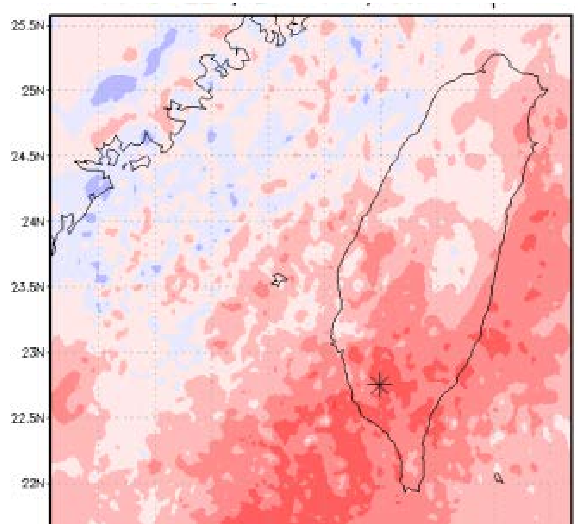
qr-T cross-correlation



qv-qv auto correlation



T-qv cross-correlation



$$Z = 43.1 + 17.5 \log(\rho q_r),$$

$$V_r = u\frac{x}{r} + v\frac{y}{r} + (w + V_t)\frac{z}{r},$$

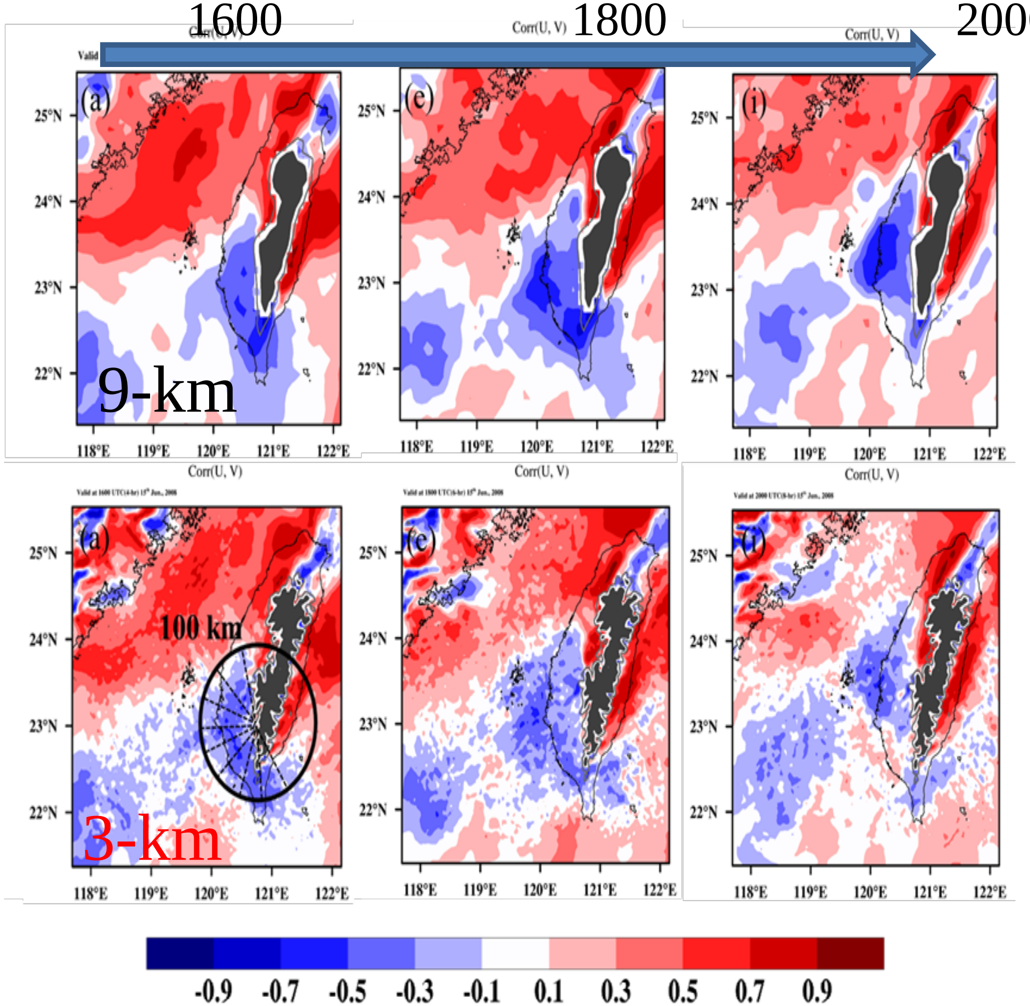
Explain why we need many cycles in DA even though with Radar network observations

Error Correlation

(cross)

Corr(U, V)

1600 1800 2000 UTC



Scale analysis in the previous study (Yeh and Chen 2002)

$h_m \sim 2\ km, U \sim 10\ m\ s^{-1}, N \sim 10^{-2}$

$f \sim 10^{-4}\ s^{-1}$

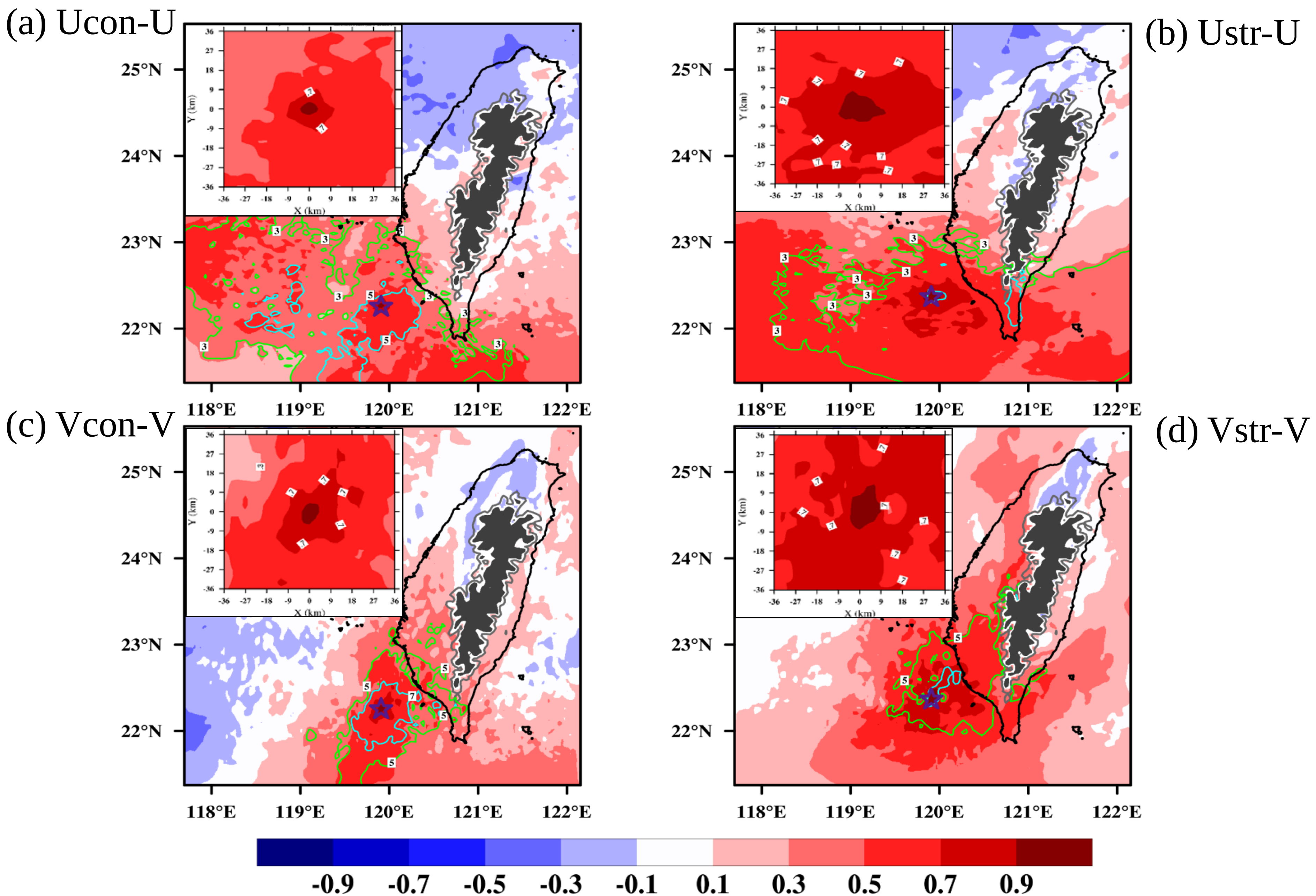
Froude Number:

$$Fr = \frac{U}{h_m N} = 0.5 < 1$$

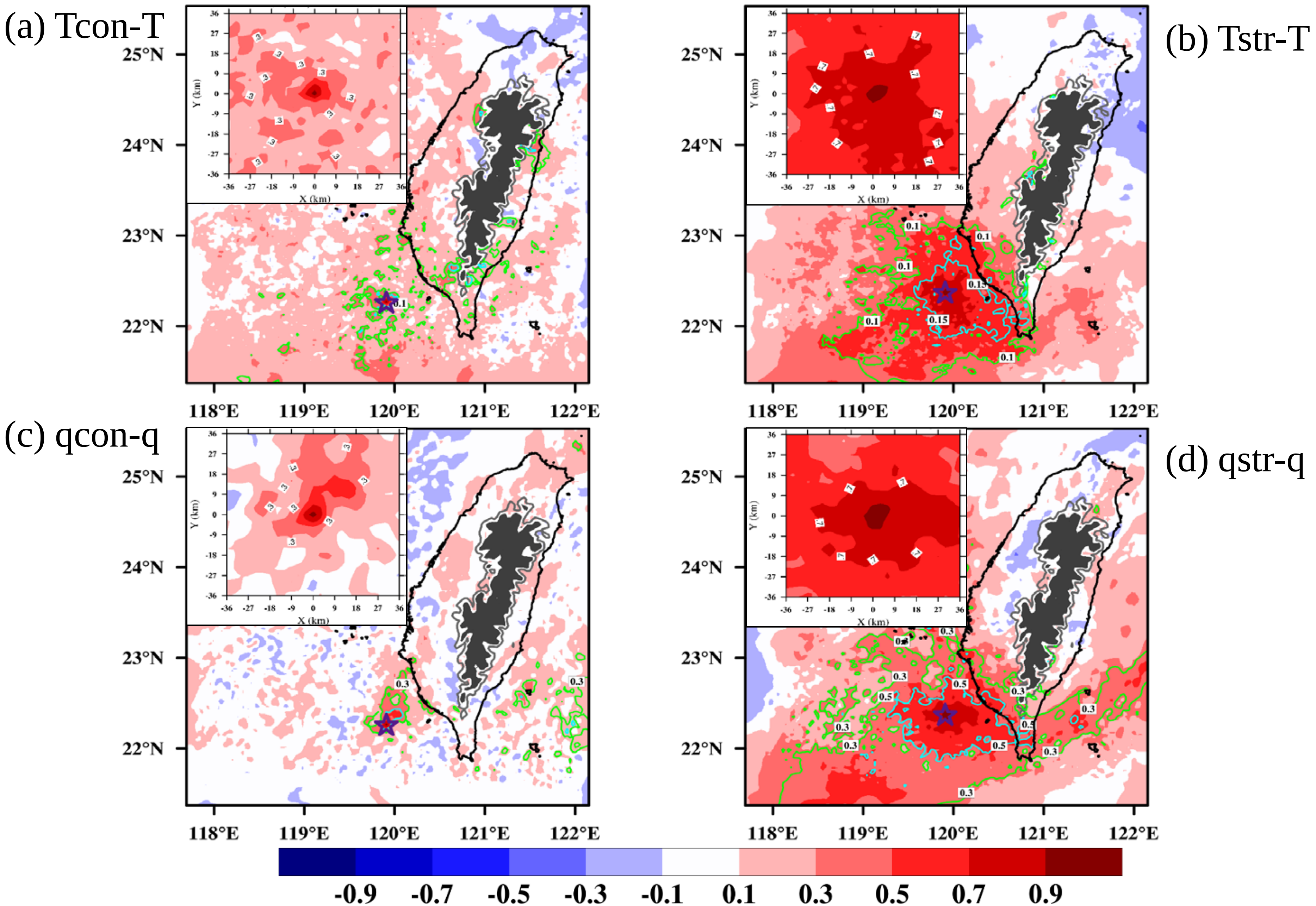
Rossby Radius:

$$L_R = \frac{N h_m}{f} Fr = 100\ \text{km}$$

Error covariance at convective scale (I)



Error covariance at convective scale (II)

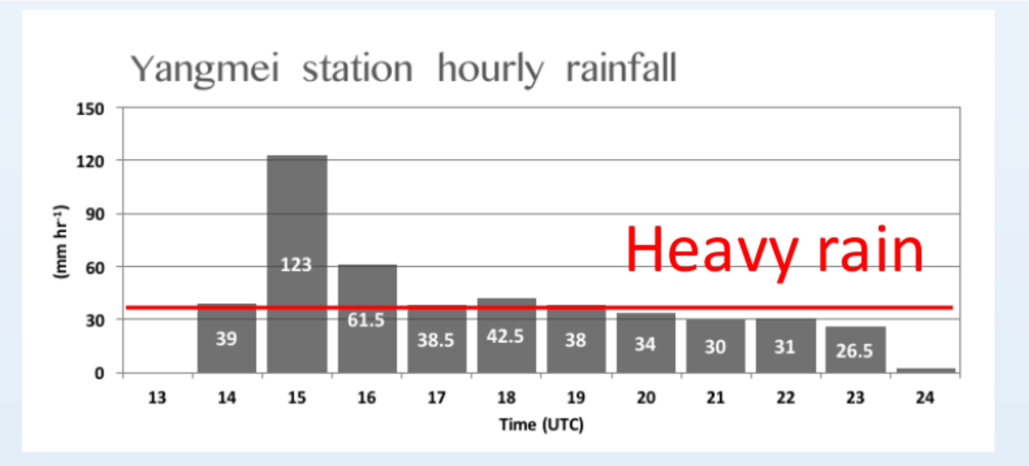


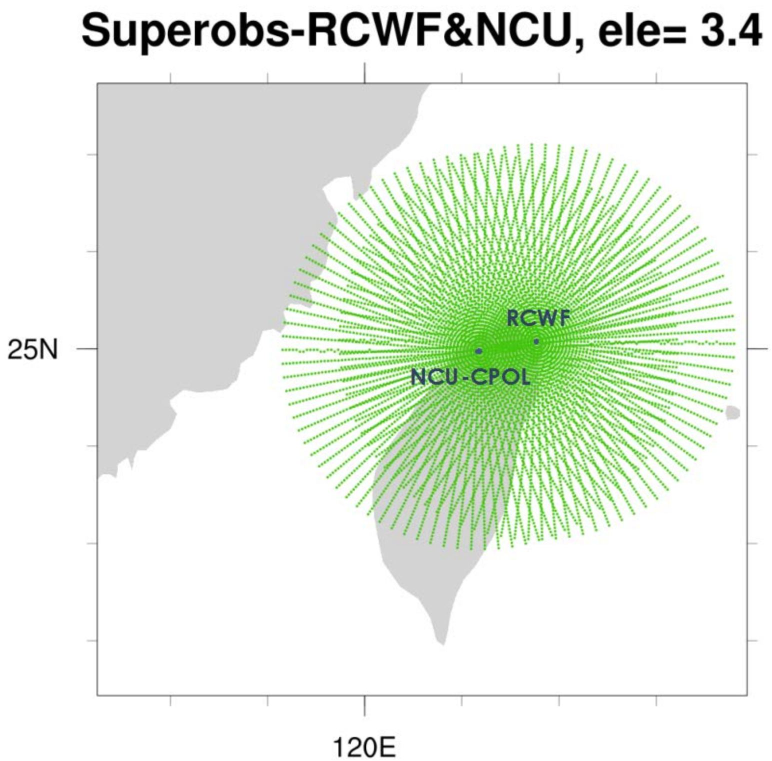
3. Impact Of Assimilating Thermodynamic Variables

Are we able to reduce the cycling procedure for convective scale QPF?

OSSE setup

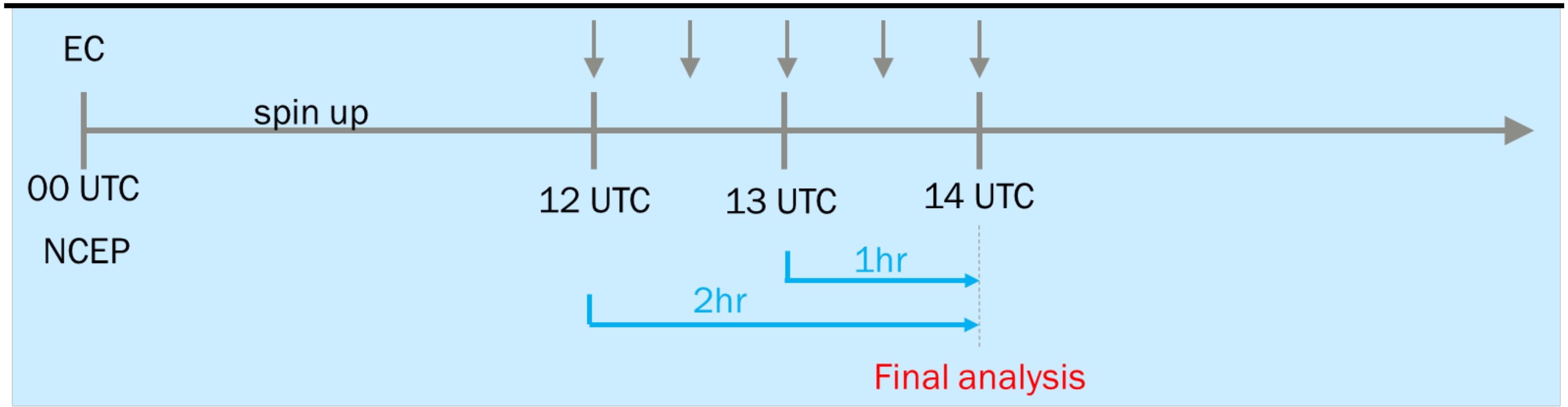
- WRF-LETKF Radar Assimilation System (WLRAS; Tsai et al., 2014)
- Case study: Mesoscale convective system in Mei-Yu season 11 June 2012
- Radar sites: RCWF and NCU-CPOL

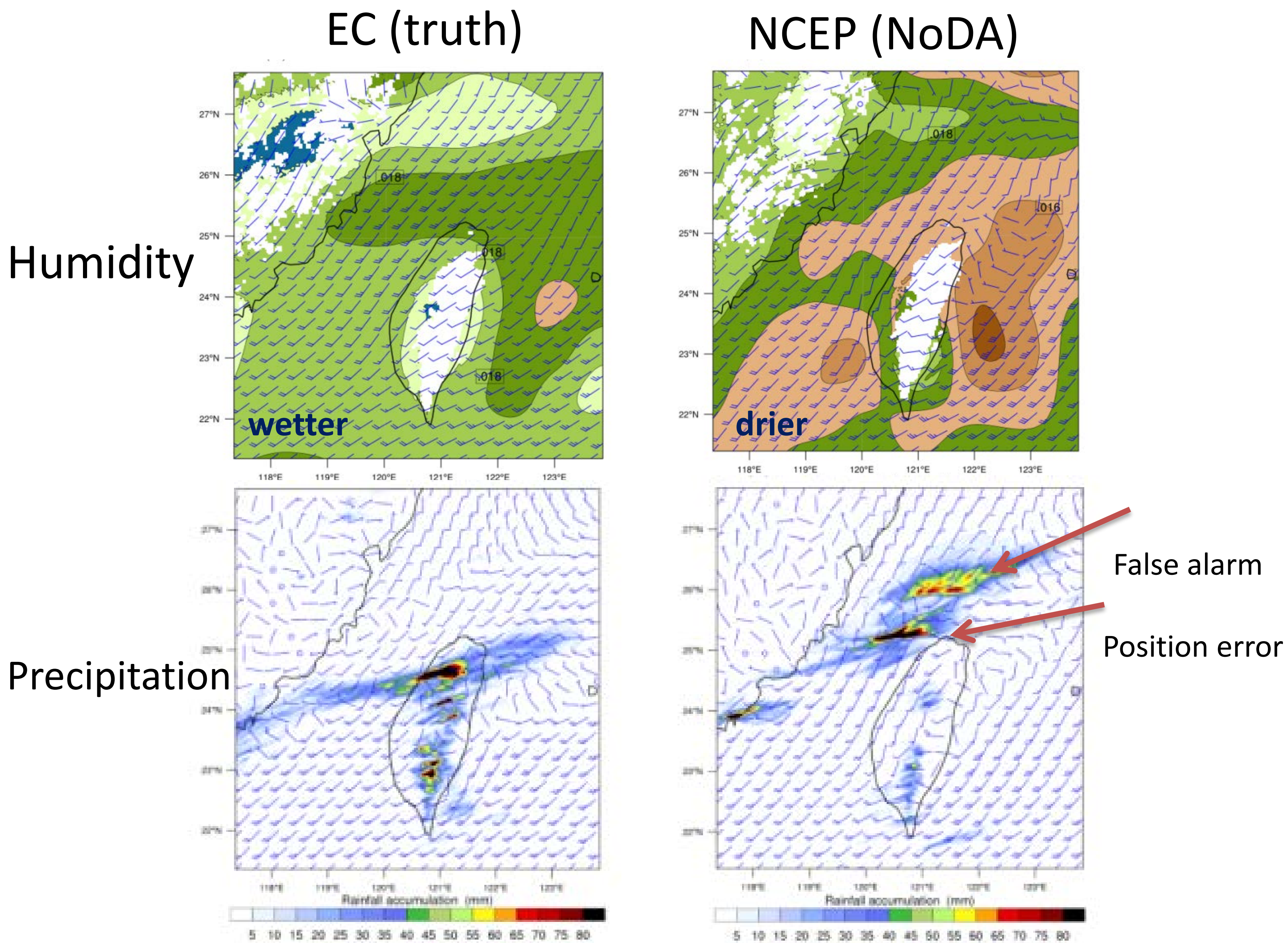




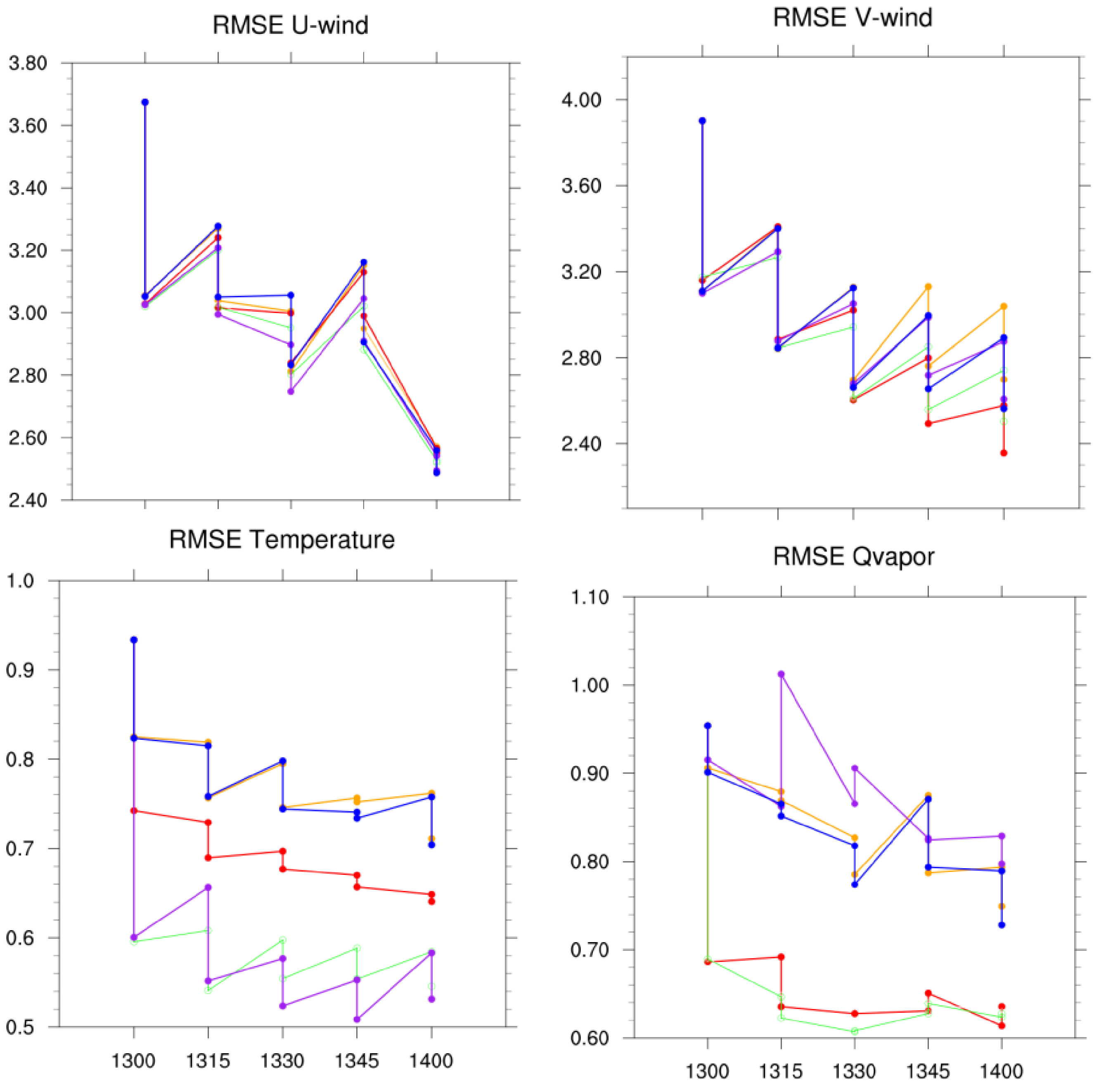
Truth: initial condition: EC-reanalysis (0611 0000UTC)
Exp. : initial condition: NCEP(0611 0000 UTC)
DA period : 1hour /2hours,every 15min
DA variables : Reflectivity, Radial wind, Temperature, Water Vapor
Observation error : Z(3 dBZ), Vr(1 m/s), T(0.5K), Qv(0.5 g/kg)
Member size: 40 members

Experiments	Observation	Assimilation period (h)
NoDA	-	-
VrZT	Vr, Z, T	1
VrZQv	Vr, Z, Qv	1
VrZ	Vr, Z	1
VrZ-2	Vr, Z	2




EC (truth)
NCEP (NoDA)
Humidity
Precipitation
wetter
drier
.018
.016
27°N
26°N
25°N
24°N
23°N
22°N
118°E
119°E
120°E
121°E
122°E
123°E
False alarm
Position error
Rainfall accumulation (mm)
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

RMSE of A and P during 1-h assimilation cycles



- ZVr
- ZVrT
- ZVrQv
- ZVrTQv

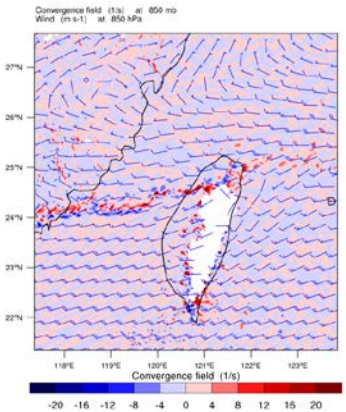
Minor differences: Assimilating Vr

Major differences

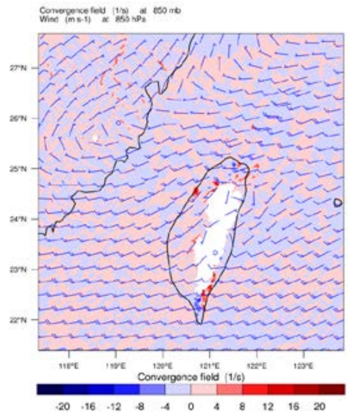
Convergence on 850mb

1400

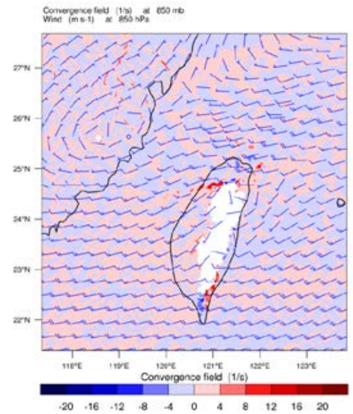
Truth



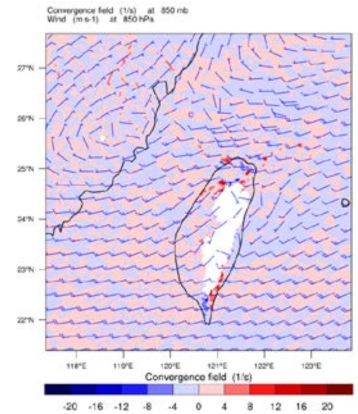
ZVr



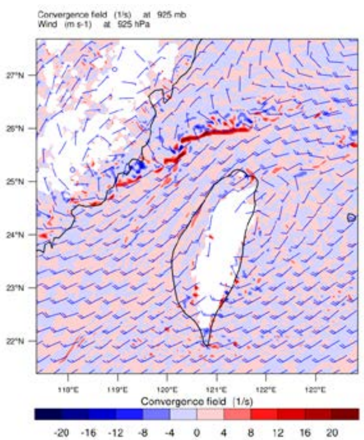
ZVrT



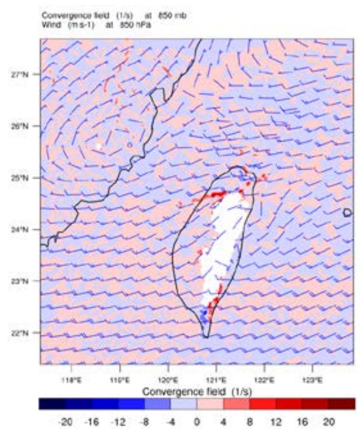
ZVrQv



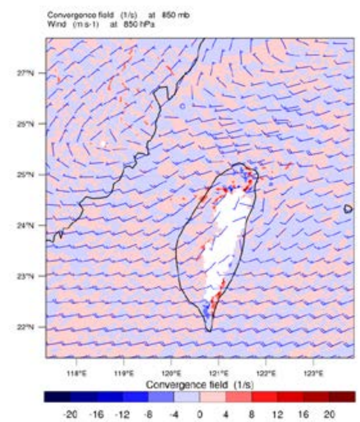
NoDA



ZVrTQv

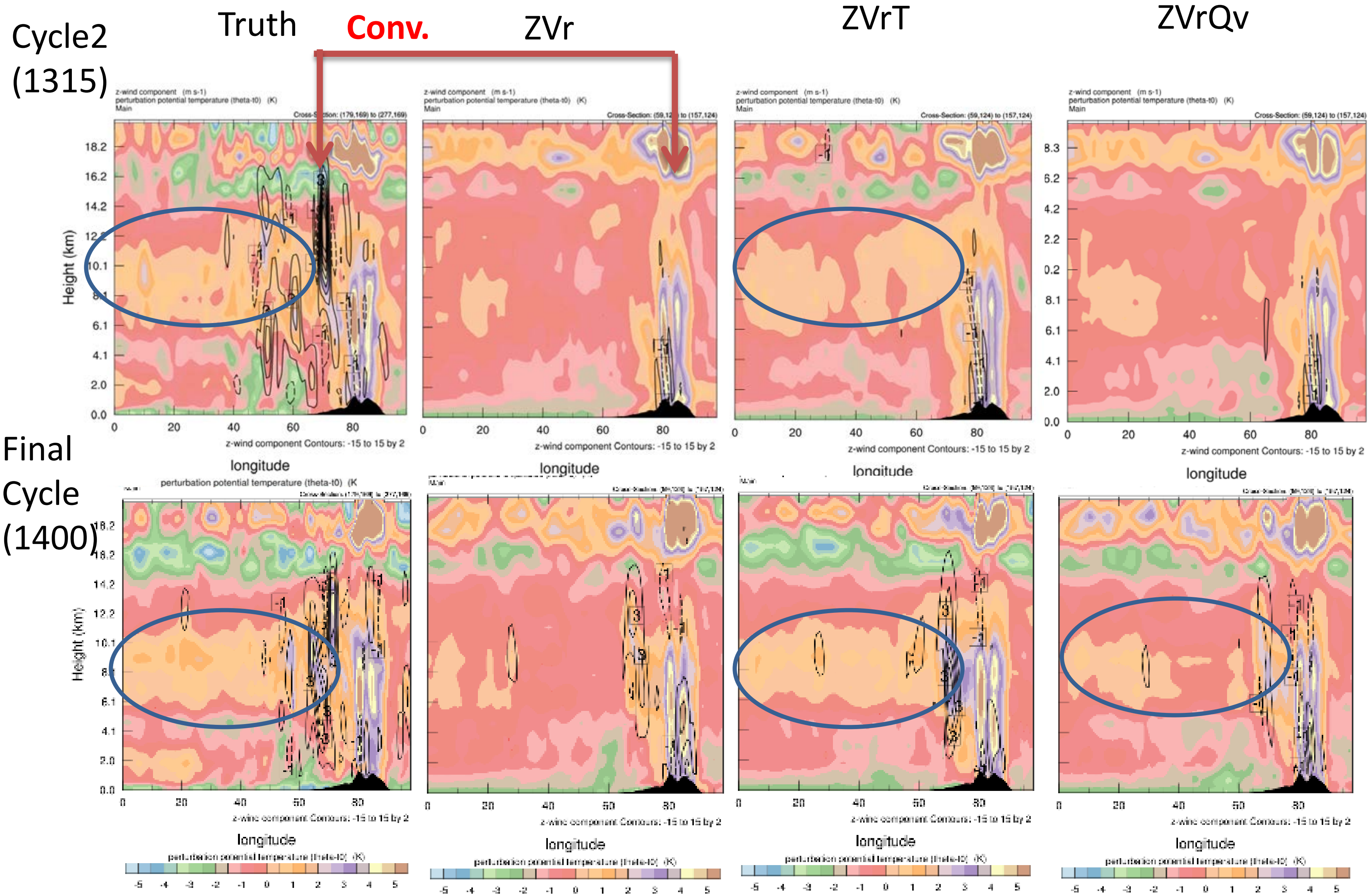


ZVr2h



Results of assimilation cycles (I)

Vertical structure of temperature & vertical velocity

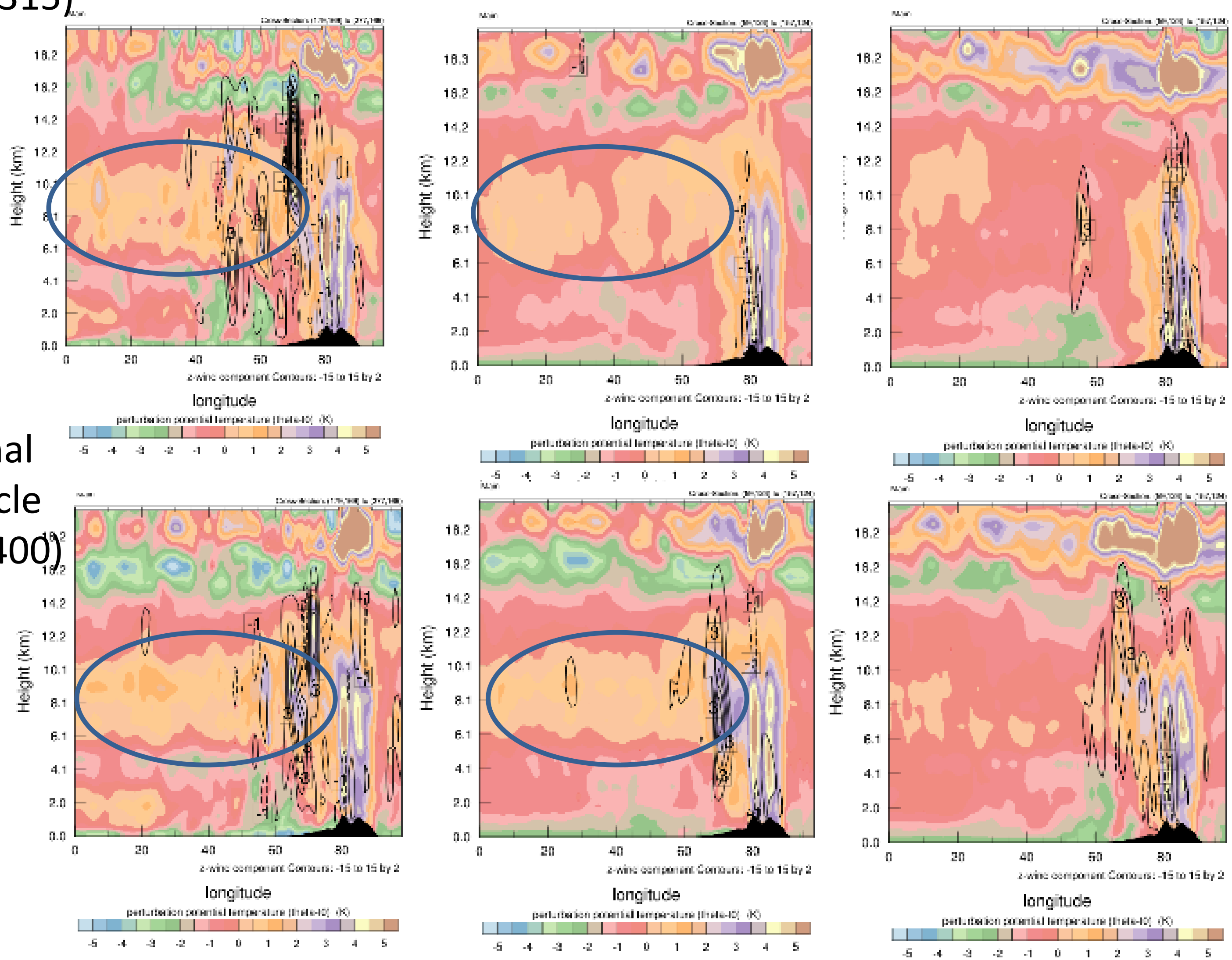


Results of assimilation cycles (II)

Vertical structure of temperature & vertical velocity

Cycle2 (1315) | **Truth** | **ZVrT** | **ZVr2h**

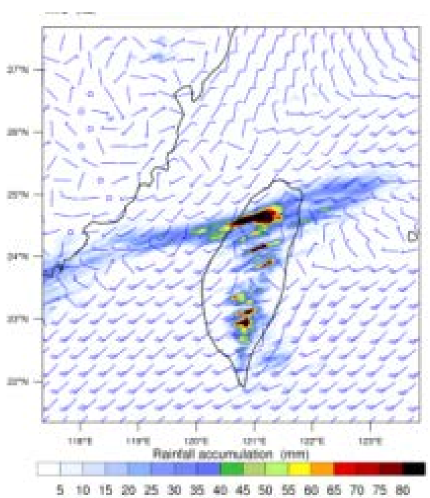
Final Cycle (1400)



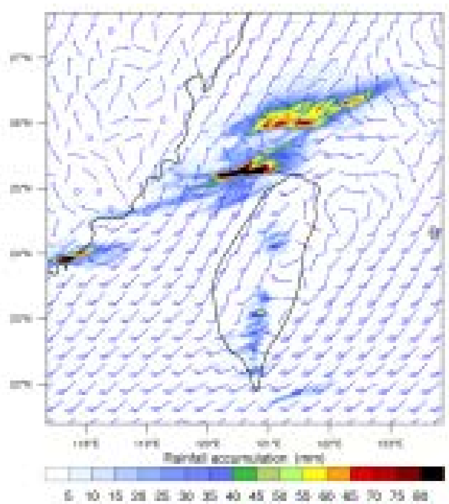
Result of the short-term forecast (I)
(3-h accumulated rainfall)

Deterministic forecast from ensemble mean analysis

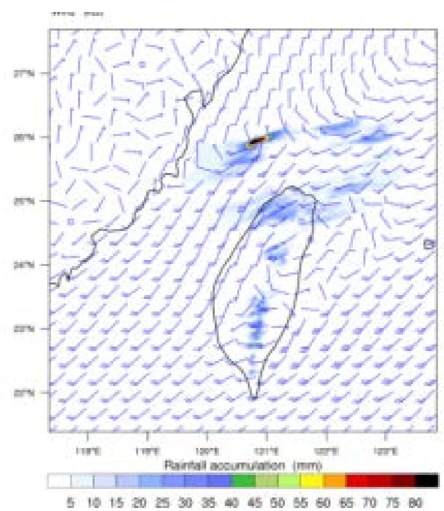
Truth



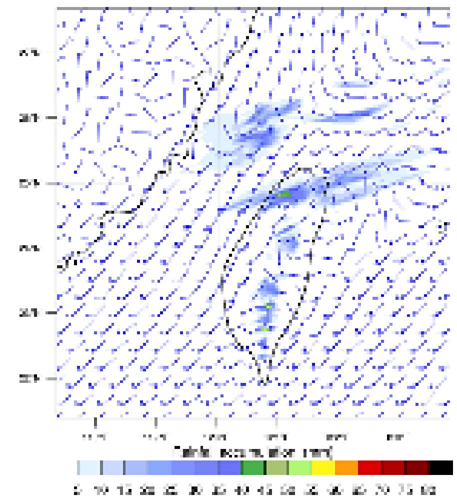
NoDA



ZVr



ZVr2h



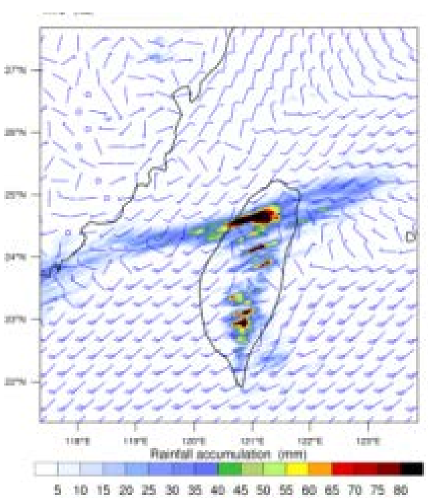
Position improved,
but less accumulated precipitation

Position and accumulated precip.
slightly improved.

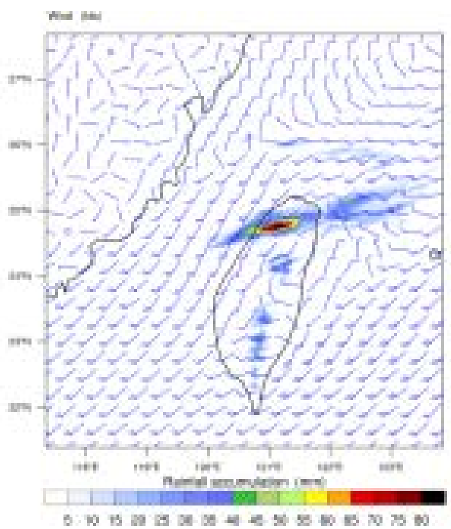
Result of the short-term forecast (II)
(3-h accumulated rainfall)

Deterministic forecast from ensemble mean analysis

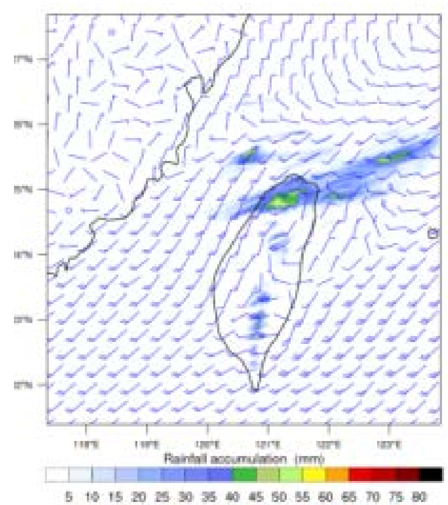
Truth



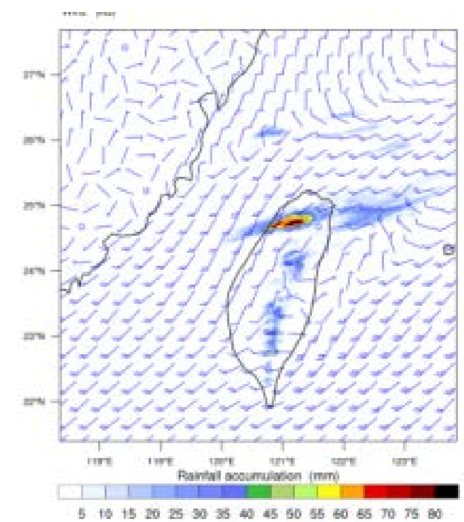
ZVrTQv



ZVrT



ZVrQv



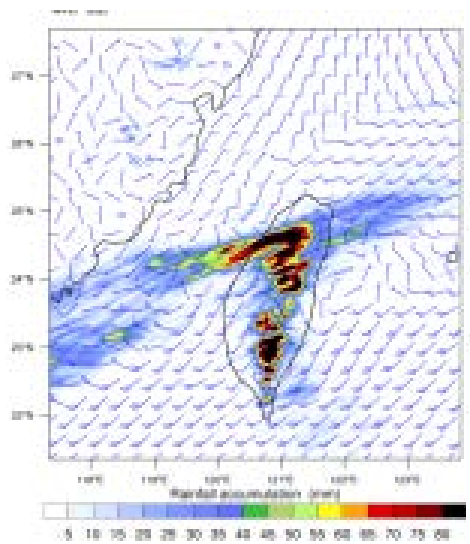
Better (location)

Better (intensity)

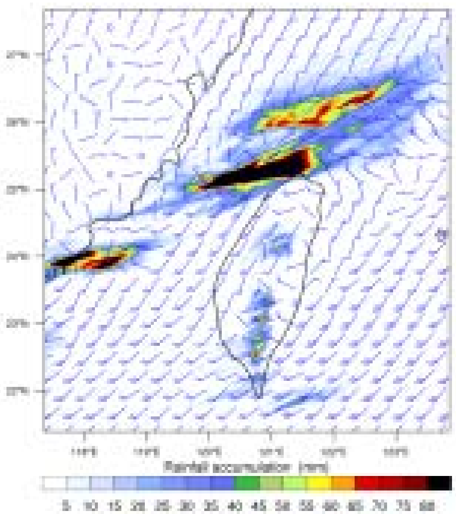
Result of the short-term forecast (II)
(6-h accumulated rainfall)

Deterministic forecast from ensemble mean analysis

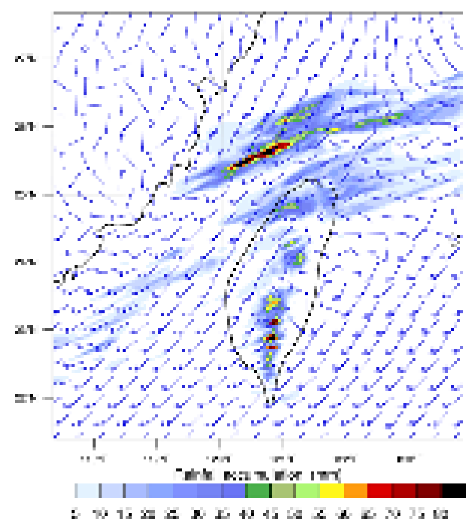
Truth



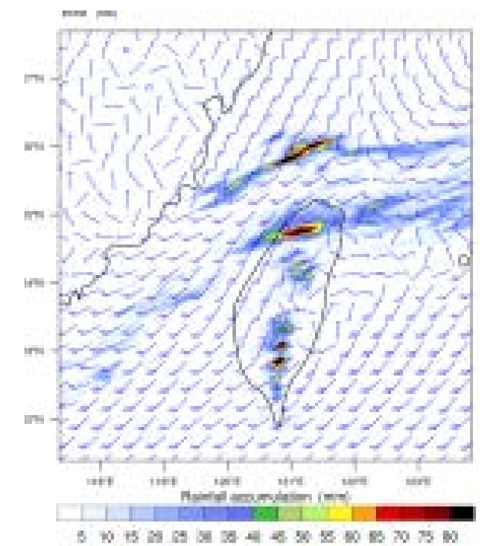
NoDA



ZVr2h



ZVrTQv



Summary

- **The examination of background errors at convective scale shows**

  1) model of higher resolution is associated with larger uncertainties;
  2) multi-scale situation is both showed in variance and correlation;
  3) less strong or very localized correlation between state variables
  -> this explains why we need many cycles with radar network
  4) error covariance has different impact at convective and stratiform area

- **Results of OSSEs show that**

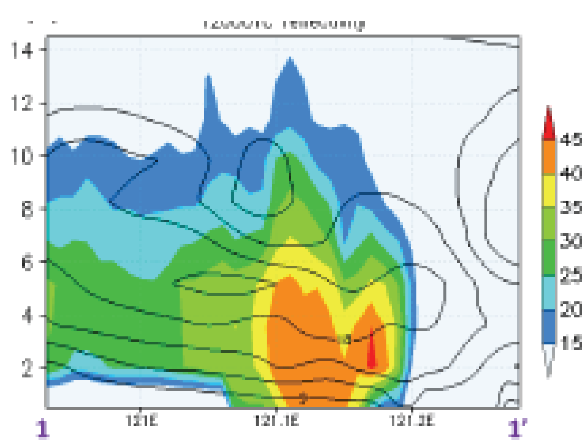
  1) one is able to reduce the cycling procedure and obtain better analysis if it is able to assimilate temperature or humidity;
  2) To correct position error of precipitation: assimilating radial wind and reflectivity may not be enough.
  → Info. of temperature or humidity is needed at convective scale;
  3) To improve the QPF for longer time: information of humidity is the key.

Observations lead the way:

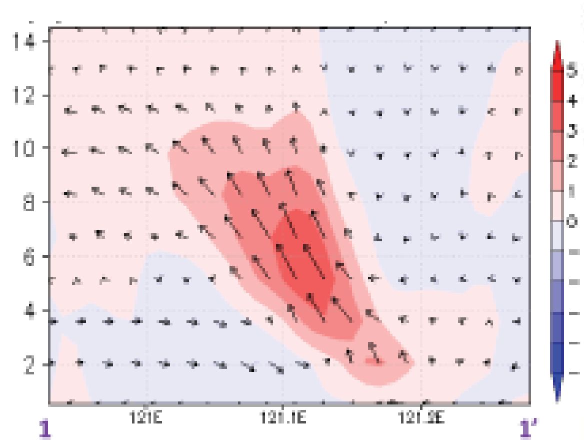
Observations of temperature and humidity in 3D are needed for convective scale

How to obtain the info ?
Retrieval from remote sensing (Himawari 8, GPS-RO, radar) & mesonet, mesoscale radiometer

Z-Qr



Vr→u,v, w



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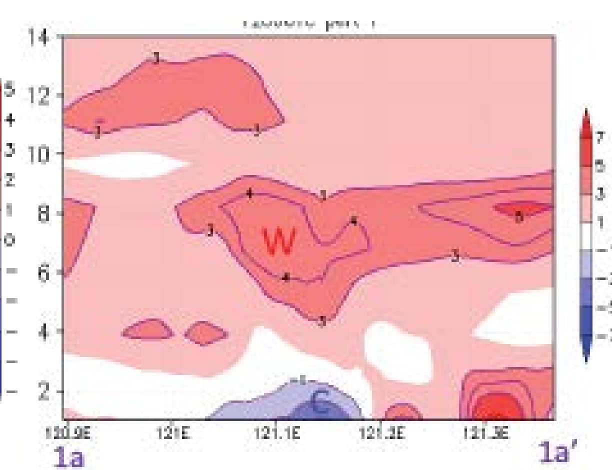


Thank you for your attention!
Any questions?